

Kamloops Future Forest Strategy II – K2 **Initial Modeling Indicators for Resource Management Goals**

June 7, 2011

Background

Indicators

In a strategic planning environment indicators are measurements or trends of interest that best reflect the progress toward strategic objectives. Because K2 is not a strategic planning exercise per se, but rather an investigation of questions posed by clients, the indicators are linked to both those questions, and the broader goals established for K2. These questions and goals were clarified by the K2 team and the clients at a workshop in Kamloops in June of 2010.

Indicators are useful both in modeling scenarios (as in K2) and in subsequent field-monitoring to evaluate potential and actual performance, and ultimately, success in achieving the strategic objectives. Indicators used in modeling may differ from those used in monitoring since modellers often must incorporate assumptions to evaluate potential performance in the modeling environment. Monitoring indicators more directly measure actual performance on the ground.

Indicators are often tied to thresholds that are known or estimated to be acceptable based on current knowledge. Often they are just trend indicators of interest based on their trend up or down relative to the current or some other baseline situation.

The Management Goals

The following goals were chosen to provide context for the project when modeling to answer project questions, thus guiding the establishment of indicators. We may in the end have some feedback to refine these goals at the end of the project, depending on how realistic they appear in light of potential climatic impacts.

These goals fit with our definition of goals under the definitions established for this project¹. They also have linkages to the intent provided by current 2008 CSA SFM guidance for certification within the TSA. The Timber objective also fits with the stated current provincial direction for the Ministry of Forests, Lands and Mines.

OVERARCHING
(ULTIMATE)
PROJECT GOAL

– Encourage resilience within the ecosystems to maintain productive, “healthy” forest that will continue to be able to provide future benefits (for timber, biodiversity, etc.) in spite of the disturbances (and surprises) that may result from climate change.

¹ From K2 Definitions Feb 4-10 – Goals are the overall intention for management with linkage back to values and key principles.

1. TIMBER – *Maintain or increase the flow of timber volume and/or value over time.*
2. HABITAT / BIODIVERSITY – *No loss of native species due to management over time.*
3. FIRE – *Minimize fire risk to people and property.*

The Management Questions

Complementary to the management goals, management questions were formulated to express key interests of Kamloops TSA clients within each broad management goal (File: *Questions with Comments June 27-10 V 1.1*). Management questions were consulted during the development of indicators to ensure that client interests were being addressed. A complete set of indicators were then built for each goal to ensure all key aspects of the goal itself would be measured.

Relevant questions are referenced for each indicator in the sections that follow. Some indicators have no questions referenced as they were built to complete the indicator set for the goal, without having a clear connection to a client question.

The Approach

The following indicators are based on the four broad management goals and the associated modeling questions that emerged through discussions with project clients in Kamloops. An indicator may be mostly related to the goal itself; or both the goal and questions from clients. The indicator should ensure the output is judged based on the best available science (within the constraints of the modeling);

The following indicators are based on a combination of the following:

- a. Indicators used for modeling in other BC planning processes based on best available science and expertise (TSR, and other selected SFM planning processes);
- b. The FREP Report #20 (*Monitoring Forest and Rangeland Species and Ecological Processes to Anticipate and Respond to Climate Change in BC*).
- c. The ability of the K2 suit of models to provide reasonable outputs (with assumptions) that can be used to examine the indicators.

Some of the indicators used in the FREP Report #20 helped formulate indicators for the K2 modelling exercise. Many of the FREP indicators are relevant for field monitoring of climate change impacts over time, but are not suited for a modelling exercise – these were therefore not used or substituted for indicators that could be modelled.

NOTE: This paper illustrates the current thinking in the K2 team for indicators. These indicators may be altered or substituted for alternates during the modelling process, as required.

A. Indicators for Timber Harvesting

GOAL = Maintain or increase the flow of timber volume and/or value over time.

Interpretation – This is a common goal for timber and is still used today. The balance between value and volume has been the focus of much debate and is yet unclear because timber value changes with markets and products. A reasonable approach to addressing value might be to maintain a “balanced portfolio” with a good range of species and timber sizes.

For the purposes of this project, it is considered reasonable to view the maintenance of volume flows as being the primary objective, with value as a secondary objective (see indicator 5). The volume flows being maintained will be those based on the recent TSR 4.

A1. Harvest Flow over Time

Indicator	• Harvest flow in m³/year established for short, mid, and long term.
Threshold or Trend	<ul style="list-style-type: none"> • Threshold – undesirable if it drops below projected BAUBC² levels (the base case). • Trend – More is better.
Modeling Scale	<ul style="list-style-type: none"> • Assessed at landscape with possible subreporting by Ecological Subzone Groups to explore trends.

Rationale for indicator A1

This indicator most directly links to the timber management goal providing an overall view of impact on what is considered to be a key timber management concern.

A2. Size of the Timber Harvesting Landbase

Indicator	Changes in Area (ha) – based on stand volumes / productivity that drop below a threshold for a potential economic harvest.
Threshold or Trend	<ul style="list-style-type: none"> • Threshold – undesirable if it drops below BAUBC levels (expected with BAUCC). • Trend – More is better (but there may be little that can be done).
Modeling Scale	<ul style="list-style-type: none"> • Tallied and reported at landscape level – based on information from stand level FORECAST modeling. The landscape model will receive information on what stands have dropped below a threshold – and will tally.
Associated Question(s) (June 27, Version 1.1)	12. How will the size and nature of the THLB change over time? Where will we harvest, when and how?

² BAUBC – Business as Usual Base Case

Rationale for indicator A2

This indicator gets at one of the important questions linked to the timber management goal – that of impacts on the size of the productive forest due to climate change.

A3. Trends in timbered landscape condition over time.

a. Indicator – Species profile	<ul style="list-style-type: none"> • Area and/or proportion of species and stand types on the THLB and the NTHLB. • AS REQUIRED (to look at trends of interest)
Threshold or Trend	<ul style="list-style-type: none"> • Trend indicator – No target. The long term trend will be carefully judged against the current situation, which could be favourable (or not) right now.
Modeling Scale	<ul style="list-style-type: none"> • Rolled up at the landscape level based on changing species composition from stand level FORECAST modelling. • As required (where we see trends we want to look at) – may be reported for a specific ecological unit.

b. Indicator – Age class profile	<ul style="list-style-type: none"> • Area and/or proportion of age classes on the THLB and the NTHLB • AS REQUIRED (to look at trends of interest)
Threshold or Trend	<ul style="list-style-type: none"> • Trend indicator – No target. The long term trend will be support inferences and rationales for other trends (AAC and biodiversity trends).
Modeling Scale	<ul style="list-style-type: none"> • Rolled up at the landscape level based on changing age-class composition from stand level FORECAST modelling. • As required (where we see trends we want to look at) – may be reported for a specific ecological unit.

c. Indicators – Mortality	<ul style="list-style-type: none"> • Amount of mortality occurring on the THLB and the NTHLB
Threshold or Trend	<ul style="list-style-type: none"> • Trend indicator – No target. The long term trend will be carefully judged against the current situation, which could be favourable (or not) right now.
Modeling Scale	<ul style="list-style-type: none"> • Assessed at landscape, reported by present NDT category and/or Ecological Subzone Group level.

Associated Question(s) (June 27, Version 1.1) for Indicators 4a- 4c:
8. Can we characterize a risk to mature stands – mortality related to drought and other related influences? Which stands are most vulnerable (and when)?
17. How will disturbances be influenced by climate change and how will this influence patterns and structures across the landbase?

Rationale for indicator A3

This is a very important group of indicators (3a-c) that addresses a number of complex questions. It provides a picture of the changing landscape. It could be used to assist in an assessment of value, based on the “diverse portfolio” concept of maintaining a range of sizes and species across the landbase. It will also provide information at the landscape scale that can be used to assess other goals related to biodiversity, and fire management. Therefore output should be considered carefully to address indicators set for those goals as well. The output will provide a learning opportunity when compared against the expert derived narratives of the future speculated in K1.

A4. Trends in growing stock volume over time.

Indicators	Volume of growing stock (timber volume) on the landbase over time.
Threshold or Trend	<ul style="list-style-type: none"> • Trend - Expect to see less growing stock over time if harvesting continues as in BAUBC and increased mortality is also occurring. <ul style="list-style-type: none"> ○ If growth and harvesting are in balance on the THLB in the long term, we will see a consistent amount of growing stock (steady state condition). This is often used as a feedback mechanism to set the long term harvest level.
Modeling Scale	<ul style="list-style-type: none"> • Rolled up at the landscape level based on changing growing stock volumes from stand level FORECAST modelling. • As required (where we see trends we want to look at) – may be reported for a specific ecological unit.
Associated Question(s) (June 27, Version 1.1)	<p>8. Can we characterize a risk to mature stands – mortality related to drought and other related influences? Which stands are most vulnerable (and when)?</p> <p>17. How will disturbances be influenced by climate change and how will this influence patterns and structures across the landbase?</p> <p><u>Comments</u></p> <p>See landscape condition comments (indicator suite 3)</p>

Rationale for indicator A4

This is a key indicator used in TSR analysis to help inform options for long term harvest levels.

A5. Timber Values (also see indicator #3).

<i>Potential Indicator</i> ³	<ul style="list-style-type: none"> • Timber Values in \$/m³.
Threshold or Trend	<ul style="list-style-type: none"> • Threshold – undesirable if it drops below projected BAUBC levels. • Trend – More is better.
Modeling Scale	<ul style="list-style-type: none"> • Assessed at landscape using stand specific values assigned based on species distribution and average species values over a nominal period.
Associated Question(s) (June 27, Version 1.1)	<p>Mostly the timber goal – and:</p> <p>13. If we manage more yellow pine in lower elevations, can we get enough of it to make it a valued species? What are the economic considerations here? Should we be looking at other alternatives?</p>

Rationale for indicator A5

This indicator is a direct measure of timber value. However, it is based on past trends for value of species and sizes, and may be misleading. Nevertheless, it is a useful starting point for a value discussion.

A6. Economics of Harvesting and Associated Development (TENTATIVE).

These indicators are being considered but have not been confirmed as some discussion is required to ensure that that appropriate conclusions will be drawn from the results.

<i>TENTATIVE Indicator</i>	<ul style="list-style-type: none"> • Costs in \$/m³. • Focused specifically on those costs that are most likely to fluctuate due to climate change.
Threshold or Trend	<ul style="list-style-type: none"> • Threshold – undesirable if it rises above projected BAUBC levels. • Trend – Less is better.
Modeling Scale	<ul style="list-style-type: none"> • Assessed at landscape, BUT it is not clear which landscape model will be suitable or if it indeed will be modeled
Associated Question(s) (June 27, Version 1.1)	None – just the timber goal.

³ ***Potential Indicators set in italics*** – may be tracked depending on the ability of the models, which will be clearer once modeling is underway.

Rationale for indicator A6

This indicator addresses the second part of the economic question – that of harvesting and related costs. A detailed analysis of fixed and variable costs over time can be very complex. For our purposes we will try to keep this reasonably simple, but first will need to confirm the usefulness of the output.

A7. Regeneration Success

Indicator	<ul style="list-style-type: none"> • Likelihood of successful regeneration and productivity over time by species and general site type for each subzone grouping.
Threshold or Trend	<ul style="list-style-type: none"> • Trend – Comparisons of projections against what we might consider normal today. • Will use TACA and FORECAST to develop tables showing probability of successful regen and productivity at various time intervals. See comment – this may help link back to point one. • NOTE: This links to other indicators - productivity changes due to regeneration success will be reflected in landscape modeling and ultimately in other indicators (e.g. growing stock changes over time).
Modeling Scale	<ul style="list-style-type: none"> • Stand level (TACA and FORECAST) by stand unit and ecological group. • Will link to the landscape level by helping to <u>rationalize</u> changes in landscape indicators BUT is not modeled or reported at that level.
Associated Question(s) (June 27, Version 1.1)	<ol style="list-style-type: none"> 1. What is the regeneration success of each key species over time? 2. Where can we push some species? 5. Can we explore detailed information that will inform regeneration success (and growth over time of species - slope, elevation, aspect?)

Rationale for indicator A7

This indicator addresses a key question from practitioners – one that relates as much to the other management goals as the timber goal, since it will influence the composition of the stand units that will comprise the future landscape. While this indicator may provide some clues relating to trends with other indicators, it will also be of direct benefit to local practitioners – providing guidance for more resilient regeneration planning over time.

B. Indicators for Habitat and Biodiversity

GOAL = No loss of native species due to management over time.

Interpretation –This goal reflects the current 2008 CSA Criterion 1 (Biological diversity) - *Conserve biological diversity by maintaining integrity, function, and diversity of living organisms and the complexes of which they are part.* Because there are many influences within and outside of the TSA that could affect biodiversity and the range of species, we have specified “no loss due to management” – meaning forest management within the TSA. This statement recognizes that climate change may alter biodiversity in ways we can’t change or manage, but emphasizes that we don’t want the management of our forests to exacerbate those changes and also recognizes that management can improve species adaptability to climate change.

An obvious and likely the best way to monitor for this goal is to design indicators for key sensitive species⁴. However, due to the limitations of the proposed modeling there is a need for surrogate measures for “no loss of species”. These are in the form of key ecological and habitat elements and attributes at various scales.

B1. Old Forest Habitats.

Indicator	<ul style="list-style-type: none"> • A level of old forest over the Case Study area by ecological subzone group.
Threshold or Trend	<ul style="list-style-type: none"> • A graduated set of thresholds will be designed based on the best available science with: <ul style="list-style-type: none"> ○ A baseline set based on the Biodiversity Guidebook thresholds for the range of BEOs (see APPENDIX 1). ○ Other “thresholds” based on thresholds used elsewhere in BC combined with best science. • Will include the THLB and NTHLB combined.
Modeling Scale	<ul style="list-style-type: none"> • Assessed at landscape
Associated Question(s) (June 27, Version 1.1)	<p>16. How will the cumulative footprint of natural disturbance and harvesting disturbance and management impact habitat and biodiversity over time?</p> <p>20. Would the landscape model have to burn a whole area or is it able to leave patches?</p> <p>21. How will the “Climate Change Adaptive Harvesting Strategies” impact habitat and biodiversity over time</p>

Rationale for indicator B1

Concern over old forest derives mostly from the amount of time it takes for such stages to develop. Old seral forest are home to many organisms, some respond to the microclimatic conditions (e.g., many lichens and bryophytes,) some respond to the stand structures of

⁴ For example using a well designed field sampling approach.

older forests. There are well-documented relationships between many species and the stand structures of older forest. Sometimes, particularly for vertebrates, if these structures are retained, then younger forests can serve as habitat. Often reasons why organisms prefer old growth are unclear (e.g., many invertebrates) and probably are a mix of microclimate, structures that take a long time to develop (e.g., large limbs, shedding bark) time for biomass to accumulate, and time for dispersal and growth to occur (e.g., many lichens).

B2. Broadleaf forest habitats.

Indicator	<ul style="list-style-type: none"> • Percent broadleaf as a proportion on the landbase
Threshold or Trend	<ul style="list-style-type: none"> • Trend – near current levels or • Slightly higher is better.
Modeling Scale	<ul style="list-style-type: none"> • Rolled up and reported at landscape level, based on FORECAST information fed into the landscape model.
Associated Question(s) (June 27, Version 1.1)	<p>16. How will the cumulative footprint of natural disturbance and harvesting disturbance and management impact habitat and biodiversity over time?</p> <p>18. What will happen to the broadleaf component across the landscape?</p> <p>21. How will the “Climate Change Adaptive Harvesting Strategies” impact habitat and biodiversity over time</p>

Rationale for indicator B2

Maintaining broadleaf trees, and allowing broadleaf species to become old, is very important for maintaining biodiversity. Broadleaf trees develop heartrot earlier than do conifers and thus provide cavity sites for a wide variety of species at a relatively early age. Inclusion of a broadleaf tree component throughout the landscape over time may also help to provide potential fire breaks and additional cavity nesting habitat and CWD.

B3. Connectivity/ Patch Size / Fragmentation (Edge to Interior ratios).

Indicator	<ul style="list-style-type: none"> • NONE – not to be used at this time, since disturbance will not be modelled spatially under FPS. • We were considering an indicator of % interior forest conditions (mature or old forest > 100m from a managed and/or younger edge). Right now this is considered out of scope. May be able to do something with Dynaplan (not yet clear).
Associated Question(s) (June 27, Version 1.1)	16. How will the cumulative footprint of natural disturbance and harvesting disturbance and management impact habitat and biodiversity over time? 20. Would the landscape model have to burn a whole area or is it able to leave patches? 21. How will the “Climate Change Adaptive Harvesting Strategies” impact habitat and biodiversity over time

Rationale for indicator B3

Concern over patch size distribution originated with concern over effects of habitat loss and fragmentation. There is clear evidence of effects on species as habitat is reduced (that is as patches of habitat get smaller), there is also evidence that breaking up of habitat into smaller pieces or patches, without actual habitat loss, has some (negative?) effect on organisms.

Generally, concern over patch size is primarily a concern over size of old forest remnants or size of young forest openings. The concern is about keeping enough habitat and making sure similar habitats are not isolated from each other (to allow movement and dispersal). There are no ideal distributions of patch size and shape.

Keeping old forest and forest interior is more important, and ensuring that old forest will be generated in sizable pieces, with some connections is important. These effects are usually expressed through effects of edges and loss of forest interior and effects of isolation as distances between patches of habitat become large. Patch sizes and forest interior amounts will have changed with some frequency during the variety of past disturbances. However, increased disturbance due to climate change and harvesting may reduce the amounts of forest interior naturally found in the TSA.

Forest interior is defined as areas away from the effects of edges. It may be beneficial to maintain interior habitat because although edges benefit some species, some are sensitive to edges and affects of nearby openings. Reviews of edge effects (Kremsater and Bunnell 1999) suggest that microclimate variables (radiation, wind, relative humidity) can be influenced up to 200 m into a forest by adjacent openings, but most effects taper off by 100 m into the forest. The depth of the microclimatic edge effects depends on the exposure of the edge. South-facing edges tend to have longer depth of edge than those with northern exposures. (there is more info on this that should be added sometime based on work at the various silvicultural system trials in the Kamloops region)

B4. Retention and Distribution of Mature-to-Old Trees / Patches.

Indicator ⁵	<ul style="list-style-type: none"> • Amount of mature and old across the landbase. • Perhaps reported by ecological unit – as required. • We were considering an indicator to look at distribution of retention. This is not possible and out of scope at this point. May be able to do something with Dynaplan (not yet clear).
Threshold or Trend	<ul style="list-style-type: none"> • Trend up or down – May be more specific - to be determined.
Modeling Scale	<ul style="list-style-type: none"> • Rolled up at the landscape level based on changing age-class composition from stand level FORECAST modelling. • As required (where we see trends we want to look at) – a report is produced for that unit.
Associated Question(s) (June 27, Version 1.1)	<p>15. How will adaptive strategies applied at the stand level to leave structure influence habitat and biodiversity over time?</p> <p>16. How will the cumulative footprint of natural disturbance and harvesting disturbance and management impact habitat and biodiversity over time?</p> <p>20. Would the landscape model have to burn a whole area or is it able to leave patches?</p> <p>21. How will the “Climate Change Adaptive Harvesting Strategies” impact habitat and biodiversity over time</p>

Rationale for indicator B4

Species richness and functional dispersal seem to be positively influenced by the degree of connectivity throughout the landscape (Collinge 1998, Haddad 1999, Schmieglow et al. 1997, Wolff et al. 1997). However, elegant reserve designs with functional connective corridors may be easier to create in theory than in practice (Bunnell 1998, Feldman et al. 2002 and Franklin et al. 1997). Indeed, retention of important stand structures during harvesting is central to such an approach. In addition to the enhancement of connectivity in the managed landscape, Franklin et al (1997) identified two other important functions of stand level retention: “lifeboating” species and processes immediately after logging and before forest cover is re-established; and “enriching” re-established forest stands with structural features that would otherwise be absent.

As uncertainty increases with influences such as climate change, it becomes more important to retain more structure to allow organisms refuge and capability to move in response to the variety and intensity of disturbance. As well, this priority should influence how much and in what pattern trees are salvaged from wildlife areas and areas attacked by insects. Simply put, as areas of disturbance increase within a landscape, more structure at the stand level should be retained.

⁵ *Potential Indicators set in italics* – may be tracked depending on the ability of the models, which will be clearer once modeling is underway.

B5. Dead standing trees (snags).

Indicator	<ul style="list-style-type: none"> • Proportion of larger/ older trees dead across the Case Study area (using snags/ha).
Threshold or Trend	<ul style="list-style-type: none"> • Trend against current levels
Modeling Scale	<ul style="list-style-type: none"> • Assessed at stand unit level, and rolled up to landscape
Associated Question(s) (June 27, Version 1.1)	<p>15. How will adaptive strategies applied at the stand level to leave structure influence habitat and biodiversity over time?</p> <p>16. How will the cumulative footprint of natural disturbance and harvesting disturbance and management impact habitat and biodiversity over time?</p> <p>20. Would the landscape model have to burn a whole area or is it able to leave patches?</p> <p>21. How will the “Climate Change Adaptive Harvesting Strategies” impact habitat and biodiversity over time</p>

Rationale for indicator B5

The importance of snags for habitat and general biodiversity is well known. In the Kamloops TSA, several red- and blue-listed species utilize snags for key life stages and functions. Larger snags are generally considered more useful to a wider range of species for a broader range of uses than smaller snags. While large snags can be maintained relatively simply, they are difficult to create over time. Retention as well as recruitment of large trees is important to ensure a sufficient supply of large snags and large down wood in the future.

B6. Coarse Woody Debris.

Indicator	<ul style="list-style-type: none"> • CWD in m³/ha on THLB.
Threshold or Trend	<ul style="list-style-type: none"> • Trend over time (against current situation) – on the THLB • Possibly reported at the Ecological Unit level as required if there is an interesting trend to explore.
Modeling Scale	<ul style="list-style-type: none"> • Assessed at stand unit level and rolled up to landscape.
Associated Question(s) (June 27, Version 1.1)	<p>15. How will adaptive strategies applied at the stand level to leave structure influence habitat and biodiversity over time?</p> <p>16. How will the cumulative footprint of natural disturbance and harvesting disturbance and management impact habitat and biodiversity over time?</p> <p>21. How will the “Climate Change Adaptive Harvesting Strategies” impact habitat and biodiversity over time</p>

Rationale for indicator B6

The scientific literature provides little guidance on how much coarse woody debris (CWD) to retain in forested stands. This is partly because studies assessing down wood have found very high variability among sites in similar ecosystems, and partly because vertebrates show inconsistent and variable responses to CWD volumes (Bunnell et al 1999).

Just as for snags, however, simple abundance of down wood is not an adequate measure. For habitat, often the value is in keeping large pieces. Whereas a certain volume may be quite adequate to maintain many species, if that volume does not include many larger diameter pieces then it will not provide habitat for some more sensitive organisms. It should also be noted that large CWD pieces are far less of a fire hazard than small pieces and may not need to be removed during fuel management activities.

B7. Ungulates (designated winter ranges).

Indicator	<ul style="list-style-type: none">• % of UWR area meeting providing cover habitat according to the age criteria in the current GAR Order.
Threshold or Trend	<ul style="list-style-type: none">• Trends against the current situation.• Note changes in structure of UWRs - % cover etc – if required.
Modeling Scale	<ul style="list-style-type: none">• Assessed at landscape
Associated Question(s) (June 27, Version 1.1)	16. How will the cumulative footprint of natural disturbance and harvesting disturbance and management impact habitat and biodiversity over time? 20. Do fires that have high impacts on people also have high impacts on habitat and wildlife? If not, should we differentiate? 21. How will the “Climate Change Adaptive Harvesting Strategies” impact habitat and biodiversity over time?

Rationale for indicator B8

For widely dispersed ungulate species in the TSA, winter range habitat is considered as the most constrained critical habitat to sustain healthy populations. Therefore, understanding how climate change will influence the nature of these habitats is an important consideration. It is reasonable that this consideration will be tempered within the context of the changing requirement for high quality winter range, as climate change may reduce the need for thermal cover and/or snow interception for some ungulates (deer).

B9. Species at risk or of concern (tentative).

<i>Potential Indicator</i> ⁶	<ul style="list-style-type: none"> It may be possible to develop a (post hoc table – after modelling) listing species at risk in one column and noting direction of change to their habitat. (e.g. below)
Threshold or Trend	<ul style="list-style-type: none"> Trend over time (against current situation) – by ecological subzone group. <i>Note: without spatial information regarding retention or forest interior, this can only be done using the amount of retention left.</i>
Modeling Scale	<ul style="list-style-type: none"> Stand level – reported post hoc – not part of modelling.
Associated Question(s) (June 27, Version 1.1)	<p>15. How will adaptive strategies applied at the stand level to leave structure influence habitat and biodiversity over time?</p> <p>16. How will the cumulative footprint of natural disturbance and harvesting disturbance and management impact habitat and biodiversity over time?</p> <p>21. How will the “Climate Change Adaptive Harvesting Strategies” impact habitat and biodiversity over time</p>

Species at risk	Habitat 1	Direction of Habitat 1	Habitat 2	Direction of habitat 2	Overall
Flammulated owl	Large Ponderosa Pine	▼	Thickets of shrubs	▼	▼
etc					

⁶ *Potential Indicators set in italics* – may be tracked depending on the ability of the models, which will be clearer once modeling is underway.

C. Indicators for Fire Management

GOAL = Minimize fire risk to people and property.

Interpretation – To minimize fire risks in the urban rural interface, and in or near areas with concentrated infrastructure and recreational activities. It will be useful to check with Nikki Rivette (the fire management specialist in Kamloops Region) to determine if we are missing anything.

C1. Area burned over time, and potential consequences.

Indicators	<ul style="list-style-type: none"> • Area burned (ha) over time. <p>Note: We wanted to look at size and the distribution of fires across the landscape - but right now that is out of scope. May be able to do something with Dynaplan (not yet clear).</p>
Threshold or Trend	<ul style="list-style-type: none"> • Trends against current or past 20 to 30 years?
Modeling Scale	<ul style="list-style-type: none"> • Assessed at landscape
Associated Question(s) (June 27, Version 1.1)	19. What might be the impact of fuel management activities on habitat and biodiversity at the landscape level?

Rationale for indicator C1

Southern and central parts of B.C. are expected to experience drier summers thereby potentially increasing the frequency, severity and intensity of fires. The length of the fire season, as defined by climatic variables within the Fire Danger Rating System is a useful mechanism to reflect the potential for more frequent, and more severe wildfires.

C3. Change in Annual Fire Severity Ranking.

Potential Indicator	<ul style="list-style-type: none"> • % change in fire severity by ecological group over time
Threshold or Trend	<ul style="list-style-type: none"> • Trends against current situation.
Modeling Scale	<ul style="list-style-type: none"> • Assessed at ecological unity level. Separate modeling completed by CraigNitschke
Associated Question(s) (June 27, Version 1.1)	<p>17. How will disturbances be influenced by climate change and how will this influence patterns and structures across the landbase?</p> <p>19. What might be the impact of fuel management activities on habitat and biodiversity at the landscape level?</p>

Rationale for indicator C3

The fire severity classes reflect potential changing impacts from fire.

C2. Fire Return Interval

<i>Potential Indicator</i>	<ul style="list-style-type: none"> • Mean length of the fire return interval (years) over time.
Threshold or Trend	<ul style="list-style-type: none"> • Trends against current or past.
Modeling Scale	<ul style="list-style-type: none"> • Assessed at ecological unit level. Separate modeling completed by CraigNitschke
Associated Question(s) (June 27, Version 1.1)	19. What might be the impact of fuel management activities on habitat and biodiversity at the landscape level?

Rationale for indicator C2

Southern and central parts of B.C. are expected to experience drier summers thereby potentially increasing the frequency, severity and intensity of fires. The length of the fire season, as defined by climatic variables within the Fire Danger Rating System is a useful mechanism to reflect the potential for more frequent, and more severe wildfires.

C2. Fire Season (tentative) – not confirmed yet – may not be required

<i>Potential Indicator</i>	<ul style="list-style-type: none"> • The annual length of the fire season. • As defined by climatic variables affecting the Fire Danger Rating across the Case Study area.
Threshold or Trend	<ul style="list-style-type: none"> • Trends against current or past 20 to 30 years?
Modeling Scale	<ul style="list-style-type: none"> • Assessed at ecological unit level. Separate modeling completed by CraigNitschke
Associated Question(s) (June 27, Version 1.1)	19. What might be the impact of fuel management activities on habitat and biodiversity at the landscape level?

Rationale for indicator C2

Southern and central parts of B.C. are expected to experience drier summers thereby potentially increasing the frequency, severity and intensity of fires. The length of the fire season, as defined by climatic variables within the Fire Danger Rating System is a useful mechanism to reflect the potential for more frequent, and more severe wildfires.

D. Other Non-Timber, Non-Habitat Indicators

While these indicators may not be directly related to any of the management goals, they may be instructive regarding impacts on other values in the Kamloops TSA (beyond the key management goals for this project).

D1. Allowable Disturbance for Visual Quality.

Indicator	<ul style="list-style-type: none"> • The proportion of the area in Modification, Partial Retention, and Retention VQOs that continues to meet the % disturbance requirements.
Threshold or Trend	<ul style="list-style-type: none"> • Thresholds – maximum disturbance percentage greater than a given height as assigned to each visual polygon in the Case Study area, calculated according to <i>Procedures for Factoring Visual Resources into Timber Supply Analyses (MoFR 1998)</i>.
Modeling Scale	<ul style="list-style-type: none"> • Assessed at landscape
Associated Question(s) (June 27, Version 1.1)	

Rationale for indicator D1

The % disturbance by height class is a common method to assess landscape level attainment of visual quality objectives.

D2. ECA in Community and Domestic Watersheds.

Indicator	<ul style="list-style-type: none"> • The proportion of the upper 60% of community and domestic watersheds that continues to meet the % ECA requirements.
Threshold or Trend	<ul style="list-style-type: none"> • Thresholds – maximum of 20% ECA in the upper 60% of these watersheds.
Modeling Scale	<ul style="list-style-type: none"> • Assessed at landscape
Associated Question(s) (June 27, Version 1.1)	

Rationale for indicator D2

ECA is a common method to assess impact of harvesting on water flows.

E. Potential Indicator of Resilience - Proposed – status to be determined at end of modelling

It may be useful to build an “index of resilience” to address the over-arching project goals in a more formalized or quantitative way. To fit with the emerging paradigm of resilience-based management (Gunderson and Holling 2002⁷, Walker and Salt 2006⁸, Chapin et.al. 2009⁹), it would be helpful to bring together a number of the indicators used here into an index to reflect availability or foreclosure of management options over time, and changes to diversity and complexity across the landscape. This index would involve a spreadsheet ranking exercise rather than modelling

These indicators may include:

- A2- size of the timber harvesting landbase
- A3 – productive capacity of the timber harvesting landbase
- A4 – trends in growing stock
- A7 – regeneration success
- B1 – representation in unmanaged habitats
- B2 – old forest habitats
- B3 – broadleaf forest habitats
- B4 – connectivity / patch size / fragmentation
- B5- retention of wildlife trees and patches
- Possibly others

⁷ Gunderson, L.H. 2002. Panarchy: understanding transformations in human and natural systems. Island Press. 507 pp.

⁸ Walker, B. and Salt, D. 2006. Resilience thinking: sustaining ecosystems and people in a changing world. Island Press. 174 pp.

⁹ Chapin, F.S., G.P Kofinas, C. Folke. 2009. Principles of ecosystem stewardship: resilience-based natural resource management in a changing world. Springer Science and Business Media. 401 pp.

APPENDIX 1 – Guidance from the Biodiversity Guidebook that will be used as a starting point to examine trends for Habitat and Biodiversity Indicator #1.

Below are targets and definitions of mature and old for various Natural disturbance types and Biodiversity Emphasis Options (low, medium, high) taken from the old Biodiversity Guidebook. They are a starting point to help assess or guide scenarios.

NDT2								
	definition	definition	targets					
	mature	old	Mature+old			old		
BEO			L	M	H	L	M	H
BEC								
ICH	>100	>250	15	31	46	9	9	13
SBS	>100	>250	15	28	46	9	9	13
ESSF	>120	>250	14	28	42	9	9	13
Interior						10 %	25%	25%

NDT3								
	definition	definition	targets					
	mature	old	Mature+old			old		
BEO			L	M	H	L	M	H
BEC								
ICH	>100	>140	14	23	34	14	14	21
SBS	>100	>140	11	23	34	11	11	16
ESSF	>120	>140	11	23	34	14	14	21
SBPS	>100	>140	8	17	25	7	7	10
MS	>100	>140	14	26	39	14	14	21
Interior						10 %	25%	25%



NDT4								
	definition	definition	targets					
	mature	old	Mature+old			old		
			L	M	H	L	M	H
BEO								
BEC								
ICH	>100	>250	17	34	51	13	13	19
IDF	>100	>250	17	34	51	13	13	19
PP	>120	>250	11	23	51	13	13	19
Interior						25 %	50%	50%