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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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Canada 



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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 m<sup>3</sup>/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, but we plan on assessing sensitivity of results to these values in the upcoming year.

Table 1. Visual quality objectives applied by BCMPB

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

### 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, an “outbreak level index” (*BMU rating*) was computed as follows:

$$\text{Area with endemic MPB state} / \text{area with MPB} > \text{endemic state}$$

The index is first computed for each BMU separately. Then the list of BMUs is sorted according to the index, with largest values first. BMUs are then processed sequentially in this order. BMUs with no detectable MPB are processed first and assigned a *monitor* type. If the single-tree budget (after reductions for previously processed BMUs) is capable of addressing at least 80% of the spots, then a BMU is assigned a *suppression* type. Otherwise, if the BMU rating is  $\geq 0.2$  (i.e. at most 80% of the attack is in higher MPB attack states) and the total area attacked in the BMU is less than 5,000 ha, then the BMU is assigned a *holding action* type. Finally, unassigned BMUs are assigned a *salvage* type.

### 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. Currently the harvest target for each management unit is specified using an area-based AAC as the number of hectares to harvest within the THLB (Table 2). The model is capable of applying the harvest target as a volume-based AAC, and this will be explored in the upcoming project year.

Table 2. Harvest levels for each management unit applied by BCMPB up to year 2013, specified as an annual area (ha) to harvest.

<b>MgmtUnit</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>
100MileHouse	4371	4371	4371	4371	4371	4371	4371	5352	5352	5352	5352
Arrow	1829	1829	1829	1829	1829	1829	1829	1882	1882	1882	1882
Arrowsmith	521	521	521	521	571	571	571	571	571	513	513
Boundary	2594	2594	2594	2594	2594	2594	2594	2821	2821	2821	2821
Bulkley	3099	3099	3099	3099	3099	3099	3099	2756	2756	2756	2756
Cassiar	1325	1325	1325	1325	1325	1325	1325	1325	1288	1288	1288
Cranberry	246	246	246	246	252	252	252	252	252	252	252
Cranbrook	3609	3609	3609	3609	3609	3609	4068	4068	4068	4068	4068
DawsonCreek	7459	7459	7459	7459	7459	7459	7459	7459	7459	6867	6867
FortNelson	6842	6842	6842	6842	6842	6842	7141	7141	7141	7141	7141
FtStJohn	11426	11426	11426	11426	11426	11426	11426	11426	11426	11449	11449
Fraser	2779	2779	2779	2779	2779	2779	2989	2989	2989	2989	2989
Golden	1393	1393	1393	1393	1393	1500	1500	1500	1500	1500	1500
Invermere	2291	2291	2291	2291	2291	2291	2291	2291	2396	2396	2396
Kalum	783	783	783	783	783	783	818	818	818	818	818
Kamloops	8050	8050	8050	8050	8050	8050	8050	7885	7885	7885	7885
Kingcome	2189	2189	2189	2189	2189	2189	2020	2020	2020	2020	2020
Kispiox	2349	2349	2349	2349	2349	2349	2349	2349	2516	2516	2516
KootenayLake	2596	2596	2596	2596	2596	2596	2680	2680	2680	2680	2680
Lakes	4698	4698	4698	4698	4698	4698	4698	4442	4442	4442	4442
Lillooet	2858	2858	2858	2858	2858	2858	2970	2970	2970	2970	2970
Mackenzie	9478	9478	9478	9478	9478	9478	9478	9478	9730	9730	9730
Merritt	5366	5366	5366	5366	5366	5366	5366	5366	5128	5128	5128
MidCoast	1631	1631	1633	1633	1633	1633	1633	1751	1751	1751	1751
Morice	7000	7000	7000	7000	7000	7000	7000	7000	7000	7500	7500
Nass	1818	1818	1818	1818	1818	1818	1818	1678	1678	1678	1678
NorthCoast	775	775	775	775	775	775	925	925	925	925	925
Okanagan	7805	7805	7805	7805	7805	7805	8786	8786	8786	8786	8786
PrinceGeorge	29000	29000	29000	29000	29000	29000	29000	29000	29000	27000	27000
QueenCharlotte	581	581	581	638	638	638	638	638	620	620	620
Quesnel	9542	9542	9542	9542	9542	9542	9542	10019	10019	10019	10019
Revelstoke	468	468	468	468	468	468	495	495	495	495	495
RobsonValley	1750	1750	1750	1750	1750	1750	1750	1720	1720	1720	1720
Soo	761	761	761	761	761	761	804	804	804	804	804
Strathcona	2077	2077	2077	2077	2077	2077	2077	1761	1761	1761	1761
SunshineCoast	1715	1715	1715	1715	1694	1694	1694	1694	1694	1670	1670

WilliamsLake	27835	27835	27835	27835	27835	27835	27835	27835	13741	13741	13741	13741
TFL1	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300
TFL10	243	243	243	243	243	243	243	243	243	243	243	243
TFL14	675	675	675	675	675	675	675	675	675	675	675	675
TFL15	361	361	361	361	361	361	361	361	361	361	361	361
TFL18	571	571	571	571	571	571	571	571	571	571	571	571
TFL19	1541	1541	1541	1541	1541	1541	1541	1541	1541	1541	1541	1541
TFL23	1863	1863	1863	1863	1863	1863	1863	1863	1863	1863	1863	1863
TFL25	2362	2362	2362	2362	2362	2362	2362	2362	2362	2362	2362	2362
TFL26	593	593	593	593	593	593	593	593	593	593	593	593
TFL3	261	261	261	261	261	261	261	261	261	261	261	261
TFL30	1096	1096	1096	1096	1096	1096	1096	1096	1096	1096	1096	1096
TFL33	67	67	67	67	67	67	67	67	67	67	67	67
TFL35	442	442	442	442	442	442	442	442	442	442	442	442
TFL37	1307	1307	1307	1307	1307	1307	1307	1307	1307	1307	1307	1307
TFL38	485	485	485	485	485	485	485	485	485	485	485	485
TFL39	901	901	901	901	901	901	901	901	901	901	901	901
TFL41	559	559	559	559	559	559	559	559	559	559	559	559
TFL42	561	561	561	561	561	561	561	561	561	561	561	561
TFL43	156	156	156	156	156	156	156	156	156	156	156	156
TFL44	5886	5886	5886	5886	5886	5886	5886	5886	5886	5886	5886	5886
TFL45	356	356	356	356	356	356	356	356	356	356	356	356
TFL46	775	775	775	775	775	775	775	775	775	775	775	775
TFL47	1313	1313	1313	1313	1313	1313	1313	1313	1313	1313	1313	1313
TFL48	2447	2447	2447	2447	2447	2447	2447	2447	2447	2447	2447	2447
TFL49	1539	1539	1539	1539	1539	1539	1539	1539	1539	1539	1539	1539
TFL5	829	829	829	829	829	829	829	829	829	829	829	829
TFL52	1738	1738	1738	1738	1738	1738	1738	1738	1738	1738	1738	1738
TFL53	1623	1623	1623	1623	1623	1623	1623	1623	1623	1623	1623	1623
TFL54	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750
TFL55	207	207	207	207	207	207	207	207	207	207	207	207
TFL56	199	199	199	199	199	199	199	199	199	199	199	199
TFL57	123	123	123	123	123	123	123	123	123	123	123	123
TFL6	988	988	988	988	988	988	988	988	988	988	988	988
TFL8	709	709	709	709	709	709	709	709	709	709	709	709

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. 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 with adequate salvage ( $> 50\text{m}^3/\text{ha}$ )
- 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), distance to roads (linear decline with distance) or salvagable volume (linear increase with volume or proportion), depending on BMU type and scenario parameters. 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, harvesting will be “highest salvage-volume first, nearest to road”.

The default cutblock size was up to 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 assumes close to 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 to determine 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

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that the MPB state is reduced by one level (i.e. endemic state becomes “no MBP”, while low becomes endemic).