Southern Interior Area Forest Health Program Pest Management Plan 2022-2027

The South Area includes the following three Forest Regions:

Thompson Okanagan Region

Cariboo Region

Kootenay Boundary Region

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Lorraine Maclauchlan
Thompson Okanagan Region
441 Columbia Street
Kamloops, B.C.
V2C 2T3

Lorraine.maclauchlan@gov.bc.ca

Executive Summary and Background

Forest Health is an important component of Natural Resource Management within the Ministry of Forests, Lands and Natural Resource Operations and Rural Development (FLNRORD). In the past four decades, the forest health (FH) program has transitioned from being primarily focused on the suppression of epidemic insect outbreaks, into a multi-faceted program focused on mitigating damage to forest values and developing innovative and proactive strategies to address current and future FH issues. The existing FH program is a hybrid of proactive and reactive management, which has led to the current state of forests in British Columbia. Proactive management creates forest conditions that mitigate the impacts of insects, diseases and abiotic factors. It creates an environment where an event can be contained and damage to the current and future forest is minimised. Reactive management addresses eruptive pest populations with thoughtful and measured control or management responses.

Over decades of practice in BC, we have developed a hybrid version of pest management that incorporates both reactive and proactive approaches. The use of integrated pest management for insect defoliator management combines both reactive and proactive elements that accomplish efficient control and mitigation. The refinement of activities like the annual aerial overview survey, trapping of native (and invasive insects), installation of long-term plots and surveys is proactive and part of a monitoring network designed to feed data into a pest management system that provides an early warning of unusual activity.

The Forest Health Program is responsible for the detection, quantification and interpretation of forest health issues (insects, disease, abiotic). When there is imminent risk to trees, stands, ecosystems or human health (e.g. western hemlock looper) control measures are conducted to minimize impact, maintain forest values and mitigate future risk. This involves developing and implementing best management practices for each damaging agent. The forest health program evaluates the impacts of forest health damaging agents on forest resource values (e.g. timber supply, habitat, old growth protection, Cultural values). British Columbia has many tree species at high risk of pest damage, and large-scale outbreaks of various pests can cause extensive and severe consequences to B.C.'s forests.

Forest pests include insects, pathogens, some animals and various abiotic events (e.g. wind, drought, flooding). The most common insects addressed in the FH program include bark beetles, defoliators, and weevils; examples of pathogens are root rots, stem rusts, and needle blights. Even some animals such as squirrels, hares, porcupines, deer, and other mammals can cause deleterious levels of damage to some forests. Forest pests may kill or damage a high volumes of timber.

The B.C. government's three key strategic forest health objectives are to:

1. Protect forest resources from pest damage by direct actions when operationally possible and justified;
2. Implement stand establishment activities (e.g. stocking standards) to minimize the expected impact of known forest pests; and
3. Assess pest impacts on forest values to improve estimates of timber yield from B.C.'s forests and prioritize management treatments.

The following **Pest Management Plan** is guided by the Provincial Forest Health Strategy (link below) and the Integrated Pest Management Act.

2019-2022 Provincial Forest Health Strategy (gov.bc.ca)

Integrated Pest Management Act (gov.bc.ca)

The Forest Health program within the three southern interior natural resource regions of B.C. oversees operational and research projects that address critical and emerging entomology and pathology issues. The Thompson Okanagan, Cariboo and Kootenay Boundary Regions cover a large and diverse geographic area. Forest lands within these regions span many ecosystems and zones. The area includes desert, low elevation drybelt forests, moist or transitional forests, as well as sub-alpine and alpine forest types. The geographic area extends from Quesnel and the Cariboo-Chilcotin in the North and west to the Alberta Border in the North and East. In the south this area borders with the United States of America.

With this highly variable and diverse environment comes a wide range of damaging pests and pathogens. Pests may include various species of bark beetles (e.g. Douglas-fir beetle, spruce beetle, mountain pine beetle, western balsam bark beetle), defoliators (e.g. western spruce budworm, Douglas-fir tussock moth, western hemlock looper) and many pests affecting young stands (e.g. spruce weevil). Forest pathogens may cause tree mortality, growth loss and defects. Some important forest pathogens in the southern interior include needle cast fungi, root diseases, stem decays, mistletoes, and stem rusts.

1 INTRODUCTION

Section 24(2)(g) of the Integrated Pest Management Regulation (IPMR) requires the preparation of a Pest Management Plan (PMP) for insecticide use for the management of native insect pests on more than 50 hectares a year of public land (e.g. provincial Crown land). This PMP replaces a previous version that was in effect 2018-2021.

A PMP is a plan that describes:

- A program for managing pest populations or reducing damage caused by pests based on integrated pest management; and,
- The methods of handling, preparing, mixing, applying, and otherwise using pesticides within the program.

This PMP is consistent with all legislation such as the Forest and Range Practices Act (FRPA) (http://www.bclaws.ca/civix/document/id/consol21/consol21/00_02069_01), and any associated operational plans or site specific prescriptions written for areas where operational treatments will occur. FLNRORD will adhere to the Forest and Range Practices Act, all of the Regulations of this Act and all other Federal and Provincial Legislation, which may apply.

1.1 Purpose and Objectives of PMP

Purpose

The primary purpose in developing this PMP is to implement a proactive program of Integrated Pest Management that involves the detection, identification, monitoring, mitigation and control of specific defoliating insects. The goal is to protect and maintain biological diversity, wildlife habitat, range forage, and a healthy and productive forest that can be enjoyed and used by First Nations, the public and forest industry. The Integrated Pest Management approach described in this PMP will ensure the effective management of **high priority defoliators** in the Thompson Okanagan, Cariboo and Kootenay Boundary Regions.

Objectives

The objectives of this PMP are to ensure:

- Legal accountability with the provisions of the *Integrated Pest Management Act* (*IPMA*) and IPMR, as well as applicable federal, provincial and local government laws and regulations;
- the responsible use of insecticides;
- the incorporation and use of the principles of IPM;
- Public and First Nations awareness of, and input into, native defoliator management;
- the effective use of an IPM program taking into account environmentally sensitive areas and land use objectives;

- a long-term planning horizon and delivery of a timely, effective Forest Health Program; and,
- continued research into biological and alternative methods of defoliator management.

Under this PMP, populations of damaging defoliators, such as the western spruce budworm, may not be controlled, but rather kept from expanding or causing compounding damage to the strategic forested areas.

1.2 Identifying Information

Identification of Plan Holder

The PMP holder is the BC Ministry of Forests, Lands and Natural Resource Operations and Rural Development (FLNRORD), Thompson Okanagan Region, 441 Columbia Street, Kamloops, B.C. V2C 2T3

Geographic Boundaries and Description of the PMP Area

The plan area will be specific to provincial Crown land in the southern interior of B.C. and is comprised of the Thompson Okanagan, Cariboo and Kootenay Boundary Regions, with offices located in Kamloops, Williams Lake and Nelson, respectively. A map showing the geographic boundaries of the area covered by this PMP is shown in Figure 1.

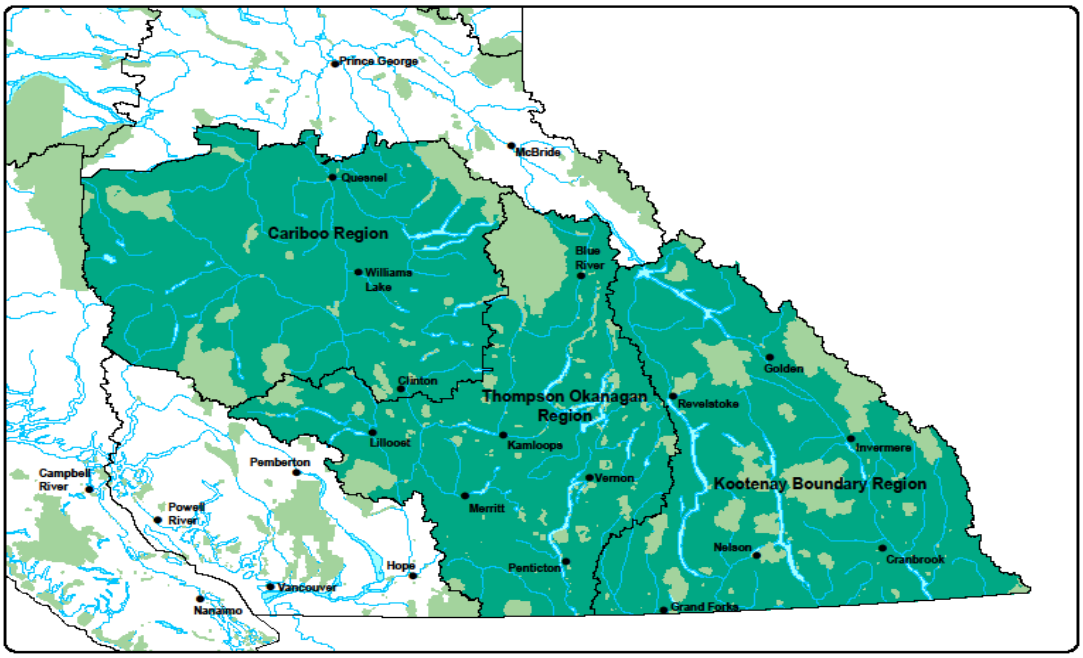


Figure 1. Map Area covered by the Southern Interior Area Forest Health Program PMP showing the boundaries of the Thompson Okanagan, Cariboo and Kootenay Boundary Regions and parks (light green).

The South Area covers 25M hectares, approximately 60% in productive forest land. The annual AAC (three regions combined) of 18,189,853 m^3 is approximately 35.5% of the provincial total. There are 86 First Nation Bands and Tribal Councils. Forested land in the southern interior range from dry semi-desert of Kamloops, Lillooet and the south Okanagan, to the interior wet-belt of Sicamous and Salmon Arm, Douglas-fir forests throughout the Cariboo-Thompson Okanagan into the Boundary-Kootenays, to sub-alpine forests in more mountainous terrain. Lodgepole pine and Douglas-fir forests, with mixes of interior spruce, sub-alpine fir, cedar and other conifer and deciduous species dominate much of the land base. As a result of this diverse landscape has numerous native defoliators that periodically erupt and cause damage to trees and forests.

The largest population centres in this area include Kamloops, Clearwater, Lillooet, Merritt, Kelowna, Vernon, Penticton, 100 Mile House, Williams Lake, Quesnel, Nelson, Castlegar, Cranbrook, Revelstoke plus many other smaller communities. The Okanagan Valley is one of the fastest growing areas in the province with a regional population of 362,258 people (2016).

The long-term objective of FLNRORD's Forest Health Program is the management of forests to minimize and ameliorate pest damage under changing climate conditions. Some management strategies outlined in this PMP include the manipulation of stand attributes, such as density, structure, species composition and age, in an effort to make stands more resilient to defoliators thus reducing mid- and long-term losses and promoting better stewardship of our forest resource.

Forest Cover

The area covered by the PMP encompasses all forested Crown land in the Cariboo, Thompson Okanagan and Kootenay Boundary Regions (Fig. 1). It must be noted that many insect defoliators have very defined ranges or specific host species therefore the potential area of treatment is also confined to those smaller geographic areas. The southern interior is ecologically one of the most diverse areas in the province, with arid grassland dominated landscapes in the Thompson and Okanagan basin, to glaciers and 2-3 meter diameter old growth cedar forests dominated by an understory of large ferns in the upper Adams and Kootenays. Coastal and interior climate conditions meet along the eastern slopes of the Coast Ranges creating large transition zones with great biological diversity.

Natural disturbance regimes such as wildfires, disease and insect outbreaks have shaped the landscape throughout most of the interior, with fires commonly occurring throughout the hot dry Thompson and Okanagan valleys every 10-25 years. By contrast, some areas in the wet Columbia mountain areas have seen fire return rates of much longer intervals.

There are about 21 tree species in the region with Douglas-fir, lodgepole pine, Engelmann spruce, Subalpine fir, western red cedar and western hemlock as the most prevalent. Deciduous species, including trembling aspen, Black cottonwood and Paper birch are often found mixed in these stands and sometimes dominate early seral stages.

Primary Land Use

The primary land uses occurring on Crown land within the PMP area include timber harvesting, regeneration, traditional use, mining, range and wildlife habitat/forage and recreation. Key goals of the Forest Health Program are to detect and monitor pest

populations, and maintain and improve the health, resilience and productivity of the forest land base while reducing unsalvaged losses caused by various insects, diseases and other damaging agents. The Forest Health Program conducts numerous annual, intermittent and long-term assessments of the impacts of damaging agents on the forest resource. Part of the overall Forest Health Program, as covered in this PMP, is the thoughtful and targeted use of insecticides to achieve these land use goals.

Public Use

A network of primary and secondary roads service the developed area under this PMP. As areas are developed for harvest, public access increases. All main forest service roads are accessible for use by the public and will have signage notifying of pesticide use at all main entry points prior to treatment.

For many Indigenous people, forests are essential to cultural traditions, such as hunting and trapping, and also serve as spiritual sanctuaries. Communication with and partnering with local First Nations is a key part in our Forest Health program and integral in the planning process of all defoliator control programs.

Outdoor recreation is a principal focus year-round in the southern interior with fishing, hunting, hiking, rock climbing, skiing, snow shoeing and various motorized activities being carried out throughout the three regions.

FLNRORD has established many high value recreation sites and trails for public use throughout the PMP area. To maintain public safety and the integrity of these sites, the occasional use of pesticides in or near these sites may be warranted.

https://forestry.valentbiosciences.com/valent-biosciences-corporation-forest-home/products/foray

Forest Insect Pests

The defoliator species described in this PMP are those considered damaging to forest management objectives and include, but are not limited to:

Western spruce budworm, *Choristoneura freemani* Razowski
Douglas-fir tussock moth, *Orgyia pseudotsugata* (McD.)
Western hemlock looper, *Lambdina fiscellaria lugubrosa* (Hulst)
Two-year cycle budworm, *Choristoneura biennis* Free

2 Background of Pest Management in southern B.C.

The southern interior has a long history of native defoliator management. Much of the pioneering research for defoliator detection, monitoring and control was conducted in southern B.C.

Defoliators

The western spruce budworm, Douglas-fir tussock moth, and the western hemlock looper are actively managed in the southern interior. To a minor extent two-year cycle budworm and other defoliators are also managed when they reach damaging levels. The western spruce budworm is currently in the building phase of its outbreak cycle throughout the three regions (Figure 2) but the next outbreak cycle is anticipated within 5

years. The outbreak area peaked in 2007 at 847,138 ha affected and the second highest mapped defoliation was in 1987 at 836,854 ha, exactly 20 years prior. Except for 1987, the ten highest recorded defoliation years have all occurred in this past outbreak cycle (2002-2015).

The three southern interior regions have a fully integrated management plan for western spruce budworm, Douglas-fir tussock moth and western hemlock looper that includes direct control using biological insecticides, *Bacillus thuringiensis* var. *kurstaki* (*B.t.k.*), nuclear polyhedrosis virus (NPV) and other non-chemical approaches. Various formulations of *B.t.k.* and NPV have been used since the defoliator program began (Tables 1-3) and numerous research trials have been conducted to determine the most biologically effective, ecologically safe and cost-effective techniques to reduce damage caused by these defoliating insects. The Forest Health Program has supported research into the effect of *B.t.k.* on non-target Lepidoptera (Boulton and Maclauchlan 2001).

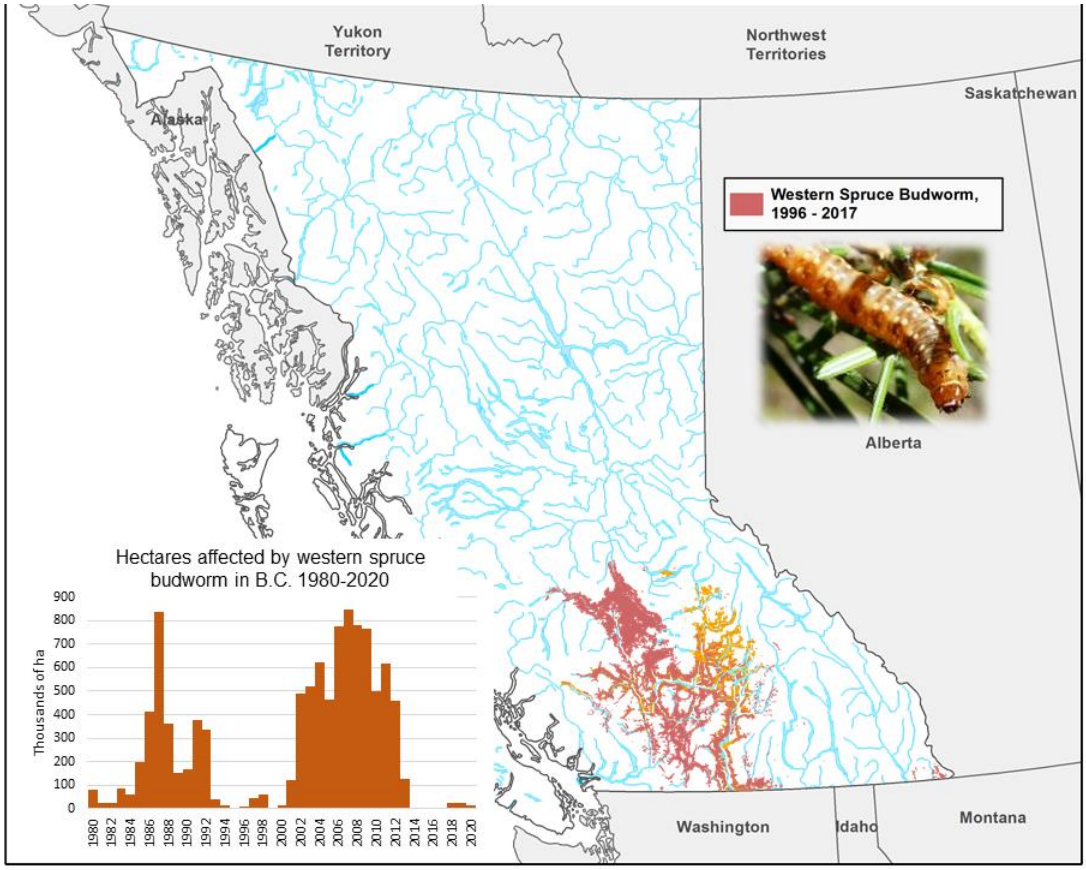


Figure 2. Map of B.C. showing the extent of western spruce budworm defoliation (yellow=1986-1995 and red=1996-2017). Inset shows annual hectares of defoliation mapped in B.C. 1980-2020.

Operational spray programs for western spruce budworm began in 1991, prior to 1991 treatments were for research purposes, and continue annually as needed (Table 1). The current application rate of *B.t.k.* for budworm is 2.4 litres per hectare applied neat (30 BIU/ha). Spray aircraft (rotary wing or fixed wing) are equipped with a spray system having a minimum of four (4) nozzles capable of delivering droplets in the range of 100-120 median micron diameter at a constant rate and pressure over an even, unbroken

swath (e.g. AU 4000 micronaires). The spray contractor must have a contingency plan and necessary equipment for containment and mop-up of any spills that may occur over the duration of the project.

Table 1. History of spray treatments against the western spruce budworm in the three southern interior regions of B.C. (1987-2021).

	Hectares sprayed				
Year	Thompson Okanagan	Cariboo	Kootenay Boundary	Total	Product Used
1987	890	0		890	Thuricide
1988	467	0		467	Thuricide
1989	550	0		550	Dipel
1990	0	0		0	
1991	4,000	0		4,000	Dipel 132
1992	35,918	0		35,918	Foray 48B
1993	33,945	0		33,945	Foray 48B
1994	14,695	0		14,695	Foray 48B
1995	7,600	0		7,600	Foray 48B, 76B
1996	160	0		0	Mimic 240 LV
1997	3,660	12,960		16,620	Foray 48B
1998	7,280	13,064		20,344	Foray 48B
1999	8,031	13,464		21,495	Foray 48B
2000	0	7,091		7,091	Foray 48B
2001	9,804	16,979		26,783	Thuricide 48LV
2002	4,548	23,110		27,658	Thuricide 48LV
2003	0	22,139		22,139	Thuricide 48LV, Foray 48B
2004	0	25,504		25,504	Foray 48B
2005	2,387	28,030		30,417	Foray 48B
2006	16,500	27,482		43,982	Foray 48B
2007	21,021	36,274		57,295	Foray 48B
2008[a]	33,800	28,182		61,982	Foray 48B
2009[b]	38,512	34,478		72,990	Foray 48B
2010	26,572	21,115		47,687	Foray 48B
2011	29,875	20,888		50,763	Foray 48B
2012	54,337	47,998	13,678	116,012	Foray 48B
2013	50,009	27,934		77,943	Foray 48B
2014	23,623	33,114		56,737	Foray 48B
2015	0	15,985		15,985	Foray 48B
2016-18	0	0		0	No spray
2019	0	16,786		16,786	Foray 48B
2020	9,076	0		9,076	Foray 48B
2021	4,132	0		4,132	Foray 48B

Total	436,641	455,891	13,678	907,416

[a] 833 ha sprayed in Chilliwack District

[b] 1,474 ha sprayed in Chilliwack District

The Douglas-fir tussock moth is a cyclical defoliator, reaching outbreak proportions every 8-10 years in some part of southern B.C. Over eleven distinct outbreak periods have occurred in B.C. since 1918 with the 2008-2012 outbreak being the largest ever recorded.

Management of the Douglas-fir tussock moth is a fully integrated system that includes: yearly monitoring with pheromones to detect building populations; sequential egg mass surveys; and, control of incipient populations using a virus (nuclear polyhedrosis virus, NPV) to collapse outbreaks or a biological insecticide (*Bacillus thuringiensis* var. *kurstaki*) to protect foliage. The first operational program integrating all aspects of this system was successfully implemented during the 1991-93 outbreak (Table 2).

Table 2. History of spray treatments against the Douglas-fir tussock moth in the southern interior of B.C. (1991-2011).

	Ha sprayed		
Year	NPV	*B.t.k.*	Product Used
1991	100		Virtuss
1992	650		Virtuss
1993	703		Virtuss, TM BioControl-1
2006			
2007			
2008	1,130		Virtuss, TM BioControl-1
2009	4,341		Virtuss, TM BioControl-1
2010	1,549	7,638	TM BioControl-1, Foray 48B
2011		12,159	Foray 48B
Total	8,473	19,797	

The western hemlock looper is a native defoliator that is periodically destructive in coastal and interior B.C. forests. It reaches outbreak proportions every 9-11 years in the interior and approximately every 20-plus years in coastal eco-systems. Western hemlock looper outbreaks usually last about 3 years and are generally brought under control by parasites, predators, diseases and heavy rains during the moth flight period. However, occasionally intervention with *B.t.k.* is needed to mitigate large areas of mortality. Recent spray programs for western hemlock looper have been conducted to save critical Caribou habitat. The western hemlock looper will readily feed on associated species in stands such as interior spruce, Douglas-fir, western red cedar and during outbreaks, even understory shrubs

Western hemlock looper population trends are monitored annually by pheromone trapping male moths; three-tree beatings at permanent sample sites; and, egg sampling (when outbreaks are imminent). Forty one permanent sites have been established and are situated throughout the Thompson Okanagan and Kootenay Boundary Regions. Six pheromone traps are deployed at each of these sites and three-tree beatings occur at a sub-sample of these permanent trapping locations.

Spray programs are implemented (Table 3) only when western hemlock looper populations reach outbreak levels and threaten stewardship goals such as Mountain Cariboo critical habitat.

The two-year cycle budworm and others are occasionally considered for treatment when damaging levels are reached. Approximately 890 hectares was sprayed with *B.t.k.* in 2012 to decrease impacts due to the two-year cycle budworm.

Table 3. History of spray treatments against the western hemlock looper in the southern interior of B.C. (2003-2021).

Year	Hectares sprayed			Total	Product Used
	Thompson Okanagan	Kootenay Boundary	Cariboo		
2003	1,405	8,610	0	10,015	Foray 48B
2012	4,014	8,783	0	12,797	Foray 48B
2021	17,735	10,183	18,902	46,820	Foray 48B
Total	23,154	27,576	18,902	69,632	

2.1 Pesticides

Pesticides to be used for defoliator management under this PMP include:

Target Insect and Active ingredient	Trade Name(s)	PCP No.	Application Rates
Western spruce budworm			
Bacillus thuringiensis var. *kurstaki*	Foray 48B, or other registered *B.t.k.* product	24977	30 BIU/ha @ 2.4 litres/ha
Douglas-fir tussock moth			
Nuclear polyhedrosis virus	Virtuss TM-Biocontrol1	17786 19293	12.5 g/ha 28.4 g/ha
Bacillus thuringiensis var. *kurstaki*	Foray 48B, or other registered *B.t.k.* product	24977	50 BIU/ha @ 4.0 litres/ha (applied twice 5-10 days apart)
Western hemlock looper			
Bacillus thuringiensis var. *kurstaki*	Foray 48B, or other registered *B.t.k.* product	24977	30 BIU/ha @ 2.4 litres/ha
Two-year cycle budworm and other Lepidopteran defoliators	Foray 48B, or other registered *B.t.k.* product	24977	30 BIU/ha @ 2.4 litres/ha
Bacillus thuringiensis var. *kurstaki*	Foray 48B, Thuricide 48LV or other	24977	30 BIU/ha @ 2.4 litres/ha

3 THE SOUTHERN INTERIOR FOREST HEALTH INTEGRATED PEST MANAGEMENT PROGRAM

Integrated Pest Management (IPM) is a pest control strategy that uses an array of complementary methods: natural predators and parasites, pest-resistant varieties, cultural practices, biological controls, various physical techniques, and the strategic use of pesticides. IPM is an ecological approach that can significantly reduce or eliminate the use of pesticides.

Techniques such as stand susceptibility rating, incorporation of population outbreak models, pheromone monitoring, stand and host species manipulation and application of biological insecticides are all part of an IPM system. The southern interior Forest Health Program fully embraces the concepts of IPM. Insecticides are part of a broader, biologically based management strategy for defoliators. Insecticides are used only after monitoring indicates that a critical threshold of damage or population density will be reached or surpassed. Insecticides are applied according to established best management practices guidelines and decision matrices, and treatments are made with the goal of removing or reducing only the target organism. Pest control methods are selected and applied in an effective and economical manner that minimizes risks to human health, beneficial and non-target organisms, and the environment. IPM has become even more important with the ever-increasing impacts of climate change that are now apparent in the changing dynamics of some of our native forest defoliators.

IPM is defined in the legislation to mean, "a decision making process that uses a combination of techniques to suppress pests and must include but is not limited to the following elements:

a) planning and managing ecosystems to prevent organisms from becoming pests;

b) identifying potential pest problems;

c) monitoring populations of pests and beneficial organisms, pest damage, and environmental conditions;

d) using injury thresholds making treatment decisions;

e) reducing pest populations to acceptable levels using strategies that include a combination of biological, physical, cultural, mechanical, behavioral, and chemical controls; and,

f) evaluating the effectiveness of treatments.

3.1 Prevention

Prevention or pro-active strategies are the keystone of the Forest Health Program. Prevention strategies include a number of long- and short-term tactics directed at the host, landscape (ecosystem) and insect. Prevention strategies and tactics will not eliminate the occurrence of defoliator outbreaks but will lessen the extent, duration, severity, spread and damage incurred when defoliator populations reach outbreak proportions.

Long-term strategies for defoliators include, but are not limited to:

- long-term plans for managing susceptible species
- stand susceptibility rating for all susceptible landscapes
- host species density, age and stand structure manipulation
- promoting age and species mosaics across susceptible landscapes
- silviculture treatments to lessen susceptibility of trees and stands

Short-term tactics for defoliators include, but are not limited to:

- annual detection (air and ground)
- population monitoring and prediction (trapping & life stage sampling)
- permanent sample sites for population monitoring and impact assessment
- monitoring weather patterns to determine stress level of forests and potential impacts on defoliator species
- treatment with biological insecticide when threshold levels of damage or insects are reached

3.2 Pest Identification and Monitoring

A pest is defined as "*any organism or damaging agent designated as detrimental to effective resource management*" (Doliner and Borden 1984). For the purposes of this Pest Management Plan, the term pest refers to major native defoliator species (Table 4).

Table 4. List of major defoliation pests (insect defoliators) referred to in the Southern Interior Pest Management Plan.

Pest common name	Latin name
Western spruce budworm	*Choristoneura freemani* Razowski
Douglas-fir tussock moth	*Orgyia pseudotsugata* (McD.)
Western hemlock looper	*Lambdina fiscellaria lugubrosa* (Hulst)
Two-year cycle budworm	*Choristoneura biennis* Free

Annual aerial overview surveys (AOS) are conducted over the entire forested landbase in the B.C. including the three forest regions covered by this PMP. This annual survey supplies critical information supporting all Forest Health activities. This survey maps current damage and identifies the causal agent, location, extent and severity. Data from this survey goes back to about 1910 so historic trends and changes in range can be analysed. The survey is conducted each year from mid-July through August. Aerial overview surveys are done to the Provincial standard and identify areas that may require a more detailed air or ground survey in order to develop appropriate management strategies. Aerial Overview Surveys - Province of British Columbia (gov.bc.ca)

Detailed aerial surveys are conducted (rotary-wing surveys) to further delineate defoliator activity and to determine where spray programs may be necessary.

Defoliator populations are monitored through the use of permanent monitoring sites. These sites can be one or a combination of the following:

- 6-trap clusters baited with pheromone
- single trap stations (pheromone baited)
- egg mass sampling sites
- three tree beating sites

There are also numerous permanent sample plots established throughout the regions to monitor treatment effects, long-term pest impacts and other pertinent stand and insect dynamics.

3.3 Treatment Thresholds, Options and Selection

The goal of this IPM program is to set clear, distinct and tangible thresholds that will assist in determining the level at which defoliators become "pests" and require treatments to control or reduce damage. See Defoliator Management Guidebooks and the provincial and Forest Health website.

Forest health - Province of British Columbia (gov.bc.ca)

3.4 Western spruce budworm

The following criteria must be met when planning a control program for western spruce budworm. These general concepts can be applied to other insect defoliators with some species-specific differences.

Damage Criteria:

- stand has suffered a minimum of 1-year defoliation (understory and/or overstory) and defoliation predictions are light to severe for the coming year; or
- high priority stand with little or no current defoliation and defoliation prediction indicates moderate to severe defoliation for the coming year; or
- consecutive years of light defoliation and defoliation predictions indicate continuing damage at this level.

Note: This criterion does not apply to eruptive defoliators such as loopers and tussock moths.

Insect Criteria: populations are building and expanding in range.

Recent and predicted defoliation: light to moderate defoliation has occurred for a minimum of one year, before treatment. Exceptions include stands, often adjacent to or in close proximity to active populations, where egg mass sampling predicts high levels of defoliation (moderate or greater) in the coming year. Defoliation in the coming season is predicted to be moderate to severe and trees in the understory layers will incur high levels of damage (mortality and top-kill) if there is no intervention.

Historic defoliation: Stands that have incurred damage in past defoliation events (e.g. top-kill) and cannot withstand another defoliation event. Historic records show the periodicity of outbreaks in given geographic outbreak areas so if historically outbreaks are very short-lived and eruptive in nature, then perhaps spraying in these areas can be deferred.

Areas considered for treatment are evaluated using the following criteria:

- should be in the Timber Harvest Land Base (THLB);
- moderate understory density (L3 and L4 layers);
- Douglas-fir dominated ecosystems such as the IDFxh and IDFdk. (e.g. ICH stands generally experience very short-lived outbreak cycles and trees rebound quickly, so do not often warrant direct control efforts);
- Past or planned silviculture investment, such as spacing, pruning, thinning or fertilization;
- recent or planned partial cutting;
- planned for harvest in the next 5-10 years;
- high in-stand mortality of other tree species such as lodgepole or Ponderosa pines;
- stand is within, or in close proximity to, an historic area of budworm activity;
- evidence of Douglas-fir beetle activity (building or adjacent); and,

The tables in this section outline the major treatments and factors governing treatments conducted by FLNRORD in its defoliator management activities under this PMP. Table 5 lists the various treatment options for select defoliator species. Table 6 lists by treatment option the various application methods and information pertaining to use and safety.

Table 5. List of management considerations for western spruce budworm, Douglas-fir tussock moth, western hemlock looper, two-year cycle budworm and other Lepidoptera defoliators.

Western spruce budworm
Hazard and risk rate stands to evaluate management options
Partial cutting or thinning stands
Promote species mixes
Manage for resilient stand structures e.g. lower densities
Biological insecticide treatment (*B.t.k.*)
Monitor/no action
Douglas-fir tussock moth
Hazard and risk rate stands to evaluate management options
Partial cutting or thinning stands
Create species mix
Mating disruption (research stage)
Monitor/no action
Western Hemlock Looper
Hazard and risk rate stands to evaluate management options
Manage for shorter rotations
Priority harvest of high susceptibility stands
Manage for mixed species stands
Biological insecticide treatment (*B.t.k.*)
Monitor/no action

Table 7. Treatment options using *B.t.k.* or NPV - describing host insect and tree species, application methods and timing, equipment, cost efficacy and safety.

Aerial application of B.t.k.

Target Douglas-fir:

Western spruce budworm

- stands with high and/or increasing (building) populations
- next season defoliation is predicted to be light, moderate or severe (**Note:** predictive egg mass sampling often underestimates defoliation)
- stands are at risk due to past stress or damage from budworm defoliation
- stands receiving silviculture treatments such as spacing, thinning
- high risk stands (e.g. multi-structured) with history of budworm
- high priority areas (mid-term timber supply; recreation; First Nations)

Douglas-fir tussock moth

- stands with moderate to high populations of Douglas-fir tussock moth
- high risk stands where other tree species may have suffered mortality (e.g. Ponderosa pine killed by MPB)
- stands receiving silviculture treatments such as spacing, thinning
- areas where human health is at risk – adjacent to private land; parks; First Nations interest; recreation areas
- historic outbreak areas
- stands with incipient populations of Douglas-fir tussock moth – NPV is the pesticide of choice, if available. *B.t.k*. is also an option.

Equipment Used and Application Method:

- aerial application using fixed or rotary wing aircraft (e.g. AT-802F Air Tractors, Ag Cats, Hiller 12E, Lama)
- equipped with spray booms having a minimum of 4 Beecomist or 4 A.U. 4000 micronair atomizers (or equivalent)

Cost of Treatment and Factors Influencing Costs:

- $35-$45 per hectare all-found (*B.t.k* application at 2.4 litres per ha – cost will increase at higher dosage rates)
- treatment size (total hectares) and spatial distribution of blocks
- individual block size and proximity to staging area
- number of treatment blocks
- geographic location – ease of access to stage spray operations if using helicopters or proximity to airstrips when using fixed-wing aircraft
- differential bud-flush and insect development due to aspect and elevation
- terrain and topography
- number and configuration of spray aircraft
- annual weather patterns
- local economics

Treatment Efficacy

- dependent on insect density, insect stage at treatment, stand structure, tree phenology and condition
- weather conditions during spray operations

Worker and Public Safety Considerations:

workers:

- overall generally accepted method of defoliator management

mitigation:

- special worker training in aerial spray technology

Effect of Treatment on Soil Properties:

- none

Effect of Treatment on Fisheries Resources:

- no effect on streams or any water body
- can overspray small streams and waterbodies

Effect of Treatment on Wildlife and Habitat:

- none

Benefits of Treatment (Social and Environmental):

- biological treatment
- treatment is very target specific (only Lepidoptera feeding at time of treatment are potentially affected and at early instar development stage)

Limitations:

- must have qualified and experienced ground crew
- must have suitable weather conditions (no rain; low wind; no extreme heat events)

Aerial application of NPV **(currently NPV supply low in Canada)**

Target Douglas-fir :

- stands with building populations of Douglas-fir tussock moth (generally year 1 or 2 of outbreak)
- stands receiving silviculture treatments such as spacing, thinning
- high priority areas – recreation; parks; First Nations interests; valuable to mid-term timber supply; wildlife habitat

Equipment Used and Application Method:

- aerial application using fixed or rotary wing aircraft (e.g. Ag Cats, Hiller 12E, Lama)
- equipped with spray booms having a minimum of 4 Beecomist or flat fan nozzles

Cost of Treatment and Factors Influencing Costs:

- $40-$50 ha (**does not include the cost of virus production**) (includes aircraft, sampling and planning)
- treatment size (total hectares) and spatial distribution of blocks
- individual block size and proximity to staging area
- number of treatment blocks
- geographic location – ease of access to stage *B.t.k.*
- differential bud-flush and insect development due to aspect and elevation
- terrain and topography
- number and configuration of spray aircraft
- annual weather patterns (delays, or perfect conditions)
- local economics

Treatment Efficacy

- dependent on insect density, stand structure and tree phenology
- dependent upon year of outbreak being treated
- must be evaluated annually

Worker and Public Safety Considerations:

workers:

- overall generally accepted method of defoliator management

mitigation:

- special worker training in aerial spray technology and working with NPV

Effect of Treatment on Soil Properties:

- none

Effect of Treatment on Fisheries Resources:

- minimal effect on streams or water
- retain appropriate buffer on critical streams and water bodies as per current Policy and procedures

Effect of Treatment on Wildlife and Habitat:

- none

Benefits of Treatment (Social and Environmental):

- biological treatment
- treatment is very specific (only effective on *Orgyia* species)

Limitations:

- must have qualified and experienced ground crew
- must have suitable weather conditions

Population reduction *versus* foliage protection

Direct control strategies include population reduction and foliage protection. Foliage protection is the strategy most used for budworm outbreaks in B.C. The aim is to reduce feeding damage early in the feeding cycle to minimize damage, decrease insect density, maintain tree vigour and promote tree resilience.

Population reduction can be applied to areas where little or no defoliation can be tolerated and when you want to "*crash*" the outbreak cycle. This strategy is applied in the early stages of an outbreak, to reduce extremely high populations, thereby minimizing significant resource impacts. *This strategy is most often applied to Douglas-ir tussock moth and western hemlock looper.*

Variation in the timing of direct control can achieve either foliage protection or population reduction and sometimes both. Higher insect mortality is achieved when later instars are targeted (5^{th} or 6^{th} instar for western spruce budworm); however more *B.t.k.* must be consumed per insect to achieve desired results, and thus more damage is incurred prior to treatment. Late instars are more open feeding, consume greater quantities of foliage, and are thus likely to encounter and consume a lethal dose of *B.t.k.*

Higher potency *B.t.k.* formulations, increased dosage rates, or double application of lower potency formulations, may be considered in the following situations:

- high larval densities early in the outbreak phase;
- building phase of outbreak when the management objective is population reduction (e.g. Douglas-fir tussock moth or western hemlock looper);
- high value stands; and,
- multi-layered, high density stands (high foliar biomass).

Defoliation history of trees and stands, combined with the predicted level of defoliation, influence which tactic will be implemented. Stands that have already sustained significant damage over 2 or more years (moderate to severe whole tree defoliation) should be managed under the foliage protection strategy. This will minimize further damage. If the population reduction strategy is applied in this situation, considerable damage could occur prior to the treatment being applied.

For western spruce budworm, peak 4th instar is targeted to minimize defoliation. Timing to achieve good foliage protection is difficult due to differences in host phenology and insect phenology. Larvae remain feeding in buds until 4th instar and are thus well protected from predators and the effects of a spray program. Larvae begin open feeding on the flushed shoots at the 4th instar. Buds on overstory trees should be >80% flushed prior to treatment and understory trees should be close to 100% flushed.

3.5 Douglas-fir tussock moth

The Douglas-fir tussock moth (DFTM) is a cyclical defoliator of Interior Douglas-fir that periodically erupts into localized outbreaks causing scattered to wide-spread tree mortality. Growth loss, mortality, reduced timber and property values and human health are often adversely affected. ***Tussockosis*** is an allergic reaction to tussock moth larval setae that affects some people who come in contact with the insect.

The building phase of a tussock moth outbreak takes 1-2 years. Detection of DFTM epicentres during the building phase is critical, and unless detected at this stage, significant damage could occur. High population levels will persist for 1-4 years and then collapse due to natural control agents that include parasites, predators, pathogens, and starvation due to the forced consumption of older, less nutritious foliage. The primary agent of this population collapse is a species-specific virus, nucleopolyhedrosis virus (NPV).

Population density, year in the outbreak cycle, and the current incidence of disease in the population will affect the subsequent year's damage levels. Egg mass sampling can be used to predict the level of defoliation for the coming year, but this level will be reduced if the outbreak is in its third or fourth year (usually due to NPV presence).

Long-term Management Strategies

The goal of long-term defoliation management is to reduce damage over stand rotation and in particular to reduce mid-term timber supply losses. Long-term plans are critical in areas of historic defoliator activity and susceptible stand types. However, outbreaks will occur even with good planning. Short-term strategies then will be required to deal with these events in specific circumstances.

Long-term monitoring provides information on population trends, changing dynamics and current and historic host ranges. Surveys enhance monitoring information by providing site specific information, confirming identity of the defoliator estimating its population size and predicting expected impacts. Long-term IPM for Douglas-fir tussock moth includes:

- Hazard and risk rating - overlay analysis of current, historic and predicted defoliation and population trends;
- Damage treatment thresholds;
- Knowledge of specified values "at risk" including ecosystem impact, First Nations impact; forestry impact; human health impact; and, wildlife habitat impact
- Permanent 6-trap monitoring sites – DFTM has an operationally calibrated pheromone monitoring system that gives an "early warning" of imminent defoliation;
- Thinning overstocked stands and promoting vigorous trees;
- Promoting mixed species where viable;
- Single trap monitoring sites to augment 6-trap clusters – usually established two years prior to a projected outbreak cycle; and

When trap catches indicate an outbreak will occur within two years, **Short-term management strategies** should be initiated which start with targeted ground surveys for egg masses to pin-point population epicentres.

Short-term Management Strategies

Short-term strategies employ direct methods to mitigate immediate losses from the tussock moth through foliage protection and population reduction. When trap catches increase to the critical level that an outbreak is predicted within two years, targeted ground surveys for egg masses should begin. Ground surveys should be conducted in the vicinity of the high trap catches and all susceptible forest types adjacent to these traps. Communication with local communities and residents should begin when an outbreak is anticipated.

DFTM moth typically occurs in rural and urban interface areas as well as on forested Crown land. The health risk coupled with the tree mortality caused by this insect necessitates a communication and treatment strategy by FLNRORD and local municipalities. The communication strategy includes:

- providing information pamphlets to municipal governments, private landowners and businesses
- providing updated information on the Forest Health web site
- holding strategic public meetings with local communities to inform people of potential impacts and control options
- provide details of any treatments FLNRORD is planning

Direct control options for DFTM include:

- Biological insecticides (e.g. NPV, *B.t.k.*) https://forestry.valentbiosciences.com/valent-biosciences-corporation-forest-home/products/foray
- Mating disruption (still in research phase).

Year 1 of outbreak cycle: Because of the eruptive nature of DFTM, treatment selection is in large part dependent upon the year in the outbreak cycle. The virus, NPV, can cause the collapse of an outbreak when applied early in the outbreak cycle on small, building populations. When populations become larger, more dispersed and occur at very high insect densities a combination of both **NPV** and ***B.t.k.*** is recommended.
Priority areas for NPV treatment in year 1 of a DFTM outbreak:

- Stands predominated by Douglas-fir
- Younger age class stands (≤ 60 years) where silviculture investments have been made (e.g. spacing, thinning)
- Mixed age forest stands containing a viable understory and intermediate age class
- Areas of high recreational use (hiking trails, recreation areas, parks)
- Woodlots
- Areas directly adjacent to private land – urban interface

Low priority sites for treatment with NPV, or "no treatment", include:

- Douglas-fir is only a minor component of stands
- Areas of low forestry value (low density stands, minimal annual increment, poor growing sites)
- In-operable areas or areas of marginal value or use
- Areas of minimal recreational use and not in critical urban interface areas

Year 2 to collapse of outbreak: Beyond the first year of a Douglas-fir tussock moth outbreak a combination of treatments should be considered. Selection of the appropriate treatment, or combination of treatments, will depend upon:

- Land status (private, Crown, First Nations)
- Human health hazard
- Forest values at risk (mid-term timber supply)
- Severity of defoliation already incurred
- Predicted defoliation (egg mass density)
- Operational logistics (terrain, size of blocks, urbanization, funding and others)

3.6 Western hemlock looper

Short-term direct control measures are taken only when western hemlock looper populations reach proportions that threaten stewardship goals such as Mountain Caribou critical habitat. Long-term management strategies, however, can reduce the risk of defoliator damage as well as improve the health and productivity of forested ecosystems. There are five components to integrating the evaluation of stand, site and insect populations in order to create plans and prescriptions. The steps are:

1. landscape level hazard and risk assessment;
2. aerial and ground surveys to map and evaluate looper activity and determine stand susceptibility and risk;
3. annual monitoring using pheromone traps and three-tree beatings;
4. predictive sampling to develop treatment prescriptions (collection of lichen to assess number of eggs will give a prediction of insect levels and subsequent damage in the coming season); and,

5. long- and short-term treatments (*B.t.k.* spray).

Stand susceptibility assessments should be done to address the current and potential impact of the western hemlock looper in terms of stand and site ecology. The long-term impacts of allowing a western hemlock looper outbreak to run its course would be the loss of integral Mountain Caribou winter range, increases in unsalvaged losses and areas that are of lower value to numerous resources.

Stand susceptibility provides some guidance as to expected impacts on various sites and can be used to establish priorities for undertaking surveys, treatments, and for developing silviculture prescriptions. Factors that are considered, and that influence stand susceptibility, are:

- historic occurrence of western hemlock looper;
- expected frequency and periodicity of outbreaks (about every 9-11 years in the interior);
- biogeoclimatic zones and subzones;
- species composition and age (predominantly old hemlock);
- stand density;
- stand structure (e.g. single *vs.* multiple canopy structure);
- elevation and aspect;
- tree vigor; and
- site characteristics.

Foliage protection and population reduction are both **short-term strategies**. Direct control should be considered when moderate to severe defoliation is predicted in a stand the following year and building populations are present. *B.t.k.* is registered for use against the western hemlock looper. Operational trials were conducted in 2003 within the Columbia Forest District to determine optimum spray timing and dosage rates to achieve desired objectives. Using these parameters, a successful spray program was conducted in 2012 targeting 2nd to 3rd instar using 2.4 litres per hectares, single application. The spray program in 2021 used 2.4 litres per hectare on all blocks and achieved very high insect mortality and foliage protection.

The use of biological insecticides has proven to be very successful as a management option for other defoliators and will greatly assist in the options available for managing western hemlock looper. Environmental impact due to the application of biological insecticides is minimal, and efficacy is high provided the insecticide is applied in a correct and timely fashion.

Table 8 should be considered when planning a control program for western hemlock looper. Special management or stewardship considerations will have to be considered when deciding to treat or not. For example, in the Revelstoke TSA the need to protect critical Mountain Caribou habitat is the key reason for controlling western hemlock looper. Due to the high probability of extensive and heavy mortality occurring during outbreak periods, there is a need to protect Mountain Caribou habitat corridors. Table 9 describes the activities involved in a management program for western hemlock looper, or similar defoliator species.

Table 8. Parameters affecting stand susceptibility to western hemlock looper*.

Factor	Level	Hazard Rating
Biogeoclimatic zone	ESSF	Low
	ICH mm, mw2,vk1, SBS	Moderate
	ICH wk1, 2, 3, mw3	High
Species Composition	He Ce <= 25 %	Low
	He Ce <= 50 %	Moderate
	He Ce >= 50 %	High
Stand Density	Open grown	Low
	Spaced with gaps	Moderate
	Dense, overstocked	High
Stand Structure	Even canopy	Low
	Single layer dominants	Moderate
	Multi-story	High
Age Class	<= 80	Low
	<= 120	Moderate
	>120	High
* Adapted from Defoliator Guidebook (1995) hazard rating for western hemlock looper.		

Table 9. Description of activities involved in a management program for western hemlock looper.

Activity Description for Western hemlock looper	
1.	Aerial overview survey to map visible pest damage. Maps are distributed to all districts, First Nations, licensees and other interested parties (e.g. Parks Canada).
2.	Annually establish pheromone baited monitoring traps at permanent sample sites (located in areas of historic defoliation) throughout high hazard stands.
3.	Annually conduct 3-tree beating samples at permanent sampling sites throughout high hazard stands.
4.	About 2 years prior to anticipated outbreak, begin population sampling by conducting egg surveys (lichen collection and egg extraction) and/or more detailed aerial surveys.
5.	When low level, small areas of defoliation is detected in annual aerial overview survey, or egg sampling indicates moderate to high levels of defoliation, additional egg surveys should be conducted at a landscape level in high hazard stands and/or in a more concentrated fashion if a direct control program is being considered.
6.	Implement control program *as per* western spruce budworm.

Post-treatment evaluations should be conducted in one of the following ways, dependent upon target insect and treatment. Table 8 details the evaluation techniques for treatment options.

Table 8. Listing of post-treatment evaluations conducted for each available insecticide treatment, by target insect species.

Target insect	Treatment	Post-treatment evaluation
Western spruce budworm *and* Western hemlock looper	Aerial spray of *B.t.k.*	• Assess spray deposit using kromecote cards (inside & outside block boundary) • Spray deposit may also be assessed (when available) using the ADAM-ELISA kit technology. This provides estimates of spray deposit. • Pre- and post-spray larval sampling is conducted to estimate insect mortality (inside & outside blocks, before and after spray application). Last post-spray is conducted when >75% insects are pupae. This can be done by branch sampling or 3-tree beating. • Fettes defoliation estimate is conducted pre- and post-spray at the time of larval sampling. • Post-spray sampling and level of defoliation mapped in the following year indicates program effectiveness.
Douglas-fir tussock moth	NPV, or *B.t.k.*	• Assess spray deposit cards after application (inside & outside block boundary). • Pre- and post spray larval sampling is conducted to estimate insect mortality (inside & outside blocks). Last post-spray conducted when >75% are pupae. • Fettes defoliation estimate is conducted pre- and post-spray (when insects have pupated) from inside and outside spray blocks.

Post-treatment evaluation is conducted in-part to refine and improve future management prescriptions and strategies and will determine the need for any immediate follow-up treatment.

4 Operational Practices and PMP Content Requirements

4.1 Qualification of Personnel

Regional Forest Health specialists in the Thompson Okanagan, Cariboo and Kootenay Boundary Regions of FLNRORD are trained in Integrated Pest Management, entomology, spray technology and pesticide use. These specialists are licensed Professionals (Association of BC Forest Professionals; http://www.abcfp.ca/) or have their M.Sc. or Ph.D. in Entomology and/or Pest Management and are responsible for the development and implementation of all programs carried out under the Pest Management Plan.

The treatment of forest insect pests (defoliators and bark beetles) within the plan area is coordinated by FLNRO staff and/or qualified contract personnel possessing valid licenses

to conduct forest insect control treatments. All pesticide use shall be carried out by, or under, the direct supervision of an individual with a valid British Columbia pesticide applicator certificate in the forestry category.

The Contractor shall provide the required number of certified Pesticide Applicators (forestry category) so as to comply with the worker/supervisor ratio required by the Integrated Pest Management Program, Ministry of Environment. Copies of the certificates of all certified personnel will be provided to the Ministry Representative upon request.

"The Contractor's project supervisor must be certified as a Pesticide Applicator, and must be familiar with the constraints and requirements of the Pesticide Use Permit(s) or approved Pest Management Plan."

"The Contractor must possess a valid British Columbia Pest Control Service Licence, and shall make a copy available for inspection upon requiest by the Ministry Representative or the Integrated Pest management Program, Ministry of Environment."

4.2 Pesticide Handling Practices

4.3 Pesticide Transportation

The Transport of Dangerous Goods Act regulates the handling and transportation of poisonous substances that may include chemical insecticides. The *Pesticide Control Act* also specifies certain transport procedures. The following procedures are followed with respect to the transport of insecticides as part of the Southern Interior Region Forest Health Program:

- Pesticide to be transported in original, labelled container(s);
- Insecticide to be carried separately from food, safety gear and people;
- Spill equipment to be carried on vehicle near insecticide; and
- Appropriate documents and placards to be carried in or on vehicle during transport.

"The Contractor shall deliver to the project area(s) sufficient quantitites of pesticide(s) (in factory sealed containers), additives and carrier (except water), as supplied or arranged by the Province, to treat the unit(s) specificied in the contract."

4.4 Insecticide Storage

Insecticides will be stored in accordance with the *Pesticide Control Act Regulations*; this includes storage at District and Region compounds, or licensed companies that have specialized cold temperature storage units and provide secure, lockable areas that are vented to the outside and accessible only to those with authority to do so. The storage is equipped with necessary spill equipment and first aid in the event of spill.

"The Contractor shall provide a means of securing equipment and supplies to prevent unauthorized access to the pesticide(s)."

4.5 Mixing and Loading Insecticides

All pesticides used under this PMP shall be mixed (if needed) at designated mixing and filling stations or will be applied "neat". Most *B.t.k.* products used are delivered to staging sites in 1,000 litre factory labelled containers and are pumped directly into application aircraft – no mixing required. Requirements and procedures to be followed during the mixing and loading of pesticides:

- Wherever possible, the mixing/loading station should be located in the treatment area and a minimum of 100 metres away from any water body. The mixing site shall be selected so that it is on level ground, and situated so that if a spill does occur, run-off into water bodies will not occur.
- The minimum crew size for mixing and loading will be one 1 dedicated person, and other then that, crew size will dependent upon the size of the project (ha to be sprayed).
- All pesticide use will be recorded by the Project Supervisor at the end of each day.

The following table outlines the minimum safety equipment required by personnel performing various functions with regards to insecticide operations under this PMP.

Method	**Function**	**Safety Equipment** (Minimum)
B.t.k. or NPV	Any	Clean coveralls, goggles, and standard safety gear

- Each *B.t.k.* or NPV load shall be recorded once loaded into the spray aircraft. The record shall include:
  a) PMP number
  b) Contractor name, service licence and certification number
  c) Date and time
  d) Insecticide name, PCP Number and concentration
  e) Volume of insecticide in litres
- The rotary-wing or fixed-wing spray aircraft shall include the following specific parts and features:
  a) Loading equipment with an accurate metering device, or the aircraft tank/hopper with a calibration as to provide a positive measure of the insecticide. Filler connections should be compatible with loading equipment.
  b) Leak proof system with positive shut off device. Loading gate and discharge tube gate shall be tight closing.
  c) Functional quick dump.

4.6 Container and Residual Insecticide Disposal

The responsibility of container disposal associated with any pesticide application program lies with the contractor. It is the contractors' responsibility to rinse empty insecticide containers (according to product recommendations) and dispose of at appropriate sites if necessary or return to vendor. Any unused pesticide will be stored at

an appropriate facility (e.g. refrigerated, secure) in the original container for future use. The responsibility of container disposal associated with the defoliator program lies with the FLNRORD Project Supervisor.

4.7 Spill Response Plan

A pesticide spill kit will be carried in the MFR Project supervisor vehicle during defoliator spray programs and shall contain as a minimum the following articles:

Instructions for spills

- Emergency telephone numbers
- Kitty litter (2-20 kg bags)
- Large plastic garbage bags (4)
- Shovels (2)
- Plastic tarp (10'X10' minimum)
- Dustpan and shop brush
- Flagging and rope
- First aid kit
- Personal protective safety gear (rubber gloves, safety glasses)

Project supervisor will approve spill plan prior to commencement of pesticide treatment.

4.8 Boundary Marking Procedures

4.9 Aerial Spray Programs

For aerial application of insecticides, rotary wing surveys will be conducted prior to final delineation of spray block boundaries. Spray blocks will be mapped on appropriate scale maps. Spray blocks are then made into spatial GIS files that are downloaded into spray aircraft navigation systems. All spray aircraft now utilize GPS spray guidance systems, showing block boundaries, priority edges, road access to the block and any other critical landscape features. Block boundaries are created in Arc GIS and all spray aircraft use these spatial files to load GPS co-ordinates of spray block boundaries. Spray areas generally encompass all high priority areas ensuring that the highest insect density areas are covered thus reducing re-invasion by insects.

Spray block boundaries are generally delineated by using distinctive features such as:

- timber types (species)
- open range
- height of land
- rock outcrops
- lakes, rivers, creeks and other water bodies or critical habitat
- fence lines and roads
- private land

4.10 Equipment Maintenance and Calibration

Spray equipment will be supplied by the contractor and be in good working condition. An inspection and calibration of spray apparatus will occur prior to commencement of

aerial spray projects each year. A spray log and digital spray swath files will be submitted to the FLNRORD Project Supervisor at the conclusion of each spray project.

As an example, for *B.t.k.* application:

- Conventional boom lengths not exceeding 75% of the rotor diameter or total wingspan.
- Equipped with at least four (4) micronair nozzles, of appropriate type (AU4000), or equivalent, for a *B.t.k.* (or NPV) spray. The pumping system shall provide a constant pressure capable of distributing the insecticide in an even and unbroken swath at the specified rate(s). This equipment shall be capable of providing 80-120 micron volume median diameter droplet sizes.
- A pressure gauge mounted in such a location that it can be read from outside the aircraft during calibration operations.
- A spray boom should be mounted according to helicopter/fixed-wing aircraft or boom manufacturer's specifications, unless the Contractor can demonstrate that a different position of spray boom will give an equal or better spray pattern.
- Nozzles mounted on the spray boom should be oriented to give best droplet spectrum for the desired job. Angle of the nozzles shall be uniform across the boom.
- When installed, a spray boom shall be of continuous construction. The nozzles will be distributed evenly along the spray boom attached to a helicopter. For a fixed-wing aircraft the inboard section of the right hand boom may require additional nozzles to compensate for propeller effect.

4.11 Pesticide Treatment Signs

The Thompson Okanagan, Cariboo and Kootenay Boundary Regions Forest Health Program, FLNRORD, commit to the following minimum standards for information on treatment signs:

Signs containing site-specific information with regards to treatment of each site shall be posted at main and secondary access points to the treatment area. Signs will be posted prior to, and during, the treatment process. Pesticide Treatment Signs should be (Fig. 3):

- large enough to be easily read by passing traffic;
- in highly visible locations;
- water resistant;
- posted a few days in advance of the spray date;
- include the title “INSECTICIDE USE NOTICE” or “PESTICIDE USE NOTICE” in large capital letters; and
- contain the following:
    1. Date of Application
    2. Pesticide Trade Name
    3. Pesticide Common Name
    4. PMP Number
    5. Purpose of Treatment

6. Method of application
7. Ministry Office, Address, Contact Name and Phone Number

Figure 3. Notice of Pesticide Treatment sign for western spruce budworm, Thompson Okanagan Region.

4.12 Weather Monitoring

For all aerial applications, on-site weather stations will be set up to monitor weather to adhere to pesticide regulations, minimize drift and achieve maximum spray deposit efficacy.

Weather and timing of aerial spray application must be carefully considered before spraying. Applications are conducted early morning (4:15am - 10:00 am) when relative humidity is high (50-100% RH), temperatures are low (≤20°C), and winds are low and steady @ <8 km/h, with gusts not exceeding 15 km/h. The best time to apply *B.t.k.* and other biological or growth inhibitor insecticides is when larvae are actively feeding. There should be no threat of heavy, continuous rain for at least 24 hours after spraying. Light rain, for short a duration will not seriously impact the efficacy of treatment. Heavy rains could wash off spray deposit, and similarly if foliage is wet (dripping) at the time of application, spray droplets may not adhere to the foliage. As long as foliage is not wet to the point of run-off, some moisture in the stand is desirable, as it will maintain a higher humidity. Budworm larvae tend to feed more during warm weather; therefore, it is advisable to spray at these times.

The Kestrel 3000® (a portable weather device) is used to monitor and record wind speed (average, gusts), relative humidity and temperature. All weather parameters are

monitored closely on spray sites before and during spray operations to ensure weather conditions are suitable for insecticide application.

4.13 Pesticide Application Procedures

4.14 Application techniques for *B.t.k.*

Weather and timing of *B.t.k.* application must be carefully considered before spraying. Applications are done when the following parameters are met:

- relative humidity is 50–100%
- foliage is dry or damp but not wet
- heavy rain is not forecast in the next 12 hours
- temperatures are between 5–20°C
- winds are 0–8 km/h, with gusts not exceeding 15 km/h.

The best time to apply *B.t.k.* is when larvae are actively feeding. Budworm larvae tend to feed more during warm weather; therefore it is advisable to spray at these times. There should be no threat of heavy, continuous rain for at least 24 hours after spraying. Heavy rains could wash off spray deposit, and similarly, if foliage is wet at the time of application, spray droplets may not adhere to the foliage. Light rain, for a short duration will not seriously impact the efficacy of treatment. As long as foliage is not wet to the point of run-off, some moisture in the stand is desirable, as it will maintain a higher humidity.

Both aerial and ground application techniques are available for applying *B.t.k.* However, aerial application gives the best coverage, and is generally the most economical method for large, continuous areas of mature forests. Either fixed or rotary wing aircraft may be used in the application of *B.t.k.* Aircraft should be equipped with spray systems capable of delivering droplets in the range of 80–120 median micron diameters at a constant pressure over an even, unbroken swath.

Sample lines inside and outside of treatment areas can be established to assess the efficacy of *B.t.k.* treatments. Treated and untreated areas should have the same budworm population, cover the same elevational range, and have similar stand structure and composition.

Establishing sample lines for pre- and post-spray sampling:

1. Sample lines should be at right angles to the predicted spray swath and cover the range of elevations within the treatment area.
2. Sample trees on sample lines should be a minimum of 50 m inside treatment boundaries and spaced about 50 m apart.
3. The number of sample trees is dependent upon the ultimate objective of the sampling (e.g. research project) and size of the project.

4.15 Application Techniques for Nucleopolyhedrosis Virus (NPV)

NPV should be applied as soon as tussock moth larvae hatch from egg masses and have moved to the foliage (May-June). NPV is specific to native tussock moths found in B.C. Ground or air application of virus is feasible as the virus will spread (±50 metres) from

the point of application within the first year via insect-to-insect contact. Aerial treatment is necessary when stands are large or not easily accessed. This is ideal for early treatment of incipient outbreaks a year before significant defoliation is expected. Treatment at the building phase of an outbreak will cause the population to collapse in strands treated. Therefore, no subsequent treatments will be necessary, and no significant defoliation will occur.

Once visible defoliation is detected (year 1–3 of an outbreak), virus can still be applied causing a population collapse, but defoliation may be significant. In later stages of the outbreak cycle, other insecticides (e.g. *B.t.k.*) may be a better choice, as they will prevent further damage to the weakened trees, reduce possible allergic reactions, and lessen the chance of Douglas-fir bark beetle attacks. Application of NPV should occur when 80% of the larvae hatch from egg masses and have moved to the foliage. The virus is mixed as follows:

- 25% food-grade molasses
- 75% water (allow chlorine to evaporate for 24 hours)
- 10% of liquid weight Orzan® (Lignosite acts as a sunscreen).

Premix these ingredients the day before spraying, at staging sites near the treatment areas. Add the virus the morning of the treatment. Mix it thoroughly to remove lumps.

Use fixed or rotary wing aircraft, or truck-mounted spray systems to apply the virus mixture. Apply at 10 litres per ha, with a desired spray droplet diameter of 100–250 microns. To ensure good droplet deposition, spray during periods of low temperature, high humidity, and low wind velocity. NPV is only registered for use by the provincial or federal government and is currently in short supply due to no source.

4.16 Written Records

The FLNRORD Project Supervisor (Regional Entomologist) in each region where spray programs are implemented (Thompson Okanagan, Cariboo, Kootenay Boundary Regions) will retain operational pesticide treatment records.

5 Environmental Protection

5.1 Community Watersheds and Water Intakes

5.2 Community Watersheds

There are numerous Community Watersheds throughout the three regions in the southern interior. Any activities within or adjacent to Community watersheds during the term of this PMP will be described in the Notice of Intent for all interested parties.

5.3 Surface Water

A Pesticide Free Zone (PFZ) of 10 meters will be maintained from all bodies of surface water when applying **chemical pesticides** as per label instructions. Adequate buffer zones will be associated with PFZ's to ensure integrity of surface water and riparian areas.

When applying **biological insecticides** such as *B.t.k.* no Pesticide Free Zones are required.

5.4 Wells and Intakes

A minimum 30 m buffer will be maintained from all domestic water intakes and wells. This information is made available to applicators prior to treatment.

During the development of the Notice of Intent to treat each year, all domestic water intakes that are within one (1) kilometre of the proposed treatment area will be identified and mapped. Consultation with the holder of the domestic water source will take place, and efforts will be made to alleviate concerns, if any arise.

5.5 Fish and Wildlife Resources and Riparian Areas

The area encompassed within this PMP includes many significant fisheries values. To prevent contamination of water in fish bearing streams, **chemical pesticides** will not be applied to ditches that flow directly or indirectly into fish bearing systems. When spraying *B.t.k.* major streams will be mapped and avoided where possible. *B.t.k.* can be sprayed over small streams and water bodies as per current Policy.

The southern interior of B.C. has many important and diverse habitats for mammals, birds, amphibians and fish species. Wildlife shall be managed according to current and evolving biodiversity guidelines.

All wildlife values and critical habitats identified in any of the numerous forest stewardship planning processes, or through the consultation/referral process, shall be protected when carrying out treatments under this PMP.

5.6 Species Requiring Protection

Where “at risk” animal or plant species have been identified in higher level planning, they will be managed accordingly within the Forest Health Program. Specialists within the Region, Districts and other Ministries will be consulted to help identify some of these species as well as locations where they are to be managed in these areas.

6 Implementation, Notification, Consultation and Reporting

6.1 Treatment Area Maps

Maps showing treatment areas will have clear legends and will be of sufficient quality, detail and scale to allow environmental risks to be assessed and to show the location of treatment sites. Two maps will be submitted.

1) A small scale, *overview* map showing the location of all sites, individually labelled, in relation to the entire PMP area.
2) A larger scale *treatment* map of the treatment areas showing:

- Unit or block number

- All major water bodies
- Location of local roads, communities or recreation areas
- Location of proposed treatments
- Scale ±1:50,000

6.2 Notices of Intent to Treat

As per section 42 of the IPMR, for the purpose of an annual Notice of Intent to Treat, the plan holder will ensure a copy of the **"Notification of Intent to Treat"** is posted each year at the appropriate FLNRORD office to allow inspection by the public. A copy of the **"Notification of Intent to Treat"** is also submitted to local newspapers in the nearest communities to the proposed treatment to give the public additional notification (Fig. 7).

The Plan holder shall submit the **"Notification of Intent to Treat"** to the Deputy Administrator at least 45 days before the start of pesticide applications on site each year. The Notification will include:

- A notice, listing each site to be treated, and pesticide
- a treatment location map

A copy of the "**Notification of Intent to Treat**" shall be supplied to the Band Office of each affected First Nation when treatment is proposed within their traditional territory or area of interest by March 31st of each year or 45 days before the start of pesticide applications on site.

NOTICE OF INTENT TO TREAT:
PEST MANAGEMENT PLAN #2013-2017-3
AND CONFIRMATION #738-0019-13/18

The Ministry of Forests, Lands and Natural Resource Operations, Thompson Okanagan Region, is planning to aerially treat up to 30,000 hectares of Douglas-fir forest to reduce populations of the western spruce budworm (*Choristoneura freemani*).

The biological insecticide Foray 48B (*Bacillus thuringiensis var. kurstaki*) will be applied by helicopter once on each site on or about June 5 to July 5, 2014, depending on weather conditions.

The proposed treatment sites are located within the Thompson Rivers District and the Cascades District, near Kamloops and Logan Lake.

Kamloops Timber Supply Area:
- Menanteau Lake area southeast of Kamloops
- Logan Lake and Tunkwa Lake areas southwest of Kamloops
- Pinantan Lake and Paul Lake area northeast of Kamloops
- Heffley Lake and Sullivan Lake areas northeast of Kamloops
- Pass Lake and Isobel Lake areas northwest of Kamloops

All sites proposed for treatment are covered by Pest Management Plan #2013-2017-3, Confirmation #738-0019-13/18. The pest management plan and maps of the treatment areas may be viewed at:

Ministry of Forests, Lands and Natural Resource Operations
Thompson Okanagan Region - Forest Health Program
441 Columbia Street
Kamloops, B.C. V2C 2T3
250 828-4179

Anyone wishing to contribute information about a proposed treatment site may send comments to the address above until April 30.

BRITISH COLUMBIA

Figure 4. Example of a "Notice of Intent to Treat" submitted to local newspapers to inform local residents of the FLNRORD's planned activity.

6.3 Advertising Treatment Sites

If required by the Deputy Administrator, additional advertising and notification requirements for particular treatments identified in "Notices of Intent to Treat" will be included in the PMP Approval document.

6.4 Public Consultation Plan

Prior to submitting a Pesticide Use Notice to Ministry of Environment for the PMP confirmation, the plan holder will carry out a consultation process with the public.

The objectives of conducting consultations when this PMP is at the draft stage are:

- To increase public awareness of the PMP process and of the principles of Integrated Pest Management which are embodied in the PMP;
- To ensure that the public have an opportunity to identify concerns, and for the plan holder(s) to address those concerns before the PMP is finalized and a Pesticide Use Notice submitted for confirmation;
- To ensure a transparent and accountable review process for the PMP;
- To educate the public on the need to manage invasive plants; and,
- To explain how the planning process that is described in the PMP recognizes the need to protect human health and the environment.

The public will be notified of the PMP development an invited to consult via notices in local community newspapers within the geographic boundaries of the plan.

As per Section 61(1) of the IPMR, at least 45 days before submitting a Pesticide Use Notice, the first of 2 notices, at least 40 cm2 in size, will be published within a 2-week period in newspapers circulated in the various communities (or nearest communities).

During the public consultation process, the draft PMP will be accessible to the public in various locations, as stated in the public notifications and on the FLNRORD Forest Health website to allow the public to view and download the PMP text and maps.

6.5 Public Consultation Report

The plan holder will submit to the Administrator of the *IPMA,* a Public Consultation Report that contains:

- A summary of public consultations, including the names of those who provided input the nature of their concerns and/or recommendations, and the plan holder response to the input from the public.
- A list of newspapers in which notification of the pending PMP submission appeared, along with the publication dates and a photocopy or tear sheet of a representative advertisement.

6.6 First Nations Consultation Plan

In addition to the objectives for public consultation outlined in Section 6.5, the plan holder will consult with First Nations to avoid infringement on aboriginal rights, treaty rights, or cultural values by the PMP. The plan holder not only has an obligation to consult with First Nations, but it must also attempt to address their concerns and accommodate their cultural interests. Consultation processes must take into account the BC Treaty negotiation process and the current litigation actions by First Nations respecting aboriginal land use or sovereignty. In light of the above sensitivities and special concerns, the plan holder is committed to establishing and maintaining positive relationships with First Nations through meaningful and respectful consultation.

In conducting these First Nations consultations, the plan holder will follow all of the procedures outlined in the May, 2006 publication entitled *"Draft Guidelines for IPM Proponents Conducting Consultations with First Nations"*, published by the BC Ministry of Environment, Integrated Pest Management Program.

Notification of First Nations in the time and manner as agreed during the First Nations consultation process will be completed prior to treatments. The plan holder will maintain a record of all First Nations notifications for each treatment area.

6.7 Annual Reporting

The Forest Health Program will submit annual summaries to the Deputy Administrator by December 31st in each year of the plan. For each site treated with pesticides within the PMP area during that calendar year, the report will list:

- PMP number
- site name, block number or description
- pesticide used, including PCP number
- method
- total area treated (ha)
- quantity of each active ingredient used (kg, litres)
- the total area treated with each pesticide (ha)
- for the entire PMP, the total quantity of each pesticide active ingredient used (litres; kg)
- treatment location and/or map identifying areas of treatment.

APPENDIX 1 – MSDS & Labels for pesticides

2017-3694
2017-09-26

Group 11 Insecticide

Foray® 48B
Biological Insecticide Aqueous Suspension

For Use in Forests, Woodlands, and Other Treed Areas

RESTRICTED
READ THE LABEL BEFORE USING

GUARANTEE:
Bacillus thuringiensis subsp. kurstaki strain ABTS-351……. Potency: 10,600 Cabbage Looper Units (CLU)/mg of product (equivalent to10 billion CLU/kg).

The potency measurements are not internationally standardized.

REGISTRATION NO. 24977 PEST CONTROL PRODUCTS ACT

POTENTIAL SENSITIZER
CAUTION EYE IRRITANT
READ THE LABEL BEFORE USING

Net contents: L (Litres)

Date of manufacture:_____

Lot No.:

Best Before:

Registrant:
Valent BioSciences LLC
870 Technology Way
Libertyville, IL 60048
USA

Canadian Agent:
Valent Canada, Inc.
3-728 Victoria Road South
Guelph, Ontario N1L 1C6

https://forestry.valentbiosciences.com/valent-biosciences-corporation-forest-home/products/foray

VALENT BIOSCIENCES

SAFETY DATA SHEET 1 of 10

Foray 48B Biological Insecticide Aqueous Suspension

SDS# VBC-0244 Revision 0 ISSUED 04/05/17

[Classification according to OSHA: 29 CFR § 1910.1200, (3/12/2012)]

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY

1.1 Product Identifier

MATERIAL NAME: Foray 48B Biological Insecticide Aqueous Suspension
Synonyms: None
PCP No.: 24977
Code Number: 12280
List Number: 60179
Chemical Family: Microbial, Btk strain ABTS-351
Substance Registration Number(s)[REACH]: N/A

1.2 Relevant Identified Uses and Uses Advised Against

Identified Uses: Agricultural Insecticide
Uses Advised Against: This pest control product is to be used only in accordance with the directions on the label. It is an offence under the Pest Control Products Act to use this product in a way that is inconsistent with the directions on the label.

1.3 Details of the supplier of the Safety Data Sheet

Supplied By: Valent BioSciences
870 Technology Way
Libertyville, Illinois 60048

1.4 EMERGENCY TELEPHONE NUMBERS

Emergency Health or Spill:
Outside the United States: 651-632-6184
Within the United States: 877-315-9819

2. HAZARDS IDENTIFICATION

2.1 Classification of the Substance or Mixture

Eye Irritation – Category 2B

2.2 Labeling Elements

Symbol(s)
Not required

Signal Word
WARNING

Hazard Statement(s)
Causes eye irritation

OMRI Listed®

The following product may be used in certified organic production or food processing and handling in accordance with the Canadian Organic Standards.

Product

Foray 48B Biological Insecticide Aqueous Suspension

Company

Valent BioSciences® LLC
Maria Pilar Herrero
1910 Innovation Way, Suite 100
Libertyville IL 60048 United States

Status	Category	Issue date
Allowed with Restrictions	COR: Biological Organisms	8-Aug-2018

Product number	Class	Expiration date
abb-10913	Crop Pest, Weed, and Disease Control	1-Mar-2022

Restrictions

May only be used if the requirements of CAN/CGSB-32.310 subclause 5.6.2 are met, which require the use of organic management practices and mechanical techniques.

Caution: This product was produced using GE substrate or growth media. If commercially available, a non-GE alternative shall be used in accordance with CAN/CGSB 32.311 subclause 4.1.3.b.

Peggy Miars
Executive Director/CEO

Product review is conducted according to the policies in the current *OMRI Policy Manual*® and based on the standards in the applicable *OMRI Standards Manual*®. To verify the current status of this or any OMRI Listed product, view the most current version of the *OMRI Canada Products List*® at OMRI.org. OMRI listing is not equivalent to organic certification and is not a product endorsement. It cannot be construed as such. Final decisions on the acceptability of a product for use in a certified organic system are the responsibility of a CFIA accredited Certification Body. It is the operator's responsibility to properly use the product, including following any restrictions.

OMRI LISTED

Organic Materials Review Institute
P.O. Box 11558, Eugene, OR 97440-3758, USA
541.343.7600 · info@omri.org · OMRI.org

29-FEB-2008 2007-4594

VIRTUSS

NUCLEAR POLYHEDROSIS VIRUS
BIOLOGICAL INSECTICIDE

FOR DOUGLAS-FIR TUSSOCK MOTH
CONTROL FOR FOREST, WOODLAND AND ORNAMENTAL USE
WETTABLE POWDER

RESTRICTED

GUARANTEE: Polyhedral inclusion bodies of Douglas-fir tussock moth nuclear polyhedrosis virus .... 2.5% (Contains at least 10^{10} polyhedral inclusion bodies per gram)

READ LABEL BEFORE USING

DANGER-EYE IRRITANT
POTENTIAL SENSITIZER
CAUTION - SKIN IRRITANT

REGISTRATION NUMBER 17786 PEST CONTROL PRODUCTS ACT

NET CONTENTS: 1.5 KG

DATE OF MANUFACTURE:

Product should be stored at 5° C and used within five months

Natural Resources Canada
Canadian Forest Service
Great Lakes Forestry Centre
1219 Queen Street East
Sault Ste. Marie, Ontario
P6A 2E5
(705) 541-5517

http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/32189.pdf

2007-3159 12-JAN-2009

TM BIOCONTROL-1

Nuclear Polyhedrosis Virus
BIOLOGICAL INSECTICIDE FOR DOUGLAS-FIR TUSSOCK MOTH

WETTABLE POWDER

FOR USE IN MANUFACTURING, FORMULATION OR REPACKAGING

GUARANTEE: Polyhedral inclusion bodies of Douglas-fir tussock moth nuclear polyhedrosis virus ..... 3.5% (Contains at least 70 million activity units per gram)

READ THE LABEL BEFORE USING

DANGER-EYE IRRITANT
POTENTIAL SENSITIZER

CAUTION: SKIN and EYE IRRITANT. Avoid contact with skin, eyes or clothing. Avoid inhalation.

REGISTRATION NUMBER 20290
PEST CONTROL PRODUCTS ACT

NET CONTENTS: _____ GRAM

LOT NO.:_____

Natural Resources Canada
Canadian Forest Service
Great Lakes Forestry Centre
1219 Queen Street East
Sault Ste. Marie, Ontario
P6A 2E5
(705) 541-5517

1

APPENDIX 2 –Description and Biology of major forest insect pests covered by the PMP

Western spruce budworm (WSB)

Budworm egg mass

Budworm moth

Budworm defoliation

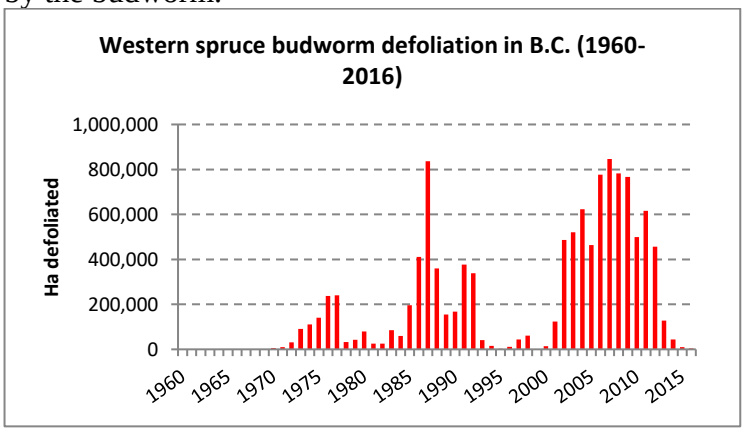
Western spruce budworm, Choristoneura freemani

The western spruce budworm is an important native defoliator of interior Douglas-fir. Outbreaks have been recorded in B.C. since the early 1900's in interior B.C. forests. Periodically, population levels reach outbreak proportions. In 1987 and 2007, over 800,000 ha were under attack by the budworm, mostly in the southern interior of the province. Budworm outbreaks may be sustained for up to 25 years.

Host trees: Primarily Douglas-fir, with other tree species such as the true firs, larch and to a lesser degree, spruce, also impacted by the budworm.

Description and life cycle: Budworm moths mate and lay eggs in late July-August. The female deposits overlapping, shingle-like egg masses on the underside of Douglas-fir foliage. Larvae hatch but do not feed that summer and overwinter as 2nd instars. When buds begin to swell and burst the following summer, the insect emerges from their overwintering site and begins to mine buds. As they develop through six instars, the larvae become larger and feed more openly.

Repeated budworm defoliation causes tree mortality over large areas, reduction of growth rates and reduced lumber quality. Sustained attack results in complete defoliation in 4 to 5 years. Once an infestation has subsided, defoliated trees take several years to regain a full foliage complement, and therefore radial growth rates require several years to attain normal growth following defoliation by the budworm.



Douglas-fir tussock (DFTM) moth larva

DFTM egg mass

Male DFTM

Tussock moth defoliation

Douglas-fir tussock moth, *Orgyia pseudotsugata*

The Douglas-fir tussock moth is a destructive native defoliator of Douglas-fir. Outbreaks of tussock moth occur every 10-12 years causing significant damage and mortality to Douglas-fir stands in the interior of the province. These outbreaks tend to last up to four years before natural controls such as predators, parasites, pathogens, and starvation lead to population collapse.

Host trees: Primarily Douglas-fir, occasionally ponderosa pine and western larch.

Description and life cycle: The tussock moth has a one year life cycle. Adults appear from late July to early September. The adult female is stout bodied, wingless and sedentary, usually remaining camouflaged on her cocoon. Males are slender bodied with about a 30 mm wingspan. Males emerge before females and fly in search of females. Females attract males by emitting a sex pheromone and mating occurs on the cocoon, typically, on the same day that the female emerges. Each female lays approximately 200 eggs in a single mass on her empty cocoon. The action of depositing her eggs dislodges hair from her abdomen which mixes with a frothy cement produced during oviposition. The egg masses overwinter. Larvae hatch in late spring and feed voraciously on the current year's foliage. As the larvae mature, they feed on both old and new foliage. In late July the larvae pupate in cocoons on the underside of foliage and emerge two weeks later as adults to begin the cycle again.

Damage symptoms: The upper part of the crown and the branch tips are defoliated first. The remainder of the foliage is destroyed as the larvae migrate down the crown. By July, defoliated trees appear scorched. Trees may die after one or more years of severe defoliation. Frequently, the top third of the crown is completely defoliated, which leads to damage in the form of top-kill and branch dieback. Douglas-fir trees that have been weakened by tussock moth defoliation may also be susceptible to attack by other insect pests, such as the Douglas-fir beetle.

Western hemlock looper

Looper pupae

Western hemlock looper moth

Western hemlock looper defoliation

Western hemlock looper, *Lambdina fiscellaria lugubrosa*

The western hemlock looper is a native defoliator that is periodically destructive in coastal and interior forests of British Columbia. It reaches outbreak proportions every 11 in the interior and about every 20-plus years in coastal ecosystems. Western hemlock looper outbreaks usually last about 3 years and are generally brought under control by parasites, predators, and diseases (heavy rains during the moth flight period can reduce egg-laying & hasten the decline of an outbreak).

Host Trees: primarily where mature western hemlock predominates, but will readily feed on associated species in stands such as spruce, Douglas-fir and understory shrubs.

Description and Life Cycle: Moths fly, mate and lay eggs in late September-October. The eggs are about the size of a pinhead, blue to gray green or brown with a characteristic impression. They are attached to moss and lichen on tree boles and limbs and on moss in understory shrubs. Larvae hatch from eggs in the spring. Feeding by early instars during May, June and early July is light, and not too noticeable. Larvae are wasteful feeders, chewing off needles at their bases; thus causing the stand to appear yellowish-red then brown. Larger larvae feed voraciously on both old and new foliage and in heavy infestations trees may be stripped in a single season. In late summer, larvae are very mobile and feed voraciously. In August-September, caterpillars drop to the ground or lower branches to secret themselves in protected places where they pupate.

Damage symptoms: Defoliation in the interior occurs at 0-1400 m elevation and is found in valley bottoms having a high proportion of western hemlock. Defoliation often occurs in distinctive elevational bands with stands appearing yellowish-red, then brown, as if scorched by fire. Early defoliation occurs in upper crowns of trees; and progresses downward. The ground becomes littered with chewed needles and in severe outbreaks, the stand is covered in large amounts of silk-like webbing and loopers are seen hanging from branches. Trees can be killed after one year of severe defoliation (>50% foliage removed).

Two-year cycle budworm larvae

Defoliation from two-year cycle budworm

Two-year cycle budworm, *Choristoneura biennis* Free

The two-year cycle budworm, *Choristoneura biennis* Free, causes defoliation of high-elevation forests in the interior of B.C. Like other budworms, repeated defoliation causes top-kill, tree mortality and volume loss in affected forest ecosystems. The range of the two-year cycle budworm includes the Engelmann spruce-subalpine fir forests of the Rocky Mountains west across the sub-boreal spruce zone of the central interior and north in the boreal spruce zone to southwestern Yukon. This range is adjacent to, or overlapping with, the ranges of three other species of *Choristoneura* but these other species generally only have a one-year life cycle.

Host Trees: The primary hosts are sub-alpine fir and the white spruce/Engelmann spruce complex. All ages of trees are susceptible.

Description and Life Cycle: *C. biennis* moths emerge from mid-July through early August, mate, oviposit and die. Each female can deposit up to 150 eggs in several flattened, shingle-like masses on the underside of needles. Eggs hatch within 2 weeks and newly emerged larvae immediately seek shelter to spin their hibernacula and overwinter as 2nd instar larvae. The following spring in late May to early June larvae become active dispersing on webs to mine needles and buds for 3 to 4 weeks then once again spin hibernacula where they overwinter as 4th instar larvae. Larval development continues the spring of the second year when the greatest amount of feeding (damage) occurs. The insect pupates in July and then emerges as an adult.

Damage symptoms: Two-year cycle budworm and the defoliation it causes are a component of the natural ecology in this region. Studies in 2001 indicated that defoliation episodes in this area have occurred roughly every 30 years over the last 300 years and the mean duration of outbreaks is estimated to be about 10 years. Tree mortality can occur after several successive years of severe defoliation, particularly on immature or suppressed trees. Other damage includes top-kill (resulting in stem defects), reduced seed production due to damaged cones, and height and volume loss.