Kamloops case study

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Projected changes in climate and disturbance

Across the Kamloops TSA, annual temperature is expected to increase from 1.1 to 3.3 °C, depending on climate projection, and annual precipitation is expected to increase by 4% (Table 1). Summers could become substantially warmer and drier. Winters may become shorter and warmer.

Table 1. Historical and projected values of selected climate variables in the Kamloops TSA. Projections are for circa 2055. Data from Table 1 in Jones and Brown 2008.

Climate Variable	Historical (1961-1990)	Projected change for PCM_B1 (warm-moist)	Projected change for HadCM3_A1FI (hot-moist)
Mean annual temperature	2.4 °C	1.1 °C	3.3 °C
Mean coldest month temperature	-8.9 °C	2.1 °C	2.0 °C
Mean warmest month temperature	13.4 °C	1.6 °C	5.6 °C
Frost-free period	68 days	28%	62%
Number of frost-free days	145 days	11%	31%
Mean annual precipitation	854 mm	4%	4%
Mean annual summer precipitation	343 mm	-1%	-9%
Precipitation as snow	396 mm	-1%	-12%

In the future, drought, fire and insects are expected to cause most disturbance in the Kamloops TSA, although impacts vary by subzone group (Table 2). Projected increases in summer temperature (and possibly less precipitation) increase drought-stress and fire hazard. Warmer annual temperatures also favour insects; warm and moist (mainly spring and fall) conditions favour disease. Drought-stressed trees are more susceptible to insects and disease, leading to increased tree mortality and relatively open stands with ladder fuels that support large wildfires.

Table 2. Subjective rating of relative trends in tree mortality from different disturbance agents due to climate change (based on expert opinion recorded in KFFS TSA Team 2009). Three arrows show a substantial increase; one arrow is minor.

Agent	Drought	Large wildfires	Armillaria root rot	Disease (not Armillaria)	Insects (e.g., bark beetles)
Dry Subzones with Lodgepole Pine	↑↑	↑↑↑*	↓	↑	↑↑↑
Dry Subzones with Douglas-Fir	↑↑↑	↑↑	-	-	↑↑↑
IDF-ICH Transition Subzones	↑↑	↑↑↑	↑↑	-	↑↑
Dry to Moist Plateau Subzones	↑	↑	↑	-	↑↑
Wet Cool Subzones	-	-	↑	-	↑

*high hazard in the near future

Ecological Vulnerability

This section describes **potential** ecological change. The next section describes **potential** changes to managed values. Potential climate-induced ecological impacts vary by subzone group (Table 3). Dry and transitional subzones face the highest risk due to drought, coupled with insects and disease, and fire. Table 3 and the text following summarize potential ecological impacts.

Table 3. Overview of ecological sensitivities for subzone groups in the Kamloops TSA (based on Table 2.1 in KFFS TSA Team 2009). The sensitivity ranking is based on the degree of ecological alteration attributed to climate change.

Subzone group	BEC subzones	% of THLB	Ecological Sensitivity	Rationale for ecological sensitivity (emphasizing the more extreme climate scenario)
Dry Subzones with Lodgepole Pine	MSxk, IDFdk, (SBPS)	28	HIGH	• 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 Subzones with Douglas-fir & Ponderosa Pine	IDFxh, PPxh	10	HIGH	• 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	• 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	• Increased growth in most species (except Bl) up to 2050. • Beyond 2050 – Bl 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	• Increased mortality in old growth • Increased growth in young stands • Weevil increasing problem for young Sx.

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

The recent mountain pine beetle epidemic has left standing dead timber, creating a high fire hazard in the near future. After 2050, the climate may be too hot and dry for pine, leading to increased insect and disease mortality (~37% of THLB in pine plantations). Increased drought, assisted by insects and disease, is also expected to cause some mortality in Douglas-fir, substantial mortality in scattered spruce stands and very high mortality in subalpine fir. Impacts of Armillaria and spruce budworm in the IDFdk will decline as the environment dries. Forest may shift to grassland on south aspects and lower elevations (primarily in the IDFdk).

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

Outbreaks of western pine beetle and mountain pine beetle have already caused substantial mortality in Ponderosa pine, a trend that will likely continue. Douglas-fir stands will experience continued and increased mortality from tussock moth and bark beetle. Drought, with or without the influence of insect attacks, will increase mortality, on south aspects. Impacts of Armillaria and spruce budworm in the IDFxh will decline as ecosystems dry. Fire risk will vary with mortality. Increased moisture stress will shift drier forested ecosystems toward open forest or grasslands

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

Many stands in these subzones contain multiple tree species. Drought stress will have a severe impact on western redcedar, birch, spruce and hemlock, limiting these species to cool wet sites over time; redcedar and birch are already stressed. A substantial increase in Armillaria root rot (until about 2050) will increase mortality of Douglas-fir and other conifers.

Beyond 2050 (beyond 2080 in the ICHmw) on dry sites, the area of shrubby or grassy openings will increase, possibly substantially 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.

There is a high risk of large fires (especially in the IDFmw; beyond 2050 in the ICHmw) due to hot, dry climate trends coupled with increased tree mortality and understory fuels. Risk is somewhat reduced by the substantial broadleaf component in many stands.

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

Overall, increases in tree mortality should be relatively small, although the potential for large fires may increase with warmer temperature. 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. Douglas-fir will likely have improved growth where it is found up to 2050. Armillaria root rot will have increased impact but will remain fragmented and localized. Spruce weevil damage will increase.

On dry sites, extensive mortality from the current epidemic of mountain pine beetle (over 30-50% of the area in this Subzone Group) increases the risk of large fires. Little or no shift from forest to grassland is expected by 2080.

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

Prior to 2050, minor increases in tree mortality are expected. In the ICHwk (mainly cedar-hemlock leading stands with minor components of spruce and Douglas-fir), slightly drier and warmer conditions may favour Armillaria root rot, increasing tree mortality (predominantly in spruce and Douglas-fir). Spruce weevil could affect the growth and development of young spruce at lower elevations after approximately 2030. Beyond 2050, increases in spruce bark beetle, western balsam bark beetle, spruce budworm, and possibly spruce weevil at lower elevations may periodically cause more substantial localized impacts.

Warmer, drier summers and a longer growing season could increase growth in the ESSFwc (spruce-subalpine fir stands) and in some portions of the ICHwk. Over the long term, drought stress may offset productivity gains.

Management vulnerability

Table 4 summarizes management vulnerabilities. The sections that follow discuss impacts on specific values: water and fish; timber; culturally-valued plants; biodiversity and wildlife.

Table 4. Overview of management sensitivities in the Kamloops TSA by subzone group, based on ecological sensitivities. High sensitivity refers to high likelihood of substantial negative impact; moderate refers to high likelihood of limited negative impact; low refers to expected minimal impact.

SUBZONE GROUP	% of THLB	Overall management sensitivity	THLB area	Prodn*	Growing stock	Biodiversity and habitat	Fish	Water	Valued plants	Urban Interface	VQ**
Dry Subzones with Pli	28	MOD-HIGH	M-H	H	H	H	H	M-H	M-H	M-H	M
Dry with Fd & Py	10	HIGH	H	H	H	H	H	H	M-H	H	M-H
ICH-IDF Transition	26	MOD-HIGH	M-H	H	H	M-H	H	M-H	M	M-H	M-H
Plateau / High Elev	15	MOD	L	L	M	M-H	M-H	M	M	L-M	L-M
Cool/Cold & Wet	21	LOW-MOD	L	L	L	M?	L	M-H?	L	L	L

*Stand productivity

**Visual quality

Water and fish

Warmer annual temperatures (and hence increased evaporative demand), wetter winters with less snow, wetter springs and falls and drier summers, combined with an increased frequency and magnitude of severe weather events will substantially influence hydrology in the Kamloops TSA. Vegetation cover will respond to the changing climate and disturbance regime, affecting interception of rain and snow, evapotranspiration and ultimately hydrology.

Water flows are expected to decline, particularly in the southern half of the Kamloops TSA, due to increased evaporative demand and potentially lower summer precipitation. In addition, smaller winter snowpacks that melt more rapidly in a warmer summer, could reduce late summer drainage. Some perennial streams may become intermittent or ephemeral. Altered flow patterns could disrupt seasonal habitat use by local fish stocks. Loss of perennial flow could strand or isolate fish. Domestic and agricultural water use, which is substantial and expected to grow in the southern portion of the TSA, will likely be affected.

Increased water temperatures can negatively impact salmon populations. Water temperature reflects warmer summer air temperatures and reduced flows. Also, less-persistent snowpacks in the ESSF (due to warming yearly temperatures) may contribute less cool water to stream systems. Many low elevation streams within warmer subzones could reach lethal temperatures for salmonids; some streams are already affected. Conversely, rising temperatures in higher elevations streams may improve fish habitat productivity, however, many of these stream habitats are inaccessible except to the existing, isolated populations.

Water quality could decline in wet, cool northern portions of the Kamloops TSA. Increased fall, winter and spring precipitation, coupled with an increased frequency and magnitude of storm events could greatly increase peak flows in some streams and watersheds, leading to increased scour, sediment transport and mass wasting. Changes in water quality can alter fish habitat.

Timber

Climate change increases uncertainty about timber productivity and yield, via potential increases in tree growth, potential increases in tree mortality and potential losses of productive forest area.

Stand mortality is expected to increase as conditions become hotter and drier through the summer, especially beyond 2050. Causes of mortality include drought stress, insects, pathogens, and a higher incidence of larger and more severe wildfires. Growing stock will decline, with substantial losses occurring in pulses of mortality that coincide with warmer, drier climatic cycles. Physical and biological disturbance agents will also reduce productivity on many sites, especially in dry subzones.

In dry subzones, abundant lodgepole pine in developing young stands increases vulnerability. Climate 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 circa 2050 and subsequent regeneration challenging if stands are clearcut.

Transitional subzones (Interior Cedar-Hemlock to Interior Douglas-fir) will be challenged by the anticipated warmer, seasonally drier conditions. As trees become drought-stressed over summer, mortality will accelerate, mostly in conjunction with disease and insects. The nature of these diverse ecosystems could change dramatically as some tree species (particularly Douglas-fir) suffer high mortality, resulting in broadleaf stands with considerable openings. 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 may limit an economically viable harvest.

The area available for timber harvesting may decrease. Some currently forested subzones may shift towards treed grasslands, particularly sites on south aspects or shallow soils. Warmer and drier summer conditions could spur expansion of recreational property into timber-harvesting land.

Some subzone groups face greater risk to timber supply:

- Moist-dry transition subzones (e.g., IDFmw) have ubiquitous root rot and a component of western redcedar and lodgepole pine that may be maladapted;
- Dry subzones with concentrations of lodgepole pine (e.g., MSxk) have high beetle mortality, leading to extensive areas of young lodgepole pine that will be susceptible to mortality from forest pests;
- Dry subzones with Douglas-fir and ponderosa pine (e.g., IDFxh): face warmer and drier conditions that will increase mortality from Douglas-fir beetle and will reduce success of Douglas-fir regeneration; grasslands may expand.

Developing a more resilient forest by planting climatically-suited species will take a long time. Simulations show that facilitated migration strategies do not bring a substantial benefit within the first 100 years.

First Nations known culturally important plants

Climate directly affects plant species; climate-related disturbance causes mortality and affects site conditions. Various aspect of climate affect plants, including extremes of cold and heat, the amount and timing of precipitation and heat sums. Plants and pollinators may react differently to climate change and fall out of synchrony.

Altered disturbance regimes can affect the regeneration environment (e.g., hot fires can reduce seed banks) and the amount of suitable habitat for young versus old forest specialists. A warmer climate increases forest health concerns, but specific risks are poorly known for most species. Increased fire disturbance and post-disturbance harvesting could negatively impact the supply of plants in the dry IDF and IDF-ICH transition subzones and could favour invasive species.

Each species will respond differently to climate change. As the climate changes, the overall vigour and competitive advantage of a species in an area is affected. In some cases, ecological tolerances for survival or reproduction can be exceeded. Long-lived species may persist for a time, but be unable to reproduce. Changes in climatic suitability and competitive advantage lead to shifting species distributions (e.g., expansion, contraction, migration) and altered species assemblages. Invasive species, supported by warm temperatures and increased disturbance, may crowd out desirable species.

Increased summer drought in the drier subzones could impact the growth and survival of a number of culturally important plant species.

Species adapted to the wettest and driest sites in a subzone often occur in multiple subzones and thus may be less affected by climate change (note that this pattern did not occur in the Nadina); for example, seepage areas and floodplains support similar species across a range of environmental conditions; for example, drought-adapted species living in sandy soils with moisture deficits occur over a range of climatic conditions.

Biodiversity and wildlife

Landscape- and stand-level reserves used for biodiversity conservation will be affected by climate directly and by related changes in disturbance events. Drying, warming and increased disturbance promote invasive species.

Wildlife tree patches face increased risk of tree mortality that will affect their habitat, refugia and connectivity value. Down wood that contributes to post-harvest stand structure increases with natural disturbance, but may decrease if large disturbances facilitate biomass harvesting or fuel-reduction activities.

Oldgrowth management areas and special management zones contribute to landscape-scale seral stage targets (Biodiversity Emphasis Options). Anticipated increases in natural disturbance will reduce old forest abundance, affecting achievement of seral-stage targets. The character of reserved areas will be affected by both disturbance and by anticipated changes in tree species composition. Similarly, Wildlife Habitat Areas (including forests, wetlands and grasslands) face changes in overstory and understory species composition and in the surrounding landscape context that could affect the target species.

Impacts to ungulate habitat vary by species. Caribou face altered snowpack conditions, influencing foraging success (shallow snowpacks reduce access to tree lichens) and predation risk (snowpacks could support predators but not caribou). Also predators will follow deer that may move further into caribou habitat. However, the ESSF and ICH areas where caribou occur are predicted to change slowly relative to other areas in the TSA.

Deep snow increases movement costs for deer. Increased disturbance (e.g., Douglas-fir beetle, Tussock moth and fire) may lead to more open forest with reduced snow interception. Snowpacks may increase: experience suggests that increased snowfall correlates with warmer winters. Conversely, snowpacks may decrease as average winter temperature increases. Snowpacks could develop harder surfaces due to more frequent freeze-thaw cycles, easing predation.

In winter, moose depend on valley-bottom riparian areas in a range of subzones. In drier subzones, riparian forage may decrease if wetland area decreases. Conversely, forest openings resulting from increased disturbance can increase forage. If snowpacks decrease, access to forage should increase. Increases in moose populations can increase predator populations, with consequences for other ungulates.

Recommended adaption

Table 5. Highlights of management direction for the Kamloops TSA.

Reforestation
• Promote tree species diversity (for forest health): reduce reliance on lodgepole pine and subalpine fir; increase broadleaf component
• Promote a range of stocking densities (for forest health)
Harvesting and stand tending
• Focus harvesting on stands facing high mortality risk (to capture value and re-establish a more resilient stand)
• Encourage broadleaf species (for habitat and fire breaks)
• Use stand-tending treatments to help establish resilient species
• Use stand-tending and fuel-reduction treatments to reduce fire risk
• Treat root disease (selected subzones)
Planning
• Use results of Kamloops study to inform and update existing plans
• Consider costs and benefits of potential adaptation across all values
• Plan over the long term (e.g., a rotation)
• Plan harvesting of susceptible stands to minimize additional costs and to conserve non-timber values
• Develop plans for urban interface areas that focus on fuel management and fire protection.
• Re-evaluate forest health management strategies, considering climate change
• Develop an explicit strategy that links wildlife tree patches and landscape level reserves to address connectivity

Barriers to adaptation

Barriers preventing the implementation of adaptation strategies listed above fall into five broad categories:

- lack of a comprehensive, integrated planning process (strategic to operational);
- more costly reforestation;
- more costly or break-even harvesting;
- the need for post free-growing stand management;
- the need for the provincial government to accept increased management risk.

References

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