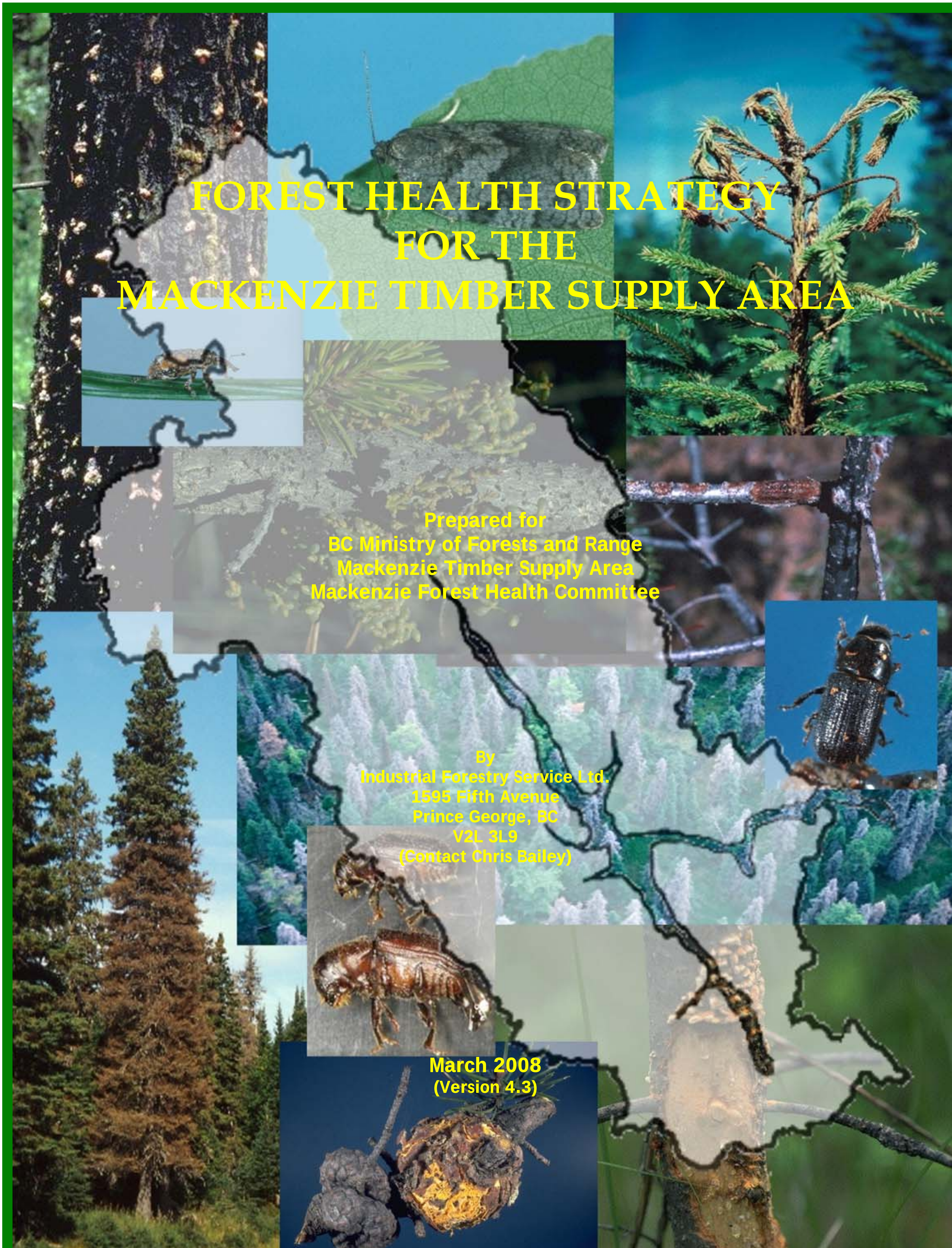

FOREST HEALTH STRATEGY FOR THE MACKENZIE TIMBER SUPPLY AREA

Prepared for
BC Ministry of Forests and Range
Mackenzie Timber Supply Area
Mackenzie Forest Health Committee

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Executive Summary

- The Mackenzie Forest Health Committee consists of licensees, BCTS and MFR staff from the Mackenzie Timber Supply Area (TSA).
- The committee has prepared a Forest Health Strategy that is consistent with the existing Provincial Forest Health Strategy and Forest Health Implementation Strategy goals and objectives. This strategy is a key information source for identifying and priority ranking the existing forest health issues and factors that exist within the TSA.
- Unranked damaging agents such as; invasive plants, blister rusts, budworm etc., along with abiotic damage agents such as; flooding, drought, Windthrow etc. have been include in the strategy.
- Beetle management units (BMU) were delineated using the existing landscape unit boundaries. These units are considered to be the base for planning and reporting of operational activities related to forest health.
- Mountain Pine Beetle continues to be the dominant forest health factors within the TSA.
- BMU control strategies were reviewed and assessed using historical and existing information for mountain pine beetle and spruce bark beetle.
- Two tactical plans were prepared for mountain pine beetle. One plan is based on the biological principals and the other is based on funding limitation.

1.0 Introduction

Insect and pathogen damage agents are normal components of forest ecosystems. They are part of the regeneration cycle for forests, killing weak trees and resulting in minor or isolated damage of healthy stands and trees. During “typical” conditions in the forest pests do not result in large-scale damage. When the balance to change is changed (as the result of some event) the new state of the forest can result in conditions that promote the growth and spread of certain forest pests.

The purpose of this document is to present a Forest Health Strategy (FHS) for Mackenzie Timber Supply Area (TSA), while ensuring consistency with the existing legislative objectives and the provincial forest health strategies and guidelines. Forest Health Strategies are regional level plans that are used to identify forest health issues, management goals and the implications of forest pest damage. These strategies are important components of the Provincial Forest Health Program that provides a framework for rating risks and hazards posed by forest pests. The provincial Forest Health Program supports the Ministry of Forests and Range (MFR) goal of sustaining forest and range values while preventing and managing wildfire and forest pests. The provincial Forest Health Program has three (3) objectives:

- Protect forest resources from pest damage by direct actions when operationally possible and justified
- Implement stand establishment activities to minimize the expected impact of known forest pests
- Assess pest impacts on forest values to improve estimates of timber yield from BC’s forests and prioritize management interventions.

The current focus of forest health is primarily on bark beetle activities, however this only accounts for a portion of potential activities. This strategy will provide a framework to co-ordinate and guide future forest health activities within the Mackenzie TSA. The intention of this strategy is to: 1) incorporate the principles of integrated forest health management to effectively manage the interactions between forest practices and forest health agents impacting on resource objectives, and; 2) apply ecologically sound techniques for the protection and enhancement of resource values. “Integrated Forest Health Management” (IFHM) is a variant of the internationally recognized approach to pest management known as Integrated Pest Management (IPM). The principles of IPM have been slightly modified within a forestry context to produce the principles of IFHM. These principles can be summed up briefly as:

- Know the land-base and resource management objectives;
- Manage from an ecological perspective;
- Don’t make the situation worse; and
- Practice adaptive management.

The next phase of the FHS will be to identify and create an action plan clarifying treatment targets and areas of responsibility for each management unit.

2.0 Background

An effective FHS is an important planning tool for a TSA and it can result in increases in the success of regeneration practices, increases in the productivity of immature stands, and decreases in the losses of mature timber. A healthy timber supply results in a more stable planning environment, both of which are important to the Ministry of Forests and Range and the timber industry. In addition, ecologically appropriate forest health practices will reduce the risk of wildfire associated with widespread timber mortality, will improve public safety in multiple use areas, and will lower the risk to non-timber resource values. The goals of the FHS are to establish a proactive management approach that emphasizes early detection of forest health problems resulting in promptly implemented, scientifically sound solutions that ensures that expenditures of resources are necessary, efficient and cost effective.

The Provincial Forest Health Implementation Strategy (March 2007) directs Ministry staff at all levels on how to implement the forest health program. This implementation strategy bridges the higher-level provincial forest health strategy and the Forest Health Program with the regional strategies for the TSA's. The Provincial Forest Health Strategy (Ver. 9a) clearly states the areas of responsibilities, while the Provincial Bark Beetle Management Technical Implementation Guidelines offers an approach to achieving treatment targets.

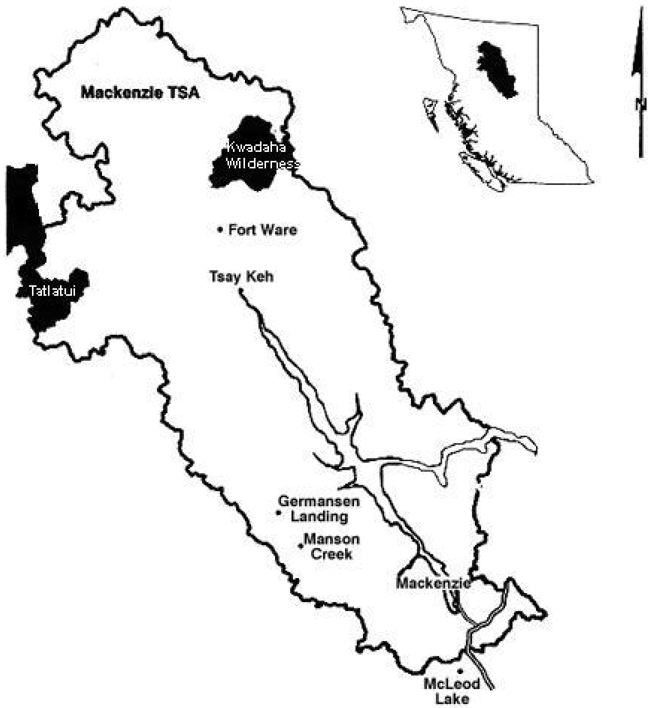
3.0 Scope of the Forest Health Strategy

The Mackenzie TSA is one of 37 administrative timber management units, established under Section 7 of the British Columbia Forest Act, for which an Allowable Annual Cut (AAC) of timber in British Columbia (BC) is determined. It is located in the north-central interior of BC and covers approximately 6.1 million hectares (see Figure 1). The current AAC is 3,050,000 m3. The Mackenzie TSA extends from the Pine Pass in the east, to the Spatsizi Plateau Wilderness Park in the northwest to Carp Lake Park in the south.

4.0 Priority Forest Health Factors: Rank, Status and Extent

To provide an effective allocation of resources, forest health factors relative to the Mackenzie TSA have been ranked. Ranking includes forest health factors from both the stand management component and the bark beetle suppression component of this forest health strategy.

Figure 1. Mackenzie Timber Supply Area.



The ranking of forest health factors is based on the following information and considerations:

- The collective knowledge of the Regional forest health specialists and local District stewardship staff,
- Known or suspected impacts to forest resource values,
- Availability of operational detection and treatment methods,
- Costs and benefits of applying detailed detection and treatment activities,
- Overall level of knowledge about the hazard and risk zones,
- Distribution of pest and current incidence levels, and
- Resources required to-fill knowledge gaps necessary for management of the pest.

It is recognized that more analysis is required to evaluate the impact of current losses of merchantable timber to those losses associated with a reduction of mature harvestable volume at some date in the future. As additional information and analysis regarding the impacts of losses in mature timber becomes known, the information will be included in the ranking of forest health factors. A review of this health factor ranking will be undertaken annually.

Table 1. Ranked Priority Forest Pest Agents Mackenzie TSA from survey data.

		Area of incidence reported from surveys (ha).								
		1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Ranked Agents	**Rank**									
Mountain pine beetle	1	1,355.0	674.1	1,529.1	6,003.9	969.3	13,703.9	104,211.6	270,540.6	215,326.4
Spruce beetle	2	1.1	4,543.1	2,511.8	28,202.5	133,244.1	4,005.1	40.3	NA	1.5
Western balsam bark beetle	3	446,915.0	282,223.2	53,021.6	221,214.7	410,987.9	559,083.0	613,746.0	358,028.2	183,085.7
Western gall rust	4	NA	NA	NA	NA	NA	NA	NA	NA	NA
Stalactiform blister rust	4	NA	NA	NA	NA	NA	NA	NA	NA	NA
Comandra blister rust	4	NA	NA	NA	NA	NA	NA	NA	NA	NA
Two-year cycle budworm	5	378,560.1	0.0	2,091.1	NA	44,170.0	NA	NA	NA	NA
Lodgepole pine beetle	6	NA	NA	NA	0.5	NA	NA	NA	NA	NA
Ips bark beetle	7	NA	NA	NA	NA	45.2	NA	NA	NA	NA
Large aspen tortrix	8	NA	NA	NA	NA	68,936.0	32,359.6	4,395.1	1,172.3	781.3
Lodgepole pine dwarf mistletoe	9	NA	NA	NA	NA	NA	NA	NA	NA	NA
Warren's root collar weevil	10	NA	NA	NA	NA	25.7	NA	NA	NA	NA
White pine weevil on spruce	10	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unranked agents										
Aspen-poplar twig blight		NA	NA	NA	5,122.2	1,112.1	12,107.0	NA	NA	NA
Bear		NA	NA	NA	NA	NA	NA	373.1	NA	NA
Drought		NA	NA	NA	NA	NA	NA	NA	494.4	NA
Eastern spruce budworm		NA	86.5	NA	NA	852.4	NA	NA	NA	NA
Fire		NA	NA	2,753.0	904.3	NA	NA	2,165.0	9,360.8	38.1
Flooding		NA	NA	NA	297.0	33.9	128.2	103.1	71.6	NA
Forest tent caterpillar		NA	NA	11,043.2	NA	NA	NA	NA	NA	NA
Porcupine		NA	NA	NA	106.0	84.2	NA	NA	NA	NA
Red belt		NA	NA	NA	NA	NA	NA	695.2	NA	49.7
Shoot frost		NA	NA	NA	NA	70.9	NA	NA	NA	NA
Slide		NA	NA	NA	48.5	65.5	NA	57.6	NA	NA
White pine blister rust		NA	NA	NA	137.0	NA	NA	NA	NA	NA
Windthrow		NA	NA	NA	156.2	NA	NA	808.6	NA	NA
Total		826,831.2	287,526.8	72,949.8	262,192.9	660,597.1	621,386.7	726,595.6	639,667.9	399,282.6

4.1 RANKED DAMAGE AGENTS

4.1.1 Mountain pine beetle (*Dendroctonus ponderosae* Hopkins)

The current outbreak of this bark beetle is the largest recorded in Canadian history. In the Mackenzie TSA it currently infests about 215,326ha or approxiamtely 9.6 million cubic meters. The beetle normally attacks highly stressed or mature (80 years or older) trees, however, certain conditions, such as large areas of over mature pine and several years of warm winters, have allowed the population to reach epidemic proportions.

The MPB lays its eggs under the bark of a pine tree and when larvae hatch they feed on the inner bark (phloem layer) which cuts off the tree's supply of water and nutrients. A bluestain fungus is associated with the beetles and is introduced when trees become infested. , The combination of the beetle action and fungus girdles and kills most attacked trees (Natural Resources Canada 2007, Unger 1993). Other forest health issues can potentially emerge as a result of the MPB infestation including increased risk of wildfires (see section 5.2.7.2) and the loss of "summer ground" for harvesting . Dead stands of timber do not transpire leading to increased soil moisture. This "watering up" effect is recorded in other TSA and it affects areas considered suitable for summer harvesting activities. As a result these areas now have soils that are too wet to support traditional harvesting techniques (S. Dubé, Regional Soil Scientist, Northern Interior Region, MFR personal communication). Increased harvesting activities have the potential to increase soil disturbance and to facilitate spread and establishment of invasive plant species. Soil disturbance promotes germination of invasive plants and movement of machinery increase the likelihood of seed transmission.

The MPB is at the northern edge of its distribution in the Mackenzie TSA and its presence was first confirmed in 1999. From 1999 to 2003 MPB damage was mistakenly/lumped reported as Lodegepole pine beetle (*Dendroctonus murryanae*) or Ips beetle (*Ips pini*). The high MPB population in the Ft. St. James and Prince George Forest Districts resulted in rapid spread into the Mackenzie TSA. The majority of the MPB infestation established itself in the southern portion of the TSA in 2001/02. In 2003, areas in the Philip and Morfee landscape units had green to red tree ratios of 10:1, indicating that MPB were coming in from outside sources. The Misinchinka and Kennedy landscape units recorded green to red tree ratios of 10:1 in 2004. By 2005, MPB had spread east and north into the Clearwater, Selwyn, Wicked River, Schooler, and Nabesche Beetle Management Units (BMUs). In 2005, aggressive single tree treatments were carried out in the Clearwater, Collins-Davis and Lower Ospika BMUs. In 2006, MPB increased its range (likely as a result of long range dispersal from the Prince George Forest District) to the northern sections of the Collins-Davis and the Lower Akie BMUs. The infestation in the southern portion of the Mackenzie Forest District was from 25 to 40% incidence and there was little evidence of previous attacks in the area. In 2006, some of the red attack trees recorded by detailed aerial survey were of the current year's attack and the trees showed small pitch tubes. Fading rates in the Mackenzie Forest District were roughly three (3) months as a result of the drought conditions of the summer. During 2006-07 single tree treatments were carried out along the eastern edge of the Mackenzie TSA with activity being concentrated in the Lower Ospika and Collins-Davis BMUs. MPB popultions continue to expand north of Williston Lake. With limited funding for 2007-08, detailed flights, ground assessments and single tree treatments continued around the northern portion of Williton Lake in the Buffalohead, Ed Bird Estella, Akie, Lower Akie and Pesika BMUs. Also in 2007-08, the provincial aerial overview flights continued to be problematic due to weather conditions which resulted in limited additional forest health information to be collected.

The current MPB management practice includes: overview and detailed aerial and ground surveys, single tree treatments of fall and burn, fall and peel, pheromone baiting, sanitation/salvage harvesting, hazard and risk rating and high hazard host removal (Ministry of Forests and Range 2007).

4.1.2 **Spruce beetle** (*Dendroctonus rufipennis* Kirby)

Spruce beetles attack mature spruce trees and causes extensive mortality. Historical outbreaks have often been associated with windthrow or poor forest sanitation practices (Humphreys and Safranyik 1993). Spruce beetle has been a problem in the Mackenzie TSA with the last major outbreak occurring in 1991 (Ministry of Forests and Range 2007). From aerial surveys done in 2007 1.5 ha of forest in the Mackenzie TSA was infested. This number has the potential to increase if winters and summers are warmer than average.

Spruce beetle life cycle usually requires two (2) years to complete. When population numbers are small beetles can be found in weakened and downed trees. As population levels increase to outbreak proportions beetles make use of healthy standing trees. Eggs are laid within a tunnel system in the inner bark (phloem layer). Once the larvae have hatched they feed on the inner bark. The movement and feeding of the beetles results in tree being girdled which cuts off the tree's supply of water and nutrients which can result in the death of the tree. If they complete a one (1) year life cycle the larvae pupate to adults and leave the tree to attack new hosts. If completing a multi year lifecycle the larvae will move to the base of the trunk of the host tree to over winter (Humphreys and Safranyik 1993, Ministry of Forests and Range 2001).

This pest has had extensive impacts on the forest industry in the past and some of the methods used to manage it are overview and detailed aerial and ground surveys, single tree treatments of fall and burn, fall and peel, pheromone baiting, sanitation/salvage harvesting, hazard and risk rating and high hazard host removal (Ministry of Forests and Range 2007).

4.1.3 Western balsam bark beetle (*Dryocoetes confuses* Swain)

Western balsam bark beetle attacks high-elevation mature sub-alpine fir, attacks have also been recorded on white and Engelmann spruce (Garbutt 1992). Historically western balsam bark beetle has caused losses in the Mackenzie TSA. Aerial survey data shows that 183,086 ha were infested in 2007.

The life cycle of the western bark beetle typically requires two (2) years to complete. Eggs are deposited in chambers within the inner bark. Adult beetles over winter in the inner bark. The phytopathogenic lesion-causing fungus *Ceratocystis dryocoetidis*, is carried on Western balsam bark beetles and could be responsible for 65% of the mortality associated with an attack. The fungus can invade the phloem and cause lesions which can girdle and cause mortality without the additional effect of beetle movement within the tree (Garbutt 1992).

Western balsam bark beetle is not extensively managed in the Mackenzie TSA because the majority of the infestation occurs in areas without road access. It was recommended and budgeted for in Forest Health Strategy and Tactical Plan Mackenzie TSA 2008 to establish a permanent sampling plot within the Mackenzie Forest TSA to gather information on western balsam bark beetle mortality and population dynamics. This information could be used by Timber Supply Branch of the MFR as an input into future timber supply analysis for the Mackenzie TSA.

4.1.4 Western gall rust (*Endocronartium harknessii* Hiratsuka), Stalactiform blister rust (*Cronartium coleosporoides* Arthur), and Comandra blister rust (*Cronartium comandrae* Peck)

Stem rusts in BC are represented by members of the fungal family Melampsorasceae. All pines are considered potential primary hosts. Western gall rust requires no secondary host while Stalactiform blister rust requires a member of the figwort family (Scrophulareacea) such as Common red paintbrush (*Castilleja* spp.) and Comandra blister rust requires *Comandra* spp. or *Geocaulon* spp., primarily bastard toadflax (*G. lividum*) (Hunt, 1992, Ministry of Forests and Range 2001).

For western gall rust spores are dispersed in the spring and land on susceptible hosts. Spores germinate and approximately two (2) years after infection the first galls appear. They are irregularly rounded, woody and perennial. Galls grow larger each year until they are attacked by secondary fungi and insects and die. Blister rusts disperse spores from their pine hosts in the spring and they infect their secondary hosts. Orange spots develop on the leaves of the suitable secondary host. Basidiospores are produced and infect suitable pine species. Signs of infection occur approximately three (3) years after infection resulting in discoloration of the needles and swelling of the bark. Blisters form from the swelling and release spores to infect secondary hosts. Infected stems and branches die from attack by secondary organisms. The majority of damage resulting from rusts are growth losses and mortality from blisters girdling the stem. Trees of all ages can be attacked however young trees are most susceptible. Damage from rusts can impact lumber quantity and quality.

Western gall rust occurs at very high levels in the Mackenzie Forest District (Ministry of Forests 2007).

Stalactiform blister rust is locally abundant although not wide spread and it can cause high levels of mortality if young trees are infected (Ministry of Forests 2007).

Comandra blister rust can result in high mortality levels as it kills rapidly and can occur in high levels. To compensate for the loss of young trees overstocking is recommended (Ministry of Forests 2007).

A rust management strategy and a Standard Operating Procedure (SOP) for ground detection was developed for the Mackenzie TSA by the Mackenzie Rust Working Group in 2006. Members of this working group include: private industry and District and Regional levels of Ministry of Forests and Range. The control measures from the SOP are focused on promoting a greater awareness of rusts and associated alternate hosts, reforesting to higher densities and planting non-susceptible species where ecologically appropriate. To control rusts, infected trees and branches can be removed during the spacing of young stands. For mature forests infested stands can be harvested first to minimize the spread of spores from old blisters.

4.1.5 Two-year cycle budworm (*Choristoneura biennis* Freeman)

This budworm is a defoliator of spruce and sub-alpine fir, it will feed on host trees of any age class. The defoliation can be severe and result in reduced growth, deformity, dieback and tree death. An infestation of two-year cycle budworm will weaken a tree which increases the possibility of secondary infection by damage agents such as bark beetles (Unger 1995).

The female moth lays eggs in the summer on the underside of needles. The larvae will over winter under bark or in needle scars in a silken web (hibernacula). Next spring larvae emerge and harvest needles and buds of developing cones during the summer. They spin another hibernaculum to over winter for a second year. Adult moths will emerge that second summer. Two-year cycle budworm infestations destroy new and old foliage as well as cones (Unger 1995).

No incidence of two-year cycle budworm was reported for the Mackenzie TSA for 2004 to 2007. An incidence was reported in the 2003 aerial overview survey; however, it is believed that this was a complex of two-year cycle budworm and spruce beetle. Several studies were conducted in the area to assess the damage caused by Two-year cycle budworm. Results indicated that it is possible to have a 12% loss in annual increment in chronically defoliated trees, top-kill and mortality is more likely in sub-alpine fir than spruce, and spruce beetles are more likely than Western balsam bark beetle to be present in infested trees. Presently there is no active management of two-year cycle budworm however strategic planning of salvage harvesting of infested stands would maximize their commercial use. Unger (1995) suggests that the biological insecticide *Bacillus thringiensis kurstaki* (Btk) could be a potential direct control measure. Currently the product is not registered for use on two-year cycle budworm (Ministry of Forests and Range 2007). Other silvicultural techniques such as developing even aged stands with a single crown stratum, maintaining a relatively open stand density, working with a variety of species as well as less susceptible species, maintaining a vigorous stand and harvesting before stand growth culmination can all minimize vulnerability to this budworm.

4.1.6 Lodgepole pine beetle (*Dendroctonus murryanae*)

This bark beetle is not considered an aggressive pest. It normally attacks only weakened mature lodgepole pine trees and it concentrates its feeding efforts to the lower bole and root crown. Only a few pairs of beetles will be found in an attacked tree and it usually requires several generations for the damage to be sever enough to kill the tree. It takes one year to complete its life cycle and it is usually carried out in old stumps or windfall (Ministry of Forests and Range 2001).

This beetle is of interest because it is sometimes misidentified as mountain pine beetle and the different species of beetle can be found in the same area. The incidence of lodgepole pine beetle recorded in the Mackenzie TSA in 2005 when surveys were carried out for mountain pine beetle was 23% in the Clearwater, Lower Ospika and Collins-Davis BMUs. It was recommended to increase surveys for lodgepole pine beetle to gain a better understanding of its population and dynamics in the Mackenzie TSA (Ministry of Forests and Range 2007).

4.1.7 Ips bark beetle (*Ips pini* Say)

This bark beetle typically attacks dead or weakened pine trees and can be found in trees attacked by mountain pine beetle. Large populations may build up after disturbances in windfall and debris because of the large supply of habitat and food (Kegley 2002, Ministry of Forests 2001).

Ips beetles excavate galleries in the phloem of infested trees and movements of beetles and maturing larva may result in the girdling of the tree. It is possible to have two (2) or three (3) generations produced in one season (Kegley 2002, Ministry of Forests and Range 2001). Increased numbers of Ips beetles have been recorded in the past in the Ft. Ware area, infestations can be managed by salvaging blowdown and promptly harvesting and processing infested trees (Ministry of Forests and Range 2007).

4.1.8 Large aspen tortrix (*Choristoneura conflictana* Walker)

This damage agent causes defoliation in trembling aspen and balsam poplar and is especially common in parts of the Northern Interior Forest Region (Ministry of Forests and Range 2001). Incidence in the Mackenzie TSA reported from aerial surveys in 2007 was 781 ha, the amount of area infested has consistently decreased since 2003. Infestations can result in thin foliage, reduced numbers of leaf buds, clumped irregular looking leaves, reduced radial growth and rarely tree mortality (Ministry of Forests and Range 2001).

Large aspen tortrixes complete their lifecycle in one year. Larvae emerge in the spring and begin to mine buds. As larvae mature they feed in rolled leaves or two leaves or more leaves that have been woven together. Adult moths emerge from the folded leaves in late June. Eggs are laid on upper leaf surfaces. Larvae hatch in approximately two (2) weeks and weave leaves together and feed on leaf tissue until mid-August. At this time they move to the bark and construct hibernation shelters under the scales (Ministry of Forests and Range 2001).

Large infestations tend to occur on a ten-year cycle and last for approximately 2 to 3 years and they tend to precede outbreaks of forest tent caterpillar (Ministry of Forests and Range 2001). The nature of the pest and the lack of commercial pressure on deciduous stands results in the large aspen tortrix not being a high management priority (Ministry of Forests and Range 2007), however chemical control is not recommended, as there are many effective parasites associated with it (Natural Resources Canada 2007b).

4.1.9 Lodgepole pine dwarf mistletoe (*Arceuthobium americanum* Nutt. ex Engelm)

Lodgepole pine dwarf mistletoe is a parasitic flowering plant and is one of four (4) species found in BC. Dwarf mistletoes are widespread and considered very destructive and result in swelling of tree stems and irregular branching patterns resulting in suppressed growth, reduced wood quality and seed production and increased mortality (Unger 1992, Ministry of Forests and Range 2007). Infested tree mortality can be a result of secondary infection from a damage agent, such as bark beetle (Ministry of Forests and Range 2007).

Dwarf mistletoe lifecycle requires five (5) years to complete. Seed dispersed from a mature plant land and attach to a suitable host tree in year one (1). Year two (2) the seed germinates, penetrates the bark of the host and increases in size. Aerial shoots can be produced in year two (2) or three (3). Two (2) years after the aerial shoots are produced flowers emerge and approximately 1.5 years after pollination mature berry fruit are formed. The fruit contain a single seed and after approximately 1.5 years of ripening the forcibly ejected from the fruit (Unger 1992).

To control lodgepole pine dwarf mistletoe in the Mackenzie TSA resistant and non-susceptible species have been planted around the perimeter of clearcuts next to infested stands to act as a barrier and pre and post-harvest monitoring and sanitization of stands has occurred. Other silvicultural control options are available because of the specificity of the hosts, and a relatively slow rate of spread allows infestations to be easily identified. To reduce the rate of re-infestation from infested forest large clearcuts can be used to minimize the number of edge trees available to infest. Avoid leaving infested trees as a result of partial cutting or as residual from clearcutting. Research is being done into possible biological controls (Ministry of Forests and Range 2007). Research into chemical controls did not result in a suitable product being developed for widespread use (Unger 1992).

4.1.10 Warren's root collar weevil (*Hylobius warreni* Wood)

The host species for this weevil includes most native pines, native spruce, some exotic species all with a root collar diameter over 2 cm (Cerezke 1994, Ministry of Forests and Range 2001). The weevil (stage) feeds on the cambium layer of the root-collar system resulting in black pitch masses on the ground and a reduction in growth or tree death (Ministry of Forests and Range 2007). Vigorous healthy trees can be attacked and extensive mortality can result in a young infested stand (Ministry of Forests and Range 2001).

The lifecycle of Warren's root collar weevil takes two (2) years and possibly longer to complete (depending on climatic conditions). Eggs are laid in niches in the bark around the roots or root collar or under the duff layer around the base of the tree (Cerezke 1994). Larvae excavate deeper into the tree as they mature, from phloem into the cambium and a little ways into the wood while they feed and mature (Cerezke 1994, Ministry of Forests and Range 2001). Their excavating activity can partially or completely girdle a tree which is more likely in a small diameter tree (Ministry of Forests and Range 2001, Ministry of Forests and Range 2007). Older trees typically die from secondary infection, ex. Tomentosus root rot (Cerezke 1994, Ministry of Forests and Range 2007).

The population levels of Warren's root collar weevil is increasing in the Prince George and Vanderhoof Forest Districts as the number of young plantations increases with mountain pine beetle sanitation activities. It was recommended to observe the population numbers in the Mackenzie TSA closely as the amount of sanitation harvesting increases (Ministry of Forests and Range 2007). To manage infested areas overstocking is currently being done. Cerezke recommends excessive stocking densities of 15,000 to 20,000 stems per ha and delaying pre-commercial thinning on medium to high productivity sites for 15 to 20 years after the presence of weevils. High productivity sites with a moist duff layer have a higher risk of infestation (Cerezke 1994). Other control options include planting non-susceptible species, removing infested stems and scarification site preparation (Cerezke 1994, Ministry of Forests and Range 2007).

4.1.11 White pine weevil (*Pissodes strobi* Peck)

In BC this damage agent feeds on Sitka, white, and Engelmann spruce, occasionally black spruce, Norway spruce, and lodgepole pine are attacked (Ministry of Forests and Range 2007). White pine weevil infestations cause leader death, stem deformation, reduced height, increased susceptibility to secondary infections and occasionally death for small trees (Ministry of Forests and Range 2007).

The lifecycle can be completed in one year and commences when adults emerge from overwintering in the duff layer in the spring. They move onto the host tree where they mate and lay eggs in the previous year's leader. When the larvae emerge they feed on the phloem and girdle the stem. As larvae mature they excavate cavities in the stem where pupation occurs. Adults emerge in August or September, fed and then move into the duff layer for overwintering (Alfaro & Lavallée 2007, Ministry of Forests and Range 2001).

Historically leader clipping was done to control this plantation pest, however, this technique was deemed to be uneconomical. Instead, overstocking and broadcast burning are being used to manage the weevil (Ministry of Forests and Range 2007). Other control options include integrated pest management along with hazard rating, silvicultural control (mixes of tree species, high density planting, retain shade trees), and the use of genetic resistance (resistant and susceptable tree mixes), (Alfaro & Lavallée 2007, Ministry of Forests and Range 2007).

The Canadian Forest Service has developed a modeling tool for BC which evaluates different levels of white pine weevil infestation in relation to plantation yield called SWAT (Spruce Weevil ATtack) Decision Support System (Alfaro & Lavallée 2007, Ministry of Forests and Range 1996).

4.2 UNRANKED DAMAGE AGENTS

The following unranked damage agents are biotic factors that can be problematic and have not have not occurred in significant numbers to cause widespread damage or are factors over which landmanagers have little or no ability to influence at this time.

4.2.1 Invasive alien plants

Invasive alien plants, also called "invasive plants" or more generally "weeds" are non-native plant species that are capable of invading and dominating an area resulting in environmental degradation. They lack natural predators and can establish quickly and easily on new sites out-competing native vegetation for habitat and resources and eventually crowding them out. Invasive plants can have widespread negative economic, social and environmental impacts. Common strategies invasive

Table 2. Strategies, tactics and measures for managing priority forest health factors.

Ranked Agents	Rank	Strategies	Measures	Tactics
Mountain pine beetle	1	Suppression	Aerial overview or detailed surveys, ground surveys, hazard & risk rating, pre/post harvest monitoring	Fall & burn, fall & peel, conventional/lethal trap trees, sanitation harvesting w/ pheromone baiting, salvage harvesting, high hazard host removal
Spruce beetle	2	Monitor, suppression	Aerial overview or detailed surveys, ground surveys, hazard & risk rating, pre/post harvest monitoring	Fall & burn, fall & peel, conventional/lethal trap trees, sanitation harvesting w/ pheromone baiting, salvage harvesting, high hazard host removal
Western balsam bark beetle	3	Salvage	Aerial overview or detailed surveys, ground surveys, pre/post harvest monitoring	Fall & burn, fall & peel, conventional/lethal trap trees, sanitation harvesting w/ pheromone baiting, salvage harvesting
Western gall rust	4	Salvage	Hazard & risk rating, pre/post harvest monitoring	Overstocking, genetically resistant stock, planting off site species, restrictions on fill planting
Stalactiform blister rust	4	Monitor	Hazard & risk rating, pre/post harvest monitoring	
Comandra blister rust	4	Monitor	Hazard risk ranking, pre/post harvest monitoring	
Two-year cycle budworm	5	Salvage	Aerial overview or detailed surveys, ground surveys,	Salvage harvesting, high hazard host removal, Btk sprays (high value stands)
Lodgepole pine beetle	6	Salvage	Aerial overview or detailed surveys, ground surveys, pre/post harvest monitoring	Fall & burn, fall & peel, conventional/lethal trap trees, sanitation harvesting w/ pheromone baiting, salvage harvesting
Ips bark beetle	7	Salvage	Aerial overview or detailed surveys, ground surveys, pre/post harvest monitoring	Fall & burn, fall & peel, conventional/lethal trap trees, sanitation harvesting w/ pheromone baiting, salvage harvesting
Large aspen tortrix	8	Monitor	Aerial overview survey	Btk sprays (high value stands)
Lodgepole pine dwarf mistletoe	9	Salvage	Pre/post harvest monitoring	Sanitation harvesting
Warren's root collar weevil	10	Salvage	Pre/post harvest monitoring	Overstocking, planting off site species
White pine weevil on spruce	10	Salvage	Pre/post harvest monitoring, hazard & risk rating	Overstocking, leader clipping, broadcast burning, genetically resistant stock, planting off site species

plants use to succeed include: releasing toxins that inhibit growth of other species (alleopathy), reproduce quickly both vegetatively and by seed, rapid growth to shade out other species, short lifecycles, and they are often not palatable to grazing animals. Invasive species found in the Mackenzie TSA include orange hawkweed (*Hieracium aurantiacum)*, oxeye daisy (*Lucanthemum vulgare*), common tansy (*Tanacetum vulgare*), and scentless chamomile (*Matricaria perforata*) (IAPP 2007).

In the Forest Health Program and under the Forest Practices Code (section 47) there is an obligation to prevent the introduction and spread of invasive plant species. The Ministry of Forests and Range has developed an Invasive Alien Plant Program with the goal of eliminating or minimize the spread of invasive alien plants that threaten BC's forest and range resources. The program takes an Integrated Pest Management (IPM) approach where tools such as mechanical, chemical, and biological methods controls are used to manage invasive alien plants. The long-term objective is to control infestations by preventative and cultural methods as well as biological control (IAPP 2007). To achieve this goal the Ministry of Forests and Range works closely with the two invasive plant councils in the area, the Northwest Invasive Plant Council and the Northeast Invasive Plant Committee. These invasive plant councils are non-profit societies who along with stakeholders, are working to prevent and control the spread of invasive plant species by doing inventory and control work as well as public education and awareness. They operate under a single agency model to collect invasive plant infestation information, coordinate control efforts and to disseminate information about invasive plants and their control. To facilitate management the Ministry of Forests and Range developed and maintains a database of invasive plant infestations reported to the invasive plant councils. There are 90 reported incidences invasive plant infestations at 71 different sites in the Mackenzie TSA from 2006 to present. The breakdown of species found at each infestation site is shown in Table 3 below.

Table 3. Invasive plant infestations in the Mackenzie TSA.

Invasive Plant Species	Incidence	% Incidence	# of Sites
Oxeye daisy	48	53.3	47
Scentless chamomile	10	11.1	7
Orange hawkweed	10	11.1	4
Yellow hawkweed	10	11.1	4
Common tansy	6	6.7	4
Unknown hawkweed	2	2.2	2
Canada thistle	1	1.1	1
Spotted knapweed	1	1.1	0
Eyebright	1	1.1	1
Bladder campion	1	1.1	1
Total	90	100.0	71

Of the 71 reported infestations 17 sites totalling 0.1 ha were treated with mechanical control (ex. digging, pulling) and 15 sites with 5.8 ha were treated with chemical control (herbicide application). Not all site were treated, treatment depends on the invasiveness of the plant and the site characteristics (NWIPC 2007).

All invasive plant infestations should be reported to the appropriate council or committee so that the site information can be added to the IAPP database and suitable control measures can begin. Invasive plant identification and reporting information sessions can be arranged for ministry and private industry staff by contacting appropriate council. The

Northwest Invasive Plant Council can be reached at 1-866-44WEEDS (1-866-449-3337), the Northeast Invasive Plant Committee 1-800-670-7773.

4.2.2 Poplar Leaf and Twig Blight (*Venturia* spp.)

In B.C., *Venturia* fungi are widely distributed throughout the range of their aspen and poplar hosts. Moist weather conditions during the growing season promote the growth of the blight that can kill most shoots in aspen stands. Repeated infection results in stem deformity and growth reduction. These diseases are most severe in young stands, and have the greatest impact in intensively managed plantations (Ministry of Forests and Range 2001).

The fungi overwinter in structures on dead shoots, leaves, and blighted twigs. Spores are dispersed in the spring by wind and rain to infect new growth of shoots and leaves. The first signs infection are black spots on the leaf, these spots will spread down the leaves into succulent branchlets. The infected areas will turn black and wilt, resembling a shepherd's crook. Mats of spores are produced on the blackened, dead tissue and it disperses by the rain to infect new leaves (Ministry of Forests and Range 2001).

4.2.3 Eastern spruce budworm (*Choristoneura fumiferana* Clemens)

This budworm is a defoliator of subalpine fir, white spruce and Engelmann spruce. It infests trees of any age. It can be found in the north-eastern forests of BC from 350 to 1050 m elevation. It causes stem defects (from top-kill), cone damage, reduction in seed production, dieback, as well as a loss of tree height and volume (Ministry of Forests and Range 2001, Unger 1995). Sever defoliation may also result in tree death (Unger 1995). The weakened state of defoliated trees renders them venerable to secondary pests such as bark beetles (Unger 1995).

The lifecycle is completed in one year. The female moths lay eggs on the underside of needles in August. Larvae hatch in a couple of weeks and move into the shelter of lichens, bark scales or in flower or needle scars. There they form a silken web (hibernacula) in which they overwinter. In the spring larvae mine needles, buds, and new cones. Older larvae mine current foliage although, they will feed on older foliage if current foliage is depleted. The larvae spin a web around foliage and use it as a feeding structure. Pupation occurs within the webbed foliage from late June to mid-July (Ministry of Forests and Range 2001, Unger 1995).

The last time this pest was recorded in the Mackenzie TSA was 2003 when 852.4 ha were infested. Unger (1995) suggests that the biological insecticide *Bacillus thringiensis kurstaki* (Btk) could be a potential direct control measure. Other silvicultural techniques such as developing even aged stands with a single crown stratum, maintaining a relatively open stand density, working with a variety of species as well as less susceptible species, maintaining a vigorous stand and harvesting before stand growth culmination can all minimize vulnerability to this budworm.

4.2.4 Forest tent caterpillar (*Malacosoma disstria* Hubner)

The forest tent caterpillar is a defoliator of deciduous trees through out BC. Infestations occur approximately every 10 years, and last roughly 3 to 5 years. One or more years of severe defoliation may result in top-kill, branch mortality, reduced radial growth, and occasional tree mortality. Large-scale tree mortality has not been recorded. Severely defoliated trees usually produce another set of leaves in mid-summer (Ferris 1994, Ministry of Forests and Range 2001, Wood 1992).

Forest tent caterpillars complete one generation per year. Adult moths lay eggs in mid-summer and larvae overwinter in the eggs. Eggs hatch between April to June and larvae feed in groups on opening buds and on leaves. Unlike northern tent caterpillars, spin a tent-like web, they spin a trail of silk wherever they go. Mature larvae spin cocoons between leaves or in any sheltered place, and pupate in these cocoons (Ferris 1994, Ministry of Forests and Range 2001, Wood 1992).

The last time forest tent caterpillar was recorded in the Mackenzie TSA was 11,043 ha in 2001. Control is usually obtained through natural factors including parasites, predators, disease, starvation, and weather conditions. Mechanical controls such as clipping egg masses from the host tree are used in urban areas. Biological insecticide *Bacillus thringiensis kurstaki* (Btk) could be a potential direct control measure (Ferris 1994, Wood 1992).

4.2.5 White pine blister rust (*Cronartium ribicola* J.C. Fisch. ex Rabenh)

White pine blister rust is caused by the rust fungus *Cronartium ribicola* that infects the branches and stems of five-needled pines (notably western and eastern white pine). The alternate host that this rust requires is of the *Ribes* spp. (currants and gooseberries). The portion of the tree after the canker may die or if the canker is at the base of the tree the entire tree may die. Mammals and insects feed on cankers and the weakened tree is more susceptible to bark beetles and other secondary infection (Hunt 1983).

The lifecycle of the rust fungus requires approximately four (4) years to complete. Mature cankers on the host pine tree produce aeciospores that infect the *Ribes* spp. alternate host. Several kinds of spores are produced on the alternate *Ribes* spp. host; basidiospores are carried by the wind to infect new pines. Pine needles are infected by basidiospores in the fall. The fungus grows down from the needles into the branch where it produces a canker in approximately 12 to 18 months (Hunt 1983).

In 2001 137 ha of the Mackenzie TSA was affected by white pine blister rust. Control options include managing the *Ribes* spp. Population, planting rust resistant trees, hazard rating sites, and removing infested branches (Hunt 1983).

4.2.6 Animal damage

Animal damage is caused by herbivorous animals feeding on trees (normally wildlife) or as a result of trampling (often from domestic livestock). This type of damage can cause stem and branch deformities or in severe cases tree mortality. Sublethal injuries weaken the tree making it more susceptible to other damage agents or overtopping by competing vegetation. Population fluctuations can result in “outbreaks” of animal damage and fluctuations can last over several years. Snowshoe hare has a fluctuation cycle of nine (9) to ten (10) years from high animal numbers to low numbers and back to high numbers. Forest practices may create conditions for population growth as a result of habitat creation and juxtaposition. There are three (3) main types of wildlife damage: seed predation, browsing and barking and girdling (Sullivan 1997).

4.2.6.1 Porcupine *Erethizon dorsatum* L

Damage from porcupine feeding activity was recorded in the Mackenzie TSA in 2002 (106 ha) and in 2003 (84 ha). Damage is an outcome of its winter-feeding activities as it gnaws bark off of stems of pines, true firs and larches. Smaller trees may be girdled and larger trees will be debarked further up the stem or on large branches. Top girdling may also occur and this results in a bushy crown and a spike top (Sullivan 1997).

To reduce the amount of damage caused by porcupines retain less palatable species after thinning, prevent climbing by placing metal collars or sleeves around the lower bole, manage fishers (*Martes pennanti*) (who are the primary predator of porcupines) to reduce porcupine abundance, or trap and specific problem animals (Sullivan 1997).

4.2.6.2 Black bears (*Ursus americanus* Pallas)

Black bears cause damage in young to intermediate aged forests by peeling bark off trees and gnawing off the exposed vascular tissues. Damage is normally found at the base of the tree however some debarking may also occur in the crown. This feeding activity may wholly or partially girdle the tree. Preferred species include Douglas fir, western white pine, and lodgepole pine. Rapidly growing trees in lightly stocked stand are favoured and most damage occurs in early summer when the sugar content of the tree is high (Sullivan 1997).

In 2005 black bears damaged 373 ha. To reduce tree damage maintain higher densities of trees, increase species diversity in young stands, hunt and remove or relocate problem bears (Sullivan 1997).

4.2.6.3 Snowshoe hares (*Lepus americanus* Erxleben)

Snowshoe hares can damage young seedlings and remove bark from stems and low branches of lodgepole pines and Douglas fir trees. Barking and girdling damage occur usually in winter and early spring and the height of bark removal depends on snow depth. Hares also browse on coniferous seedlings (Douglas fir, lodgepole pine, spruce and true firs) during the winter and clip terminal and lateral buds, specific plantation may be drastically impacted. Targeted trees are typically less than 2 m in height. Damage is most severe in stands with enough understory cover to provide appropriate habitat (Sullivan 1997).

As of yet damage from snowshoe hares has not been recorded in the Mackenzie TSA although it has the potential to be a significant local problem (R. Hodgkinson Forest Entomologist, Northern Interior Forest Region MFR personal communication). To reduce impacts time planting to years when hare populations are low (the predictable 6 or 7 year lull between population peaks), plant larger stock, use nursery stock with a lower fertilization regime as this may make seedlings less susceptible to attack, plant less susceptible species (spruce and true firs), reduce understory habitat or use tree guards recommend for deer. Trapping, hunting and poisoning are not recommended techniques for population control because of the rapid re-colonization that occurs and the possible negative effects it can have on non-target species such as lynx (*Lynx canadensis*) (Sullivan 1997).

4.2.7 Abiotic damage

Abiotic damage results from extreme weather and associated events. Damage as a result of drought, fire, flooding, red belt, shoot frost, slides and windthrow have been recorded from aerial surveys in the Mackenzie TSA.

4.2.7.1 Drought

Drought is usually a result of low rainfall and its effects are most prominent on sites with dry aspects and shallow, well drained soils or in areas where soil disturbance has changed the site characteristics. All species of conifers are susceptible and young trees, trees growing in the understory and trees with shallow roots are most susceptible. Drought and water stress can result in needle loss, wilting, discoloration, branch and stem dieback, growth reduction or tree mortality (Ministry of Forest and Range 2001). Drought stressed trees are more susceptible to secondary infection and some pest outbreaks have been reported to start under drought conditions (Joy and Maclauchlan 1999).

Drought affected 494 ha in the Mackenzie TSA in 2006. The effects of drought can be minimized by hazard risk ranking and planting drought tolerant species on susceptible sites.

4.2.7.2 Fire

Fire, has a significant impact on forest ecology and the resulting landscape. Fire damage has been recorded in the Mackenzie TSA in five (5) of the past nine (9) years. The lowest amount of area affected was in 2007, 38 ha and the largest amount of area affected was 2006, 9, 361 ha. The majority of damage occurs in June, July, and August. In BC lightening is the cause of 50% of forest fires (Ministry of Forest and Range 2008). Human-caused fires account for the other 50% and usually start close to communities, where they are reported quickly and dealt with quickly (Ministry of Forest and Range 2008, Natural Resources Canada 2007). Fire damage is not equal across tree types, conifers burn 5 to 10 times faster than deciduous trees as a result of resin in the bark and needles whereas deciduous trees are considered more resistant to fire after leaf flush. Fire disturbance can be frequent in boreal forest types because of the combustible nature of the trees and its warm, dry climate which permits severe fire weather. Fires in the boreal forest typically kill most trees (Natural Resources Canada 2007).

4.2.7.3 Flooding

Flooding in forested areas changes soil conditions influencing tree survival and seedling germination and development. Flooding or waterloging decreases soil aeration which has negative impacts on growth, morphology, and metabolism of seedlings and trees although response depends on age, soil type, and duration of flooding. Stem height and diameter, foliage growth and root development are all negatively impacted by a high watertable. Certain species are more tolerant of flooding including black spruce (*Picea mariana*) and balsam fir (*Abies balsamea*) than white spruce (*Picea glauca*) and jack pine (*Pinus banksiana*) (Roy et al. 1999).

Waterlogging of soils has the potential to increase in the Mackenzie TSA. As a result of forest stands dying of MPB infestation more sites have the potential to show increased soil moisture as seen in the Vanderhoof Forest District. This "watering up" effect is a result of dying and dead trees not transpiring (S. Dubé 2008). This problem would be exacerbated on already wet sites.

Management strategies include proactive strategies of risk hazard evaluations, planting flood tolerant species, and water control structures (dykes, ditches) and reactive strategies to improved flooded areas (dykes and ditches). With in the past six (6) years, five (5) years have recorded flooding totalling 639 ha.

4.2.7.4 Red belt

Red belt, this damage occurs to all conifer species throughout BC typically on mid to upper slopes with south or southwest aspects. Red belt is caused by desiccation injury, warm, dry winds during the day followed by cold night air result in a loss of moisture. Water cannot be replaced fast enough if soils are frozen and open buds and foliage are killed. Normally red belt is a sub-lethal injury however repeated damage or destruction of all buds could lead to tree mortality. Red belt causes a reduction in growth rate, an increase in combustibility and increases susceptibility to secondary attack. Red belt was last reported in 2007 at 50 ha (Ministry of Forests 2001).

4.2.7.5 Shoot frost

Shoot frost, results from unusually cold temperatures that freeze sensitive new growth or older tissues not yet sufficiently hardened off for winter. All species and all ages of trees are susceptible. Late spring frosts are result in more injuries than early fall frosts. Damage includes reduced lateral and leader growth and tip dieback, lesions, or cracks. Frost lesions and cracks can act as entry points for canker and decay fungi or result in stem breakage. Growth of cankers and cranks can result in girdling of the tree (Ministry of Forest 2001). Damage by shoot frost was recoded in 2003 with 71 ha damaged.

4.2.7.6 Slide

Slide, unstable slopes can slough or breakaway from the hillside, resulting in the loss of substrate and the attached vegetation. Slide activity damaged 48, 65 and 58 ha of forests in the Mackenzie TSA, 2002, 2003, 2005 respectively.

4.2.7.7 Windthrow

Windthrow, strong winds can break stems and branches and up root whole trees regardless of tree species. Trees that are diseased, growing along the margin of a harvested area, having shallow roots due to a high water table are more susceptible. Windthrow damage in 2002 was 156 ha and 809 ha in 2005.

5.0 BEETLE MANAGEMENT UNITS, STRATEGIES, AND ACTIVITIES

A Beetle Management Unit (BMU) is a unit with consistent management objectives used in operational beetle management for planning and operational purposes. BMU boundaries are generally consistent with Landscape Unit boundaries. BMUs provide a framework to justify allocations of resources and management activities to meet management goals. The strategy chosen for a BMU should remain in place for as long as objectives are being met, or until additional resources become available to allow a more aggressive strategy to be implemented. However, situations change from year to year calling for strategies to be reassessed on an annual basis. Strategies of adjacent BMUs should be considered when carrying out management activities.

There are four (4) BMU strategies used to address bark beetle infestations in a BMU. The selection of the appropriate strategy depends on the forest health issues in the area, the stated integrated resource management objectives, and the expected impact of beetle activity in adjacent management areas.

The strategies include the following: Prevention\Suppression, Holding Action, Salvage and Monitor as well as the special cases of Undesignated and Protected Areas\Ecological Reserves.

1. Suppression/Prevention: This is the most aggressive strategy. It is selected when the infestation status is such that aggressive direct control actions are expected to keep an area at a low level of infestation. Areas are lightly infested, and resources for direct control or harvesting and milling capacities are equal to or exceed the amount of the infestation. The intent is to reduce or keep the outbreak to a size and distribution that can be handled within "normal resource capability".

2. Holding Action: The intent of this strategy is to maintain an existing outbreak at a relatively static level. It is a delaying strategy until adequate resources are available or access created that allows for a more aggressive approach, or to reduce overall loss while waiting for a killing climatic event. This is appropriate in areas with chronic beetle infestations that are too large to deal with using single-tree treatments, or where access is poorly developed for directed harvesting.

3. Salvage: Applied to areas where management efforts would be ineffective in substantially reducing the beetle populations and subsequent levels of damage. Such areas have extensive outbreaks covering a large proportion of susceptible stands. The objective in this case is to salvage affected stands and minimize value loss. This strategy may also apply to areas containing small volumes of pine, or areas where the pine is marginally economic - that is, where control is not worth the effort that would be expended and the objective is to salvage whatever values are there.

4. Monitor: This strategy is applied to areas where management efforts would be ineffective in substantially reducing the beetle population and subsequent levels of damage, or where there is no short-term (less than 5 years) possibility of salvaging dead timber. This may be due to management constraints such as in Wilderness areas, Parks, or Ecological Reserves, or because access cannot be put in place before substantial merchantable degradation of the dead material occurs.

<u>Special Cases</u>

I. Undesignated: These units have not been assigned a strategy because no forest health factors have been identified for treatment.

II. Parks, Protected Areas, and Ecological Reserves: There is a requirement to have a description for the Protected Area polygons on MFR strategic beetle plans and maps. The bark beetle management strategies (e.g. suppression, holding, etc.) do not fit with the mandate BC Parks has to manage these areas. Therefore, a separate category was established to provide direction and management for Protected Areas and Ecological Reserves. Beetle management in protected areas considers a different set of values. Planning for beetle management in protected areas will occur through co-operation between Ministry of Environment and MFR.

The control tactics available for use in BC Parks include:

- Allowing natural processes to prevail (i.e. do nothing);
- Pheromone baits and traps;
- Individual tree fall and burn on-site;
- Large-scale prescribed burn; and
- Skid piles and burn on-site with low impact machinery.

Commercial logging and road building is strictly prohibited in protected areas as directed through the Park Act.

Selection of a management option depends on a technical and ecological evaluation, as well as protected area size and relation of the infestation to neighboring forest lands. Treatment method is determined through joint decision-making with the MFR that takes into consideration protected area values.

Table 4. Examples of characteristics of BMUs under various strategy designations.

	Strategy			
Factor	**Suppression or Prevention**	**Holding**	**Salvage**	**Monitor**
% current infestation to treat	Approx. 80	Approx. 50 to 70	Approx. 50	0
Hazard Rating	All	Moderate to High	Moderate to High	All
Road Access	Required	Needed in short term	Short term or planned	Not necessary
Infestation Status	Light to low	Low to outbreak	Extensive or collapsed	N/A
Spot : Patch	High	High to Moderate	Low	N/A
Estimate chance of control	High	Moderate	Nil to low	N/A

Table 5. Objectives for beetle population removal for BMU strategies.

Strategy	**% of Current Infestation to Treat**	**Comments**
Suppression or Prevention	Approx. 80	Address all current attack within 2 yrs, stand proofing, other actions. Intent is to “control” the outbreak in the area and stop spread.
Holding	50 to 70	Address the largest proportion of the new infested material, at least close to the rate of expansion. Intent is to maintain beetle populations at a level that can be dealt with annually without huge expansion.
Salvage	< 50	Priority is to salvage timber previously attacked to min. value loss. Relevant in areas where suppression or holding actions are no longer appropriate or feasible.
Monitor *and Undesignated or Protected Areas*	0	No action required beyond monitoring and recording. Most appropriate in Parks, Ecological Reserves and inoperable areas where the outbreak has peaked, salvage is not possible and there is no chance for mitigation of further loss.

Control strategies are subject to review and modification based on changes in infestation levels, access, and other higher level plans. A yearly review will include an assessment of the success of the plan and how it may be improved in order to better meet the goals and objectives stipulated.

Selecting the appropriate strategy or combination of strategies for a given area is based on a number of factors. Some of those factors include:

- beetle species,
- stand hazard,
- extent and distribution of the beetle infestations both current and historical,
- expected impact of the beetle within the particular area and surrounding areas,
- land use objectives and non-timber resource values within the area,
- stage of the beetle outbreak, strategies of adjacent landscape units, and accessibility.

BMUs cannot be considered in isolation, as each will have an effect on the beetle situation of its neighbor. Therefore, the strategy selected for a BMU must be compatible with those taken in adjacent units. Table 6 outlines the parameters for allowable adjacent control strategies.

Table 6. Adjacent BMU Control Strategy Evaluation.

Assigned Strategy/ Adjacent Strategies	**Suppression/ Prevention**	**Holding Action**	**Salvage**	**Monitor, *Undesignated, Parks, Protected Areas and Ecological Reserves***
Prevention /Suppression	X	X		
Holding Action	X	X	X	
Salvage		X	X	X
Monitor or *Undesignated, Parks/ Protected Areas and Ecological Reserves*			X	X

The mountain pine beetle and spruce bark beetle strategies for 2008-09 are depicted in figure 2 and figure 3 that follow. A tabular summary of these control strategies by BMU has been included at table 7.

It is important to note that priority activities in non-suppression BMUs are not directly eligible for bark beetle suppression funding. The Mackenzie Forest Health Working Group will work together with other agencies (e.g. Canadian Forest Service - Federal MPB Initiative) to ensure that funding is only allocated for control activities within suppression BMUs.

Figure 2. 2008 Mackenzie TSA Mountain Pine Beetle Strategies.

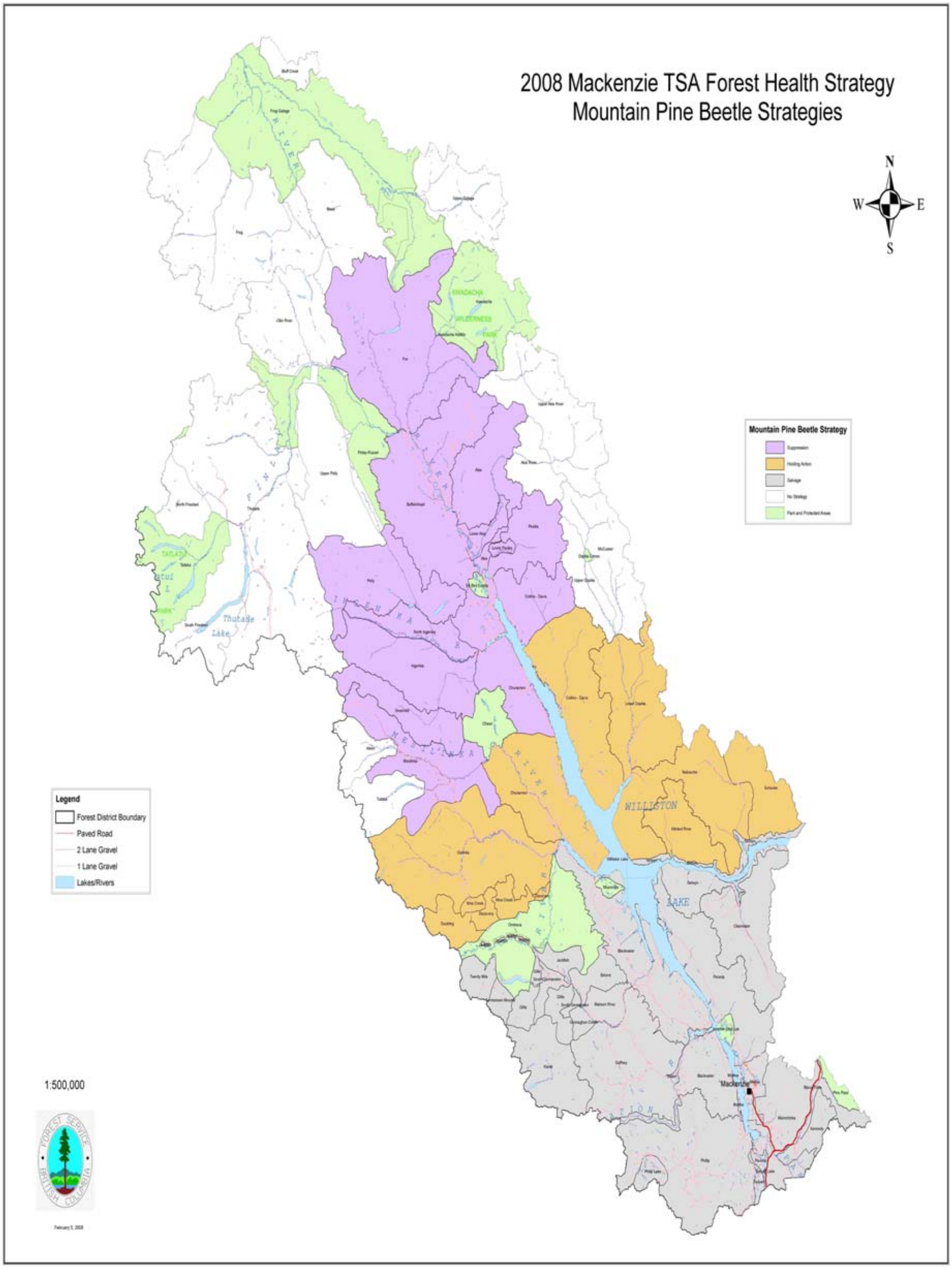


Figure 3. 2008 Mackenzie TSA Spruce Beetle Strategies.

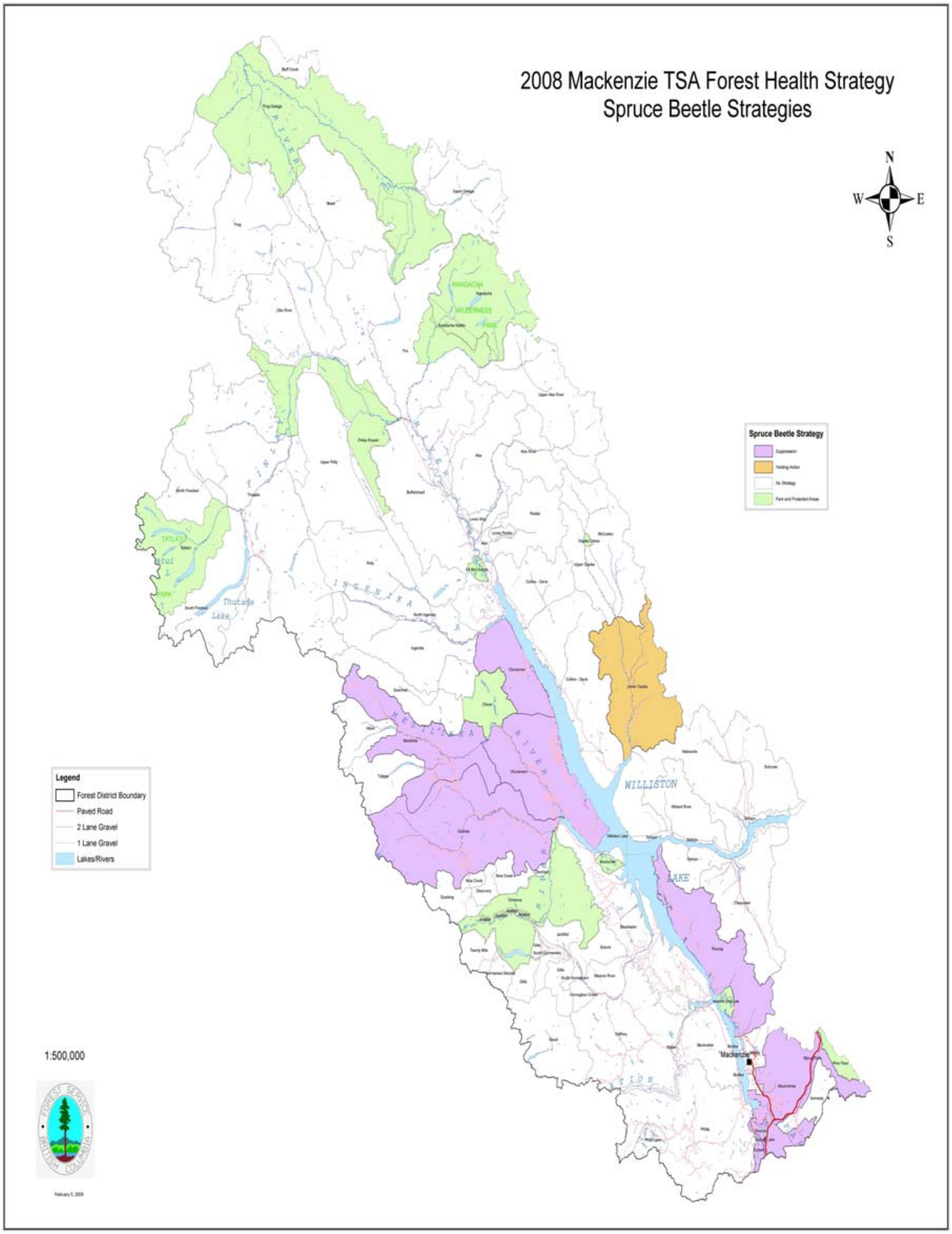


Table 7. Beetle Management Units list and control strategies.

BMU	IBM	IBS	IBD		BMU	IBM	IBS	IBD
Aiken	N\A	Monitor	N\A		Mesilinka	Suppression	Suppression	N\A
Akie	Suppression	Monitor	N\A		Misinchinka	Salvage	Suppression	N\A
Akie River	Suppression	Monitor	N\A		Morfee	Salvage	Monitor	N\A
Bijoux Falls	N\A	N\A	N\A		Muscovite	N\A	N\A	N\A
Blackwater	Salvage	Monitor	N\A		Nabesche	Holding Action	Monitor	N\A
Bluff Creek	Monitor	Monitor	N\A		Nation	Salvage	Monitor	N\A
Braid	Monitor	Monitor	N\A		Nina Creek	Holding Action	Monitor	N\A
Buffalohead	Suppression	N\A	N\A		North Firesteel	Monitor	Monitor	N\A
Chase	N\A	N\A	N\A		North Ingenika	Suppression	Monitor	N\A
Chunamon	Holding Action	Suppression	N\A		Obo River	Monitor	Monitor	N\A
Clearwater	Salvage	Monitor	N\A		Omineca	N\A	N\A	N\A
Collins - Davis	Holding Action	Monitor	N\A		Osilinka	Holding Action	Suppression	N\A
Connaghan Creek	Salvage	Monitor	N\A		Ospika Cones	N\A	N\A	N\A
Discovery	Holding Action	Monitor	N\A		Parsnip	Salvage	Suppression	N\A
Duckling	Holding Action	Monitor	N\A		Pelly	Suppression	Monitor	N\A
Ed Bird Estella	N\A	N\A	N\A		Pesika	Suppression	Monitor	N\A
Eklund	Salvage	Monitor	N\A		Philip Lake	Salvage	Monitor	N\A
Finlay-Russel	Monitor	Monitor	N\A		Phillip	Salvage	Monitor	N\A
Fox	Suppression	Monitor	N\A		Pine Pass	N\A	N\A	N\A
Frog	Monitor	Monitor	N\A		Schooler	Holding Action	Monitor	N\A
Frog-Gataga	Monitor	Monitor	N\A		Selwyn	Salvage	Monitor	N\A
Gaffney	Salvage	Monitor	N\A		South Firesteel	Monitor	Monitor	N\A
Germansen Mounta	Salvage	Monitor	N\A		South Germansen	Salvage	Monitor	N\A
Gillis	Salvage	Monitor	N\A		Swannell	Suppression	Monitor	N\A
Heather Dina Lake	N\A	N\A	N\A		Tatlatui	N\A	N\A	N\A
Ingenika	Suppression	Monitor	N\A		Thutade	Monitor	Monitor	N\A
Jackfish	Salvage	Monitor	N\A		Tudyah	Salvage	Suppression	N\A
Kennedy	Salvage	Monitor	N\A		Tudyah Lake	Salvage	Suppression	N\A
Klawli	Salvage	Monitor	N\A		Tutizza	N\A	Monitor	N\A
Kwadacha	Monitor	Monitor	N\A		Twenty Mile	Salvage	Monitor	N\A
Kwadacha Additio	Monitor	Monitor	N\A		Upper Akie River	Monitor	Monitor	N\A
Lower Akie	Suppression	Monitor	N\A		Upper Gataga	Monitor	Monitor	N\A
Lower Ospika	Holding Action	Holding Action	N\A		Upper Ospika	Monitor	Monitor	N\A
Lower Pesika	Suppression	Monitor	N\A		Upper Pelly	Monitor	Monitor	N\A
Manson River	Salvage	Monitor	N\A		Wicked River	Holding Action	Monitor	N\A
McCusker	Monitor	Monitor	N\A		Williston Lake	N\A	N\A	N\A

6.0 MACKENZIE TSA TACTICAL PLAN FOR 2008-09

The purpose of the tactical plan is to provide a basis for proposed activities and budget estimates for bark beetle management activities in the Mackenzie TSA. Suppression unit designations were assigned using a biological bases approach that did not take in to account existing funding or resource limitations. The budget estimates for beetle detection and treatments were done using historic data and knowledge plus and estimate of the total new current attack that may require treatments. A tabular summary and map depicting the biological bases tactical plan for all forest health activities has been include as APPENDIX I.

Since there is limited funding available for bark beetle suppression BMU Provincially, the Mackenzie Forest Health Committee has prepared a separate tactical plan submission to meet these requirements. APPENDIX II contains a map that outlines (purple boundary) the suppression BMUs that are being requested for funding in the 2008-09 season. A tabular summary has also been included outlining the budget and activities associated with these select suppression BMUs for IBM.

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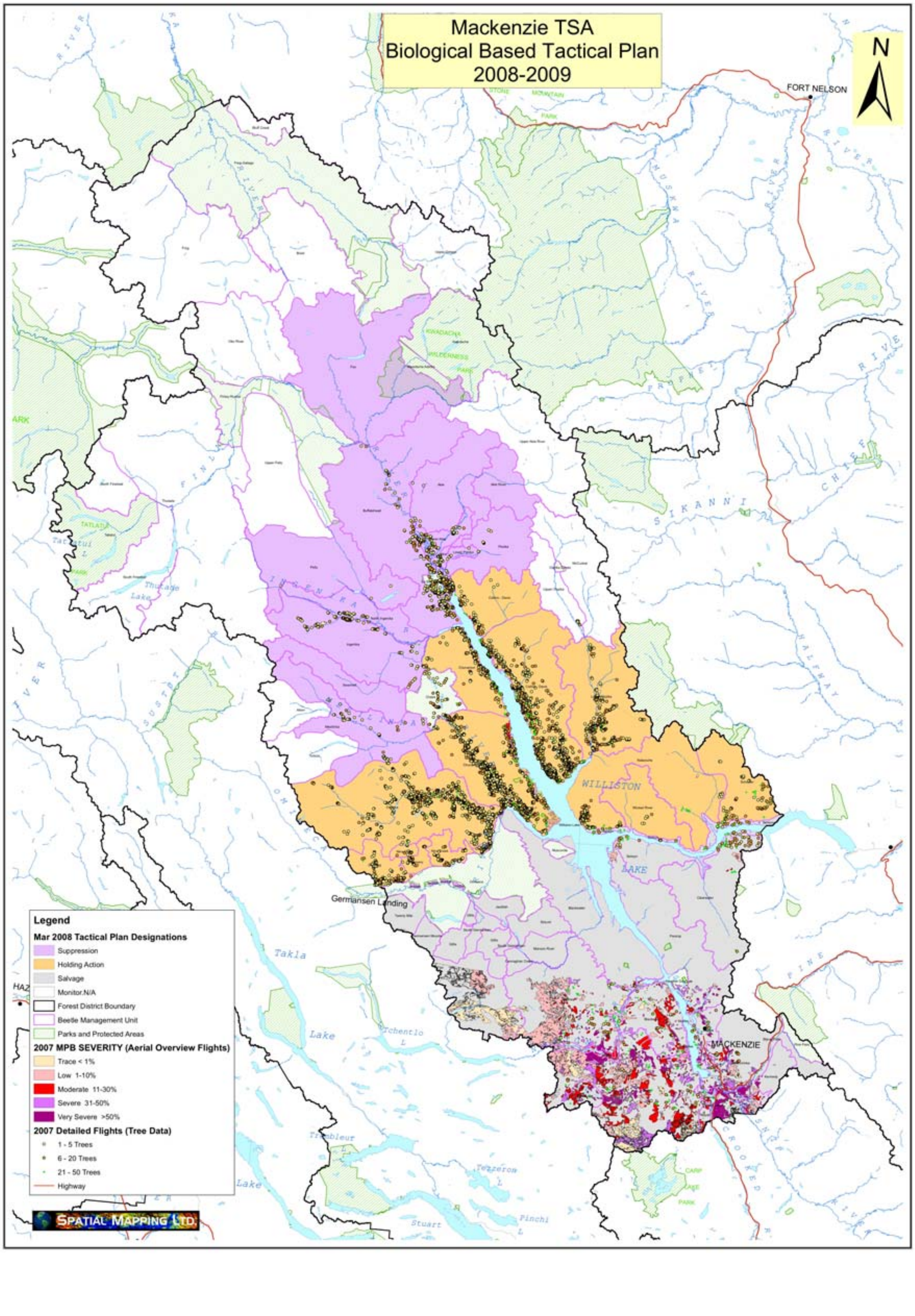
APPENDIX I

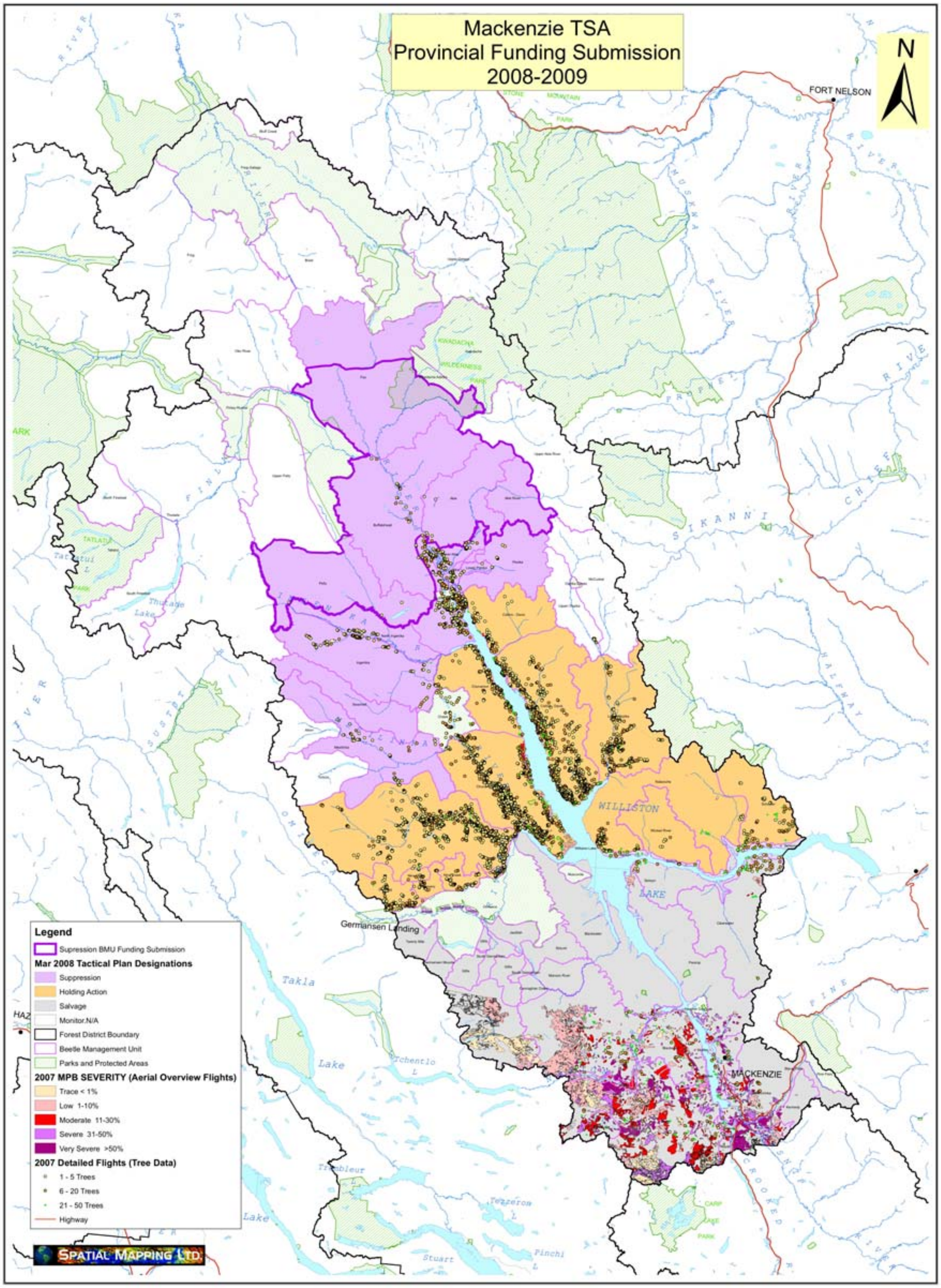
Biological Based Tactical Plan


Mackenzie TSA
Biological Based Tactical Plan
2008-2009
N
FORT NELSON
Germansen Landing
MACKENZIE
WILLISTON
LAKE
Takla
Lake
Tchentlo
L
Stuart
Pinchi
L
Legend
Mar 2008 Tactical Plan Designations
Suppression
Holding Action
Salvage
Monitor,N/A
Forest District Boundary
Beetle Management Unit
Parks and Protected Areas
2007 MPB SEVERITY (Aerial Overview Flights)
Trace < 1%
Low 1-10%
Moderate 11-30%
Severe 31-50%
Very Severe >50%
2007 Detailed Flights (Tree Data)
1 - 5 Trees
6 - 20 Trees
21 - 50 Trees
Highway
SPATIAL MAPPING LTD.

Insert table from spreadsheet manually

APPENDIX II

Provincial Funding Submission Tactical Plan



Mackenzie TSA
Provincial Funding Submission
2008-2009
N
FORT NELSON
WILLISTON
LAKE
Germansen Landing
MACKENZIE
Takla
Lake
Legend
Supression BMU Funding Submission
Mar 2008 Tactical Plan Designations
Suppression
Holding Action
Salvage
Monitor.N/A
Forest District Boundary
Beetle Management Unit
Parks and Protected Areas
2007 MPB SEVERITY (Aerial Overview Flights)
Trace < 1%
Low 1-10%
Moderate 11-30%
Severe 31-50%
Very Severe >50%
2007 Detailed Flights (Tree Data)
1 - 5 Trees
6 - 20 Trees
21 - 50 Trees
Highway
SPATIAL MAPPING LTD.

Insert table from spreadsheet manually

APPENDIX III

Digital Documents and Maps