Potential impacts of Mountain Pine Beatle infestation on Rocky Mountain tailed frog (*Ascaphus montanus*), southeastern British Columbia

Report to

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1.0 Introduction

As part of the ongoing assessment of the impacts of Mountain Pine Beatle (MPB), I have been asked to provide a review of potential MPB impacts on tailed frog WHAs in southeastern British Columbia (Figure 1). These WHAs consist of 50 m buffers along either side of breeding and headwater dispersal reaches on all streams containing tailed frog in the Yahk and Flathead watersheds (Figure 2). The specific questions to be addressed are listed below:

- Through what processes may MPB infestation affect tailed frog?
- What portions of tailed frog WHAs may currently, or in the future, be affected by MPB infestation, and to what degree?
- What are some restoration techniques that may mitigate any negative impacts caused by MPB, including possible negative impacts associated with salvage operations adjacent to WHAs?
- Are there priorities for possible restoration activities or areas?

This report assumes the reader has a familiarity with tailed frog habitat and conservation needs: for detailed information on the distribution and habitat associations of tailed frog in southeast British Columbia, the reader is referred to Dupuis and Friele (2002, 2004, 2006); for information on conservation status see Dupuis (1998) and Dupuis and Friele (2005a). Dupuis and Friele (2006) is attached to this document as Appendix 1.

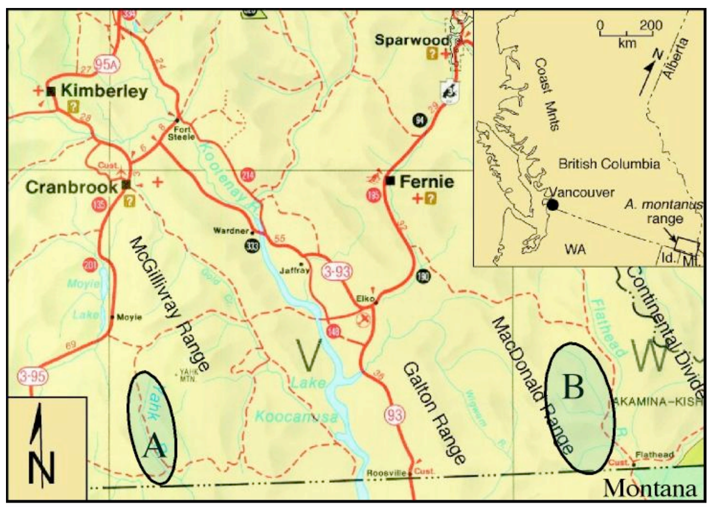

Figure 1. Distribution of tailed frog in southeast BC. A) Yahk River, B) Flathead River.

2.0 Background Materials

The materials supplied by MoE that form the foundation for this assessment are a series of maps (1:10,000 scale) and associated Excel spreadsheet showing vegetation polygons and forest cover data within tailed frog wildlife habitat areas (WHAs) in the Yahk and Flathead rivers southeast of Cranbrook, BC (Fig. 1). The vegetation cover maps provided do not cover the entire contributing watershed, nor do they provide any information on MPB infestation rates. Nor was summary data, such as total pine by age class within each major subbasin, provided.

3.0 Limitations

This assessment is limited to direct riparian impacts only. Watershed level MPB infestation and salvage operations, likely to affect hydrogeomorphic processes along WHAs, are not considered in detail. Only pine percentages by age class were provided, with no indication of infestation rates. Thus, it is assumed that *potential* infestation rates are proportional to pine percentage by age class. Estimates of areas of affected are made by visual estimate from maps provided. See Appendix 2 for recommended GIS queries to improve estimates of areas affected.

4.0 *Ascaphus*' distribution and environmental setting

Rocky Mountain tailed frog (*Ascaphus montanus*) is distributed within two watersheds in southeastern British Columbia: the Yahk and the Flathead, west and east of the Rocky Mountain Trench, respectively (Figure 1). Within the Yahk the main sub-basins are the upper Yahk, Norge, Malpass, Sprucetree, Cedartree, Paired, Noname, and Boyd, with a satellite population in Screw Creek, tributary to west Yahk River (Figure 2). Within the Flathead the main sub-basins are the Storm, Cabin, Burnham, Canadian Couldrey and American Couldrey drainages; satellite populations also exist within the North Fork of Bighorn and Leslie drainages (Figure 2).

The two regions differ in their climate and physiography. The Yahk River mainstem flows at 1200 m elevation, and its tributaries drain forested catchments with a relief of about 600 m (Dupuis and Friele 2002). Consequently, the Yahk supports a relatively warm, moist climate regime is reflected in two of its three predominant biogeoclimatic zones: moist, warm Interior Cedar Hemlock (ICHmw), and Engelmann Spruce-Sub-alpine fir (ESSFwm). Conversely, the mainstem valley Flathead River flows at 1400 to 1500 m elevation, with some sub-basin tributaries draining alpine catchments with relief up to 1100 m (Dupuis and Friele 2004). The result is a drier and colder climate, supporting primarily ESSFdk and Msdk biogeoclimatic zones. Fire is a characteristic disturbance in these ecosystems, with regeneration creating extensive areas of pine-dominated forest.

5.0 Mechanisms for potential MPB impacts to tailed frog

Potential impacts to tailed frog will arise from changes to stream hydrology and sedimentation regimes; and, in the terrestrial environment, to alterations in the availability and interconnectedness of moist microhabitats, especially to those that provide stepping stones or linkages across drainage divides, thereby facilitating dispersal between subpopulations. Further, increased fire hazard may increase risk of sedimentation or direct mortality in some settings. The mechanism are discussed in more detail below:

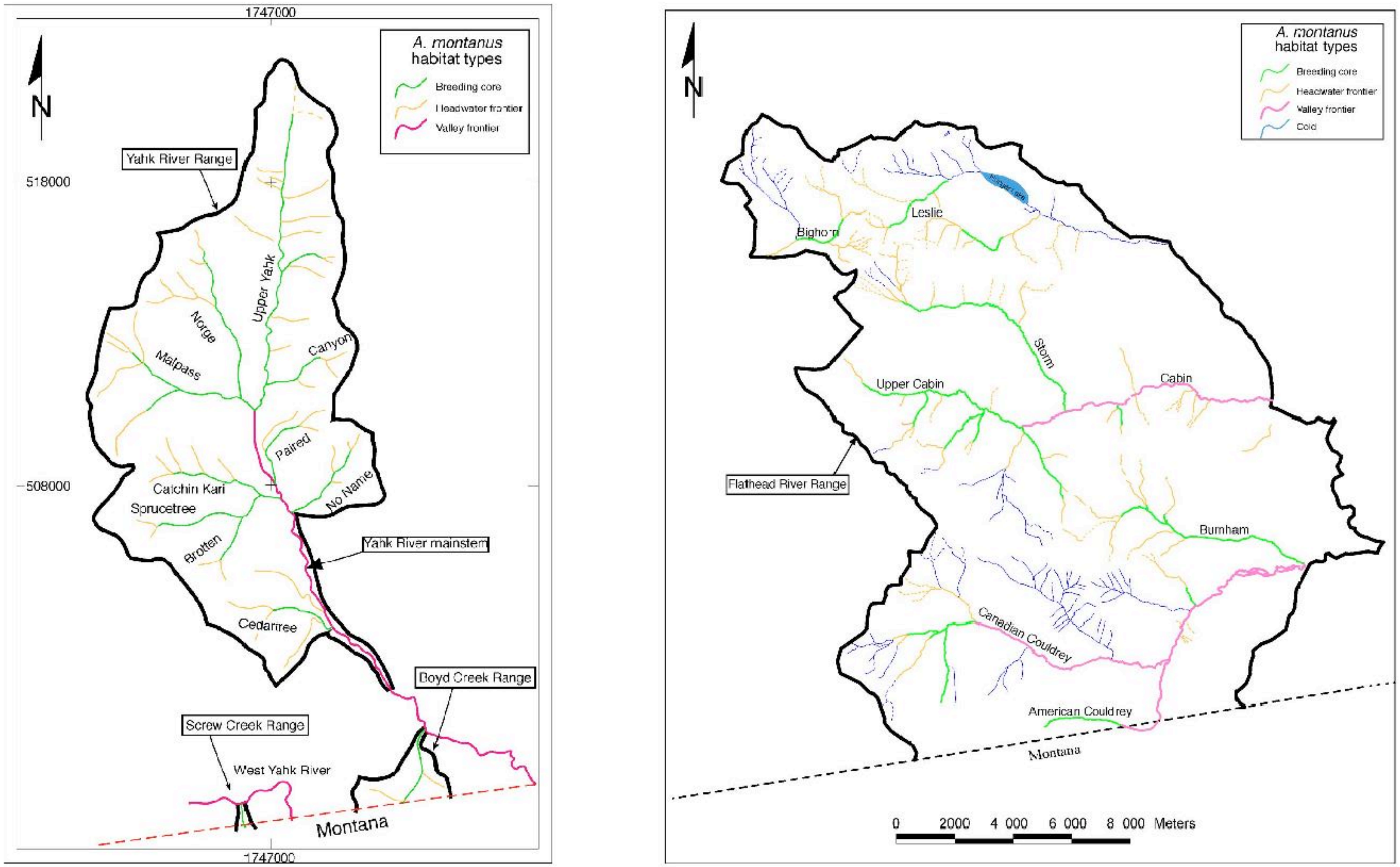

Figure 2. Distribution of tailed frog: A) Yahk River, and B) Flathead River watersheds (from Dupuis and Friele 2005). WHAs are coincident with breeding reaches and perennial headwaters.

5.1 Watershed level impacts

Mountain Pine Beatle infests vast areas, often covering entire watersheds. Further, conventional management of MPB infestation includes salvage logging, with clearcut sizes much larger than allowed under normal operational conditions, possibly exceeding "equivalent clearcut area" thresholds. As a consequence of MPB infestation, the combined effect of infestation and salvage over large areas may impact the hydrology and geomorphology of tailed frog habitat.

The available research on the hydrologic effects of MPB were recently summarized by Uunila et al (2006):

> "Overall, the <available information> suggests that the effects of MPB on forest hydrology may be similar to those experienced after forest harvesting. Within even-aged stands without significant understorey, these effects include (1) increases in annual water yield (10-20%), (2) increases in late summer and fall low flows (10-30%), (3) variable responses (no change or increases up to 50%) in peak flow size, and (4) possibly earlier timing of peak flows. Furthermore, these effects may last up to 60–70 years. The presence of uneven-aged, multi-storied stands will likely reduce these impacts." Pg. 5.

As with any potential affects of timber loss, the hydrologic impacts are likely to be highly variable from watershed to watershed, depending largely on the magnitude and distribution of the disturbance in relation to topography (Schnorbus and Alila 2004). With attendant salvage logging, these hydrologic impacts are likely to be more certain and/or pronounced (Jones and Grant 1996; Thomas and Megahan 1998; and successive debate).

Of the potential hydrologic impacts cited, increase of overall water yield should not negatively impact tailed frog; while increases in peak instantaneous flow may cause impacts if peak flows exceed thresholds for bedload transport leading to breakdown of channel structure. In Interior snowmelt-dominated watersheds, these extreme instantaneous fall floods are exceedingly rare, and likely present a low risk.

The literature on hydrologic impacts of MPB, with and without salvage, suggests there will be an increase of low flows during late summer/fall. This would benefit tailed frog. However, it is noted that these conclusions are based on studies where flow is measured, or modeled, at downstream locations. No literature exists that maps the impacts over the entire stream network. Presumably, if snowmelt occurs earlier in the year, headwaters would experience low flows earlier, and this could lead to headwater drying and contraction – representing a direct loss of habitat.

A fundamental impact of logging is riparian and channel disturbance associated with road construction and use (Jones et al 2000). These effects, resulting largely from sedimentation impacts, have the potential to adversely impact tailed frog population viability.

Finally, MPB caused forest mortality results in a high risk of forest fire. At the watershed level, forest fire can result in an increased sedimentation hazard, through slope wash and or debris flow activity (Grainger and Wilford 2004). This effect would be most pronounced in areas of severe burn, and in areas of steep topography with high slope-to-channel connectedness. The 2003 Ram-Cabin fire did not result in a severe sedimentation impact because the affected basins were very gentle (Friele and Dupuis 2005a). Post fire regeneration, dominated by pine, may set up a watershed for a future MPB infestation.

5.2 Direct Riparian Impacts

Partial or complete mortality of riparian stands would cause a short-term an increase in the input of fine woody debris into the channel, and a long-term increase in coarse woody debris recruitment. The degree of woody debris loading would presumably be proportional to the initial percentage of pine in the stand.

It is possible that a large increase in woody debris could increase the number of forced-steps (see Montgomery and Buffington 1997) along the channel. These forced-steps, or sediment wedges, could result in an overall fining of bed texture resulting in a loss of stream habitat quality. Further, heavy debris loading could hamper animal dispersal (adults, juveniles and tadpoles) both upstream and downstream. The impact cycle would take several decades to initiate and could persist as long as it takes for fine woody debris to flush and woody jams to rot out, perhaps half a century or more. Clearcutting or selective harvest within the WHA would lessen this impact, provided yarding does not result in direct impact to channel banks.

The loss of foliage, taking up to several years, would result in a slight loss of shade (somewhere between green canopy and clearcut conditions), which might decrease terrestrial habitat quality by an increase in insolation and desiccation of ground cover, reducing foraging and dispersal opportunities for adults and juveniles. However, this would likely be compensated by a rapid increase in understory vegetation, so the impact to riparian terrestrial environment is likely to be minimal and short lived (<20 years).

Again, the direct riparian impacts cannot be separated from the watershed level impacts. For, the degree of riparian impact is linked to what occurs adjacent to the riparian zone. For example, clearcutting adjacent to riparian stands may allow wind to penetrate the riparian stand, increasing desiccation of riparian terrestrial habitat. This could further limit foraging and dispersal opportunities.

Following MPB infestation, there may be increased risk of fire within the WHA. Fire may or may not have an instant and direct impact on tailed frog, and this would be dependant on the intensity of the burn. Burn intensity is a function of riparian soil moisture, which if moist to wet may reduce intensity. Fires with high burn intensity along streams could raise water temperatures above lethal and cause direct mortality. The 2003 Ram-Cabin fire, burnt intensely along a portion of the upper Storm WHA, and likely caused direct mortality to any individuals in that area, both terrestrial and instream. However, in large portions of the burn, along the main breeding reaches of the Storm and Leslie WHAs, the fire intensity was light, with ground creep and scattered candling, and the impact on stream temperature and ground cover was minor. So impacts were not considered severe (Friele and Dupuis 2005). Again, natural revegetation of pine stands after a burn may set up conditions for a future MPB infestation.

Clearcut salvage of the riparian vegetation along WHAs would increase insolation, resulting in (1) a warmer stream temperature regime, and (2) increased desiccation of terrestrial habitat. The impact of warmer stream temperatures on tailed frog is dependant on the situation; and only where stream temperatures rise above lethal thresholds (18-21°C), would the impact be considered negative. Since stream temperatures adjust to ambient air temperatures relatively quickly, the change would be dependant on both the initial condition (cold versus warm flow) and on the length of channel open to direct insolation. Site-specific assessment of thermal sensitivity is required (Teti, 2004, 2006). The impact of clearing on terrestrial animals would be to limit foraging and dispersal as discussed above. These impacts are expected to persist until understorey and canopy cover are replaced, perhaps over 20-60 years.

6.0 Vegetation distribution and assessment of potential infestation areas

Vegetation distribution patterns within *WHAs*, with pine percentages as the proximate variable for potential MPB infestation areas, are summarized below. It is assumed that areas with dominantly mature (61-120 years) to old (120^+) forest with >60% Lodgepole pine presently have potential for high infestation; while, areas of dominantly young forest (<60 years old) with >60% pine represent areas of future high infestation. Correspondingly, areas of moderate pine (31-60%) and low pine (0-30%) have potential for moderate and low infestation, respectively, with the imminence depending of stand age.

6.1 Yahk

6.1.1 Upper Yahk River

The northern portion of upper Yahk WHA, upstream of the first breeding tributary from Canyon Creek, contains 40% non-pine and about 60% mature (60-120 years) and old (120+ years) forest of which the majority is <60% pine. Canyon Creek and the downstream 1/3 of the mainstem are composed of young (1-60 years) forest, and of this about 50% is >60% pine.

Aside from Canyon Creek, the upper Yahk River is a mosaic of age classes and is not dominated by pine. The WHA is not at risk of heavy infestation, but about 25% of the headwater area has a risk of moderate infestation. In future (30-100 years), only Canyon Creek appears potentially susceptible to heavy MPB infestation.

6.1.2 Norge Creek

The Norge Creek WHA is about 90% young forest (1-60 years), with about 70% of the area composed of <60% pine. Only the northern headwater, upstream of Happy Ted Creek, has about 80% coverage of young forest composed of >60% pine. The east slopes of this tributary have recently been salvage logged (Figure 3).

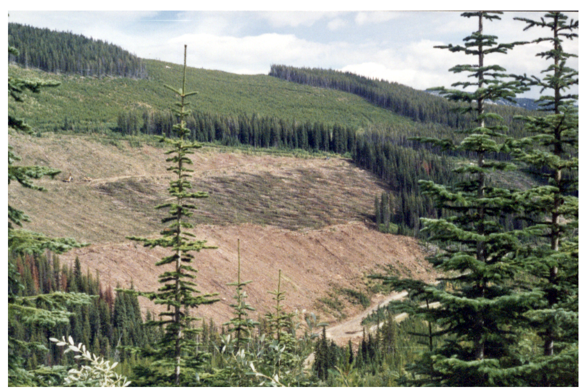

Figure 3. MPB salvage in the Norge Creek subbasin, Yahk River, 2005.

At present, Norge Creek has a low risk of MPB infestation. Only the north Fork presents a future (30-100 years) potential for heavy MPB infestation.

6.1.3 Malpass Creek

The Malpass WHA is comprised of 2 main tributaries. The south tributary and the mainstem down to the mouth are 80% non-pine forest. The northern tributary is 90% mature (61-120 years) and old (120^+ years) forest, with about 40% of this, concentrated in the headwater, composed of >60% pine.

The Malpass Creek mainstem and south tributary have low potential for MPB infestation. Presently, only the north fork of the northern tributary has a potential for heavy infestation.

6.1.4 Sprucetree Creek

Sprucetree WHA is 90% covered by young (1-60 year) forest with limited area of mature (60-120 year) forest in the two northern tributaries. The WHA is almost exclusively <60% pine, with only a few >60% pine polygons on the alluvial fan at the mouth. Presently and in the future, Sprucetree Creek has a low risk of significant MPB infestation.

6.1.5 Paired Creek

No data was provided for this WHA.

5.1.6 No Name Creek

Noname WHA is non-pine and young (1-60 year) forest. The downstream 1/2 of the channel is >60% pine, resulting from an old burn. In the future, this WHA has potential for heavy MPB infestation.

6.1.7 Cedartree Creek

Cedartree WHA is 70% mature (60-120 years), with 30% young (1-60 year) forest located in the headwater. The entire area is non-pine or <60% pine. The WHA support a low risk of significant MPB infestation.

6.1.8 Boyd Creek

Boyd WHA supports non-pine and mature (61-120 years) forest. Only about 10% of the area is >60% pine. Boyd Creek has a low potential for significant MPB infestation.

6.1.9 Screw Creek

No data was provided for this WHA.

6.2 Flathead River

6.2.1 Storm Creek

Storm WHA is 60% non-pine forest, with the remaining composed of young to mature, <60% pine. The majority of the watershed has low potential for MPB infestation, with the lower canyonized reach supporting a risk of moderate MPB infestation.

6.2.2 Cabin Creek

The Cabin Creek WHA consists of the mainstem with four north flowing tributaries, numbered successively from west to east. The mainstem from the headwater downstream to just downstream of tributary 1 is 100% non-pine forest, as are tributaries 1 and 4, and 70% of tributary 2. These areas have low risk of MPB infestation. The remaining portion of the mainstem and tributaries 2 and 3 are mixed non-pine and young to mature pine forest, with <60% pine in the mix. These areas have low to moderate risk of significant MPB infestation.

6.2.3 Burnham Creek

The Burnham WHA can be divided into headwaters above the major confluence, and the mainstem downstream. The headwaters are 70% non-pine forest, with a small area of young (1-60 year), <60% pine along a southern tributary, and a small area of mature, <60% pine along the northern tributary. Both headwaters form an important link to the adjacent Cabin WHA. The mainstem is 40% non-pine forest and the remaining mature (61-120 years), <60%pine. Pine infestation in the headwater is expected to be low, and along the mainstem it is expected to be moderate.

6.2.4 Canadian Couldrey Creek

Canadian Couldrey WHA is 90% non-pine forest with only a small amount of old (120+ years) >60 pine forest near the lake outlet. The potential for significant MPB infestation is low.

An isolated tributary to Canadian Couldrey forms an important stepping-stone into Burnham WHA. This WHA is 100% mature (61-120 years) forest. The headwaters are >60% pine, and support a risk of heavy MPB infestation.

6.2.5 American Couldrey Creek

The American Couldrey WHA is about 50% mature (61-120 years) to old (120+ years) forest and 50% non-pine. The >60 year old stands are about 50% >60% pine stands. Heavy MPB infestation is expected along the downstream 1-km especially along the right bank. Elsewhere infestation risk is expected to be low.

6.2.6 North Fork Bighorn Creek

North fork of Bighorn WHA is 50% non-pine and 50% young to mature, <60% pine forest. This WHA has low potential for MPB infestation.

6.2.7 Leslie Creek

Leslie WHA is 90% non-pine forest, with the remaining area, mature to old, <60% pine forest. This WHA has low potential for MPB infestation.

7.0 Summary of areas subject to potential infestation

In the Yahk WHA system, only 25% of upper Yahk supports a potential for moderate infestation. Canyon Creek, the northern headwaters of both Norge and Malpass creeks, and the lower 1/2 of Noname Creek support a potential for heavy infestation during future outbreaks. Elsewhere, there are mixed forests with <60% pine dominance, supporting generally low risk of significant MPB infestation.

In the Flathead WHA system, areas to be concerned about moderate to heavy pine infestation are the lower 1-km of the American Couldrey, the headwater of the isolated tributary to Canadian Couldrey, the Lower Burnham, the headwater of the north fork of Burnham, and the lower Storm. These are important stream reaches in that they have been previously identified as important linkages between sub populations (Dupuis and Friele 2004). Elsewhere, there are mixed forests with <60% pine dominance, supporting generally low risk of MPB infestation and/or a low infestation density.

Where forests are mixed non-pine and pine, and infestation rates are moderate to low dead trees will be scattered or clumped throughout WHAs. The expected impact at the stand level from such a distribution of standing dead trees is expected to be low. It seems only where heavy infestation causes extensive, contiguous zones of standing dead would intervention be required to reduce woody debris loading or fire hazard. However, it is recognized that each eco-socio-economic context/condition will demand distinct mitigation and/or restoration techniques (Section 8.0) for a variety of reasons.

8.0 Recommended mitigation/restoration techniques

8.1 Monitoring

• As a method of measuring the effectiveness of WHAs, FRPA has initiated a monitoring program in the Yahk and Flathead drainages (Dupuis and Friele 1995b; Friele and Dupuis 1996b). Monitoring is divided into different levels: routine, extensive and intensive. A MPB monitoring program for tracking infestation in and around tailed frog WHAs should be developed. Only with baseline monitoring can responses to infestation be initiated.

8.2 Watershed level

- As part of MBA management plan, conduct watershed level "equivalent clearcut area analysis", and/or detailed numerical modeling, to predict potential impacts from MBA infestation alone and/or projected salvage operations;
- Based on results above, design salvage to minimize impact to length of low flow period and length of perennial stream network, focused on headwater reaches;
- Since MPB infestation may occur at rates much less than 100%, determine whether conventional clear-cutting is required, or is selective harvest more appropriate (Snetsinger 2005);
- Map moist to wet ecosystem variants and ensure these are not clearcut, and leave corridors between patches if feasible;
- Identify important headwater linkages between sub-basins (see Dupuis and Friele 2004) and maintain forested corridors between them, preferably along ephemeral channels;
- Where selective cutting is not possible, or has not been done, then replant as soon as possible, to accelerate hydrologic green-up;
- Restock logged or burned sites using ecosystem appropriate, non-pine species or mixed species assemblages;
- Avoid road construction in stability class IV or V terrain polygons with direct connectivity to the stream network;
- Minimize road density and number of road crossings;
- Reduce connectivity between ditch and stream networks;
- Undulate road grades;
- Deactivate road system upon completion of salvage operations.

8.3 Direct riparian impacts

- Assess direct riparian impacts in the context of overall basin-wide impacts. For example, do clearcuts extend to the edge of the WHA or are wider buffers present, thereby mitigating desiccating effects of wind;
- Where infestation rates are moderate to low (<60%), leave WHA as is;
- Where infestation rates are high (>60%) consider leaving WHA as is. However, if salvage is deemed necessary, due to concerns about woody debris loading, fire hazard or other issues, then conduct selective salvage using fall-away, yard-away logging, and replant with ecosystem appropriate, non-pine species (e.g., spruce/cedar);
- If channel banks have been cleared or burned, restock to replace shade. The use of fast growing understorey shade plants might be considered. This would have to be balanced against competition with site appropriate conifers.
- Minimize the number of road crossings;
- Reduce connectivity between ditch and stream networks.

9.0 Conclusions

Overall the forest composition of tailed frog WHAs in southeast BC is mixed, with predominantly young (1-60 year) to mature (61-120 year) forest, with non-pine and pine types, with pine types typically <60% pine. This reflects a history of extensive logging, rather than widespread post-burn regeneration. Overall, the risk of MPB infestation is judged to be low, but there are several WHAs within the Flathead that have a potential for heavy infestation. These sites are ecologically significant in terms of tailed frog dispersal between sub-populations. These and other areas, summarized in Section 7.0, should be monitored for MPB infestation.

The potential impacts of MBP infestation on the effectiveness of tailed frog WHAs may result from MPB caused forest mortality alone and/or from attendant salvage logging operations. The mechanisms include (1) forest mortality and its impact on stream hydrology, (2) increased fire hazard and the risk of direct tailed frog mortality and/or population declines resulting from post-fire sedimentation, (3) hydrologic and sedimentation effects resulting from salvage logging, (4) increased insolation and wind penetration into riparian stands, causing desiccation of terrestrial habitats and/or stream temperature increases, and (5) fragmentation of forested ecosystem networks impacting foraging and dispersal opportunities.

Any assessment of the potential affects of MPB on tailed frog cannot be complete unless it considers watershed level impacts, focused on (1) the magnitude and timing of low flows and peak flows, (2) the length of the perennial channel network, (3) sedimentation, especially from road networks, (4) the impact to moist sites away from the channel network, and (5) the maintenance of forested ecosystem networks over drainage divides deemed important dispersal corridors.

Maintaining hydrologic function and forested ecosystem networks, while minimizing sedimentation impacts and direct riparian impacts are consistent with the recent recommendation of BC's chief forester to increase retention at both the watershed and stand levels to reduce ecosystem impacts posed by MPB salvage logging (Snetsinger 2005).

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Appendix 1. Dupuis and Friele (2006)

Appendix 2. Potential infestation assessment matrix.

The following table presents the structure for a GIS query that would provide more accurate estimates of potential infestation rates by individual WHA.

Table 1. Potential infestation rates, tailed frog WHAs, Yahk and Flathead River, SWBC.

			Forest > 60 years old			Forest < 60 years old		
WHA	Total area	%area non-pine	%area <30% pine	%area 31-60% pine	%area >60% pine	%area <30% pine	%area 31-60% pine	%area >60% pine
Yahk area								
Upper Yahk								
Norge								
Malpass								
Sprucetree								
Cedartree								
Paired								
Noname								
Boyd								
Screw								
Flathead area								
Storm								
Cabin								
Burnham Creek								
Canadian Couldrey								
American Couldrey								
North Fork Bighorn								
Leslie								

Notes:

1) %area pine cover refers to percent cover of class over entire WHA segment noted (i.e., Storm).
2) Infestation ranks (L, M, H) are classed as follows: If %area >60% pine = 71-100% then H; if %area 31-60% pine = 71-100% then M; if %area <30% pine = 71-100% then L.
3) Forest cover >60 years represent area of present infestation hazard; while forest cover <60 years represents future infestation hazard.