

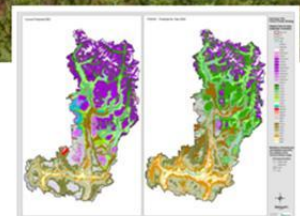
Adapting Forest Management in the Kamloops TSA to Address Climate Change

The Kamloops Future Forest Strategy

FINAL REPORT



By the KFFS TSA Team



June 8, 2009

“Even if you’re on the right track, you’ll get run over if you just sit there.”

Will Rogers

ACKNOWLEDGEMENTS

This report was written by the Symmetree Consulting Group team of professionals who also produced the background documents found in the *Compendium of Supporting Documents*:

- **Ken Zielke and Bryce Bancroft of Symmetree Consulting Group** - managed the project, led the consulting team, wrote a number of sections, assembled and edited the report.
- **Cam Brown of Forsite Consulting** - helped with all aspects of the project and was pivotal in providing data analysis, assistance in climate mapping and analysis, and assistance with forest management issues throughout the project.
- **Colleen Jones, an ecologist with Shamaya Consulting and Stephen Smyrl of Forsite Consulting** - worked closely with numerous others to develop a unique approach to interpretation of climate data in the BC biogeoclimatic context using local ecological knowledge.
- **Laurie Kremsater, a consulting habitat / conservation biologist** - worked with local biologists and data to explore sensitivities and direction for biodiversity and habitats.
- **Ken Day, the UBC Alex Fraser Research Forest Manager** - helped to write several sections, and provided insights and assistance throughout the project.

The approach and content of this project was led and influenced through every step by the KFFS TSA team of licensees and agency participants. This team made this project relevant to operations. This team included:

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The Ministry of Forests Executive, Forest Stewardship Division steered the project from the provincial level, providing guidance and advice throughout:

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The credit for this project goes beyond the team of consultants, local licensees and agencies and the Ministry of Forests Executive. It reflects thoughtful advice and suggestions from numerous specialists, academics and practitioners in various informal meetings and project workshops. These folks included:

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¹ Due to the level of detail surrounding the sensitivities and vulnerabilities found in the TSA the report has been structured to have general information presented in the main body of the report with the detailed direction and analysis presented in Appendices. Some reports would have this information provided as chapters or sections. The use of appendices was done to allow those interested in more detail to download only those Appendices they are interested in, saving time for downloading, and printing.

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1 REPORT STRUCTURE.

The Kamloops Future Forest Strategy (KFFS) has information and discussion that may be of interest for a number of audiences, from policy makers to practitioners. Thus a brief description of the report structure is provided:

The KFFS is made up of three major parts:

1. **The Report:** This document provides the detailed recommendations, along with an overview of components of the strategy that lead to these recommendations. It is intended for those who are either interested in the general outcomes and the key recommendations from the strategy, or a general understanding of a process to conduct a vulnerability assessment at a localized level using expert opinion. For the Kamloops Timber Supply Area (TSA), it provides: the background and intent of the project; an overview of the process to build the strategy; a summary of ecological and management sensitivities; management options; and an adaptive capacity / vulnerability discussion.
2. **The Appendices:** There are six appendices that provide the details of the proposed strategy. Much of what is found here can be considered to be the “essence of the strategy,” containing specific sensitivities and suggested adaptive actions that will be of interest to those who are involved in implementation, or those wish to develop a similar strategy for their management unit. These are meant to specifically provide:

Appendix 1 – a description of the process used in this project, including suggested efficiencies for those interested in pursuing a similar approach elsewhere.

Appendix 2 – general climate change trends and assumptions for the entire TSA based on TSA climate change modelling.

Appendix 3 – a summary of specific sensitivities and adaptive management direction / actions by groupings of similar biogeoclimatic subzones. This appendix provides detail that is meant to inform operational strategic planning and implementation. Along with Appendix 4, these two appendices are the main components of the strategy.

Appendix 4 – a summary of specific sensitivities and adaptive management direction for the entire TSA, by value (e.g., biodiversity, First Nations Cultural plants, timber...). It works in conjunction with Appendix 3 to provide a detailed picture of issues and options within the TSA by value.

Appendix 5 – a vision of the Kamloops TSA up to 2080 with and without the implementation of the suggestions identified in recommendations (and found in more detail in the previous two appendices). This appendix is useful for those who wish to envision the future landscapes and the condition of the range of management values using the plausible futures, to understand the potential benefits and limitations of the proposed adaptive strategy.

Appendix 6 – provides a detailed discussion of adaptive capacity issues and subsequent vulnerabilities for climate change. It is useful for managers and policy specialists who are interested in a detailed discussion of the implementation barriers associated with the TSA vulnerabilities. It too would be useful for those contemplating using a similar approach elsewhere.

3. **Compendium of Supporting Documents.** A number of documents and presentations were created as background and as part of the building process for the KFFS, they are provided as separate files that may be of interest to both policy makers, those interested in pursuing their own strategy or for general interest. They are as follows:

A Summary of Current Management Regimes Relevant to the Future Forest Strategy for the Kamloops TSA (March 31, 2008) - This document provides detail on the various objectives outlined for the area within the various plans for the area. This document provided guidance on what to assess within the climate lens.

Climate Modeling and Future Ecosystem Climate Mapping (Version 2.0 September 26, 2008), and *Maps of Subzone Climate Envelopes (Version 2.0 September 26, 2008)*. These documents provide a detailed description of how the climate scenarios were used to help envision the future and allow vulnerabilities to emerge.

Ecological Narratives – Simple bold narratives were created to summarize plausible future forest conditions and ecological sensitivities based on the climate change scenarios and the subsequent ecological sensitivity discussion workshops. These were done for 12 major subzones in the area. Each provides a slightly different view of the future and helped guide management vulnerabilities.

2 INTRODUCTION

2.1 Background: The BC Context

The British Columbia forest sector has experienced and continues to experience many challenges, including:

- Global climate change with expected significant impacts on species and ecosystem distribution and the range and impact of many forest pests and diseases;
- The largest recorded mountain pine beetle outbreak in North America;
- A provincial timber harvesting land base that is constantly under pressure and scrutiny from various competing interests and agencies;
- International market forces and economic drivers, impacts; and
- Increasing public concern regarding sustainable forest management.

A future forest strategy endeavours to articulate the vision of the desired forest condition, providing greater resilience to ecological, economic and social issues or drivers such as climate change, transition from harvesting old growth to second growth stands, and mountain pine beetle. Articulating a vision for our future forests and applying a “lens” to that vision of any forestry related challenges as they arise will provide the information that informs existing strategies, the need for new strategies and analysis, and potential gaps to be addressed.

The current management approach evolved over time in BC to have a solid foundation of high-level land use plans, comprehensive legislative and policy regimes that regulate forest practices, and a myriad of operational and tactical forestry plans and strategies, most of which are predicated on the current forest condition. Ultimately a future forest strategy can:

- Provide further assurance to the public, stakeholders, and government that their current and future forest needs are understood, balanced and addressed;
- Guide forest land base investments, and influence silviculture treatments, research activities, Forest Investment Account (FIA) activities and priorities;
- Inform future development of Sustainable Forest Management Plans (SFMP), Forest Stewardship Plans (FSP), Timber Supply Review (TSR) and forest management strategic documents;
- Inform the need for updates to land-use plans and / or legal land-use objectives and to identify possible legislative issues;
- Identify the need for potential changes to forest management policies relative to achieving the objectives outlined for the future forest strategy; and
- Promote First Nations information sharing at a strategic level.

2.2 Intent of the Kamloops Future Forest Strategy

The KFFS was initiated as a pilot project by the Ministry of Forests and Range in 2007-08 to create a vision of forest management for resilient conditions and a strategy to achieve those conditions within a Timber Supply Area² (TSA). The project was initiated to inform existing strategies, and explore the need for new strategies and scenarios. An additional objective was to identify any potential “gaps” that need to be addressed.

The intent of the Kamloops Future Forest Strategy is therefore principally to provide general management direction for future planning processes that:

- considers the changing context provided by climate change,
- integrates overlapping objectives and,
- seeks well-informed solutions to fit with stand and landscape structures and functions over time.

To effectively integrate management for multiple objectives over time it is important to have a vision of the mix of stand types and structures for various landscapes to reasonably fit with those objectives and the ecosystems present. Global climate change presents an uncertain, moving target for forest managers as they try to understand ecosystem attributes and function over the next rotation. This influence cannot be ignored.

Gaining a perspective on climate change and potential impacts on an integrated management strategy is not simple. It requires best estimates of changing future ecological conditions, with a reasonable consideration of the uncertainty tied to those estimates. Climate change therefore became the lens through which the Kamloops Future Forests Strategy would examine the future forest condition.

What emerges in this strategy is not intended as an accurate prediction of the future. This project intentionally avoided comprehensive modeling and analysis, except to initially explore changing climate variables across the TSA. Climate change was examined to explore how much change we may realistically expect. At the same time, numerous qualitative estimates are made regarding sensitivities, adaptive capacity and vulnerabilities. These estimates may be improved in future planning through more quantitative analyses. Accordingly, the direction provided in the KFFS would benefit from further discussion and analysis to refine the options and better integrate them across the various objectives.

The KFFS Team views the strategy as a critical tool for long term management within the TSA. However, it must be emphasized that the KFFS was from the onset not intended to be a plan. It was intended as a strategy that provides direction for development of assumptions, targets, indicators and tactics in planning processes such as: Timber Supply Reviews (TSR), Sustainable Forest Management (SFM) planning for certification, Forest Stewardship Plans (FSPs) and other operational plans.

² TSA – within BC a timber supply area is managed strategically as one unit with a number of tenures for harvesting and management within it. Allowable cut is re-determined every five years for the area and split accordingly between licensees.

Clearly, the KFFS takes the first small glimpse into a previously unexplored future for the Kamloops TSA, and it provides the first small steps to address some significant impacts from climate change. These steps should be considered just the start of an on-going journey for management over the long term.

2.3 Objectives of the Kamloops Future Forest Strategy

With the primary goal of rationalizing expectations and direction for future management in the context of expected impacts of climate change and other influences the following objectives for the KFFS were designed:

- a. Identify current expectations and management direction for the future forest condition, and to highlight potential overlap.
- b. Understand the range of plausible impacts from climate change, based on well-informed local climate modeling.
- c. Identify sensitivities and vulnerabilities associated with forest management expectations and direction based on the impacts of climate change and other influences.
- d. Develop management options to adapt the future forest to minimize the impacts of climate change and other influences.
- e. Articulate an adaptive vision of the future forest that will promote resilience and adaptability to meet ecological, economic and/or social expectations over time in the context of climate change.
- f. Identify data / research gaps and uncertainties and clarify assumptions.
- g. Develop the KFFS as useful pilot example for other TSAs wishing to design a similar strategy.

2.4 Project Area

Description of KFFS Area:

The Kamloops Future Forest Strategy was designed for the Kamloops TSA, which has the following characteristics:

- A total area of approximately 2,666,375 hectares, when TFLs 18 (74,620 hectares) and 35 (36,564 hectares) are included (Fig 1.1).
- The project area follows the boundaries of the Kamloops Forest District and a portion of the Headwaters Forest District in the southern interior of British Columbia.
- The area extends from the Logan Lake area south of Kamloops north to Wells Gray Park, and is bounded by the Columbia Mountains to the east and the Cariboo/Chilcotin area to the west.
- Leading species distributions as a proportion of the Timber Harvesting Landbase are as follows: Douglas-fir (33%), lodgepole pine (30%), spruce (18%), true fir (9%), broadleaf species, western redcedar and hemlock (10%).
- The current annual allowable cut (AAC) for the Kamloops TSA is approximately 4.3M m³ per year which is an increase from the base AAC of 2.7M m³. This AAC is apportioned between replaceable Forest Licenses (36%), Non Replaceable Licenses (mountain pine beetle and cedar-hemlock with 37%), BCTS (20%), and various other small tenures for the remaining seven percent.
- The topography of the Kamloops TSA is one of sharp contrasts, from dry, hot grasslands in the south, to very wet and rugged mountain landscapes in the north. As a TSA, Kamloops is among the most diverse ecologically in the province, containing nine of the eleven interior biogeoclimatic (BEC) zones. The TSA is dominated by the four most important BEC zones for forest management in the southern interior – the Interior Douglas-fir (IDF), Interior Cedar-Hemlock (ICH), Montane Spruce (MS), and Engelmann Spruce-Subalpine Fir (ESSF). These zones break down into over thirty subzones across the TSA (Fig 1.2).
- As in other parts of the BC interior, the mountain pine beetle (MPB) is having a significant impact on the TSA. Beetle susceptibility models indicate that the majority of the pine stands in the TSA will be attacked by MPB within the next eight years. The diversity of ecosystems and forest types also provide conditions suitable for most of the other major insect and pathogenic disturbance agents found in the BC interior.

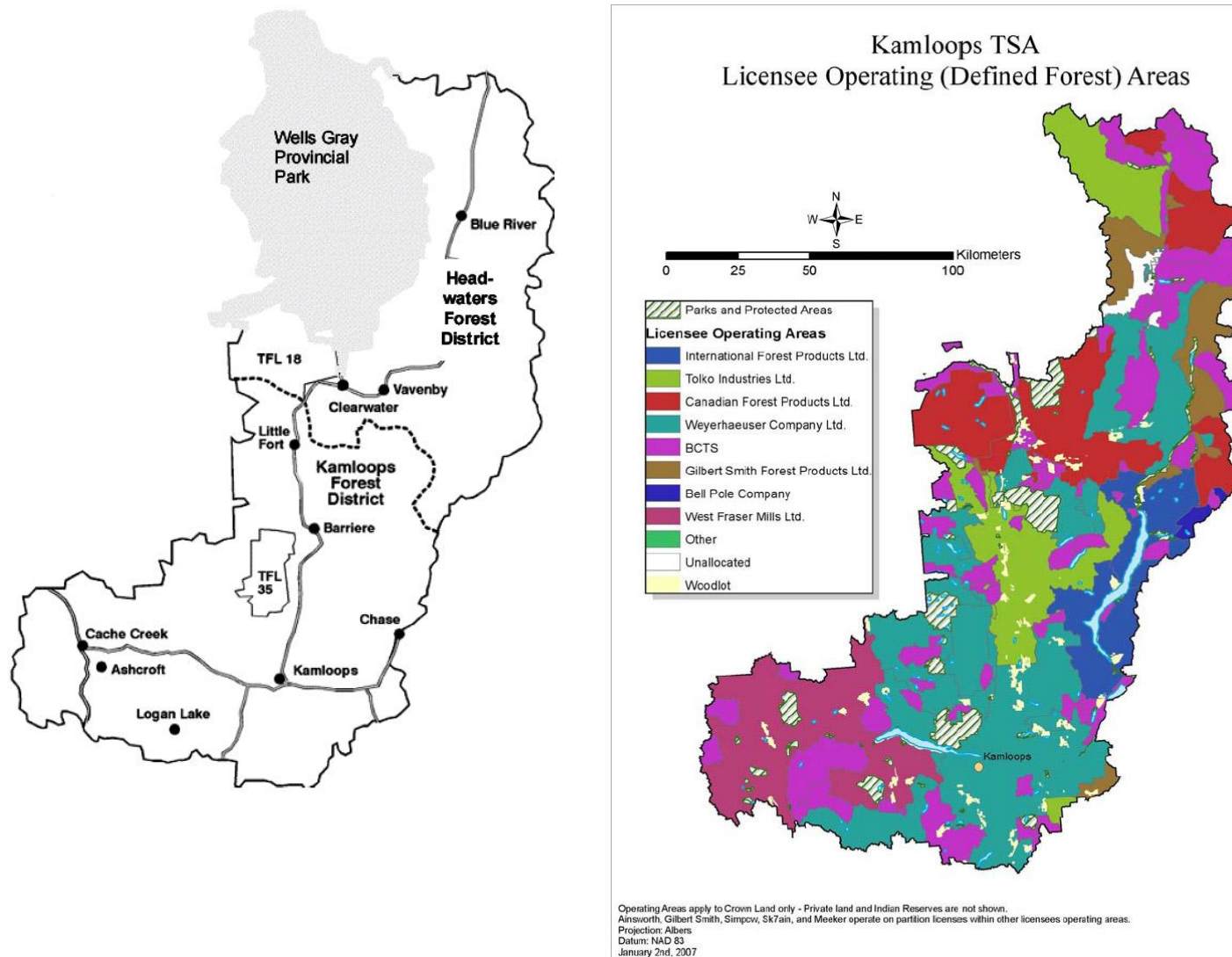


Fig 1.1. The project Area – in general (left), and showing the operating areas for the replaceable licensees (2007).

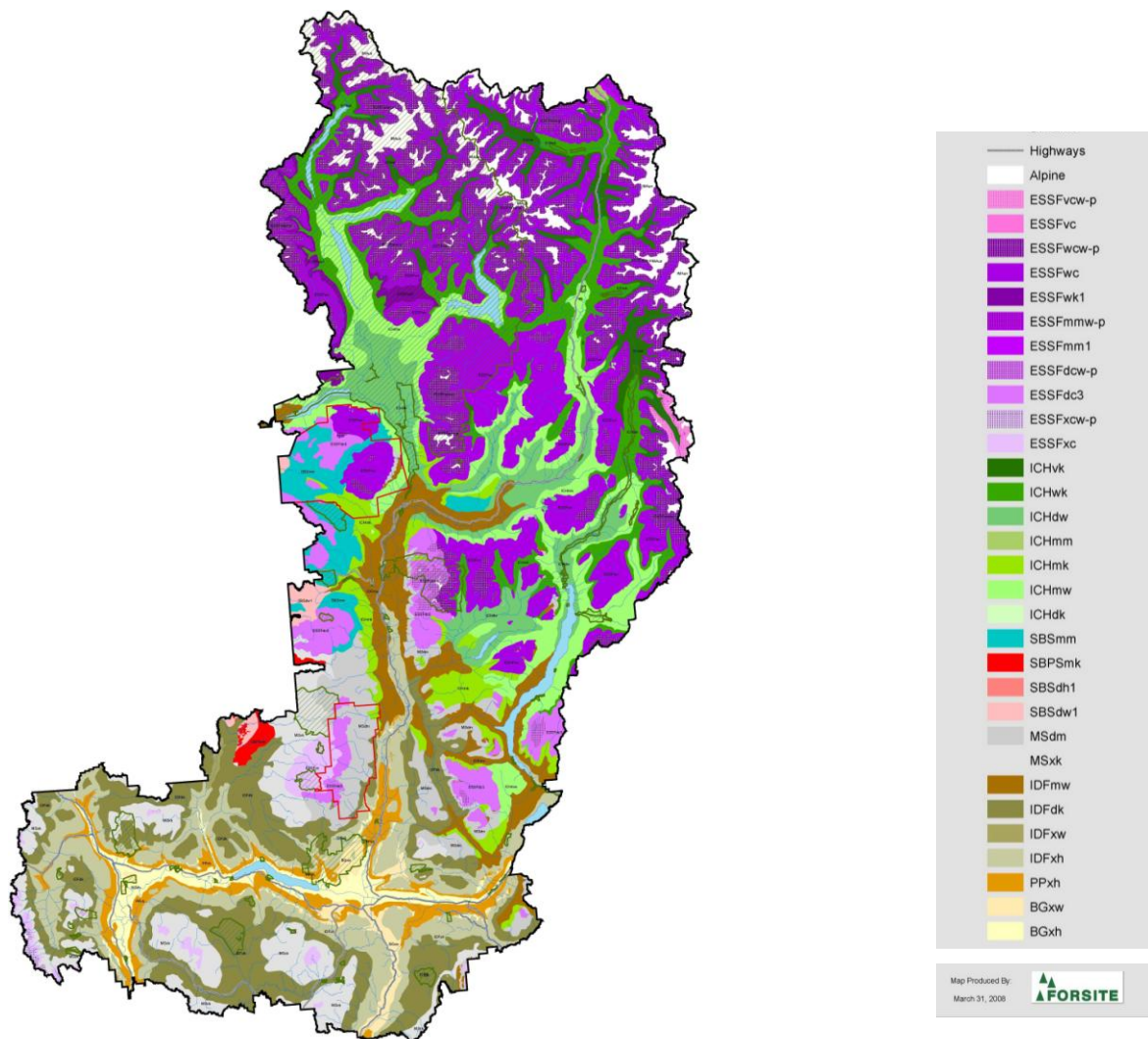


Fig1.2. The diversity of Biogeoclimatic subzones across the Kamloops TSA.

2.5 How the Future Forest Strategy fits within a Strategic Planning Framework.

A Future Forest Strategy (FFS) uses the lens of climate change to inform the strategic management planning cycle by changing the context for planning over the landbase (Fig 1.3). Climate change will alter ecosystem components, relationships and processes, sometimes profoundly, depending on the ecosystem. The future forest strategy (FFS) begins the exploration of those impacts, identifying vulnerabilities and potential management options.

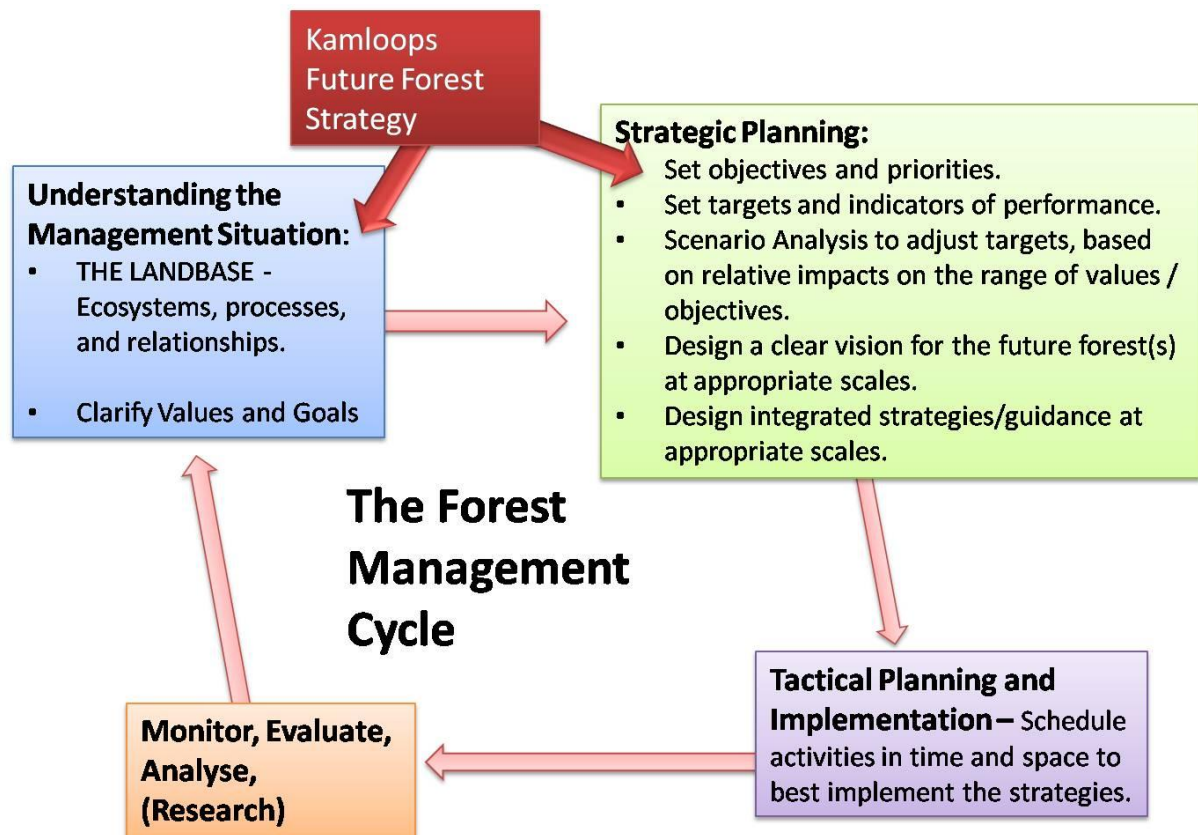


Fig 1.3. The relationship of the Future Forest Strategy (to address climate change) and the forest management planning cycle.

The FFS is not a plan. Strategic planning is a complex cycle of analysis, exploration, monitoring and continual improvement. The FFS is an important step in this process to ensure it is conducted with a reasonable consideration of climate change. The following section is designed to provide an overview of the FFS process, as explored in Kamloops with suggestions for efficiencies along the way. For more detail on the framework of a FFS process – SEE: Appendix 1 - The Roadmap to Success: The *Framework for a Future Forest Strategy*.

AN OVERVIEW OF THE FUTURE FOREST STRATEGY APPROACH USED IN THE KAMLOOPS TSA

FOR MORE INFORMATION – SEE: APPENDIX 1

A. Assemble the TSA Team / Steering Committee and the Strategy Development Team

- A steering committee of the TSA major licensees, First Nations licensees, the Ministry of Forests and Range, BCTS, and others to champion the project.

B. Summarize current management direction for the unit, based on the pertinent plans

- See *A Summary of Current Management Regimes Relevant to the Future Forest Strategy for the Kamloops TSA (March 31, 2008)* compendium of support documents for the summary of plans for the TSA.

C. Explore plausible future climate change scenarios locally.

- See *Climate Modeling and Future Ecosystem Climate Mapping (Version 2.0 September 26, 2008)*, and *Maps of Subzone Climate Envelopes (Version 2.0 September 26, 2008)* in the Compendium of Supporting Documents for direction on use, and an example of the final product.

D. Analyse and Understand the Ecological Sensitivities in your Management Unit

- Use ecological sensitivity workshops with experienced local practitioners, regional specialists, and academics - to explore the potential ecological sensitivities of subzones or subzone groups to plausible climate changes.
- Create ecological narratives - from the input of the participants, to provide a plausible future by BEC unit. See *Ecological Narratives* in the compendium of supporting documents for examples.

E. Analyse the Management Sensitivities in your Management Unit

- a. Use management sensitivity workshops - with local, regional and provincial specialists and experienced local practitioners.

F. Design Management Direction and Options for Adaptation

- Use input from management sensitivity workshops. Explore issues, as much as possible, by analysing additional data, conferring with additional specialists, and reviewing studies and reports.

G. Assess Adaptive Capacity and Vulnerabilities for Management

- Use the summaries of implementation barriers and knowledge gaps to pinpoint the major adaptive capacity concerns.
- Use adaptive capacity to rank potential and projected vulnerabilities – thereby providing a complete picture of vulnerabilities across the TSA in the context of adaptive capacity issues.

H. Design Recommendations

- To move forward with the strategy.

I. Communication to Engage Participation and Ensure Support

- The KFFS used a range of communication approaches throughout the development of the strategy to engage participation and support. Considering the number of range of expertise required, this was a critical part of the strategy.

3 RESULTING ECOLOGICAL SENSITIVITIES

The KFFS explored detailed predictions for climate from global circulation models to predict changes and impacts on twelve important biogeoclimatic (BEC) subzones in the Kamloops TSA. While the climate modeling in the Kamloops TSA reflect some variations across BEC subzones, there are general climate trends across the TSA that are important to use as context when considering general TSA sensitivities and management direction (Appendix 2).

3.1 ClimateBC modeling in the Kamloops TSA

The ClimateBC model was used to assign climate data to each point on a 100 m grid covering the TSA, recognizing that coarser grids may not account well for steep elevational gradients and finer grids became too onerous to work with. The climate data at each point was then overlaid on the 52 biogeoclimatic (BEC) subzones (or portions thereof) that occur in the Kamloops TSA. This allowed the production of a spreadsheet showing climate variables rolled up to each BEC subzone.

Because the future climate is fraught with many uncertainties, no one climate change scenario should be considered ‘most likely’ and the range of possible outcomes should be explored (Meidinger, 2007, Spittlehouse 2006). Best and worst case greenhouse gas emission scenarios were needed to characterize the range of potential climate changes outcomes – ideally coming from different global climate models. Based primarily on the advice of Andreas Hamann (developer of the scenarios in ClimateBC), the HadCM3-A1FI scenario (from the Hadley Centre for Climate Prediction and Research) was selected as the worst case scenario and the PCM-B1 scenario (National Center for Atmospheric Research, Department of Energy Panel) was selected as the best case scenario. These future greenhouse gas emissions scenarios assume minimal reductions (HadCM3-A1FI) or significant reductions (PCM-B1) in future carbon emissions (Hamann and Wang, 2006). It should be noted that these scenarios have also been used for projecting impacts on forests elsewhere in the Western United States (Hayhoe et al 2004).

Climate variables were analyzed to identify shifts as ecological BEC subzone-climate envelopes, appearing as shifting BEC subzones across the TSA to provide context for subsequent ecological and management sensitivity discussions. To determine potential shifts in BEC subzone, the historical climate data were linked to the one hectare grid and analyzed to derive predictive variables/circumstances that would allow automated mapping of the current BEC subzones, as an initial calibration. This process was initiated through the use of ‘data-mining’ software and then further refined by our team ecologist. The process was designed to cluster points with similar attributes (i.e. climate variables) into specific BEC subzones. Once the process was established, it was then run using the climatic attributes predicted at the various time intervals (2050, and 2080) for the best case or least change (PCM B-1) and worse case or most change (HadCM3-A1FI) GCM scenarios. In this way, best case and worse case climate change scenarios were expressed spatially with equivalent BEC subzone-climate changes for the various time periods.

A second iteration of subzone mapping was completed because our emerging subzone climates did not always appear to be good matches for the existing suite of subzones in the Kamloops TSA, or even the Southern Interior. Our second iteration used a range of symbols to denote climates that were moister or drier than that indicated by the subzone label. As well, we relied more on the summer heat:moisture index (SHM) than in the first approximation to interpret changes over time. The SHM index is similar to a drought code for the growing season and therefore is very important to describe conditions for plants during that time. The approach to modeling and BEC subzone-climate mapping is described in detail in the report *ClimateBC Modeling and Future Ecosystem Climate Mapping Version 2.0* (September 26, 2008), which is found in the *Compendium of Supporting Documents*.

3.2 Determination of Ecological Sensitivities

Ecological sensitivities were discussed and assessed qualitatively for twelve key subzones³ in “expert workshops”. Input and advice was provided by local ecologists, other resource specialists, practitioners and academics. The KFFS team synthesized this information into “ecological narratives” to generate plausible stories of how ecological conditions within these BEC subzones may change over time with a warming climate, and the ecological sensitivities that could emerge.

The sensitivities of these twelve subzones were distilled into five “subzone groups” based on their similarities (Table 2.1). Over 60% of the Timber Harvesting Land Base (THLB) within the TSA is projected to be threatened with a moderate-to-high or a high ecological sensitivity (Table 2.1). This means that a high or moderate-to-high degree of ecological alteration is expected within these subzone groups. The most susceptible subzones fall within the two dry subzone groups and the moist transitional subzones in the ICH and IDF. Only 21% of the THLB in the Kamloops TSA is expected to have a low ecological sensitivity.

It should be noted that these ecological sensitivities, like the climate modeling on which they are based, are not presented as a precise prediction of what the future will be like. These projections must be viewed as plausible⁴ scenarios designed to help us understand the potential amount and types of changes that could occur and inform us on possible management options to address change as it emerges.

For more information on ecological sensitivities:

- For the five ecological groups – see *Appendix 3*.
- For the 12 individual subzones - see *Ecological Narratives* in the *Compendium of Supporting Documentation*.

³ **Key Subzones** – generally more than 100,000 ha in size with significant management values. The twelve subzones were also chosen to cover the natural range of ecological conditions in the TSA.

⁴ **Plausible** - describes the scenarios used to forecast impacts from climate change because no one can predict the future with certainty. The rate of climate change and its actual influence on ecosystems is highly uncertain. Yet, some believe that considering current trends and potential positive feedback mechanisms, the worse-case (most change) scenarios used in this project may be conservative.

Table 2.1 Overview of ecological sensitivities in the Kamloops TSA, based on expected impacts from climate change, ecological conditions and perceived ecological adaptive capacity. The sensitivity ranking is based on the degree of ecological alteration that is attributed to climate change (beyond what is considered to be normal) by the scenarios tested (e.g. changing plant communities, disturbance regimes and other processes). The rationale includes key points from the ecological narratives, that tend to emphasize the worst-case most change climate scenario to explore how much change may occur.

SUBZONE GROUP	BEC subzones	% of THLB in TSA	Ecological Sensitivity	Summarized Rationale for Vulnerability
Dry Subzones with Pli	MSxk, IDFdk, (SBPS)	28	HIGH	<ul style="list-style-type: none"> • Too hot and dry after 2050 for Pli. • Estimate 37% of THLB in young Pli that will not be ecologically suitable past 2050. • Increased fire risk.
Dry with Douglas-fir & Ponderosa Pine	IDFxh, PPxh	10	HIGH	<ul style="list-style-type: none"> • Continuing mortality in Fd will thin out and open up stands. • Increased grassland patches. • Increased fire risk.
Interior Cedar-Hemlock Transition to Dry Douglas-fir	ICHmw, ICHdw, IDFmw, (ICHmk)	26	MOD-HIGH	<ul style="list-style-type: none"> • Fd drops out of mixedwoods due to drought / Armillaria / D-fir beetle combo. • Lose considerable Cw, Sx, Ep past 2050 • Increased fire risk.
Dry- Moist Plateau/ High Elevations	MSdm, SBSmm, ESSFdc, (ESSFxc)	15	MOD	<ul style="list-style-type: none"> • Increased growth in most species (except BI) up to 2050. • Beyond 2050 – BI drops out, Pli at high risk, Sx questionable on some sites lower down. May see a few large fires.
Cool/Cold & Wet	ESSFwc, ICHwk, (ICHvk)	21	LOW	<ul style="list-style-type: none"> • Increased mortality in old growth • Increased growth in young stands • Weevil increasing problem for young Sx.

4 RESULTING MANAGEMENT SENSITIVITIES

Using the understanding of ecological sensitivities and the types of changes that may occur across the TSA, management actions can be adjusted over time to avoid being “painted into a corner” with only a few difficult options available. To achieve this goal with the KFFS, management values and potential climate change concerns were investigated using a range of specialists and practitioners from the TSA and the region, similar to the approach used to explore ecological sensitivities. Potential management sensitivities were estimated for the important aspects of each management value in each subzone group, and then summarized for the TSA (Table 3.1). The rationale for each sensitivity ranking in each subzone group was explored and is provided in more detail (Appendix 3).

Table 3.1 Overview of management sensitivities in the Kamloops TSA, based on expected impacts on management from the ecological sensitivities in Table 2.1. The sensitivity ranking indicates the degree of impact on various aspects of key management values.

SUBZONE GROUP	BEC subzones	% of THLB in TSA	Management Sensitivity	Summarized Rationale for Sensitivity
Dry Subzones with Pli	MSxk, IDFdk, (SBPS)	28	MOD-HIGH	<ul style="list-style-type: none"> • High impacts on productivity and growing stock for timber. • High impacts on biodiversity and a range of habitats and fish. • Significant issues for water, interface, and First Nations culturally important plants.
Dry with Fd & Py	IDFxx, PPxx	10	HIGH	<ul style="list-style-type: none"> • High impacts on THLB, productivity and growing stock for timber. • High impacts on biodiversity and a range of habitats and fish. • High impacts for water, interface, and First Nations culturally important plants. • Significant issues for visual quality
ICH-IDF Transition	ICHmw, ICHdw, IDFmw, (ICHmk)	26	MOD-HIGH	<ul style="list-style-type: none"> • High impacts on productivity and growing stock for timber. • Significant issues on biodiversity and a range of habitats and fish. • Significant issues for water, and interface. • Significant issues for visual quality
Dry- Moist Plateau/ High Elev	MSdm, SBSmm, ESSFdc, (ESSFxc)	15	MOD	<ul style="list-style-type: none"> • Moderate impact on growing stock for timber. • Significant issues for some habitats and fish • Moderate impacts for water and First Nations culturally important plants.
Cool/Cold & Wet	ESSFwc, ICHwk, (ICHvk)	21	MINOR-MOD	<ul style="list-style-type: none"> • Minor timber supply concerns long term – may be some short term benefits. • Minor concerns for habitat, except for Caribou where there are many outstanding questions. • Significant issues possible for water quality.

The rankings used in the table were determined as follows:

High sensitivity– There is a high likelihood of a substantial negative impact on the management concern.

Moderate sensitivity – There is a high likelihood of a limited negative impact on the management concern.

Minor Sensitivity – There is a likelihood of a small or minimal impact.

The most important management sensitivities in the Kamloops TSA emerge due to increased stand mortality as conditions become hotter and drier through the summer, especially beyond 2050. This mortality will be due to drought stress, insects, pathogens, and a higher incidence of larger and more severe wildfires. It should be noted that for timber management these extreme conditions will reduce productivity on many sites, especially in dry subzones. It will also have large impacts on growing stock, with substantial losses occurring in pulses of mortality that coincide with warmer, drier climatic cycles. These impacts will similarly have a major influence on biodiversity and habitat, with a significant decline in structural and habitat complexity, a large increase in early seral communities, the appearance of novel plant communities and an increase in invasive species.

In dry subzones with lodgepole pine, the dominant issue is the continuing domination of lodgepole pine in developing young stands in spite of high levels of beetle-mortality in older stands. Combined with a climate that will become less favourable for the pine stands over time, beyond 2050 these stressed mid-aged lodgepole pine stands are projected to be highly susceptible to mortality due to a range of factors. Timber values in these stands may be marginal and subsequent regeneration challenging if these stands are clearcut at that time.

Transitional subzones (Interior Cedar-Hemlock to Interior Douglas-fir) are similarly challenged for management in the anticipated warmer, seasonally drier conditions. As trees become drought-stressed over summer, mortality will be accelerated, mostly in conjunction with disease and insects. The nature of these diverse ecosystems could change dramatically with fewer tree species resulting in open broadleaf stands with considerable mortality. Broadleaves will not be immune to mortality and the current trend of birch die-back is expected to worsen. The trend of mortality in conifers, Douglas-fir in particular, may challenge the potential for an economic harvest in these stand types, impacting timber management, and making a conversion to more resilient stand types a slow process.

Similarly, other values that depend on forest cover, such as habitat and visual quality will be degraded in a number of areas, as drought stress and losses to disturbances increase. First Nations culturally important plants will be displaced locally in some subzones. Water quantity will be a major concern, especially in watersheds with a preponderance of drier subzones. In the cool wet subzones, the projected increase in precipitation delivered during extreme weather events may cause problems with water quality, and could possibly threaten infrastructure. Salmonid populations are expected to decline, potentially

disappearing in some locales, as adverse water temperatures spread through the warmer portions of the TSA.

While mortality will likely be cyclic, it will at times significantly increase fine fuel loading in some stand types for short periods. Also, more open stands may develop dense understories that will further increase ladder-fuels in these stand types. If these conditions coincide with expected more frequent hot / dry summer extremes, larger and more severe fires will increase as well. Where these conditions occur in the rural urban interface, important habitats, or areas with visual sensitivities, sustained and significant impacts could result.

For a more detailed discussion of sensitivities in each subzone group refer to Appendix 3.

5 MANAGEMENT DIRECTION SUGGESTED ACROSS THE TSA

A Perspective on the Management Direction in this Report

As has been described in the introduction to this report, the future is uncertain. The KFFS used plausible futures to identify sensitivities and management direction, which is presented by ecological grouping in Appendix 3, and by value (TSA-wide) in Appendix 4. The KFFS direction is designed as a first step to incrementally adapt planning and practices in the TSA. The intent is to prudently manage risk and avoid the major issues anticipated, while recognizing that climate change may have more or perhaps less impact than general predictions suggest. Accordingly, the direction provided is a first step in continuous improvement and adaptation.

This direction allows for both a deterministic and indeterministic future. Some guidance is meant to provide resilience based on the concept that the changes will be within the scenarios assessed - a somewhat deterministic approach. With this approach we are assuming we know what the future will provide, albeit only within a range of plausible futures. Additional guidance and recommendations allow for experimentation and learning over a varied future - allowing for an indeterministic future. With these approaches we may cross thresholds we have not yet identified and we may have disturbance from sources we are not presently aware of. Continuous learning based on good communication and a combination of both deterministic and indeterministic management approaches will promote success. Modification of approaches and continuous learning as new information becomes available will be a cornerstone of adapting to climate change.

Adaptation to climate change can take a number of forms. To be effective the Kamloops Forest Strategy suggests using a range of approaches to maintain or help create healthy resilient forests. In some cases there are no clear options to address the sensitivities that climate change will bring. What are presented are available today and should be considered as a starting point. As new information becomes available they should be reviewed and reconsidered.

An Overview of Management Direction/Actions Suggested in this Report

The most prominent management direction / actions for specific practices on the ground across the TSA include:

Reforestation

- Promote species diversity and limit climate induced mortality by increasing the amount of Douglas-fir, ponderosa pine, western larch, and white pine, and reducing the reliance on lodgepole pine (in a range of subzones) and occasionally subalpine fir (in several subzones). As well, in a number of subzones broadleaf species should be promoted in some areas, and not discouraged in others.
- Promote more flexible stocking standards that allow for a range of stocking densities (specific direction depends on subzone group).

- Evaluate licensee obligations regarding the existing free-growing policy.

Harvesting and stand tending

- Direct harvesting at specific stand types anticipated to be at-risk for high amounts of mortality over time. By harvesting these stands before this mortality occurs, economic values can be realized, and more resilient new stands established.
- Encourage broadleaf species in a prudent manner (see subzone groups), as broadleaf species are expected to be vulnerable in large portions of the TSA, their ecological and habitat values are high, and they hold potential benefits for mitigating fire risks, and forest health issues.
- Target stand-tending treatments in some subzones to help establish more resilient species or to mitigate fuel concerns for wildfire.
- Target specific subzone groups for actions to address one or two specific management concerns, such as fuel reduction or root disease treatments.

Planning

- Most remaining direction ties into a range of specific planning elements. A few examples of broad themes are:
 - In urban interface areas, enhanced fuel management or fire protection should be a central feature of forest planning.
 - Existing forest health management and strategies need to be reexamined and discussed based on the sensitivities highlighted in the KFFS.
 - Wildlife tree retention requires an explicit strategy that functionally links it to other landscape level reserves such as OGMA and ungulate winter ranges to meet stated objectives for biodiversity in different ecological and landscape settings.
- The need for a comprehensive strategic and tactical planning process is clearly apparent for a number of reasons:
 - Few of the suggested planning direction items (including the three examples above) will be effectively implemented if they are not integrated with other values over appropriate, possibly several, spatial scales.
 - Specific management actions such as *targeted, proactive harvesting in susceptible stands* can only be successfully implemented if they are tied to a comprehensive operational strategic process, which integrates such direction with other values and associated targets and indicators.
 - Managing to adapt the forest to mitigate climate change sensitivities for all values is complex and multi-layered. It will not be accomplished successfully by addressing each issue for each value separately.
 - A long term planning view, across the life of the forest, is required for proper implementation of this direction over time. Currently, many of the suggestion management actions are outside of the current short term planning horizons.

Detailed Direction for Future Management Direction/Actions

For a more detailed discussion of the full range of suggested management actions and the rationale for each, refer to:

- Appendix 3 – for a discussion of management actions by subzone-group.
- Appendix 4 – for a discussion of management actions / direction by management value (biodiversity, timber, etc.).

Detailed Descriptions of Future Forest Conditions Resulting from Management Direction/Actions

For a more detailed description of future forest conditions resulting from management actions, refer to Appendix 5. This appendix will describe:

- A “vision” of the developing landscape in each subzone group at 2050 and 2080 as a result of the KFFS.
- Potential opportunities for the range of forest values if the KFFS is followed, and if the KFFS is not followed. This comparison provides a subjective estimate of the benefits of the KFFS over time.
- A conceptual overview of potential timber supply impacts if the KFFS is followed.

6 MANAGEMENT ADAPTIVE CAPACITY AND VULNERABILITIES

A central focus for the KFFS is to provide direction and management actions and/or options to help address potential impacts from climate change. In designing this direction, implementation barriers and knowledge/ data gaps were also tracked. With the climate modeling data and the ecological sensitivities identified, the essential components are present for an initial vulnerability analysis to climate change in the TSA (Fig 6.1). Such an analysis helps to characterize priorities and challenges for implementation.

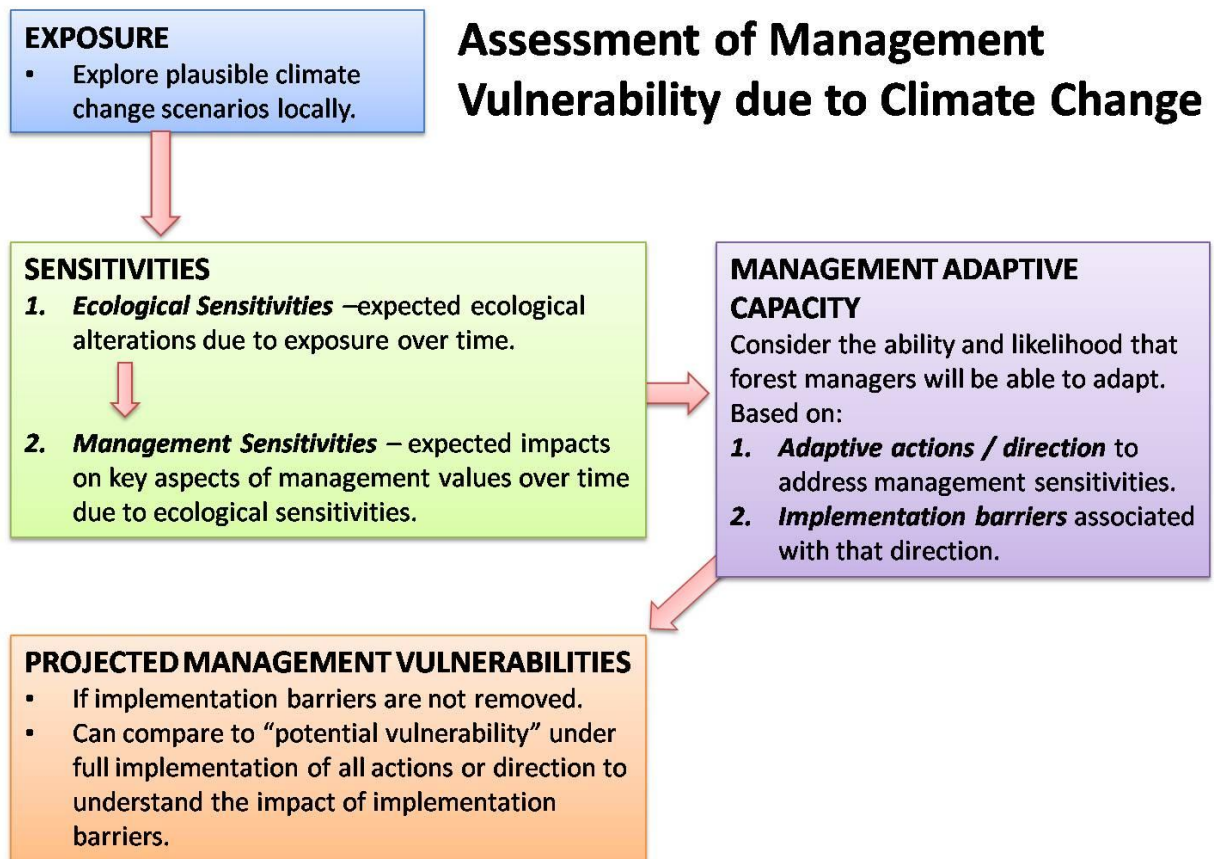


Fig 6.1. Diagrammatic flow chart of the assessment procedure for management vulnerability in the Kamloops Future Forest Strategy.

Management adaptive capacity is a measure of the ease or difficulty attached to implementation of the direction in the strategy. It is simply the likelihood that a manager will be willing and able to implement this strategy. Issues associated with adaptive capacity for management can significantly contribute to the vulnerability of a range of management concerns. Accordingly, adaptive capacity was examined and considered by exploring the influence of implementation barriers on the strategy and its potential to mitigate climate change impacts.

A range of existing implementation barriers emerged that will impede the success of this strategy. These barriers fell into five broad themes or general barriers:

- (1) the lack of a comprehensive, integrated, operational strategic planning process;
- (2) more costly reforestation;
- (3) more costly or break-even harvesting;
- (4) the need for on-going stand management beyond free growing through the rotation;
- (5) a requirement for government to take on increased management risk.

These barriers were explicitly considered for their impact on the implementation of all management direction across all subzone groups. The result is a snapshot of management vulnerability if none of the implementation barriers are removed – *projected vulnerability* (right hand coloured column in Table 6.1). When these management vulnerabilities are summarized across all subzone groups and compared to the *potential vulnerability* if all direction is followed and all barriers are removed (middle column, Table 6.1), the influence of management adaptive capacity in the Kamloops TSA is striking. It is estimated that over 60% of the TSA would still have a vulnerability ranking beyond moderate if the strategy is implemented without addressing the identified barriers.

Table 6.1. Comparison of potential management vulnerability (assuming all barriers for implementation were removed), and projected vulnerability (assuming no barriers are removed)

SUBZONE GROUP	Mgmt Sensitivity	Potential Vulnerability	Projected Vulnerability	% OF AREA
<i>Dry with Pli</i>	MODERATE TO HIGH+	MINOR TO MODERATE +	MODERATE TO HIGH -	28%
<i>Dry with Doug-fir and Ponderosa pine</i>	HIGH -	MINOR TO MODERATE +	MODERATE TO HIGH +	10%
<i>Transitional Cedar-Hemlock to Douglas-fir</i>	MODERATE TO HIGH -	MINOR TO MODERATE -	MODERATE TO HIGH --	26%
<i>Transition to Plateau or High Elevations</i>	MODERATE -	MINOR -	MODERATE -	15%
<i>Cool and Wet</i>	MINOR TO MODERATE -	MINOR -	MINOR +	21%

Vulnerability with FULL implementation (barriers removed)

Vulnerability with PARTIAL implementation (Due to barriers)

For more information on the assessment of adaptive capacity and vulnerability refer to Appendix 6.

7 RECOMMENDATIONS

The Kamloops Future Forest Strategy is multi-layered, with analysis, interpretations, suggestions and observations that may be useful for agencies and licensees at many levels. The focus for the project was two-fold – to provide operational management direction for resource managers and practitioners in the Kamloops TSA, while providing suggestions for the Ministry of Forests and Range (MFR) when they initiate similar projects in other areas of the province. In the learning process associated with meeting these two broad goals, the KFFS team developed a suite of ideas for the MFR and the Kamloops TSA team to facilitate implementation. These ideas are presented below as general recommendations, and suggested next steps.

Forest management has evolved over time from focussing on sustained yield of timber to a more holistic approach that values a much broader range of goods and services. Because forest management is done on time frames of multiple human generations, a backdrop of change is part of the natural framework. A key consideration for management is to work with our knowledge of biological and other systems to provide desired outcomes or a desired future forest - one that will provide goods and services to future generations.

Climate change has added another dimension to the process. It has made us look more carefully to the future and to focus attention on what we are calling vulnerabilities. It is realized that we will not have all the solutions and the future will be uncertain and provide unexpected twists, with this in mind the following recommendations are provided.

1. The province should develop a comprehensive, continuous, integrated, operational strategic planning process for provincial forest lands, including TSAs and other management units.

A common theme emerged from the management workshops within this project. Managers and practitioners from every agency and licensee company expressed frustration that the forest management cycle is too fragmented and dysfunctional within the TSA. Planning and implementation for different values and objectives is often done in silos with little connection between them.

Climate change is anticipated to cause considerable disturbance over a relatively short period to many of the ecosystems in the Kamloops TSA. This disturbance could have a variety of implications for a range of values at different scales. We will not be successful by continuing to plan for biodiversity, timber, ungulate winter range, the urban-forest interface, and other values in disconnected silos, often using simplistic approaches.

Management decisions to address the impacts of climate change, require a coordinated and structured planning process to promote multidisciplinary communication to provide effective and timely approaches to address area-specific vulnerabilities. One option is to build on the current TSR process, refining the focus

toward one that is forward-looking, with scenario-based decision making to set targets and indicators that licensees use to guide their management and subsequent monitoring. Such a process must be operationally focused, with senior operational staff managing the process. It must be led by government with clear goals and policies to provide support and incentives. And, it must be well supported by agency, consulting and academic specialists used as participants on planning teams.

What is envisioned is a on-going process of integrated operational management and learning, not just a plan. This process is strategic, and operational. It is not a stakeholder negotiation. In this type of planning process a vision for the future forest condition continually evolves, influenced by evolving management values, forest health, fire, climate change and other influences. Management targets and performance indicators are designed to fit with the future forest condition. Modeling and scenario analysis can be used to provide a clearer picture of the impacts of various targets on different resource values over time, helping to effectively balance those targets. Long-term monitoring programs are focused by this process, linked to operations through local performance indicators that evolve with research and operational trials, targeted to test the assumptions associated with them.

Strategic planning must be continuous to evolve with monitoring and improvement over time. Focussing management in this way within Forest Districts will increase effectiveness, management efficiency, promote timely research and learning, and clarify issues and options for stakeholders and the general public. Such an approach would also provide an effective conduit to reflect evolving provincial goals and priorities. This type of process, generally loosely referred to as “sustainable forest management planning” is currently becoming the foundation for forestry in other provinces such as Alberta, Saskatchewan, Manitoba and Ontario.

2. Governments, all levels and branches in relevant agencies, licensees, forest professionals, and others need to be organized so that they are working in a coordinated and integrated fashion around a common vision, set of principles, and goals.

This recommendation is linked to one above. The challenges involved in interagency planning with multiple licensees cannot be unestimated. All too often multi-disciplinary planning teams function more as a committee interested more in their agency’s stated values, than as a team interested in designing a holistically robust design solution (Andison 2009⁵).

It is not only a strategic planning process that is required, but a cultural corporate shift within governments, agencies and companies to promote cooperation, good communication and operational management under a common vision with a clear connected set of goals and priorities. It is time to get all agencies, branches, departments, licensees and others in the same boat, rowing in the same direction. The

⁵ Andison, D.W. 2009. The Hwy40 North Demonstration Project: Using Natural Patterns as the Foundation for Operational Planning -Part 2: What Did We Learn? Alberta Foothills Disturbance Ecology Demonstration Series, Report No. 2.

strategic planning process suggested in recommendation #1 could serve as a focal point for this to happen locally, supported by provincial and regional specialists, monitoring programs and research.

3. Utilize the broad direction and recommended specific actions to help prioritize management action.

Within Appendix 3 and 4 are a set of issues, identified as sensitivities with associated management direction. The sections are set up to provide an overview using tables with rankings followed by more detailed guidance. This guidance is meant to help managers prioritize opportunities. It is noted in a number of options that to be effective, recommendation number 1 is desired or needed.

4. Assess general direction and recommended actions for specific areas to gauge the overall impact.

This project attempts to answer questions about how we should start managing for climate change on the ground, with a minimum of modeling and technical analysis. As such, it capitalizes on the knowledge of local specialists and practitioners to provide a picture of general trends and suggestions to move forward. It must be viewed for what it is, examined critically, and improved with more detailed analysis and discussion where required as implementation proceeds.

5. Use the information provided as management sensitivities in Appendix 3 and 4 to help direct Forests For Tomorrow planting projects, species selection and other activities.

For example lodgepole pine and subalpine fir are projected to be outside of their ecological tolerance in a number of areas by 2050, thus impacting reforestation decisions being made today.

6. Use the KFFS to help address other implementation barriers that will be common across the province.

The KFFS has identified numerous implementation barriers, many of which will be regional and/or provincial in scope (Appendix 3 and 4). An example is the lack of a fair cost accounting mechanism, or incentives for planting less common species, discouraging such management options. It is recommended that the province should address those barriers in a coordinated fashion to support the operational direction to promote diversity and forest resilience.

7. Use this strategy to help direct and/or refine research priorities for climate change in the province.

The KFFS identify a number of information gaps (Appendix 3 and 4). These may be useful to help direct limited funding toward the key questions that will help forest management address climate change over time. As other strategies are designed and evolve over time, more questions will emerge.

8. Use the KFFS as guidance to proceed with similar planning in other areas in the province.

The *Roadmap for Successful Future Forest Strategies* (Appendix 1) should be considered to help move this process to other areas in the province. This document outlines the key steps in development of a future forest strategy, with insights and lessons based on the Kamloops experience.

9. Consider using the Kamloops TSA as a case study to more thoroughly explore potential impacts and comprehensive strategic planning within a TSA.

The KFFS provides a good starting point to explore comprehensive strategic planning to implement the future forest strategy. The ideas and direction that emerges may be useful throughout BC.

7.1 Suggested Next Steps for the KFFS TSA team.

1. Review the KFFS document(s) – ensure structural barriers, gaps or suggestions for management actions are not missed.
2. Highlight direction in the strategy that can be initiated right away (Appendix 3 and 4).
Licensees and the District should work together starting with management actions that have been confirmed as being easy to moderately easy to implement. There may also be some initial steps that can be taken within the District on more challenging direction, while the province addresses barriers, or research addresses gaps.
3. Identify the implementation barriers that may be addressed within the District and cooperatively explore ideas to solve them.
4. Confirm or identify the structural barriers that must be addressed by the Province and communicate with the appropriate agencies.
5. Confirm or identify priority research questions and discuss with local researchers at Thompson Rivers University and the Ministry of Forests and Range.
6. Design an Action Plan for implementation.

7.2 Suggested Next Steps for the Province.

1. Develop a long term action plan with the District/Licensees to confirm an approach to move forward with the strategy, with some short term goals to maintain momentum over the next year.
2. Review the KFFS document with the FFEI – to highlight issues and barriers that are provincial in scope and discuss ways to address them.
3. Consider how to approach development of future forest strategies elsewhere in the province.
4. Be realistic about what can be achieved by the TSA steering committee. Support them as they explore ways to move the strategy forward.
5. To address the provincial issues and barriers – determine:
 - a. Which require new policies?
 - b. Which require new legislation?

- c. Which can be addressed over the short term? Long term?
 - d. What Ministries, branches and departments are involved? Consider inter-agency overlap and conflicting regulations and ways to resolve them.
- 6. Design a long term action plan to address the issues / barriers / opportunities.
- 7. Carefully determine who should be involved to help support work at the provincial level and within the TSA and engage them to be involved.
 - a. Regional specialists and research groups (government, consulting, universities)
 - b. The Future Forests Ecosystem Initiative
 - c. The “Forests for Tomorrow” (FFT) program
 - d. The provincial Forest Investment Account (FIA) and the Forest Science Program (FSP) funding account.
 - e. Other agencies
 - f. Other programs such as “the New Vision for BC Silviculture”.
- 8. Communicate over time with the Kamloops TSA team as they try to implement the strategy and the province tries to address barriers and other issues. Compare action plans together and track progress.

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APPENDIX 1 - The Roadmap to Success: *The Framework for a Future Forest Strategy.*

The Future Forest Strategy within the Strategic Planning Framework.

A Future Forest Strategy (FFS) uses the lens of climate change to inform the strategic management planning cycle by changing the context for planning over the landbase (Fig A1.1). Climate change will alter ecosystem components, relationships and processes, sometimes profoundly, depending on the ecosystem. The future forest strategy (FFS) begins the exploration of those impacts, identifying vulnerabilities and potential management options.

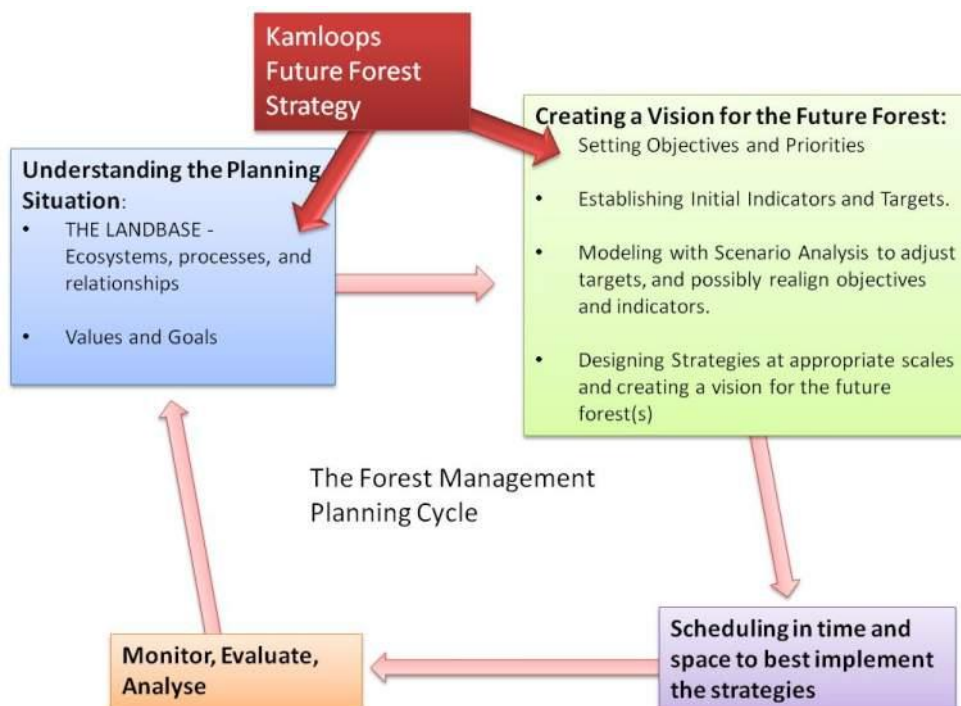


Fig A1.1 The relationship of the Future Forest Strategy (to address climate change) and the forest management planning cycle.

The FFS is not a plan. Strategic planning is a complex cycle of analysis, exploration, monitoring and continual improvement. The FFS is an important step in this process to ensure it is conducted with a reasonable consideration of climate change. The following section is designed to provide an overview of the FFS process, as explored in Kamloops with suggestions for efficiencies along the way. The entire KFFS report and associated compendium of supporting documentation can be used to provide more detail on work undertaken in Kamloops.

A QUICK OVERVIEW OF THE FUTURE FOREST STRATEGY APPROACH

A. Assemble the TSA Team / Steering Committee and the Strategy Development Team

- a. A strategy like this requires a group to champion and guide its development.
 - In the KFFS, this group was a steering committee of the TSA major licensees, First Nations licensees, the Ministry of Forests and Range, BCTS, and a researcher from TRU.
- b. The strategy development team should have a range of expertise that ties well into climate modeling and mapping, as well as the values and potential issues anticipated, and includes facilitation skills to organize and manage workshops.

B. Summarize current management direction for the unit, based on the pertinent plans

- See *A Summary of Current Management Regimes Relevant to the Future Forest Strategy for the Kamloops TSA (March 31, 2008)* compendium of support documents for the summary of plans for the TSA.

C. Explore plausible future climate change scenarios locally.

- a. Choose a combination of climate change models and carbon emission scenarios to balance efficiency and effective interpretation, and choose relevant timeframes.
- b. Create model output and use it to effectively interpret plausible climatic influences on future conditions of local ecosystems (identify key subzones).
 - The KFFS correlated climate data to biogeoclimatic (BEC) subzones as subzone-climate envelopes.
 - The BEC subzone-climate envelopes were projected over time for two timeframes – 2050 and 2080.
 - See *Climate Modeling and Future Ecosystem Climate Mapping (Version 2.0 September 26, 2008)*, and *Maps of Subzone Climate Envelopes (Version 2.0 September 26, 2008)* in the Compendium of Supporting Documents for direction on use, and an example of the final product.

D. Analyse and Understand the Ecological Sensitivities in your Management Unit

- a. Use ecological sensitivity workshops with experienced local practitioners, regional specialists, and academics - to explore the potential ecological sensitivities of subzones or subzone groups to plausible climate changes, specifically regarding the future of present stands and species suitability for new stands.

- The KFFS identified participants that are able to envision BEC units as they are today with the ability to overlay future climate to envision changes to forest structure and condition over time.
- The KFFS used vignettes of local landscapes to focus discussion of each climate-envelope. See *Ecological Summaries* in the compendium of supporting documents.
- b. Create ecological narratives - from the input of the participants, to provide a plausible future by BEC unit. These are used to help frame management options and priorities.
 - See *Ecological Narratives* in the compendium of supporting documents for examples.

E. Analyse the Management Sensitivities in your Management Unit

- a. Use management sensitivity workshops - with local, regional and provincial specialists and experienced local practitioners.
 - The KFFS used the *Ecological Narratives and Ecological Summaries* to provide background information on potential change in each subzone.
 - As well, the KFFS used the *A Summary of Current Management Regimes Relevant to the Future Forest Strategy for the Kamloops TSA (March 31, 2008)* to help determine the key management values of concern and the important aspect of management to consider.

F. Design Management Direction and Options for Adaptation

- a. Use input from management sensitivity workshops.
- b. Explore issues, as much as possible, by analysing additional data, conferring with additional specialists, and reviewing studies and reports.
- c. Summarize management sensitivities as well as potential management direction, options, barriers for implementation, knowledge and data gaps and assumptions. This was done by key subzone groups and by key management value across the TSA (See Appendices 3 and 4).

G. Assess Adaptive Capacity and Vulnerabilities for Management

- a. Use the summaries of implementation barriers and knowledge gaps to pinpoint the major adaptive capacity concerns.
- b. Use the exploration of adaptive capacity to summarize projected vulnerabilities (without addressing barriers and gaps) and compare to potential vulnerabilities (if barriers and gaps were addressed).

H. Design Recommendations

- To move forward with the strategy.

I. Communication to Engage Participation and Ensure Support

- The KFFS used a range of communication approaches throughout the development of the strategy to engage participation and support. Considering the number of range of expertise required, this was a critical part of the strategy.

DETAILED ROADMAP STEPS.

A. Assemble the TSA and the Strategy Development Teams

A strategy like this requires a group to champion and guide its development. In the KFFS, this group was a steering committee of:

- the TSA major licensees,
- First Nations licensees,
- the Ministry of Forests and Range,
- BC Timber Sales.

It should be noted that the key feature of the TSA team is for them to be engaged and fully supportive. A similar FFS was initiated in the Strathcona TSA, and it is being led exclusively by the Ministry of Forests and Range.

The strategy development team should have a range of expertise that ties well into climate modeling and mapping, as well as the values and potential issues anticipated, and includes facilitation skills to organize and manage workshops.

B. Summarize current management direction for the unit, based on the pertinent plans

The intent with this step is to examine all strategies, plans and guidelines over the range of resource values in the TSA to identify key management values and the regimes or guidance that is currently being used in the TSA⁶. This identification of management regimes is a first step to provide an overview of potential issues, concerns and attributes of management that should be considered to assess the management sensitivities in the TSA.

C. Explore plausible future climate change scenarios locally.

Kamloops TSA Approach:

Climate change presents an uncertain, moving target for forest managers as they try to understand ecosystem attributes and function over the next rotation. To limit considerations to what could practically be handled, two “best and worst case” bookend scenarios were designed to characterize the range of potential climate changes outcomes⁷.

⁶ Note while the Kamloops strategy focused on a TSA, other administrative or planning units may be suitable for a future forest strategy, TSA is being used here as an example.

⁷ After a review of literature and direct consultation with Tongli Wang (UBC), Andreas Hamann (UofA), Dave Spittlehouse (MoF), and Del Meidinger (MoF), it was clear that no one climate change scenario should

These best and worst case scenarios or least-change and most-change scenarios, were depicted with a number of climate variables as well as mapped using surrogate biogeoclimatic climate envelopes to represent future climatic conditions. This work was completed for the entire TSA. The intent of this data analysis and mapping was not to re-engineer the biogeoclimatic mapping in the Kamloops TSA. It instead was intended as a starting point for dialogue regarding ecological and management sensitivities. BEC climate envelopes were used due to the familiarity most resource management professionals have with climatic conditions within the range of local biogeoclimatic units. In this way the maps can be used as a board game to prompt discussion and tease out key potential sensitivities in a workshop setting.

For more information - SEE: *Climate Modeling and Future Ecosystem Climate Mapping* (Version 2.0 September 26, 2008) in the *Compendium of Supporting Documents*.

Suggestions for Consideration:

It is not clear that comprehensive mapping is necessary for every TSA or planning unit to be assessed. While it would be beneficial to complete similar mapping for at least one TSA in each of the: Southern Interior, Northern Interior and Coastal Regions, it is not clear if all TSA's will require similar mapping. The first time mapping is initiated in a region, it is important to involve local Ministry ecologists in the process to gain their insights and input and to ensure everyone understands the intent and subsequent use of the mapping tool.

It may be possible to transfer projected subzone climate envelopes from one TSA to another where similar sensitivities exist. This assumption should be tested for TSAs that are quite different in latitude. For example, a project in the Kootenays may be instructive to see if the ICHmw and ICHdw closer to the US border will truly change similarly to the Kamloops TSA. It is estimated that the same mapping approach used in the KFFS could be replicated for another Southern Interior TSA in a cost effective manner. Alternatively, ClimateBC could be run to provide climate data across the entire TSA, while mapping subzone-climate envelopes for a few sample landscapes with a good representation of subzones to provide vignettes to focus workshop discussions.

D. Analyse and Understand the Ecological Sensitivities in the Management Unit

Identify Key TSA Subzones

Once future climates can be characterized for the range of biogeoclimatic subzones in the TSA, sensitivities for key TSA subzones should be explored. The range of subzones should be analysed to choose subzones that are either significant due to their size, or the role that they play for key resource values in the TSA. It is best if the number of subzones

be considered 'most likely' and that the range of possible outcomes should be explored (Meidinger, 2007, Spittlehouse 2006). Bookend "best case" and "worst case" scenarios were constructed using a distinctly optimistic and pessimistic carbon emission scenarios coupled with several Atmospheric / Oceanic Global Circulation Models and interpreted locally by the program – ClimateBC.

to be explored is kept at a manageable level. Twelve subzones were identified as key in the Kamloops TSA, which is one of the most diverse TSAs in the province.

Explore Ecological Sensitivities in a “Working Workshop”

For this workshop people with valuable local and general ecological knowledge are identified and assembled. This group may encompass a wide range of people.

In the KFFS the following specialists were included or considered:

- regional ecologists,
- experienced field foresters,
- local biologists or naturalists,
- forest health specialists,
- fire management specialists,
- First Nations,
- academics and researchers.

These participants may be found locally or may come from adjacent areas with similar subzones and/or stand types and ecological conditions. Some participants may be engaged from further afield to utilize their cumulative knowledge from a range of ecosystems regarding key ecological or biological processes (see the acknowledgements section for a list of participants for the KFFS).

Summarize Sensitivities and Create Ecological Narratives of Potential Change

The results of the workshop discussions are summarized and used to write ecological narratives of potential change for each subzone. Additional specialists may need to be questioned and data or literature explored to answer questions that will increase the clarity of the proposed sensitivities and improve the narratives.

The resulting narratives act as plausible stories of the future forest ecosystems in these subzones out to 2050 and beyond to 2080. These plausible stories are intended to be boldly worded, avoiding qualifiers and vague statements to provide a picture of possible future forest conditions resulting from climate change.

The intent is to describe just how sensitive these forests may be and how that may affect their development over time. This information is not intended to accurately forecast the future, but rather to provide a picture that is less “unbelievable” than assuming that nothing will change in the face of climate change.

E. Analyse the Management Sensitivities in the Management Unit

Explore Management Sensitivities in a “Working Workshop”

The ecological narratives, along with forecast subzone-climate envelopes and summarized climate variables are used identify management sensitivities based on the range of resource

management values and associated objectives in the TSA. Accordingly, a range of resource managers and specialists are assembled for input.

In the KFFS the following specialists were included or considered:

- field foresters,
- wildlife biologists,
- conservation biologists,
- First Nations specialists with knowledge of culturally important plants,
- fish biologists,
- hydrologists,
- visual landscape specialists,
- timber supply analysts.

These specialists and practitioners consider the ecological narratives and supporting data to predict associated management sensitivities and management direction to address these sensitivities. The focus is to try to identify the range of actions that can be taken today to avoid major challenges and issues in the future. Quite simply, the intent is to avoid collectively painting ourselves into a corner over time.

Identify Key Management Sensitivities

Key sensitivities are identified during the management workshops. Those sensitivities are then ranked based on the expected impact that climate change will impart. The ratings are general but instructive. At this point if many ecological subzones or other units are being considered separately, they may be aggregated into fewer larger groups based on similar ecological conditions affecting similar management sensitivities. In the KFFS, an initial investigation of twelve major BEC subzones was refocused to use five main Subzone Groups. See Appendices 3 and 4 for sensitivity rankings.

F. Design Management Direction and Options for Adaptation

Using the output generated by the workshops along with an understanding of the planning intent for the administrative unit provide management direction and options to address management sensitivities. Two approaches were used for the KFFS:

- One approach provides direction based on management objectives, e.g., biodiversity, timber, visuals, First Nations culturally known plants (Appendix 4).
- A second approach summarizes direction and issues by groups of BEC subzones with similar characteristics, e.g., dry subzones with significant amounts of lodgepole pine (Appendix 3).

These two approaches were meant to provide those interested in general issue guidance by value as well as those looking for more specific guidance relating to an area with specific vulnerabilities. Additionally implementation barriers were summarized and discussed.

G. Assess Adaptive Capacity and Vulnerabilities for Management

Once the management direction and options are identified and explored, the management adaptive capacity is analysed to assess overall management vulnerability. Management adaptive capacity is the ability of the management system to adapt, or the likelihood that the manager will be willing and able to implement actions to adapt (management adaptive capacity) considering our present management system of legislation, policies planning and implementation processes.

This step is based on the implementation barriers and knowledge/data gaps identified for the broad management values and Subzone Groups. Other jurisdictions in BC will have many similar adaptive capacity issues and opportunities, thus the KFFS should be useful in identifying areas that require attention and those that may not. The importance of this step cannot be under-estimated as it highlights the challenges to adequately address climate change in the TSA.

H. Design Recommendations

The focus for the recommendations are to provide key steps for successful implementation, not to reiterate all of the management direction included in Appendices 3 and 4. The section should focus on moving the strategy forward to discuss the direction and start implementation, while addressing implementation barriers and gaps.

I. Communication to Engage Participation and Ensure Support

Ongoing communication throughout the development of the strategy is critical to ensure engagement of the range of expertise that is necessary. A range of communication approaches may be useful, including brief updated overview, progress reports, posters, and presentations. See compendium of support documents for examples of a technical and layman's presentation for the KFFS.

As the first FFS in the province, it was important for the KFFS to communicate widely and engage many different people and organizations at all levels. The following efforts were made by the KFFS team in this communication effort:

1. Information Session - presentation of climate mapping and intent of the strategy to:
 - a. Ministry of Forests and Range Southern Interior staff
 - b. Ministry of Forests and Range Kamloops District staff
 - c. Ministry of Environment, Kamloops Office staff.
 - d. BCTS – Southern Interior Business Unit at their AGM.
 - e. Thompson Rivers University – interested researchers for input and advice – Dr. Karl Larsen, Alan Vyse, Dr. Brian A. Heise, Dr. John Karakatsoulis.
 - f. University of BC – interested researchers for input and advice – Dr. Sally Aitken, Dr. Tongli Wang, Dr. Stephen Mitchell.
 - g. Ministry of Forests and Range Victoria Branch Specialists who are working on projects associated with Climate Change – Dave Spittlehouse, Del Meidinger, Kathy Hopkins, Silvia Lac, and Tom Niemann.

2. Background materials and progress reports sent to:
 - a. All participants in ecological and management workshops, and information sessions – above.
 - b. The Future Forest Ecosystems Initiative Coordinator - Colin Rankin.
 - c. Dr. Helen Sellars, Research Manager, British Forestry Commission, Silvan House, Edinburgh, UK.
3. Other Presentations or Communications
 - a. Worked with Dr. Mark Johnston and Shelley Webber, who are developing a Canadian forest sector adaptation strategy for climate change – participated in a workshop in Toronto in November, 2008. The KFFS will be a case study for this National Strategy.
 - b. Poster presentation to the Summer Workshop of the Southern Interior Silviculture Committee – September, 2008 in Clearwater BC.
 - c. A distance education climate change seminar on the Kamloops Future Forest Strategy for the Climate Change and Forest Carbon Strategic Unit of the Ministry of Forests and Range – December, 2008, Victoria.
 - d. Contributed a subzone-climate envelopment mapping example in an article entitled, *Learning to Deal with Climate Change and Catastrophic Forest Disturbances*, in the FAO publication *UnaSilva*.
 - e. Breakout presentation- Winter Workshop of the Southern Interior Silviculture Committee – April, 2009 in Naramata, BC.
 - f. Conference Presentation to the *Leader's Roundtable on Climate Change Adaptation* – Conference Board of Canada, May 5, 2009 in Vancouver BC.
 - g. Electronic Lecture - Canadian Institute of Forestry Electronic Lecture Series for Professionals across Canada – June 3, 2009.

APPENDIX 2 - General TSA Sensitivities

Introduction

While our climate modeling in the Kamloops TSA reflect some variations across BEC subzones, there are general climate trends across the TSA that are important to use as context when considering general TSA sensitivities and management direction. To put that information into context, this section first describes the anticipated general climate trends across the TSA based on our climate modeling, followed by the uncertainties associated with the modeling and the ecological interpretations that result from it.

Climate Parameters - 2008 to 2050 (relative to 1960-90)

- | | |
|----------------------|---|
| Temperature | <ul style="list-style-type: none">• Mean annual temperature - increase by 1 to over 3 degrees (consistent across subzones).• Mean temperature of the warmest month - increase by 2 to 6 degrees (relatively consistent).• Extreme minimum temperature – increase by 3 to 5 degrees (relatively consistent).• Mean temperature of the coldest month – increase by about 2 degrees (relatively consistent).• NOTE: Modellers more comfortable with temperature trend forecasts. |
| Precipitation | <ul style="list-style-type: none">• Mean annual precipitation will increase by 3 – 4% (sometimes as low as 2% and as high as 5%).• Summer precipitation will generally decline by 1 – 10%.• Precipitation in the Fall, Winter and Spring will generally increase.• More rain in winter with precipitation as snow declining by 2 to 23% (variable between subzones).• NOTE: Modellers more uncertain with precipitation trend forecasts. However, increased temperatures are expected to somewhat reduce winter snowpack and increase summer drought. |

Climate Parameters - 2050 to 2080 (relative to 1960-90)

Temperature

- Mean annual temperature - increase by 3 to over 7 degrees (varies by subzone).
- Mean temperature of the warmest month - increase by 2 to 10 degrees (varies by subzone).
- Extreme minimum temperature – increase by 5 to 10 degrees (varies by subzone).
- Mean temperature of the coldest month – increase by about 2.8 to 3.5 degrees (slight variation between subzones).
- NOTE: Modellers more comfortable with temperature trend forecasts.

Precipitation

- Mean annual precipitation will increase by 4 – 8% (varies by subzone).
- Summer precipitation will generally decline by 1 – 20% (varies by subzone).
- Precipitation in the Fall, Winter and Spring will generally increase.
- More rain in winter with precipitation as snow declining by 1 to 40% (highly variable between subzones).
- It is expected that a significant portion of precipitation may occur in severe weather events.
- NOTE: Modellers more uncertain with precipitation trend forecasts. However, increased temperatures are expected to somewhat reduce winter snowpack and increase summer drought.

Climate Cycles

El Nino & PDO

- El Nino Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) climate cycles are expected to continue to affect short term climate and weather.
- ENSO events persist for 6 – 18 months while PDO events seem to persist for 20-30 years (less is known about PDO).
- We appear to be entering a cool phase after a “warm PDO” cycle since the late 70’s – However, PDO did seem to shift back and forth – cool to warm again in 2002 / 03.
- If we are in a cool PDO phase, climate will generally be moderated by cooler / wetter winters and springs in BC for 20 years or more.
- La Nina in the cool phase will make climate even cooler and wetter, while El Nino will have the opposite impact.
- A switching into a warm PDO phase at 2030 or 2040 could significantly exacerbate impacts of climate change.

Tree Growth

- Climate change will extend the growing season. It varies by subzone but may be as much as a week or two at either end. It has been suggested in temperate and boreal European forests that this will increase photosynthesis and net primary production in trees, especially with higher CO₂ concentrations.
- In moist to drier subzones growth will be mostly influenced by drought and the summer heat:moisture index.
- In wetter subzones in the Kamloops TSA anticipated increase in mature tree growth due to milder temperatures, increased growing season, and continued high to moderate moisture inputs may be a bit simplistic. Improvement in growth may be less than expected.
 - A longer growing season may not necessarily be warmer, and it is possible that an advance in spring dates and a delay in autumn may be of minor importance to trees physiologically. Spring-time changes (e.g. bud-burst date) may be easy to see but relatively unimportant to tree growth.
 - Weather conditions in the heart of the growing season may be more important to productivity than an earlier bud-burst. A significant dry period in the summer will still have an impact on growth.
 - Also, as general climate moves out of sync with the normal phenological cycles of dormancy and frost hardiness, periodic unusual weather patterns may have a significant impact on vigor and growth of trees, especially younger stands. A generally warmer early winter may put stands at risk of damage if followed by a late winter deep cold period and the chilling requirements for most trees are already satisfied with growth tissues already reactivated.
 - There are still questions regarding increased incidence of insects and disease that are challenging to answer.

General Data Uncertainty

Models used

- These are the most complex models in use, consisting of an AGCM (atmospheric global circulation model) coupled to an OGCM (oceanic global circulation model). Some recent models include the biosphere, carbon cycle and atmospheric chemistry as well. AOGCMs can be used for the prediction and rate of change of future climate. They are also used to study the variability and physical processes of the coupled climate system.
- Global climate models typically have a resolution of a few hundred kilometres. Climate projections from the Met Office Hadley Centre make use of the HadCM2 AOGCM, developed in 1994, and its successor HadCM3 AOGCM (the one used in the Kamloops TSA), developed in 1998.
- AOGCM can predict changes in carbon dioxide concentration, given the emissions of carbon dioxide into the atmosphere. At the Met Office Hadley Centre, this was first done in 1999. Similarly, an AOGCM coupled to an atmospheric chemistry model is able to predict the changes in concentration of other atmospheric constituents in response to climate change and to the changing emissions of various gases. Further information is available on: some aspects of

Modelling Uncertainty

ocean simulation in HadCM3 (thermohaline circulation, ventilation, vertical mixing), decadal variability in the ocean of HadCM3.

- All the ranges in the general trends exist for several reasons:
 - First, no one is sure about future scenario for global carbon emissions so we have used booked scenarios – one high emission / high change scenario (A1FI) and one low emissions / low change scenario (B1).
 - We also paired the low change scenario with a model that deals with a number of climate processes in ways that moderate their impact (PCM). This provided us with what we thought would be the most optimistic bookend of the future if you want a low degree of change. We paired the high change scenario with a model that deals with a number of climate processes in ways that provide for hotter drier summers (Hadley). This provided us with our pessimistic bookend for the future if you do not want to see lots of change.
- The GCM Models used in the 2007 4th IPCC assessment differ considerably in their estimates of the strength of different feedbacks in the climate system, particularly cloud feedbacks, oceanic heat uptake and carbon cycle feedbacks, although progress has been made in these areas, the confidence in projections is higher for some variables (e.g. temperature) than for others (e.g. precipitation), and it is higher for larger spatial scales and longer time averaging periods.
- Modellers are more uncertain with precipitation trend forecasts. However, increased temperatures are expected to somewhat reduce winter snowpack and increase summer drought.
- Note: We are learning more about climate change all the time. The shrinkage of the polar ice caps in 2007, and now in 2008 were not just surprising to scientists, but “very alarming” (Arcticnet 2008). This is one example of a biofeedback mechanism that global climate modellers may have underestimated.
- Large-scale ocean circulation changes beyond the 21st century cannot be reliably assessed because of uncertainties in the melt water supply from the Greenland ice sheet and model response to the warming.
- Projections of climate change and its impacts beyond about 2050 are strongly scenario and model dependent, and improved projections would require improved understanding of sources of uncertainty and enhancements in systematic observation networks.

Ecosystem Dynamics

- The dynamic nature of ecosystems makes predictions about future conditions challenging at best. A number of conditions could come together – perfect synchronicity of weather conditions at key developmental times for an insect generally not even thought of as a concern, vulnerability of host trees and perhaps one of two other factors and we are blindsided by an epidemic we couldn't predict that changes the whole picture for the subzone.

Tree Species Suitability

- Tree species suitability to the shifting climate envelopes in the Kamloops TSA are educated guesses at best. Many of these climate envelopes would be unique. BC foresters will have little experience with them. Introducing new species now to anticipate conditions decades from now is also a challenging endeavour. There many questions about different species growing under different conditions that will require monitoring, more analysis, species and provenance testing over time to resolve. Targeting new species on sites where there is a high likelihood of survival and persistence both now and over time is the best strategy for now.

For more detailed information on Management Sensitivities by Biogeoclimatic Grouping see Appendix 3 and by Value see Appendix 4.

APPENDIX 3 - Specific Sensitivities and Adaptive Management Direction by Subzone Groupings.

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Overview and Intent of this Section

This section summarizes the analysis, interpretations, and discussions from the climate change modeling, ecological vulnerability, and management vulnerability workshops for five major subzone groupings found within the TSA.

Each subzone grouping begins with three overview tables followed by a discussion under the following topics:

- Ecological sensitivities due to climate change;
- Potential future forest conditions;
- Management sensitivities by management value and specific concerns;
- Management direction, both broad and recommended specific actions;
- Barriers and gaps for implementation; and
- Key assumptions.

The tables up front are meant to provide a quick overview of the main issues and options for the subzone grouping. They are organized as follows:

- **An overview of management sensitivities for the subzone grouping.** The table is set up with four columns:
 - The General Management Value – main management themes taken from the management guidance for the TSA.
 - Specific concern – these subcategories of the management value were taken directly from the present day guidance documents for the TSA
 - Sensitivity rank – these subjective rankings are meant to focus attention on the management concern. A footnote is provided that define the rankings. Note they are color coded with red denoting a high sensitivity, yellow moderate and green low.

- Related Direction see discussion for the management direction summary table (below).
- **Management direction summary.** It too has four columns:
 - Management direction – these are numbered and are what are being referred to in Related Direction in the sensitivity table (above). They summarize the main options that could be used to mitigate the challenges of climate change.
 - Ease of Implementation – is provided to identify the ease of implementing the management direction within the present regulatory framework. This rating is meant to be connotative, i.e., challenging means there are steps required before the management direction can proceed, these may include policy or legislative changes.
 - Planning linkage – plans that may link to the management direction are provided, e.g., FSP - Forest Stewardship Plan, SFMP - Sustainable Forest Management Plan, TSR – Timber Supply Review.
 - Ability to mitigate impacts on timber supply –using arrows as a general indication on the potential to mitigate the impacts of climate change through management. See the footnote for the table for more detail.
- **Priority / ease of implantation matrix** - summarizes the priority for management direction (based on the assumed impact of the management action on the identified management concern) against ease of implementation.
 - The table is color coded using green tones to indicate greater ease and impact, red tones to indicate options with less impact and more difficult to implement (yellow and orange to denote options between the two extremes).
 - The numbers in the matrix refer to the numbers in the *management direction* table.
- NOTE: Appendix 4 provides general guidance that may be pertinent to the guidance provided in this section. Appendix 4 has general direction for the entire TSA, by management value. In this section where management concerns prompt no specific direction or elaboration of Appendix 4 direction, Appendix 4 direction is not repeated, simply referenced. The assumption is that Appendix 4 direction applies where applicable across all subzone groups. Where further elaboration or more specific direction is needed for a particular subzone, it is provided in here in Appendix 3.

Dry Subzones Dominated by Lodgepole Pine – MSxk and IDFdk (SBPSmk)

Table A3.1 Overview of Management Sensitivities for Dry Subzones dominated by lodgepole pine - MSxk and IDFdk (SBPSmk). Details follow the tables.

General Management Value	Specific Concern	Sensitivity Rank⁸	Related Direction (In Table A3-2)
TIMBER	Size of the working landbase	MODERATE TO HIGH	2 to 6
	Productive capacity of the working landbase	HIGH	2 to 6
	Growing stock on the working landbase	HIGH	1 to 7
	Economics	MODERATE	2 to 6
BIODIVERSITY	Old growth habitats	HIGH	2, 8
	Wildlife trees / wildlife tree patches and landscape permeability	HIGH	2, 3, 4, 5, 6, 7
	Coarse woody debris	MODERATE	In Appendix 4⁹
	Ungulates (and designated winter ranges)	MINOR	2, 3, 4, 5, 6, 7
	Other species of concern or at risk (provincial red and blue)	HIGH	2, 3, 4, 5, 6, 7
	Invasive species	HIGH	In Appendix 4
FIRST NATIONS	Culturally important plants	MODERATE TO HIGH	2, 3, 4, 5, 6, 7
INTERFACE	Fire risks	MODERATE TO HIGH	1, 4, 5, 7
WATER AND AQUATIC ECOSYSTEMS	Watershed management – water supply	MODERATE TO HIGH	In Appendix 4
	Fish Habitat – Salmonids	HIGH	In Appendix 4
OTHER	Visual Landscape Management	MODERATE	1, 5, 8
OVERALL SENSITIVITY RANKING		MOD TO HIGH	

⁸ **Sensitivity Rankings** – The sensitivity rankings are provided to focus attention on management concerns by area and value. The rankings used are as follows:

- **HIGH SENSITIVITY** – There is a high likelihood of a substantial negative impact on the management concern.
- **MODERATE SENSITIVITY** – There is a high likelihood of a limited negative impact on the management concern.
- **MINOR SENSITIVITY** – There is a likelihood of a small or limited impact.

⁹ **General Direction found in Appendix 4 will apply to all of these sensitivities** – It is listed only where more specific direction has not been provided here.

Table A3.2 Management Direction Summary. For more information on the management direction listed below see the following discussion.

Management Direction	Ease of Implementation	Planning Linkage	Ability to mitigate impact on Timber Supply ¹⁰
1. In areas within the urban-forest interface (primarily the IDFdk) strategic planning will be needed that addresses fire risk with other values.	Moderate to Challenging	FSP, SFMP & TSR (currently no strategic plan)	(↑?)
2. Increase the proportion of Douglas-fir and ponderosa pine (possibly western larch) in this ecological group (harvest mature pine and diversify plantations).	Moderate to Challenging	FSP, SFMP & TSR	↑↑
3. Consider ponderosa pine as a primary species for regeneration on specific sites.	Moderate to Challenging	FSP, SFMP & TSR	↑
4. Target young lodgepole pine stands that cannot be treated as suggested above in #1 for harvesting at 2050 or shortly thereafter if economically possible.	Challenging	TSR and provincial policy. (Need strategic plan)	↑↑
5. Maintain broadleaf presence, primarily aspen, throughout this ecological area at historic levels for as long as possible.	Moderate - Challenging (legislation/policy)	FSP, SFMP & TSR	↔
6. Increase flexibility for lower density and/or cluster planting of Douglas-fir and/or ponderosa pine on drier sites.	Moderately Easy (legislation/policy)	FSP, SFMP and TSR	↔ to ↑
7. Identify stands in the urban-forest interface that could benefit from some specific interface treatments.	Moderate to Challenging	FSP, SFMP & TSR – (strategic plan is missing)	(↑?)
8. Strategically plan wildlife tree retention and partial cutting in appropriate areas over time, integrating several spatial scales, to help build landscape level permeability for biodiversity.	Moderate to Challenging	FSP, SFMP & TSR (unclear if these fit for a “comprehensive strategy”)	↔ to ↓
9. Risk assess mature Douglas-fir stands for future insect infestations to help build priorities for harvesting or protection	Challenging (no assessment method currently available)	Once assessed – FSP & TSR	↑↑

¹⁰ **Ability to mitigate influence on Timber Supply** – The broad influences to mitigate future timber supply impacts from climate change are illustrated conceptually for each direction item. Moderate, Mod-High, and High sensitivities in the preceding table for the Timber concerns will have correspondingly downward pressure on timber supply. The intent here is to broadly illustrate how management direction is expected to influence timber supply by moderating these downward pressures. One up arrow indicates one benefit with upward mitigation (e.g. regeneration species capturing more potential productivity) while two arrows means several benefits. SEE Appendix 4 for the overall expected influence of management direction from this strategy on timber supply within the TSA.

Management Direction	Ease of Implementation	Planning Linkage	Ability to mitigate impact on Timber Supply ¹⁰
efforts.			
10. Important local watersheds in this ecological grouping should be a TSA priority for watershed analysis and planning as described in Appendix 4.	Moderate - Challenging (legislation and policy)	Not clear	↔

Table A3.3 Management Direction Priority-Ease of Implementation Comparison¹¹. Numbers correspond to the numbered direction items above.

		Ease of Implementation			
		Easy	Moderately Easy	Moderately Challenging	Challenging
Priority for Management Direction	Very High			1, 5	
	High		6	2, 3, 7	
	Mod-High			8	
	Mod			9, 10	
	Low - Mod				

¹¹ **PRIORITIES** – Priorities were identified as follows:

- VERY HIGH – A high potential to improve at least four sensitivities.
- HIGH – A high potential to improve at least two sensitivities.
- MOD-HIGH – A high potential to improve at least one sensitivity, or a mod-high potential to improve at least two sensitivities.
- MOD – A moderate potential to change at least two sensitivities, or a mod-high potential to improve one sensitivity.
- LOW-MOD – a moderate potential to help change one sensitivity.

Note these priorities should be considered a starting point, actual management direction should be informed by additional scenario testing to determine the most effective options.

Ecological Sensitivities due to Climate Change

The descriptions below are designed to paint a vivid and clear picture of the future. Words such as “will” are used to indicate plausibility not inevitability. In reality there is a high degree of uncertainty involved in making forecasts of this nature. Nevertheless, these projections are the result of an exploration of future scenarios which allowed for the development of what should be considered as credibly plausible forecasts. The important thing is to remember what these plausible forecasts are intended to help managers avoid blindly painting themselves into corners as our climate changes.

Sensitivities in Lodgepole pine stands: High

The following is a general overview. For more information SEE: *Compendium of Supporting Documents – Ecological Narratives for the MSxk and the IDFdk*.

- Recent mountain pine beetle epidemic severely reduced the area occupied by mature pine stands. Many of these have been salvaged and converted to young pine plantations. It is estimated that once salvaging is complete close to 89,000 ha of this area (37% of the THLB in this subzone grouping¹²) will be in young pine plantations (0-20 years old). Some stands will remain with high levels of dead standing timber.
 - The standing dead timber will pass through several stages that will create a high fire hazard in the near future. Likely this hazard will return more to normal for much of the time until 2050.
 - The mostly-dead stands of pine will regain full stocking very slowly over time.
- As climate warms lodgepole pine will not be suited to the environment here, resulting in greatly reduced vigour coupled with high mortality risks from a range of forest health agents, predominantly insects.

Sensitivities in Douglas-fir and other stands: Moderate

The following is a general overview. For more information SEE: *Compendium of Supporting Documents – Ecological Narratives for the MSxk and the IDFdk*¹³.

- With increasing drought in warm cycles, it is anticipated that there will be some Douglas-fir mortality assisted by several forest health agents such tussock moth,

¹² This subzone grouping includes all of the MSxk and IDFdk in the Kamloops TSA.

¹³ Note the **SBPSmk** occurs is several isolated pockets adjacent to the MSxk and the IDFdk along the western edge of the TSA where it transitions into the Central Interior Plateau (no ecological narrative due to limited area). Temper the information found here for the SBPSmk by that provided in the Dry to Moist Plateau / High Elevation Group. Note that lodgepole pine may be quite sensitive in the SBPSmk as early as 2050.

bark beetles and spruce budworm. This mortality will thin out these stands and create more gaps and potentially more fuels¹⁴.

- The minor scattered spruce stands will see significant mortality, and subalpine fir¹⁵ will virtually disappear during hot/dry cycles over the next 70 years – due to drought, assisted by bark beetles and other forest health agents.
- Impacts of Armillaria and spruce budworm in the IDFdk will be reduced in this drier environment.

Potential Future Forest conditions

The following description of potential future forest conditions are intended to portray how the forests in this ecological grouping may develop without intervention by forest managers. It is a general overview. For more information SEE: Compendium of Supporting Documents – Ecological Narratives for the MSxk and the IDFdk.

- After the mountain pine beetle epidemic subsides, this area will develop as a mosaic of Douglas-fir stands interspersed with large swaths of early seral pine plantations, significant patches of dead standing pine, and ribbons of wetter sites with species such as redcedar, birch, spruce and cottonwood (depending on the subzone).
 - In significant portions of the IDFdk there will be a matrix of Douglas-fir with ribbons and scattered patches of early seral lodgepole pine, while other portions of the IDFdk may look similar to the MSxk with extensive lodgepole pine.
- Within large patches of young pine, there will also be scattered fragments of mature or old timber (mostly Douglas-fir and aspen with a small bit of spruce and cottonwood).
 - These pine stands (young plantations now) will be very stressed from 2050 to 2080, suffering high levels of mortality from drought and bark beetles.
 - Aspen will decline, being restricted to slightly moister slopes and draws in small clumps and stands.
- Douglas-fir stands will have many gaps due to scattered mortality from Douglas-fir bark beetle and other species. On warm slopes these stands will become generally more open with mortality. These stands will generally develop an irregular structure with younger Douglas-fir.
 - By 2080 there will be a greater presence of grassy openings in these stands due to drought and mortality from beetle, tussock moth and spruce budworm.

¹⁴ Fuel loading from mortality is a concern over certain time periods – when there are lots of fine branches still on the trees, and when dense dead pine starts to fall over but remains tangled and elevated like “pick-up sticks.” These susceptible stages need to coincide with hot dry fire seasons to increase risk.

¹⁵ Subalpine fir currently only has very minor presence only in the MSxk on moister north aspects.

- Continuous Douglas-fir stands by 2080 may be confined to moist draws, cool slopes and higher elevations.
- Wet site plant communities will shrink in size locally and some will disappear.
- In 2050 to 2080 large fires will likely contribute to extensive stand mortality, creating extensive early seral patches, which may not regenerate to forested conditions, instead remaining dominated by grassland species with scattered residual trees.
- The small scattered subalpine fir currently present in the MSxk will decline significantly by 2050, disappearing by 2080.

Management Sensitivities:

The following list of sensitivities is intended to provide a general picture specific to the ecological group. For more information about sensitivities that are found throughout the Kamloops TSA SEE: Appendix 4.

TIMBER - Size of the Working Landbase: Moderate To High Sensitivity

- A contraction of the THLB is expected, especially from 2050 to 2080 as some poorer lodgepole pine sites will not reach economic thresholds but will require an intervention to transition to a more suitable species. Reduction in site productivity, possibly combined with high densities on some sites, will see some pine stands that never reach a merchantable size.
- A transition to grasslands on south aspects and lower elevations (primarily in the IDFdk) may further reduce the working landbase. Note that this contraction may become extensive if pine stands harvested between 2050 and 2080 cannot be adequately regenerated to timber species due to extreme climatic conditions.

TIMBER – Productive Capacity of the Working Landbase: High Sensitivity

- Productive capacity will decrease due to increased stresses on most species and severe stress for lodgepole pine.
- Also productivity will be impacted on some sites where dead pine is left to occupy the site for extended periods – this factor may already be considered in TSR.

TIMBER –Growing Stock on the Working Landbase: High Sensitivity

- Future volumes are significantly threatened by the amount of young pine stands that will emerge out of the current mountain pine beetle epidemic and be unsuitable to the climate after 2050, which will be more like the IDFxh. The amount of area that will be affected is currently estimated at close to 89,000 ha of this area (37% of the THLB in this subzone grouping) – with young pine plantations (0-20 years old) resulting from salvaging of lodgepole pine.
- Future merchantable volumes in the non-lodgepole pine stands are expected to be reduced due to drought and forest health related mortality and possibly wildfire.

TIMBER – Economics: Moderate Sensitivity

- It will be a challenge to utilize greater amounts of small pine, perhaps with lower quality.
- Costs (harvesting and silviculture) could increase significantly if more artificial regeneration is necessary.
- Partial cutting will likely become more important past 2050, which will add to costs, although the terrain in these areas is mostly favourable for ground based logging.

BIODIVERSITY – Old growth habitats: High Sensitivity

- A large increase in disturbances (insects, fire and salvage) will reduce the availability of old seral. Although old seral is not a key feature of this landscape, it may be severely diminished as a habitat.

BIODIVERSITY – Wildlife tree patches and landscape permeability: High Sensitivity

- With high levels of disturbance over an extensive area, a good distribution of patches of mature timber will become more important as stepping stones for slow dispersers to make the landscape more permeable.
- Mature broadleaf patches, highly valuable as wildlife trees, will become much rarer due to a combination of drought, fire and forest health agents.

BIODIVERSITY – Coarse Woody Debris: Moderate Sensitivity

- Initially there will be more CWD with dead and dying lodgepole pine, although this could be fairly concentrated in some areas.
- Beyond 2050 the role of CWD will become more important, as habitat and a moisture holding medium in a much hotter drier environment.
- If salvage of smaller material in this area increases with few limitations – *for biofuels and other products the sensitivity could increase further.*

BIODIVERSITY – Ungulates and designated winter ranges: Minor Sensitivity

- The MSxk is of minor importance for deer winter range and likely use will not be much affected. However, winter range is more important on warmer aspects in the IDFdk. As these Douglas-fir-dominated stands open up and have more gaps their value may be reduced or improved, depending on the stand.
- Increased fire risk will threaten the scattered winter ranges found here. This is a general sensitivity – SEE Appendix 4
- Moose utilize wetter ecosystems which will shrink slightly over time.

BIODIVERSITY – Species at Risk or of Conservation Concern (Provincial red and blue lists and SARCO lists): High Sensitivity

- Some red and blue listed species that rely on forest cover will have less available habitat with higher levels of disturbance over time.
- NOTE: Some grassland species may improve with an expansion of grassland habitat – depending on the quality of the expanded grasslands and the presence of invaders and other factors.

BIODIVERSITY – Invasive species: High Sensitivity

- With high disturbance levels and grasslands expansion, grassland invasive species will increase significantly. These will impact presence of red and blue listed plants and abundance of native species in general.

FIRST NATIONS – Culturally Important Plants – Moderate To High Sensitivity

- Wet to moist site plants will see suitable habitat shrink, while some dryland species may be threatened by competition from invasive species.
- Impacts will depend on the ability for the First Nations to utilize other subzones.

FIRE – Interface Risks – Moderate To High Sensitivity

- Interface is not a dominant feature, but important for several small communities like Logan Lake, farming areas like the Heffley Creek valley, and a number of permanent and seasonal residents near recreational lakes.
- Fire risks will be elevated in the near term as dead pine pass through susceptible stages. After that fire risk will diminish up to 2050 due to the mosaic of young stands scattered through the landscape.
- After 2050 the prominent dense middle-aged pine stands will once again pose a high risk in a very hot and dry landscape.

WATER AND AQUATIC ECOSYSTEMS – Watershed management – Moderate To High Sensitivity

- These dry subzones, often forming an elevational gradient from IDFdk to the MSxk, comprise the headwaters for watersheds in this TSA. Nearby settled areas and agricultural lands in major valleys depend on these watersheds for water-supply.
- With less winter snow (up to 20% less at 2050), and extended summer droughts the supply of water for domestic and commercial purposes could be threatened.

WATER AND AQUATIC HABITATS – Fish Habitat (salmonids) – High Sensitivity

- Salmonids may be threatened in many streams due to water temperatures. Streams previously temperature sensitive, or close to it, in the southern portion of the TSA where this ecological grouping is concentrated will be particularly sensitive.

OTHER – Visual Landscape - Moderate Sensitivity

- Related to the high sensitivity of the maturing large stands of lodgepole pine (now early seral) and related fire risks.

Management Direction

The following management direction is to start the process of long term risk management for climate change. It is intended to focus prudent management over the short and mid-term to increase resilience if the future unfolds as indicated in the plausible forecast. Yet, even if climate fails to have the degree of impact indicated in the previous section, future forest conditions should not be negatively impacted by the management direction provided here.

Broad Direction

In regeneration strategies and associated silvicultural systems, there needs to be a reduction in the amount of lodgepole pine and a greater use of other species, principally: Douglas-fir, ponderosa pine, and possibly western larch on some sites. In addition, where significant young lodgepole pine currently exists, work to facilitate significantly reduced harvest ages will be necessary, in combination with strategies to maintain some cover once the pine is harvested.

Benefits:

- May significantly reduce the expected contraction of the THLB in the long term if extensive conversion to grassland-dominated ecosystems is reduced.
- Threats to growing stock and the productive capacity of the landbase will be reduced, resulting in greater capacity for carbon sequestration.
- A greater range of habitats and possibly culturally important plants will be supported.
- Visual aesthetics over the long term may be improved.

Challenges:

- Most existing early seral stands are already in young lodgepole pine.
- Most lodgepole pine stands currently being salvaged regenerate well naturally to a high component of lodgepole pine.
- Douglas-fir is susceptible to frosts and is delicate and vulnerable to damage and mortality in its establishment phase.

Recommended Specific Actions

1. Within this Subzone Group, the IDFdk will have some area with urban-forest interface concerns, similar to the IDFxh. It is critical moving forward that a strategic management plan is designed in this area to make interface management the priority, while integrating other values. (See Appendix - 4 Fire for more information).

2. The following strategy is recommended to address the very large area anticipated to be in young lodgepole pine leading stands in this ecological grouping (37% of the THLB in this ecological grouping):

For new harvesting in lodgepole pine dominated stands: It is important to get as much Douglas-fir and/or ponderosa pine into these plantations as possible (even in the MSxk):

- i. For sites conducive to high levels of Douglas-fir and/or ponderosa pine survival in a clearcut situation, plant uniformly with these species, expecting lodgepole pine fill-in.
- ii. For sites where Douglas-fir and/or ponderosa pine establishment will be challenging but possible, cluster-plant in suitable microsites – 3-4 trees at intervals of 10-15 m (may need to experiment initially), or fill-plant under the cover of lodgepole pine regeneration. The objective is to get enough Douglas-fir or ponderosa pine on-site so if there is sudden mortality of the lodgepole pine in the future, prior to its anticipated harvest age, an open overstory of other species will be available to act as a nurse shelterwood to allow for planting in the understory.
- iii. For sites where Douglas-fir or ponderosa pine survival is doubtful even on suitable microsites, encourage higher densities of lodgepole pine (3000-5000 stems/ha with infill) to allow for mortality over time.
- iv. Where mature Douglas-fir or ponderosa pine are present - retain some seed trees on-site, selected and distributed to reduce losses from windthrow. The intent is to provide for natural regeneration that may help increase on-site genetic diversity to assist with adaptation to the changing climate¹⁶.

For existing young (0-20 year old) lodgepole pine plantations (previously established):

- v. Target appropriate stands for fill-planting clumps of Douglas-fir as described above. This fill planting should become a priority for government funding as it will benefit timber, biodiversity and occasionally recreation/visual management.
 - vi. In slightly taller plantations, clearing patches in the lodgepole for the establishment of clumps may be necessary.
3. Consider ponderosa pine as a primary species for regeneration on mesic to drier sites in the IDFdk and at some lower elevations in the MSxk. Also experiment with western larch on slightly moister /cooler sites lower down in the MSxk and in the IDFdk.

¹⁶ This concept may be more important for ponderosa pine (or larch) if individuals are found, because Douglas-fir has a high degree of genetic variation, even in planted stock.

4. Lodgepole pine stands that are currently young, and cannot be treated with the regeneration interventions suggested above, should be targeted for harvesting at 2050 or shortly thereafter if economically possible.

Clumps of pine retention may be necessary when harvesting to shelter developing planted Douglas-fir and/or ponderosa pine. If these clumps survive wind and snow damage even for a few years that may be enough to allow for some establishment of Douglas-fir and ponderosa pine over a portion of these stands.

5. Pure broadleaf stands and mixedwood stands should be maintained as a biodiversity feature to provide the diversity of habitats associated with broadleaf species (e.g. soft snags for cavity nesting birds). Also, broadleaf trees will be valuable to strategically break continuous coniferous cover as a fire break.

As broadleaf trees are highly desirable but currently make up a very small proportion of the growing stock and are highly sensitive to climate change in this subzone, the following practices should be pursued to maintain broadleaf species as long as possible:

- i. Include aspen and cottonwood as a preferred species in standards units adjacent to riparian features.
 - ii. Include aspen as a preferred species in all standards units where they are ecologically suitable (as denoted by the presence of mature individuals preharvest) and where regeneration is prescribed.
 - iii. Favour aspen and cottonwood, where they are available, for retention as wildlife trees or in wildlife tree patches.
6. Increase flexibility to use lower densities and/or clumpy stocking standards with Douglas-fir and ponderosa pine in areas with challenging microclimates (e.g. clearcuts on drier sites).

The intent should be to best utilize optimal microsites (consider clump or cluster planting). On dry sites that remain in the THLB, partial-cutting silvicultural systems will likely be necessary in the future to deal with the anticipated severe microclimate. Therefore, cluster planting may promote an irregular structure that could work well with partial cutting over time. On sites that become marginal in the future for timber production, scattered clumps of trees in a grassland-dominated community will encourage a range of habitats.

7. For existing stands of Douglas-fir in the urban-forest interface (mostly the IDFdk):
 - i. Identify stands of Douglas-fir with high understory densities that could benefit from hazard abatement spacing and other treatments used to manage fire risk in the forest-urban interface.
 - ii. Identify merchantable stands of Douglas-fir that are predicted to decline and fall out of the THLB due to climate change. Consider partial harvest purely to reduce both overstory and understory fuels and maintain habitat. No regeneration objectives or obligations should be attached to these

stands, unless some planting is needed to establish some structure for habitat – these would have very different stocking standards than those used for timber objectives.

8. When harvesting mature stands with a significant component of Douglas-fir or other non-pine (lodgepole) species, target a mix of partial cutting and wildlife tree retention to help maintain landscape level permeability for biodiversity in newly harvested blocks.

Develop a comprehensive strategy using foresters and habitat specialists to provide more specific direction over time regarding the range and distribution of retention that should be targeted here. This direction must consider climate change and other impacts over time. It also should integrate retention at several scales to consider OGMAs and other large reserves. See recommendations for biodiversity in Appendix 4.

9. Mature stands of Douglas-fir will be of critical importance for timber supply and habitat. These will be threatened by tussock moth (possibly), Douglas-fir beetle (when trees are defoliated or drought-stressed), and possibly spruce budworm. The risk of these forest health agents should be further explored with specialists to more appropriately target stands for reserves or harvesting.
10. Important watersheds in this ecological grouping for domestic and commercial water use should be a priority for watershed analysis and planning as described in Appendix 4 since these are some of the drier subzones in the TSA, often forming a significant portion of some local watersheds.
11. Consider the importance of this subzone in the general management direction provided for all values in Appendix 4.

Barriers and Gaps for Implementation

Structural Barriers

Note: where these barriers are already discussed in Appendix 4 (General TSA Sensitivities), they are just mentioned here, with a reference to those portions of Appendix 4 where they are discussed in more detail.

1. Currently Douglas-fir and ponderosa pine are more expensive to establish than lodgepole pine. This means that until planting of species other than lodgepole pine becomes standard practice and suitable stumpage allowances are in place (see below), there is an economic disincentive to utilize these species.
 - For more information see: Timber Management in Appendix 4.
2. Currently there is reluctance to encourage broadleaf species through stocking standards in FSPs when it is not clear what the impacts will be on future timber supplies.

- For more information see: Timber, Biodiversity and Fire Management in Appendix 4.
3. Incentives or suitable allowances that will encourage utilization of small pine harvested at age 40-60 from sites in this ecological grouping should be explored by the province.
 - For more information see: Timber Management in Appendix 4.
 4. See other barriers by management value in Appendix 4.

Gaps in Knowledge, Data, or Tools

1. Cluster planting of Douglas-fir and other species in new clearcuts and in existing lodgepole pine plantations, with or without clearing of existing pine, should be explored with a review of existing literature¹⁷ and data.

Possibly an operational trial should be pursued to determine: a feasible height and density threshold for such interventions in existing pine plantations; added criteria to prioritize stands (regarding treatment economics and other values); the amount of area that could be reasonably treated over a period of time; the resulting benefits anticipated for such work (including TSR implications), and operational tips to facilitate feasible projects with reasonable costs.

2. A risk forecasting protocol for forest health agents influenced by climate change is needed for prioritizing stand types within the various ecological groups – in this case for non-lodgepole pine stands.
3. Over the next 10-15 years the lodgepole pine dominated site types should be identified that are most at risk to becoming marginalized in the THLB due to climate change. More comprehensive planning should target treatments for the range of values present.
4. See other gaps by management value in Appendix 4.

Key Assumptions

While it may be true that all of the proposed sensitivities and impacts from climate change are assumptions, or speculation, this section lists additional assumptions that should be scrutinized.

1. Douglas-fir, ponderosa pine and larch seed will be available in suitable provenances for planting in these subzones.
2. Loss of growing stock and increased regeneration delays have been accounted for in TSR for dead pine stands (that will not be salvaged from the current beetle epidemic).

¹⁷Some pertinent studies in the southern interior should be reviewed for direction. An example is the Douglas-fir underplanting trial, EP841.08, conducted in the Cariboo. After such a review, operational trials should be conducted to explore best practices and efficiencies.

3. Assigned “ease of implementation” and “priority for management direction” are estimates based on the judgement of the KFFS team. For “ease of implementation” the number and difficulty of implementation barriers and gaps were considered. For “priority of management direction” the perceived ability of the direction to help mitigate and address management sensitivities across all important values were considered. All of these estimates required numerous assumptions regarding the importance of barriers and the potential impact of direction on management sensitivities. These relative rankings should therefore be scrutinized carefully by managers before they are assumed to apply as indicated and utilized in planning.

Dry Subzones dominated by Douglas-fir and Ponderosa pine – IDFxh, PPxh

Table A3.4. Overview of management sensitivities for Dry Subzones dominated by Douglas-fir and ponderosa pine (IDFxh and PPxh). Details follow.

General Management Value	Specific Concern	Sensitivity Rank ¹⁸	Related Direction (In Table A3.5)
TIMBER	Size of the working landbase	HIGH	2, 3, 4, 5
	Productive capacity of the working landbase	HIGH	3, 4, 5
	Growing stock on the working landbase	HIGH	1, 3, 4, 5, 6, 9
	Economics	MODERATE	4, 5
BIODIVERSITY	Old growth habitats	HIGH	1, 8, 9
	Wildlife trees / wildlife tree patches and landscape permeability	HIGH	1, 2, 3, 6, 7, 8, 9
	Coarse woody debris	MINOR	1, 7, 8
	Ungulates (and designated winter ranges)	MODERATE	1, 3, 5, 6, 8, 9
	Other species of concern or at risk (provincial red and blue)	MODERATE TO HIGH	1, 2, 3, 5, 6, 7, 8, 9
	Invasive species	HIGH	In Appendix 4 ¹⁹
FIRST NATIONS	Culturally important plants	MODERATE TO HIGH	3, 6, 7, 8, 9
INTERFACE	Fire risks	HIGH	1, 3, 5, 6, 9
WATER AND AQUATIC ECOSYSTEMS	Watershed management – water supply	HIGH	10
	Fish Habitat – Salmonids	HIGH	In Appendix 4
OTHER	Visual Landscape Management	MODERATE TO HIGH	1, 2, 3, 6, 7, 8, 9
OTHER	Range (more opportunities than sensitivity)	MINOR	2, 3
OVERALL SENSITIVITY RANKING		HIGH	

¹⁸ **Sensitivity Rankings** – The sensitivity rankings are provided to focus attention on management concerns by area and value. The rankings used are as follows:

- HIGH SENSITIVITY – There is a high likelihood of a substantial negative impact on the management concern.
- MODERATE SENSITIVITY – There is a high likelihood of a limited negative impact on the management concern.
- MINOR SENSITIVITY – There is a likelihood of a small or limited impact.

¹⁹ **General Direction found in Appendix 4 will apply to all of these sensitivities** – It is listed only where more specific direction has not been provided here.

Table A3.5. Management Direction Summary Table. For more information on the management direction listed below see the following discussion.

Management Direction	Ease of Implementation	BC Planning Linkage	Ability to mitigate impact on Timber Supply ²⁰
11. Complete strategic planning in the urban interface areas that addresses fire risk with other values.	Challenging	None to FSP partially	↔ to (↑)
12. Zone THLB for timber production and open forest grasslands to clarify management intent.	Moderately easy	Not clear	↔
13. Identify management options for open forest grasslands.	Easy	FSP, SFMP and TSR	↔
14. Promote ponderosa pine, and undertake a review of ponderosa pine management.	Easy	None	↑
15. Modify stocking standards to build in greater flexibility and variability.	Challenging	FSP, SFMP and TSR	↔ to (↑)
16. Identify stands in the urban-forest interface that could benefit from some specific interface treatments.	Moderate to Challenging	FSP, SFMP and TSR (need strategic plan)	↔
17. Maintain broadleaves, and include in stocking standards.	Challenging	FSP, SFMP and TSR	↔
18. Develop a comprehensive retention strategy at varying scales.	Challenging	FSP, SFMP and TSR	↔
19. Create a risk rating procedure for forest health agents.	Moderately Challenging	Once assessed, FSP, SFMP and TSR	↑
20. Identify priority watersheds for planning as outlined in Appendix 4.	Challenging	Not clear	↔

²⁰ **Ability to mitigate influence on Timber Supply** – The broad influences to mitigate future timber supply impacts from climate change are illustrated conceptually for each direction item. Moderate, Mod-High, and High sensitivities in the preceding table for the Timber concerns will have correspondingly downward pressure on timber supply. The intent here is to broadly illustrate how management direction is expected to influence timber supply by moderating these downward pressures. One up arrow indicates one benefit with upward mitigation (e.g. regeneration species capturing more potential productivity) while two arrows means several benefits. SEE Appendix 4 for the overall expected influence of management direction from this strategy on timber supply within the TSA.

Table A3.6. Management Direction Priority-Ease of Implementation Comparison²¹.
Numbers correspond to the numbered direction items above.

		Ease of Implementation			
		Easy	Moderately Easy	Moderately Challenging	Challenging
Priority for Management Direction	Very High				1
	High			6	5
	Mod-High	3, 4	2	7, 8	
	Mod			9	10
	Low - Mod				

²¹ **PRIORITIES** – Priorities were identified as follows:

- VERY HIGH – A high potential to improve at least four sensitivities.
- HIGH – A high potential to improve at least two sensitivities.
- MOD-HIGH – A high potential to improve at least one sensitivity, or a mod-high potential to improve at least two sensitivities.
- MOD – A moderate potential to change at least two sensitivities, or a mod-high potential to improve one sensitivity.
- LOW-MOD – a moderate potential to help change one sensitivity.

Note these priorities should be considered a starting point, actual management direction should be informed by additional scenario testing to determine the most effective options.

Ecological Sensitivities due to Climate Change²²

The descriptions below are designed to paint a vivid and clear picture of the future. Words such as “will” should be viewed with caution. In reality there is a high degree of uncertainty involved in making forecasts of this nature. Nevertheless, these projections are the result of an exploration of future scenarios which allowed for the development of what should be considered as “credibly plausible forecasts”. The important thing is to remember what these plausible forecasts are intended to help managers avoid blindly painting themselves into corners as our climate changes.

Sensitivities in Ponderosa pine stands: High Sensitivity

- Ponderosa pine has already been severely impacted by western and mountain pine beetle outbreaks. High mortality levels have occurred within the study area with little salvage.
- While ponderosa pine regeneration is occurring under present conditions, its location will remain patchy; conditions suitable for new regeneration will become less common with hotter and drier summers.
- Fire risk will vary depending upon the density and decay condition of the dead pine and the development of ladder fuels in the understory of stands.

As climate warms surviving ponderosa pine will experience higher levels of drought stress making them susceptible to future beetle attacks. Regeneration will be limited to cool wetter years that could occur periodically. Survival will be inconsistent resulting in a patchy tree distribution.

Sensitivities in Douglas-fir and other stands: High Sensitivity

- Douglas-fir stands will experience continued and increased mortality from tussock moth and bark beetle. Drought with or without the added insect attacks will be a factor in mortality. North slopes and higher elevations will have less mortality.
- With the added mortality, the chance of stand replacing fires will increase if the conditions of fine fuels, hot dry conditions and an ignition source line up.
- The pockets of other species found in draws and wetter areas will recede as moisture from snow derived sources decreases and overall moisture levels decline.
- Impacts of Armillaria and spruce budworm in the IDFxh will be reduced in this drier environment.

Potential Future Forest conditions

The following description of potential future forest conditions are intended to portray how the forests in this ecological grouping may develop without intervention by forest managers. It is a general overview.

²² The following is a general overview. For more information SEE: *Compendium of Supporting Documents – Ecological Narratives for the IDFxh and PPxh*.

- The present mortality in ponderosa pine will create a sparse patchy mosaic of new ponderosa pine regeneration, snags and early seral vegetation. Douglas fir will be found in patches along with scattered remnant ponderosa pine. Areas that were primarily Douglas-fir stands will also be patchy as mortality increases. Early seral species and invasives will expand into disturbed areas.
- Stands of cottonwood and aspen found in wetter areas will undergo cycles of significant stress resulting in periodic mortality. Understory species will become more prevalent.

Management Sensitivities:

The following list of sensitivities is intended to provide a general picture of sensitivities specific to the ecological group.

TIMBER - Size of the Working Landbase: High Sensitivity

- The THLB will contract as increased moisture stress begins to render many sites unproductive for commercial tree production (trending toward open forest / grasslands – with BG+ climate extremes in the present PP).
- By 2080 the PPxh is unlikely to support commercial timber production.
- Productive areas within the present IDFxh will also contract, moving towards more grassland dominated ecosystems over the next rotation. Northern aspects and/or upper elevations of the subzone will be impacted more slowly allowing a full rotation, after which options for timber production may become limited.

TIMBER – Productive Capacity of the Working Landbase: High Sensitivity

- Mature stands, both ponderosa pine and Douglas-fir will experience reduced productivity from moisture stress and will experience widespread mortality within a rotation age (initially on south slopes and drier ecosystems).
- Ponderosa pine will outperform Douglas-fir in most cases for growth and vigour.
- Plantations will be difficult to fully establish and patchy survival will dominate. As time proceeds it will become more difficult to regenerate harvested areas. Regeneration that is successfully established will see productivity declines over the present in the medium to long term. Volume production in the medium to long term will be tenuous at best.

TIMBER –Growing Stock on the Working Landbase: High Sensitivity

- As described above, mature stands are at a significant risk from moisture stress plus increased fire frequency. Ponderosa pine has already being highly impacted by beetles.
- Existing regeneration will be challenged by extreme drought years – especially on south facing slopes. As time proceeds, existing clumps of Douglas-fir regeneration on north facing slopes will suffer from increasing moisture stress, spruce, budworm, and tussock moth impacts.

TIMBER – Economics: Moderate Sensitivity

- Harvesting costs may or may not cover return, depending upon the decay class of the remaining stands. There may be some opportunities to obtain funding support for management of the interface. This could be a win-win situation for a number of values.
- Salvage of mortality will dominate unless proactive harvesting of green trees is acceptable.
- Harvesting costs are unlikely to change, since partial cutting is generally required right now, however reforestation costs will increase due to an increase in failures and an increase in planting utilizing assisted migration (in concert with the use of natural regeneration).

BIODIVERSITY – Old growth habitats: High Sensitivity

- The amount of old habitat will be reduced due to an increase in disturbance from drought, insects and fire. In the short term OGMA's become even more important as refugia as plants and animals begin to move with shifting habitats.

BIODIVERSITY – Wildlife tree patches and landscape permeability: High Sensitivity

- Due to the level of present and projected future mortality trees still present as stand level retention are seen as important as stepping stones to allow species movement to more suitable habitats over time. The location and characteristics of wildlife tree patches becomes more critical as impacts increase.
- Wetter sites and gullies with the associated vegetation will become rare with time.

BIODIVERSITY – Coarse Woody Debris: Minor Sensitivity

- Initially there will be more CWD with dead and dying ponderosa pine, although this will be concentrated in some areas.
- Beyond 2050 the role of CWD will become more important, as habitat and a moisture holding medium in a much hotter drier environment.
- If salvage of smaller material in this area increases with few limitations – for biofuels and other products the sensitivity could increase.

BIODIVERSITY – Ungulates and designated winter ranges: Moderate Sensitivity

- The impact on moose is uncertain; impacts will likely be limited to reduced aerial extent of wetter areas.
- Winter range in the IDF may have less Douglas-fir over time, but with that there will likely be less snow at lower elevations. However, there will remain a need for winter range as the IDF goes to above 1100 m.

- It is not clear whether deer will utilize less optimal aspects where the overstory may survive longer (e.g., north aspects), may depend upon location, it may be suitable if it is adjacent to and contiguous with the present predominantly southern exposures.

BIODIVERSITY – Species at Risk or of Conservation Concern (Provincial red and blue lists and SARCO lists): Moderate To High Sensitivity

- NOTE: Some grassland species may improve with an expansion of grassland habitat – depending on the quality of the expanded grasslands and the presence of invaders and other factors.
- Species at risk with limited ranges could be at additional risk due to fire and resulting ingress of invasives.

BIODIVERSITY – Invasive species: High Sensitivity

- With high disturbance levels and grasslands expansion, grassland invasive species will increase significantly. These will impact presence of red and blue listed plants and abundance of native species in general.

FIRST NATIONS – Culturally Important Plants – Moderate To High Sensitivity

- Wet to moist site plants will see suitable habitat shrink, while some dryland species may be threatened by competition from invasive species.
- Impacts will depend on the ability for the First Nations to utilize other subzones.

FIRE – Interface Risks – High Sensitivity

- Interface is a dominant feature in these units, with IDFxh and PPxh being the dominant forest interface for most communities south of Little Fort.
- Dense stands of immature Douglas-fir present a ladder fuel risk when encountered. Additional drought will predispose the stands to mortality agents, resulting in conditions suited to fire when weather conditions coincide.
- Fire risks will be elevated in the near term as dead pine pass through susceptible stages. After that fire risk will remain a concern as stands undergo drought stress and ongoing mortality.

WATER AND AQUATIC ECOSYSTEMS – Watershed management – High Sensitivity

- These dry subzones rely on upland moisture to replenish wetlands and stream discharge. With less winter snow (up to 20% less at 2050), and extended summer droughts the supply of water for domestic and commercial purposes could be threatened.

WATER AND AQUATIC HABITATS – Fish Habitat (salmonids) – High Sensitivity

- Salmonids may soon be threatened in numerous streams due to increases in water temperature. Streams previously temperature sensitive, or close to it, in the

southern portion of the TSA within the PPxh and IDFxh will be particularly sensitive.

- Decreased water flows could reduce available fish habitat and could limit movement in some smaller stream systems.
- Increased frequency and magnitude of storm events could impact habitat in some isolated areas.

OTHER – Visual Landscape - Moderate To High Sensitivity

- This Subzone Group dominates the visual landscape around communities, travel corridors and some recreational areas in the southern half of the TSA.
- Mortality and large severe fires in particular could significantly reduce the quality of the visual landscape. The 2003 fires here underscore the impact.

OTHER – Range- Minor – Actually An Opportunity

- This Subzone Group could provide the most significant gains for range, due to potential losses to forestland in the THLB.
- A concern in this zone is that of invasive plants, which must be addressed if this gain in range can be utilized. Good range management to avoid adding more disturbance in an area that is already anticipated to have significant disturbance is extremely important to keep invasive plants to a minimum.

Management Direction

The following management direction is to start the process of long term risk management for climate change. It is intended to focus prudent management over the short and mid-term to increase resilience if the future unfolds as indicated in the plausible forecast. Yet, even if climate fails to have the degree of impact indicated in the previous section, future forest conditions should not be negatively impacted by the management direction provided here.

Broad Direction

In regeneration strategies and associated silvicultural systems, there needs to be a realization that the options are limited. The use of Douglas-fir and ponderosa pine may at times be limited to moister microsites, resulting in a patchy distribution. Multi entry silvicultural systems, favouring the retention of healthy overstory trees will promote natural regeneration while allowing for assisted migration. Management to protect temperature sensitive streams will encourage buffers with a range of species, including shrubs and broadleaves. Planning to reduce fire hazard should inform harvesting or thinning options.

Benefits:

- May significantly reduce the expected contraction of the THLB in the long term.

- Threats to growing stock and the productive capacity of the landbase will be reduced, resulting in greater capacity for carbon sequestration.
- Fish streams will be provided suitable conditions to maintain habitat as climate changes.
- A greater range of habitats and possibly culturally important plants will be supported.
- Visual aesthetics over the long term may be maintained.
- Risk of fire will be managed.

Challenges:

- There is considerable mortality of ponderosa pine in present stands, making economic harvesting a challenge.
- Harvesting in these variants has been a low priority over the last 25 years.
- Survival will be challenging except in cool, moist cycles.

Recommended Specific Actions

1. This Subzone Group is the most important in the TSA for urban-forest interface. It is critical moving forward that a strategic management plan is designed in this area to make interface management the priority, while integrating other values. (see Appendix 4- Fire for more information).
2. Identify areas that should continue to be managed for timber and areas that, because of climate change, should be managed as open forest grassland, based on slope, aspect and present tree mortality.
3. For areas to be managed as open forest grassland, identify management options and silvicultural regimes to promote open conditions and a range of habitats.
4. Undertake a review of ponderosa pine management from availability of seed to the range of potential products, use information from areas where ponderosa pine is presently managed. In the interim, promote the increased establishment and utilization of ponderosa pine in suitable areas.
5. Modify stocking standards to allow flexibility to promote a range of densities at the stand and higher scales. Increase flexibility for lower and/or clumpy stocking standards with Douglas-fir and ponderosa pine in areas with challenging microclimates (all sites within these variants). The intent is to best utilize optimal microsites (consider clump or cluster planting). On dry sites that remain in the THLB, partial-cutting silvicultural systems will be necessary to address the anticipated severe microclimates. Therefore, cluster planting may promote an irregular structure that will provide for future shading.

Consider the following recommendations²³:

- i. Clearcutting should be avoided; use systems that provide some level of shade protection for Douglas-fir and a seed source of ponderosa pine.
 - ii. For sites where Douglas-fir and/or ponderosa pine establishment will be challenging but possible, cluster-plant in suitable microsites – 3-4 trees at intervals of 10-15 m (may need to experiment initially).
6. For existing stands of Douglas-fir in the urban-forest interface:
- i. Identify stands of Douglas-fir with high understory densities that could benefit from hazard abatement spacing and other treatments used to manage fire risk in the forest-urban interface.
 - ii. Identify merchantable stands of Douglas-fir that are predicted to decline and fall out of the THLB due to climate change. Consider partial harvest purely to reduce both overstory and understory fuels and maintain habitat. No regeneration objectives or obligations should be attached to these stands, unless some planting is needed to establish some structure for habitat – these would have very different stocking standards than those used for timber objectives.
7. Broadleaf and mixedwood stands should be maintained as a biodiversity feature as long as possible to maintain diversity of habitats (e.g. soft snags for cavity nesting birds).

As broadleaf trees are highly desirable but currently make up a very small proportion of the growing stock and are highly sensitive to climate change in these variants, the following practices should be pursued to maintain broadleaves as long as possible:

- i. Include aspen and cottonwood as a preferred species in standards units adjacent to riparian features.
 - ii. Include aspen as a preferred species in all standards units where they are ecologically suitable (as denoted by the presence of mature individuals preharvest) and where regeneration is prescribed.
 - iii. Favour aspen and cottonwood, where they are available, for retention as wildlife trees or in wildlife tree patches.
8. Leave a mix of wildlife tree patches and retention to help build landscape level permeability and stand level biodiversity.

Develop a comprehensive strategy using foresters and habitat specialists to provide more specific direction over time regarding the range and distribution of retention that should be targeted here. This direction must consider climate change and other impacts over time. It also should integrate retention at several

²³ Note guidance on use of ponderosa pine should be updated based on the recommended additional work to review management options for ponderosa pine.

scales to consider OGMAs and other large reserves as well as. See recommendations for biodiversity in Appendix 4.

9. Mature stands of Douglas-fir will be of critical importance for timber supply, habitat, and visual landscapes. These will be threatened by tussock moth (possibly) and Douglas-fir beetle (when trees are drought-stressed). The risk of these forest health agents should be further explored with specialists to more appropriately target stands for harvesting or reserves in long term plans.
10. Important watersheds in this ecological grouping for domestic and commercial water use should be a priority for watershed analysis and planning as described in Appendix 4.
11. Consider the importance of this subzone in the general management direction provided for all values in Appendix 4.

Barriers and Gaps for Implementation

Structural Barriers

Note: where these barriers are already discussed in Appendix 4 (General TSA Sensitivities), they are just mentioned here, with a reference to those portions of Appendix 4 where they are discussed in more detail.

1. There is a lack of coordinated planning to identify interface management options and opportunities (see Appendix 4 Fire).
2. Need a process to identify future options for timber management in areas presently treed that will likely experience conditions not suited to tree growth and survival.
3. Currently there is reluctance to encourage broadleaf species through stocking standards in FSPs when it is not clear what the impacts will be on future timber supplies. For more information see: Timber, Biodiversity and Fire Management in Appendix 4.
4. See other barriers by management value in Appendix 4.

Gaps in Knowledge, Data, or Tools

1. Management of ponderosa pine has not been a priority in this area, resulting in little operational experience. Information on ponderosa pine management available from the adjacent states with warmer climates should be compiled.
2. See other gaps by management value in Appendix 4.

Key Assumptions

1. Douglas-fir, ponderosa pine seed will be available in suitable provenances for planting in these subzones.
2. Loss of growing stock and increased regeneration delays have been accounted for in TSR for dead pine stands that will not be salvaged.

3. Assigned “ease of implementation” and “priority for management direction” are estimates based on the judgement of the KFFS team. For “ease of implementation” the number and difficulty of implementation barriers and gaps were considered. For “priority of management direction” the perceived ability of the direction to help mitigate and address management sensitivities across all important values were considered. All of these estimates required numerous assumptions regarding the importance of barriers and the potential impact of direction on management sensitivities. These relative rankings should therefore be scrutinized carefully by managers before they are assumed to apply as indicated and utilized in planning.

ICH to IDF Transitional Subzones – IDFmw, ICHdw and ICHmw (ICHmk²⁴)

Table A3.7 Overview of Management Sensitivities for ICH-IDF Transitional Subzones -ICHmw, ICHdw, IDFmw (ICHmk). Details follow.

General Management Value	Specific Concern	Sensitivity Rank ²⁵	Related Direction (In Table A3.8)
TIMBER	Size of the working landbase	MOD. TO HIGH	1 to 3, 5
	Productive capacity of the working landbase	HIGH	1 to 3, 5, 7
	Growing stock on the working landbase	HIGH	1 to 3, 5, 7
	Economics	MODERATE	1 to 3, 5
BIODIVERSITY	Old growth habitats	HIGH	7
	Wildlife trees / wildlife tree patches and landscape permeability	MODERATE	4 and 6, 7
	Coarse woody debris	MINOR	In Appendix 4
	Ungulates (and designated winter ranges)	MODERATE	In Appendix 4
	Species at risk or of conservation concern	MODERATE	4, 6, 7
	Invasive species	HIGH	In Appendix 4
FIRST NATIONS	Culturally important plants	MODERATE	4, 6
URBAN-FOREST INTERFACE	Fire risks	MOD.TO HIGH	6, 7
WATER AND AQUATIC ECOSYSTEMS	Watershed management – water supply	MOD.TO HIGH	In Appendix 4
	Fish Habitat – Salmonids	HIGH	In Appendix 4
OTHER	Visual Landscape Management	MOD. TO HIGH	7
OVERALL	SENSITIVITY RANKING	MOD to HIGH	

²⁴ The ICHmk is transitional from the IDFmw and the ICHdw to the MSdm - Discussion here should be considered along with those provided for the Moist to Dry Plateau / High Elevations, remembering the elevational context of the ICHmk.

²⁵ **Sensitivity Rankings** – The sensitivity rankings are provided to focus attention on management concerns by area and value. The rankings used are as follows:

- **HIGH SENSITIVITY** – There is a high likelihood of a substantial negative impact on the management concern.
- **MODERATE SENSITIVITY** – There is a high likelihood of a limited negative impact on the management concern.
- **MINOR SENSITIVITY** – There is a likelihood of a small or limited impact.

Table A3.8 Management Direction Summary Table. Details follow the tables. For more information on the management direction listed below see the following discussion.

Management Direction	Ease of Implementation	BC Planning Linkage	Ability to mitigate impact on Timber Supply ²⁶
1. Target stands for harvesting that are expected to lose considerable volume to mortality in the next fifty years.	Easy	FSP, SFMP, TSR	↑↑
2. Pursue aggressive mitigation measures for root disease on harvested sites.	Easy	FSP, SFMP, TSR	↑
3. Diversify plantations to include less lodgepole pine by using a range of other species.	Moderate to Challenging	FSP, SFMP, TSR	↑
4. Utilize a range of wildlife tree patches with a broadleaf conifer mix in all new cutblocks to maintain landscape permeability.	Moderately Easy	FSP, SFMP, TSR	↔ to ↓
5. Monitor plantations beyond free-growing to assess mortality and target future harvest ages.	Moderate - Challenging	Not clear	(↑)
6. Design strategic landscape targets for a broadleaf stand component.	Moderate to Challenging	Not clear	↔
7. As we approach 2050, consider using fertilization to improve growth and reduce the potential harvest age of lodgepole stands	Moderately Easy	FSP, SFMP, (missing strategic)	(↑)
8. Choose a landscape unit to test management direction related to strategic planning.	Moderate - Challenging	Not clear	↔

²⁶ **Ability to mitigate influence on Timber Supply** – The broad influences to mitigate future timber supply impacts from climate change are illustrated conceptually for each direction item. Moderate, Mod-High, and High sensitivities in the preceding table for the Timber concerns will have correspondingly downward pressure on timber supply. The intent here is to broadly illustrate how management direction is expected to influence timber supply by moderating these downward pressures. One up arrow indicates one benefit with upward mitigation (e.g. regeneration species capturing more potential productivity) while two arrows means several benefits. SEE Appendix 4 for the overall expected influence of management direction from this strategy on timber supply within the TSA.

Table A3.9. Management Direction Priority-Ease of Implementation Comparison²⁷.
Numbers correspond to the numbered direction items above.

		Ease of Implementation			
		Easy	Moderately Easy	Moderately Challenging	Challenging
Priority for Management Direction	Very High				
	High	1, 2		3	
	Mod-High		4	6	
	Mod		7	5, 8	
	Low-Mod				

Ecological Sensitivities due to Climate Change

The descriptions below are designed to paint a vivid and clear picture of the future. Words such as “will” should be viewed with caution. In reality there is a high degree of uncertainty involved in making forecasts of this nature. Nevertheless, these projections are the result of an exploration of future scenarios which allowed for the development of what should be considered as “credibly plausible forecasts”. The important thing is to remember what these plausible forecasts are intended to help managers avoid blindly painting themselves into corners as our climate changes.

²⁷ **PRIORITIES** – Priorities were identified as follows:

- VERY HIGH – A high potential to improve at least four sensitivities.
- HIGH – A high potential to improve at least two sensitivities.
- MOD-HIGH – A high potential to improve at least one sensitivity, or a mod-high potential to improve at least two sensitivities.
- MOD – A moderate potential to change at least two sensitivities, or a mod-high potential to improve one sensitivity.
- LOW-MOD – a moderate potential to help change one sensitivity.

Note these priorities should be considered a starting point, actual management direction should be informed by additional scenario testing to determine the most effective options.

Sensitivities in Mixed Stands:

- Drought stress will have a severe impact on redcedar, birch, spruce and hemlock limiting these species to cool wet sites over time.
 - Redcedar and birch in the ICHdw and IDFmw are already showing signs of stress and mortality this will intensify as we progress toward 2050.
 - This process will not be as evident in the ICHmw until beyond 2050, except on warmer aspects at lower elevations.
- Conifers, particularly Douglas-fir, will drop out of these stands at an increasing rate.
 - This is a result of a significant increase in Armillaria activity and associated impacts up to 2050 (beyond 2050 in the ICHmw). Warmer conditions with good spring and fall moisture will improve the environment for fungi, and the increased drought stress on conifers will make them more susceptible. Beyond 2050 Armillaria impacts may subside as hot/dry climatic conditions become less optimal for the fungus.
- There is a high risk of large fires in this ecological group (especially in the IDFmw) during hot dry climatic cycles up to 2050 (beyond 2050 in the ICHmw) due to the increased mortality and understory fuels. This risk is somewhat reduced by the fact that a large portion of this ecological grouping could have a significant broadleaf component where most of the mortality is occurring.

Sensitivities on Dry Sites:

- Beyond 2050 (beyond 2080 in the ICHmw) there will be more shrubby or grassy openings, some possibly significant due to increased mortality from drought-stress and bark beetles. In the IDFmw tussock moth may start to have an impact, while budworm will likely decline somewhat.
- Risk of extensive wildfires will be increased on dry sites as well.

Potential Future Forest conditions

The following description of potential future forest conditions are intended to portray how the forests in this ecological grouping may develop without intervention by forest managers. It is a general overview. For more information SEE: *Compendium of Supporting Documents – Ecological Narratives for the IDFmw, ICHdw and the ICHmw.*

Mature Stands

- Mixedwood and Mixed Conifer stands – will become either gappy with brushy openings, or see an increase in aspen, mostly due to scattered mortality in Douglas-fir, redcedar, hemlock, spruce, and birch. Past 2050 some unusual shrub-dominated communities may appear with scattered clumps of conifers or broadleaf trees.
 - Birch and redcedar may gradually disappear over time. This is already occurring in the IDFmw and ICHdw and will more fully manifest itself over the next 40 years.

- In the ICHmw there will be reduction in vigour and associated mortality in redcedar, hemlock, spruce and birch over the next forty years, intensifying beyond 2050.
- Economic concentrations of Douglas-fir in mixed stands will become significantly fragmented with increased amounts of aspen and/or shrub species. This may dramatically reduce the amount of harvestable area in this Ecological Group. Again, this will happen over the next forty years in the IDFmw and ICHdw, while it will be beyond 2050 to be noticeable in the ICHmw.
- Merchantable Douglas-fir dominated stands – will become more open, with uniformly scattered mortality on warm slopes at lower elevations (especially in the IDFmw) where these stands are generally found.
 - Grasslands – or grassy openings will become a more noticeable component of this landscape after 2050 with the increases in mortality described above, combined with impacts from large wildfires.
 - Aspen – may expand (especially on warm aspects) where it has a foothold throughout this Subzone Group.

Young and Maturing Stands

- Douglas-fir dominated stands will generally continue to do reasonably well in young and maturing stands where stumping was done post harvest to reduce Armillaria innoculum (something that is relatively common).
 - Mortality on warmer aspects in the IDFmw will create gappy / open stands with regeneration developing if there is sufficient shelter. Shade will be important for regeneration by 2080 except on cool aspects.
- Lodgepole pine plantations will see significant mortality as problems with rusts, root collar weevil and other pests increase. As these stands mature after 2050 they will likely see significant mortality from bark beetles. Stands mixed with other species (Douglas-fir, larch, ponderosa pine and white pine and broadleaf species) will see less mortality in general.

Management Sensitivities:

The following list of sensitivities is intended to provide a general picture of sensitivities specific to the ecological group. It is not intended to provide a comprehensive discussion of these sensitivities. For more information about sensitivities that are found throughout the Kamloops TSA SEE: Appendix 4 – General Sensitivities.

TIMBER - Size of the Working Landbase: Moderate To High Sensitivity

- There is a potential for the working landbase within this Subzone Group to contract by up to 18% for some time if economic species (i.e. Cw, Fd) drop out of mixedwood stands before harvesting is possible, and these stands are then dominated by non-economic species and brush. It is estimated that the amount of THLB area affected is as follows:

- over 22,000 ha of THLB - a high sensitivity.
- 9,000 ha of THLB with a moderate sensitivity.
- TOTAL = 31,000 ha moderate to high sensitivity, or 18% of the THLB in the Moist Transitional Subzone Group (3% of the TSA THLB²⁸).
- NOTE: This issue is more acute in the ICHdw and IDFmw up to 2050, but will likely be evident in the ICHmw only after 2050.
- The landbase may further contract through increases in grasslands or grassy openings in stands, especially on drier sites in the IDFmw after 2050.

TIMBER – Productive Capacity of the Working Landbase: High Sensitivity

- Increased drought stress, combined with increasingly active Armillaria and bark beetles, will significantly decrease timber productivity across the landbase.
 - Species and age cohorts will be impacted differently – see future forest conditions above.

TIMBER – Growing Stock on the Working Landbase: High Sensitivity

- Widespread mortality in redcedar, Douglas-fir and lodgepole pine from forest health agents and fire will have large impacts by 2050 (2080 in the ICHmw). Stands of hemlock and spruce are also subject to mortality from the changing climate. See future forest conditions above for details.

TIMBER – Economics: Moderate Sensitivity

- An increased proportion of stands with marginally economic conifer volumes will impact the economics of harvesting.

BIODIVERSITY – Old growth habitats: High Sensitivity

- Old stands in this ecological group are dominated by Douglas-fir and other conifers. These stands are already seeing significant mortality in the drier subzones (IDFmw and ICHdw) which will continue right up to 2050 and beyond, when old growth will be limited to wet sites.
- Old stand components (predominantly Douglas-fir dominated) in mixedwood stands seem to be the most sensitive to climate change impacts (in the form of increased impacts from drought, Armillaria and bark beetles). The chance of losing a large proportion of these stand components are high.

²⁸ Based on inventory information for stands with at least 10% broadleaf component and 100 to 300 m³/ha of conifer volume per ha (which under normal economic conditions would make the stand economic for harvest).

BIODIVERSITY – Wildlife tree patches and landscape permeability: Moderate Sensitivity

- The diversity of species and patchy nature of expected mortality in this ecological grouping may leave considerable mature timber on the landscape, unless it is extensively impacted by large fires, which is an increasing risk.
- The quality of landscape level or stand level retention may be slightly reduced as it could be dominated over large areas by broadleaf species, which have some advantages as wildlife trees but rarely get large nor do they have much longevity.
- Birch dieback beyond 2050 in IDFmw and ICHdw broadleaf stands may see unusual shrub-dominated habitats develop.

BIODIVERSITY – Coarse Woody Debris: Minor Sensitivity

- Initially there will be high levels of CWD with dead and dying trees from a number of species.
- Over time, especially closer to 2080, there will be more concern on warmer aspects especially in the ICHdw and IDFmw as CWD will be more important as a moisture holding medium for tree and plant establishment and as habitat for a range of species.

BIODIVERSITY – Ungulates (and designated winter ranges): Moderate Sensitivity

- Deer winter ranges on warm southern slopes in the IDFmw may be impacted, especially beyond 2050. However, as these stands are opened up with more gaps, their value as winter range may be reduced or improved, depending on the stand.
- Increased fire risk will definitely increase the threat to these winter ranges as they could lose most overstory in one event.

BIODIVERSITY – Species at Risk or of Conservation Concern (Provincial red and blue lists and SARCO lists): Moderate Sensitivity

- Red and blue listed species may have less habitat with higher disturbance. However, the mix of tree species in this ecological grouping will likely allow for diversity of habitat for a long period of time.

BIODIVERSITY – Invasive species: Moderate To High Sensitivity

- Localized high levels of disturbance associated with fires, salvage logging and stumping for Armillaria will increase the potential spread of invasive plants substantially.

FIRST NATIONS – Culturally Important Plants – Moderate Sensitivity

- This is highly diverse ecological group that will lose diversity over time. Dry site plants and trees will become more abundant and moist (mesic) site plants and trees will become less abundant.

- Some tree species like redcedar and birch could go from being widespread to being confined to wet sites only. Other associated shrubs and herbs could be similarly affected.

FIRE – Interface Risks – Moderate To High Sensitivity

- Interface is a significant feature of this ecological grouping for:
 - Communities such as Chase, Little Fort and Clearwater.
 - Agricultural areas in the Thompson River Valley between Little Fort and Clearwater (and beyond), and in some added smaller valleys, such as Sinmax Creek and the Barriere River.
 - Some major recreational areas, including all of Adams Lake, Johnson Lake, East Barriere Lake, North Barriere Lake, and some major valley bottoms in Wells Gray Park.
- Fire risks will be mitigated somewhat by the scattered nature of mortality and the persistence of broadleaf stands and mixes throughout the area (which help serve as a fire break). Warmer, drier slopes may be more at risk.

WATER AND AQUATIC ECOSYSTEMS – Watershed management – Moderate To High Sensitivity

- This is a general concern through the TSA (for water supply) especially in areas that will warm considerably like this ecological group – due to reduced snow loading (up to 25% less) and summer drought.
- See Appendix 4.

WATER AND AQUATIC HABITATS – Fish Habitat (salmonids) – High Sensitivity

- Salmonids may be threatened in a number of streams due to water temperatures. Streams previously temperature sensitive, or close to it, will be particularly sensitive. Populations in streams such as the Barriere River may see significant and rapid declines.

OTHER – Visual Landscape - Moderate To High Sensitivity

- The proximity of this ecological grouping to towns, agricultural areas and recreational areas, as well as its presence in the major travel corridor from Little Fort beyond Clearwater makes it important for visual landscape management.
- Mortality and subsequent disturbance from wildfire and/or harvesting could have significant impacts. While harvesting impacts can be planned and controlled, the wildfire impacts could be substantial.

Management Direction

The following management direction is intended to start the process of long term risk management for climate change. It is intended to focus prudent management over the short and mid-term to increase resilience if the future unfolds as indicated in the plausible

forecast. Yet, even if climate fails to have the degree of impact indicated in the previous section, future forest conditions should not be negatively impacted by the management direction provided here.

Broad Direction

Management in these subzones should be directed at harvesting and regeneration to build more species resilience into the landscape. This Subzone Group should be a priority for harvesting particularly in mixedwood stands that are at risk of becoming uneconomic to harvest over the next 10-20 years, due to increasing mortality. Regeneration strategies and associated silvicultural systems, should make greater use of species other than lodgepole pine, principally: Douglas-fir, western larch, western white pine and ponderosa pine.

Benefits:

- May significantly reduce the expected contraction of the THLB in the long term if a significant proportion of mixedwood stands can be converted to a more resilient mix.
- Threats to growing stock and the productive capacity of the landbase will be reduced over time, resulting in greater capacity for carbon sequestration.
- A greater range of habitats and possibly culturally important plants will be sustained, as long as a good distribution of retention is maintained in the short term.

Challenges:

- Many mixedwood stands may already be beyond reasonable harvesting economics due to mortality in the past couple years.
- The combination of more active root disease and drought stress may be difficult to adequately address on some sites with steep slopes and challenging terrain.
- The visual landscape will be affected in localized areas for a period of time.

Recommended Specific Actions

1. Within a strategic planning framework target the following stands for harvesting in the near future:
 - i. Mixedwood stands in the IDFmw and ICHdw where the conifer component shows signs of continuing mortality. Bark beetle monitoring, and general monitoring of mortality should be a high priority to assist in setting harvesting priorities

These stands are often very productive for Douglas-fir and other species, but also very favourable for *Armillaria* root disease. The intent of this recommended action is to focus harvesting to improve stand health and maintain a conifer component on the landscape before negative economics preclude such interventions. While the situation is less urgent in the ICHmw, it will likely be similar by 2050.

- ii. Conifer stands on warmer aspects in the ICHmw with a high component of redcedar, spruce and hemlock, before significant stress and mortality sets in. These stands are a lower priority than the stands described above in 1(i), and can likely be addressed at some point 10-20 years from now. Monitoring of mortality in the interim should be pursued.
2. After harvesting in mixedwood stands, aggressive mitigation of *Armillaria* impacts should be pursued, including:
 - i. Stumping of potential inoculum on as many mixedwood sites as slope terrain and other limitations will allow.
 - ii. Where stumping cannot be used, work with pathologists to try other approaches to reduce *Armillaria* impacts – such as use of the competing fungus *Hypholoma fasciculare*²⁹ and promotion of greater species mixtures (including broadleaf species).
3. Diversify plantations to include less lodgepole pine (especially in the ICHdw and IDFmw) and:
 - i. Include as preferred species - more Douglas-fir with western larch on cooler mesic sites, and ponderosa pine on drier sites. This assumes that *armillaria* has been addressed on the site.
 - ii. Mix in white pine on mesic and cooler sites at lower elevations in the ICHmw (possibly the ICHdw, but with caution).
 - iii. Include birch as an acceptable species in the ICHmw on sites where it is currently ecologically suitable, even though it is at risk to mortality from climate change over the long term. With expected significant reduction in birch over the IDFmw and ICHdw, maintaining birch in the ICHmw may be helpful for biodiversity.
 - iv. Avoid promoting redcedar, spruce, and hemlock, which are all high risk species for mortality over the long term (even over the short term in portions of the ICHdw and IDFmw).
4. Use a range of wildlife tree patch sizes and shapes in new cutblocks to promote dispersal of species through what will become a significantly disturbed landscape. Use patches that have significant broadleaf species to minimize *Armillaria* impacts, but ensure some conifers are present for diversity. These patches should

²⁹ Chapman, B., and G. Xiao. 2000. Inoculation of stumps with *Hypholoma fasciculare* as a possible means to control *armillaria* root disease. Canadian Journal of Botany: 78 (129-134).

fit within a comprehensive plan for landscape retention, integrated with other values including timber and visual management.

5. Design a monitoring schedule to track mortality trends beyond free-growing in developing plantations.

Target plantations that are either dominated by lodgepole pine or Douglas-fir without stumping. The intent is to determine an earlier economic harvest age before stands become marginalized due to high mortality losses.

6. Design strategic landscape targets to manage for a component of pure broadleaf stands across the landscape in this Subzone Grouping, particularly birch and aspen in the ICHmw and the ICHdw on cooler, moister slopes.

Work with habitat biologists and fire management specialists to set targets that will ensure a suitable distribution for broadleaf habitat and as potential firebreaks within a matrix of conifers and mixedwoods. Design the target to include an acceptable proportion of both mature stands (as WTPs or reserves) and young stands, where conifer establishment is especially challenging due to limitations on treatment for root disease. These targets should fit in a comprehensive plan for landscape retention, integrated with other values including timber and visual management.

7. As we approach 2050, consider using fertilization to improve growth and reduce the potential harvest age of lodgepole stands that are expected to be vulnerable to mortality beyond 2050 (likely the ICHmw, possibly some stands in the ICHdw). Use late rotational fertilization and target stands that can be harvested 10-15 years after fertilization. The intent is to encourage harvesting of these stands during favourable markets, allowing reforestation of more resilient species mixtures before the stands succumb to mortality induced by a changing climate.

8. Choose a landscape unit to test the management direction suggested here for both the stand and landscape levels in a planning case study.

This case study should help fine tune approaches to integrate harvest planning and scheduling with the reserve and retention planning to meet timber, biodiversity, fire management, and visual objectives. Engage the assistance of specialists and design planning protocols for use in subsequent landscape units.

As the most diverse and dynamic subzone group in the TSA, this area would benefit from such an initial case study.

Barriers and Gaps for Implementation

Structural Barriers

Note: where these barriers are already discussed in Appendix 4 (General TSA Sensitivities), they are just mentioned here, with a reference to those portions of Appendix 4 where they are discussed in more detail.

Gaps in Knowledge, Data, or Tools

1. The location and distribution of high risk stands with economic (but marginally economic) volumes of conifers due to *Armillaria* needs to be identified.
2. We need more clarity from pathologists on best practices in stands that cannot be stumped for *Armillaria* where potential impacts may be high. More work is required to clarify the benefits and use of *Hypholoma fasciculare* as an *Armillaria* mitigation treatment. There seems to be a considerable number of trials but little information on results.
3. See other gaps by management value in Appendix 4.

Key Assumptions

1. Assigned “ease of implementation” and “priority for management direction” are estimates based on the judgement of the KFFS team. For “ease of implementation” the number and difficulty of implementation barriers and gaps were considered. For “priority of management direction” the perceived ability of the direction to help mitigate and address management sensitivities across all important values were considered. All of these estimates required numerous assumptions regarding the importance of barriers and the potential impact of direction on management sensitivities. These relative rankings should therefore be scrutinized carefully by managers before they are assumed to apply as indicated and utilized in planning.

Dry to Moist Plateau or High Elevation Subzones – MSdm SBSmm and ESSFdc

Table A3.10 Overview of Management Sensitivities for Dry to Moist Plateau or High Elevation Subzones - MSdm, SBSmm and ESSFdc (ESSFxc).

General Management Value	Specific Concern	Sensitivity Rank³⁰	Related Direction (In Table A3.11)
TIMBER	Size of the working landbase	MINOR	1-2
	Productive capacity of the working landbase	MINOR	1-2
	Growing stock on the working landbase	MODERATE	1-2
	Economics	MINOR TO MODERATE	Appendix 4
BIODIVERSITY	Old growth habitats	MODERATE TO HIGH	1,3 & 6
	Wildlife trees / wildlife tree patches and landscape permeability	MODERATE TO HIGH	1, 3, 4, 5, 6
	Coarse woody debris	MINOR	Appendix 4
	Ungulates (and designated winter ranges)	MINOR	Appendix 4
	Species at risk or of conservation concern	MODERATE	1 to 6
	Invasive species	MODERATE	Appendix 4
FIRST NATIONS	Culturally important plants	MODERATE	1 - 6
URBAN-FOREST INTERFACE	Fire risks	MINOR TO MODERATE	1, 2, 5, 6, 7
WATER AND AQUATIC ECOSYSTEMS	Watershed management – water supply	MODERATE	Appendix 4
	Fish Habitat – Salmonids	MODERATE TO HIGH	4
OTHER	Visual Landscape Management	MINOR TO MODERATE	3 to 6
OVERALL	SENSITIVITY RANKING	MODERATE	

³⁰ **Sensitivity Rankings** – The sensitivity rankings are provided to focus attention on management concerns by area and value. The rankings used are as follows:

- **HIGH SENSITIVITY** – There is a high likelihood of a substantial negative impact on the management concern.
- **MODERATE SENSITIVITY** – There is a high likelihood of a limited negative impact on the management concern.
- **MINOR SENSITIVITY** – There is a likelihood of a small or limited impact.

Table A3.11 Management Direction Summary Table. For more information on the management direction listed below see the following discussion.

Management Direction	Ease of Implementation	BC Planning Linkage	Ability to mitigate impact on Timber Supply ³¹
9. Focus short term harvesting on subalpine fir (first) and spruce stands (second), avoiding Douglas-fir stands.	Moderate	FSP, SFMP, TSR	↑
10. Mix in more resilient species such as Douglas-fir and other species normally found at lower elevations.	Challenging	FSP, SFMP, TSR	↑
11. Favour Douglas fir in wildlife retention and patches.	Easy	FSP, SFMP, TSR	↔ to ↓
12. Favour headwater streams to locate wildlife tree patches	Easy	FSP, SFMP, TSR	↔
13. Determine a target for broadleaf stands in these landscape units and plan distribution in time and space. (considering climate change).	Moderate - Challenging	Not clear – will tie to FSP and TSR.	↔
14. Design comprehensive landscape plans, and implement to improve outlook for future mature and old stand types	Challenging	Not clear – will tie to FSP, SFMP and TSR.	↔
15. Design monitoring of mortality beyond free-growing	Moderate to Challenging	Not clear	↔
16. As we approach 2050, consider using fertilization to improve growth and reduce the potential harvest age of lodgepole stands	Moderately Easy	FSP, SFMP, (missing strategic)	(↑)

³¹ **Ability to mitigate influence on Timber Supply** – The broad influences to mitigate future timber supply impacts from climate change are illustrated conceptually for each direction item. Moderate, Mod-High, and High sensitivities in the preceding table for the Timber concerns will have correspondingly downward pressure on timber supply. The intent here is to broadly illustrate how management direction is expected to influence timber supply by moderating these downward pressures. One up arrow indicates one benefit with upward mitigation (e.g. regeneration species capturing more potential productivity) while two arrows means several benefits. SEE Appendix 4 for the overall expected influence of management direction from this strategy on timber supply within the TSA.

Table A3.12 Management Direction Priority-Ease of Implementation Comparison³².
Numbers correspond to the numbered direction items above.

		Ease of Implementation			
		Easy	Moderately Easy	Moderately Challenging	Challenging
Priority for Management Direction	Very High				
	High		1		
	Mod-High	3		7	2, 6
	Mod	4	8	5	
	Low - Mod				

Ecological Sensitivities due to Climate Change

The descriptions below are designed to paint a vivid and clear picture of the future. Words such as “will” should be viewed with caution. In reality there is a high degree of uncertainty involved in making forecasts of this nature. Nevertheless, these projections are the result of an exploration of future scenarios which allowed for the development of what should be considered as “credibly plausible forecasts”. The important thing is to remember what these plausible forecasts are intended to help managers avoid blindly painting themselves into corners as our climate changes.

³² **PRIORITIES** – Priorities were identified as follows:

- VERY HIGH – A high potential to improve at least four sensitivities.
- HIGH – A high potential to improve at least two sensitivities.
- MOD-HIGH – A high potential to improve at least one sensitivity, or a mod-high potential to improve at least two sensitivities.
- MOD – A moderate potential to change at least two sensitivities, or a mod-high potential to improve one sensitivity.
- LOW-MOD – a moderate potential to help change one sensitivity.

Note these priorities should be considered a starting point, actual management direction should be informed by additional scenario testing to determine the most effective options.

Sensitivities in Most Stands:

- Douglas-fir will likely have improved growth where it is found up to 2050.
- Subalpine fir will start to show signs of stress especially at lower elevations with increased mortality (from drought and bark beetle) by 2050.
- Spruce will likely have improved growth, except in the MSdm where it will be stressed by drought, potentially leading to localized bark beetle damage by 2050.
- Armillaria will have more impact but remain fragmented and localized. Spruce weevil damage will increase.

Sensitivities on Dry Sites:

- Extensive mortality from the current epidemic of mountain pine beetle over 30-50% of the area in this Subzone Group will increase fuels at different stages, increasing the risk of large fires here if the fuel hazard coincides with a hot and dry summer.

Potential Future Forest conditions

The following description of potential future forest conditions are intended to portray how the forests in this ecological grouping may develop without intervention by forest managers. It is a general overview. For more information SEE: *Compendium of Supporting Documents – Ecological Narratives for the MSdm, SBSmm and ESSFdc* (ESSFxc³³).

Mature Stands

- Spruce/subalpine fir and Douglas-fir – Mortality gaps that started with the death of lodgepole pine will continue with scattered subalpine fir mortality that will become common after 2050.
 - Initially the open spruce and Douglas-fir stands will respond with increased growth on mature trees up to 2050. Beyond 2050, spruce will become stressed and likely suffer localized episodic bark beetle mortality in the SBSmm, with more extensive mortality in the MSdm, and scattered mortality in the ESSFdc. The result will be:
 - More open, gappy, possibly irregular Douglas-fir and spruce stands in the MSdm by 2050, and after 2050 in the SBSmm and the ESSFdc (spruce stands), and
 - Extensive mortality in spruce dominated stands beyond 2050 from spruce bark beetle –throughout the MSdm, but also scattered through the SBSmm (lower elevations on mesic and drier sites) and even in the ESSFdc (at lower elevations).

³³ **ESSFxc** – There is no narrative for the ESSFxc due to its limited area in the TSA. The information presented here is generally applicable, however the drier conditions should be considered as well.

- Aspen – these stands may expand into gaps created by drought and forest health agents. Growth and productivity will likely improve, especially on mesic or moister sites.

Young and Maturing Stands

- Lodgepole pine - Over 30% of this area will be in young lodgepole pine stands dominated by lodgepole pine up to 2050. These stands may improve growth for a time, but will likely become stressed and show extensive mortality from bark beetle closer to 2080.
- Douglas-fir – will be well suited throughout this Subzone Grouping by 2050, except in the ESSFdc where it will be confined to lower elevations on terrain that is not prone to frost damage.
- Spruce and Subalpine fir – Subalpine fir will become increasingly stressed, disappearing from most of this Subzone Group, except in the ESSFdc, where it may persist with poor vigour. Spruce will grow well up to 2050 but will likely be increasing hit by terminal weevil. After 2050 spruce will suffer increasing mortality that will eventually limit it to moister sites (wet sites in the MSdm).
- Broadleaf stands and Mixedwoods – will likely expand, especially with increased fire disturbance. While broadleaf and mixedwood stands will be dominated by aspen for some time, birch will move in from lower elevations with disturbance.

Management Sensitivities:

The following list of sensitivities is intended to provide a general picture specific to the ecological group. For more information about sensitivities that are found throughout the Kamloops TSA SEE: Appendix 4 – General Sensitivities.

TIMBER - Size of the Working Landbase: Minor Sensitivity

- Little change expected up to 2050, possibly minor contraction in drier portions nearer 2080.

TIMBER – Productive Capacity of the Working Landbase: Minor Sensitivity

- Productivity may improve for some time (up to 2050) in many stands.
- Beyond 2050 there will be some gradual impacts on growth, depending on species present.

TIMBER –Growing Stock on the Working Landbase: Moderate Sensitivity

- Minor to 2050 mostly due to mortality in subalpine fir.
- Beyond 2050 mortality will become more extensive in subalpine fir, much of the spruce and once again in lodgepole pine (closer to 2080).

TIMBER – Economics: Minor To Moderate Sensitivity

- Increased mortality will reduce recoverable volumes and impact the economics of harvesting.

BIODIVERSITY – Old growth habitats: Moderate To High Sensitivity

- Old stands up to 2050 will continue to persist perhaps with improved old-growth characteristics, due to frequent gaps from new mortality in subalpine fir and existing dead lodgepole pine. Improved growth on spruce and Douglas-fir will provide larger individuals (up to 2050).
- Beyond 2050, spruce will become more susceptible to drought and bark beetles with extensive episodic mortality possible over this landscape. Stands with a high component of Douglas-fir will remain relatively intact.
- A few extensive wildfires could increase the dominance of early seral and young stands in this Subzone Group.

BIODIVERSITY – Wildlife tree patches and landscape permeability: Moderate To High Sensitivity

- The patchy nature of expected future mortality in this ecological grouping may ensure considerable mature timber on the landscape up to 2050, unless it is extensively impacted by large fires, which is an increasing risk.
- Beyond 2050 mature timber patches may become more fragmented and separated as spruce and lodgepole stands could be hit with extensive mortality. Expansion of broadleaf stands may improve this situation.

BIODIVERSITY – Coarse Woody Debris: Minor Sensitivity

- There will likely be high levels of CWD with dead and dying trees from a number of species right through 2080.
- CWD may decline if the build up of fuels and hotter / drier summers combine to create larger extensive wildfires.

BIODIVERSITY – Ungulates (and designated winter ranges): Minor Sensitivity

- Impacts on moose winter ranges are difficult to predict and are likely minor.

BIODIVERSITY – Species at Risk or of Conservation Concern (Provincial red and blue lists and SARCO lists): Moderate Sensitivity

- Red and blue listed species may have fewer habitats and more competition from new species with higher disturbance.
- The mix of tree species in this ecological grouping will likely allow for significant diversity of habitat for a long period of time. However species (particularly birds) from other areas may expand their range into the changing landscape and may outcompete some endemic species.

BIODIVERSITY – Invasive species: Moderate Sensitivity

- The concern increases with some large wildfires if they are intense.

FIRST NATIONS – Culturally Important Plants – Moderate Sensitivity

- This is a moderately diverse ecological group that will lose diversity over time in some places but likely gain diversity elsewhere.
- Plants associated with higher elevations may be reduced, while those associated with lower elevations may increase presence. A significant concern may be for huckleberry and other berry producing shrubs. This process will be very slow. It may or may not be evident at 2080.

URBAN-FOREST INTERFACE – Fire Risks – Minor To Moderate Sensitivity

- Interface is not a significant feature of this ecological grouping for most of the area in which it is found, except for Sun Peaks Ski Resort, which represents an important year round interface concern.
- Fire risk is anticipated to significantly increase with hotter, drier summers, increased mortality in stands, and more ladder fuels with regeneration and brush filling mortality gaps. While some large intense fires may occur, they will be isolated and localized.

WATER AND AQUATIC ECOSYSTEMS – Watershed management – Moderate Sensitivity

- This is a general concern through the TSA (for water supply) especially in areas that will warm considerably like this ecological group – due to reduced snow loading (up to 25% less) and summer drought.
- These moist-to-dry subzones, often forming an elevational gradient from the MSdm or SBSmm to the ESSFdc, comprise a significant portion of the headlands for watersheds between Kamloops and Little Fort. Nearby settled areas and agricultural lands in major valleys depend on these watersheds for water-supply.
- With less winter snow (up to 20% less at 2050), and extended summer droughts the supply of water for domestic and commercial purposes could be affected.
- See Appendix 4.

WATER AND AQUATIC HABITATS – Fish Habitat (salmonids) – Moderate To High Sensitivity

- There is little salmonid habitat in this subzone grouping.
- However, cool meltwater from this Subzone Grouping normally helps lower stream temperatures lower down for salmonids during early summer. That influence may be reduced as snowpacks shrink and temperatures rise.
- As well, higher rainfall in spring in this subzone grouping may increase flooding lower down and impact habitat there.

OTHER – Visual Landscape - Minor To Moderate Sensitivity

- The proximity of this ecological grouping to towns, travel corridors and recreational areas is minor, limited to Sun Peaks Ski Resort mostly.
 - Mortality and subsequent disturbance from wildfire and/or harvesting could have significant impacts. While harvesting impacts can be planned and controlled, the wildfire impacts could be substantial, although likely isolated.

Management Direction

The following management direction is intended to start the process of long term risk management for climate change. It is intended to focus prudent management over the short and mid-term to increase resilience if the future unfolds as indicated in the plausible forecast. Yet, even if climate fails to have the degree of impact indicated in the previous section, future forest conditions should not be negatively impacted by the management direction provided here.

Broad Direction

Management in these subzones should be directed at building more species resilience into the landscape gradually over time. Where harvesting is conducted, subalpine fir leading stands should be targeted first and spruce leading stands second. Regeneration strategies and associated silvicultural systems should over time make greater use of species other than lodgepole pine and spruce. Where possible use: Douglas-fir, western larch, western white pine and ponderosa pine.

Benefits:

- May reduce threats to growing stock over the long term, possibly reducing the threat of extensive mortality past 2050. This will promote carbon sequestration over the landbase.
- A greater range of habitats and possibly culturally important plants will be sustained, as long as a good distribution of retention is maintained in the short term.

Challenges:

- There is currently significant subalpine fir leading stands less than twenty years old in the ESSFdc (roughly 50%) and the MSdm (16%) that may not reach a merchantable size before climate change impacts them.
- Over a significant portion of this area it may be difficult to establish species other than lodgepole pine, spruce and subalpine fir due to frost, snow damage and other issues.
- Old stands with subalpine fir as a leading species have marginal or uneconomic timber quality.

Recommended Specific Actions

1. Over the short term, focus harvesting as much as possible in subalpine fir leading stands (all subzones) and spruce leading stands (MSdm and SBSmm). Douglas-fir stands should generally be avoided until a strategic plan for mature and older stand habitat can be designed in time and space.
2. In newly harvested cutblocks consider the following when reforesting:
 - i. Mix in more Douglas-fir for regeneration in the short term, and plan over the long term to mix in more western larch, white pine and ponderosa pine (especially in the MSdm and SBSmm). Start on warmer slopes at lower elevations, on sites where frost will not be a concern.
 - ii. Limit spruce for regeneration in the MSdm as a minor component except on wet sites, or sites where establishment of species suggested in (i) above is not possible.
 - iii. Where (i) and (ii) above is not possible in the near term due to local climatic conditions (especially in the ESSFdc), spruce should be the focus for regeneration.
 - iv. Subalpine fir should not be relied on for future stocking except on wetter sites or cool aspects in the ESSFdc.
3. Where Douglas-fir is a minor stand component, favour it for wildlife tree patches, along with aspen, cottonwood, and spruce.
4. Favour headwater streams (even S6 streams) as a location for WTP and wildlife tree retention wherever possible, considering windthrow risk and other concerns, especially where spruce, aspen or cottonwood can be used as retention. Avoid subalpine fir and lodgepole pine as much as possible as a major component of these WTPs.
5. Determine an appropriate landscape level proportion for these subzones that should be managed for broadleaf stands. Consider current presence and the fact that a greater range of broadleaf species will become more suited to this environment over time, as broadleaf species become less suited to subzones at lower elevations. A conservation biologist may be helpful in this determination.
6. Design comprehensive landscape plans in these subzones with assistance from conservation biologists to integrate timber management with conservation of biodiversity (and other values if present) - specifically to manage for mature and older trees and habitat over the long term.

The focus should be to avoid a significant loss of landscape structure in larger/older trees and stands due to extensive mortality and salvage between 2050 and 2080. This may be facilitated by strategically planning the harvest of some well-distributed sensitive stands in time and space, and introducing and distributing less sensitive regeneration species to provide a more resilient mix of stands and structures over the landscape beyond 2050.

In addition to recommendations already provided above, the following actions should be considered in such a plan:

- i. Re-evaluate OGMA locations in the SBSmm and the MSdm to favour a Douglas-fir component, and avoid high levels of subalpine fir.
 - ii. As a recruitment strategy, harvest well-distributed openings (0.5 ha or greater in size) throughout selected marginally economic subalpine fir leading stands and establish nodes of other less sensitive tree species.
 - iii. As a recruitment strategy fall-to-waste patches of subalpine fir throughout selected immature stands of non-merchantable subalpine fir (10-60 years old) and plant less sensitive species. Focus on lower elevations and south aspects for candidate sites.
7. Design a monitoring schedule to track stand performance (growth and vigour) and mortality trends beyond free-growing in developing young stands.
 8. As we approach 2050, consider using fertilization to improve growth and reduce the potential harvest age of lodgepole stands that are expected to be vulnerable to mortality beyond 2050. Use late rotational fertilization and target stands that can be harvested 10-15 years after fertilization. The intent is to encourage harvesting of these stands during favourable markets, allowing reforestation of more resilient species mixtures before the stands succumb to mortality induced by a changing climate.

Barriers and Gaps for Implementation

Structural Barriers

Note: where these barriers are already discussed in Appendix 4 (General TSA Sensitivities), they are just mentioned here, with a reference to those portions of Appendix 4 where they are discussed in more detail.

1. Current stumpage appraisal allowances may provide a disincentive for harvesting subalpine fir stands.

Currently scaled volumes often fall below cruise volumes in these stands due to the high rate of decay, waste and breakage. This factor reduces silvicultural allowances on a dollars-per-cubic metre basis. Since harvesting is prioritized here more as a silvicultural intervention, this administrative trend will not encourage proper management.

2. Fall-to-waste treatments and subsequent planting would require a funding source and are currently outside of licensee responsibility.
3. See other barriers by management value in Appendix 4.

Gaps in Knowledge, Data, or Tools

4. Site conditions that have the best potential to ensure acceptable survival and vigour of Douglas-fir, western larch, white pine, and ponderosa pine need to be identified throughout these subzones. Such work should involve ecologists and practitioners.
5. See other gaps by management value in Appendix 4.

Key Assumptions

1. No new forest health agents will move into these subzones as a major disturbance agent, beyond those that are already present.
2. Fertilization will not increase susceptibility to insects or other mortality agents for lodgepole pine stands targeted later in the rotation (closer to 2050) before they can be harvesting 10 or 15 years later.
3. Assigned “ease of implementation” and “priority for management direction” are estimates based on the judgement of the KFFS team. For “ease of implementation” the number and difficulty of implementation barriers and gaps were considered. For “priority of management direction” the perceived ability of the direction to help mitigate and address management sensitivities across all important values were considered. All of these estimates required numerous assumptions regarding the importance of barriers and the potential impact of direction on management sensitivities. These relative rankings should therefore be scrutinized carefully by managers before they are assumed to apply as indicated and utilized in planning.

Wet Cool/Cold Subzone Group – ESSFwc and ICHwk (ICHvk³⁴)

Table A3.13 Overview of Management Sensitivities for Wet Cool/Cold Subzone Group ESSFwc and ICHwk (ICHvk). Details follow the tables.

General Management Value	Specific Concern	Sensitivity Rank³⁵	Related Direction (In Table A3.14)
TIMBER	Size of the working landbase	MINOR	1
	Productive capacity of the working landbase	MINOR	2, 3
	Growing stock on the working landbase	MINOR	1, 2 & 3
	Economics	MODERATE	1
BIODIVERSITY	Old growth habitats	MINOR	Appendix 4
	Wildlife trees / wildlife tree patches and landscape permeability	MINOR	Appendix 4
	Coarse woody debris	MINOR	Appendix 4
	Ungulates Winter Range (see SAR below)	MINOR	1
	Species at Risk or of Conservation Concern (provincial red and blue lists and SARCO lists)	MODERATE TO HIGH	1
	Invasive species	MINOR	Appendix 4
FIRST NATIONS	Culturally important plants	MINOR	Appendix 4
INTERFACE	Interface risks	MINOR	Appendix 4
WATER AND AQUATIC ECOSYSTEMS	Watershed management – water supply	MINOR	Appendix 4
	Watershed management – water quality and infrastructure.	MODERATE TO HIGH	Appendix 4
	Fish Habitat – Salmonids	MINOR	Appendix 4
OTHER	Visual Landscape Management	MINOR	Appendix 4
OVERALL SENSITIVITY RANKING		MINOR	

³⁴ The direction here and references to the ICHwk should generally apply to the wetter ICHvk.

³⁵ **Sensitivity Rankings** – The sensitivity rankings are provided to focus attention on management concerns by area and value. The rankings used are as follows:

- HIGH SENSITIVITY – There is a high likelihood of a substantial negative impact on the management concern.
- MODERATE SENSITIVITY – There is a high likelihood of a limited negative impact on the management concern.
- MINOR SENSITIVITY – There is a likelihood of a small or limited impact.

Table A3.14 Management Direction Summary Table. For more information on the management direction listed below see the following discussion.

Management Direction	Ease of Implementation	Planning Linkage	Ability to mitigate impact on Timber Supply ³⁶
1. Monitor mature and old stands and risk rank for balsam bark beetle and hemlock looper. Place harvesting priorities within strategic context with the rest of the TSA.	Challenging (legislation and policy)	None in place	↑
2. Promote assisted migration of Douglas-fir and redcedar (white pine, larch, and possibly birch and aspen) into suitable areas.	Mod- Challenging – ongoing direction occurring provincially	FSP, SFMP	↑
3. Promote species diversity and density diversity	Moderately Easy	FSP, SFMP & TSR	↑

³⁶ **Ability to mitigate influence on Timber Supply** – The broad influences to mitigate future timber supply impacts from climate change are illustrated conceptually for each direction item. Moderate, Mod-High, and High sensitivities in the preceding table for the Timber concerns will have correspondingly downward pressure on timber supply. The intent here is to broadly illustrate how management direction is expected to influence timber supply by moderating these downward pressures. One up arrow indicates one benefit with upward mitigation (e.g. regeneration species capturing more potential productivity) while two arrows means several benefits. SEE Appendix 4 for the overall expected influence of management direction from this strategy on timber supply within the TSA.

Table A3.15 Management Direction Priority-Ease of Implementation Comparison³⁷.
Numbers correspond to the numbered direction items above.

		Ease of Implementation			
		Easy	Moderately Easy	Moderately Challenging	Challenging
Priority for Management Direction	Very High				
	High				
	Mod-High		3	2	
	Mod				1
	Low-Mod				

Ecological Sensitivities due to Climate Change³⁸

The descriptions below are designed to paint a vivid and clear picture of the future. Words such as “will” should be viewed with caution. In reality there is a high degree of uncertainty involved in making forecasts of this nature. Nevertheless, these projections are the result of an exploration of future scenarios which allowed for the development of what

³⁷ **PRIORITIES** – Priorities were identified as follows:

- VERY HIGH – A high potential to improve at least four sensitivities.
- HIGH – A high potential to improve at least two sensitivities.
- MOD-HIGH – A high potential to improve at least one sensitivity, or a mod-high potential to improve at least two sensitivities.
- MOD – A moderate potential to change at least two sensitivities, or a mod-high potential to improve one sensitivity.
- LOW-MOD – a moderate potential to help change one sensitivity.

Note these priorities should be considered a starting point, actual management direction should be informed by additional scenario testing to determine the most effective options.

³⁸ The following is a general overview. For more information SEE: Compendium of Supporting Documents – Ecological Narratives for the ICHwk and ESSFwc.

should be considered as “credibly plausible forecasts”. The important thing is to remember what these plausible forecasts are intended to help managers avoid blindly painting themselves into corners as our climate changes.

Sensitivities in Cedar Hemlock with minor Spruce and Douglas-fir stands (mainly in the ICHwk):

- Overall expect minor impacts up to 2050.
- With slightly drier and warmer conditions impacts from Armillaria may increase mortality of all species, predominantly spruce and Douglas-fir.
- The impacts of spruce weevil could have a significant impact on the growth and development of young spruce at lower elevations after approximately 2030 as warming continues.

Sensitivities in Spruce Subalpine fir stands (mainly in the ESSFwc):

- Minor impacts to 2050 similar to the ICHwk. Limited drier and warmer summers will allow for an extended growing season. Mature tree growth may increase overall, fluctuating with warm and cool cycles.

The scale of change projected for these units appears to be well within the ecological tolerance of the tree species growing in the area. There may be some issues with timing of phenological events that could prevent full utilization of the increase in growing season and more benign conditions.

Potential Future Forest conditions

The following description of potential future forest conditions are intended to portray how the forests in this ecological grouping may develop without intervention by forest managers. It is a general overview.

- Stands in the ICHwk (mature and old western redcedar, western hemlock with pockets of Douglas-fir) will mostly continue growing and dying as they have during recent history. The warmer and drier summers will allow for continued growth of healthy trees. Increased growth will occur in thrifty stands at higher elevations and cooler aspects.
- Hemlock stands will experience periodic dieback due to pulses of hemlock looper that cycle through the area. Armillaria, where established, will continue to create gaps at an accelerated pace creating a varied structure. Generally the rate of mortality of old trees will increase where the productive capacity of the tree (photosynthesis) cannot keep up with increased respiration over the extended growing season. This will create stands with a higher snag component, and potentially lower economic margin for harvest.
- Fire frequency in the ICHwk is presently low. However with projected warming and drying in the summer months, fire risk may increase. Where lightning coincides with an extended warm period, gaps of varying sizes will be created allowing ingress of a mixture of species including broadleaves at lower elevations.

- Stands in the ESSFwc (mature and old spruce and subalpine fir with a minor component of lodgepole pine) will continue growing and dying as they have during recent history. The warmer and drier summers will allow for continued growth of healthy trees. Mortality of subalpine fir will occur periodically with pulses of western balsam bark beetle and spruce with spruce beetle.
- Fire has not been a major disturbance agent in the ESSFwc, however with warmer and slightly drier summers in the area and contiguous lower elevation subzones, the fire return interval may increase. Lightning caused fires may increase with increased extreme weather events. The overall risk will likely remain low to moderate as summer precipitation is projected to remain relatively high.

Management Sensitivities:

The following list of sensitivities is intended to provide a general picture of sensitivities specific to the ecological group. For more information of sensitivities that are found throughout the Kamloops TSA SEE: Appendix 4 – General Sensitivities.

TIMBER - Size of the Working Landbase: Minor Sensitivity

- Minor change expected. Productivity gains may bring a small amount of areas into the THLB in the long term but gains are limited by soil development and other non-climatic factors. Productivity gains are not considered large enough to bring marginal sites into the landbase.

TIMBER – Productive Capacity of the Working Landbase: Minor Sensitivity

ICHwk

- With warmer overall temperature and longer growing seasons there is a potential to see an increase in growth rates, these must be tempered by the possible increase in forest health agents and those trees near the end of their natural life that may die sooner as respiration outperforms the ability to photosynthesize.
- Drought stress may reduce gains by 2080 on warmer sites.
- Productivity for the full range of species in young stands will improve to 2050. After 2050 spruce will likely experience moisture stress and impacts from weevil on mesic and drier sites. After 2050, lodgepole pine plantations will likely begin to experience more rust, root collar weevil, and other pests. Douglas-fir plantations will remain productive when on stumped sites.

ESSFwc

- As in the ICHwk there could be slight to moderate increases in productivity, tempered by forest health agents. However, most of the area is forested with stands greater than 120 years old which may not be capable of responding positively to the more favorable growing conditions. With warming heartrots will become more productive too.
- As well productivity increases may be limited due nutrient availability from the present soil and humus form types.

- There is a potential for increased productivity in thrifty young stands. Assisted migration will promote additional growth potential in both these units.

TIMBER –Growing Stock on the Working Landbase: Minor Sensitivity

- Overall impacts on growing stock should be relatively minor. There may be a slight increase in potential for large fires with warmer temperature.
- Localized impacts from Hemlock Looper and Armillaria will continue.
- By 2080, pests impacting Pl stands will be more active.
- Increases in spruce bark beetle, western balsam bark beetle, spruce budworm, and possibly spruce weevil at lower elevations will periodically cause significant localized impacts (small to insignificant impacts overall to 2050, increased impacts at 2080 – mostly with subalpine fir).
- Spruce weevil could begin to increase after approximately 2030 at lower elevations.

TIMBER – Economics: Moderate Sensitivity

- Harvesting costs will remain high due to steep terrain and relatively remote location of the units.
- Individual tree mortality in old stands slowly moves them away from being economic to harvest; this slow process is minor compared with plausible impacts in the warmer drier subzones.
- Silviculture costs should remain similar as planting is presently the main form of reforestation.

BIODIVERSITY – Old growth habitats: Minor Sensitivity

- The amount and availability of old seral is not likely to change significantly up to 2050. Slight increase in disturbance from fire, insects and disease may reduce the amount of old in some localized areas. BEO designation will not likely change due to changes in climate in these units.

BIODIVERSITY – Wildlife tree patches and landscape permeability: Minor Sensitivity

- Wildlife tree patch species composition, abundance, and importance will likely not change in the two units.

BIODIVERSITY – Coarse Woody Debris: Minor Sensitivity

- The appropriate levels of down wood should remain fairly constant. Availability is high in first growth stands.

BIODIVERSITY – Species at Risk or of Conservation Concern (Provincial red and blue lists and SARCO lists): Moderate To High Sensitivity

- Caribou habitat management is a key consideration in this area. The large set-asides provide for movement flexibility and options in varying snow conditions.

Lichen abundance is presently available through the elevational range. Uncertainty remains regarding snow depths, crust formation, predator prey relationships and general adaptation of the Caribou to the changing conditions over time, resulting in the moderate to high sensitivity ranking.

BIODIVERSITY – Invasive species: Minor Sensitivity

- Native plant growth may be sufficient to stave off establishment of invasives. Presently invasives are rare in these areas, nevertheless vigilance is required to avoid spread of invasive plants to all areas, especially those with mineral soil exposure.

FIRST NATIONS – Culturally Important Plants – Minor Sensitivity

- Native plant ranges should remain relatively stable. Use will depend upon traditions and traditional territory. These areas may become more important for certain plants as drier areas in southern portions of the TSA lose species of interest.

FIRE – Interface Risks – Minor Sensitivity

- The long fire return interval in these units is due to the high levels of annual and seasonal precipitation. With greater warming and slightly drier forecasted summers, fire hazard could increase with risk increasing in years where warm cycles coincide.
- Risk could increase in years where warm cycles coincide (i.e., ENSO and PDO), resulting in hotter drier summers even in previously wet areas. Lightning frequency could increase with an increase in extreme weather events.
- Compared with the other areas in the TSA, fire risk is seen to be less but still a potential issue in years where all the factors line up.

WATER AND AQUATIC ECOSYSTEMS – Watershed (water quantity) – Minor Sensitivity

- Precipitation is forecast to remain high as the proportion as snow up to 2050. There should be little change based on climate for these units over the short and medium term (to 2050).

WATER AND AQUATIC ECOSYSTEMS – Watershed (water quality and infrastructure) – Moderate To High Sensitivity

- A considerable amount of precipitation is expected to occur through severe events with climate change. With the amount of precipitation that already occurs in these subzones and the potential for a significant increase, water quality and infrastructure could be at risk.

WATER AND AQUATIC HABITATS – Fish Habitat (salmonids) – Minor Sensitivity

- The streams in these areas are often headwater streams that flow to more concentrated fish habitat below. Their flow and function should not change significantly over the short and medium term (to 2050).

OTHER – Visual Landscape - Minor Sensitivity

- With little indication of natural disturbance agents increasing in these units, visual management can proceed as it has building upon the natural visual absorption capacity of the area.

Management Direction

The following management direction is to start the process of long term risk management for climate change. It is intended to focus prudent management over the short and mid-term to increase resilience if the future unfolds as indicated in the plausible forecast. Yet, even if climate fails to have the degree of impact indicated in the previous section, future forest conditions should not be negatively impacted by the management direction provided here.

Broad Direction

Overall the ICHwk and ESSFwc will have the least climate based change within the TSA. Management for Caribou remains a principle objective. As stands in other areas of the TSA lose vigour, there is an opportunity to proactively focus harvesting in those areas to help promote resiliency and avoid unwanted effects such as high fuel loading. The ICHwk and ESSFwc should be considered as a lower priority for harvesting in the short to medium term to maintain future harvest opportunities in the TSA.

Benefits:

- Allows for a directed approach for harvest priorities to address climate derived mortality and potential impacts.
- Provides future harvesting options when areas to the south have experienced significant disturbances such as fire or drought related mortality.
- Utilizes intact stands as a carbon sink.

Challenges:

- Presently there are limited mechanisms to direct harvesting to areas identified as higher risk and leave those with lower risk.
- Licence obligations and area specific harvest requirements.

Recommended Specific Actions

1. Harvesting priority over the near term (20-40 years) is in other subzones. However, monitor stands with a high component of subalpine fir or hemlock especially during periods when unusually warm summer conditions are occurring. Risk rank stands for balsam bark beetle and hemlock looper under warming summer conditions.
2. Explore the use of redcedar (Douglas-fir as time goes on) on lower elevations of the ESSF. Experiment with ideas to minimize damage from frost and snow.

3. Encourage a mix of species (especially on warmer aspects) in the ICHwk including Douglas-fir, redcedar, spruce, (possibly white pine and lodgepole pine). Explore ideas to minimize damage from snow and frost.
4. Encourage a range of reforestation densities. Consider higher densities, where unproven species are being mixed in.

Barriers and Gaps for Implementation

Structural Barriers

1. See other barriers by management value in Appendix 4.

Gaps in Knowledge, Data, or Tools

1. Need to summarize existing knowledge on frost and snow damage in these subzones (especially in the ESSFwc and upper elevations in the ICHwk), and explore practices to reduce snow damage so that species other than spruce and subalpine fir can be encouraged.
2. See other gaps by management value in Appendix 4.

Key Assumptions

1. Mortality and climate derived disturbance will be less in these units than in the rest of the TSA.
2. Assigned “ease of implementation” and “priority for management direction” are estimates based on the judgement of the KFFS team. For “ease of implementation” the number and difficulty of implementation barriers and gaps were considered. For “priority of management direction” the perceived ability of the direction to help mitigate and address management sensitivities across all important values were considered. All of these estimates required numerous assumptions regarding the importance of barriers and the potential impact of direction on management sensitivities. These relative rankings should therefore be scrutinized carefully by managers before they are assumed to apply as indicated and utilized in planning.

APPENDIX 4 – Management Sensitivities by Value

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Introduction

Appendix 4 summarizes all the analysis, interpretations, and discussions from the climate change modeling, ecological vulnerability workshops, and management vulnerability workshops for each major value across the TSA.

For managers the subsections that follow will show upfront at a glance the general direction for each major TSA value, priorities for this direction and a indication of the ease of implementation (in tables). For practitioners, specialists, and others who may be interested, more clarity and detail is included for direction item. As well, rationale is provided with a description of general sensitivities behind the direction.

For managers, policy makers, researchers and others who may be interested, each subsection ends with a description of implementation barriers, knowledge and data gaps, and key assumptions.

NOTE: Appendix 4 links to Appendix 3 in a significant manner. Appendix 4 has general direction for the entire TSA, by management value. Appendix 3 details direction that is specific to the five BEC subzone groups that were identified for this strategy. In Appendix 3 where management concerns prompt no specific direction or elaboration of those described by value, Appendix 4 direction is not repeated, just referenced. The assumption is that Appendix 4 direction applies where applicable across all subzone groups. Where further elaboration or more specific direction is needed for a particular subzone, it is provided in Appendix 3.

Biodiversity Management Sensitivities and Direction

Most issues and tools pertaining to managing biodiversity apply to the TSA as a whole rather than to specific BEC subzones. Issues and approaches that are specific to particular groups of BEC units are noted in Appendix 3.

Table 4.1 Management Direction Summary Table

For more information on the management direction listed below see the following discussion.

Management Direction	Ease of Implementation³⁹	Planning Linkage
1. Biodiversity management strategies must be integrated with other values /objectives in a comprehensive strategic planning process.	Challenging (legislation and policy)	Not clear– strategic plan
2. Move to develop flexibility in the old growth management area(OGMA) network.	Moderately Easy	Not clear– strategic
3. Clarify the intent of biodiversity emphasis options (BEOs) and special management zones (SMZs) for strategic planning and consideration of climate change impacts.	Moderately Challenging (policy)	Not clear– strategic plan
4. There should be a degree of flexibility to re-locate wildlife habitat areas (WHAs) to better suit needs of species over time due to impacts of climate change.	Challenging (policy)	Not clear – strategic plan
5. to 9. Track changes in ungulate (deer, moose, caribou) ranges over time. Evaluate snow conditions. Be prepared to move winter ranges only if ungulates move, otherwise existing management applies. Moving winter ranges means other old forest needs to exist outside of ungulate winter ranges (UWRs) which requires coordinated planning.	Moderately Challenging	None - Provincial initiative (one off)
10. Coordinate planning of landscape and stand to provide old forest at various scales in useful amounts. Requires assessment of adequacy of existing management for biodiversity and 4% impact as a target.	Challenging (legislation and policy)	FSP & TSR, SFMP
11. Increase importance of wildlife tree patches (WTPs) and set guidelines, targets and monitoring directions more clearly.	Moderately Easy	TSR, FSP, SFMP
12. Assess likely levels of down wood into the future and coordinate planning to provide large down wood into the	Moderately Easy	FSP, SFMP

³⁹ **Ease of Implementation** – The categories were assigned a relative value based on how easy or difficult it was perceived to achieve the task within the present forest management process. Moderately challenging or challenging direction has some significant barriers to implementation or knowledge gaps associated with it (See the end of this subsection).

Management Direction	Ease of Implementation ³⁹	Planning Linkage
future.		
13. - 14. Identify locations and habitats of species of conservation concern. Track changes in distribution of localized species.	Some easy, some challenging	Not clear
15. Track invasive species and decide appropriate management.	Challenging overall (some easy)	Not clear

Table A4.2 Management Direction Priority-Ease of Implementation Comparison⁴⁰. Numbers correspond to the numbered direction items above.

		Ease of Implementation			
		Easy	Moderately Easy	Moderately Challenging	Challenging
Priority for Management Direction	Very High			10	1
	High		11, 12	5, 6, 7, 8, 9, 13, 14	15
	Mod-High		2		4
	Mod			3	
	Low - Mod				

⁴⁰ **PRIORITIES** – Priorities were identified as follows:

- VERY HIGH – A high potential to improve at least four sensitivities.
- HIGH – A high potential to improve at least two sensitivities.
- MOD-HIGH – A high potential to improve at least one sensitivity, or a mod-high potential to improve at least two sensitivities.
- MOD – A moderate potential to change at least two sensitivities, or a mod-high potential to improve one sensitivity.
- LOW-MOD – a moderate potential to help change one sensitivity.

Note these priorities should be considered a starting point, actual management direction should be informed by additional scenario testing to determine the most effective options.

Sensitivities

Sensitivities to climate change were explored by considering landscape and stand level tools used to manage biodiversity in the TSA. Landscape level tools include: Old Growth Management Areas (OGMAs), Special Management Zones (SMZs), Biodiversity Emphasis Options (BEOs) and Wildlife Habitat Areas (WHAs). Caribou management and management of ungulate winter range overlaps both landscape and stand-level habitat management. Stand level tools include designation of wildlife tree patches (WTPs) and retention of habitat elements outside of formal WTPs. Some sensitivities pertain to species themselves.

General sensitivities to climate change for the Kamloops TSA:

Old Growth Management Areas (OGMAs)

- Climate change will alter the character of OGMAs, often reducing the amount of old forest or changing tree species composition. Note that the need for old forest to provide habitat elements for a range of organisms is unlikely to change.

Biodiversity Emphasis Options (BEOs) and Special Management Zones (SMZs)

- Climate change will alter the character of the landscape and may bring into question whether existing objectives for biodiversity will remain appropriate in a particular place. BEOs and SMZs sometimes have specific biodiversity concerns or objectives which may shift spatially with climate change.

Wildlife Habitat Areas (WHAs)

- WHAs are intended to capture the needs of species of concern that have specific local habitat requirements. Climate change may alter the composition of overstory, understory, wetland and grassland habitat, and proximity to other resources that could alter the ability of existing WHAs to support their target species.

Caribou Management

- Climate change will likely alter the amount, timing, and quality of snow in caribou winter ranges. The largest concern for caribou is shallower snowpacks which would reduce access to lichens. A reduced snowpack may result in the caribou remaining at lower elevations for longer periods making them more susceptible to predation. Another concern is that the snowpack may develop a crust insufficient to support caribou but sufficient to allow predators access to transitional and winter ranges. Additional risk to caribou will occur if deer move into the ESSF, as predators will follow.
- The ESSF and wetter ICH areas are not predicted to change quickly with climate change. These wet cool subzones have less ecological sensitivity to climate change than many of the other subzones.

Ungulate Winter Ranges (UWRs)

Currently UWRs encompass important habitat for ungulates during winter. Most winter ranges are designated for mule deer and moose.

For Deer

- Climate change likely will create more open forests, reducing snow interception. Tussock moth and Douglas-fir beetle may impact Douglas-fir more as climate changes. More open forests will benefit deer in terms of forage, but winter ranges need cover, and fires and beetle may reduce that cover.
 - If climate change reduces snow levels then winter ranges may diminish as a priority for management. For example, if there is only one severe year in 10 instead of in 5 then deer populations may be able to recover in the interim periods.
 - It is just as possible; however, that climate change will increase winter precipitation and increase snowpacks, especially during cool extreme years in cooler climate cycles. Experience to date correlates precipitation as snow with warmer temperature during winter in many areas.
 - There is some concern that snow packs could develop a hard surface more often, increasing ease of predation.

For Moose

- Most winter ranges for moose are in riparian areas in valley bottoms over a range of subzones. In the cooler subzones these areas will likely be resilient to climate change but in drier subzones those areas may experience shifts in vegetation cover due to drying.
- Climate change will likely result in reduced canopy cover resulting in more open forests that will benefit moose (primarily by increasing forage).
- If the snowpack decreases (not as predictable as the increase in temperatures) it would likely increase winter forage as long as wetlands persist.
- An increase in predators may accompany any increases in moose abundance, which could influence all ungulate populations.

Wildlife Tree Patches (WTPs)

- As climate shifts there may be additional tree mortality within WTPs reducing their utility. The role of WTP's with climate change is going to be increasingly important to provide a permeable forested landscape through which species can move with changing conditions.
 - WTPs are maintained to provide a range of habitat elements, based on varied but living structure. WTPs do not just provide habitat for many organisms. They also provide refuge for small organisms to escape disturbed conditions and facilitate dispersal by providing small but connected stepping stones of habitat for those species with limited dispersal capabilities.
- Many of the WTPs that contain pine will now (or soon) have large proportions of dead trees due to pine beetle. Dead trees provide critical habitat elements but are

most useful in WTPs if they are not already abundant on the landscape. Retaining live trees remains important.

Downed Wood

- Down wood provides important microsites for many organisms including lichens, bryophytes, invertebrates, amphibians and small mammals. These sheltered microsites will likely become more important as subzones become warmer and drier. The roles of down wood in providing feeding sites for birds and travel routes for furbearers will continue during climate change.
- Typically, down wood is plentiful in natural stands and in stands right after harvest. Indeed, the amounts right after harvest may be high relative to natural stands. Rather, it is the long term retention of down wood that is of concern. The amount of down wood may decrease as harvesting and salvage for biofuels increases and concerns regarding fuel reduction for urban interface increase. Both the amount of down wood in the future, and its size and distribution, are of concern. As we harvest second growth and third growth, trees will have smaller diameters and stands will be 'cleaner' than the natural or old growth forests, making provision of down wood increasingly difficult, particularly for the large sizes that have the most value for biodiversity.

Species of Conservation Concern

- Species of concern may be significantly challenged with climate change. There will also be increased anxiety about preventing other sensitive species from becoming listed.
 - As climate changes, and habitat is altered and/or disturbed, existing species may be forced to move due to the new conditions or to avoid competition from new species moving into the area.
- Some currently-listed species that are associated with dry, grassland habitat may experience an increase in habitat availability, thus benefiting from the expected warming and drying trends. However, this situation is not certain, as other resources may in turn become limiting.
- For species associated with wetlands, effects of climate change will likely be detrimental, but the degree of threat depends on the degree of change of wetland size and character.
- Harvesting and fire (natural and prescribed) may have large impacts on species with small local distributions.

Invasive Species

- In dry subzones, invasive species are already a significant issue and will likely become a larger issue. Invasive exotics are being found in moister cooler subzones too, even appearing in the ESSF.

- Salvage or proactive harvesting could increase disturbance in sensitive areas resulting in conditions suited to invasive plant establishment.
- Larger intense fires as a result of hotter drier summers could increase the abundance of invasive plants

Management Direction

Overview:

While not a panacea, it will be especially important to integrate small patches or clumps of retention at the stand level through to the landscape to make it more permeable so plants and animals can more readily move to more suitable habitat if the need arises. There will be a need for flexibility with some of the large reserves (OGMAs, UWRs, etc) to move them if the species for which they are designated shift their use of habitats. A certain proportion should be fixed spatially, with some identified as transient or flexible, depending on the purpose of the reserve. Knowing the species of conservation concern and their local habitats can help direct specific planning actions.

Direction:

Specific Management Actions

General:

1. It is critical to strategically plan for biodiversity in a comprehensive fashion, integrated with other values and associated objectives.
 - Without coordinated planning, broad biodiversity objectives established in the LRMP will be threatened by climate change. The LRMP indicates the intent to ‘conserve the diversity and abundance of native species and their habitats throughout the Kamloops LRMP’. It is not clear if biodiversity objectives will be met given current practices and even less certain once climate change is considered.
 - Coarse-filter, landscape-level objectives for preserving biodiversity need to be woven into management planning, along with species-specific objectives (i.e. where particular species drive ‘biodiversity concerns’).
 - Scenarios based on risk, present conditions and important habitat requirements need to be analysed to identify options and opportunities to maintain habitat at the various scales and balance impacts against other values. Planning to incorporate WHAs, OGMAs, stand retention, and timber harvest patterns should be evaluated and planned in concert. In that way, distribution of habitat (old growth, edge, variety of seral stages, important habitat attributes) over the landscape can be evaluated over the TSA when planning harvesting options.

Old Growth Management Areas (OGMAs):

2. Move to develop flexibility in the OGMA network to fit with a more dynamic future and recommended strategic planning.

Both legal spatial and non-spatial designations of OGMAs should be utilized in the TSA, because natural disturbances (with and without climate change) will alter the character of old forest over time. A flexible approach, where a proportion of OGMAs can be relocated after major disturbance, will likely be useful heading into this period of climate change.

To provide an optimal level of old growth over time would require flexibility in OGMA planning beyond approaches currently entrenched in policy. Planning would require modeling forest structure over a range of natural disturbances, climate and harvesting scenarios resulting in recommended options for maintaining old growth.

Biodiversity Emphasis Options (BEOs) and Special Management Zones (SMZs)

3. The value and use of BEOs and SMZs in the TSA should be determined, to address uncertainty and promote resilience. As sensitivities are not equal across the TSA these units could be useful planning tools in response to climate change. They are presently under-utilized for strategic planning.
 - BEOs and SMZs do not appear to direct or influence forest management in the Kamloops TSA in a significant fashion. Yet, such designations could be useful tools as climate changes, where different areas in the TSA have different priorities for biodiversity management.
 - Objectives for SMZs and management direction to achieve those objectives have not been clarified in the Kamloops TSA. This is quite different from some other areas of the Province (such as northern Vancouver Island) where SMZs are well-described as part of the Vancouver Island Land Use Plan and where direction to attain SMZ objectives drive management for biodiversity.
 - BEOs were set in place to translate a legally-set 4% timber supply impact allowed for biodiversity in the LRMP to operations on the ground. Different BEOs have different targets for Old Growth retention and various other management directions, but again aren't really focal to forest planning. They could be useful with climate change.

Wildlife Habitat Areas (WHAs)

4. There should be a degree of flexibility to re-locate WHAs (or at least some WHAs) to habitats that best meet the needs of the species if the desired attributes are lost through climate change. The general approach needs to incorporate static reserves with an understanding and identification of stand types and ages that could be available across the landscape through time

Caribou Management

5. Caribou management planning should consider climate change impacts.
 - i. The recovery plan in the North Thompson is focused on set-asides. These areas are static, but are spatially large so there is considerable room for caribou to move in response to climate change. A considerable amount of caribou habitat is captured in WHAs.
 - ii. Actual impacts of climate change on snow depth, timing, and crusting need to be evaluated before any changes are made to winter ranges. If caribou move in response to climate change, then locations of established transitional and winter ranges should be assessed for re-location. However, the current set-asides are sufficiently large and likely allow room for caribou movement without re-designing set asides in the near term.
 - iii. The utility of partial-cutting to create and maintain habitat should be explored in areas adjacent to the set asides. It may or may not be appropriate as climate changes. Effects on lichens should be explored. (Research is currently being done on these issues).
 - iv. Predator impacts on caribou due to climate change should be evaluated and control should be considered. To reduce predation on caribou it may be necessary to control the predator (primarily wolves) and/or other prey species (deer, moose) that buoy up predator populations. Controlling numbers of these alternative prey species without concomitant predator control may not necessarily decrease predation rates on caribou.

Ungulate Winter Ranges (UWRs)

For Deer

6. Unless deer move their winter ranges, current harvesting guidelines are valid.⁴¹
7. There should be some flexibility to reposition winter ranges if ungulates change their ranges in response to climate. That would require old forest in areas outside of existing winter range to allow for potential future movement of UWRs.

For Moose

8. Moose will move if BEC subzones change in character and become less hospitable or more hospitable. Be prepared to change winter range locations.

⁴¹ CURRENT DEER WINTER RANGE GUIDELINES SUMMARIZED: Disperse timber harvest throughout the winter range and spread it out evenly over the rotation. Maintain at least 25% of forested area in thermal cover. Link thermal cover units together with suitable travel corridors, especially mature Douglas-fir vets on ridges. Practice uneven aged management wherever possible. Apply clearcuts smaller than 5 ha where uneven aged management cannot be practiced. Ensure maintenance of browse species such as Ceanothus, wild rose and Saskatoon through range management practices. Pursue mixed forest management, with similar species distribution to natural stands (including deciduous). Establish access management guidelines. Incorporate management objectives for Critical Deer Habitat into local level planning for the area.

9. Current guidelines are valid⁴².

Wildlife Tree Patches (WTPs)

10. Develop a comprehensive strategy using foresters and habitat specialists to provide more specific direction over time regarding the range and distribution of retention that should be targeted here. This direction must consider climate change and other impacts over time. It also should integrate retention at several scales to consider OGMA's and other large reserves.
- To promote resilience stand level retention needs to be carefully integrated with landscape level retention and applied to provide habitat and dispersal mechanisms. Stand level retention will become increasingly important as a coarse filter tool to manage biodiversity over time to provide habitat islands and stepping stones for dispersal during climate change. As uncertainty increases, so does the need to provide more habitat and more dispersal mechanisms.
 - There is currently no explicit plan for stand level wildlife tree retention and reserves in the TSA. The entire 4% impact on timber supply allowed for biodiversity was reached by designating OGMA's. Consequently no targets were set for WTPs in the TSA. This does not mean that no WTPs are left. Licensees feel that WTPs are left in every cutblock, however the amount of WT retention is not clear.
11. Design and locate WTPs to include trees that will be adapted to the site and also use WTPs to include habitats likely to be hospitable to trees (e.g., use more riparian areas than rock outcrops as anchors).
- There is no information currently available in the TSA on what has been used as ecological anchors for WTPs, or what is being left in WTPs. The provincial Forest Resource Evaluation Program (FREP) has done some basic monitoring of WTPs in cutblocks, but the coverage is cursory at a TSA level.

Downed Wood

12. Objectives for retaining down wood in the TSA and planning for contributions into the future need to be assessed in light of climate change and then integrated into strategic planning.
- Activities such as harvesting, prescribed fire, biofuels, pulpwood agreements, and salvage need to reconcile their objectives with importance

⁴² CURRENT MOOSE WINTER RANGE GUIDELINES SUMMARIZED - Maintain suitable forest cover attributes with respect to thermal cover and forage production. Promote shrubs in riparian situations and ensure adequate forage is maintained during silvicultural activities (brushing and weeding, stand tending). Provide visual screening of swamps and openings along highways, secondary roads and main forest roads. Pursue mixed forest management with similar species distributions to natural stands (including deciduous). Ensure grazing management practices that maintain browse species such as red osier dogwood and willow. Establish access management guidelines. Incorporate management objectives for critical moose habitat into local level planning for the area.

of downed wood for biodiversity (and consider effects of natural fire and climate change).

Species of Conservation Concern

13. Work already done in the TSA to identify habitat needs of the red and blue species, SARCO (species at risk coordination office) listed species and other species of conservation concern should be taken one step further. Steps to develop explicit strategic management targets and planning that consider climate change and integrate with other management objectives is needed to promote long term survival of these species within the changing environment.
 - In 2007 Cascadia Natural Resource Consultants (Cascadia) in cooperation with Tolko Industries Ltd. Heffley Creek division and Canfor developed a Species at Risk (SAR) database application to assist licensees in the Kamloops, Merritt and Okanagan TSA's make informed decisions regarding sensitive wildlife habitats and Species at Risk during strategic and operational planning exercises.
 - This tool provides quick access to common habitat attributes and management strategies by species, BEC Unit and TSA allowing forestry staff to focus in on those habitat attributes during planning to ensure the appropriate management strategies are addressed. This information needs to be explicit within strategic plans as targets, with indicators of performance that can be monitored over time. In that way, impacts on other resource values, such as timber supply, would be clearer.
14. Wetland changes in the face of climate change should be tracked for key species of conservation concern that utilize these wetlands.

Invasive Species

15. Tracking invasive species is necessary and a coordinated approach for management needs to be followed⁴³.
 - The best opportunity to control invasive species occurs through prevention, which should be concerted objective..

Gaps and/or Barriers for Implementation

Overview – Broad Concerns for Biodiversity and Habitat currently on the TSA

In general, objectives for biodiversity in the TSA are not clearly expressed, even though some tools used to manage biodiversity have clear objectives.

- Individual habitat (WHA's and UWRs) have clear objectives for their specific function within the TSA, and OGMAs may have specific objectives (A current

⁴³ See <http://www.for.gov.bc.ca/hra/Plants/index.htm> for the present approach.

project by Ministry of Environment is attempting to describe the rationale and objectives underlying the location of Old Growth Management Areas). However, most other activities (stand retention, maintaining habitat elements, and attention to species of concern) are not guided by targets or overall goals, in part because the allocation of land to OGMA's already met the 4% impact that attention to biodiversity was allowed to have on timber supply under legislation.

Specific Barriers:

Old Growth Management Areas (OGMA's):

1. Currently the OGMA's in the TSA are spatially but non-legally defined. Currently an interagency management committee is deciding on the OGMA's to be made legal, which could reduce the flexibility suggested here.
2. In many instances, it is not clear why particular OGMA's were designated or why they are located where they are, making it difficult to determine if they may be relocated as a result of climate change.
 - A current project by Ministry of Environment (Mike Burwash contact) intends to find and describe the rationale and objectives underlying the location of Old Growth Management Areas. Currently that information is in hardcopy notes.
3. The TSA does not have a comprehensive, coordinated and ongoing strategic planning process that allows for a flexible allocation of old growth reserves as climate changes.

Wildlife Habitat Areas (WHAs)

4. For most identified wildlife, WHAs do not exist and where they do, they may not be the best planning tool considering climate change.
 - At present there are no mechanisms to allow WHAs to change location should climate change alter the character of the WHAs. Ideally some type of landscape unit planning would further define and plan direction for Identified Wildlife.

Caribou Management

5. While it is a suggested strategy for management of caribou habitat, it is unlikely that predator control will be acceptable to the general public.

Ungulate Winter Ranges (UWRs)

6. Currently winter ranges are viewed as static with no options for relocation if the target ungulates change their range in response to climate.

Downed Wood

7. As harvesting becomes more focussed in second growth and third growth, trees will have smaller diameters and stands will be 'cleaner' than the natural or old growth forests, making provision of down wood increasingly difficult through incidental

logging debris, particularly for the large sizes which have the most value for biodiversity.

Species of Conservation Concern

8. Small scale salvage harvesting, mining, and government objectives for range, biofuels etc can all have impacts on species of concern. Currently such cumulative effects are not well considered in monitoring or strategic planning.

Invasive Species

9. Although there has been considerable effort directed to managing invasive species and there are committees and pilot projects around the province targeting invasive species, limited funds are being directed to the problem and efforts are not fully coordinated.
10. Invasive species are difficult to manage now in the Kamloops TSA, and will likely be more problematic as climate and disturbance creates more open available habitat. Specific issues include:
 - a. There is little appetite to spray herbicides, close off access, or implement more costly practices.
 - b. It is difficult to exclude weeds in herbivore dominated range systems. Cows tend to graze on native bunchgrasses and avoid invasive weeds.

Specific Gaps - Knowledge, Data, or Tools

1. Adequacy of OGMAs, WHAs and WTPs combined with other nonharvestable areas to support species associated with old growth forests or old forest structures needs to be explored to ensure that specific objectives for biodiversity are being met. This would require a broad assessment of how current practices do or do not maintain species and habitats. Adjustments to targets for these conservation tools need to be integrated with management of other values in a true strategic planning process.
2. If WTPs are to be useful as possible mechanisms for dispersal and habitat to allow species to shift with changing forest conditions, there needs to be basic information on how much there is, what they contain, and where they are spatially.
 - (NB. Doug Lewis of the MoE noted he had some data which indicated most WTPs established in openings less than 100 ha are less than 1 ha in size. Even in larger blocks most WTPs are less than 5 ha., FREP too has some data for the TSA that could be sourced)
3. Exactly how SFM targets for downed wood in the TSA compare to natural levels in various subzones should be explored and clarified.
 - The FRPA default levels for downed wood are widely regarded by most habitat specialists as being too low for almost all sites. However, the SFMP has higher targets of 5 m³ in drier areas and 20 m³ in wetter areas.

- Informed forecasts of down wood for at least a rotation would assist planning.
4. Knowledge of how partial cutting may affect lichens for caribou, considering climate change, needs to be improved.
 - Some research is underway but it is not clear what cumulative effects are being considered.
 5. In wetter subzones (ESSFwc and ICHwk) effort should be directed investigating the difference between levels of down wood when second growth stand area harvested with natural levels. In these zones rotten wood provides raised microsites favouring establishment of natural regeneration.

Key Assumptions

1. This section on biodiversity attempts to discuss the likely sensitivities and useful management direction for the TSA. However, much depends on if the predicted changes in overstory composition and amount of old forest actually take place. As well, the actual (versus predicted) change in snowpacks will affect management decisions.
2. It is assumed that native species in the TSA will be maintained by providing habitat and dispersal areas to allow them to remain in place as long as possible, or move if needed. This has been the guiding philosophy for this project. Because projected changes in temperature and particularly precipitation are uncertain, responses of vegetation and organisms is also uncertain. Generally most biologists agree that as uncertainty increases so does the need to be cautious in managing habitat and so leaving more habitat and retaining more within-stand structure is appropriate.
3. Assigned “ease of implementation” and “priority for management direction” are estimates based on the judgement of the KFFS team. For “ease of implementation” the number and difficulty of implementation barriers and gaps were considered. For “priority of management direction” the perceived ability of the direction to help mitigate and address management sensitivities across all important values were considered. All of these estimates required numerous assumptions regarding the importance of barriers and the potential impact of direction on management sensitivities. These relative rankings should therefore be scrutinized carefully by managers before they are assumed to apply as indicated and utilized in planning.

Fire Management Sensitivities and Direction

Table A4.3 Management Direction Summary Table

For more information on the management direction listed below see the following discussion.

Management Direction	Ease of Implementation⁴⁴	Planning Linkage
1. Hazard and risk mapping in the TSA needs to be coordinated and integrated into fire management strategies	Moderately Easy	Not clear
2. The mapping described above should be used in TSR to better estimate fire disturbance impacts over time (incorporated with well-designed assumptions using fire managers).	Moderately Easy	TSR
3. Pure broadleaf and mixed stands to strategically break continuous coniferous cover should be strategically planned in key ecological subzones.	Challenging (legislation and policy)	FSP, SFMP & TSR
4. Fuel reduction and fire management strategies must be integrated with other management values and objectives in a strategic planning process that will be implemented and monitored over time. Fire issues and or processes need equal consideration to other values or concerns.	Challenging (legislation and policy)	Not clear
5. Stakeholders and the general public need to be aware of the critical threat posed by forest fuel accumulations and climate change.	Moderately Easy	None - Provincial initiative
6. The name of the fuel/fire management program should be changed to consider climate change.	Easy	None - policy related
7. Fuel management strategies should go beyond traditional approaches such as prescribed burning to incorporate efficiencies with emerging economies associated with biofuels and other products. Also other provincial policies need to be supportive.	Challenging (economics and policy)	Not clear – FSP? SFMP

⁴⁴ **Ease of Implementation** – The categories were assigned a relative value based on how easy or difficult it was perceived to achieve the task within the present forest management process. Moderately challenging or challenging direction has some significant barriers to implementation or knowledge gaps associated with it (See the end of this subsection).

Table A4.4 Management Direction Priority-Ease of Implementation Comparison⁴⁵.
Numbers correspond to the numbered direction items above.

		Ease of Implementation			
Priority for Management Direction		Easy	Moderately Easy	Moderately Challenging	Challenging
	Very High				4
	High		1, 2		
	Mod-High				3
	Mod		5		7
	Low - Mod	6			

Sensitivities

The risk of large fires is expected to increase in the Kamloops TSA. The dry IDF subzones, as well as the ICH-IDF transition subzones could see profound ecological changes as mortality from a combination of drought and forest health agents takes a significant toll on many tree and plant species (See Ecological Narratives in the Compendium of Supporting Documents). The very hot and dry conditions in these low elevation valleys, combined with the increased fuels from extensive mortality, could make large and intense fire disturbance more frequent.

⁴⁵ **PRIORITIES** – Priorities were identified as follows:

- VERY HIGH – A high potential to improve at least four sensitivities.
- HIGH – A high potential to improve at least two sensitivities.
- MOD-HIGH – A high potential to improve at least one sensitivity, or a mod-high potential to improve at least two sensitivities.
- MOD – A moderate potential to change at least two sensitivities, or a mod-high potential to improve one sensitivity.
- LOW-MOD – a moderate potential to help change one sensitivity.

Note these priorities should be considered a starting point, actual management direction should be informed by additional scenario testing to determine the most effective options.

These dry and transition subzones exist in the TSA close to where most people currently live, or close to lakes and other recreational areas. As well, most mule deer winter ranges are found here. The dry IDF and transitional IDF subzones currently are designated a high to very high priority for “ecosystem restoration” activities to reduce fuels and lower the risk of high intensity wildfires (Blackwell and Assoc. 2008).

General sensitivities to climate change for the Kamloops TSA:

1. Future timber supply could be more heavily impacted by disturbance from large wildfires than current TSR assumptions might indicate. These impacts may be both direct, and indirect (through impacts on age class distributions). These impacts may be underestimated for most subzones except the wettest and coolest subzones.
2. The sustainability of future timber supply for small tenures such as woodlots and community forest may be profoundly affected by increased wildfires in large southern valleys in the TSA, since this is where many woodlots and community forests are found. These valleys are mostly in Dry Douglas-fir and ICH-IDF transitional subzones which will be the most sensitive to climate change from a fire perspective.
3. As the urban interface expands, the current fire risk to people and property will be increased and expanded throughout the dry montane spruce, dry Douglas-fir and transitional ICH-IDF subzones by 2050 and 2080. This risk affects: most communities and major travel corridors south of Vavenby in the TSA and many recreational areas such as Adams Lake, East and North Barrier Lakes, Lac La Jeune, Sun Peaks Ski Resort, and larger valleys in the southern portion of Wells Gray Park.
4. Throughout the dry Douglas-fir and Transitional ICH-IDF subzones risk of wildfire for people and property values will increase as demand for recreation and recreational properties expands. Mule deer winter ranges and other habitats in dry Douglas-fir forests requiring some level of mature forest cover, possibly associated with red-listed species or species at risk will be under an increased and expanding risk of significant alteration from stand-replacing wildfires.

Direction

1. **Current mapping in the TSA of “Ecosystem Restoration Priorities” should be modified to consider the climate change sensitivities and direction from the KFFS and then integrated with the BC Wildland Fire Management Strategy.**

The Ecosystem Restoration Priority mapping in the Kamloops TSA is based on the deviation of individual stands from their natural disturbance regime, coupled with a consideration of stand condition, terrain factors, proximity to interface and treatment challenges (Steele et.al. 2008). The mapping was completed for the entire southern moist-to-dry half of the TSA. It should be modified to consider climate change sensitivities from the KFFS as a major driver, and de-emphasize historic natural disturbance regimes. This mapping may be a good starting point to guide strategic fuel reduction and fire management objectives in the DRAFT

BC Wildland Fire Strategy. These objectives must also be designed to fit with forest management and other strategic objectives in the TSA. (See Point #7 below).

The DRAFT BC Wildland Fire Management Strategy is a cross government strategy, which aligns underneath the Canadian Wildland Fire Strategy. It has been endorsed in principle, and is in the final stages of sign off. It is intended to facilitate the setting and implementation of fuel reduction and fire management strategies that are integrated and accounted for within comprehensive forest and land management plans seeking to balance the social, ecological, and economic aspects of sustainable forest management.

The MFR has recently signed off a revised Fire Management Planning Policy, 9.4, which directs the need for integrated fire management planning across the Ministry. To be effective, these plans need to integrate other local objectives to ensure that all land and forest management policies consider the biological, ecological, and physical characteristics of wildland fire.

In Phase 1 of Fire Management Planning at the Districts level, critical values at risk to wildland fire are identified to support fire response decision making. Phase 2 plans will take this one step further by defining the impacts of fire on values at risk and potentially define areas where, and under what conditions, fire is beneficial - including what is currently defined as “ecosystem restoration” treatments.

Ultimately licensees would be involved, to explore how fire can be "managed" at a landscape level, shifting to a proactive approach to fire using a combination of modelling, strategic placement of cutblocks, landscape and stand level fuels management. This stage will need an integrated strategic approach with feedback mechanisms – something that is currently lacking at the TSA level.

2. **The mapping described in #1, and the corresponding strategies to reduce fuels and manage fire should be used in TSR to better estimate fire disturbance impacts over time (incorporated with well-designed assumptions using fire managers).**

Currently, impacts of climate change on rate and intensity of fire disturbances over time are not considered. Stands in dry and transitional moist-to-dry ecosystems that are anticipated to have high levels of mortality due to climate change should have those added fuels factored into such risk ranking processes along with all other considerations for wildfire risk. Fire hazard mapping process, should be updated to consider climate change and ensure all specialists and supporting agencies are comfortable with the approach.

3. **Pure broadleaf and mixed stands to strategically break continuous coniferous cover should be strategically planned in dry PP, IDF and transitional IDF stands, possibly in other moist-dry subzones as well**

Broadleaf trees are known to be less volatile slowing ignition and spread of wildfires. The following practices should be pursued in these subzones:

- i. Designate aspen, cottonwood, and birch as a preferred species in standards units adjacent to riparian features. .
- ii. Consider using broadleafs as preferred species as part of a landscape plan using input from ecological and fire specialists. .
- iii. Designate aspen, birch, and cottonwood as acceptable species in all standards units where they are ecologically suitable (as denoted by the presence of mature individuals preharvest – see recommendations by ecological group. Aspen, birch, and cottonwood should be retained as a minor component of the residual stand after partial cutting (see recommendations by ecological group).
- iv. Brushing treatments will retain deciduous trees and shrubs where they are not overtopping the species under management.

4. Fuel reduction and fire management strategies designed as described in #1 should be integrated with other management values and objectives in a strategic planning process that will be implemented and monitored carefully over time.

Fire management strategies to reduce fuels has the potential to improve or degrade habitat values, site productivity for timber, and objectives for visual landscape management, water and other values. With that in mind these strategies can only be implemented effectively if they are developed in an integrated fashion that tests potential outcomes first through modeling, and then sets targets that will be monitored against clear performance indicators and revisited in iterative cycles of planning.

5. Stakeholders and the general public need to be made aware of the critical threat posed by forest fuel accumulations and climate change.

This threat could impact lives, property, public infrastructure, recreation, visual landscape objectives, wildlife habitat and biodiversity. The landscape changes in the Kamloops TSA very much still evident from the 2003 fires provide a good objective lesson of the potential threat.

6. The name of the fuel/fire management program should be changed. “Ecosystem Restoration” is no longer an appropriate term in the forest ecological science community, considering climate change.

Ecosystem restoration typically manages disturbance based on: historic range of variation; natural range of variability; and ecological sustainability (Millar 2007). The historic range of variation provides guidance by looking back at pre-settlement “natural” disturbance patterns to help set reference conditions. However, presettlement conditions reflect conditions during a climate cycle referred to as the “little ice age”, while current conditions are much warmer and likely will be even more divergent moving forward with natural climate cycles and climate change.

Many ecologists locally and international are looking forward, applying what we know about natural processes and the range of natural variability for existing forest types, the value of ecological diversity and then considering plausible impacts of climate change to design a working hypothesis of future forest conditions (Millar 2007, 2006, Brett 2008, Arsenault and Klenner 2008). With this in mind, the term “ecosystem restoration” might be better replaced with something like “ecosystem realignment”.

Further to this, ecosystem restoration or realignment is a part of fire management in certain ecosystems. To be effective as land managers there is a need to consider the full landscape, as per the intention of Policy 9.4, as well as current fire management activities in Provincial and National Parks.

7. **Effectiveness of fuel reduction strategies will require economic efficiencies and engagement of all agencies and licensees at an operational level.** With that in mind:
 - i. Local Fuel reduction strategies should be encouraged by higher levels of government (beyond the Regional level) to go beyond traditional approaches such as prescribed burning to incorporate efficiencies with emerging economies associated with biofuels and other products.
 - ii. Provincial waste policies also need to be designed to match well with such strategies across the province.
 - iii. Liabilities for fire escapes need to be addressed where they discourage engagement of licensees operationally.

Gaps and/or Barriers for Implementation

1. The type of strategic planning envisioned to bring fire management and fuels reduction strategies in line with climate change sensitivities and other forest management objectives currently does not occur at the TSA level, although policies (including the DRAFT BC’s Wildland Fire Management Strategy) are intended to support this vision. It is not just a plan that is required but a process led by the government and supported by policies and legislation so that the resulting strategies (with targets and indicators) will actually be implemented and monitored for performance.
2. Currently there is reluctance to encourage broadleaf species through stocking standards in FSPs when it is not clear what the impacts will be on future timber supplies. Yet these species provide important diversity and therefore resilience in young stands. These considerations need to be modeled and discussed for their respective merits and impacts upfront (considering all values and climate change) in strategic planning with explicit targets for landscape level species deployment and monitored of those targets afterwards.
3. Operational experience with prescribed burning is not as high as it was in the past. Challenges associated liabilities and smoke management need to be overcome, requiring close cooperation and support from all government agencies. There is now a BC Council for Prescribed fire which is working on bringing previous fire

certification courses up to date, as a means of supporting capacity issues, both internal to government, licensees, and First Nations. This program needs to be well supported over time.

4. The type of subunit planning envisioned within visual landscapes most at-risk to climate change is extremely difficult to initiate within a TSA. Any one Licensee with a volume-based tenure overlapping with other licensees are reluctant to lead such a process since it generally will not be funded by FIA, and will be difficult to coordinate with all the other licensees. The Ministry of Forests and Range seem reluctant to lead such planning because they do not believe it is their role under FRPA to do so. There are a few models where collaboration between licensees, FN and MFR is happening, and these should be built on and incorporated across the province.
5. Provincial policies for economic development (biofuels) and revenue from crown forests (waste and residue) are not well linked to provincial and regional forest management goals and objectives. This disconnect can create unintended outcomes and hamper implementation to address climate change impacts.

Key Assumptions

1. Increased standing mortality combined with emerging understory trees, shrubs and grasses will significantly increase risk when combined with longer stretches of hot dry summer weather. These two factors will both be episodic. Research and monitoring that will improve knowledge and predictive skills regarding both these factors may be helpful.
2. Historic fire disturbance regimes are informative for understanding ecological processes and relationships between different ecosystem components - however they are less important as a template for future management considering climate change.
3. Assigned “ease of implementation” and “priority for management direction” are estimates based on the judgement of the KFFS team. For “ease of implementation” the number and difficulty of implementation barriers and gaps were considered. For “priority of management direction” the perceived ability of the direction to help mitigate and address management sensitivities across all important values were considered. All of these estimates required numerous assumptions regarding the importance of barriers and the potential impact of direction on management sensitivities. These relative rankings should therefore be scrutinized carefully by managers before they are assumed to apply as indicated and utilized in planning.

First Nations Known Cultural Important Plants - Sensitivities and Direction

Table A4.5 Management Direction Summary Table

For more information on the management direction listed below see the following discussion.

Management Direction	Ease of Implementation⁴⁶	Planning Linkage
1. Begin the dialogue with First Nations on potential impacts of climate change on the availability and distribution of culturally important plants. The topic is complex and requires significant dialogue to address the complexity.	Moderately Easy (difficult to know)	Information sharing
2. Work with First Nations and licensees to rank sensitivity and identify options for management of culturally important plants. Options may be limited, but need to be explored.	Moderately Challenging (difficult to know)	FSP, SFMP – information sharing
3. Spatially define direction within a strategic plan that is integrated with other values.	Challenging	None
4. Sharing information amongst First Nations	Moderately Challenging	Not clear

Sensitivities

While known culturally important plants focus our attention on those plants of importance to First Nations, all plants will experience potential growth and survival issues within a changing climate. Some long lived species may be able to survive the changes, but at some point may not be able to reproduce. Overall vigour will suffer if the conditions go beyond the ecological tolerance of a species.

Species that are adapted to wet or dry conditions will likely survive where biophysical factors influence the amount of moisture available. For example seepage areas and floodplains may continue to harbour similar species as often those species live over a wide range of climates (e.g., the same species are found in seepage areas in the IDF and ESSF).

Drought adapted species too may have a wide range of adaptation, living in sandy or moisture deficit sites over a range of climatic conditions. These plant species may survive and in some cases thrive under conditions where summer droughts are more severe and often. Therefore, sensitivities for known culturally important plants will vary by species.

⁴⁶ **Ease of Implementation** – The categories were assigned a relative value based on how easy or difficult it was perceived to achieve the task within the present forest management process. Moderately challenging or challenging direction has some significant barriers to implementation or knowledge gaps associated with it (See the end of this subsection).

Depending upon the species and its ecological tolerance its range could shrink, expand or stay the same.

Table A4.6 Management Direction Priority - Ease of Implementation Comparison⁴⁷.
Numbers correspond to the numbered direction items above.

		Ease of Implementation			
		Easy	Moderately Easy	Moderately Challenging	Challenging
Priority for Management Direction	Very High				
	High				
	Mod-High		1	2	3
	Mod			4	
	Low - Mod				

Species growth and survival will be affected by a range of climatic influences, from the amount and timing of precipitation to the amount of heat the plant receives and when. On top of climate, factors such as an increase in fires and fire severity could significantly alter species assemblages, as some species may not be able to reproduce under the revised condition. Plant diseases and insects could very well affect species reproduction and survival.

As stated in the Fire Section, the dry and the ICH-IDF transition subzones could see profound ecological changes as mortality from a combination of drought, forest health

⁴⁷ **PRIORITIES** – Priorities were identified as follows:

- VERY HIGH – A high potential to improve at least four sensitivities.
- HIGH – A high potential to improve at least two sensitivities.
- MOD-HIGH – A high potential to improve at least one sensitivity, or a mod-high potential to improve at least two sensitivities.
- MOD – A moderate potential to change at least two sensitivities, or a mod-high potential to improve one sensitivity.
- LOW-MOD – a moderate potential to help change one sensitivity.

Note these priorities should be considered a starting point, actual management direction should be informed by additional scenario testing to determine the most effective options.

agents, and fire takes a significant toll on many tree and plant species (See Ecological Narratives in the Compendium of Supporting Documents). With increased temperature and summer drought, species that are adapted specifically to mesic conditions will see their abundance shrink as they shift to the moister and cooler portions of their range within these subzones.

As well species sensitivities will differ depending on their life cycle. Annuals may or may not have the necessary conditions required for reestablishment each year. Perennials may persist but become less vigorous with time, resulting in death and reduced numbers. Synchronicity with pollinators may become uncoupled. The combination of sensitivity of each species along with its location and whether there is a mechanism to manage that species will inform its vulnerability.

General sensitivities to climate change for the Kamloops TSA (known culturally important species):

1. Locations that are presently used by First Nations for culturally important plants may or may not be within the ecological tolerance of the species over time.
2. Increases in summer drought in the drier subzones could impact the growth and survival of a number of culturally important plant species.
3. Warmer conditions could result in new and increased forest health concerns over the entire TSA. At this time there is no indication on which species will be impacted and by how much.
4. Species composition and occurrence may be impacted by disturbance from large wildfires. These impacts could result in reduced abundance or extirpation of some species if they do not have the requisite conditions for regeneration (e.g., cooling requirement).
5. As per the fire section, the sustainability of supply for First Nation users may be profoundly affected by increased wildfires in large southern valleys in the TSA as these valleys are mostly in Dry Douglas-fir and ICH-IDF transitional subzones which will be the most sensitive to climate change from a fire perspective.
6. With reduced vigour stands may become candidates for increased salvage harvesting, this could impact growth and survival of culturally important plants.
7. Increased disturbance through fire and or salvage harvesting could result in an increase of invasive species, which in turn may 'crowd out' desirable native species (see Section on Biodiversity).

Direction

1. Communication with First Nations on the plausible impacts of climate change in general is first needed to highlight options and issues surrounding known culturally important plants. First Nations concerns about other resource values should be noted and also explored.
2. Once a basic understanding of climate change trends is established: species sensitivity should be explored separately with each First Nation; species that are

expected to be under risk should be identified; and management options and adaptive strategies designed. This may require multi-licensee cooperation.

To begin this process, workshops should be convened with First Nations to discuss the issue and next steps. To assist with this dialogue a First Nations Culturally Important Plants spreadsheet with climate change sensitivities has been created using a list of species taken from the Secwepemc website⁴⁸. The spreadsheet provides information on known occurrence based on indicator species by site series from the local Biogeoclimatic field guides and information from Plants of the Southern Interior of BC (Parish et al, 1996⁴⁹). A preliminary indication of the sensitivities by species is provided based on the ecological narratives by subzone.

Information sharing is needed to engage each First Nations on the use and location of their culturally important species, and then begin the process of designing strategies and practices to mitigate long term impacts. These practices may include for example:

- i. Planting of some culturally important shrub species on sites where they are currently not found, but that are ecologically suitable in the short term, and preferred over the long term (facilitated migration).
 - ii. Intentionally reserving some sensitive⁵⁰ culturally important species during operational brushing treatments conducted by forest licensees.
 - iii. Using a sensitive culturally important species to help locate retention patches if such species are interior forest dwelling plants.
 - iv. Possibly increasing buffer sizes in areas where sensitive culturally important plants are recognized to require overstory canopy protection.
3. Management of First Nations culturally important plants that are sensitive to climate change must be planned within a comprehensive strategy that integrates these objectives and targets with all other values spatially across the landscape. Direction for culturally important plants will in some cases fit well with direction for biodiversity and riparian/aquatic values.

Instead of approaching this as a one-off process with each licensee, a comprehensive TSA strategy to manage these species would provide help clarify important species and options for management within the context of direction for other management objectives. This could be done in phases. Phase 1 would identify important species with moderate or high sensitivities. Phase 2 would identify management options that would mitigate impact if possible. Phase 3 would integrate with other resource values.

⁴⁸ http://www.secwepemc.org/SECethnogardens2/dry_land_garden.htm

⁴⁹ Parish, R., R. Coupe, and D. Lloyd. 1996. Plants of southern interior British Columbia. B.C. Ministry of Forests and Lone Pine Publishing.

⁵⁰ Sensitive – to climate change impacts

4. Sharing of information between First Nations on cultural use, sensitivities and opportunities will help inform all First Nations in the TSA on the potential impacts from climate change. There may be a range of awareness on species and their sensitivities that can be shared among First Nations. As climate modifies the occurrence of species, it may be useful to begin identifying areas that are outside the traditional use and traditional territories, to promote agreements amongst First Nations on continued sources of culturally important plants.

Gaps and/or Barriers for Implementation

1. Information on the impact of climate change is emerging. Many First Nations may not be aware of the potential impacts of climate change on the plants they find culturally important, thus a dialogue to increase awareness is needed.
2. A clear listing or mapping of known culturally important plants and their sensitivities is needed; this requires input from First Nations and local ecologists.
3. Currently there is no specific direction on retention for known culturally important plants other than individual agreements worked out by licensees with First Nations.
4. Information on sensitivities by species to changes in various climatic variables is not readily available. As an interim step estimates of sensitivity are provided based on edaptopic amplitude. Sensitivities should be updated regularly as information becomes available.
5. For important culturally important species a literature review on species sensitivities should be undertaken.
6. The type of strategic planning envisioned to bring management of culturally important plants in line with climate change sensitivities and other forest management objectives currently does not occur at the TSA level.

Key Assumptions

1. Different species will have varying degrees of success in adapting to climate change. Location, amount and future use of known culturally important plants need to be identified to allow exploration of management options.
2. Assigned “ease of implementation” and “priority for management direction” are estimates based on the judgement of the KFFS team. For “ease of implementation” the number and difficulty of implementation barriers and gaps were considered. For “priority of management direction” the perceived ability of the direction to help mitigate and address management sensitivities across all important values were considered. All of these estimates required numerous assumptions regarding the importance of barriers and the potential impact of direction on management sensitivities. These relative rankings should therefore be scrutinized carefully by managers before they are assumed to apply as indicated and utilized in planning.

Timber Management Sensitivities and Direction

Table A4.7 Management Direction Summary Table

For more information on the management direction listed below see the following discussion.

Management Direction	Ease of Implementation⁵¹	Planning Linkage
1. Develop a strategy which ranks risks and designs harvesting priorities in landscapes throughout the TSA.	Challenging (Legislation, Regulation, Experience)	Missing Strategic Planning
2. Harvesting priorities should be directed toward subzones with higher risk of loss or damage.	Moderately Challenging	SFMP, FSP – Missing strategic planning
3. Use the full range of silvicultural systems and retention to address stands at risk, and possibly recruit replacement habitats.	Challenging (Cost, Experience)	SFMP, FSP, TSR, Missing Strategic
4. Increase the diversity of species for reforestation, and reduce reliance on lodgepole pine and subalpine fir (with a few exceptions).	Moderately Challenging (Cost, Experience)	SFMP, FSP, TSR, Appraisal, Site Plans
5. Broaden stocking standards to allow for greater diversity in regeneration and provide flexibility for management.	Moderately Challenging (Regulation)	SFMP, FSP, TSR, Missing Strategic Planning
6. Consider using fertilization to reduce the potential harvest age of stands that are expected to be vulnerable over time.	Moderately Easy	FSP, SFMP, Silvi Strategy (missing strategic)
7. Ensure continuous monitoring of stands beyond the free-growing stage to measure productivity, growth, health and structure.	Moderately Challenging	Not clear
8. Recognize areas where silvicultural investments cannot be justified on the basis of timber production and consider appropriate options using strategic and tactical planning.	Challenging (No decision set presently available)	SFMP, TSR, Missing Strategic
9. Finish rendering presently assumed net-downs into spatial format, to prevent expending effort in areas not presently in the THLB.	Easy (Almost done?)	TSR, Missing Strategic

⁵¹ **Ease of Implementation** – The categories were assigned a relative value based on how easy or difficult it was perceived to achieve the task within the present forest management process. Moderately challenging or challenging direction has some significant barriers to implementation or knowledge gaps associated with it (See the end of this subsection).

Table A4.8 Management Direction Priority-Ease of Implementation Comparison⁵².
Numbers correspond to the numbered direction items above.

		Ease of Implementation			
		Easy	Moderately Easy	Moderately Challenging	Challenging
Priority for Management Direction	Very High				
	High			2, 4	
	Mod-High		6	7	1, 3
	Mod			5	8
	Low - Mod	9			

Sensitivities

Climate change in the Kamloops TSA will put significant stress on timber harvesting. Forest health impacts will result from hotter temperatures, particularly in the dry Biogeoclimatic subzones. These forest health impacts will be disrupt harvest planning and timber supply even more so than in the past. Some currently forested subzones may tend towards treed grasslands, particularly on hot aspects or shallow soils. Our capacity to respond to the changes is constrained by the structure of existing planning processes, the contractual arrangements between government and forest companies, and other forest regulations and policies.

⁵² **PRIORITIES** – Priorities were identified as follows:

- VERY HIGH – A high potential to improve at least four sensitivities.
- HIGH – A high potential to improve at least two sensitivities.
- MOD-HIGH – A high potential to improve at least one sensitivity, or a mod-high potential to improve at least two sensitivities.
- MOD – A moderate potential to change at least two sensitivities, or a mod-high potential to improve one sensitivity.
- LOW-MOD – a moderate potential to help change one sensitivity.

Note these priorities should be considered a starting point, actual management direction should be informed by additional scenario testing to determine the most effective options.

The impact of changing climate can be mitigated by our silvicultural approaches – increasing diversity in plantations, and in stand structures, deployment of provenances that are adapted to future climates, and managing mid-aged stands for improved vigour will all help to mitigate the effects of climate change. To achieve this, the province needs an integrated approach for continuous planning to understand and manage risks, ultimately to devise comprehensive strategies to balance and achieve long term land management goals across several scales.

General sensitivities to climate change for the Kamloops TSA:

1. Changing productivity expectations and related yield assumptions creates additional uncertainty in the calculation of long term timber supply.
2. Potential contractions of the Timber Harvesting Land Base through the loss of dry forest to treed grasslands, or loss of productive forest to non-commercial cover can also impact future timber supply.
3. There is a preponderance of species in young stands that will be highly susceptible to mortality over time due to climate change.

These stands, which include species such as lodgepole pine and subalpine fir, are currently viewed as suitable from an ecological and management standpoint. However, expected impacts from higher temperatures, drought and forest health agents make the attainment of an economically merchantable stand tenuous at best.

4. Warming climate will sometimes lower productivity and increase losses to forest health agents.

Warmer temperatures favour insects, leading to more damage by bark beetles, tip weevils and defoliators. Subzones that are expected to get warmer and yet maintain moderate to high levels of precipitation, may see increasing pathology issues, particularly from fungi. Increases are expected in root disease, foliage diseases, and stem cankers. While pathogenic activity may diminish at some point as conditions get progressively drier, prolonged drought may impact productivity as much or more.

5. New forest health issues are likely to emerge, either through the introduction of non-native insects and diseases, or through changes in species communities and changing host/climate/pest interactions.
6. Some Subzone Groups⁵³ are more sensitive to climate change than others, including:
 - i. The moist-dry transition subzones (e.g. IDFmw) - with ubiquitous root disease, mixed stands with low timber values, and a component of redcedar (possibly hemlock) and lodgepole pine that will be maladapted to the future climate.

⁵³ SEE Appendix 3 (Sensitivities and Direction for Ecological Subzone Groups) for analysis of sensitivities and more specific direction.

- ii. The dry subzones with concentrations of lodgepole pine (e.g. MSxk) – recent mortality from mountain pine beetle will result in extensive young stands of lodgepole pine that will be highly susceptible to mortality over time due to an unsuitable climate and forest health factors.
 - iii. The dry subzones with Douglas-fir and ponderosa pine (e.g. IDFxh) – warmer and drier conditions will increase mortality from Douglas-fir beetle and reduce success of Douglas-fir regeneration. Grasslands may expand, potentially aided by large wildfires which will become a greater threat.
7. Warmer and drier summer conditions, along with human demographic trends could see portions of the TSA more desirable as recreational property or urban space.

Interface communities will increase in number and area, putting pressure on fuel management, recreational opportunities, and visual/aesthetic qualities. These trends will exert a downward pressure on timber supply.

Direction

Harvesting

1. Develop a system for risk rating stands to further refine strategies for harvesting priorities unique to individual landscapes across the TSA (See: Direction in Ecological Groups for initial harvest priorities). Monitor health, general growth and vigour of post-free growing stands to support this ranking.
2. Strategically direct harvesting toward forest type/ecosystem combinations that are at risk of loss, balancing against other objectives and priorities.

Prioritize harvesting to those situations where sanitation and salvage operations can minimize the impacts of climate change on forest management for the range of values. Revisit the priorities frequently to react to change. This question should be further explored to see how big the window of opportunity is to address high risk subzones, a more precise picture of the stands involved, the amount and the distribution of those stands.

3. Use the full range of silvicultural systems and retention to address stands at risk, and encourage stand structures that may allow for recruitment of replacement habitats.

Harvesting with post harvest structure will be useful to address stands in hotter, drier environments (e.g., maintain shade trees) and with anticipated forest health issues (e.g., maintain species better suited to future climate). Harvesting interventions may also be useful to speed recruitment of replacement old growth and other habitats, allowing for more flexibility to meet an increasingly dynamic situation.

It will be important with these silvicultural systems to be able to manage stands throughout the rotation to maintain tree and stand vigour and direct management toward clear stand structural targets that tie to a vision for forest condition over landscapes, especially where numerous values are important. For stands that are

currently economic, but clearly destined to be outside of the THLB due to climate change, identify harvesting opportunities (possibly in conjunction with other management interventions) for interface fuel reductions, while meeting objectives for habitat and other applicable values. Such harvesting situations will likely have requirements for retention and/or reserves but not for regeneration.

Reforestation and Stand Tending

4. Increase the diversity of species for reforestation, and reduce reliance on lodgepole pine and subalpine fir (in most subzones, with a few exceptions). Refer to the recommendations in the Ecological Subzone Groups. Generally:
 - i. Increase the use of other species for regeneration, particularly Douglas-fir, ponderosa pine, and larch. As well, white pine should be reintroduced as a reforestation species.
 - ii. Aim to establish a high proportion of mixed species stands with regeneration strategies. Using the direction provided for Subzone Groups, species mixtures should be encouraged as a hedge against future uncertainties with climate change.
 - iii. Diversify the species composition in existing young stands:
 - Indirectly through species choices during stand tending, or,
 - Directly through targeted interventions that clear small dispersed patches in existing young stands to plant other species in a effort to develop less sensitive clusters of trees throughout the stand over time.
 - iv. Experiment with novel species mixtures in all ecosystems (e.g. increasing use of Douglas-fir and cedar in the wet high elevation sites).
5. Broaden stocking standards to allow for greater diversity in regeneration and provide flexibility for management.
 - v. Focus the use of stocking standards through strategic and tactical planning that integrate objectives for all values, and use diversity as an insurance policy for the unknown.
 - vi. Promote a range of densities at the stand and landscape level, build these into the planning process.
6. Consider using fertilization to improve growth and reduce the potential harvest age of stands that are expected to be vulnerable over time. The intent is to encourage harvesting of these stands during favourable markets, allowing reforestation of more resilient species mixtures before the stands succumb to mortality induced by a changing climate.

General

1. Ensure continuous monitoring of stands beyond the free-growing stage to measure productivity, growth, health and structure. This will support management of stands

throughout the rotation and requirements for timely interventions related to pre-emptive harvesting, stand tending for habitat recruitment and a range of management actions to help reduce excessive fuels and manage fire risks. It should also be used to check assumptions in the timber supply review process

2. Recognize areas where silvicultural investments cannot be justified on the basis of timber production and depending on objectives – either use as a reserve, minimize forest management effort, or secure funding support (if required) to manage for non-timber values (e.g. urban-forest interface fuel management).
3. It will be necessary to finish rendering presently assumed TSR net-downs into spatial format, to facilitate comprehensive strategic planning and prevent expending management effort in areas not presently in the THLB.

Gaps and/or Barriers for Implementation

Structural Barriers

1. Strategic planning to align timber management strategies with climate change sensitivities and other forest management objectives currently does not occur at the TSA level. What is required is a continuous process, led by operational foresters and supported by teams of specialists, and a framework of government goals, policies and legislation, with iterative reporting-out periods. This will ensure that the resulting strategies to address climate change (with targets and indicators) will actually be implemented and monitored for effectiveness over time.
2. Tactical planning (on the landscape level or in similar units) to support the strategic planning described above also currently does not often occur. Such planning ensures harvesting and silvicultural interventions emerging from strategic planning occurs appropriately across landscapes in time and space. This ensures effective implementation, efficient operations, and communication with all who are interested and/or affected by the outcomes.
3. Current policies which focus on “free-growing ecologically suitable species” provide incentives for the continued reliance on lodgepole pine in reforestation programs. Our current thinking about what is “ecologically suitable” should be adjusted in the face of future climate change, and our planning horizon must be extended beyond free-growing to mid-rotation (at least) and preferably beyond.
4. Currently Douglas-fir, ponderosa pine and other species are more expensive to establish than lodgepole pine. The main issue is that until planting of species other than lodgepole pine becomes standard practice and fair cost recognition or incentives are in place (see below), there is an economic disincentive to utilize these species when lodgepole pine is considered ecologically suitable.

Additional costs for Douglas-fir over lodgepole pine on the same sites where both are currently suitable for regeneration are estimated as follows⁵⁴:

Cost element	Rationale for increased cost	Increase in Cost
Planting Stock	Douglas-fir requires larger 412B stock (lodgepole is normally grown as PCT313B)	\$120-130 / ha
Fill Planting	Higher mortality in Douglas-fir due to drought and deer damage generates a greater requirement for fill planting – estimated at 30-40% of area.	\$140 / ha (\$400 /ha x 35%)
Surveys	Because Fd will take 2-5 years longer to attain free-growing there will be at least one added survey, perhaps 3-4 if issues arise.	\$20 – 60 /ha
TOTAL		\$280 – 330 / ha

5. There is reluctance to encourage broadleaf species through stocking standards in FSPs when it is not clear what the impacts will be on future timber supplies. As well, the mechanics of the free-growing assessment procedure frustrate many managers as it does not seem to account enough for the autecological characteristics of local tree species and stands dynamics.

Yet it is clear that broadleaf trees provide important diversity and resilience in young stands and supply critical habitat for many species. Flexibility to allow more broadleaves in areas managed for conifers is needed. These considerations need to be modeled and analysed for their respective merits and impacts upfront, considering all values and climate change. This measure should occur in a strategic planning process, with explicit targets and ranges for landscape level species deployment and monitoring of those targets afterwards.

6. Currently, there is a lack of government economic measures to encourage harvesting in highly susceptible, marginal-value stands. Measures, such as existing stumpage allowances and partition-cut tenures, may be insufficient to address this problem.

Marginally economic stands, such as subalpine fir, hemlock, mixedwood stands with a marginal conifer component, and stands of small pine (or other species) are always the least attractive economically, even when markets are high. When these stands are a high priority for conversion to more resilient types to address numerous sensitivities for a range of values, government should explore a range of measures to encourage their harvest, beyond what has been used in the past. The priority should be management of, rather than revenue from these stand types.

7. The current stumpage appraisal system encourages a “least cost silviculture approach” to meet targets or standards that will be accepted in an FSP.

⁵⁴ Summarized based on information from several practitioners in the Southern Interior.

Currently silviculture allowances will only address more costly treatments when they becomes standard practice and are therefore reflected in average costs by licensees. Accordingly, there is a disincentive in the appraisal system for a licensee to take leadership and incur higher silviculture costs voluntarily, especially when others are looking for ways to more for less.

This problem is further exacerbated in stands with high amounts of dead lodgepole pine or other species (something that could become common with climate change). This is because the appraisal allowance is calculated based on the cruise volume and then is applied based on the delivered volume. On these types of blocks the delivered volume is generally lower because decay waste and breakage is typically underestimated. The result is a lower silviculture allowance even though the silviculturist has the same amount of area with the same (or tougher) challenges to reforest.

The bottom-line is that silvicultural innovation or leadership on a large scale, unless it directly improves stocking at freegrowing, is discouraged until it becomes so common that it is required for FSP approvals. Fair cost recognition or incentives for innovative reforestation that will address climate change concerns is needed.

8. Forest companies are often are not interested in managing stands that do not provide a suitable log profile for the products they manufacture.

While this is understandable, it can be inappropriate for the long time frames involved in forest management on public lands. As the life-span of companies and mills are relatively short compared to forests, the best strategy might be to provide a diversity of stand types to allow for a range of products, most of which are difficult to predict at this time. Diversity would have added benefits for general resilience and other values. As the landowner, it is appropriate for government to take leadership on this issue.

Gaps in Knowledge, Data, or Tools

1. There is a significant shortage of seed for all species used in the TSA, particularly Douglas-fir, ponderosa pine, larch and cedar.

While current changes to seed transfer guidelines in BC will be helpful, there may be considerable uncertainty around the deployment of provenances suggested in this strategy. Considerable work is necessary to improve our understanding of suitable provenances considering the impacts of climate change.

2. Existing knowledge should be synthesized regarding the regeneration of Douglas-fir and ponderosa pine in climates with greater extremes in temperature than that normally experienced in BC. This information will mostly be found in the USA. It should form the basis for guides and other tools that will assist practitioners in BC.
3. Investigate more closely the impact of the predicted climate envelopes on the persistence and productivity of subalpine fir to refine our understanding of its role in regeneration.

Forecasted future climate scenarios in this project suggest subalpine fir will undergo significant stress in some subzones and a better understanding of this issue is important. Similar investigations would be worthwhile for redcedar, spruce and birch as they are forecast to decline in some subzones, but improve growth in others. These predictions should be checked more closely to see how they align with species phenology and physiology.

4. Our present workforce has little experience or tradition in partial-cutting. Administrative systems discriminate against its greater use.

Assumptions

1. Assigned “ease of implementation” and “priority for management direction” are estimates based on the judgement of the KFFS team. For “ease of implementation” the number and difficulty of implementation barriers and gaps were considered. For “priority of management direction” the perceived ability of the direction to help mitigate and address management sensitivities across all important values were considered. All of these estimates required numerous assumptions regarding the importance of barriers and the potential impact of direction on management sensitivities. These relative rankings should therefore be scrutinized carefully by managers before they are assumed to apply as indicated and utilized in planning.

Visual Management Sensitivities and Direction

Table A4.9 Management Direction Summary Table

For more information on the management direction listed below see the following discussion.

Management Direction	Ease of Implementation⁵⁵	Planning Linkage
1. Work cooperatively with other values to ensure coordination of plans and implementation	Easy to Challenging (difficult to know)	Not clear
2. In areas identified for salvage or pre-emptive salvage that have visual quality objectives, coordinate planning to address fire and habitat with visual options.	Easy to Challenging (difficult to know)	Not clear
3. Involve public with information on climate change, sensitiveness and options	Difficult	None

Sensitivities

Visual management will be more difficult as stands deteriorate and additional areas are burned by wildfire. Public involvement will be needed along with coordination of other values to promote viable options. Visual landscapes are impacted by a variety of causes. Climate change will impact a number of factors.

As pointed out in the Fire section forests in dry and transitional subzones will be more susceptible to wildfire as summers warm and become drier, this could have significant impacts on visual quality. These forests are key components of the visual landscapes for most communities and travel corridors south of Vavenby, as well as surrounding a number of recreational areas in the TSA.

Increased mortality due to drought stress and other forest health agents will occur in a number of areas. Dead trees are often seen as less visually appealing compared with live trees. Salvage harvesting may increase as stands die or lose vigour. Options for block shape, retention configuration and timing of harvest may be limited to respond to visual management concerns.

⁵⁵ **Ease of Implementation** – The categories were assigned a relative value based on how easy or difficult it was perceived to achieve the task within the present forest management process. Moderately challenging or challenging direction has some significant barriers to implementation or knowledge gaps associated with it (See the end of this subsection).

Table A4.10 Management Direction Priority-Ease of Implementation Comparison⁵⁶.
Numbers correspond to the numbered direction items above.

		Ease of Implementation			
		Easy	Moderately Easy	Moderately Challenging	Challenging
Priority for Management Direction	Very High				
	High				
	Mod-High			2	
	Mod			1, 3	
	Low - Mod				

General sensitivities to climate change for the Kamloops TSA (visual management)

1. Visual management will be more difficult to achieve within increased fire and other agents of tree mortality.
2. With reduced vigour, stands may become candidates for increased salvage harvesting, this could severely impact options for visual management.
3. Increased disturbance through fire and or salvage harvesting could result in an increase of invasive species, which in turn may 'crowd out' desirable native species resulting in a negative public response (see also Biodiversity).

⁵⁶ **PRIORITIES** – Priorities were identified as follows:

- VERY HIGH – A high potential to improve at least four sensitivities.
- HIGH – A high potential to improve at least two sensitivities.
- MOD-HIGH – A high potential to improve at least one sensitivity, or a mod-high potential to improve at least two sensitivities.
- MOD – A moderate potential to change at least two sensitivities, or a mod-high potential to improve one sensitivity.
- LOW-MOD – a moderate potential to help change one sensitivity.

Note these priorities should be considered a starting point, actual management direction should be informed by additional scenario testing to determine the most effective options.

Direction

1. Identify areas that are sensitive to climate changes and plan visual management in concert with other management direction for interface fire, timber, habitat, and other values.
2. To adequately address interface fire management, timber and other objectives in specific areas where visual landscape management objectives are significant, detailed assessments and subunit plans should be designed to integrate all targets to carefully construct an approach to management over time that has the best chance for success.
3. It is highly unlikely in landscapes at significant risk of impact from climate change that visual quality objectives can be maintained in an ideal state. To adequately adapt these ecosystems to minimize climate impacts, significant treatment disturbance may be necessary. Comprehensive subunit planning and scheduling of treatments may help minimize short term impacts on visual objectives, while helping to avoid extensive and persistent impacts from climate change and associated large scales disturbances such as wildfire.
4. Promote public awareness to the risks of not addressing climate sensitivities, e.g., larger scale fires with the resultant reduction in visual quality. For public acceptance planning that identifies future sensitivities and options at an appropriate local scale, e.g., landscape, watershed or viewscape with public involvement is needed.

Gaps and/or Barriers for Implementation

1. Information on the impact of climate change is emerging and the impacts on visual management have not yet been incorporated into present planning.

Key Assumptions

1. Visual management will remain important and the public has a role in valuing visual options. Climate change will impact the future forests with or without intervention; our assumption is that with planning, visuals can be accommodated within the direction needed to promote other values such as habitat and water conservation.
2. Assigned “ease of implementation” and “priority for management direction” are estimates based on the judgement of the KFFS team. For “ease of implementation” the number and difficulty of implementation barriers and gaps were considered. For “priority of management direction” the perceived ability of the direction to help mitigate and address management sensitivities across all important values were considered. All of these estimates required numerous assumptions regarding the importance of barriers and the potential impact of direction on management sensitivities. These relative rankings should therefore be scrutinized carefully by managers before they are assumed to apply as indicated and utilized in planning.

Watershed Management Sensitivities and Direction

Table A4.11 Management Direction Summary Table

For more information on the management direction listed below see the following discussion.

Management Direction	Ease of Implementation⁵⁷	Planning Linkage
1. Existing coarse filter watershed risk screening (and associated mapping) within the TSA needs to be augmented with climate change considerations, at least out to 2050.	Moderately Easy	Not clear- – no strategic plan
2. High risk watersheds (from the coarse filter screening process) need a detailed analysis and plan based on risks to water and fish (especially salmonids) as influenced over time from climate change.	Challenging (legislation and policy)	Not clear – no strategic plan
3. Until coarse filter TSA watershed screening has been updated to account for climate change - shade should be provided on all small fish streams and the shorelines of small lakes after timber harvesting except in wet cool BEC subzones, and timber retention for other purposes should be concentrated on any existing inblock streams as much as practicable.	Easy	FSP, SFMP & TSR
4. Need to coordinate local strategic forest management planning with the Regional District and appropriate government agencies in watersheds where consumptive use is significant.	Challenging (legislation and policy)	Not clear- – no strategic plan

Sensitivities

Trends for climate change over time as earlier indicated show warmer overall temperatures, wetter winters but with less snow, and wetter falls and springs and drier summers. Combined with the prediction generally that severe weather events will increase in severity and magnitude, such trends will have a significant influence on the water and waterbodies in the Kamloops TSA. The basic influences will include: increased atmospheric evaporative demand; altered vegetation composition affecting evaporation and interception; altered seasonal streamflows; increased frequency/ magnitude of storm events; and increased stream and lake temperatures.

⁵⁷ **Ease of Implementation** – The categories were assigned a relative value based on how easy or difficult it was perceived to achieve the task within the present forest management process. Moderately challenging or challenging direction has some significant barriers to implementation or knowledge gaps associated with it (See the end of this subsection).

Table A4.12 Management Direction Priority-Ease of Implementation Comparison⁵⁸.
Numbers correspond to the numbered direction items above.

		Ease of Implementation			
Priority for Management Direction		Easy	Moderately Easy	Moderately Challenging	Challenging
	Very High				
	High		1		2
	Mod-High				4
	Mod	3			
	Low - Mod				

General sensitivities to climate change for the Kamloops TSA:

1. WATER – Decreased water flows and supplies appears to be the most important water sensitivity due to climate change.

There are numerous reasons to expect reduced water supplies especially in the southern half of the TSA. Warmer summer temperatures increase atmospheric evaporative demands at a time when precipitation inputs are expected to be below normal. Even though winter precipitation may be higher, there is an anticipation generally of less snow, reducing the magnitude of the spring peak flow and

⁵⁸ **PRIORITIES** – Priorities were identified as follows:

- VERY HIGH – A high potential to improve at least four sensitivities.
- HIGH – A high potential to improve at least two sensitivities.
- MOD-HIGH – A high potential to improve at least one sensitivity, or a mod-high potential to improve at least two sensitivities.
- MOD – A moderate potential to change at least two sensitivities, or a mod-high potential to improve one sensitivity.
- LOW-MOD – a moderate potential to help change one sensitivity.

Note these priorities should be considered a starting point, actual management direction should be informed by additional scenario testing to determine the most effective options.

exacerbating summer low-flow conditions further. Loss of winter snowpack may even reduce the late summer drainage network with some perennial streams becoming intermittent.

While climate change has an impact on supply of water, at the southern end of the TSA where most people live and agriculture is significant, demands for irrigation, consumption and other purposes is expected to grow.

2. WATER – Water quality could decline in isolated areas.

While likely less of a concern than water supply, quality may be impacted in the wet cool northern portions of the TSA due to a general increase in fall, winter and spring precipitation (which is already high) coupled with an anticipated increased frequency and magnitude of storm events. These factors could create huge water volume increases locally in some streams within certain watersheds, increasing impacts on channels, banks and sediment loads. Also, periodic natural hillslope mass wasting events could become more frequent in these areas.

3. FISH- Water temperature increases in warmer lower elevation streams could reduce salmonid populations.

Plausible warming scenarios for climate over the next 50-80 years suggest lethal conditions in many streams in lower elevations within warmer subzones, especially considering that some of these streams may be experiencing impacts from warming temperatures already. Rising temperatures in upper elevations may actually improve productivity for fish, in many cases these habitats are inaccessible except for isolated existing populations. As well, less persistent snowpacks in the ESSF with warming overall temperatures could mean that streamwater from upper elevations may be less able to help cool warming lower elevation streams.

4. FISH – Decreased water flows could reduce available fish habitat through portions of the TSA.

As precipitation patterns shift, reducing accumulations in snow, flow patterns may substantially shift, disrupting seasonal habitat use by local fish stocks. Where groundwater flows are important, it may be sufficiently reduced that some streams may be dewatered for a portion of the year, or perennial stream reaches may become ephemeral, stranding fish in the process. This is a higher risk in the southern half of the TSA, with warmer temperatures and drier summers.

5. FISH – Increased frequency and magnitude of storm events could impact habitat in some isolated areas.

See water quality point #2.

Direction

1. **Existing course filter watershed risk screening (and associated mapping) within the TSA needs to be augmented with climate change considerations, at least out to 2050.**

A GIS based watershed risk screening procedure was developed for and applied to 371 drainage units in the Kamloops TSA to understand relative potential risk across the TSA before and after expected MPB infestation (Milne et al. 2007⁵⁹). These relative rankings are intended to help identify those watersheds where the more detailed assessment is required and where investment of management resources can yield the greatest risk reduction.

The KTSA watershed risk screening process was initiated to investigate the impacts of MPB over time on watersheds in the KTSA. The strengths of the process are as a coarse filter for all watersheds in the TSA regarding hazard and risks. This would be extremely useful in strategic planning at a TSA level mostly because it goes beyond the provincial designations of “fisheries sensitive watersheds” and “community watersheds” under FRPA to designate approximately 60 watersheds with high or very high environmental risk and over 50 watersheds with high or very high social risk – some of which overlap with one another. This gives a much clearer picture of the nature of the TSA on a map, which is a much better strategic starting point than just focusing on the fisheries sensitive and community watersheds.

The KTSA approach fits somewhat with the provincial approach used to designate fish sensitive watersheds (Reese-Hanson and Parkinson 2006⁶⁰) but goes beyond it to also tease out the watersheds with high to very high social risks. These risks are associated with private land and populations centers, water intakes, irrigation, highways and associated infrastructure. All of these elements will likely be impacted by climate change and therefore need some consideration in planning.

2. High risk watersheds (from the coarse filter screening process) need a detailed analysis and plan based on risks to water and fish (especially salmonids) as influenced over time from climate change.

Strategies to mitigate these risks should then be designed and integrated into other targets and objectives. A pilot watershed may be useful to design a suite of mitigation practices that could be used in other high priority watersheds with similar sensitivities and attributes.

The MoE have been working on a more detailed risk assessment procedure in the Kamloops TSA for high risk watersheds identified in the watershed risk screening procedure using the Tranquille Watershed as a pilot area. The intent is to identify the specific risks within the watershed and design mitigation approaches. This could be a logical next step for all high and very high risk watersheds that emerge

⁵⁹ Milne, M.J., B.Grainger, C. Brown, L. Laithewaite. 2007. A risk-based watershed screening procedure for the Kamloops timber supply area. Version 4.0, May 22, 2007. Unpublished for the Kamloops TSA licensees and the BC Ministry of Environment.

⁶⁰ Reese-Hansen, L, and E. Parkinson. 2006. Evaluating and designating fisheries sensitive watersheds (FSW): An overview of BC’s new FSW procedure. Draft August 2006, BC Ministry of Environment.

from the coarse filter risk screening approach. It is critical however to build climate change implications into this procedure.

The result of such planning may see rate of cut may actually increased in some watersheds and decreased in others, depending on the nature of the watershed, its general condition, water use and importance, approaches to harvesting and road building, and other resource values. It may even be worthwhile to reforest stands to lower densities to improve snow accumulation and storage, but this must be strategically determined and integrated with other values.

In such detailed planning it will be a priority to carefully incorporate risk rankings for salmonids⁶¹ that explicitly considers climate change impacts on stream temperatures and other attributes into the detailed watershed assessment procedure. This information should be used to prescribe treatments using the triage approach to assign reasonable management priorities and targets, based on the ability to actually improve conditions suitable for future fish stocks within specific watersheds.

3. Until coarse filter TSA watershed screening has been updated to account for climate change, the following practices are suggested:

- i. Shade should be provided on all small fish streams and the shorelines of small lakes after timber harvesting except in wet cool BEC subzones.
- ii. Timber retention for other purposes should be concentrated on any existing inblock streams as much as practicable, whether they are fish streams or not.

Riparian shading is one of the few options available to help reduce stream temperatures. Even shading small upslope non-fish streams could help reduce water temperatures lower downslope. These are relatively easy practices to implement, but they could carry added costs for forest licensees. As well, shading of small streams is of no benefit if stream temperatures are expected to rise to lethal levels in spite of the added shading. Therefore, this direction underlines the importance of updating the TSA watershed screening approach with climate change considerations, and more detailed planning within high risk watersheds using a triage approach for priorities (higher priority for those that are urgent, where management can provide some help).

4. Coordinated local strategic forest management planning is required, involving the Regional District and appropriate government agencies in watersheds where consumptive use is significant.

First these local government bodies and agencies need to be aware of the impacts of climate change and possible steps that may be necessary to address these impacts. Watershed assessments conducted for forest management should be coordinated to feed information to other local planning bodies concerned with water consumptive use and associated infrastructure so they can adequate plan

⁶¹ Because salmonids appear to be the most sensitive fish to climate change, especially temperature.

into the future for the water storage facilities and licensing requirements that will likely be needed.

Gaps and/or Barriers for Implementation

1. There is a need for informed modeling of snowpack development and degradation over time and changes due to climate over time.
2. Need some monitoring of peak and low flows, carefully placed on selected watersheds that are at-risk for various reasons to test actual rate of change compared to assumptions based on climate modeling.
3. The detailed watershed-level planning envisioned for high risk watersheds and considering climate change is extremely difficult to initiate within a TSA. Any one Licensee with a volume-based tenure overlapping with other licensees are reluctant to lead such a process since it generally will not be funded by FIA, and will be difficult to coordinate with all the other licensees. The Ministry of Forests and Range at this time appear reluctant to lead such planning because they do not believe it is their role under FRPA to do so.
4. There is currently no clear mechanism in the province to coordinate local strategic planning goals between levels of government and agencies, in watersheds where consumptive use is significant.

Key Assumptions

1. Salmonids are the most sensitive fish species to climate change. This assumption should be checked. Other rare or sensitive species or groups of species may also be useful to help assess risk.
2. See climate trends for temperature and precipitation.
3. Assigned “ease of implementation” and “priority for management direction” are estimates based on the judgement of the KFFS team. For “ease of implementation” the number and difficulty of implementation barriers and gaps were considered. For “priority of management direction” the perceived ability of the direction to help mitigate and address management sensitivities across all important values were considered. All of these estimates required numerous assumptions regarding the importance of barriers and the potential impact of direction on management sensitivities. These relative rankings should therefore be scrutinized carefully by managers before they are assumed to apply as indicated and utilized in planning.

APPENDIX 5 - A Vision Of The Future Forest In The Kamloops TSA: Adapting future forest conditions for climate change.

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Introduction

This section provides a plausible view of what the future may be like with, and without, the KFFS. The intent is to summarize in one section the benefits of the strategy. In a way, this section is the argument for engaging in such a strategy over the long term. To be clear, the futures described here are believed to be realistically plausible if:

- The direction (and corresponding sensitivities) described in this report are viewed as merely a first step in exploring how climate change will impact TSA forests over time, and how we can change management to mitigate these impacts. This direction is built upon and modified as we understand more about climate change impacts and practitioners test and further explore approaches and practices to mitigate these impacts.
- On-going continuous strategic and tactical planning processes are followed as described in the recommendations (Section 6).
- On-going monitoring occurs and functional linkages to research are created as described in Section 6.
- Learning from formal monitoring, research, or informal operational trials and experience is quickly incorporated into planning and practices. And, provincial policies and legislation supports such a process.

A Vision of Managed Future Forest Conditions in the Kamloops TSA up to 2080

What follows is a vision of how forests will develop over time across the Kamloops TSA, in the five subzone groups, as a result of the direction in this strategy. It may be useful to compare this vision to descriptions of the future forest without following any KFFS direction - in the “potential future forest conditions” described by subzone or the more detailed *Ecological Narratives and Vulnerability Summaries* in the *Compendium of Supporting Documents*.

A Vision of the Dry Subzones Dominated by Lodgepole Pine with Management up to 2080

Includes - MSxk, IDFdk (SBPSmk)

Size – 28% of the THLB

After the mountain pine beetle epidemic subsides, this area will develop as a mosaic of Douglas-fir stands interspersed with large swaths of early seral pine plantations (30-40% of the THLB), scattered patches of dead standing pine, and ribbons of wetter sites with species such as redcedar, birch, spruce and cottonwood (depending on the subzone). In significant portions of the IDFdk there will be a matrix of Douglas-fir with ribbons and scattered patches of early seral lodgepole pine, while other portions of the IDFdk may look similar to the MSxk with extensive lodgepole pine.

As the extensive pine plantations mature, high levels of mortality from drought and bark beetles after 2050 will be avoided, by harvesting small wood for a variety of products, including biofuels and pellets and other new products. Not all of this stand type will be pre-emptively harvested and there will be a need for some salvaging beyond 2050. Nevertheless, when harvesting many of these pine stands, well-distributed clumps of maturing Douglas-fir and other species, established earlier in the rotation under the KFFS, will help provide shelter in this hot environment to recruit new stands of more resilient species.

Aspen presence will decline over time, but will still be prominent on slightly moister slopes and draws, where it has been protected and promoted through good planning and appropriate stocking standards. Douglas-fir stands will have many gaps, but close monitoring of bark beetle activity and prompt salvage will avoid large losses due to mortality. Douglas-fir stands will generally be managed using a range of silvicultural systems to ensure appropriate shelter for establishing suitable stocking levels. High stocking in young stands will not be desirable to promote forest health and manage fuels.

Although wildfire ignitions will increase due to more severe weather patterns and some larger fires will occur in this area, integrated planning for fire, biodiversity and timber, with subsequent harvesting, fuel management and other treatments will keep fire impacts at a manageable level. Some tree species, such as subalpine fir will disappear by 2080, although ponderosa pine (possible western larch on cooler slopes at lower elevations) will become a more prominent feature in several age classes scattered through the area.

A Vision of the Dry Subzones Dominated by Douglas-fir and Ponderosa Pine with Management up to 2080

Includes - IDFxh and the PPxh

Size – 10% of the THLB

The present mortality in ponderosa pine will change the nature of stands in this area over the short term. In the IDFxh, a gappy Douglas-fir matrix will remain, especially on warmer aspects with ponderosa pine regeneration, grasses and other early seral vegetation in the gaps. In the PPxh, ponderosa pine, Douglas-fir regeneration and early seral conditions will dominate, with patches of mature Douglas fir and scattered remnant ponderosa pine creating a sparse patchy mosaic.

As conditions get hotter and drier, pre-emptive harvesting, salvage and well-planned fuel management will help to regenerate and maintain open stands of ponderosa pine and Douglas-fir well-distributed on some of the more productive sites throughout this area. A considerable amount of area may revert to a grassland-dominated state, although stand treatments will encourage widely scattered clumps of trees for structure and habitat.

Beyond 2050 continuous Douglas-fir stands may be limited to north slopes and upper elevations, while open ponderosa pine stands, and semi-forested grasslands will dominate lower elevations and on warmer aspects, maintained in part by integrated planning to manage fire risks and fuels. Aspen on moist sites and cottonwood on wet sites will continue to maintain a presence on the landscape, albeit a diminished one, through management efforts to maintain and promote broadleaf species.

A Vision of the Moist-to-Dry Transitional Subzones ICH to IDF with Management up to 2080

Includes – IDFmw, ICHdw, ICHmw (ICHmk)

Size – 26% of the THLB

Mixedwood and mixed conifer stands will see a higher proportion of aspen or become gappy with brushy openings. This will be mostly due to scattered mortality from drought, root disease and insects in Douglas-fir, redcedar, hemlock, spruce and birch. Harvesting of these stands will be well-timed before economic timber volumes are lost. This pre-emptive effort will allow a significant proportion of these stands to be regenerated after stumping with a resilient mix of Douglas-fir, western larch, ponderosa pine, possibly white pine and other species. Past 2050 many lodgepole pine stands will be targeted for pre-emptive harvesting before significant mortality from a range of factors.

It is likely that past 2050 birch and redcedar will gradually disappear over much of this area. Management to strategically maintain a broadleaf component on the landscape (mostly aspen) will help maintain habitats and forest health, and reduce the potential spread of large wildfires. Past 2050 some unusual shrub-dominated communities may appear with clumps of conifers or broadleaf trees, but these will be limited to scattered patches between relatively healthy and productive stands.

Douglas-fir stands on warmer aspects will be managed with a range of silvicultural systems and fuel management treatments as open stands, possibly with irregular stand structure. Some grassy openings will develop on less productive drier sites, but will not be prominent on the landscape.

The amount of harvesting, other treatments and mortality in this area will ensure a significant distribution of seral stages across the landscape. Continuous integrated strategic planning and management treatments will ensure functional representation of old-forest winter range and other habitats through active recruitment and replacement on the landscape.

A Vision of the Dry to Moist Plateau or High Elevation Subzones with Management up to 2080

Includes – MSdm, SBSmm, ESSFdc (ESSFxc)

Size – 15% of the THLB

In stands with a mixture of spruce/subalpine fir and Douglas-fir, mortality gaps that started with the death of lodgepole pine will continue with scattered subalpine fir mortality that will become common after 2050. Initially the open spruce and Douglas-fir stands will respond with increased growth on mature trees up to 2050. Beyond 2050, targeted harvesting using a mix of silvicultural systems will remove vulnerable spruce, avoiding excessive episodic bark beetle mortality mostly in the MSdm and SBSmm.

Over 30 % of this area will be in 40-70 year old lodgepole pine stands by 2050. Continuous monitoring, well-targeted late rotational fertilization, and well timed pre-emptive harvesting beyond 2050 will facilitate conversion to more resilient species combinations over much of this area prior to 2080. Some proactive harvesting on a smaller scale in vulnerable spruce-subalpine fir stands beyond 2050 will help establish more resilient mixtures in those stands as well.

Aspen will be allowed to expand into some gaps created by drought and forest health agents throughout the area, and birch will be encouraged in some disturbed areas at lower elevations. This Subzone Group will become one of the more favourable landscapes for broadleaf trees, so they will be encouraged over a strategically planned proportion of the subzone for all the inherent benefits they provide.

The proactive harvesting and integrated strategic planning will allow for a good mix of age classes and seral stages. Although wildfire ignitions will increase, large fires will not have a huge impact over the TSA.

A Vision of the Wet Cool/Cold Subzones with Management up to 2080

Includes – ESSFwc, ICHwk, (ICHvk)

Size – 21% of the THLB

Existing stands in this area will mostly continue growing and dying as they have during recent history. Younger stands, particularly on cool aspects will likely improve productivity with warmer temperatures and a prolonged growing season. However, the anticipated growth reduction in young spruce stands due to weevil damage, and the accelerated mortality in old stands (increased respiration and increased saprophytic activity with limited ability to increase photosynthesis to compensate) will likely negate substantial gains in productivity.

Harvesting will likely not occur here in a major way for some time as priorities for harvesting will be strategically planned in other, more vulnerable, areas. When significant harvesting does occur here, some gains in productivity may be accomplished due to a greater use of species other than spruce – such as: redcedar, Douglas-fir, possibly white pine and lodgepole pine. The degree to which these species will be used is still uncertain as significant questions remain regarding the impacts of future snow loading and frost events. The bottom line in this subzone grouping is that some minor impacts may be felt on a number of habitat values, and some minor gains in productivity may be realized for timber, but impacts, both positive and negative, will not be large.

Opportunities for Biodiversity and Habitat in the TSA with Management up to 2080

With the KFFS Direction:

The Kamloops Forest Strategy direction was created to provide options for species movement and survival within a warming climate. As well as remaining in situ, many species will move to find conditions they can tolerate because management has created a permeable forest. Despite management efforts, some species may not be able to move to find suitable conditions and some native species will not persist in the area in the new climatic conditions. However, new emerging conditions may favour other species. Although management efforts help contain and reduce rates of spread of invasive species, invasive species will likely increase to some degree in many areas in response to the warmer (and often drier) climate trends.

If the direction provided in the KFFS is followed and built upon over time the following results are envisioned for biodiversity:

1. Species survival may increase or decrease in response to a range of climatic factors, however it will not be limited by either stand level or landscape level retention, due to coordinated planning and implementation at both scales. Other factors like competition from invading species may have an impact.

In-block retention will be present in varying amounts, depending on stand types and ecosystems, providing sufficient structures and habitats for endemic species across the TSA as refugia in disturbed areas and as stepping stones of habitat to allow organisms to disperse to more favourable areas. Active on-going monitoring and associated research will provide feedback and continuous learning to facilitate timely adjustment to retention strategies and shifting of priorities (using a mix of flexible and fixed retention and reserves).

2. There will continue to be suitable representation of old forest habitats throughout the TSA over the longer term, because of the flexible approach used to designate OGMA's, the well reasoned purpose for OGMA's in various locations, and the managed and sustained presence of sufficient alternate areas to re-allocate and recruit OGMA's.
3. Ungulate movement in response to climate change, including that of deer and caribou, will be anticipated and facilitated by sustaining suitable habitat for movement and through recruitment of new winter ranges.
4. For caribou, important forage lichens will persist as climate conditions shift, partially due to well-designed partial-cutting silvicultural systems in managed portions of winter ranges. The evolution of effective partial-harvesting methods will be facilitated by careful monitoring, research and operational trials. Caribou survival may be influenced by other factors such as predator populations and movement, snowpack attributes and recreation patterns, which will be studied and monitored over time.

5. Most species of concern (red, blue and SARCO listed species) will tolerate the changing climate, with only a few being severely impacted, likely due to influences outside of the TSA (possibly outside of BC as in neotropical migrant birds).

Strategic planning of harvesting and retention patterns across the landscape will initially be designed to maintain species of concern. Over time habitat locations will be understood, and monitored. When populations appear to be struggling, management directions to assist those species are identified and implemented. Levels and timing of disturbance will be regulated to protect disturbance sensitive species. The potential for assisted migration is explored for plants with local distributions threatened by climate change (if and only if they appear not to be tolerating local conditions).

6. Invasive species are held to relatively low levels, through timely coordinated efforts to identify and control them before they became a widespread problem.
7. Wildfires occur more occur regularly but are controlled with only limited impacts on important habitats and plants or ecosystems sensitive to burning. Prescribed burning, harvesting and stand tending treatments that are used as fuel-reduction tools and good monitoring all help to manage risks.

Risks of Not Implementing the KFFS Direction:

Lack of strategic integration of harvesting and habitat needs together with increased fire impacts and inadequate and non-flexible reserves, will mean habitat for many species is insufficient in amount and distribution. The result could well be:

- Many species are unable to use or move through stands with inadequate stand level retention and will become locally extirpated.
- Areas of old forest presently in OGMAs are disturbed by natural disturbance and, because planning has not taken into account natural disturbance and harvesting patterns, there are no replacement areas of old forest available.
- Available habitat for species that prefer mature or old forests will be severely reduced and fragmented except in isolated sub-basins, generally in upper elevations, within the southern and central portion of the TSA.
- Ungulates will be limited in their ability to move suitable winter ranges as no old forest exists due to disturbance and harvesting or salvage. Numbers are reduced over severe winters.
- Locally rare species or species of conservation concern are overlooked in management plans so areas are harvested, burned or grazed without realizing geographically restricted populations are harmed.
- The number of invasive species increases and their distributions increase because efforts to control them are un-coordinated and not as effective as necessary.

Opportunities for Interface and Fire Management in the TSA up to 2080

With the KFFS Direction:

As future climate warms it is most likely that the occurrence of wildfires will increase, regardless of precautions and mitigation practices that are put in place. However, when the KFFS is followed, in an adaptive manner (with continuous improvement over time), fuel reduction treatments in the drier and transitional moist-to-dry subzones will help reduce the extent and severity of wildfires in this area. These practices will be well planned strategically to integrate with other values and ensure treatments are timely, effective, appropriately funded and efficient. Cooperation and communication within and between government agencies, local communities, and stakeholders will be high. The following plausible results are envisioned for biodiversity:

- Timber availability will be more predictable with well-planned harvesting in a proactive manner in priority areas to reduce fuels and wildfire impacts on future age class distributions. These harvesting activities, when combined with fuel reduction techniques will ensure that even though wildfires will occur, their impacts will be less severe than originally anticipated with climate change.
- Significant impacts of wildfire on property and infrastructure in the rural-urban interface will be occasional and kept relatively low, and loss of human lives will be avoided.
- Recreational use and recreational properties will continue to be important within landscapes that are still considered visually attractive, even though human and natural disturbances are apparent.
- Broadleaf tree species will suffer some decline in drier subzones but through a concerted effort, will continue to have a significant well-distributed presence over the landscape. In this way, broadleaf species will help to reduce fire spread and improve general habitat structure at the landscape and stand scales.
- Extensive and severe changes in seral stage compositions due to extensive wildfires across large landscapes will generally be avoided.

Risks of Not Implementing the KFFS Direction:

Wildfires will have an extensive, often severe impact on the landscape character, forest age classes, tree species diversity and habitats across 65% of the TSA. This impact will be felt in all but the wet and very wet, cool and cold subzones that are concentrated mostly in the Northern portion of the TSA. The result could well be:

- A large variation in the availability of timber with unpredictable salvaging cycles followed by imbalanced age classes creating frequent divergent boom and bust cycles.
 - The reduction in timber supplies will be felt across the TSA and may be catastrophic for some small licensees with area-based tenures near warmer drier valleys that are most at risk to wildfire.
- A succession of fires in the rural-urban interface causing large amounts of damage to property and infrastructure, possibly threatening or costing human lives. This will result in escalating provincial costs for protection and fire suppression.
- Reduction in use and value of recreational property will occur as lakeside views in the southern half of the TSA are extensively and severely disturbed by wildfire and salvage logging.
- Available habitat for species that prefer mature or old forests will be severely reduced and fragmented except in isolated upper elevation sub-basins, within the southern and central portion of the TSA.

Opportunities for First Nations Culturally Important Plants in the TSA with Management up to 2080

With the KFFS Direction:

As future climate warms with drier summers, some plant species will no longer be adapted to survival within their historical location. First Nations use of known culturally important plants will be impacted by this change. The following plausible results are envisioned for First Nations culturally important plants:

1. First Nations will continue to have access to most important cultural plants within traditional territories, although sites and use patterns may change. Some plants may need to be accessed outside of traditional territories.
2. Protection and use of important cultural plants will occur with good communication and sharing of information between First Nations bands, licensees and the province, through good strategic planning and a common understanding of general climate and ecological trends.

This trend will be mostly facilitated through a process of information sharing and cooperative management that evolved since the inception of the KFFS.

Risks of Not Implementing the KFFS Direction:

Lack of strategic, integrated planning without following and building on the direction in the KFFS will result in:

1. Local losses of known culturally important plants.
2. Missed opportunities to manage Known Culturally Important Plants that may be at risk.

Opportunities for Timber in the TSA with Management up to 2080

With the KFFS Direction:

If the direction provided in the KFFS is followed and built upon over time the following results are envisioned⁶²: Also see 7-9 – at the end of this subsection.

1. A good distribution of growing stock is available through the range of age classes. Even though timber supply will be somewhat reduced overall, there will still be considerable timber available for harvesting by the end of the century in well stocked healthy stands and productivity will remain at acceptable levels (Table 7-1 – at the end of this subsection).
2. Opportunities to take advantage of potential increases in productivity in moist and wet subzones will be maximized by matching species choices including the use of assisted migration to fit with the anticipated future climate and microsites. This will help offset declines in productivity in hot and dry subzones.
3. Various parts of the TSA will see unexpected sudden mortality in stands -this will not be a common continuous occurrence. Rather, many vulnerable stands will be harvested and regenerated in a proactive manner before they die (and reactive harvesting is necessary) and timed to maximize value. Increased use of smaller logs for novel products will help (such as biofuels and pellets).
4. A wide range of species, sizes and grades will be available to choose from for harvesting at the end of the century and beyond.
5. Mature mixes of tree species on hot dry sites will allow for retention of shade trees at harvest to promote regeneration and continuation of a productive contribution to timber supply.
6. Contraction of the timber harvesting landbase will be relatively minor (averaged across the TSA), limited to stands that are already somewhat marginal for timber production becoming uneconomic, and some expansion of grasslands in the dry Douglas-fir / ponderosa pine subzones.

⁶² With any plan or direction the outcomes are subject to a range of known and unknown factors. The intent of this section is to point out the possible gains that would occur if the KFFS is followed based on the plausible futures assessed. A separate section follows that provides a narrative of what the impact of not following the KFFS might look like.

7. Well integrated proactive, strategic planning will avoid reactive management decisions and/or policies and regulations that could severely and suddenly constrict timber supply.

Risks of Not Implementing the KFFS Direction:

If the direction provided in the KFFS IS NOT followed and built upon over time the following results are envisioned: Also see 7-9 – at the end of this subsection.

1. Future harvesting options will be driven by mortality, resulting in sub-optimal mixes of species, grades and sizes.
2. A significant reduction in the THLB due to mortality in numerous stands (on dry sites and in former transitional mixedwood types) that will become uneconomic and not be harvested.
3. TSA growing stock with substantial gaps in age classes, reducing harvest sustainability and impacting the availability of timber at the end of the century.
4. Wide-spread catastrophic mortality in younger timber of marginal or uneconomic size classes could become relatively common. These may be difficult to address with harvesting and result in significant impacts on timber supply.
5. As high levels of disturbance from harvesting, drought, insects, disease, and wildfire start to have a large impact on habitats and other values, stakeholder and public concerns prompt extensive additional set-asides and a major reduction in timber supply.

Opportunities for Visual Landscape Management in the TSA up to 2080

With the KFFS Direction:

As future climate warms disturbance through insect and disease will result in greater mortality of old stands resulting in an increase in salvage logging. Disturbance due to wildfires will increase, regardless of precautions and mitigation practices that are put in place. This will impact options and the ability to manage for visuals to some extent. However, when the KFFS is followed, using a coordinated approach, visual management can be incorporated into proactive harvesting (targeting stands that are highly susceptible to mortality, prior to it occurring), salvage logging and management approaches to reduce the risk of fire. The following plausible results are envisioned for visual landscape management:

1. A coordinated and well designed visually-acceptable harvest pattern will be apparent, even though the focus is on other management objectives such as slope stability, habitat protection, and fuel management.
2. The public will be satisfied with visual quality, in part because of their knowledge regarding the risks of inaction and their informed input into options and outcomes.

Risks of Not Implementing the KFFS Direction:

Management for visuals will be severely limited by unplanned disturbance. The result could well be:

1. There will be highly altered viewsapes due to forest health agents and large fires. Retention that will not be coordinated with other values resulting in added area retained that may not be suited to other purposes, possibly reducing the allocation to more specific uses such as habitat or open space for regeneration.
2. There will be a reduction in use and value of recreational property as recreational areas and associated viewsapes in the southern half of the TSA are extensively and severely disturbed by wildfire and salvage logging.

For more information on the sensitivity and KFFS direction for this management value – see Appendix 2.

Opportunities for Watershed Management in the TSA up to 2080

With the KFFS Direction:

Water and aquatic habitats will see significant impacts as higher summer water temperatures, lower snow levels and/or earlier spring runoff and extended summer droughts have an impact. The following plausible results are envisioned for watershed management:

1. Gradually up to and beyond 2050 salmonids across the southern portion of the TSA decline and locally disappear in key waterbodies and habitats. However these declines will not be as extensive as originally expected due to screening of high risk watersheds and habitats, and targeted treatments for habitat improvement and additional riparian reserves, based on realistic opportunities to reduce water temperatures and sustain salmonids.
2. Water consumption is managed within anticipated demands before shortages occur, by construction of carefully-targeted local water storage, combined with policies and licensing for water use, coordinated between provincial agencies and local governments. As well, harvesting is carefully planned in watersheds designated to be at-risk for supplying anticipated water demand – with more or less harvesting planned in various portions of the watersheds over time.
3. Water quality is maintained in spite of significant increases in amount of precipitation per storm event, and the intensity of storms in wet subzones where precipitation levels are already high. Again this achievement will be facilitated by risk ranking, and coordinated strategic watershed planning in high risk watersheds.
4. Very little infrastructure damage is incurred due to flooding and debris torrents. Infrastructure is upgraded and planned to appropriately match anticipated increased precipitation and intensity of delivery, and increased risks of mass wasting and debris torrenting is carefully managed.

Risks of Not Implementing the KFFS Direction:

Watersheds and aquatic habitat may be significantly impacted without planned management action to address climate change. The result could well be:

1. Widespread loss of salmonids in throughout the southern portion of the TSA.
2. Significant, periodic water shortages for communities and agriculture throughout the area.
3. A general reduction in water quality in cool/cold wet subzones, with significant reductions during periods of high precipitation.
4. Significant episodic infrastructure damage in cool/cold wet subzones due to flooding and associated debris torrenting events, with impacts on transportation, commerce, and possibly property and lives.

Conceptual Timber Supply Impacts Table for the KFFS:

SUBZONE GROUP	BEC Subzones	% of THLB	THLB Change ¹		Productive Capacity Change ²		Growing Stock on the THLB ³ (loss to disturbance)	
			Without KFFS	With KFFS	Without KFFS	With KFFS	Without KFFS	With KFFS
1. Dry with Fd & Py	IDFxh, PPxh	10%	↓	↓	↓↓	↓	↓↓	(↓)
2. Dry with Pli	MSxk, IDFdk (SBPSmk)	28%	↓	↓	↓	↔	↓↓	(↓)
3. ICH-IDF transition	ICHmw, ICHdw, IDFmw, (ICHmk)	26%	↔	↔	↓	↔	↓↓	(↓)
4. Moist-Dry Plateau / High Elev	MSdm, SBSmm ESSFdc (ESSFxc)	15%	↔	↔	↔(↑)	↑(↑)	↓(↓)	(↓) to ↔
5. Cool/Cold and Wet	ESSFwc, ICHwk (ICHvk)	21%	↔	↔	↔↑	↑	↓	(↓)

- THLB Change:** Refers to the size of the Timber Harvesting Land Base (THLB). This is the subset of the land base where commercial forest harvesting and silviculture practices are expected to occur. It is partially defined by its ability to grow commercially viable trees in a reasonable timeframe. Climate change has the potential to render some currently marginal sites uneconomic from a commercial forestry perspective.
- Productive Capacity:** Refers to the areas inherent ability to grow trees (site index). Climate change can have an impact on site productivity through changes in temperature and moisture regimes. Management can mitigate this through selection of tree species that are optimally productive under changing conditions.
- Growing Stock on THLB:** Refers to the amount and type of stands currently on the landbase and includes the merchantable stands that short term harvesting activities depend on. Our goal is often to hold growing stock on the landbase until harvesting can remove it in an orderly way that allows previously harvested stands time to regrow. Climate change has the potential to impact growing stocks by changing natural disturbance patterns and/or impact levels that result from fire, pests, and disease. Unplanned losses of growing stock have a negative impact on timber supply, and the older the stand is when it is impacted the larger and more immediate the negative impact.

Rationales for effect of KFFS on Timber Supply:

Dry with Douglas-fir and ponderosa pine

- Will lose ground to grassy openings and grassland patches – likely little can be done but maintain some scattered clumps. May lose less with good species management.
- Will likely lose productivity as it gets really dry(drought index goes up – precip not changing significantly) – however might lose less productivity if we can start getting better mixes of ponderosa pine and Douglas-fir in these stands.
- Anticipate some loss of growing stock here, but less with the KFFS.

Dry with lodgepole pine:

- Some marginal sites will be lost to NP – likely little we can do.
- Productivity may not be lost but rather maintained if we can utilize a better mix of species with more Douglas-fir (possibly ponderosa pine on dry sites).
- We might be able to save considerable growing stock, but it is likely that some non-merch Lodgepole pine will slip through the cracks and increased frequency of fire and insect disturbances will result in the loss of existing volume. Vigilant efforts to fight fires and proactively address insect infestations can mitigate....

ICH-IDF Transition

- We anticipate THLB will stay about the same (might be a small loss on south slopes) – may be avoided with management if we can get more ponderosa pine on those sites.
- The productive capacity we expect to improve and be maintained on majority of sites– Armillaria up to 2050 will get worse but if we stump and use a mix of species we should be able to take advantage of better growing conditions to balance the losses to Armillaria.
- We should be able to reduce losses of growing stock by targeting marginal mixedwoods before an economic harvesting chance is lost. Proactive management of pests...

Moist-Dry Plateau/ High Elevations

- THLB loss not an issue. Some marginal site index stands may see productivity improve enough to bring them into the THLB but on a very small scale.
- Thoughtful management can take advantage of better growing conditions, particularly close to 2050 with a better mix of species (Douglas-fir, western larch, white pine, ponderosa pine, birch, aspen) resulting in improved productivity.
- Should also reduce losses of growing stock by targeting the right stands for harvest. One concern remains – existing young subalpine fir stands which may still be lost.

Cool/Cold Wet ICH/ESSF

- Increasingly favourable climates for growth trees unlikely to result in more THLB because these alpine areas don't have the soils to support tree growth even if the climate is suitable. There may be a slight improvement as marginal productivity stands improve enough to allow commercial harvesting to be viable. This is expected to be a very small area.
- The favourable growing conditions may be better utilized with a greater range of species – however this could be challenging with the snow-loading in this zone and other pests.
- Under FFS, we may see a bit of a reduction in growing stock losses – however here they are mainly in old growth stands that cannot take advantage of better growing conditions and yet cannot resist increased activity of heart-rots and other fungi. With all the set asides here, it will likely be difficult to deal with these stands much.

APPENDIX 6 - ASSESSING TSA VULNERABILITIES TO CLIMATE CHANGE – A Summary of Sensitivities, Adaptive Capacity Vulnerabilities.

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Background – Assessing Adaptive Capacity and Vulnerabilities

Intent and Focus of this Section:

A central focus for the KFFS is to provide direction and management actions and/or options to help address potential impacts from climate change. In designing this direction, implementation barriers and knowledge/ data gaps were also tracked. With the climate modeling data and the ecological sensitivities identified, the essential components are present for an initial vulnerability analysis to climate change in the TSA. Such an analysis helps to characterize priorities and challenges for implementation.

Since vulnerability assessments are relatively new to forestry practitioners, this section will first review classic vulnerability assessment concepts and introduce the approach used in the Kamloops TSA. As well, relevant components will be summarized and discussed for the entire TSA including:

- Ecological sensitivities
- Management sensitivities
- Adaptive Capacity considerations – implementation barriers.

Lastly this section will describe the potential management vulnerability and the projected management vulnerability by Subzone Group, explain the difference between the two, and their implications for management.

Background on Vulnerability Assessment

Vulnerability assessments for climate change are characterized using the following relationship (Johnston and Williamson 2007⁶³):

$$V = f(E, S, A)$$

With this approach, *V* is vulnerability of the system of interest, *E* is exposure, *S* is system sensitivity, and *A* is adaptive capacity. *V* is a positive function of the system's exposure and sensitivity, and a negative function of the system's adaptive capacity.

Exposure (*E*) refers to the nature of the changing climate. In this project it was explored in detail for twelve BEC subzones. Sensitivity of the management system is based on sensitivity of the ecosystems that are being managed. For that reason, in this project ecological sensitivity was differentiated from management sensitivity (Fig A6.1).

Ecological sensitivity was first assessed for the twelve key BEC subzones by considering how local climate is expected to impact (exposure) the current ecological conditions and processes to help predict the subsequent alterations in ecosystems that may occur (ecological sensitivity). Similarities in ecological sensitivities, and current ecological attributes that influence management prompted aggregation of the twelve subzones into five Subzone Groups.

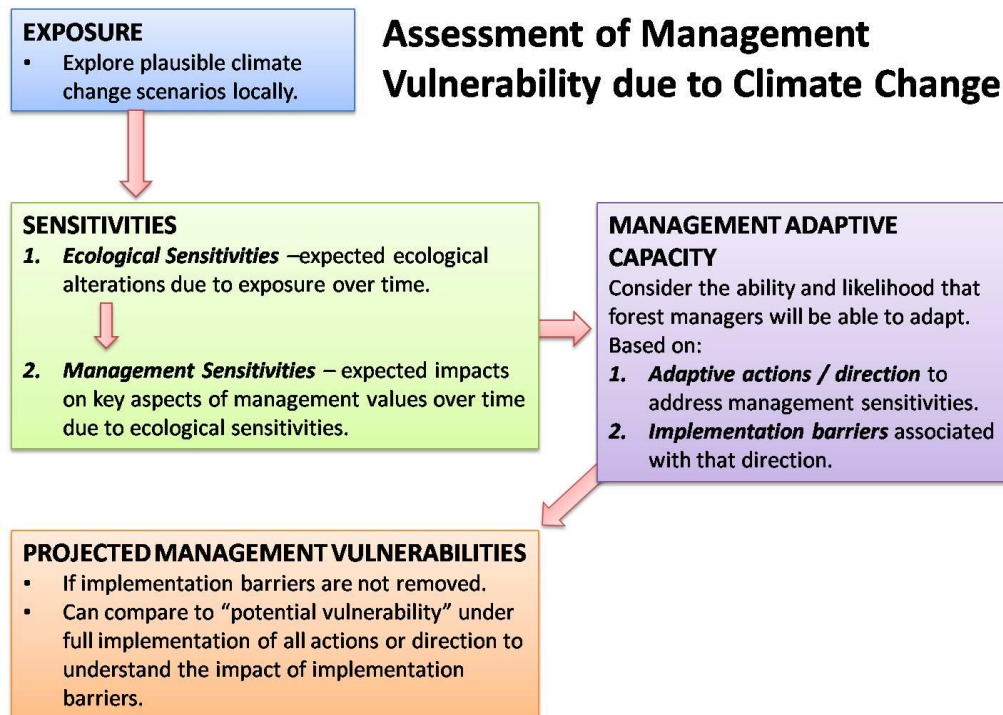


Fig A6.1. Diagrammatic flow chart of the assessment procedure for management vulnerability in the Kamloops Future Forest Strategy.

⁶³ Johnston, M., T. Williamson. 2007. A frameworks for assessing climate change vulnerability of the Canadian forest sector. *Forestry Chronicle*, Vol. 83, No. 3. Pp 358-361.

Management sensitivity was determined by considering the expected alteration, either positive or negative to the key aspects of management values in the five subzone groups, i.e., the level of impact on the value based on climate change. Projected management vulnerabilities are the product of management sensitivities adjusted by the ability of the management system to adapt, or the likelihood that the manager will be willing and able to implement actions to adapt (management adaptive capacity).

The management adaptive capacity is determined by considering the proposed management actions / direction and the implementation barriers associated with those actions / direction. The importance of the implementation barriers can be highlighted by considering the difference between projected vulnerability, and potential vulnerability - if all management actions/direction is followed and implementation barriers removed (no adaptive capacity issues).

It should be noted that determination of adaptive capacity in the KFFS only considered climate change as a feature of “exposure”. Additionally, only implementation barriers that can be influenced by the government and stakeholders in British Columbia were explored. Exposure influences such as projected population expansion and land use changes were not considered. Adaptive capacity influences such as projected global markets were also not considered.

Summary of Ecological Sensitivities in the Kamloops TSA

Over 60% of the Timber Harvesting Land Base (THLB) within the TSA is projected to be threatened with a moderate-to-high or a high ecological sensitivity (Table A6.1). This means that a high or moderate-to-high degree of ecological alteration is expected within these subzone groups.

The most susceptible subzones fall within the two dry subzone groups and the moist transitional subzones in the ICH and IDF. In the dry subzone groups a significant proportion of the area is forecast to change from coniferous forests to a grassland or forested grassland type. In the ICH-IDF transitional subzones a significant decline in the proportion of the coniferous content in mixedwood types is expected. Continuous coniferous stands are expected to become open, irregular conifer stands or mixedwoods.

Only 21% of the THLB in the Kamloops TSA is expected to have a low ecological sensitivity. This area is in the wet cool / cold subzones where stands will change in subtle ways with fewer obvious changes across the landscape over time.

For more information on ecological sensitivities:

- For the five subzone groups – see *Appendix 3*.
- For the 12 individual subzones - see *Ecological Narratives* in the *Compendium of Supporting Documentation*.

Table A6.1 Overview of ecological sensitivities in the Kamloops TSA, based on expected impacts from climate change, ecological conditions and perceived ecological adaptive capacity. The sensitivity ranking indicates the degree of ecological alteration that is forecast by the scenarios tested (e.g. changing plant communities, disturbance regimes and other processes). The rationale includes key points from the ecological narratives, that tend to emphasize the worst-case / most change climate scenario to explore how much change may occur.

SUBZONE GROUP	BEC subzones	% of THLB in TSA	Ecological Sensitivity	Summarized Rationale for Sensitivity
Dry Subzones with Pli	MSxk, IDFdK, (SBPS)	28	HIGH	<ul style="list-style-type: none"> • Too hot and dry after 2050 for Pli. • Estimate 37% of THLB in young Pli that will not be ecologically suitable past 2050. • Increased fire risk.
Dry with Fd & Py	IDFxh, PPxh	10	HIGH	<ul style="list-style-type: none"> • Continuing mortality in Fd will thin out and open up stands. • Increased grassland patches. • Increased fire risk.
ICH-IDF Transition	ICHmw, ICHdw, IDFmw, (ICHmk)	26	MOD-HIGH	<ul style="list-style-type: none"> • Fd drops out of mixedwoods due to drought / Armillaria / D-fir beetle combo. • Lose considerable Cw, Sx, Ep past 2050 • Increased fire risk.
Dry- Moist Plateau/ High Elev	MSdm, SBSmm, ESSFdc, (ESSFxc)	15	MOD	<ul style="list-style-type: none"> • Increased growth in most species (except BI) up to 2050. • Beyond 2050 – BI drops out, Pli at high risk, Sx questionable on some sites lower down. May see a few large fires.
Cool/Cold & Wet	ESSFwc, ICHwk, (ICHvk)	21	LOW	<ul style="list-style-type: none"> • Increased mortality in old growth • Increased growth in young stands • Weevil increasing problem for young Sx.

Summary of Management Sensitivities in the Kamloops TSA

Using the understanding of ecological sensitivities and the types of changes that may occur across the TSA, management actions can be adjusted over time to avoid being “painted into a corner” leaving only a few difficult options available. To achieve this goal management values and the impact of plausible climate change scenarios were investigated.

Potential management sensitivities were estimated by considering the ecological sensitivity, the ecological conditions that create that sensitivity, and the important aspects of each management value in each subzone group (Table A6.2). The rankings help focus attention on management concerns by area and value.

Table A6.2 Overview of management sensitivities in the Kamloops TSA, based on expected impacts on management from the ecological sensitivities in Table A6-1. The sensitivity ranking indicates the degree of impact on various aspects of key management values. The rationale tends to emphasize impacts from the worst-case / most change climate scenario to explore how much change may occur.

SUBZONE GROUP	BEC subzones	% of THLB in TSA	Management Sensitivity	Summarized Rationale for Sensitivity
Dry Subzones with Pli	MSxk, IDFdK, (SBPS)	28	MOD-HIGH	<ul style="list-style-type: none"> • High impacts on productivity and growing stock for timber. • High impacts on biodiversity and a range of habitats and fish. • Significant issues for water, interface, and First Nations culturally important plants.
Dry with Fd & Py	IDFxh, PPxh	10	HIGH	<ul style="list-style-type: none"> • High impacts on THLB, productivity and growing stock for timber. • High impacts on biodiversity and a range of habitats and fish. • High impacts for water, interface, and First Nations culturally important plants. • Significant issues for visual quality
ICH-IDF Transition	ICHmw, ICHdw, IDFmw, (ICHmk)	26	MOD-HIGH	<ul style="list-style-type: none"> • High impacts on productivity and growing stock for timber. • Significant issues on biodiversity and a range of habitats and fish. • Significant issues for water, and interface. • Significant issues for visual quality
Dry- Moist Plateau/ High Elev	MSdm, SBSmm, ESSFdc, (ESSFxc)	15	MOD	<ul style="list-style-type: none"> • Moderate impact on growing stock for timber. • Significant issues for some habitats and fish • Moderate impacts for water and First Nations culturally important plants.
Cool/Cold & Wet	ESSFwc, ICHwk, (ICHvk)	21	MINOR-MOD	<ul style="list-style-type: none"> • Minor timber supply concerns long term – may be some short term benefits. • Minor concerns for habitat, except for Caribou where there are many outstanding questions. • Significant issues possible for water quality.

The rankings used in the table were determined as follows:

High sensitivity– There is a high likelihood of a substantial negative impact on the management concern.

Moderate sensitivity – There is a high likelihood of a limited negative impact on the management concern.

Minor Sensitivity – There is a likelihood of a small impact.

A comparison of tables A6.1 and A6.2 reveals that ecological sensitivity has a significant impact on management sensitivity. It is clear however that the two sensitivities should not be assumed to be the same in the subzone groups. Management sensitivity is influenced by the range of management values present and their importance in the subzone group (Table A6.3).

Table A6.3 Example of a subzone group overview of management sensitivities, potential managed vulnerability (all direction followed and barriers removed), and projected managed vulnerability (no barriers removed and implementation is impeded accordingly). The +/- symbols merely help to show relative perceived changes. Similar tables for all subzone groups are found in subsection 8-6 (end of this section)

Dry Subzones with Lodgepole Pine - MSxk, IDFdk (SBPSmk)					
Management Value	Specific Concern	Sensitivity RATING	Potential Managed Vulnerability		PROJECTED MGMT. VULN.
			Ability to change with Mgmt	Potential Managed Vuln Rank	RANK
SUBZONE GROUP	Size of working landbase	MODERATE TO HIGH	Very Low	MODERATE TO HIGH	MODERATE - HIGH
	productive capacity of the working landbase	HIGH	High	MINOR	HIGH -
	Growing stock on the working landbase	HIGH	Mod-High	MINOR TO MODERATE	HIGH -
	Economics	MODERATE	Very Low	MODERATE	MODERATE
BIODIVERSITY	Old growth habitats	HIGH	Mod	MODERATE	HIGH -
	Wildlife trees/ WTPs and landscape permeability	HIGH	High	MINOR	HIGH -
	CWD	MODERATE	High	MINOR - -	MINOR TO MODERATE ++
	Ungulates (designated winter ranges)	MINOR		MINOR	MINOR
	Other species of concern or at risk (red and blue)	HIGH	Mod	MODERATE	HIGH -
	Invasive species	HIGH	Mod	MODERATE	HIGH -
FIRST NATIONS	Culturally important plants	MODERATE TO HIGH	Mod	MINOR TO MODERATE	MODERATE TO HIGH -
INTERFACE	Fire risks	MODERATE TO HIGH	High	MINOR -	MODERATE ++
WATER AND AQUATIC ECOSYSTEMS	Watershed management - water supply	MODERATE TO HIGH	Mod	MINOR TO MODERATE	MODERATE TO HIGH -
	Fish Habitat - Salmonids	HIGH	Very Low	HIGH	HIGH
OTHER	Visual Landscape Management	MODERATE	High	MINOR - -	MINOR TO MODERATE ++

The most important management sensitivities in the Kamloops TSA emerge due to increased stand mortality as conditions become hotter and drier through the summer, especially beyond 2050. This mortality will be due to drought stress, insects, pathogens, and a higher incidence of larger and more severe wildfires. Impacts will be significant for biodiversity, habitats, fish, timber, interface values, watershed values, and First Nations culturally important plants.

It should be noted that for timber management these extreme conditions will reduce productivity on many sites, especially in dry subzones. It will also have large impacts on growing stock, with substantial losses occurring in pulses of mortality that coincide with warmer, drier climatic cycles. These impacts will similarly have a major influence on biodiversity and habitat, with a significant decline in structural and habitat complexity, a large increase in early seral communities, the appearance of novel plant communities and an increase in invasive species.

Other values that depend on a significant amount of forest cover, such as visual quality will be degraded in a number of areas. First Nations culturally important plants will be displaced locally in some subzones. Water quantity and storage will be a major concern, especially in watersheds with a preponderance of drier subzones. In the cool wet subzones, the projected increase in precipitation delivered during extreme weather events may cause problems with water quality, and could possibly threaten infrastructure. Salmonid populations are expected to decline, potentially disappearing in some locales, as adverse water temperatures spread through the warmer portions of the TSA.

Adaptive Capacity considerations

As previously mentioned adaptive capacity describes ability of the management system to adapt, or the likelihood that the manager will be willing and able to implement actions to adapt to climate change.

For the purposes of this strategy, management adaptive capacity is defined as:

The ability of our current management system to adapt and adequately address the management challenges we face with climate change, using the direction from this project as a starting point. The current management system is intended to include: current legislation, policies, administrative structures, and other factors that shape the way forest management functions in the TSA, including its influence on the direction and management actions that managers will be willing and/or able to implement.

Management adaptive capacity may therefore be considered to be a measure of the ease or difficulty attached to implementation of the direction in the strategy. In the KFFS it is reflected by two different expressions of vulnerability over time - potential and projected vulnerability.

Issues associated with adaptive capacity for management can significantly contribute to the vulnerability of a management value or attribute of that value. Accordingly, adaptive capacity was examined and considered by exploring the estimated influence of implementation barriers on the ability of the strategy to mitigate expected climate change impacts over time.

For each subzone group management sensitivity was ranked based on the sensitivity from low to high. Next, each proposed management action was considered for its ability to mitigate climate change impacts and lower the sensitivity ratings for the various management concerns associated with each management value. This was achieved by applying an appropriate factor to net-down the sensitivity ranking. Adaptive capacity was then considered by grouping all the implementation barriers into five broad themes or general barriers:

- (1) the lack of a comprehensive strategic planning process;
- (2) more costly reforestation;
- (3) more costly or break-even harvesting;
- (4) the need for on-going stand management beyond free growing through the rotation;
- (5) a requirement for government to take on increased management risk.

Adaptive capacity issue 1. Lack of strategic planning process

A common theme emerged from the management workshops within this project. Managers and practitioners from every agency and licensee company expressed frustration that the forest management cycle of planning and implementation is too fragmented and dysfunctional within the TSA. Planning and implementation for different values and objectives is often done in silos with little connection between them. There are numerous examples of this problem in the TSA.

Example A: Some excellent mapping was conducted through the ecosystem restoration program in the dry southern portion of the TSA to identify “ecosystem restoration” opportunities, based on fuel loading and fire risks. Currently, BC is designing a provincial wildland fire management strategy that is intended to eventually help explore how fire can be managed at a landscape level, shifting to a proactive combination of modelling, strategic placement of cutblocks and fuel management at several scales. The mapping completed under the restoration program would be very instructive to build on this process and improved to incorporate climate change influences. However, the regional staff involved in the wildland fire management strategy were not aware of this mapping. It would be useful to integrate these initiatives and include climate change considerations over time, but there is currently no strategic process to facilitate such integration.

Example B: Some wildlife habitat biologists are similarly frustrated by the vague parameters and objectives used to establish landscape level reserves such as OGMAs in the TSA. As well, there is little strategic direction or spatial targets for wildlife tree retention, with no functional linkage to OGMAs and other habitat considerations. A retention strategy was designed by Tolko in 2003, which had broad direction for retention based on biogeoclimatic zones. Although this strategy was supported by the Ministry of Forests and Range and other licensees, it is not clear how this direction was implemented and if it is achieving the desired results, again mostly because there is no strategic planning mechanism in which to implement such strategies beyond SFM plans for certification. Clearly the

major issue facing management of habitat is that it is unknown whether or not the overall pattern and amount of retention and reserves is appropriate to sustain native biodiversity now or in the face of changing climate.

Example C: Currently, strategic timber management is often acknowledged to be a process of finding enough timber volume to sustain milling requirements over the short term, while meeting short term obligations set by the government. The types of actions suggested in the KFFS including: proactive harvesting of vulnerable stands, harvesting to reduce fuels, stand tending treatments and monitoring of post free growing stands - have no planning process or forum in which they can be adequately analysed, discussed and integrated with other values so they can be implemented effectively in time and space.

Climate change is anticipated to cause considerable disturbance, even over the next forty years in many of the ecosystems in the Kamloops TSA. This disturbance could have a variety of impacts on a range of values at different scales. Management to mitigate these impacts will not be successful by continuing to plan for biodiversity, timber, ungulate winter range, the urban-forest interface, and other values in disconnected silos, often using simplistic approaches.

The type of strategic planning that is needed to adequately address climate change is not a new concept for forest management:

- Rempel et al. (2004)⁶⁴ suggest that forest management should involve five elements: 1) establishing a clear set of values and goals, 2) planning actions that are most likely to meet those goals, 3) implementing appropriate management activities, 4) monitoring the outcomes of management to check on predictions, effectiveness, and assumptions, 5) evaluating monitoring outcomes and adjusting management if goals are not met.
- Baskerville (2002)⁶⁵ suggests that the key to forest management is to functionally link all local actions to one overall outcome. The leading aspect of “good forest management” defined by Baskerville (1986)⁶⁶ is that there is a responsible manager of a defined forest with an explicit target forest structure that a management plan is attempting to reach.
- Kimmins (2002)⁶⁷ suggested that we must use our accumulated knowledge and experience, projected in ecosystem management scenario models linked to visualization, to conduct an ethical audit on the decisions we make today about changing the way we management forests.

⁶⁴ Rempel, R.S., D.W. Andison, and S.J. Hannon. 2004. Guiding principles for developing an indicator and monitoring framework. *Forestry Chronicle*, Vol 80, No 1, pp. 82-90.

⁶⁵ Baskerville, G.L. 2002. A functional basis for planning management of a forest. Unpublished report.

⁶⁶ Baserville, G.T. Understanding forest management. *The Forestry Chronicle*, August, 1986.

⁶⁷ Kimmins, J.P. 2002. Future shock in forestry – Where have we come from; where are we going; is there a “right way” to manage forests? Lessons from Thoreau, Leopold, Toffler, Botkin and Nature. *The Forestry Chronicle*, Vol. 78, No. 2, pp263-271.

- Johnson and Williamson (2007)⁶⁸ highlight the importance of strategic planning to address climate change by suggesting that long-term forest management plans are the vehicle for considering and addressing the effects of climate change.

Climate change requires a long-term, multi-layered focus for forest management that must be approached proactively with operational strategic planning. Otherwise, management will fail to address the issues as they emerge over time.

Adaptive capacity issue 2. More costly reforestation

Management actions suggested in the KFFS to address climate change impacts are dominated by the introduction of more resilient species mixes across the TSA. More specifically there is a general suggestion to reduce the reliance on lodgepole pine and subalpine fir and increase the use of a range of other species in a number of subzones. The challenge is that both lodgepole pine and subalpine fir are often less expensive reforestation options on many sites.

Both of these species often provide significant amounts of natural regeneration after disturbance. When planting is necessary, Douglas-fir and other species may cost up to \$300 per hectare more, considering: nursery costs, fill planting requirements, and possible additional survey costs. As well, the current stumpage appraisal system encourages a least-cost silviculture approach to meet free-growing obligations, with no allowances or incentives for more costly innovative species choices. Lastly, the more rapid achievement of free-growing generally provided by lodgepole pine represents a lower cost, lower risk approach for licensees concerned about meeting legislated obligations (See the Timber Management section in Appendix 4 for more information).

It is anticipated that some planting of the more resilient species mixes promoted by the KFFS will occur without addressing the implementation barriers described above. However, it is expected that this effort will not be sufficient to make the changes required to the future forest condition.

Adaptive capacity issue 3. More costly or break-even harvesting

This barrier is related to the lack of strategic planning, in that it refers to the suggested proactive harvesting of stands that are vulnerable to climate change. First, there is no planning mechanism to actually set targets for such harvesting, nor to integrate it effectively with other resource values (e.g., through scenario evaluation). Also, there is little incentive or allowance, economic or otherwise, for licensees to undertake such harvesting.

Adaptive capacity issue 4. The need for on-going stand management beyond free growing through the rotation.

This broad barrier is also related to the lack of a strategic planning process. But it also relates to the lack of incentives for licensees to engage in management beyond free-

⁶⁸ Johnston, M., T. Williamson. 2007. A frameworks for assessing climate change vulnerability of the Canadian forest sector. *Forestry Chronicle*, Vol. 83, No. 3. Pp 358-361.

growing. It is likely that some stand management beyond free growing suggested in the KFFS may occur in the TSA through FFT projects and funding. However, without a clear mandate, a long-term strategic plan, and a long-term commitment to funding, these treatments are likely to be ephemeral. It is also doubtful that they will be well-integrated into planning for biodiversity, fuel management and other objectives.

Adaptive capacity issue 5. Requirement for government to take on increased management risk

Even if the other barriers are addressed, management of the forest throughout the rotation and use of tree species for planting and other untested silvicultural treatments will require government to take on more of the risks associated with these activities. It is not clear whether the government will accept such risk.

Vulnerability Determination

Once adaptive capacity is considered, vulnerabilities across the TSA, general TSA vulnerabilities were determined. To determine vulnerabilities, a factor was designed for each broad barrier described above, based on the estimated degree to which it would impede full implementation of the KFFS direction. The result is a snapshot of *projected* management vulnerability compared to *potential* management vulnerability (Table A6.4).

When *projected* management vulnerabilities are summarized across all subzone groups and compared to the *potential* management vulnerability if all direction is followed and all barriers are removed (middle column, Table A6.4), the influence of management adaptive capacity in the Kamloops TSA is striking.

Using the assumptions associated with the *projected* management vulnerabilities, some of the initial sensitivities may be partially addressed, but not significantly, unlike the situation if all barriers were removed and the KFFS was followed as suggested (*potential* management vulnerability). With none of the barriers removed, planning would occur as it does now, with no operational strategic process in place. It would therefore be unlikely that managers would be willing to undertake many of the management actions suggested. There would be no forum to discuss and plan these actions across a TSA, and little incentive for individual licensees to do so on their own.

The comparison of vulnerabilities, based on a consideration of adaptive capacity, illustrates that mitigation of many climate change impacts on management is achievable to a certain extent with thoughtful and timely management actions. Those actions will be challenging to implement without first addressing the implementation barriers that influence adaptive capacity. Many of these barriers and issues are provincial in scope. Until these barriers and issues are addressed, much of the TSA is projected to have a moderate to high vulnerability to climate change.

Table A6.4. Comparison of *potential* management vulnerability (assuming all barriers for implementation were removed), and *projected* vulnerability (assuming no barriers are removed). The two vulnerabilities are compared to the original management sensitivity ranking.

SUBZONE GROUP	Mgmt Sensitivity	Vulnerability with FULL implementation (barriers removed)		% OF AREA
		Potential Vulnerability	Projected Vulnerability	
<i>Dry with Pli</i>	MODERATE TO HIGH+	MINOR TO MODERATE +	MODERATE TO HIGH -	28%
<i>Dry with Doug-fir and Ponderosa pine</i>	HIGH -	MINOR TO MODERATE +	MODERATE TO HIGH +	10%
<i>Transitional Cedar- Hemlock to Douglas-fir</i>	MODERATE TO HIGH -	MINOR TO MODERATE -	MODERATE TO HIGH --	26%
<i>Transition to Plateau or High Elevations</i>	MODERATE -	MINOR -	MODERATE -	15%
<i>Cool and Wet</i>	MINOR TO MODERATE -	MINOR -	MINOR +	21%

Potential management vulnerability - is the expected result if the KFFS was fully implemented as suggested with all implementation barriers removed. This vulnerability ranking expects the strategy to evolve over time, with comprehensive strategic planning, good monitoring and adequate research of key questions. Learning is quickly incorporated into the strategy and good use of models for integrated scenario forecasting helps to balance impacts and adjust targets to adequately meet the objectives for management values.

Projected management vulnerability - is the expected result if the KFFS was implemented with none of the implementation barriers removed (Table A6.4 - right hand coloured column). Implementation would be attempted without any changes to our current approaches to planning, monitoring systems and other administrative structures. Likely the easier proposed management actions would mostly be implemented, possibly with some progress on a few more difficult management actions.

Comparison of Sensitivity, Potential Vulnerability and Projected Vulnerability for the Five Subzone Groups in the Kamloops TSA.

Dry Subzones with Lodgepole Pine - MSxx, IDFdk (SBPSmk)					
Management Value	Specific Concern	Sensitivity RATING	Potential Managed Vulnerability		PROJECTED MGMT. VULN.
			Ability to change with Mgmt	Potential Managed Vuln Rank	RANK
SUBZONE GROUP	Size of working landbase	MODERATE TO HIGH	Very Low	MODERATE TO HIGH	MODERATE - HIGH
	productive capacity of the working landbase	HIGH	High	MINOR	HIGH -
	Growing stock on the working landbase	HIGH	Mod-High	MINOR TO MODERATE	HIGH -
	Economics	MODERATE	Very Low	MODERATE	MODERATE
BIODIVERSITY	Old growth habitats	HIGH	Mod	MODERATE	HIGH -
	Wildlife trees/ WTPs and landscape permeability	HIGH	High	MINOR	HIGH -
	CWD	MODERATE	High	MINOR - -	MINOR TO MODERATE ++
	Ungulates (designated winter ranges)	MINOR		MINOR	MINOR
	Other species of concern or at risk (red and blue)	HIGH	Mod	MODERATE	HIGH -
	Invasive species	HIGH	Mod	MODERATE	HIGH -
FIRST NATIONS	Culturally important plants	MODERATE TO HIGH	Mod	MINOR TO MODERATE	MODERATE TO HIGH -
INTERFACE	Fire risks	MODERATE TO HIGH	High	MINOR -	MODERATE ++
WATER AND AQUATIC ECOSYSTEMS	Watershed management - water supply	MODERATE TO HIGH	Mod	MINOR TO MODERATE	MODERATE TO HIGH -
	Fish Habitat - Salmonids	HIGH	Very Low	HIGH	HIGH
OTHER	Visual Landscape Management	MODERATE	High	MINOR - -	MINOR TO MODERATE ++

Dry Subzones with Douglas-fir and Ponderosa Pine - IDFxh, PPxh

		Potential Managed Vulnerability		PROJECTED VULNERABILITY RANK
Management Value	Specific Concern	Sensitivity RATING	Ability to change with Mgmt	
SUBZONE GROUP	Size of working landbase	HIGH	Very Low	HIGH
	productive capacity of the working landbase	HIGH	Mod-High	HIGH -
	Growing stock on the working landbase	HIGH	Mod-High	HIGH
	Economics	MODERATE	Very Low	MODERATE
BIODIVERSITY	Old growth habitats	HIGH	Mod	MODERATE
	Wildlife trees/ WTPs and landscape permeability	HIGH	High	MINOR
	CWD	MINOR	High	MINOR -
	Ungulates (designated winter ranges)	MODERATE	High	MINOR -
	Other species of concern or at risk (red and blue)	MODERATE TO HIGH	Mod	MINOR TO MODERATE
	Invasive species	HIGH	Mod	MODERATE
FIRST NATIONS	Culturally important plants	MODERATE TO HIGH	Mod	MINOR TO MODERATE
INTERFACE	Fire risks	HIGH	High	MINOR
WATER AND AQUATIC ECOSYSTEMS	Watershed management - water supply	HIGH	Mod	MODERATE
	Fish Habitat - Salmonids	HIGH	Very Low	HIGH
OTHER	Visual Landscape Management	MODERATE TO HIGH	High	MINOR

ICH-IDF Transition Subzones - IDfmw, ICHdw, ICHmw (ICHmk)

		Potential Managed Vulnerability			
Management Value	Specific Concern	Sensitivity RATING	Ability to change with Mgmt	Potential Managed Vuln Rank	PROJECTED VULNERABILITY RANK
SUBZONE GROUP	Size of working landbase	MINOR	Very Low	MINOR	MINOR
	productive capacity of the working landbase	HIGH	High	MINOR	HIGH - -
	Growing stock on the working landbase	HIGH	Mod-High	MINOR TO MODERATE	HIGH - -
	Economics	MODERATE	Very Low	MODERATE	MODERATE
BIODIVERSITY	Old growth habitats	HIGH	Mod	MODERATE	HIGH -
	Wildlife trees/ WTPs and landscape permeability	MODERATE	High	MINOR -	MODERATE
	CWD	MINOR	Very High	MINOR --	MINOR -
	Ungulates (designated winter ranges)	MODERATE	Mod	MINOR	MODERATE
	Other species of concern or at risk (red and blue)	MODERATE	Mod	MINOR	MODERATE +
	Invasive species	HIGH	Mod	MODERATE	HIGH -
FIRST NATIONS	Culturally important plants	MODERATE	Mod	MINOR	MODERATE +
INTERFACE	Fire risks	MOD.TO HIGH	HIGH	MINOR -	MODERATE TO HIGH --
WATER AND AQUATIC ECOSYSTEMS	Watershed management - water supply	MOD.TO HIGH	Mod	MINOR TO MODERATE	MODERTATE TO HIGH - -
	Fish Habitat - Salmonids	HIGH	Very Low	High	HIGH
OTHER	Visual Landscape Management	MOD. TO HIGH	High	MINOR -	MODERATE ++

Dry to Moist Plateau or High Elevation Subzones - MSdm, SBMmm, ESSFdc (ESSFxc)

		Potential Managed Vulnerability		PROJECTED VULNERABILITY RANK
Management Value	Specific Concern	Sensitivity RATING	Ability to change with Mgmt	
SUBZONE GROUP	Size of working landbase	MINOR	Very Low	MINOR
	productive capacity of the working landbase	MINOR	High	MINOR --
	Growing stock on the working landbase	MODERATE	Mod-High	MINOR -
	Economics	MINOR TO MODERATE	Very Low	MINOR TO MODERATE
BIODIVERSITY	Old growth habitats	MODERATE TO HIGH	Mod	MINOR TO MODERATE
	Wildlife trees/ WTPs and landscape permeability	MODERATE TO HIGH	High	MINOR -
	CWD	MINOR	Very High	MINOR --
	Ungulates (designated winter ranges)	MINOR	Mod	MINOR --
	Other species of concern or at risk (red and blue)	MODERATE	Mod	MINOR
	Invasive species	MODERATE	Mod	MINOR
FIRST NATIONS	Culturally important plants	MODERATE	Mod	MINOR
INTERFACE	Fire risks	MINOR TO MODERATE	High	MINOR --
WATER AND AQUATIC ECOSYSTEMS	Watershed management - water supply	MODERATE	Mod	MINOR
	Fish Habitat - Salmonids	MODERATE TO HIGH	MOD	MINOR TO MODERATE
OTHER	Visual Landscape Management	MINOR TO MODERATE	MOD	MINOR -

Wet Cool / Cold Subzones - ESSFwc, ICHwk, (ICHvk)

		Potential Managed Vulnerability		PROJECTED VULNERABILITY RANK
Management Value	Specific Concern	Sensitivity RATING	Ability to change with Mgmt	
SUBZONE GROUP	Size of working landbase	MINOR	Very Low	MINOR
	productive capacity of the working landbase	MINOR	High	MINOR --
	Growing stock on the working landbase	MINOR	Mod-High	MINOR --
	Economics	MODERATE	Very Low	MODERATE
BIODIVERSITY	Old growth habitats	MINOR	Mod	MINOR -
	Wildlife trees/ WTPs and landscape permeability	MINOR	High	MINOR --
	CWD	MINOR	Very High	MINOR --
	Ungulates (designated winter ranges)	MINOR	Mod	MINOR -
	Other species of concern or at risk (red and blue)	MODERATE TO HIGH	Mod	MINOR TO MODERATE
	Invasive species	MINOR	Mod	MINOR -
FIRST NATIONS	Culturally important plants	MINOR	Mod	MINOR -
INTERFACE	Fire risks	MINOR	High	MINOR --
WATER AND AQUATIC ECOSYSTEMS	Watershed management - water supply	MINOR	Mod	MINOR -
	Watershed management - water quality and infrastructure	MODERATE TO HIGH	Mod	MINOR TO MODERATE
	Fish Habitat - Salmonids	MINOR	LOW	MINOR -
OTHER	Visual Landscape Management	MINOR	High	MINOR --