

Provincial Level Projection of the Current Mountain Pine Beetle Outbreak:

An Overview of the Model (BCMPB) and Results

Appendix 2. Management Sub-model Details

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Marvin Eng, Research Branch, BC Min. of Forests
Andrew Fall, Gowlland Technologies Ltd.
Josie Hughes, Research Consultant

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The management sub-models include planning, single-tree treatment and harvesting components. The broad objectives of these components are to capture the interaction between human forest management planning and actions, with feedbacks between the forest state, the MPB state and forest management constraints and goals (see Figure 1 in main summary document).

A2.1 Planning: Inventory Availability

This event performs an inventory analysis each time step. Unlike in a timber supply model, volume/ha is not updated by the model, but is rather an input grid. That is, the model tracks depletion of growing stock from harvesting and MPB, but not accrual of new volume due to stand aging. Given the short time horizon of model runs, this helps reduce model complexity.

We define *merchantable* stands as those with at least 150 m³/ha. We define *available* stands as merchantable stands that are within 2km of road access, and in zones not exceeding amount of young to meet visual quality objectives. The visual quality constraints applied are shown in Table 1, and were met within each landscape unit. These were estimated from values used in some TSAs and revised from values used in year 1 based on sensitivity analysis results. We plan further sensitivity analysis assessments these values in the upcoming year.

Table 1. Visual quality objectives applied by BCMPB

VQO Type	Young age	Max. young
IRM	12 years	25%
Maximum Modification	20 years	25%
Modification	20 years	25%
Partial Retention	20 years	15%
Retention	20 years	5%
Preservation	20 years	1%

Cells that may potentially be harvested as salvage are also identified. A cell may be classified as “salvage” if three criteria are met:

- (i) There is sufficient pine in the cell (percent pine is $\geq 50\%$)
- (ii) There is sufficient beetle mortality in the cell (percent of the pine that is killed is $\geq 50\%$)
- (iii) There is sufficient merchantable sawlog volume in the standing dead wood and residual live wood (sawlog yield is $\geq 100\text{m}^3$).

The first criterion ensures that the amount of non-pine “by-catch” is limited. The second ensures that the stand has sufficient cumulative attack to be classified as a salvage cell and to limit “by-catch” of live pine. The last criterion ensures that the stand is still economic to harvest. Note that, since a cell may experience multiple years of attack, it is possible for a cell to meet both the requirements for “green” harvest and for salvage. In this case, the logging sub-model will select the classification with the highest preference, which depends on the type of the BMU in which the cell resides.

A2.2 Planning: BMU rating

The second key task of this sub-model is to establish beetle management unit (BMU) types: monitor, suppression, holding action or salvage. For each BMU, the detectable area attacked as computed, and stratified by within/outside THLB and endemic/non-endemic, and an “outbreak level index” (*BMU rating*) was computed as:

$$(\text{Area with endemic MPB state}) + (\text{Area with MPB state} > \text{endemic})^2$$

The area of non-endemic MPB attack was squared is to place more weight on heavier attack levels, but the rating otherwise corresponds to increasing levels of MPB activity. The list of BMUs is then sorted according to the index, with smallest values first and BMUs are processed sequentially in this order. BMUs with no detectable MPB are processed first and assigned a *monitor* type. If the single-tree budget and AAC budget (after reductions for previously processed BMUs) is capable of addressing at least 80% of the “treatable” attack (i.e. all attack in the THLB plus endemic outside the THLB can be treated with harvesting and/or single-tree treatments), then a BMU is assigned a *suppression* type. Otherwise, if the AAC budget (after reductions for previously processed BMUs) is capable of addressing at least 50% of the “treatable” attack (i.e. attack in the THLB can be treated with harvesting), then a BMU is assigned a *holding action* type. Finally, unassigned BMUs are assigned a *salvage* type. Once a BMU is assigned a *salvage* type in a given year, it remains that type for the remainder of the simulation.

A2.3 Operations: Harvesting

This event performs forest harvesting in some portion of available cells. It applies target AACs simultaneously in each TSA/TFL in the province. Each management unit is processed independently, and so the model can be described from the perspective of a single unit. The harvest target for each management unit can be specified using a volume-base (m^3/year) or an area-based AAC (ha/year) to harvest within the THLB. All main analyses in year 2 applied a volume-based harvest, with base values shown in Table 2.

Table 2. Base harvest levels (in 1000’s of m^3) for each management unit applied by BCMPB up to year 2013, specified as an annual volume (m^3) to harvest.

MgmtUnit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
100MileHouse	1334	1334	1334	1334	1334	1334	1334	1334	1334	1334	1334
Arrow	550	550	550	550	550	495	495	495	495	495	495
Arrowsmith	392	392	392	392	392	392	392	350	350	350	350
Boundary	700	700	700	700	700	700	700	700	700	700	700
Bulkley	882	882	882	882	882	787	787	787	787	787	787
Cassiar	305	305	305	305	305	305	305	305	305	305	305
Cranberry	110	110	110	110	110	110	110	110	110	110	110
Cranbrook	838	941	941	941	941	941	941	941	941	941	941
DawsonCreek	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860
FortNelson	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500

Fraser	1079	1080	1080	1080	985	985	985	985	985	985	985
FtStJames	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482
FtStJohn	2115	2115	2115	2115	2115	2115	2115	2115	2115	2115	2115
Golden	485	485	485	485	485	485	485	485	485	485	485
Invermere	537	582	582	582	582	582	523	523	523	523	523
Kalum	437	437	437	437	437	437	437	437	437	437	437
Kamloops	4353	4353	4353	4353	4353	4024	4024	4024	4024	4024	4024
Kingcome	1204	1240	1240	1240	1115	1115	1115	1115	1115	1115	1115
Kispiox	977	977	977	977	977	977	879	879	879	879	879
KootenayLake	681	681	681	681	681	681	681	681	681	681	681
Lakes	2962	2962	2962	2962	2962	2962	2962	2962	2962	2962	2962
Lillooet	636	636	636	636	636	636	636	636	636	636	636
Mackenzie	3050	3050	3050	3050	3050	3050	3050	3050	3050	3050	3050
Merritt	1508	1358	1358	1358	1358	1358	1358	1358	1358	1358	1358
MidCoast	795	795	795	795	795	795	795	795	795	795	795
Morice	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961
Nass	865	865	865	865	865	776	776	776	776	776	776
NorthCoast	547	547	547	547	547	547	547	547	547	547	547
Okanagan	2655	2655	2655	2655	2655	2655	2655	2655	2655	2655	2655
PrinceGeorge	4385	4385	4385	4385	4385	4385	4385	4385	4385	4385	4385
QueenCharlotte	361	361	361	361	361	361	361	361	361	361	361
Quesnel	3248	3248	3248	3248	3248	3248	3248	3248	3248	3248	3248
Revelstoke	230	230	230	230	230	230	230	230	230	230	230
RobsonValley	602	602	602	602	602	542	542	542	542	542	542
Soo	503	503	503	503	503	503	503	503	503	503	503
Strathcona	1278	1278	1278	1278	1278	1125	1125	1125	1125	1125	1125
SunshineCoast	1143	1143	1143	1143	1143	1143	1143	1143	1143	1143	1143
Vanderhoof	5377	5377	5377	5377	5377	5377	5377	5377	5377	5377	5377
WilliamsLake	2923	2923	2923	2923	2923	2923	2923	2923	2923	2923	2923
TFL1	611	611	611	611	611	611	611	611	611	611	611
TFL10	171	171	171	171	171	171	171	171	171	171	171
TFL14	160	160	160	160	160	160	160	160	145	145	145
TFL15	70	70	70	70	70	70	70	70	65	65	65
TFL18	178	178	178	178	178	178	178	152	152	152	152
TFL19	940	940	940	904	904	904	904	904	869	869	869
TFL23	680	680	680	680	680	680	680	680	680	680	680
TFL25	557	557	514	514	514	514	514	514	514	514	514
TFL26	45	45	45	43	43	43	43	43	43	43	43
TFL3	80	80	80	80	80	80	80	80	80	80	80
TFL30	330	330	330	330	330	330	330	330	315	315	315
TFL33	21	21	21	21	21	21	21	21	30	30	30
TFL35	126	326	326	326	326	326	326	326	326	326	326
TFL37	1068	1068	1068	1068	1068	1068	1049	1049	1049	1049	1049
TFL38	251	251	251	251	251	233	233	233	233	233	233
TFL39	3547	3547	3547	3547	3547	3547	3547	3547	3502	3502	3502
TFL41	400	400	400	400	400	400	400	400	400	400	400
TFL42	160	160	160	160	160	160	160	160	160	160	160
TFL43	40	40	40	40	40	40	40	40	40	40	40
TFL44	1327	1327	1327	1288	1288	1288	1288	1288	1249	1249	1249
TFL45	208	208	208	208	208	208	208	208	208	208	208

TFL46	500	500	500	500	500	500	500	500	500	500	500
TFL47	780	780	780	780	780	780	780	780	780	780	780
TFL48	580	580	580	580	580	580	580	580	580	580	580
TFL49	380	380	380	380	380	380	380	380	380	380	380
TFL5	300	300	300	300	300	300	300	300	300	300	300
TFL52	570	570	570	570	570	570	570	570	570	570	570
TFL53	500	500	500	500	500	500	500	500	500	500	500
TFL54	76	76	76	76	76	76	76	76	76	76	76
TFL55	90	90	90	90	90	90	90	90	81	81	81
TFL56	100	101	101	101	101	101	99	99	99	99	99
TFL57	124	124	124	124	124	124	124	124	124	124	124
TFL6	1737	1737	1737	1737	1644	1644	1644	1728	1728	1728	1728
TFL8	175	175	175	175	175	175	175	175	175	175	175

Each model year, the target AAC provides a “beetle management potential”. How this is allocated across a unit depends on the BMU ratings, MPB state, stand ages/volumes and salvage volumes, and is designed to capture the fundamentals of bark beetle management (MOF and BCE 1995). The available cells in the unit are stratified into groups based on BMU rating and MPB outbreak state, and processed according to a priority order. The following described the strata, from highest to lowest priority within a management unit:

- Low and moderate MPB in suppression BMUs: focuses harvesting on leading edge attack.
- Endemic and severe MPB in suppression BMUs: focuses harvesting on other MPB attack in suppression BMUs.
- Low and moderate MPB in holding action BMUs: focuses harvesting on leading edge attack
- Severe MPB in holding action BMUs: focuses harvesting on high populations
- Salvage in salvage BMUs: areas that meet salvage criteria described in section A2.1.
- Moderate and severe MPB in salvage BMUs: focuses harvesting on areas likely to result in substantial salvage
- Salvage in other BMUs, and low and endemic MPB in salvage BMUs: remaining “mop-up” classes
- Green harvest (no MPB) in any BMU: regular green harvest

All available cells within a stratum are harvested before any cells in subsequent strata. Within each stratum, ordering is according to stand age (linearly increase with age relative to average minimum harvest age of 60 year for pine leading stands and 120 years for other stands), distance to roads (linear decline with distance) or salvagable volume (linear increase with volume or proportion), depending on BMU type and scenario parameters (i.e. cells classified as salvage base preference on the live plus standing dead sawlog quality volume, while other stands use age). In units with no MPB (i.e. all BMUs are *monitor* types), harvesting will be “green harvest”, and hence according to “oldest-first, nearest to road”. In management units with a mixture of BMU types and MPB states, the

actual allocation of harvesting will primarily focus on reducing populations (i.e. using MPB state), followed by salvage. In management units dominated by salvage BMU types, the default harvesting strategy will be “highest salvage-volume first, nearest to road”.

In some scenarios, the preference ordering above was modified. For example, to set up an “early switch to salvage” scenario, the preference for salvage blocks can be increased. If a cell is available for harvest according to both green criteria (i.e. min. harvest age, VQO) and salvage criteria (i.e. min. percent pine, min percent killed and min. volume yield), then the class with the highest preference will be applied. In addition, for salvage cells, parameters can control the relative weight of live and sawlog volume in determining preference (e.g. preference could be based entirely on standing dead wood, live wood, or some combination, depending on scenario objectives; the default focus is on dead wood volume).

The default cutblock size was 16-32ha (1-2 cells), based on a spatial assessment of recent block sizes in different regions of the province, and on the bark beetle regulations. Blocks are placed sequentially within a management unit until the harvest target is met.

Where blocks are placed, volume (green and salvage) is recuperated, harvest indicators are updated, MPB state is reset to “no MPB” (i.e. the model effectively assumes 100% efficacy), stand age is reset to 0, and visual targets are updated. In addition, this sub-model explicitly connects cutblocks to the main road network by adding a link from the first cell harvested in a block to the nearest existing road. It then updates a map indicating the distance from each cell to the nearest existing road. This step permits estimation of the amount of road constructed under a given management regime, and influences accessibility in the future.

A2.4 Operations: Single-Tree Treatments

This sub-model simulates fell and burn and MSMA treatment methods in each *suppression* BMU of the province simultaneously. First the provincial budget is allocated among *suppression* BMUs proportionally based on level of endemic MPB state. That is, if a suppression BMU has x% of the total endemic cells of all suppression BMUs, then it will receive x% of the single-tree treatment budget. Given a single-tree treatment allocation, the remainder of the model description can be cast from the perspective of a single BMU. Single-tree treatments are generally applied in inaccessible areas (up to 5km from a road) or areas with low (endemic and some low MPB state) beetle populations. These treatments are applied to individual cells, and the volume is not recovered. The model assumes that the MPB state is reduced by one level (i.e. endemic state becomes “no MBP”, while low becomes endemic).