Gowlland

Kispiox Timber Supply Area
Timber Supply Review

A “risk tranche” assessment of Western Balsam Bark Beetle disturbance

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prepared by: Andrew Fall, Gowlland Technologies Ltd.

Mark Perdue, RPF, Ministry of Forests

Executive Summary

Subalpine fir (*Abies lasiocarpa (Hook.) Nutt*) stands cover a large portion of the timber harvesting land base in Kispiox Timber Supply Area (TSA), and contribute a significant portion of the timber supply in the base case analysis done in support of the current timber supply review (TSR).

Western Balsam Bark Beetle (IBB; *Dryocoetes confusus Swaine*) is a major natural disturbance agent in subalpine fir stands, and reported as the largest disturbance agent contributing to non-recovered losses in the Kispiox TSA data package. However, there is significant uncertainty regarding the timing, location and variability of IBB disturbance in BC, as well as evidence to indicate that climate change will improve the conditions for IBB and result in increasing rates of disturbance.

This uncertainty of occurrence leads to uncertainty in future timber supply because of the reliance on subalpine fir stands and IBB disturbance assumptions in the Kispiox TSA base case timber supply projection.

To address these uncertainties, we applied a structured sensitivity analysis (the "*risk tranche*" approach) to explore IBB disturbance in subalpine fir-leading stands in the Kispiox TSA, using the forest estate model setup in the SELES Spatial Timber Supply Model (STSM).

1 Risk to Timber Supply Posed by Western Balsam Bark Beetle in Kispiox TSA

1.1 General ecology of Western Balsam Bark Beetle

Western balsam bark beetle (*Dryocoetes confuses* Swaine; also referred to as "*IBB"* in this memo) is primarily associated with subalpine fir (*Abies lasiocarpa (Hook.) Nutt.*), and is the primary mortality agent of subalpine fir, where it causes widespread, low intensity, mortality, with significant cumulative impact[6,10,9].

The British Columbia Provincial Aerial Overview Survey (OAS) from 2016-2021 identified IBB as the forested land base's single largest biotic factor by area[9].

There is relatively low knowledge regarding IBB compared to other bark beetles in BC, and the scale, extent and increase in affected area warrants further research to understand risk and potential impact to forest ecosystems and values within the coming decades[9]. Despite the key role of subalpine fir in BC's forested ecosystems, there is a lack of research regarding potential biotic and abiotic risks associated with changing climate, mortality rate, shelf life, or its value for traditional Indigenous peoples' use[8].

Available research indicates:

- Susceptibility increases with volume of subalpine fir, and historic outbreaks are correlated with longer growing seasons, higher growing degree-day accumulation and drought[6]. Volume losses of subalpine fir in a stand is correlated with stand composition (the percent of subalpine fir in the stand) and stand age.
- A study in southern BC found that, on average, up to 1% annual fir mortality and in excess of 30% cumulative mortality, occurred in affected mature and old subalpine fir-leading ESSF stands[7].
- Mortality is likely to increase with changing climate[6,7].
- Biannual

1.2 Subalpine Fir and Western Balsam Bark Beetle in Kispiox TSA

Based on the Kispiox TSA data package[5], the forest land base in Kispiox TSA includes a significant amount of subalpine fir (about 40%), as does the THLB land base (about 27% of the base case THLB) (Table 1).

The prevalence of subalpine fir is higher in areas characterized as "remote" (netted out of the base case THLB, but assessed as a sensitivity analysis) than in the THLB applied in the base case analysis (about 65% in the remote area THLB, resulting in about 31% for the THLB combining the base case and remote areas).

Table 1. Area of subalpine fir in Kispiox TSA (rounded to nearest 100 ha, based on 1-ha resolution grids used in the TSR analysis)

	Forest Area (ha)	**Base Case THLB (ha)**	**Base Case THLB + Remote THLB (ha)**
Total	762,700	258,100	295,900
Subalpine fir (scaled by % subalpine fir)	307,400 (~40% of the forest)	68,700 (~27% of the THLB)	93,200 (~31% of the combined THLB; ~ 65% of the remote THLB)
Subalpine fir-leading stands (≥ 50% subalpine fir)	307,100 (~40% of the forest)	62,900 (~24% of the THLB)	90,000 (~30% of the combined THLB; ~ 72% of the remote THLB)

1.3 Natural Disturbance in the Kispiox TSA Base Case Analysis

The Kispiox TSA data package includes the following information and assumptions regarding IBB[5]:

- Annual average volume losses of over 140,000 m^3/year of THLB due to IBB and not harvested from 1999 to 2018.
- *"… balsam comprises close to 40% of residual mature THLB volume*."
- *"District experience is that largest and highest volume trees are killed and canopy gaps fill with younger cohorts, resulting in a forest matrix where merchantable stand volumes stabilize at levels below or equal to 70% of potential. "*
- *"… mortality in the largest and highest volume balsam stems continues, and currently balsam mortality is typically not recovered."*

The data package includes the following information and assumptions regarding natural disturbance[5]:

- Explicit modelling of generalized natural disturbance within each BEC zone / natural disturbance type, with rotations based on the Biodiversity Guidebook, and modelled over the entire forest land base (i.e. affecting THLB and non-THLB stands).
- Non-recovered loss (NRL) estimates for the base case were based on annual loss of THLB volume based on annual averages over 20 years:
    - Western balsam bark beetle: 142,400 m^3/year
    - Mountain pine beetle: 13,789 m^3/year
    - Spruce Beetle: 6,623 m^3/year
    - Drought: 2,673 m^3/year
    - Wildfire: 18,946 m^3/year
    - Flooding: 501 m^3/year
    - Total: 184,932
- The aggregate of these NRL estimates were used to adjust the Biodiversity Guidebook rotations so that the emergent NRLs from the base case were consistent with the NRL estimates in the data package, particularly in the short- to mid-term. This created disturbance intervals that were more specific to the Kispiox TSA (which lowered disturbance rates somewhat by lengthening occurrence intervals).

- In the model setup, disturbed forest may be incidentally salvaged if there is sufficient volume, but due to low historic salvage in the TSA, the model setup does not prioritize salvage.

1.4 Modelling Western Balsam Bark Beetle as an Agent

A limitation of the approach used in the base case is that the generalized disturbance agents affect all forest equally, and do not target specific species.

To address this for the tranche analysis, our first step was to model IBB as a separate agent, which required two changes to the base case model setup:

- We removed the portion of generalize disturbance attributed to IBB: this was done by lengthening rotations (reducing disturbance) to only include the remaining natural disturbance agents.

- We added an IBB disturbance agent.

The forest estate model used for this analysis (SELES Spatial Timber Supply Model; STSM2022[1]) supports modelling of stand-replacing natural disturbance events, and Kispiox TSA was represented in the TSR analyses using raster grids with 1-ha resolution (100m x 100m grid cells). Given this forest representation, and that IBB susceptibility generally increases with amount of subalpine fir, we set up an IBB disturbance agent with the following:

- Forest types that can be disturbed: subalpine fir-leading stands ($\geq$ 50% subalpine fir).

- Relatively likelihood of initiation of disturbance: increasing with percent subalpine fir and with age.

- Based on converting the estimated NRLs to return intervals:

    - Mean volume/ha in subalpine fir stands $\geq$ 250 years old: 328 m^3/ha (estimated volume divided by area of old subalpine fir: 18,627,000 m^3 / 56,700 ha).

    - Expected area/year of IBB disturbance in old subalpine fir stands based on NRL estimate: 434 ha/year (NRL volume / mean volume per ha: 142,000 m^3/year / 328 m^3/ha).

    - Estimated interval of subalpine fir stands in the THLB: 215 years (area of subalpine fir in the THLB, including remote areas as in the data package NRL estimates, divided by area/year of expected disturbance: 93,200 ha / 434 ha/year).

The NRL volume / year implies an estimated 215 year rotation in subalpine fir, which we applied over all subalpine fir-leading stands (THLB and non-THLB).

2 Risk Tranche Method to Assess Timber Supply Risk

The “*risk tranche*” method is a structured sensitivity analysis to assess a gradient of risk factors that contribute to timber supply[2,3,4], and is based on the concept of *risk tranches* (“slices” in French) used in finance to stratify investments from lower to higher risk classes, each of which contributes differently to expected levels of return and/or loss of capital.

We adapted this concept to timber supply assessment, in which timber supply can be partitioned into components that contribute with different expected levels of risk due to their respective uncertainty. This approach can be used to explore sources of uncertainty inherent to timber supply analysis, including data uncertainty (e.g. accuracy and completeness), natural process uncertainty (e.g. magnitude and variability of natural disturbance and climate change), and operational uncertainty (e.g. variability of economic drivers of timber harvesting).

A low risk tranche represents the portion of timber supply with high certainty of being achievable, while a high-risk tranche represents the portion of timber supply with lower certainty.

Defining a set of risk classes in which higher risk categories embed lower risk categories allows net timber supply to be expressed in terms of the contribution of each risk class to timber supply (i.e. identifying the *timber supply tranche* associated with the risk class). This provides a tool to help interpret the degree of risk associated with timber supply overall and in different time periods.

This concept can be applied with the following steps:

Step 1: Define risk classes: Define components that range from relatively low to relatively high uncertainty or risk related to factor(s) of interest. These should be designed to illuminate understanding and may be based on geographic areas, stand attributes, regeneration assumptions, natural disturbance, priorities, etc.

Step 2: Structured sensitivity analysis: Assess a set of “nested” sensitivity analysis scenarios, in which risk increases from more risk-averse assumptions to more risk-inclined assumptions. Each scenario is a harvest flow for a given risk class plus all lower-risk classes. In this way, the timber supply outcome for each risk class will normally be the same or higher than the previous outcome. The scenario with the highest timber supply will include all risk classes.

Step 3: Overlay and assess results: The resulting harvest flows can be structured graphically to show the timber supply volume (total or %) contributed from each risk class. This can be used to identify the magnitude and timing to which each risk class contributes to timber supply.

3 Western Balsam Bark Beetle Disturbance Risk Classes

In this analysis in the Kispiox TSA, we designed and assessed five risk classes (Table 2). Given relative lack of knowledge regarding IBB, risk classes were designed to be quite general, and focused on

- The amount of harvest in subalpine fir-leading stands ("*B50*" refers to stands with ≥ 50% subalpine fir); and
- The rotation of IBB in subalpine fir-leading stands (using 215 years as the mid-level based on the NRLs reported in the data package, and applying increased and decreased rotations that may be plausibly be caused by climate change, host availability, etc.).

The lowest risk class assumed no harvest in subalpine fir-leading stands (and so impacts of IBB would be limited to interactions with forest cover objectives), and a relatively short IBB rotation. The highest risk (most optimistic) class assumed no IBB disturbance at all. These scenarios can be viewed as book-ends.

Table 2. Scenarios assessed for the risk tranche analysis in Kispiox TSA regarding Western Balsam Bark Beetle (IBB) and harvest in subalpine fir-leading stands (B50), ranging from lowest to highest risk.

Scenario	**Western Balsam Bark Beetle (IBB)**		**Management Actions**
	Rotation (years)	**Affected stands (% subalpine fir)**	
No-Harv B50 & IBB 100yr	100	≥ 50%	No harvest in subalpine fir-leading stands (netted out of THLB)
IBB-100yr	100	≥ 50%	As in base case
IBB-215yr	215	≥ 50%	As in base case
IBB-400yr	400	≥ 50%	As in base case
No-IBB	n/a	n/a	As in base case

4 Results

The results indicate (Figure 1):

- The majority of the base case timber supply volume is not sensitive to disturbance in subalpine fir-leading stands (Tranche 1; "*No Harv B50 & IBB-100yr*");
- Modelling IBB explicitly (with a disturbance rate that was nearly double the interval derived from the NRLs reported in the data package) resulted in a harvest flow similar to the base case ("*IBB-100yr*") which indicates that the base case harvest level is relatively robust to potential increases in IBB disturbance;
- In the 215 year IBB disturbance interval scenario (derived from the NRLs) harvest flow was increased significantly relative to the base case, which helps quantify the degree of resilience of the base case to potential IBB increases ("*IBB-215yr*"); and
- In the two scenarios that assume: 1) reduced disturbance to approximately half compared to the rotation derived from the NRLs reported in the data package ("*IBB-400yr*"), and 2) no IBB disturbance ("*No-IBB*"), harvest flow increases were disproportionally less relative to the change in disturbance interval. .

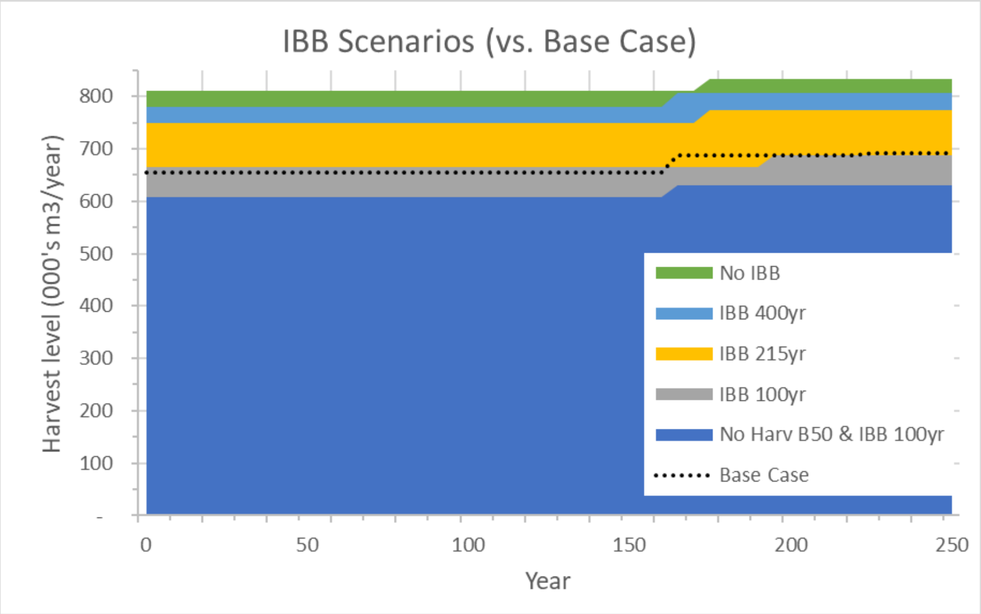

Figure 1. Timber supply from the assessed risk classes. Tranche 1 included no harvest of subalpine fir-leading stands and IBB with a 100-year rotation (dark blue);

Tranche 2 included timber supply from subalpine fir-leading stands (grey); Tranche 3 reduced IBB disturbance to a 215-year rotation (yellow); Tranche 4 reduced IBB disturbance to a 400-year rotation (light blue); and Tranche 5 assumed no IBB disturbance at all (green). The base case harvest flow is overlain with a dotted line.

The results for the scenarios that included THLB contributions from remote areas indicate (Figure 2):

- Timber supply contribution from the remote areas are less resilient to IBB than the base case, that is the contribution of timber supply from remote areas is less when modelling IBB explicitly than in the base case, particularly in risk classes with higher assumed IBB disturbance (Tranches 1-3).

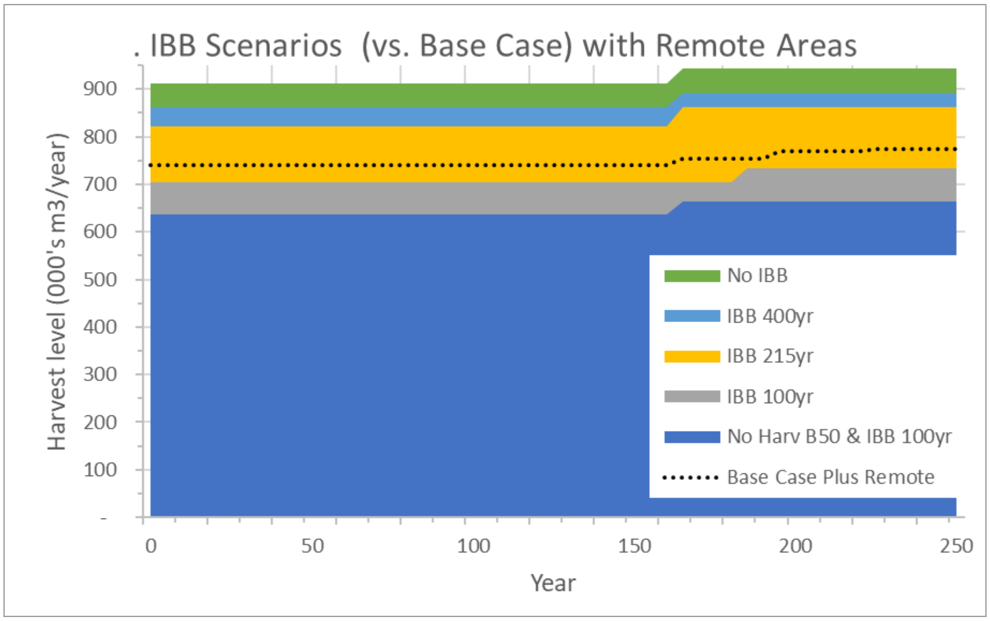

Figure 2. Timber supply from the assessed risk classes and including remote area THLB. Tranche 1 included no harvest subalpine fir-leading stands and IBB with a 100-year rotation (dark blue); Tranche 2 included timber supply from subalpine fir-leading stands (grey); Tranche 3 reduced IBB disturbance to a 215-year rotation (yellow); Tranche 4 reduced IBB disturbance to a 400-year rotation (light blue); and Tranche 5 assumed no IBB disturbance at all (green). The base case + remote areas harvest flow is overlain with a dotted line.

5 Conclusions

The following summarize some conclusions that can be drawn from this analysis:

- General:
  - IBB outbreaks have a significant effect on timber supply in Kispiox TSA, which is captured in the base case. This impact is approximated by comparing the base case scenario to the *No-IBB* scenario, where relative to the base case, timber increased by about 155,300 m^3/year (24%), and by 171,000 m^3/year (23%) when remote areas are included.
  - Under the base case assumptions, overall timber supply in Kispiox TSA has a relatively low dependence on subalpine fir-leading stands. Specifically, excluding all subalpine fir-leading stands from the THLB reduced timber supply by about 7% in the base case and 14% when including remote areas.
  - The range of potential timber supply impacts between these benchmarks (*No-IBB* at one end, and *No-Harvest* in subalpine fir-leading stands at the other) is -7% to +23% in the base case (a range of approximately 200,000 m^3/year), and about -14% to +23% when including remote areas.
- Base case:
  - Timber supply in the base case (which includes an aggregate natural disturbance assumption that includes NRLs due to IBB) is fairly robust to potential increases in IBB outbreaks, nearly double the disturbance levels seen in the 1999-2018 period.

    In particular, by limiting IBB disturbance to subalpine fir-leading stands, as well as increasing the likelihood of disturbance relative to the percent subalpine fir and stand age, rather than modelling disturbance without consideration of species composition (base case), increased timber supply.
  - Timber supply in the base case is similar to timber supply in the *IBB-100yr* scenario which represents an IBB disturbance rate approximately double the base case (reducing rotation from 215 years to 100 years), indicating that the base case has some resilience to possible increases in IBB outbreaks due to climate change. It is worth noting that doubling the IBB disturbance is

  generally based on expectation that this would require climatic conditions that would support an annual, rather than the typical bi-annual, IBB lifecycle.

  - Between tranche risk classes, the largest change in timber supply was between the scenarios that applied a 100 year rotation vs. a 215 year rotation (about 13% relative to the base case, or nearly half of the total potential range of effects between the benchmark scenarios). This indicates some sensitivity to increases in IBB outbreaks, but noting that timber supply for the scenario with a 100 year rotation is close to the base case.

- Remote areas:

  - Timber supply in the remote areas (which were not included in the base case) seems to be at relatively high risk to IBB, as well as any potential outbreak increases. This is due to the high proportion of older subalpine fir-leading stands.

    The timber supply benefit of including remote areas was less when modelling IBB in subalpine fir-leading stands than in the base case (about 73,200 m^3/year compared to about 86,800 m^3/year). This benefit further decreased at higher IBB disturbance rates (for a 100 year rotation, the benefit declined to about 39,200 m^3/year), which indicates that the remote areas are less resilient to increased IBB disturbance (mostly because about 72% of the areas are composed of older subalpine fir-leading stands).

6 Recommendations

Based on the conclusions, we make the following recommendations regarding the TSR analysis for Kispiox TSA:

- The base case assumptions regarding IBB are on the conservative (precautionary) side, which indicates that the base case timber supply projection includes some resilience to potential future increases in IBB outbreaks.

- The results add support to the exclusion of remote areas from the base case, considering the relatively higher IBB risk, higher access cost and lower value timber, these remote areas should not be considered for sustainable and robust harvest level projections.

- More research should be done to increase knowledge on landscape-scale IBB dynamics in BC.

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Appendix 1: Harvest Flows

Table 3 shows the harvest flows for the base scenarios.

Table 3. Harvest flows from base risk tranche analysis scenarios.

Year	Base Case	No Harv B50 & IBB 100yr	IBB 100yr	IBB 215yr	IBB 400yr	No IBB
10	654,200	607,400	665,900	748,000	779,200	809,500
20	654,200	607,400	665,900	748,000	779,200	809,500
30	654,200	607,400	665,900	748,000	779,200	809,500
40	654,200	607,400	665,900	748,000	779,200	809,500
50	654,200	607,400	665,900	748,000	779,200	809,500
60	654,200	607,400	665,900	748,000	779,200	809,500
70	654,200	607,400	665,900	748,000	779,200	809,500
80	654,200	607,400	665,900	748,000	779,200	809,500
90	654,200	607,400	665,900	748,000	779,200	809,500
100	654,200	607,400	665,900	748,000	779,200	809,500
110	654,200	607,400	665,900	748,000	779,200	809,500
120	654,200	607,400	665,900	748,000	779,200	809,500
130	654,200	607,400	665,900	748,000	779,200	809,500
140	654,200	607,400	665,900	748,000	779,200	809,500
150	654,200	607,400	665,900	748,000	779,200	809,500
160	654,200	607,400	665,900	748,000	779,200	809,500
170	686,600	631,100	665,900	748,000	805,700	809,500
180	686,600	631,100	665,900	773,400	805,700	833,000
190	686,600	631,100	665,900	773,400	805,700	833,000
200	686,600	631,100	688,500	773,400	805,700	833,000
210	686,600	631,100	688,500	773,400	805,700	833,000
220	686,600	631,100	688,500	773,400	805,700	833,000
230	691,900	631,100	688,500	773,400	805,700	833,000
240	691,900	631,100	688,500	773,400	805,700	833,000
250	691,900	631,100	688,500	773,400	805,700	833,000

Table 4 shows the harvest flows for the scenarios that included THLB in remote areas.

Table 4. Harvest flows from scenarios that included THLB in remote areas.

Year	Base Case + remote	No Harv B50 & IBB 100yr	IBB 100yr	IBB 215yr	IBB 400yr	No IBB
10	741,100	637,600	705,000	821,200	861,300	912,100
20	741,100	637,600	705,000	821,200	861,300	912,100
30	741,100	637,600	705,000	821,200	861,300	912,100
40	741,100	637,600	705,000	821,200	861,300	912,100
50	741,100	637,600	705,000	821,200	861,300	912,100
60	741,100	637,600	705,000	821,200	861,300	912,100
70	741,100	637,600	705,000	821,200	861,300	912,100
80	741,100	637,600	705,000	821,200	861,300	912,100
90	741,100	637,600	705,000	821,200	861,300	912,100
100	741,100	637,600	705,000	821,200	861,300	912,100
110	741,100	637,600	705,000	821,200	861,300	912,100
120	741,100	637,600	705,000	821,200	861,300	912,100
130	741,100	637,600	705,000	821,200	861,300	912,100
140	741,100	637,600	705,000	821,200	861,300	912,100
150	741,100	637,600	705,000	821,200	861,300	912,100
160	741,100	637,600	705,000	821,200	861,300	912,100
170	754,700	662,500	705,000	862,000	890,600	943,100
180	754,700	662,500	705,000	862,000	890,600	943,100
190	754,700	662,500	732,500	862,000	890,600	943,100
200	768,600	662,500	732,500	862,000	890,600	943,100
210	768,600	662,500	732,500	862,000	890,600	943,100
220	768,600	662,500	732,500	862,000	890,600	943,100
230	774,600	662,500	732,500	862,000	890,600	943,100
240	774,600	662,500	732,500	862,000	890,600	943,100
250	774,600	662,500	732,500	862,000	890,600	943,100