Insects and Diseases of Balsam Fir Christmas Trees

Natural Resources Canada
Canadian Forest Service - Atlantic Forestry Centre
P.O. Box 4000
Fredericton, NB E3B 5P7

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P.C. McCarthy and C.I.G. Adam

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NRCan, Canadian Forest Service - Atlantic Forestry Centre
P.O. 4000
Fredericton, N.B. Canada E3B 5P7
Tel.: (506) 452-3500
Fax: (506) 452-3525

Abstract

This manual is a tool to help Christmas tree growers protect their trees by enabling them to detect, identify, and control damaging insects, diseases, and other agents. Written primarily for growers in Atlantic Canada, the manual describes 15 insect pests and six diseases commonly found on balsam fir (*Abies balsamea* [L.] Mill.) Christmas trees. The manual describes life cycles, occurrence, monitoring, damage, and control methods. It also describes other biological hazards, such as mammals and birds, and several abiotic (non-living) factors, such as drought, frost, and winter injury.

The concept of integrated pest management is explained, and several beneficial insects that play an important role in controlling pest insects are discussed.

Résumé

Le présent guide vise à aider les producteurs d'arbres de Noël à protéger leurs plantations, en leur permettant de déceler, d'identifier et d'éliminer les insectes ravageurs, les maladies et les autres agents néfastes. Créé principalement pour les producteurs de la région de l'Atlantique, ce guide décrit 15 ravageurs et six maladies qui s'attaquent communément au sapin baumier (*Abies balsamea* [L.] Mill.). Il renferme aussi des détails sur les infestations antérieures, le cycle biologique, l'occurrence, les techniques de surveillance, les dommages causés et les méthodes de lutte. En outre, les auteurs y décrivent d'autres menaces biologiques, telles que les mammifères et les oiseaux, et plusieurs menaces abiotiques (non vivantes), telles que la sécheresse, le gel et le stress hivernal.

Il est également question du concept de lutte intégrée et de plusieurs insectes bénéfiques qui jouent un rôle important dans la lutte contre les insectes ravageurs.

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Introduction

Growing balsam fir (*Abies balsamea* [L.] Mill.) Christmas trees is a way of life in eastern Canada and is an important component of the rural Atlantic Canadian economy. The annual wholesale value of Christmas trees in the Atlantic provinces is more than 40 million dollars. Christmas trees are also one of the few finished forest products that are produced directly by woodlot owners.

A premium balsam fir Christmas tree should be conical, symmetrical, dark green, and free from injury. In order for the Christmas tree grower to produce the best product, the trees must be protected from damaging insects, diseases, and other agents.

This manual will help growers protect their investment, by enabling them to identify and control damaging insects, diseases, and other agents that affect the quality and value of their Christmas tree crop. It also describes several beneficial insects that are important to the natural control of pest species.

Balsam Fir

Balsam fir is native to eastern and central Canada and is an important component of our forest ecosystems. It is used to produce lumber and pulp and paper and is the species of choice for Christmas tree plantations.

Balsam fir is a medium-sized evergreen that lives an average of 60 years and grows to 14–20 m, naturally attaining a symmetrical cone shape. Each year, the uppermost shoot—the leader—produces a new leader and a whorl of branches originating from the buds at its tip. Smaller branches, called internodal branches, are produced from buds along the leader, thus filling the space between the annual whorls. Over the years, the resulting crown develops a layered conical appearance.

The foliage of healthy balsam fir is dark green and aromatic. Needles are long lived, lasting 3–4 years. The oldest needles, situated deep within the crown, turn yellow and fall every autumn. This is a natural process and should not be confused with any disease or condition.

Balsam fir begins to produce male and female flowers in the upper crown at around 20 years of age, but this can occur much earlier. Both sexes occur in the same tree; the male flowers are produced lower in the crown than the female flowers (cones). The male flowers are tiny (3 mm), yellow-red, and tinged with purple; they are produced in clusters on the underside of 1-year-old shoots. The female flowers are large (50–90 mm), upright, and borne on the upper side of 1-year-old shoots; they are purple (brown when mature) and resinous. They fall apart and release seed in fall and early winter, leaving only their central axis remaining on the shoot.

Balsam fir is an ideal species for Christmas tree production because of its unique characteristics—shape, color, aroma, and needle retention. The goal of Christmas tree producers is to use these characteristics to produce premium trees, trees that are conical and symmetrical, dark green, and free from injury.

Female cones, mid-June, southern NB.

Male flowers, mid-June, southern NB.

Fraser Fir

The closely related Fraser fir (*Abies fraseri* (Pursh) Poir.) is also a popular Christmas tree, with soft, dark blue-green needles and branches turned slightly upward. It has many of the desired characteristics of balsam fir, and is also affected by the same pests and diseases. Fraser fir is grown in small numbers in some farms in Atlantic Canada, but it is a finicky species and does not do well on marginal soils in this part of the country. It is prone to root decay when grown in heavy soils, when planted too deep, or when exposed to too much rain.

Fraser fir, southern NB.

Fraser fir cones, southern NB.

Choosing the Best Sites

Although balsam fir tolerates almost any site and growing conditions, the best Christmas trees are often produced when growers pay close attention to site conditions.

- Choose relatively rich sites with good access and a flat or gently sloping terrain. These sites are easier to manage, and crop rotations are shorter.
- Avoid close proximity to forest lands with a history of pest infestations. Insect pests and diseases may spread from the neighboring forest into cultivated trees.
- Avoid sites where the alternate hosts of certain fungal diseases (needle casts and rusts) are abundant or very difficult to control.
- Choose sites near a convenient and reliable source of water, such as a pond or a brook.
- Avoid cultivating trees within the buffer strips bordering watercourses, where chemical pest control is forbidden or severely restricted. Check the regulations regarding spraying near watercourses.
- Cultivate trees where competing vegetation (grasses, brush, etc.) can be kept under control. Heavy growth of weeds extending into the lower crowns of Christmas trees will encourage the development of fungal disease and provide cover for rodent pests.
- Choose well-drained sites and avoid low-lying areas where the water table is at or near the soil surface at any time of the year. Trees growing in poorly drained sites will grow poorly and will be more susceptible to disease. Newly planted trees growing on poorly drained soil may be subject to frost heaving.
- Avoid low areas or areas surrounded by hills. These areas are frost pockets that may be subject to late spring frost damage.
- Avoid south-facing slopes when choosing sites for growing Christmas trees because they promote early bud break and shoot growth, which is then subject to damage from late spring frosts. Gentle, north-facing slopes are ideal.
- Choose a location where browsing by moose or deer will not be a significant problem. Moose browsing is particularly significant in Newfoundland, where moose are abundant.

Balsam Fir Shoot Development

Shoots develop in spring, and can vary in timing of development because of many factors, including site location, tree health, and weather. Development occurs in five stages, as illustrated below.

Stage 1. Balsam fir buds tight, bud caps still on.

Stage 2. Balsam fir buds expanding, showing first green.

Stage 3. Balsam fir buds green, tight, but exposed to base of bud.

Stage 4. Balsam fir buds elongating and partially expanded.

Stage 5. Balsam fir shoots fully expanded.

Shoots fully elongated. (Photo credit: INFOR.)

Integrated Pest Management

Health Canada's Pest Management Regulatory Agency (PMRA) is responsible for the regulation of pest control products in Canada. As part of its mandate, the PMRA encourages the wise use of pesticides to protect both the user and the environment.

Pest management that does not rely only on insecticides or herbicides is preferable. Integrated pest management (IPM) is one such method that considers all suitable control measures to reduce pest-related losses to an acceptable level. It respects genetic diversity and human and environmental health.

Integrated pest management includes the following features:

- Planning and managing farms to prevent organisms such as insects, diseases, and competing vegetation from becoming problems.
- Identifying potential pests of Christmas trees.
- Monitoring populations of pests, beneficial insects, competing vegetation, desired ground vegetation, soil conditions, and all other relevant environmental factors (and keeping good records).
- Establishing economic, damage, and action thresholds.
- Applying silvicultural, physical, biological, chemical, and biochemical control measures to maintain pest populations below threshold levels (and documenting all control measures taken).
- Evaluating the effects and efficacy of pest control measures used.

Control Methods

Control methods for insects and diseases can be classified into five broad groups: silvicultural, physical, biological, chemical, and biochemical.

Silvicultural control includes the wise selection of species, suitable ground vegetation composition, reduction in forest cover density, and promotion of increased tree vigor through pruning or fertilization (the latter most suitable for ornamentals and Christmas tree plantations).

Physical control includes removing insects by hand, or pruning and disposing of infected parts of the tree. This is a suitable method for growers who have only a few Christmas trees or only a small number of trees affected by pests.

Biological control is the use of naturally occurring predators, parasites, or diseases to control or reduce an undesirable pest; it includes the release of live organisms, such as predators and parasites (e.g., wasps (familes Bracondiae, Chalcidae, Ichneumonidae, Vespidae), ladybird beetles (family Coccinellidae)), or microorganisms, such as viruses and bacteria.

Chemical control includes the use of chemical insecticides, miticides, and fungicides to control insects, mites, and fungal diseases, respectively.

Biochemical control is achieved by spraying biochemical insecticides, which have as their active ingredient a biological organism or chemical derived from an organism, microorganism (such as viruses and bacteria), or plant. These include:

1. *Bacillus thuringiensis* (*Bt*), a naturally occurring soil bacterium that produces a toxic protein. Several formulations of *Bt* have been developed to manage the spruce budworm, hemlock looper, and other lepidopteran forest pests.
2. Baculoviruses, some of which are registered for use against some pests. These viruses occur naturally in the environment and are specific to each insect species. Their main advantage is that they will not harm any other insect species in the forest ecosystem.

Pesticides

Pesticides include control agents used to kill or inhibit many specific plant and animal groups and include herbicides for weeds (grasses, woody plants, and their seeds), fungicides for fungi (including rusts and needlecast), insecticides for insects, rodenticides for rodents, and acaricides (or miticides) for mites.

Precautions When Using Pesticides

Pesticides, by their very nature, are designed to control pests. Because of this, people using pesticides must ensure that they use them correctly. Always read the product label before using the product. Ensure that the product is registered for the target pest and follow label specifications for mixing, application rates, disposal, and safety precautions.

Pesticides must be handled with care. They are toxic if swallowed, inhaled, or absorbed through the skin. Wear appropriate protective clothing, especially during mixing, to protect yourself from the pesticide. Wash thoroughly with soap and water after using pesticides and before eating, drinking, smoking, or using the toilet. Ensure protective clothing is washed after each use. Wash clothing worn while applying pesticides separately from other articles of clothing and run the washer through a full cycle before washing another load.

Ensure pesticide containers are disposed of properly. Check to see if recycling facilities for plastic pesticide containers exist in your province. Before disposal, ensure that the containers are completely empty, triple rinsed or jet rinsed, and punctured. For further information on the disposal of pesticide containers, contact your local pesticide regulatory agency.

Poisoning

In case of pesticide poisoning, contact your local Poison Control Centre by dialing 911. Consult the product label for immediate first aid instructions.

Pesticides Available for Use by Christmas Tree Growers

Currently, the pesticide of choice for many common pests of Christmas trees is diazinon, which is known by several trademark names. It is used especially against balsam gall midge and balsam twig aphid. On 11 May 2004, diazinon was placed on a list with several other chemicals that are currently under a general review by Health Canada's PMRA. The review "addresses the reassessment of pest control products, paying particular attention to pest control products with a common mechanism of toxicity, the aggregate exposures arising from all sources and from all uses, and the risks to susceptible subgroups in the exposed population, such as children" (PMRA 1999). The situation for diazinon as of 2007 is as follows: "The following uses of diazinon are proposed for phase-out as registrants do not support continued registration or because of the human health risks and/or risks to the environment: air blast application on Christmas tree plantations...."

Users of this manual should ascertain the current registration status of any pesticide that they plan to use as part of their pest management strategy.

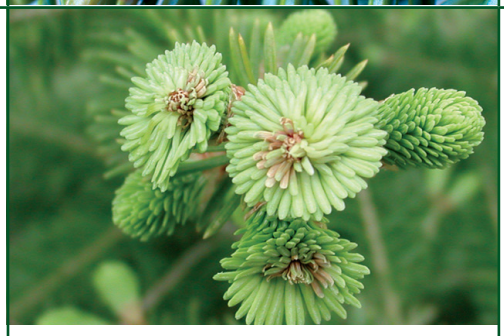
The following is a table of common pests and the pesticides and control methods to be used against them.

Pest	Pesticide	Application	Timing	Comments
Ants (mound ants)	Diazinon (under review by PMRA)	Spot treatment. Apply Diazinon at 3 g/ant hill	Chemical treatment of ant hills is more effective if watered in or applied before a rainfall	Chlordane was formerly used to control ants, but is no longer registered for this use
	Diatomaceous earth	Apply diatomaceous earth in a light dusting on hill and repeat as necessary	Conversely, the effectiveness of diatomaceous earth is greatly reduced by rain, thus it should only be applied during dry conditions	
Aphids (*Cinara* spp.)	Diazinon (under review by PMRA)	—	—	—
Balsam fir sawfly	Malathion (under review by PMRA)	Thorough, full-coverage applications should be made	Apply at first appearance of sawfly larvae, and repeat as necessary	See product label for specific application details
	Abietiv™ (an application for label expansion to include Christmas tree plantations is currently (2012) in progress)			
Balsam gall midge	Diazinon (under review by PMRA)	Apply with a mist blower	Spray once shoots have reached stage 5 in development to provide adequate coverage	See product label for specific application details
Balsam shootboring sawfly	No registered product available	—	—	—
Balsam twig aphid	Diazinon (under review by PMRA), Malathion	Diazinon should be applied with a mist blower Malathion should be applied in thorough, full-coverage applications	Spray during Stage 2 of shoot development, as soon as the buds begin to swell and show green (usually during the last 10 days of May). Repeat 10 days later if aphids are still numerous	Timing of spray is particularly important with this pest. Keep in mind that natural control of the balsam twig aphid is usually accomplished by the predatory larvae of ladybird beetles, lacewings, hover flies, and others
Balsam woolly adelgid	No registered product available	—	—	—
Eastern blackheaded budworm	No registered product available	—	—	—

Pest	Pesticide	Application	Timing	Comments
Gypsy moth	Physical removal and *Bacillus thuringiensis* (*Bt*) products	If numbers are low and localized, remove and destroy egg masses Place a burlap bag or sticky band around tree to catch larger caterpillars that move up the tree at night after seeking shelter during the day. Remove and destroy them every day If numbers are high and widespread, spray with *Bt* (use a mist blower) when caterpillars are <2 cm	Best times are autumn, before snowfall or spring, before leaves flush out Two applications 4 days apart	An excellent guide for the control of gypsy moth is published by the Government of New Brunswick (NBDNR 2001)
Hemlock looper	*Bacillus thuringiensis* (*Bt*) products, Foray and Dipel, are registered for control Chemical products (fenitrothion, permethrin and tebufenozide) are also registered for use		Apply in late June or early July during Stage 5 of shoot development	See product labels for application details for each product
Spider mite	Registered miticide such as Sanmite or Floramite; also insecticidal soap	Mist blower	Apply in the third week of May before egg laying begins. Follow by a second spray in late June or early July	If a May treatment is not possible, spray in early June. Follow by a second spray in mid-July
Spruce budworm	*Bacillus thuringiensis* (*Bt*) products, Foray and Dipel, are registered for control Malathion is also registered		Spray *Bt* just as balsam fir buds are elongating and shoots are expanded, at Stages 3 and 4 of shoot development	Successful application controls the larvae before they reach the fifth and sixth instars, when most feeding takes place
Whitemarked tussock moth	Permethrin, tebufenozide, *Bacillus thuringiensis* (*Bt*) products (Foray 48B)		Best control is obtained when the larvae are about 12 mm long, usually about 10 July	Protection against caterpillars migrating from woodland is provided by spraying the areas immediately surrounding Christmas tree plantations

Disease	Comments
Needle Casts	Spray with a registered fungicide when needle cast fruiting bodies release spores, in early summer during wet weather. The fruiting bodies (black lines on underside of needles) open up and release spores during rain and periods of high humidity.
Needle rusts	Best control of rust is accomplished by removing alternate hosts that are necessary for the rust to reproduce, including fireweed, sensitive fern, and blueberry.
Shoestring root rot	As with other tree diseases, sanitation is the primary method of control. This includes removal of stumps and woody material from soil of sites where Christmas trees are being cultivated.
Yellow witches' broom	Remove witches' brooms before they produce spores in early summer. Control the alternate host, chickweed, especially on former agricultural soils where it is often abundant.
Seedling diseases	Young seedlings may be subject to attack from damping off fungi. Snow molds may kill seedlings especially in seedbeds where snow lingers in spring. Improperly planted transplants may suffer root decay, especially during wet weather or when planted in heavy soil. Fraser fir is particularly susceptible to root decay if planted too deeply or when grown in heavy soils. To minimize fungal problems, create raised seedbeds that are well drained. Sandy loams are best for growth and good drainage. Establish seedbeds in protected areas but not in areas where snow may drift and linger in spring.

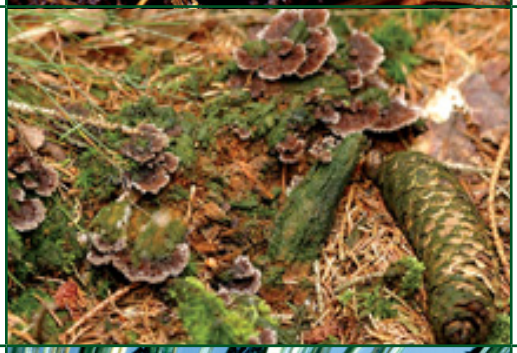
SUMMARY OF INSECTS, DISEASES AND OTHER PROBLEMS

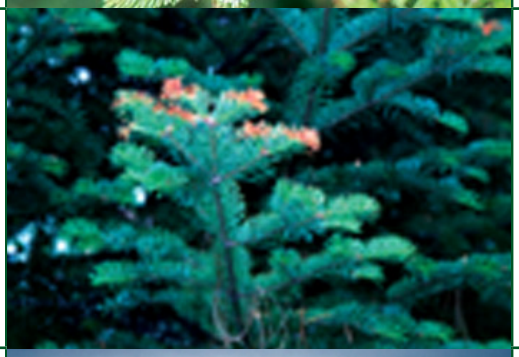
Symptom	Insects	Cause	Page
Ant hills among Christmas trees; yellowing, declining vigor and death of crop trees		Ants	20
Dense colonies of large black aphids on new shoots or on stem near base of branches. Ants often present		Aphids	21
Larvae feeding in colonies on old needles, partially defoliated upper crowns		Balsam fir sawfly	22
Swellings on new needles, yellowing needles, premature needle drop		Balsam gall midge	24
New shoots stunted, rosette-shaped tips with reddish center, larvae often found feeding at base of shoot; often confused for late frost damage		Balsam shootboring sawfly	26

Symptom	Insects	Cause	Page
New needles curled and shoots twisted and sticky		Balsam twig aphid	27
Dead leader and a mass of several leaders forming from side branches, eventually twigs distorted and gouty at nodes		Balsam woolly adelgid	29
Several needles tied together with silk, larva feeding inside; feeding causes needles to redden, but they remain attached to webbing		Blackheaded budworm	32
Large, tan-brown egg masses in protected spots, on vehicles or equipment; later, distinctive, spotted larvae aggressively feeding on nearby trees		Gypsy moth	34
Wasteful feeding on old and new needles, dead foliage giving tree a scorched appearance		Hemlock looper	36

Symptom	Insects	Cause	Page
In spring, tiny larvae tunnel inside old needles; later larger larvae draw needles and shoots together to form feeding tunnels. Crowns develop scorched appearance		Spruce budworm	38
Dense webbing between needles, yellowing or bronzing of foliage		Spruce spider mite	40
Distinctive larvae feeding on needles and back of shoot; dirty white, hairy egg masses on trunk and branches		Whitemarked tussock moth	43
Scars on branches from bark feeding, girdling and red flags		Whitespotted sawyer beetle	45

Symptoms	Diseases	Cause	Page
Off-color foliage and reduced vigor, followed by needle browning. Fungal growth of cream-colored mycelial fans can be seen if bark is stripped away at base of trunk. Death of infected trees can occur within 2 months.		Armillaria root rot (Shoestring root rot)	47
Distinctive tricolor foliage: light green current needles, red–brown, 1-year-old needles intermingled among healthy, dark-green, 1-year-old needles		Needle casts	49
Small, orange–yellow or white fruiting bodies on the underside of current needles		Needle rusts	51
Perennial witches' broom is easily detected, especially early in the growing season when the shorter and thicker yellowed needles contrast sharply with the healthy green needles		Yellow witches' broom	57

Symptoms	Seedling Transplant Beds	Cause	Page
Brown foliage under the snow line, sharply delineated from the normal foliage above, and mycelia forming white mats similar to cobwebs		Snow blight	55
Feeding in the soil causes dead or dying seedlings; larvae, found in upper soil, curl up in a “C” shape		White grubs	42 and 56
Large fruiting bodies (up to 15 cm) grow rapidly around the lower stems of seedlings, smothering them.		Smothering disease	56
Any of the following: - Shoot dieback - Shoots turn brown or red, shrivel and droop - Sooty shoots and needles - Red branch tips		Several possible causes: cytospora dieback, balsam fir tip blight, sooty mold, red flag	53

Abiotic Agents	Abiotic Factors	Page
Chemical damage		61
Frost		63
Sun injury and drought		65
Weather		67

Insects

Ants (*Formica* spp.)

Importance. Mound or field ants (*Formica* spp.) are very common general predators and scavengers and are capable of killing trees within several meters of their hills or nests, especially in unmowed plantations and on drier sites. They are active foragers and feed (for sugar) on the secretions of twig and Cinara aphids, as well as on many types of small insects found on the ground. Ants do not kill aphids, but actually "herd" them within the crowns of trees and protect them from natural predators and parasites. In fact, ants can severely limit the effectiveness of lacewings and ladybird beetles, two important predators of balsam twig aphids. The ant hills are created by ants bringing soil to the surface from their excavated burrows and chambers, which can extend to 1 m below the surface and 1.2 m from the hill. The size of the hill is an indication of the size and extent of the colony below. The bare ant hill retains heat, helping to incubate the eggs and larvae below.

Mound ant hill, southern NB.

Damage. In an attempt to keep vegetation away from the mound, ants inject formic acid into the bark of young trees near their mounds, causing cankers, blisters, girdling, yellowing of foliage, and eventually death.

Detection. A search for yellowing trees in the plantation may reveal the presence of ant hills. Trees in the vicinity of the hill may suffer from declining vigor (yellowing foliage, poor shoot growth, premature flowering) or be completely dead (with red foliage). Ants active on a living tree are often associated with aphid infestations.

Ants tending Cinara aphids, mid-June, southern NB.

Seasonal History. Ants are colonial insects that form an organized society. Winged adults emerge from the colony in the spring and summer. After mating, the queen lays eggs in a new colony and worker ants care for the developing eggs, larvae, and pupae. New colonies can spread from the original ant hill in late May and early June, and numbers can increase rapidly. A mound 45–90 cm in diameter can have a population of several thousand ants.

Control. Ants can be controlled by drenching mounds with a residual insecticide any time between spring and fall. Level the mound with a rake or mix the insecticide into the top 10 cm of the mound; this is best done just before a rain. The ants must carry the residual insecticide back to the colony to kill the queen and the non-foraging ants, or the queen will repopulate the colony. It is also a good idea to limit aphid populations. Some measures, such as mechanical disruption, burning, and use of naphthalene, will not be effective unless the queen is killed, as the colony will relocate elsewhere.

Dead and dying trees near an active ant hill, late May, southern NB.

Tree declining in vigor because of ant damage, late May, southern NB.

Aphids
(*Cinara* spp.)

Importance. Aphids of the genus Cinara (giant conifer aphids) are pests of balsam fir, pine, and spruce. Infestations are often localized and short term, and usually not serious, although the marketability of some trees may be affected. The aphids suck the juices from the needles, shoots, and branches, but rarely kill Christmas trees. There may be a distinctive sooty appearance to twigs and foliage, and ants are often present where aphids are feeding. Cinara aphids resemble engorged ticks.

Damage. These large black aphids form dense colonies on new shoots and stems at the bases of branches. Tree growth is most often unaffected, but trees can become discolored (turning yellow or red), lose foliage, and decline in vigor if the infestation is severe. Pitted bark is visible on the stem after an infestation. Small colonies such as those pictured here usually do not affect the tree.

Aphids produce sugary honeydew, which supports the growth of a black sooty mold fungus (see *Sooty Mold* in *Other Diseases*). A sooty crust may appear on the surface of needles and twigs, reducing transpiration or photosynthesis and thus the vigor of a young tree. This unsightly sooty appearance can stay on a tree until winter.

Detection. Look for groups of tiny black nymphs and larger adult aphids and the presence of sooty mold and sparse discolored foliage. Areas of pitted bark can indicate a previous year's infestation. Ants, wasps, and bees searching foliage for honeydew can direct you to aphid colonies. Cinara aphids do not curl the branch tips and do not secrete white waxy wool, as does the balsam twig aphid.

Seasonal History. Aphids undergo a complex sexual and asexual life cycle. The eggs overwinter and, in the spring, develop into small nymphs (at least 1 mm long) that eventually turn into wingless females. Large shiny, black-winged females (3–4 mm) fly to other trees and form new colonies in the spring and early summer. These winged and wingless females produce more females asexually, and the population can build quickly. Adults are large, round bodied, shiny black, hairy, and six legged, and may be mistaken for ticks or small spiders (which have eight legs). In the autumn, winged and wingless males and females mate and produce the eggs that overwinter.

Control. Trees that are about to be harvested may need to be treated if aphid numbers are high, i.e., if more than 30% of the shoots have colonies. If only a few trees are affected, spot spray them with a solution of liquid detergent in water (3.1 mL:10 L) to wash off the sooty mold. Leave it on overnight and rinse it off with water in the morning. You can also crush them and scrape them off the stem.

Monitor fertilizing, as nitrogen applied to young trees can cause an increase in aphid numbers.

Ladybird beetles and lacewings can control small numbers of aphids naturally, so limit general spraying to avoid killing these beneficial predators. Control mound ant colonies, as ants can severely limit the effectiveness of these aphid predators. Registered insecticides can be harmful to beneficial insects, but insecticidal soap can be an effective alternative if spraying trees is necessary.

Cinara aphid nymphs and winged females being tended by ants, late June, southern NB.

Winged female adult ready to fly to another tree, late June, southern NB.

Cinara aphid damage (pitted bark), late June, southern NB.

Balsam fir sawfly (*Neodiprion abietis* (Harr.))

Importance. The balsam fir sawfly is a widespread native species that may be a problem periodically and locally. Since the early 1990s, the balsam fir sawfly has become an increasing problem in balsam fir stands in eastern Canada. Prolonged severe infestations can kill trees and spoil survivors for the Christmas tree market.

Damage. Damage is caused by the larvae feeding on the mature needles (1 year old or older), which then turn brown, shrivel, and drop off. Young larvae consume only parts of the needle, but mature larvae consume almost the entire needle. It is rare for this species to consume new growth. Tree mortality does not usually occur in the first stages of an infestation, but growth may be reduced and the trees may be severely defoliated. The weakened trees may be subject to attack by other organisms.

Detection. The larvae blend in well with the foliage, but because the larvae feed in colonies of 30 to 100 individuals, damaged shoots are noticeable early on in the season. In winter, sawfly presence can be detected by the partially defoliated upper crowns of affected trees, with the current-year shoots still green, resulting in a characteristic silhouette. In summer, the first sign of damage is a reddening of the needles in the interior of the crown.

Seasonal History. The balsam fir sawfly overwinters in the egg stage and hatches in late June to mid-July, depending on the weather. The colonial-feeding larvae complete their development by late August, and by this time, they are feeding singly. The head is black and the body is dull green, with darker longitudinal stripes. After the last molt, when the larvae are about 20 mm, their color fades, and they spin reddish-brown cocoons among the needles on the twigs and in the litter on the ground. The adults emerge in early September, and the female saws open slits in the needles of the current-year shoots with her ovipositor (hence the name “sawfly”), into which she lays her eggs.

Control. Outbreaks usually last 4–5 years, and are often terminated by naturally occurring parasites and a virus that is specific only to the balsam fir sawfly. Natural enemies, including parasites, are important mortality factors of sawflies in the field and possess potential as biological control agents for these pests. Targeting young larvae early in the season is essential because most parasites do not become active until late in the season.

A naturally occurring virus is registered for forest and woodlot use against balsam fir sawfly. An application for label expansion to include Christmas tree plantations is underway in 2012. The virus will not affect any non-target species.

Homeowners or Christmas tree farm operators can, by striking the trunk, knock masses of feeding larvae on small trees to the ground where they can be easily killed.

Beneficial Insects. Beneficial insects that can act against the balsam fir sawfly include:

- the larvae of parasitic non-stinging wasps, which feed on caterpillars
- adult stinging wasps and stink bugs, which feed on the caterpillars of forest

Balsam fir sawfly larva, Newfoundland.

Balsam fir sawfly larvae feeding in colonies.

Damage to Christmas tree from previous year. Early June, southern NB.

Damage to previous year's needles (Newfoundland). Note that the new growth is unaffected.

Sawfly egg beside a slit in a fir needle.

Egg slits noticeable on new fir needles. These will hatch out the following year.

Newly emerged adult male (top) and adult female (lower left) sawflies. The pupal case in on the right.

Parasitic wasp that preys on balsam fir sawfly.

Virus-killed larva, Newfoundland.

defoliators (the presence of wasps and their nests is beneficial to Christmas tree cultivation)

- Trichogramma wasps (also known as red-eyed bees) are important egg parasites of most Christmas tree insect pests
- Tachinid flies lay eggs on sawfly larvae
- rove beetle adults feed on sawfly larvae; rove beetle larvae feed on sawfly pupae in the soil.

Balsam gall midge (*Paradiplosis tumifex* Gagné)

Importance. Balsam gall midge infestations may significantly lower the quality of Christmas trees. Infested needles are usually shed in October and November, and trees with a noticeable number of galls may be rejected because of excessive needle drop. The insect can cause severe injury during outbreak; sustained populations can cause mortality within 2–3 years if left untreated. Trees within 3 years of market may become unmarketable.

Damage. Appearance of adult midges in May coincides with the development of fir buds. Most infected needles only have one gall, but up to 12 galls may occur. Needles are distorted and yellowed and most drop prematurely. A heavy infestation may cause significant defoliation, especially in the upper crowns. Fortunately, growth in subsequent years will mask the defoliated portions of the branches.

Detection. Adults are in flight from mid May through early to mid June in NB. Calm, dry evening hours (i.e., 1800–2200 h) are recommended for observation. Look for females laying eggs on current-year foliage in the mid to upper crown. In early July, galls are typically visible. One south-facing mid-crown terminal shoot cluster is sufficient to predict gall densities for an individual tree. Stand damage estimates can be achieved by sampling 25–40 trees along a belt transect at 10 m intervals throughout the widest endpoints of a stand. The gall that contains the larvae is green at first but becomes pale green to yellow at maturity. In winter, look for thin foliage and bare branches, especially in the mid and upper crown.

Seasonal History. The adult is a small (3 mm) fly that resembles a mosquito with long legs, long antennae, and an orange abdomen. Adults emerge from the soil from mid May until mid to late June. They lay white oval eggs between the tight needles of partly opened buds. Newly hatched larvae make their way to the base of the needles; their feeding causes the needles to swell and enclose the larvae. The small (3 mm) larvae become orange at maturity and feed all summer within the galls. Beginning in mid September and lasting, in some cases, until early December, the gallmaker drops, and the larvae crawl into the ground where they overwinter.

Control. Natural biocontrol agents help reduce gall midge populations. The most significant of these is Dasineura balsamicola (Lintner) (Diptera: Cecidomyiidae), a very similar looking midge species that follows an almost identical life cycle, yet it is unable to create a gall itself. The inquiline invades the gall formed by the balsam gall midge, ultimately resulting in the demise of the gallmaker itself. Other natural controls include numerous parasitoid wasps, predatory insects such as ladybird beetle larvae, lace wings, and hover flies.

Gall midge emergence takes place over a short time, ruling out the opportunity for effective chemical control of adults before the eggs are deposited. Good results have been obtained, however, by spraying in early June, at the first sign of gall formation. Trees can be sprayed with a contact or systemic insecticide as soon as the buds begin to swell and flare out (late May and early June) to kill the adult midges and larvae. The timing of the spray application and thorough coverage are important. Once the larvae are within the gall, they are protected from sprays.

Galls on fir needles about to drop in the fall.

Galls on fir needles, showing excessive damage.

Galls cut away to show larva within.

Adult balsam gall midge on fir bud.

Gall midge monitoring trap.

At present, the decision to use insecticidal control must be made on the basis of the preceding year's infestation. If moderate or heavy infestations were experienced one year, a thorough check of the trees should be made when the buds are expanding and opening the following spring. A large number of orange-colored winged adults around the trees from mid-May to mid-June is also a sign of infestation.

Remove and burn heavily infested trees or branches before the needles drop in late summer. Do not do this in spring, as the emerging midges will lay eggs on unaffected trees.

Monitoring. The timing of adult emergence can be monitored with a simple trap for gall midges that have spent the winter in the ground. Construct a small wooden box (18w x 24L x 18h), cut a hole in the side and attach the screw-cap piece of a Mason jar lid to the side of the box over the hole, using caulking/staple gun. Inside this, place a small opaque funnel with the narrow end facing outward then attach the jar itself. Cut a hole in the top of the box to allow light/rain etc. in and over this attach a light sheer fabric to prevent insect escape. Bury the open side of the box about 3 cm deep to prevent additional light or escape routes for the insect. Place the trap on the ground beneath trees that were infected the previous year. Place a piece of thick carpet or similar material over the sheer material for about 1 h daily in mid-afternoon and check the Mason jar for adults. A series of traps set under trees in early May may aid you in identifying the exact timing of emergence, because any adults that emerge from the soil beneath the pot will be seen in the jar as they try to escape toward the light.

Beneficial Insects. Rove beetle larvae feed on the larvae or adults in the soil, and an inquiline midge often controls the gall midge naturally.

Adult male P. tumifex *(Photo: D. Carleton).*

Balsam shootboring sawfly (*Pleuroneura brunneicornis* Rohwer)

Importance. The balsam shootboring sawfly can cause serious damage if numbers are high, especially on young trees that are establishing their form. It occurs across Canada from the Maritimes to Alberta and in the northeastern United States, but fortunately it is rare for it to occur in high numbers, although it is becoming an increasing problem in Nova Scotia. This pest is most prevalent in areas near native balsam fir stands. Damage to trees 3 years before sale date can usually be remedied by shearing and pruning. Trees damaged in the harvest year may be reduced in quality.

Damage. Larvae tunnel into the center of new shoots, causing the needles to turn red and die. The injured shoot tip dies later in the season, once the larvae have dropped to the ground. This stage is often mistaken for frost damage, but unlike frost-damaged shoots, sawfly-damaged tips are easily pulled off or drop off on their own.

Damage in balsam fir is usually limited to the shoot tips, but may result in entire shoot death on Fraser fir.

Detection. In spring, look for flattened buds with a reddish center that have formed into a rosette shape. Pulling the bud from the branch will reveal a small white sawfly larva feeding at the base.

Seasonal History. Adults emerge in late April to mid May and lay eggs singly in buds or through the bud sheath before the buds swell. Newly hatched young larvae feed at the tip of the bud and later burrow into it and tunnel toward its base. When mature (6–7 weeks), the larvae crawl out and fall to the ground, where they burrow and spin a cocoon. In more northerly regions, it is thought that sawflies may spend 2 years in the cocoon, contributing to outbreaks, which may be worse every second year.

Control. There is currently no registered pesticide control for this insect.

Beneficial Insects. Rove beetle larvae feed on the larvae and pupae in the soil.

Sawfly larva exposed in center of bud.

Adult female mounted (Photo: D. Carleton).

Later appearance of shoots showing more dead foliage, southern NB, mid-June.

Holes created by sawfly larva visible after bud has been removed, southern NB, early August.

Dead elongated shoots, resembling frost damage, southern NB. (Photo: INFOR.)

Balsam twig aphid (*Mindarus abietinis* Koch)

Importance. The balsam twig aphid is one of the most important pests of Christmas trees in Atlantic Canada. It is common across North America throughout the range of fir trees. Infestations may significantly lower the quality of Christmas trees. Major infestations have occurred in eastern Canada.

Damage. Feeding by these small, pale green aphids causes new shoots to twist and new needles to curl. Shoots will also feel sticky with honeydew. This damage is sometimes permanent, but if growing conditions are right (adequate soil moisture and nutrients), the needles can uncurl and recover. Trees damaged in the harvest year may have to be held back a year so that new growth will cover the affected shoots.

Aphids have the capacity to multiply rapidly, especially if weather conditions are warm; cool springs will slow down the process. Trees whose buds break early are the most vulnerable to twig aphid damage, although a cold spring will mean that trees that break buds late will have the most damage.

The sticky, sugary honeydew produced by aphids attracts ants and supports growth of a black sooty fungus (*see* Sooty Mold in Other Diseases). A sooty crust may appear on the surface of needles and twigs, reducing transpiration and photosynthesis, and thus the vigor of a young tree. This unsightly sooty appearance can stay on a tree until winter.

Detection. Infestations can occur with predictable regularity every 4–5 years. With some effort, growers can detect potential balsam twig aphid problems. Examine 10–15 trees per hectare in each block of trees. At each tree, hold a white piece of paper or cardboard under a single branch in the lower third of the crown and beat the branch several times. With the aid of a hand lens, count the number of aphids on the board. If more than six or seven first-generation aphids are found on any two trees, control measures should be taken, as populations can build rapidly.

Seasonal History. There are three to four generations produced between early May and mid-June; the rest of the year the insect is in its egg stage. The eggs hatch into 2-mm wingless nymphs, which occur in small numbers; these are called stem mothers, and serve to increase aphid numbers. They feed around the bud, mostly on the old needles, and do little or no damage.

Each stem mother produces 40–60 offspring, mostly in early June, which quickly grow into a colony. These second- and third-generation aphids suck the juice from the new needles and cause the most damage, sometimes permanent deformation. This form molts three times and secretes masses of waxy wool and large quantities of honeydew, which makes the shoot woolly and sticky. Some of the adult aphids produced in the second half of June are winged, wool-free adults about 3 mm long.

After weakly flying or being blown to other balsam fir trees, each adult produces about 10 living young that become reproductive males and females (up to this point, all aphids are female). They are tiny (1 mm or smaller), wingless, and lightly woolly. They conceal themselves in the shoots, feed lightly, molt three

Typical curled shoot tips, early June, southern NB.

Aphids on an uncurled branch, mid-June, southern NB. The gray color comes from cast skins and waxy material.

Nymph of the balsam twig aphid.

Nymphs at the base of a new shoot.

Winged adult.

Beating a branch to assess infestation.

times, and become adults about 1 week after birth. After mating, each female lays one or two black eggs around the buds and covers them with white wax scales. These eggs overwinter on the tree and hatch in May the next year.

Control. Stink bugs and the predatory larvae of ladybird beetles, lacewings, and hover flies provide some natural control, but twig aphids have usually done their damage by the time populations of natural predators have built up. Weather conditions will limit twig aphids: freezing temperatures will kill aphids and heavy rain will wash them from the trees.

Control of balsam twig aphid is only necessary when trees are within 2 years of going to market. Trees can produce new growth to cover the damage and recover within 2 years with no evidence of prior infestation. Some growers only treat their trees during the year before and the year of sale, even if there are few signs of damage.

To minimize damage in trees close to market age, the aphids can be killed by applying a contact or systemic insecticide as soon as the buds begin to swell and show green (late May). A second application may be necessary about 10 days later if aphids are still numerous. The timing of the application and thorough coverage are important, because aphids are protected from sprays within the immature buds. A late second treatment is discouraged as it will kill beneficial insect predators. Spruce spider mites and balsam woolly adelgid can also be controlled at this time.

Balsam woolly adelgid (*Adelges picea* (Ratzeburg))

Importance. The balsam woolly adelgid (formerly called balsam woolly aphid) is a tiny sucking insect of firs that was accidentally introduced to North America from Europe in the early part of the 20th century. Its main host tree is balsam fir, and the adelgid has ranked in importance with the spruce budworm as a major cause of balsam fir mortality in North America. In some areas, severe outbreaks can kill the host trees; it can distort or kill Christmas trees and nursery seedlings. Growers who do not cull their infected trees, thinking that the trees will recover the following year, can eventually lose their entire crop as the insect spreads.

The numbers of adelgids are frequently limited by cold winter temperatures, but the mild winters of the 1990s and early 2000s have allowed the pest to increase to damaging levels. The insect remains a threat in areas damaged in the past, including New Brunswick, Nova Scotia, Newfoundland, and the Gaspé region of Quebec.

A Christmas tree with a mass of leaders, indicating infection by balsam woolly adelgid, mid-August, southern NB.

Damage. The adelgid feeds by inserting its pointed mouthparts into the bark and sucking nutrients from the tree. This causes two types of damage: twig attack and stem attack. Both types are marked by increased cell growth, which is a response from the host tree to chemicals in the insect's saliva, which it injects when feeding.

Twig attack is most common in Christmas trees and is the first sign of an adelgid problem. The leader is killed, and a mass of several leaders forms from side branches into a flattened top. The tree still looks healthy at this stage, which can cause you to think the tree will recover. Eventually the shoots swell and become distorted or gouty at the nodes. Bud growth is stopped, height growth is retarded, and the trees slowly die from the top down. The infestation will spread from the infected tree.

A balsam fir severely infected with adelgid, mid-August, southern NB. This plantation was wiped out by the adelgid and abandoned.

Detection. Multiple leaders and crown expansion are the first signs of infestation regardless of the time of year. Death of the original leader is often mistaken for frost damage. The presence of mature balsam fir trees with flat or cup-shaped tops in the forest bordering a Christmas tree plantation indicates that the adelgid is present and will probably infect the planted trees. Look for stem attack on these trees, with white woolly masses on the lower stem and possibly on large branches in the spring and summer.

Typical flat-topped form of Christmas trees showing the first signs of infection by adelgids (foreground trees), mid-August, southern NB.

Typical growth form of an transplant infected with adelgids, mid-August, southern NB. A new leader has taken over from that on the right.

Scattered woolly adelgids on trunk of severely infested tree, mid-August, southern NB.

The Nova Scotia Department of Natural Resources has developed a procedure for detecting the presence of adelgids. Cut some mid-crown branches and place the cut ends in a bucket with about 10 cm of water. Keep the bucket and branches in a warm area for 5 days. Examine the branches carefully with a hand lens. If adelgids are present, you will see white woolly masses that have matured from the dormant nymphs. Once you know that adelgids are present, keep a close watch on the trees for signs of damage.

Close-up of woolly stage on bark.

Seasonal History. The adelgid has a complex life history.

Adult adelgids are blackish purple, roughly spherical, and, at less than 1 mm long, they are almost invisible. The tiny adult females begin laying about 30–60 orange eggs in early May. They deposit them around their own bodies, beneath the wool; the eggs hatch about the end of May. The microscopic orange nymphs crawl about the tree in search of a suitable place to settle and feed. This crawler is the only mobile stage of the adelgid. Once settled, they turn into adults and remain stationary for 3–4 weeks before beginning to feed. The adults insert their mouthparts into the tree, and remain stationary until death. By late summer, this generation of adelgids is laying eggs that will eventually become overwintering nymphs—the second generation. The generation that overwinters remains dormant over the winter, with their mouth parts inserted into the bark, and resumes feeding in May, molting three times before becoming an adult. At this stage, they secrete the white waxy wool that makes them visible as white dots about the size of pinheads (2 mm). The adults are wingless and there are no males.

Gout on twig, early May, southern NB.

The adelgid usually has two generations per year, but three generations may be completed, depending on summer temperatures.

Wind can blow aphids to new locations, and birds and mammals can carry them; they are also dispersed by the movement of young crawlers on the branches. Adelgid life stages can also be introduced to a Christmas tree plantation on infected nursery stock and on wood that still has the bark attached.

Control. The most important natural factor that limits adelgid populations is climate, specifically the temperatures during winter. A series of recent milder winters has probably contributed to population increases and range expansion. However, mortality of dormant stages increases when temperatures reach -20°C, and is complete at -37°C.

Swollen nodes on a severely infected tree, mid-August, southern NB.

Infestations generally reach high proportions on larger trees. Check for outbreaks in early stages by identifying the infested trees, ideally in late August or during September. Infested trees should be cut down in the winter, when the nymphs are anchored to the tree but before deep snow can cover and protect the adelgids below the snow line. Dispose of the culled trees as far away as possible from the plantation and, if possible, burn them.

Salvage cutting of Christmas trees and natural trees near infested stands appears to be the best method of minimizing losses. Some growers have had to remove several hundred trees in one year. If this occurs, then only a few additional trees will have to be culled each year. Constant vigilance is important if this extremely damaging insect is to be controlled.

A Christmas tree with a severe leader problem, mid-August, southern NB.

A mature forest tree (center of image, in the background) infested with adelgid, mid-August, southern NB. Note the characteristic flat top. Such a tree can infect the Christmas trees in the foreground.

Some insecticidal soaps and insecticides are highly toxic to the adelgid and can effectively control stem infestations as well as outbreaks in nursery seedlings and transplants. High concentrations are required for effective control, and this treatment is only suitable for small trees that can be easily drenched; large trees should be culled. Spraying should target the nymphs in the early spring (early to late May) during a 3-week period up to bud break, then again in the first week of September. After a winter with minimum temperatures of -37°C or lower, infestations can be virtually eradicated by spraying only the bases of those trees that were protected by snow.

Seedlings purchased from a nursery can be infected with the adelgid, and can appear healthy until transplanting. After the stress of transplanting, the seedlings become disfigured as the insect causes multiple leader growth.

Blackheaded budworm (*Acleris variana* Fernald)

Importance. The eastern blackheaded budworm is a moth native to North America that periodically erupts in coniferous forests across Canada. Most severe defoliation by the blackheaded budworm occurs on the current-year foliage of mature balsam fir, but the insect can also cause damage to immature stands or Christmas tree plantations. Tree mortality can occur, usually where other defoliators are also active. The outbreaks always seem to occur in areas that have damp, cool climates, such as the Gaspé, northern New Brunswick, and Cape Breton Island. Outbreaks recur approximately every 10–15 years in eastern Canada, and can last 2–6 years, although significant defoliation usually only occurs over 1–2 years.

Damage. Newly hatched larvae burrow into the opening buds. They draw several needles together with silk and feed inside these shelters. Larvae feed on current-year foliage, and defoliation is similar to that caused by the eastern spruce budworm. Severe defoliation results in the reddish-brown appearance of infested trees in late July. Discoloration is most pronounced in the upper crown.

In eastern Canada, outbreaks often occur with or following outbreaks of other forest defoliators, such as balsam fir sawfly, spruce budworm, or hemlock looper. Damage by these other insects can sometimes obscure the damage caused by the blackheaded budworm.

Detection. In June and July, look for needles gathered together, with feeding larvae enclosed among them. When large numbers of larvae are present, it is possible to observe small green caterpillars with brown or black heads suspended by silk threads.

Seasonal History. Blackheaded budworm moths (wingspan 15 mm) are predominantly gray to brown, with a highly varied color pattern on the wings. Moths are active fliers from early August through September, depending on location and weather conditions. They lay yellow oval eggs on the underside of needles near the tips of branches in the mid to upper crowns of the host trees. The eggs overwinter and hatch in late May to early June, in time with the development of the host trees' current-year shoots.

The blackheaded budworm goes through five larval stages. Young larvae are pale yellow-green with a black or dark brown head and thoracic shield. Mature larvae are green with no distinctive body markings; they have a brown head capsule and black thoracic shield. The length of a fifth-instar larva is 14–16 mm. Small larvae move to and then feed inside opening buds, becoming bright green and full grown by late June. They pupate on the shoots in the feeding tunnels among dead needles. Pupae are shiny brown with greenish wing plates.

Larvae move to the base of the opening buds to feed and may descend from branch to branch by means of silk threads if they are disturbed. The availability of suitable host foliage is critical at this stage. The larvae bind the damaged needles, silk, and frass (fecal matter) with webs to form feeding shelters. Larvae move out of the shelters and feed openly in the final two instars.

Young larva in expanding bud.

Defoliation caused by blackheaded budworm.

Larva on cut branch.

Larva encased in silk webbing and ready to undergo pupation.

Pupa.

Control. There are no products registered for use against the blackheaded budworm. *Bacillus thuringiensis* products would probably work, but as yet, the species is not on the label of any registered *Bt* product.

Many generalist parasites and predators attack budworm larvae, and diseases and weather also play a role in naturally controlling populations.

Adult moth.

Gypsy moth (*Lymantria dispar* L.)

Importance. The gypsy moth was introduced from Europe and has caused severe defoliation in the northeastern United States; it also has the potential to devastate the forests of eastern Canada. It is well established in Ontario and Quebec and has been threatening parts of southern New Brunswick and Nova Scotia for many years. It has been found most recently in the Grand Lake area in southern New Brunswick. Christmas trees from infested areas may be subject to official quarantine by the Canadian Food Inspection Agency and may require costly inspections before export.

Damage. The older larvae have a voracious appetite and devour a wide array of plants. Christmas trees and other trees growing in infested areas may be completely stripped of all foliage and killed in one season.

Detection. In fall and early spring before bud break, look for egg masses in sheltered spots and on recreational vehicles and equipment used on Christmas tree farms. Gypsy moths can lay their egg masses anywhere, even on small balsam fir trees. Look for larvae anytime from mid-May until late July. Larvae feed aggressively on the foliage of numerous species of hardwood and softwood trees, although hardwood trees are preferred. Caution should be used if handling larvae; some people have allergic reactions to their hairs.

Seasonal History. Eggs are laid in the fall and remain on the tree all winter; they hatch between mid-May and June. Egg masses can be deposited anywhere from stems of trees to buildings and vehicles. Eggs are laid in clusters of 100 to 1000 and covered with buff to tan hairs that make the egg mass look like a piece of chamois. Egg masses from the previous year remain on the trees, and are dirty white with a tufted appearance.

Larvae emerge from their eggs in early spring, and in 1 day, climb to the top of a tree or the tip of a branch, where they hang by a silk thread. Breezes then "balloon" these caterpillars to neighboring trees, thus spreading the infestation. The spotted and hairy caterpillars grow until late July and feed for up to 7 weeks. Young larvae feed in the morning and seek shelter when the temperature rises. Older larvae usually feed only at night, except during heavy infestations when they feed night and day. Caterpillars are 2.5 cm or longer, and have five pairs of blue spots followed by six pairs of brick red spots; this pattern of dots distinguishes the gypsy moth larvae from all other hairy larvae (see whitemarked tussock moth). The mature larvae search for a shady protected spot to pupate; the pupae are dark reddish brown and produce adults within 7–10 days.

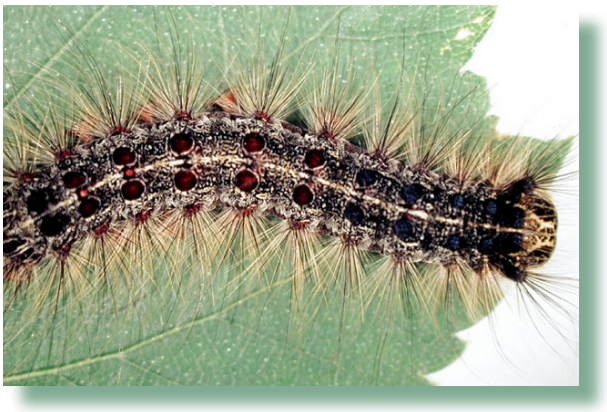
The adults emerge in July and August. Male and female moths are very different from each other. The fast-flying male has brown wings heavily streaked with black and feather-like antennae. The female has a heavier body and is swollen with eggs; she does not fly, despite having wings. The female is white with brown streaks and has threadlike antennae.

Control. Several species of flies and wasps parasitize the eggs, larvae, and adults of the gypsy moth. Other natural control factors include small mammals, birds such as blue jays and black-capped chickadees that eat the larvae, and diseases (fungal and viral) that infect the larvae. Prolonged periods of extreme

Gypsy moth egg mass and previous year's pupae on a small balsam fir, late April, southern NB.

Egg masses laid under a whorl of a small balsam fir, late April, southern NB.

Newly hatched larvae about to undergo "ballooning," early June, southern NB.



Gypsy moth caterpillar.

Adult female gypsy moth.

Adult male gypsy moth.

Burlap tree band placed around a larger tree, southern NB.

cold also limit populations, but egg masses located at the bottom of tree stems can survive under the protective layer of snow.

Some contact insecticides are registered for use against the gypsy moth and can be applied at night when the larvae are feeding. If the infestation is small and localized, scrape the egg masses from the trees and place them in a dish of vegetable oil for a few days. A dormant oil applied to the egg masses on the tree in late winter will smother the eggs.

The larvae descend each day to seek shelter in the litter or on protected places on the trunk. Double-layer burlap tree bands can be placed around the trunks of the trees to prevent them from moving to the tree crowns and foliage.

Hemlock looper (*Lambdina fiscellaria fiscellaria* (Guen.))

Importance. In eastern Canada, the eastern hemlock looper is an important native pest in forest stands dominated by hemlock, balsam fir, and white spruce. It can cause extensive forest defoliation of mature and over-mature forest stands over large areas. Severe infestations in Christmas tree stands may cause complete defoliation and death in the first year of an infestation; lighter infestations may reduce the value of Christmas trees. Infestations may last up to 6 years but generally do not last longer than 3 years in any one area; they are often marked by a sudden population collapse. Although mortality may not occur, there can be a significant decrease in tree growth and vigor, making the stands more vulnerable to other insect and disease attacks.

The moth is of particular concern in Newfoundland where it threatens large areas of forest in association with other serious forest pests, such as balsam woolly adelgid, spruce budworm, and balsam fir sawfly. Epidemics have also developed in coastal regions of Quebec, and severe but smaller infestations also occur periodically throughout the Maritimes.

Severe hemlock looper defoliation.

Damage. The larvae feed wastefully on new foliage, and as they mature, feed on old foliage. They usually consume only parts of needles. Damage is visible in late July to early August. A heavily damaged tree will be covered in silk threads produced by the larvae as they drop down in search of more food or pupation sites, and the ground will be covered by a mat of clipped needles. From mid-July to mid-August, the dead material turns yellow or red, giving the tree a brown, scorched appearance, which is typical of damage by this insect.

Detection. The larvae are mobile but difficult to find because they are so well camouflaged. In the tree, look for partially eaten needles, bits of needles entangled in silk threads, and branches covered with dead needles. Beating branches over a light-colored tarp laid on the ground will dislodge larvae for identification and counting. The larvae will at first lie still, but will soon loop their way across the tarp in a typical inchworm manner.

Late-stage larva feeding on hemlock branch.

Seasonal History. The delicate tan or gray adult moths are active from August until late October. The front wings are marked with two transverse, wavy, narrow lines; the hind wings have a single line. Eggs are laid individually or in groups of two or three on the branches, twigs, and tree trunks, where they overwinter. The eggs hatch in June and the larvae migrate to developing foliage. The young caterpillars are dark gray with black transverse bands; older larvae, about 32 mm long when fully grown, are yellow to dark brown, with both head and body speckled with black. In late July, the larvae seek out protected spots in which to pupate. Pupation takes place during August, either on the host tree or within ground debris.

Hemlock looper larva.

Adult on balsam fir, early June, southern NB.

Hemlock looper pupa.

Virus-killed larva.

Control The hemlock looper is usually controlled naturally by a combination of several factors, including a virus and a disease that affects starving populations and a wasp that parasitizes the eggs in the spring.

Local infestations in Christmas tree farms can be controlled by spraying a registered insecticide in late June or early July. More than five to ten larvae per tree, as counted on a tarp laid beneath the tree, may indicate a need for control.

Spruce budworm (*Choristoneura fumiferana* (Clem.))

Importance. The eastern spruce budworm is the most important defoliator of spruce–fir forests in Canada. The spruce budworm is native to North America, and periodic outbreaks are part of the natural cycle in spruce–fir forests. Successive years of defoliation cause poor growth, dead crowns, and tree death over wide areas of infestation. Christmas trees growing near infested forests may be killed, but damage usually involves defoliation, leading to rejection for the Christmas tree market.

Spruce budworm populations peak about every 30 years. The last peak was in the early 1980s, and populations have been at low levels since 1995. The spruce budworm mainly attacks balsam fir, but also defoliates spruce, larch, and hemlock in years of severe infestation.

Damage. In spring, young budworm tunnel into needles and later into current buds. As the larvae develop and as buds turn into shoots, feeding continues until the new shoot is severely defoliated or killed. Back-feeding on previous years' foliage may also occur. Damaged needles turn reddish brown, giving the tree a scorched appearance. Trees will put out new growth the next year and will recover, unless the attack remains severe for 3 or more years. After 3 years of severe defoliation, many balsam fir trees will have dead tops, and will be stunted or dead. In areas of moderate to severe infestation, Christmas trees are likely to sustain sufficient damage to cause downgrading or rejection.

Detection. In early spring, look for hollowed-out buds and needles, needles webbed together, or needles webbed against buds. Later in the season, examine branches for shoots with needles drawn together with webbing. Spruce budworm create feeding tunnels by enclosing themselves among needles on a shoot or between shoots. These feeding tunnels are often dirty with budworm droppings and pieces of needles. In July, adult moths may be observed milling about the upper crowns of trees especially in the evening hours. Bright green egg masses may be found on the underside of needles.

Overwintering populations can be estimated by collecting branches from balsam fir trees in late March or early April. Choose large dominant or smaller trees from adjacent forest land. Remove some whole mid-crown or lower branches, pruning as close to the trunk as possible. Measure and record the length and average foliated width of each branch. Tie the side shoots of each branch with string so they are drawn together to form a large cigar-shaped branch. Wrap each branch with a couple of layers of brown paper towel, taking care to leave the basal end exposed. Secure the paper towel with string tied midway along the length of the branch. Suspend each branch on a string tied to the cut end, and cover a section of the string with petroleum jelly. Suspend the branches near a window or under a light source in a warm location (room temperature). Thoroughly wet the paper towelling each morning to mimic morning dew and daily drying. Within several days, young budworm will break out of hibernation and crawl up the branches, eventually becoming trapped in the petroleum jelly on the string above the branch. After 10 days, count the number of larvae trapped in the petroleum jelly. More than 18 larvae per square meter of foliage issuing from each branch indicates a potential threat to Christmas trees growing nearby.

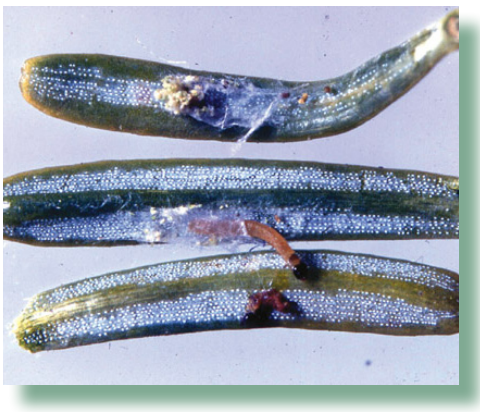
Defoliation caused by spruce budworm. Note the bare shoots and red dead foliage, characteristic of heavy and wasteful feeding.

Feeding damage by spruce budworm on balsam fir. Note the mass of needles and frass webbed together.

Adult spruce budworm moth.

Spruce budworm egg mass.

Larva tunneling in new spruce shoot.



First-instar larvae mining in needles.

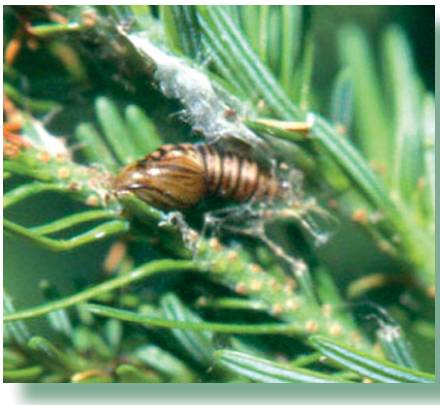
Seasonal History. Spruce budworm moths are active during most of July. They may infest Christmas tree plantations by flying in from nearby infested forests or they may also fly or be carried by windstorms many or sometimes hundreds of kilometers away. Female moths lay masses of 10–15 bright green eggs in overlapping rows on the undersides of needles. The eggs hatch in 10–14 days. The young (first-instar or first-stage) larvae are not brown like the other five stages, but are the same green color as the egg masses. These larvae disperse among trees by crawling to the tips of needles and shoots, and hanging from silken threads. Even a slight breeze will transport the larvae long distances. In late August or early September, the young larvae seek sites to spend the winter. They spin tightly woven "hibernacula" in bark crevices, under lichen, or anywhere there is protection from the elements.

Second-instar larvae emerge from their hibernacula in late April to early May and disperse again on silken threads. These older larvae are hairless, pale brown with light spots, and have a dark brown head. By the first week of May, the larvae start feeding by mining in the needles and buds. Spruce budworm feed, grow, and molt as the shoots develop. The last-stage (sixth-instar) larvae grow to 2.5 cm, stop feeding, and form dark brown pupae in mid-June to early July. The adults emerge several days later; they are drab-colored, grayish moths with light and dark brown markings, and they are about 1.5 cm long.

Control. Natural enemies of the budworm, such as predators and parasites (e.g., parasitic wasps), act to contain or stop budworm outbreaks.

Damage by spruce budworm can be minimized by spraying trees with any of a number of registered insecticides just as balsam fir buds are elongating and shoots are expanded (stages 3 and 4 of shoot development).

Larva on balsam fir..



Pupa.

Spruce spider mite (*Oligonychus* spp.)

Importance. Spiders and mites are arachnids, not insects, but are included in the Insect section for convenience. There are many species of mites that fall under the label spider mite. The spruce spider mite is distributed throughout Europe and North America. This mite seems to be more abundant during hot dry seasons than in years when rainfall is abundant. Damaged trees may not be suitable for sale as Christmas trees. Several years of severe infestations may reduce tree vigor and lead to branch dieback or premature death.

The spruce spider mite attacks most conifers, especially those in ornamental plantings. It is the most common spider mite found on Christmas trees and other conifers. Trees growing in poor soil or without adequate care are attacked most often by this pest. Mites can be spread by wind or by infected Christmas trees.

Spider mite damage (yellow mottling) on fir needles.

Damage. The spruce spider mite inflicts most of its damage in spring and early summer, and again in the fall. The mite feeds by inserting its mouth parts into the needle tissues and sucking the sap; the resulting punctures turn yellow or rusty brown. Many damaged needles dry up and drop off prematurely. The damage begins inside the lower crown branches and gradually spreads outward and upward. Damage is not evident until the mite populations begin to decline from high summer temperatures.

Detection. A dense network of webbing between needles is strong evidence of a significant mite infestation, as is the yellowing or "bronzing." Close inspection of the needles will reveal tiny white flecks and speckles where the mites have fed. The presence of silken webbing usually indicates a high population of mites. Dust particles, dead needles, and other debris collect on this webbing and turn the infested branches a dirty grayish color.

Webbing on spruce needles.

Holding a white sheet of paper or sample board under a branch and beating it with a stick is an easy method of detecting infestations on trees. Strike the branch sharply three or four times with a stick to dislodge the mites from the foliage. Wait for about 10 seconds and pour off any of the dirt, loose needles, and other debris. The spider mites will appear as slowly moving tiny black or olive-green specks on the paper. Other mites that do not damage conifers may be present. In order to distinguish these, crush one of the suspected mites in a streak. If the streak is greenish, the mites are probably spruce spider mites. If the streak is black, brown, or reddish, the mites are probably scavengers or beneficial mites (*see* Beneficial Insects).

Extensive spider mite damage on spruce.

Seasonal History. The spider mite has a complex life cycle with numerous overlapping generations that appear at 15-day intervals, causing populations to build quickly. There are four developmental stages: egg, larva, nymph, and adult. The eggs are pale yellow at first, but later turn reddish brown. They are globular and tiny, only about 0.1 mm in diameter. Newly emerged larvae are pink but change to green after feeding. Larvae have three pairs of legs; nymphs and adults have four pairs. Nymphs are mottled green, whereas the adults may vary from dark green to dark brown.

The eggs overwinter under loose bud scales or at the base of the needles and hatch in early June; a second generation begins appearing by early July. There are four more generations during the summer, the last occurring in September. The early generations feed on the old foliage, whereas those that develop later feed almost entirely on the current year's shoots. All active stages of the mite spin webbing.

Control. Heavy rains and high humidity help keep numbers down. Infestations can be lessened to some extent by thoroughly washing the trees several times during the summer with a strong stream of water. This removes much of the silken webbing and debris, dislodges many mites, and raises the humidity level, which may reduce populations.

Beneficial insects include predatory mites, lady beetles, and bugs. Some of these can be purchased (through garden centers or mail order) and released for natural control of mites.

When weather favors mite population development, artificial control often becomes necessary. The most effective control can be obtained by spraying the infested trees, especially those to be harvested that year, with a registered contact miticide at the first sign of symptoms. Insecticidal soap is also effective. Timing is important for good results. Usually two spray applications are required per season for effective control. Apply the first spray during the third week in May, before egg-laying begins, and the second in late June or early July, before the second generation occurs. Balsam twig aphid and balsam woolly adelgid can also be controlled at this time. If treatment in May is not possible, spray in early June and again about mid July.

Severe spider mite damage to a whole tree.

White grubs (*Phyllophaga* spp.)

Importance. White grubs, the larvae of June beetles (also called May beetles, scarab beetles, and June bugs), are pests of transplant beds and small Christmas trees, although they prefer grass sod. They occur across Canada and are especially common in plantations that have been recently established on abandoned farmland.

White grub, the larval stage of the June beetle.

Damage. The larvae feed beneath the soil, cutting off the roots of the seedlings 2–5 cm below the surface; the seedlings eventually die or become stunted. The grubs prefer grass roots but will damage Christmas tree roots if grass roots are not available. Although damage can occur every year, serious damage occurs in 3-year cycles, specifically the year after the appearance of the adults.

Detection. Look for dead or dying seedlings in the bed and dead or missing roots in dead seedlings that have been pulled up. The grubs will be visible in the upper few centimeters of the soil. Mature larvae are whitish with a brown head and six long legs, and are shaped like a capital C. The hind portion is darker because of ingested soil grains. Larvae feeding on grass roots can cause the grass to roll up like a carpet.

Adult June beetle.

Seasonal History. The various species of June beetles can have life cycles of from 1–4 years. The robust adults of the most common species emerge in late May or June, mate, and eventually return to the soil, where the females lay eggs. After 3–4 weeks, the eggs hatch, and the large white larvae feed upon decaying vegetation throughout the summer. In the fall, they burrow deep in the soil where they remain until spring; it is the feeding of this second-year stage that causes the most damage to roots. In the third year, the mature larvae feed until June when they form pupae. The adult beetle emerges from the pupa a few weeks later but remains under the soil until the next spring (the fourth year).

Control. Check for grubs in July and August of the year before planting a seedbed. If you find more than one grub in a line 3 m (10 ft) long, then you may want to treat the bed with a registered insecticide before or after planting. Monitor the seed bed for 3 years after planting. An application of fertilizer with a high potassium content will stimulate root production and strengthen ailing seedlings. Control grasses, the preferred food of white grubs.

Some parasitic wasps and flies are natural enemies of white grubs. Certain bacteria (available commercially) are also effective in controlling populations.

Whitemarked tussock moth (*Orgyia leucostigma* Fitch)

Importance. This native insect occurs periodically in large numbers in eastern Canada, especially southern New Brunswick and Nova Scotia, primarily as a pest of broadleaved trees. There have been three or four outbreaks since 1950. The tussock moth often acts together with the spruce budworm, blackheaded budworm, and hemlock looper to devastate forest stands. When numbers are high, it can attack evergreen species such as fir, spruce, and larch. Tussock moths can deform and defoliate Christmas trees, and the presence of unsightly egg masses and cocoons makes the trees unmarketable.

Damage. Tussock moth larvae feed on the needles and bark, causing defoliation and twig curling. Trees can be killed in a single season when the infestation is heavy. Top kill will occur in trees that have had 75% or more defoliation over 2 years.

Some people may have an allergic reaction to the many larval hairs that float around a heavily infested stand.

Damage to twigs—defoliation and curling.

Detection. Look for the distinctive larvae in July and August and egg masses on trunks and branches during winter. Egg masses are covered with a protective crystallized spiny material.

Seasonal History. The eggs hatch in late June or early July. The larva has a red head, long black tufts of hair on each side of the head and near its hind end, and four grayish, brush-like tufts (resembling tussocks) together with two bright red spots on its back. Small caterpillars are often dispersed by wind (called “ballooning”) to other trees. They feed for about 6 weeks, until early August, and grow to 38 mm. They spin loose gray cocoons made of silk and body hair on twigs and branches or on the bark of the tree. Grayish moths emerge about 2 weeks later, in late August to early September. The males are ash gray with a wingspan of 26–30 mm; the females are wingless, dirty white, hairy, and about 13 mm long. The females lay their eggs on or near the empty cocoons, and the eggs overwinter on branches, crevices of buildings, or wherever the cocoons were placed.

Whole tree damage.

Control. Tussock moths can be controlled in Christmas tree plantations with any of several registered insecticides. Apply as soon as an infestation is detected and before the caterpillars become too large (about 12 mm), usually about 10 July. Treatments before this date are not recommended because small caterpillars are still ballooning and will reinfest the sprayed trees. A second application may be necessary 7–10 days later. Spraying the areas immediately surrounding Christmas tree plantations will protect against caterpillars migrating from woodland, although to be effective, all trees and underbrush must be thoroughly sprayed.

Growers can control small infestations in Christmas tree plantations by collecting and destroying the egg masses. Place the egg masses in a jar of vegetable oil for 2 days, then dispose of it.

Wingless female tussock moth.

Male tussock moth.

Egg masses with webbing on stem of spruce tree.

Tussock moth egg mass.

Larva on fir branch. The tussocks are the four prominent yellow areas.

Tussock moth outbreaks normally last 2–4 years and are usually brought under control by natural mortality factors, such as viral and fungal diseases that affect the caterpillars. The collapse is usually dramatic. Dying larvae produce a sickening smell that can be detected for long distances. Following collapse, parasites and predators exert virtually complete population control. Birds and other predators eat larvae, egg masses, and cocoons, and Trichogramma wasps parasitize the eggs.

Whitespotted sawyer beetle (*Monochamus scutellatus* (Say))

Importance. The whitespotted sawyer beetle is a widely distributed wood-boring insect in North America. The adults feed on the needles and bark of twigs of many trees, including occasionally Christmas trees, causing “red flags” (see Abiotic Injuries) but seldom the death of the tree.

Damage. The bark feeding can cause scars on the undersides of twigs, and girdling can cause the twig to die and a red flag to form. Pathogenic fungi (described under Cankers and Dieback) can enter the tree at these wounds and cause dieback.

Detection. The adults are large (up to 2.5 cm) and black, but can appear bronze because of brown hairs; they have a white spot on the back. Look for scars on twigs and dead or dying branches. On felled trees, look for evidence of tunneling larvae and sawdust accumulation around tunnel holes on the trunk.

Seasonal History. Adult beetles emerge from infested logs in mid-June to mid-July to feed. They mate and lay eggs on newly cut logs, dying or fallen trees, and tree tops. The eggs hatch in 10 days and the larvae excavate galleries between the wood and the bark. Larvae can be heard gnawing inside the wood of infested trees. The larvae overwinter in holes bored in the wood, feed during the second season, and hibernate again that winter. They pupate the following spring and emerge through exit holes as adults in early summer of the third year.

Control. Be careful not to leave freshly cut logs or branches exposed in the sun. Logs should be piled in the shade of tall trees or covered with slash. The whitespotted sawyer is a sun-loving insect that will not lay eggs on shaded piles of wood.

Natural control occurs when the larvae burrowing in the logs encounter each other, resulting in cannibalism. Woodpeckers and some parasitic flies also prey on the larvae.

Whitespotted sawyer beetle, early August, southern NB. This adult is about 2.5 cm long.

Scar caused by feeding of whitespotted sawyer beetle.

Damage on fir twig probably caused by whitespotted sawyer beetle. (Photo: INFOR.).

Sawyer beetle exit hole in fallen tree, early August, southern NB.

Sawdust on logs caused by feeding of sawyer beetle larvae.

Habitat of sawyer beetle.

Diseases

Armillaria root rot (*Armillaria* spp.)

Importance. Armillaria is a complex of fungal species that are common in forests, orchards, and gardens throughout the world. These soil-borne fungi can occur in many host species, including balsam fir. They are common and long-term residents in natural and planted forestland in eastern Canada. Trees infected with Armillaria eventually die. Disease can spread to neighboring trees through root contact and by spores produced by the mushrooms. Armillaria is difficult to contain; research suggests that the rate of infection increases with shorter rotations, where stumps and roots are more numerous.

Damage. Armillaria root rot causes girdling at the root collar, loss of foliage, death of roots, and eventually death of the tree. Resin will exude from the base of the tree, and can soak the ground around the stump. The disease can progress rapidly in small trees, such as Christmas trees, which may turn completely red-brown within a short time and die when girdled by the fungus or when the major roots die. Trees are more susceptible if they are already damaged or if they have poor vigor.

Dead tree, a result of Armillaria, mid-June, southern NB. Note the woody debris around the base of the tree.

Detection. Infected Christmas trees first show off-color foliage and reduced vigor. Needle browning and death of the infected trees can occur within 2 months. Fungal growth of the cream-colored mycelial fans occurs beneath the bark and can be seen if the bark is stripped away at the base of the trunk. Black “shoestring”-like threads or cords (rhizomorphs) with a white interior can be seen on the bark of the roots. Over time, the wood yellows, then whitens, and becomes soft, spongy, and stringy, appearing water soaked. In early autumn, clusters of “honey mushrooms,” 5–12 cm in diameter, grow at the base of infected trees. Patterns of damage within a plantation are often focused around an infected tree stump. The soil around the base of small dead trees is often resin soaked. Death can be sudden, so signs of the disease may not be seen.

Trunk with bark cut away showing fan-like mycelia.

Seasonal History. The “shoestrings” grow beneath the ground from infected roots or stumps and infect healthy roots. The fungus then moves up the roots and into the root collar and the stem near the tree’s base. In early autumn, honey-colored mushrooms (the fruiting bodies) grow near the base of dead or dying trees and near old hardwood stumps. The mushrooms release spores that infect live trees, dead trees, or stumps. The disease spreads primarily though diseased roots, and healthy trees growing within 2.5 m of diseased trees are at risk. Under favorable conditions, this disease can spread 1–2 m each year.

Mushrooms (fruiting bodies) at base of a tree.

Armillaria mushrooms around a maple stump.

Rhizomorphs or shoestrings filled with numerous strands.

Control. Vigorous trees, those not stressed by insect attack or other damage and well suited to their site, are less susceptible to this disease. Root rot can be severe in young Christmas tree plantations that are established on land where broadleaved trees, especially oaks, formerly grew. Avoid establishing a new plantation on higher risk sites and use silvicultural practices such as site preparation and vegetation management. On established sites, reduce stress-causing pests and practise good sanitation measures, such as removal and on-site burning of tree stumps and roots, which can harbor the disease for decades. Ensure that all new imported seedlings are disease free. Fungicides are not recommended.

Needle casts (*Lirula mirabilis, L. nervata, Isthmiella faullii*)

Importance. Needle casts are usually most severe on small trees, such as Christmas trees, where they may cause growth reduction and death. Trees show varying degrees of resistance to needle casts. The disease, which only affects needles, is caused by three closely related fungi: *Isthmiella faullii* and two species of *Lirula*. *Isthmiella faullii* infects younger trees and is the most common and destructive to Christmas trees.

Needle casts can be a particular problem on sheared Christmas trees grown on low sites that are subject to extended periods of humidity or fog, or on sites surrounded by tall balsam fir. Dense foliage that does not dry out, such as the lower branches, is vulnerable to needle cast infection. This is especially true when weeds are growing among the branches.

Damage. Needles drop, and Christmas trees can be degraded and suffer growth reduction. Severe cases of infection can defoliate seedlings and possibly cause death.

Detection. Needle casts are sometimes confused with winter injury. An *I. faullii* infection usually takes place on new foliage in early summer, although the reddening of foliage is not apparent until the following year. Look for the disease on small trees and on the lower branches of larger trees.

Infection over the years can result in a distinctive tricolor foliage: the light green new shoots, and dead red-brown needles intermingled among healthy dark green of the previous year. The fruiting bodies of needle casts appear as black spots or lines on the undersides of diseased needles.

Seasonal History. The life histories of needle casts do not require alternate hosts. *Isthmiella faullii* needle cast infection begins in early summer on current-year foliage. Symptoms appear the following summer. Brown spots develop and spread, and the infected needles gradually turn red or brown. Fruiting bodies on these infected needles release an intermediate type of spore. It is not until midsummer of the third year that mature fruiting bodies form. During wet weather, these mature fruiting bodies release spores that cause further infections when dispersed by wind or rain.

Lirula nervata *on the underside of a branch. Note the black lines of the fruiting bodies. Early July, southern NB.*

Note the characteristic tricolor foliage: dark green, red-brown, and light green needles. This tree was infected in the previous year and does not show third-year symptoms. Early June, central NB.

Needles infected by the two *Lirula* species turn brown in the first year rather than in the second.

Tree showing extensive needle cast damage. Early June, central NB.

Close-up of Lirula nervata *needlecast on balsam fir. Note the black lines containing the fruiting bodies.*

Control. There are no cost-effective control measures for needle casts, although a registered fungicide can be applied to Christmas trees at the time of spore release in midsummer. Correct timing is important. Infections can sometimes be prevented by avoiding planting in areas near forest land dominated by tall balsam fir, where the infection generally occurs naturally at low levels. Practice good sanitation, which can prevent or reduce infections, by removing the infected foliage and disposing of the trimmings. Mowing or weed control around Christmas trees will also lower humidity among the lower branches and reduce foliage susceptibility to infection.

Needle rusts of balsam fir (*Pucciniastrum, Uredinopsis* and other species)

Importance. Christmas tree mortality is rare, but a severe infection of needle rust may result in growth loss, especially in young trees, and affect quality. These rusts are distributed widely across the northern hemisphere. Infection does not occur every year, but does occur in cool moist periods when shoots are expanding; dry periods will limit infection in some years.

Damage. In a light attack, infected current-year needles turn yellow, die, and fall off. The damage is more severe in young trees and in the lower crowns of larger trees where many needles can become infected.

Detection. Several rust species occur in the Atlantic provinces, and trees are usually infected by more than one species of rust.

- Fir–fireweed rust (*Pucciniastrum epilobii*) has fireweed (*Epilobium angustifolium*) as the alternate host.
- Fir–blueberry rust (*Pucciniastrum goeppertianum*) has lowbush blueberry (*Vaccinium* sp.) as the alternate host and forms perennial witches' brooms on blueberry plants.
- Fir–fern rust is a group of several species that have various ferns as the alternate hosts; the common fir–bracken rust (*Uredinopsis pteridis*) has bracken fern (*Pteridium aquilinum*) as the alternate host. This species is unique in having white fruiting bodies and spores; those with orange-yellow spores are either the fir–fireweed rust or the fir–blueberry rust.

Small, orange-yellow or white spores (depending on the species and life stage) appear on the undersides of scattered current-year needles. Rubbing the needles between the fingertips will release a powder of spores. The orange-yellow spores may appear white in the field, but an accurate determination of color can only be made with the aid of a microscope.

Seasonal History. Like most rust fungi, needle rusts require two different hosts to complete their complex life cycles. Fruiting bodies develop on fir needles during spring to summer, and the spores produced infect the alternate host after being blown by the wind. The fungus overwinters on the alternate hosts and the new spores are windblown back to infect balsam fir.

Fir–fireweed rust forms orange-yellow spores on fir needles in early summer. The spores are windblown to young fireweed shoots where they germinate. The infection appears as yellow or brown spots on the undersides of the leaves of the fireweed plant. The rust overwinters on the dead leaves and infects fir needles and other fireweeds the following spring and early summer. This rust can become perennial in fireweed by overwintering in the roots and reinfecting the leaves in summer. Infection of fir by fir–fireweed rust occurs earlier in summer than does infection by fir–blueberry rust.

Fir–blueberry rust spores from the infected balsam fir germinate on stems and leaves on its alternate host, blueberry, and produce witches' brooms in late summer. The rust is perennial in the blueberry plant, and the spores produced on the infected blueberry shoots infect fir needles in late May to mid-June.

Fruiting bodies of Uredinopsis *rust.*

Needles with yellow and white fruiting bodies of two rust species, mid-June, southern NB.

Fireweed, alternate host to fir-fireweed rust, near Christmas trees, southern NB.

Fir–bracken rust spores produced on the fir needles between May and September infect young bracken ferns, which show discolored yellowish marks on the upper side of the fronds and white structures on the underside. The rust overwinters in the dead bracken fronds and infects balsam fir in the spring.

Control. Control is warranted when more than 50% of the new foliage in any tree is infected, and is accomplished through removal by mowing or other methods or reduction of the alternate hosts (fireweed, blueberry, and bracken and other ferns). Management is not necessary if the incidence is low. If rust has been a recurring problem, a fungicide can be applied to Christmas trees just after bud break.

About 2–6% of blueberries in fields in Nova Scotia are infected with fir–blueberry rust, so Christmas tree farms should not be established near an existing blueberry field. The rust is systemic in blueberries, i.e., it is spread throughout the tops and roots, so it can only be eradicated if the entire plant is removed and burned.

Bracken fern, alternate host to fir–bracken rust, mid-July, southern NB.

Sensitive fern, alternate host to another fir–fern rust, mid-July, southern NB.

Witches' brooms on blueberry plant, the alternate host of fir–blueberry rust.

Heavy infestation of fir–blueberry rust on a small balsam fir, with blueberry plants in background.

Other diseases of balsam fir

Dieback (*Valsa* spp.)

Cytospora dieback (*Valsa friesii*) inhabits dead needles and may kill new shoots. It does not kill its host but can cause dieback and deform small trees. Recently killed shoots are medium brown and show black spots on the upper surfaces of the needles and small dark mounds on the twigs. These fruiting bodies can be observed in late summer or early fall. Trees are probably infected in the fall or early spring. A related branch canker that also causes branch dieback on balsam fir is *Valsa abietis*.

Control. No control measures exist, except for removal of the infected branches. Tools should be wiped clean with bleach or alcohol between cuts to avoid spreading the diseases. Avoid pruning during wet conditions.

Black fruiting bodies on needles affected by Cytospora dieback.

Balsam Fir Tip (Shoot) Blight (*Delphinella balsameae*)

Importance. Balsam fir tip blight reduces the value of Christmas trees, especially in years of severe infection. It is common in scattered patches in eastern Canada, and is similar to frost damage. A chronic infection that has killed many terminal buds will result in a bushy tree that is not acceptable for market.

Damage. The needles and expanding current-year shoots turn brown or red, shrivel and droop; they often drop off in the fall or the next spring, leaving bare twigs. The needles are usually not fully developed when they change color. Only a few branches in a tree may be damaged.

Detection. Look for the characteristic wilting, shriveling, and curling of the new branch tips. Note the constriction formed between the living and dead portions of the shoot. Tiny black fruiting bodies form on the upper surfaces of the dead needles in midsummer. The dead tips can remain on the branch for 1 or more years, and are similar to those caused by the balsam shootboring sawfly, but those are easily removed because of their hollow centers.

Tip blight is distinguished from frost damage by its scattered appearance on the tree; frost damage is usually more extensive. If fruiting bodies are present on the dead shoots in midsummer, and there is no evidence of frost damage on nearby trees or on other species, then the cause is probably *Delphinella* sp.

Seasonal History. Fruiting bodies form on the infected needles. These mature over the winter and release their spores in the spring when they infect new needles.

Control. No control is recommended, except for pruning of infected branches.

Drooping shoots of [possibly] balsam fir tip blight, early July, southern NB.

Sooty Molds

Aphids produce sugary honeydew that supports, infrequently, the growth of a black sooty mold fungus on ornamentals and Christmas trees. A sooty crust may appear on the surface of needles and twigs, reducing transpiration or photosynthesis and thus the vigor and survival of a young tree. This unsightly sooty appearance can stay on a tree until winter, but usually declines once the aphid infestation is over. Trees with a heavy sooty mold presence look as if they have been exposed to dense smoke, but often the growth and appearance is localized to a few branch tips. The best control method, if required, is to eliminate the infestation as early as possible.

The aphids that produce honeydew on Christmas trees are the Cinara aphids and balsam twig aphid (see Insects).

Close-up of sooty mold on fir needles.

Red Flag, Bud and Shoot Dieback, or Fusicoccum Canker (*Fusicoccum abietinum*)

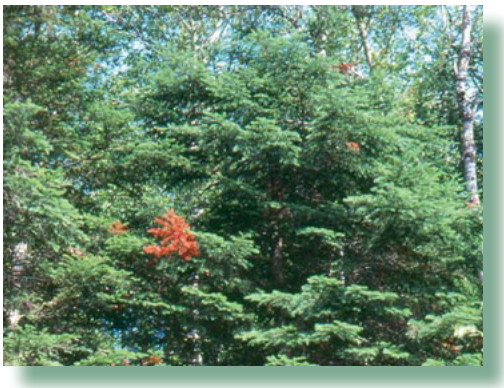
Importance. Scattered red flags can be caused by several species of fungus, physical injuries (hail or mechanical injury; see Abiotic), and feeding by sawyer beetles (see Insects). Numerous red flags may cause the Christmas tree to be downgraded or culled.

Damage and Detection. This branch-girdling fungus, which girdles the twig and kills it, occurs on only a few branches per tree, but sometimes the stem may be affected. Look for a distinct constriction between the dead and living portions of the twig. Black fruiting bodies embedded in the sunken canker produce spores in late spring and summer, and are spread by mechanical means and by rain. The branch tips, which turn red and die, are visible from early summer to late fall and even over the winter. This fungus is most common on poor sites; vigorous trees growing on good sites are usually not affected.

Control. Remove the affected twigs by cutting back to green wood.

Red flag fungus, showing a constriction on the stem.

A red flag, cause unknown. (Photo: INFOR.)



Red flag caused by cankers on balsam fir.

Seedling and transplant bed diseases

Snow Blight, including *Phacidium abietis* ((Dearn.) Reid & Cain)

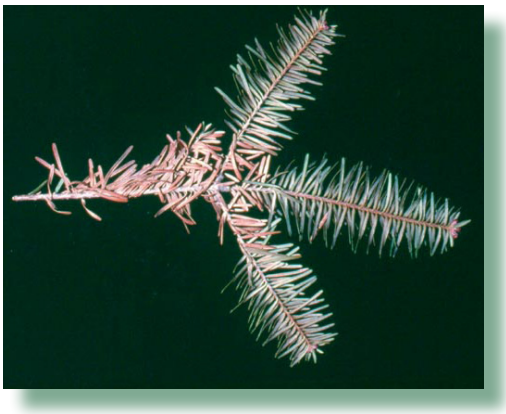
Importance. This disease affects seedlings and naturally regenerating stock under snow that is slow to melt in late winter or early spring. Several species of fungus cause snow blight in balsam fir.

Damage. The fungus spreads rapidly under snow or foliage near the seedling's stem. The disease kills the needles, but not the new buds, and the affected needles turn brown and hang from the twig. The disease occurs in well-defined patches, especially in seedling beds, where severe damage and mortality can occur. The degree of damage depends on the amount of snow cover and the length of time it persists. Seedlings that appear healthy in the fall can undergo severe browning by spring.

Detection. Look for brown foliage under the snow line, sharply delineated from the normal foliage above, and mycelia (cobweb-like threads) forming white mats similar to cobwebs.

Seasonal History. Spores are produced within the tiny black fruiting bodies that occur in rows on the brown needles; they are released in mild, moist, fall weather and are windborne to other trees. The spores germinate on the needle surfaces under the snow. White mycelia spread the fungus to healthy needles under the snow, especially on mild winter days.

Control. This disease is not serious enough to require control measures. Plant only resistant trees, and avoid establishing seed beds where there is poor air circulation and where snow can form in drifts.



Snow blight damage on twig.

Snow blight in a spruce seedling bed.

Mycelia of snow blight.

Fruiting bodies of snow blight.

Whole tree damage—spruce.

Smothering disease (*Thelephora terrestris*)

This fungus is widespread in eastern Canada and affects many species of conifers. Large fruiting bodies (up to 15 cm) grow rapidly around the lower stems of seedlings and smother them without infecting the tissue; usually only a few seedlings are affected. The fungus can grow profusely and uses the seedlings as support. The seedlings can usually be transplanted after the fungus has been removed. Dense seedling growth and humid conditions favor the growth of the fungus, but fast-growing seedlings are usually not killed. Physical removal is necessary to allow water to penetrate the soil, especially with container-grown seedlings.

The large fungal fruiting bodies of smothering disease

White Grubs

White grubs, the larvae of June beetles, are pests of transplant beds and small Christmas trees. They are especially common in plantations that have been recently established on abandoned farmland. The larvae feed beneath the soil, cutting off the roots of the seedlings, which eventually die or grow slowly. The grubs prefer grass roots, but will damage Christmas tree roots if grass roots are not available.

See Insects for more details.

Seedling bed and potted seedlings, central NB.

Extremely stressed seedling, southern NB.

Yellow witches' broom (fir broom rust) (*Melampsorella caryophyllacearum* Schröter)

Importance. Yellow witches' broom occurs wherever fir trees occur across North America and Eurasia.

The conspicuous mature brooms are the result of a rust disease that causes a proliferation of twigs to develop from a single point on a branch, thus disfiguring the branch with an upright, broom-like growth. Growth on stems is uncommon but usually more serious. Witches' brooms are more common on Christmas trees growing on former agricultural soil where chickweed is present. The brooms rarely kill, but can significantly reduce the growth and value of Christmas trees.

The fungus has a primary host, balsam fir, and an alternate host, chickweed; both hosts are required for the disease to spread. Chickweeds are common throughout North America, and grow in pastures and fields, and along roadsides. The various species include field or mouse-ear chickweed (*Cerastium arvense*), common stitchwort (*Stellaria graminea*), and common chickweed (*Stellaria media*). Common chickweed is a major pest in fields with heavy soils.

Damage. Witches' brooms can disfigure and reduce the growth of trees, sometimes to such a degree that the tree has to be culled from the plantation. The brooms lose all their stunted needles each year, leaving a bare tangle of shoots that detracts from the appearance of the tree.

Detection. Initial infections may be a small branch swelling, but once the perennial witches' brooms develop, the disease is easy to detect, especially early in the growing season when the shorter and thicker yellowed needles contrast sharply with the healthy green needles. They can be located anywhere within the crown of the tree. In spring, witches' brooms have a distinctive heavy odor that can be detected within a few meters. The bare brooms are also easily found after the needles fall at the end of the growing season.

Seasonal History. Spores are produced in spring on the yellow stunted needles borne on the broom. The spores form in fruiting bodies that look like small, round, orange-yellow blisters on the upper and lower surface of the needles. Later, in early to mid-summer, another type of spore is produced on the lower surface of the needles. These spores spread in the wind and infect the alternate host, chickweed, on which, over the course of the year, the fungus produces leaf and shoot blight and three types of spores. The most visible evidence consists of orange-red pustules that form on the underside of the leaves. The following spring, spores produced on the chickweed host infect balsam fir when they land on the newly opened buds, thus spreading the disease. The infection grows slowly the first year, causing small swellings on the new shoot that are difficult to detect. Upright shoots are formed the following year, and these grow bigger as the branch matures.

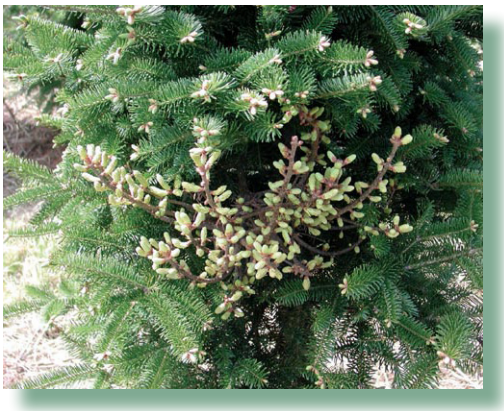
Field chickweed, the alternate host of yellow witches' broom. (Photo: INFOR.)

The underside of the needles of a witches' broom showing spore-producing pustules, mid-June, southern NB.

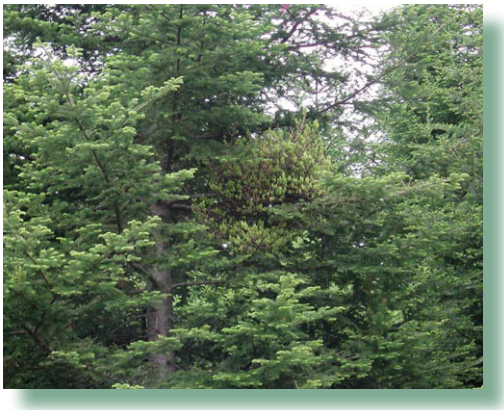
A witches' broom before needle growth, mid-April, southern NB.

The infected needles are shed each year, but the disease is systemic; it survives in the woody tissues of the witches' broom and in the chickweed, and new shoots become infected year after year. Brooms appear about 2 years after infection, but are first seen as swellings or galls on the infected branches. Moist conditions favor the spread of the disease.

Control. Witches' brooms should be removed while they are small and burned as soon as detected, ideally in early summer before the spores are released. Remove all trees that have stem infections (swellings or brooms) or large brooms. Infected mature trees in neighboring forest land often contain immense brooms high in the mid-crown. Remove and destroy these trees or at least the large brooms, if possible. Control of chickweed with a registered herbicide or by mowing will also reduce the spread of the disease, but this also may be impractical as chickweed is a widespread plant.



Witches' broom with needles not yet expanded, late May, southern NB.



A large witches' broom on a mature fir that may act as a source of infection for nearby Christmas trees, early June, southern NB.

Small witches' broom on a Christmas tree, early July, southern NB.

Abiotic Factors

Abiotic injuries

Some injuries are abiotic, that is, not caused by insects or diseases:

1. Weather events, including snow, ice, hail, wind, and lightning
2. Seasonal conditions, including winter drying and sunscald
3. Mechanical or physical, including injuries from mowing, harvesting, and soil compaction, and caused by animal feeding
4. Site-related conditions, including ocean spray and frost pockets
5. Human-related, including roadside salt, faulty planting, pesticide and fertilizer application, and general pollution

The exact cause of abiotic injuries on Christmas trees is often difficult to determine, because similar symptoms may be caused by different agents.

Needle reddening from an unknown cause, late June, southern NB.

This tree shows a general yellowing at the base but not the crown. Early May, southern NB.

Chemical damage

Importance. Herbicides, fertilizers, and salt can all damage Christmas trees. Herbicides and fertilizers are widely used in forestry and agriculture to control weeds and to enhance tree growth.

Road salt can damage balsam fir growing next to roads, intersections, and septic tank drainage fields (if salt is used for water conditioning). Ocean spray can also affect trees; often it is carried many kilometers inland.

Damage—Herbicides. When applied properly, herbicides rarely damage Christmas trees. Growers should follow label directions closely in order to achieve safe and effective vegetation control. When herbicide damage does occur, it is difficult to diagnose. The type and extent of damage depends on the herbicide used. Problems can be more readily identified if careful records of application have been kept over the years.

Damage may not be noticeable until the following growing season. A pattern of damage is often detectable, such as browning of needles along one side of a row of trees. Damaged needles turn red and drop, leaving current shoots barren, especially on the side exposed to the herbicide. Some herbicides can cause abnormal growth, such as needles that are twisted and shoots that are distorted, especially if the tree is actively growing.

Broad-spectrum herbicides can kill all or most of the vegetation in the plantation area. Herbicides applied with a sprayer on a windy day can drift, thus affecting one side of the nearest tree or the entire row.

Herbicides can also be absorbed from the soil and translocated by the root system, causing damage to the whole tree or to part of the crown. Some herbicides stay in the soil for years, e.g., in plantations established on fields that formerly supported potato or corn crops.

Damage—Fertilizers. Granular fertilizers add nutrients to the soil that are taken up by the tree, which will respond with healthy growth, but excessive amounts of chemical fertilizers can “burn” the tree, causing browning of the needles. Also, shoots may grow faster and become weak, thus becoming susceptible to breaking by birds. Conversely, they may actively grow late in the season, and thus be susceptible to frost damage. Trees that grow too fast can become stressed, and are also susceptible to aphid and other insect infestations and winter injury.

Damage and Detection—Salt. Diagnosis of salt damage can be difficult, especially during the growing season. In spring, browning or reddening and early needle loss on the side of trees that faces a road or the ocean is the obvious result of salt damage. Balsam fir trees can turn bright orange-red. Even though needles drop off, the buds usually form normally, and new foliage replaces the lost needles. The tree may appear healthy by summer, but repeated salt exposure can weaken it and stunt its growth, leaving it susceptible to infestation by insects or diseases, sometimes resulting in death.

Damage can occur from road salt sprayed directly onto the needles and from buildup of salt-laden water in the soil, and can vary from year to year, depending on the amount of salt used. Usually only the outermost one or two

Herbicide injury on small spruce.

Trees damaged by herbicides.

Twisted fir needles as a result of an extreme case of herbicide damage.

rows of the plantation are affected, but runoff from the road can flow downhill on frozen soil and affect trees far from the road.

Symptoms that are similar to salt injury include winter injury and drying, and some blights and needle casts (*see* Diseases).

Control. Prevention is an important factor when managing a Christmas tree plantation.

- Carefully read and follow the instructions on the herbicide and fertilizer containers. Know which herbicides are effective in your area and against what target vegetation. Do not apply the herbicide directly to the foliage of the tree. Be aware of atmospheric conditions—such as temperature and humidity—that affect the way herbicides behave. Avoid drift by not spraying on windy days.
- Light damage may be repaired by pruning away affected shoots. Remove and dispose of weakened or damaged trees to prevent insects or diseases from infesting them, and thus spreading to healthy trees.
- Maintain a detailed record of your pesticide and fertilizer applications.
- Plan the location of your plantation. Do not establish your plantation near power lines or agricultural crops (especially if corn or potatoes are the adjacent crop)—these locations may be subject to vegetation control and thus herbicide drift, or they may have residual chemicals from former crops.
- Do not overfeed your trees. Use only enough fertilizer to supplement the deficiencies in your soil, as indicated by soil tests.
- Avoid establishing your plantation beside major roads or near the ocean. If you do have such a plantation, then monitor the edges closely in spring for signs of salt damage. A buffer strip may limit exposure.

White drops of herbicide residue visible on previous year's needles, early June, central NB.

Top branches broken by birds, mid-June, southern NB.

Herbicides have been used to eliminate much of the ground vegetation at this farm, early June, central NB.

A plantation untreated with herbicides. The vegetation is competing with a small fir tree.

Herbicide burn on seedlings.

Effects of roadside salt spray on a pine, southern NB.

Frost

Importance. Late spring frosts are common in eastern Canada and may occur in frost pockets or on south-facing slopes, where spring bud break and shoot growth are premature. A late spring frost occurring after bud break can damage the new growth. Young balsam fir trees are particularly susceptible to shoot damage.

A severe fall or early winter frost can freeze and kill the sensitive new growth or branches not yet hardened off for winter, thus degrading the Christmas tree. Damage over several years can produce stunted or bushy trees, or trees with forked tops.

Damage and Detection.

Shoot mortality. Within 2 days of a severe spring frost, new shoots will wilt, droop, and turn yellow. After a week, the killed buds turn dark brown, and the adjacent foliage turns red-brown and droops. Dead or damaged current foliage can persist on the tree for up to a year, existing beside new shoots. Severely affected trees can turn almost completely reddish. Smaller trees such as Christmas trees exhibit the damage first in the emerging foliage of the upper crown. A severe frost can kill seedlings.

Frost heaves. Frost heaving is caused by the repeated freezing and thawing of the ground, resulting in significant seedling mortality, especially on recently planted sites on higher elevations. The seedling is lifted out of the ground, exposing the root collar and potentially breaking some of the roots.

Control. Do not plant Christmas trees in known frost pockets or on slopes with a history of early bud break and frost damage.

If a site is subject to frost heaves, then leave mulch or ground cover to provide some protection from the temperature changes. Also, planting seedlings in the root zone of a previously harvested tree will help anchor the seeding in the soil for the first few years.

Typical frost-damaged tree.

Frost-heaved tree, mid-April, southern NB.

Frost damage to branch tips.

Red flag

Importance. Red flag is the death and browning of part or all of a branch. Although red flag is not a serious problem, numerous red flags on one tree may cause it to be downgraded or culled.

Scattered red flags can be caused by several species of fungus, physical injuries (hail or mechanical injury) and feeding by sawyer beetles and squirrels.

Damage and Detection

- Hail damage. Hail causes scars on the upper sides of branches and usually on one side of the tree, resulting in the formation of red flags (*see* Weather). These wounds may become entry points for other diseases.
- Sawyer beetle feeding. Adult whitespotted sawyer beetles (*see* Insects) feed on the needles and bark of twigs of Christmas and other trees. The bark feeding can scar the undersides of twigs, and girdling can cause the twig to die and a red flag to form. Certain fungi (described under Diseases) can enter the tree at these wounds and cause dieback.
- Squirrels can scar twigs when they strip the cones, resulting in a red-flagged twig.
- Red flag, bud and shoot dieback, or *Fusicoccum* canker. Only a few branches per tree may be affected by this branch-girdling fungus, which girdles the twig and kills it. (*See* Diseases.)

Control. Remove the affected twigs by cutting back to green wood.

Damage caused by mechanical injury, early July, southern NB.

Red flag caused by broken branch, early May, southern NB.

Sun injury and drought

Importance. Sunlight can damage trees in winter and summer especially on vulnerable sites. Winter drying is a common occurrence in eastern Canada. Sunscald injuries provide a direct entry for fungi and may cause trees to be prone to root rot.

Trees that are affected by drought—especially seedlings and young saplings that have less extensive root systems—are stressed, and thus may be susceptible to insect pests and diseases. Trees also lose foliage and grow slowly, resulting in downgrading. Even if trees survive a serious drought, their growth may be retarded for years.

Damage and Detection. Drought-related injuries include sunscald and drought stress. Some of these injuries resemble diseases, but the absence of fruiting bodies will confirm an abiotic injury.

Sunscald. Sunscald may occur in summer or winter. In summer, bark injury occurs when intense summer temperatures are high enough to harm the tree's cambium layer. The affected bark turns red then dark brown, but fades and then sloughs off by the end of summer. These sunscald cankers can affect the entire length of the exposed stem, but injury is generally confined to the southwest side. Trees in dry exposed sites, shade-grown trees that have been exposed after thinning or pruning, especially those on the edges of a southerly exposed stand, and rapidly growing trees are the most susceptible. This condition mostly affects young trees. Death seldom occurs.

Winter sunscald (or winter drying) is common on flat terrain in midwinter or early spring when mild sunny days with warm dry winds alternate with periods of cold air drainage at night. Under such conditions, water is lost from the needles above the snow (through transpiration) but cannot be replaced because the water in the soil or tree stem is frozen. Foliage under snow is usually not affected. Look for browning or reddening of foliage above the snow line, dying or dropped needle tips and a general wilting, especially on the south side of the trees, where exposure to the sun is greatest. Sometimes there is a definite line apparent between the dead foliage and the healthy foliage, which was below the snow and thus protected. A severe occurrence can kill some buds, but terminal buds are seldom killed, and affected plants may appear to be tufted when new growth begins.

Daytime temperatures in late winter or early spring may rise high enough during the day to raise bark temperatures above freezing. A rapid drop in temperature at night may cause the death of bark on the southwest face of the trees, resulting in cankers. This damage occurs in trees situated in droughty areas, or in stands that have been thinned where trees that were once protected are now exposed.

Tree affected by sunscald.

Close-up of sunscald.

Small balsam fir showing winter drying. Note red-green foliage line. Early May, southern NB.

Drought stress occurs in summer when trees need more moisture than is available in the soil. This can occur in one summer as a result of severe drought or after a few seasons of below normal rainfall. The symptoms of drought are most apparent in late summer and early fall, although symptoms may not appear until a year after the drought stress. Young trees are affected sooner than older trees, as they have less extensive root systems. Some older needles will be shed prematurely. Seedlings will show wilting, yellowing, and necrosis (tissue kill). Older trees exhibit symptoms from the top down and the outside in, and the foliage gradually turns brown. Needle death and tip dieback will occur if the drought is advanced, and extensive mortality can occur several years later.

Pests or conditions that cause similar symptoms are air pollution, Armillaria (shoestring) root rot, herbicide, salt injury, and some blights and cankers.

Control. Use care in thinning wild stands for Christmas trees. Sudden exposure to unfiltered sunlight may cause sunscald. Open up new areas gradually, if practical.

Inspect trees for pests if drought stress is suspected. Stressed trees are susceptible to insect pests and diseases. Controlling weeds and grasses around the trees is essential to reduce competition for water. Irrigation in dry periods may be necessary, especially for young trees. Remove all dead trees as soon as possible to reduce pest and disease problems.

Pine Christmas trees showing distinct red tops caused by winter drying.

Weather

Importance. Weather conditions such as snow, hail, ice, and wind can damage Christmas trees.

Damage and Detection.

Snow can bend the main stems of the trees, either permanently or temporarily, depending on the depth and location of the snow pack. Stems can be broken or branches stripped from the stem, and tops broken (resulting in deformity).

Ice can abrade or scar the main stem above the snowline.

Wind can topple Christmas trees already weakened by any of several conditions, such as disease or drought stress. Wind can also contribute to winter desiccation damage, especially on trees at higher elevations.

Hail can cause destruction over a wide area, but usually only on one side of the trees. Symptoms include stripped branches, stem lesions, scars and bruises, and tattered crowns with missing foliage and buds. Dropped foliage and buds can be seen on the ground.

Snow damage.

Ice storm damage.

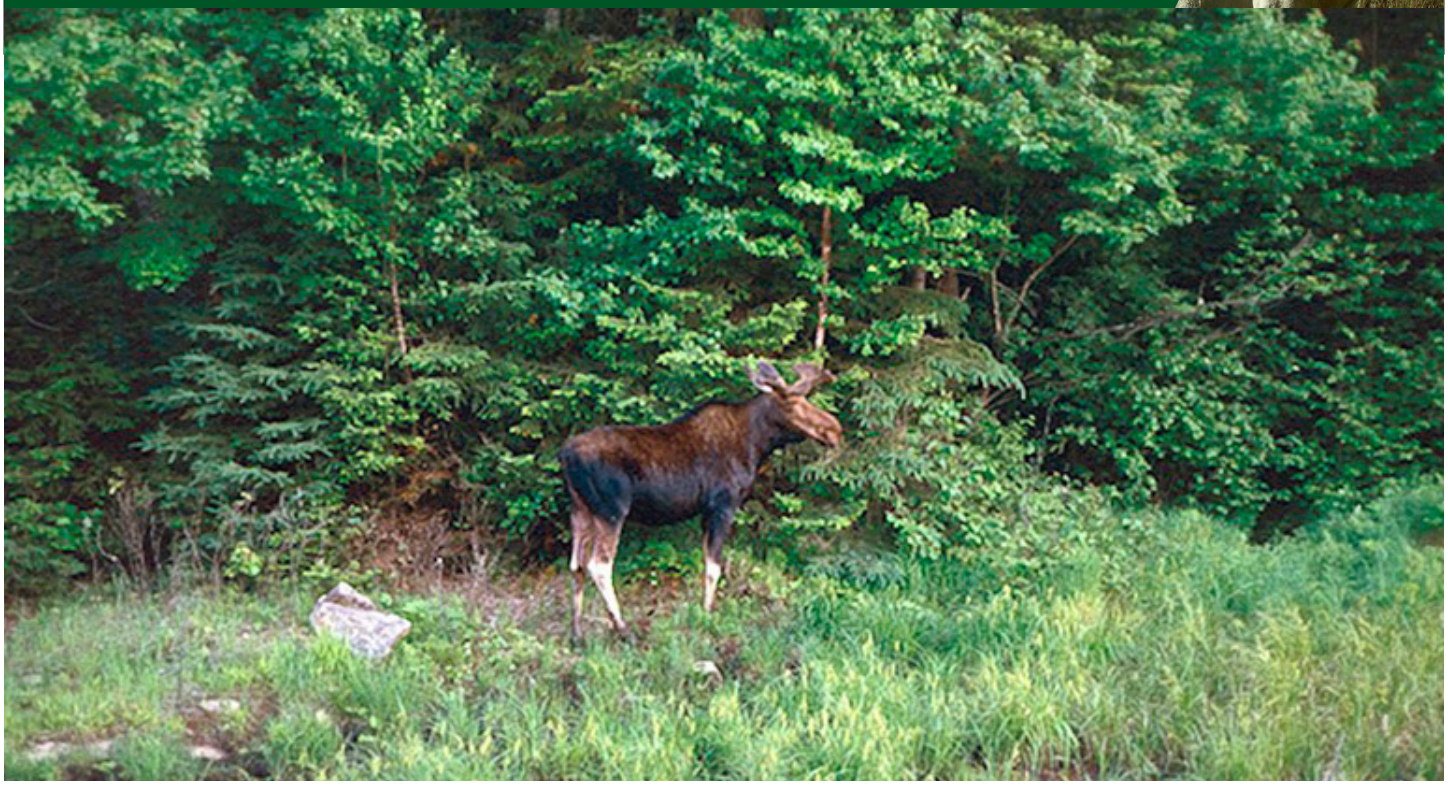
Distorted stem due to snow damage.

Scars caused by hail.

Hail damage.

Tree toppled by wind.

Mammals and Birds



Mammals and birds

Importance. Several species of mammals and birds can damage Christmas trees. Balsam fir is a food source for moose, deer, red squirrel, and grouse. Individual trees can be killed or disfigured by girdling or other feeding, resulting in loss to the grower. Additional losses occur from insects and diseases that infect trees through wounds created by mammals and birds.

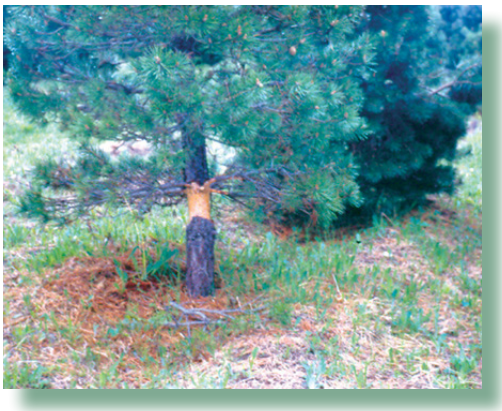
Damage and Detection. Some smaller foraging mammals, such as mice and hares, prefer small trees such as Christmas trees; others, such as porcupines, prefer larger trees. The animal responsible for the damage can usually be identified by the size of the tree and the part of the tree damaged.

Meadow voles, which are common in grassy fields, often remove the bark at the base and on the lower branches of trees during the winter while living under the snow. This may weaken trees and slow their growth; needles may also be discolored. The entire tree may turn red by midsummer and die if it is girdled during the winter. Extensive mortality can occur within a Christmas tree farm in years of high vole populations. Look for burrows, runways cleared of vegetation in areas of heavy plant growth, droppings, and deposits of clipped grass.

Snowshoe hares often feed on buds and on the portion of bark that remains above the snow on pine and balsam fir. Cuts on the twigs are smooth and slanted, and horizontal tooth marks can be seen on the stems. Damage will be noticed in the spring, especially in areas of heavy brush, which is the hare's preferred habitat. Smaller-diameter balsam fir is also a common food source in winter, when hares often girdle the stems by eating the bark. This can cause high tree mortality. Look for the hare's characteristic round droppings near the trees.

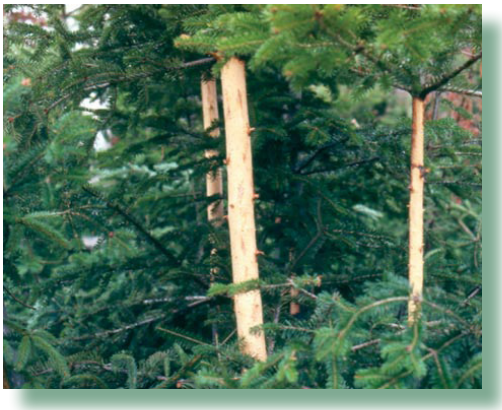
Red squirrels may eat the flowers and the buds from the leaders. They often clip cone-bearing twigs, letting them fall to the ground where they collect the cones. These habits leave scars that may result in red flags. This is especially common in balsam fir in fall and winter, when twigs and cones can be found on the snow at the base of the tree.

Porcupines strip bark from limbs and girdle them or the entire tree; they prefer hardwoods and larger conifers. The snipped branches will have a smooth, slanted cut at the sheared end and will usually be located high in the tree.



Girdling of pine caused by porcupine.

Pine trees damaged by rodents during the winter.



Tree stems stripped by porcupines.

Birds. Large or medium-sized birds can break young and tender leaders by landing on them.

Flocks of pine grosbeaks can damage and consume buds, especially on pine trees, in fall and winter, resulting in multiple leaders and stunted growth.

Yellow-bellied sapsuckers can damage or kill a tree in the summer by pecking numerous small holes in the bark, although this is not common in Christmas trees. The birds feed on insects attracted to the sap oozing from the holes. Sapsuckers are often attracted to stressed trees.

Large domestic mammals. Cattle and horses can compact the soil around Christmas trees, and damage trees by breaking branches.

Deer. Browsing by deer on buds and small branches can affect tree regeneration over large areas. Trees browsed by deer have twigs with ragged ends and shredded or peeled bark. Deer also rub their antlers on small trees, breaking branches and damaging the bark. In Atlantic Canada, provincial biologists have identified the locations of traditional deer wintering areas. If your plantation is located near one of these, you should look out for damage by deer in the winter and spring. Densely grown firs in some Christmas tree woodlots offer excellent winter cover for deer. Droppings and tracks will confirm the presence of deer in the area.

Moose. Balsam fir is one of the preferred foods of moose, and feeding occurs in winter and early spring when other species are unavailable. Growers who establish Christmas trees where moose are abundant will suffer damage that can vary from light to severe. Moose tend to select high quality browse, such as Christmas trees, especially if the trees are located within areas of high black spruce density. Moose will not feed on black spruce, and will thus concentrate on patches of fir. Twigs browsed by moose show a rough, shredded tip and a ragged break. Moose browsing is of particular concern in Newfoundland where moose numbers are high.

Sapsucker holes in a birch tree.

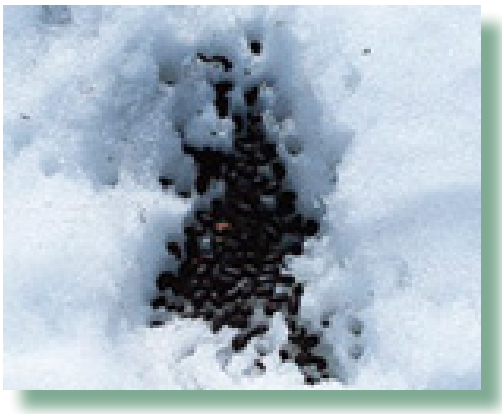
Bud damaged by birds.

Top branches broken by birds, mid-June, southern NB.

Control. No control is necessary if the damage by all these species is random and not extensive. As a general measure, prune girdled branches and remove heavily damaged or girdled trees.

- Voles prefer weeds and grass that offer them cover, so control weeds by mowing or applying herbicides. Poison baits can also be used.
- To discourage hares, remove brush piles and the bushy borders of your plantation. Heavy hunting and trapping are also effective.
- Prevent bird damage to tender leaders by providing perches that are higher than the tops of the Christmas trees.
- Repellants sprayed on trees can discourage deer and hares in the short term, but will have to be reapplied frequently, which might be difficult in winter.
- Porcupines are difficult to control effectively, but they can be hunted or trapped in live traps baited with salted corn cobs, and removed to other areas.
- Proper fencing is the most reliable method for keeping domestic animals, moose, and deer out of a plantation, but is warranted only if the damage is severe and extensive.
- To avoid or reduce moose damage, establish farms near areas of high human activity and away from large areas of black spruce; do not consider sites that have historically been used by moose. Local hunters can also remove problem moose from the farm area.

Moose browse damage.



Deer droppings in snow, NL.

Beneficial Insects

General

Of the thousands of species of insects that live in our environment, a small percentage—half of 1%—are pests. When pest problems occur on Christmas tree farms, it is very important to consider the impact of proposed control measures on the many beneficial insects that inhabit the same environment. Beneficial insects provide natural control of many pest insects and about 300 species are considered to be beneficial to the Christmas tree producer.

Beneficial insects fall under two main groups: predators and parasites.

Predators, which include the adult and larval forms of many insects, spiders, and mites, actively attack and capture their prey. They either eat the entire prey or suck out its body contents. Specialist predators that prey on particular pest species are the most valuable in controlling pests, whereas generalists eat almost anything, including other beneficial insects. About 50 species of insect predators are beneficial to the Christmas tree producer.

Parasites (parasitoids) are usually the larval stages of wasps and flies; the adults often feed on other food sources. The adults lay eggs in or on the larva or eggs of the host species, and the parasite larva feeds on the host from within. Parasites can be extremely effective and can severely limit a pest population. About 250 species of insect parasites are beneficial to the Christmas tree producer.

Populations of beneficial insects can be artificially augmented by releasing purchased insects within Christmas tree plantations, although this is often difficult and expensive. Many species of beneficial insects, including ladybird beetles and lacewings, are widely available from garden centers and other commercial suppliers.

Predators

Hoverflies (Syrphid flies, Flower Flies)

Hoverflies are colorful striped flies of many species that are often observed hovering in and around plants, especially around flowers. The harmless adults are often confused with wasps. Adult hoverflies are not predators, but feed on the pollen and nectar of flowering plants, which should be considered when you manage competing vegetation.

Hoverfly larvae are small, legless, and maggot-like, with the body tapering toward the head. The head is constantly moving when they are searching for prey. They are important predators of the balsam twig aphid, balsam woolly adelgid, mites, and other insects. They can be found actively feeding among aphids on developing shoots. One hoverfly larva can consume several hundred aphids. Other predators and parasites can also feed on the larvae of hoverflies.

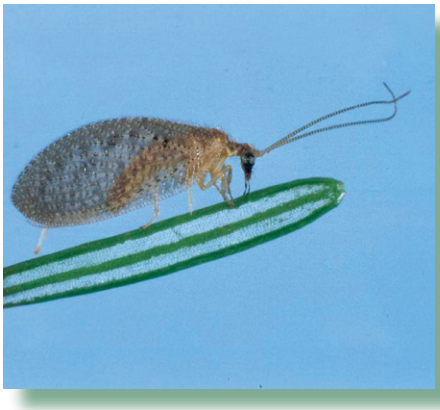
Adult hoverfly on a flower. Hoverflies of several species are common around flowers in the summer.

Hoverfly larva on a Christmas tree, early June, central NB.

Hoverfly larva eating a balsam twig aphid.

Lacewings

Lacewings are predators that kill soft-bodied pests such as balsam twig aphids, balsam woolly adelgids, other small insects and mites. The adults have large wings that are finely veined and fold tent-like over the body. Some species are green with transparent wings and others are brown with hairy wings. Eggs are laid on the needle and are supported by a stalk. The larvae, sometimes called “aphid lions” or “antlions,” are more important as a predator, and feed on almost anything. The larva resembles a lady beetle larva, but with a large pincer jaw, and is pointed at both ends like a tiny alligator.



Adult brown lacewing.

Lacewing larva.

Adult green lacewing, late August, southern NB.

Stinging Wasps

Large wasps are aggressive predators and attack many Christmas tree pests. Adult wasps feed on nectar and pollen but kill and capture the caterpillars of several moth species as well as the balsam fir sawfly, which they chew up and take back to the nest in a semi-digested state. Although wasps may be annoying to humans, their presence and their paper nests are a benefit to the cultivation of Christmas trees.

Eastern yellowjacket at flower.

Paper wasp nest from previous year in a fir tree, early July, southern NB.

Beetles

Beetles are important predators of many Christmas tree pests. Rove, ground, and soldier beetle larvae prey on the soil-dwelling stages of many pests.

Rove beetles feed actively on small to medium-sized pests such as sawflies, balsam gall midges, and mites. The adults can forage on foliage but most prefer to forage actively in litter and duff. The larvae are soil dwellers that feed on soil insects and mites.

Ground beetles prefer caterpillars but will catch and eat most insect pests in the soil. Ground beetles are large, dark colored, and often metallic looking. They are fast moving and seldom fly. They are active ground feeders but will climb trees to seek prey.

Ground beetle, late July, PEI.

Rove beetles.

Soldier beetle searching for prey.

Soldier beetle adults feed mainly on flowers, but the larvae eat the soil stages of balsam fir sawfly, balsam shootboring sawfly, and mites.

Fireflies. Although the adults will be most familiar, the firefly larvae consume the larvae of various beetles and caterpillars. The larvae are active at night, usually on the soil surface or under vegetation. Fireflies are actually beetles, not flies.

Lady beetles are well-known insect predators of soft-bodied insects. They are easily identified by their characteristic oval shape and colors (red, orange or black with black or red spots). The larvae look like tiny alligators with black and red or yellow spots; they feed voraciously for a few weeks before pupating. Both larvae and adult beetles feed on twig aphids, balsam woolly adelgids, insect eggs, mites, and other insects. A single lady beetle can eat dozens of aphids in one day. Ants can drastically reduce the effectiveness of both adult and larval ladybird beetle predators.

A soldier beetle common on goldenrod in late summer.

Adult firefly, late May, southern NB.

Ladybird beetle (seven-spotted) on a Christmas tree, early June, central N.B. This species was introduced from Europe as a biological control agent for aphids on crops and is now very common.

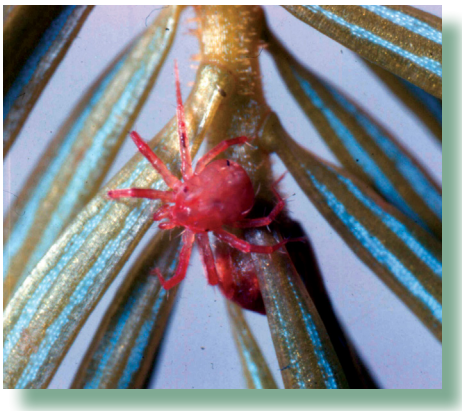
Ladybird beetle larva, mid-June, southern NB.

Adult assassin bug.

Assassin bug nymph feeding on a moth larva.

Spined soldier bug (a stink bug) sucking body fluids from a larva, early August, southern NB.

Spider, early August, southern NB.



A predatory spider mite

True Bugs

Stink bugs are often mistaken for beetles. Their shield-shaped bodies are softer than beetles and their mouthparts are adapted to piercing and sucking prey. Most stink bugs feed on plants, but some attack caterpillars of blackheaded budworm, spruce budworm, white-marked tussock moth, hemlock looper, balsam fir sawfly, and also large aphids.

Assassin bugs are fierce-looking insects. They have long narrow heads that give the appearance of having a neck. The nymphs resemble the adults, but are smaller with no wings; they feed on small insects such as aphids. The adults are ambush predators and use their sharp, beaklike mouthparts to stab and suck out the juices of the larvae of moths, June bugs, and many other pests.

Spiders and Mites

Spiders and mites are arachnids, not insects, and have eight legs and two body parts. Spiders are important predators of many species of pest insects and beneficial insects, which fly into the webs they spin in fir trees. Some predatory mites are excellent at controlling plant feeding mites such as spider mites. Predatory mites tend to be colored golden-tan to reddish-orange, as opposed to the spider mite, which is dark green to dark brown.

Parasites

Non-stinging Wasps

There are many species of non-stinging wasps, ranging from tiny to large. Some wasps are important parasites of spruce budworm, other caterpillars and the balsam shootboring sawfly. The wasps pierce caterpillars or the eggs of the host with their ovipositor and lay eggs inside, or they lay their eggs on top of the host larva. When the egg hatches, the wasp larva devours and kills its host from the inside out. Adult wasps depend on nectar to survive, so flowering plants should be promoted to manage competing vegetation.

Trichogramma (also known as red-eyed bees) are extremely small parasitic wasps that are well known for biological control. They are important egg parasites of most Christmas tree insect pests, including moths such as spruce budworm, and the sawflies. The adults lay single eggs on the host eggs, and the larvae develop inside, eating the contents, thus killing the hosts before they hatch. The parasitized eggs turn black.

A tiny non-stinging wasp, Glypta fumiferanae*, that is also a parasite of spruce budworm caterpillars.*

Meteorus trachynotus*, another tiny wasp that parasitizes the spruce budworm.*

A tiny wasp on a Christmas tree, mid-June, southern NB.

Flies

Tachinid flies are one of several types of parasitic flies. They look similar to common houseflies, but are heavily bristled with red, yellow or cream abdomens. The adults are common around flowers and lay eggs in, on or near the caterpillars of spruce budworm and several other moth species. They also parasitize balsam fir sawflies and balsam shootboring sawflies. The eggs hatch, and the larvae burrow into the caterpillar, eventually killing the host. In most species, the adults emerge from their pupae in the spring at the same time as their host's larval stage.

A tiny Trichogramma wasp parasitizing spruce budworm eggs

Tachinid fly on vegetation beside Christmas trees, mid-July, southern NB.

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Appendix 1
Glossary

Abiotic agent: Agent that is not related to anything biological, e.g., not related to insects or organisms that cause disease.

Adelgid: A type of insect that feeds and forms galls on conifers.

Alternate hosts: One of the two hosts of a pathogen that has different stages of its life cycle occuring on unrelated hosts; several plant species may be hosts of a given pathogen.

Aphids: Small sluggish insects that suck the juices from plants.

Apical: Referring to the top portion of a stem or tree (the apex).

Asexual: Reproduction that occurs without fertilization (the union of male and female), e.g., the balsam twig aphid.

Axis: The central column (stem) of a plant.

Bacillus thuringiensis (Bt): A naturally occurring soil bacterium used because of its ability to produce a protein toxic to destructive insect pests.

Ballooning: Floating away on silk strands. Some larvae may be blown by the wind to new locations, assisted by their light, hairy bodies and long silk threads produced by special head glands. Although ballooning has been recorded over 50 km, it usually adds about 5 km per year to new infestations.

Beetle: Members of the order Coleoptera (Beetles).

Beneficial insects: Insects that prey on insects that are destructive to a crop.

Biological control: The use of naturally occurring predators, parasites, or diseases to control or reduce an undesirable pest (e.g., insects, weeds); includes the release of live organisms such as predators and parasitoids (nematodes, wasps, protozoans) or microorganisms such as viruses or bacteria.

Biological insecticide: An insecticide that has as its active ingredient a biological organism or chemical derived from an organism.

Blight: A fungal disease of plants that results in withering, cessation of growth, and death of parts without rotting.

Branch: The part of a tree or shrub that grows from the trunk or stem.

Bud burst: The period when the swollen buds open and new growth emerges.

Bud cap or scale: A modified leaf (or similar structure) that covers and protects the bud.

Budworm: The larva of a moth that feeds on the buds of plants.

Buffer strip: A band of forest left relatively undisturbed so as to protect some element of the environment, such as a stream bank, from erosion.

Cambium: A layer of dividing cells found in the stems of plants that forms a specialized layer that causes the stem to increase in thickness.

Chemical control: The use of chemicals to control or reduce an undesirable pest. Organochlorine chemicals such as DDT, used in the 1950s, and fenitrothion have now mostly been phased out. Chemicals are not used very much in forestry these days, although some biochemicals are being developed and used.

Climatic factors: Events—e.g., minimum and maximum temperatures, average rainfall, frost susceptibility, snow cover, and windspeed—that influence a plant's ability to survive.

Cocoon: An envelope, often of silk, that an insect larva forms about itself and in which it metamorphoses to the adult stage.

Coleoptera: An order of insects (beetles), distinguished by having four wings; the outer two of which are modified into a stiff protective covering for the inner pair when at rest. Members include ground beetles, lady bird beetles, June beetles, and sawyer beetles.

Conifers: Evergreen trees and shrubs that bear naked seeds in cones, including pine, fir, larch, and spruce trees.

Contact insecticide: An insecticide that is toxic to insects by direct contact.

Crown: The tree's live branches and foliage. The part of a tree bearing branches and foliage.

Crown pruning: Removal of shoots or branches from the tree, primarily to control height.

Cull: Trees or logs or portions thereof that are of merchantable size but are rendered unmerchantable by defects. In nursery practice, a seedling that does not match the grade or specifications.

Current-year foliage: Foliage that has grown from buds in the current year.

Defoliation: The process of depriving a plant of its leaves.

Defoliators: Insects, primarily caterpillars and sawfly larvae, that consume the foliage of conifers and hardwoods. Also compounds that cause the leaves or foliage to drop from the plant.

Diptera: An order of insects (flies), distinguished by having two wings. Members include black flies, mosquitoes, houseflies, and Syrphid flies.

Disease: Harmful deviation from normal functioning of physiological processes, generally pathogenic or environmental in origin.

Duff: A general term referring to the litter and humus layers of the forest floor.

Epidemic: Affecting many individuals within a population, community, or region at the same time.

Feeding tunnel / feeding shelter: Tunnels created by spruce budworm from silk and plant materials.

Formulation: A preparation of a pesticide according to a formula. There may be several formulations of a pesticide, each varying in concentration of the active ingredient.

Frass: The excrement produced by insects or their larvae.

Frost heave: Upward displacement of normal soil level as a result of expansion due to ice formation in frozen soil; in nurseries and plantations, the partial or total extrusion of seedlings or other small plants caused by such soil displacement.

Fungicide: A chemical used to kill and/or prevent the growth of fungi.

Gall: Abnormal growth on the plant caused by another organism, mainly insects. Can also be caused by mites, fungi, viruses, bacteria, and nematodes.

Genetic diversity and variation: A term used to describe the range of genes present, typically within a species.

Genus: In biological classification, a group of related or similar organisms containing one or more species. A group of similar genera (the plural of genus) forms a family. In the scientific name of an organism, the first name is its genus and the second, its species (e.g., *Abies balsamea*, balsam fir).

Girdling: The act of removing or cutting away of some or all of the bark and cambium in a ring around a plant. Destruction (on the part of agencies other than human, e.g., insects, rodents) of tissue, particularly living tissue, in a rough ring around a stem, branch, or root.

Granular application: A general process by which fertilizers or herbicides in the form of grains are applied to a given area.

Grub: A soft, thick, wormlike larva of an insect.

Head capsule: Spherical, hardened, and dark-colored covering of the head of lepidopterous (moths and butterflies) larvae.

Herbicide: Any chemical preparation used to kill or inhibit the growth of forbs, grasses, woody plants, and their seeds.

Hibernation: Passing the winter in a dormant or resting state.

Hibernaculum / hibernacula: The protective covering of an animal, such as a small silk cocoon, that protects it during its dormant stage in the winter.

Homoptera: An order of insects (aphids, hoppers, scale insects), distinguished by having two pairs of wings, which form a roof-like structure at rest. Members include balsam woolly adelgid and balsam twig aphid.

Honeydew: Liquid excretions of aphids, consisting largely of sugars and amino acids.

Host tree: A tree used by a parasite for food or shelter.

Humus: The rich, organic portion of the soil composed of decayed plant and animal materials.

Hymenoptera: An order of insects (ants, bees, sawflies, wasps), distinguished by having two pairs of membranous wings. Members include mound ants, balsam fir sawfly, and balsam gall midge.

Insecticide: Any chemical or biological preparation used to kill or disrupt the development of insects.

Infestation: Invasion of tree or plant by parasites either on or under the surface.

Instar: A stage in the life of an insect (larva) or a mite (nymph) that exists between two molts; usually designated as L1, L2, L3, etc.

Integrated Pest Management (IPM): The use of various techniques to control pests, as opposed to the application of just one method.

Internodal branches: Branches located between two nodes (joints or points on a stem where a leaf is or had been attached).

Introduced species: A species that does not occur naturally in a given area, but that has been introduced into it.

Larva / larvae: Immature stage in the life of certain insects that exists between hatching of the egg and pupation.

Leader: The growing apex or main shoot of a plant (shrub or tree).

Lepidopteran: A member of the order Lepidoptera (butterflies and moths), distinguished by having broad wings, covered with minute overlapping scales and usually brightly colored. Members include blackheaded budworm, gypsy moth, hemlock looper, and tussock moth.

Lichen: An organism that is a mutually beneficial symbiosis between algae and a fungus. The photosynthetic algae produce food and the fungus provides protection for the algae.

Litter: The uppermost layer of organic debris on a forest floor, i.e., essentially the freshly fallen or only slightly decomposed vegetable material, mainly foliate (leaf litter) but also bark fragments, twigs, flowers, fruits, etc. This and the less decomposed humus are together often termed “duff.”

Loam: Good quality soil with adequate supplies of clay, sand, and organic matter.

Looper: A small, hairless, caterpillar having legs on only its front and rear segments; mostly larvae of moths (Lepidoptera) of the family Geometridae.

Midge: A small, delicate, long-legged fly of the order Hymenoptera.

Mite: An arthropod of the order Acarina, which is related to the spiders, usually having a transparent or semitransparent body.

Miticide: A pesticide destructive to mites.

Molt: In insects, the old skin is sloughed off and a new one replaces it; this occurs between two stages or instars.

Moth: Adult stage of a lepidopteran.

Native species: A species that originated in a particular region.

Natural enemy: An organism that causes the premature death of another organism.

Needle: A long, thin, pointed, needle-shaped leaf of the pines, firs, and spruces.

Nematodes: A parasitic wormlike organism that attacks insect pests and kills or hampers the development of the insect host. Its ability to mass produce allows it to be an effective biological control agent.

Non-target organisms: Organisms that are affected indirectly by a treatment, typically a pesticide.

Nutrient: A chemical compound used by plants to promote growth, development or reproduction.

Nymph: Stage in the life of aphids and some other insects between hatching of the egg and the transformation to the adult form, during which the animal becomes sexually mature.

Overwinter: To spend the winter in a dormant form.

Outbreak: A sudden rise in the incidence of a disease or an increase in numbers of a harmful organism, especially of an insect, within a particular area.

Ovipositor: The egg-laying apparatus of female insects.

Parasite: Organisms, mostly insects, that live at the expense of another, called the host.

Parasitoids: An insect parasite (e.g., a wasp) that completes its larval development within the body of another insect, eventually killing it.

Pathogen: An organism, e.g., a fungus, bacteria, or virus, that causes disease. A microscopic organism or virus directly

capable of causing disease.

Perennial: A plant that grows and flowers for many years. Some are evergreens; others may die back to the ground, but then grow back again the following season.

Pest: An insect, pathogen, weed, mammal, or bird that is judged to cause harm to people, crops, animals, or property. Forest pests include insects, tree diseases, and noxious fungi.

Pesticide: Any preparation used to control populations of injurious plants or animals.

Pesticide drift: An application of pesticide that has drifted away from the target area because of wind.

Physical control: Includes trapping of insects or collecting affected parts of the tree, suitable for small numbers of ornamental trees or Christmas trees.

Phytotoxicity: Capability or liability to damage or kill plants through the intentional action of herbicides or adverse side effects caused by fungicides, insecticides, or formulating agents.

Predator: An animal that kills its prey and then feeds on it to survive.

Previous-year foliage: Foliage that has grown from buds in the previous year. In Christmas trees, this is the darker green foliage situated closer to the stem than the lighter green current-year foliage.

Primary host: An organism a parasite prefers for food or shelter.

Product label: To a manufacturer or registrant, a label is a “license” for product distribution, sale, and use; to an enforcement official, a label represents the legal sale, use, and disposal of a product. A label provides the user with directions for correct and legal use to control a pest problem and, as well, it provides valuable information to a physician in case of a pesticide poisoning accident.

Pruning: To cut off or cut back parts of a plant to achieve a better shape or to promote growth.

Pupa / Pupae: The intermediate stage between the larva and the adult in insects. Pupal covering is hardened and often colored, but leg, wing, and antenna pads of the future adult are visible. The pupa is almost immobile and often enclosed in a cocoon.

Registration: A rigorous process that includes extensive testing to determine the potential risks posed to human health and the environment; this process must be completed before a pesticide can be used in Canada.

Root collar: The area on the plant where the stem meets the root or the soil layer.

Root rot: A disease caused by fungi. As parasites, the fungi can cause mortality, wood decay, and growth reduction.

Rust: A type of fungus that is parasitic on plants.

Sawfly: Type of hymenopterous insect, the larva resembles a plant-feeding caterpillar. Others in this family include bees, wasps, and ants.

Shoot: New growth on part of a plant.

Shoot dieback: A condition in which the newer growth of a shoot is dead or dying.

Shoot elongation: The growth or lengthening of a shoot.

Silk: The fine, soft thread produced by various species of caterpillars in forming the cocoons within which the worm is enclosed during the pupa state.

Silvicultural control: Includes the wise selection of species for reforestation, suitable vegetation composition, reduction in forest-cover density and increased tree vigor promoted through pruning or fertilization (the latter most suitable for ornamentals and Christmas tree plantations). Silviculture is the theory and practice of controlling the establishment, composition, growth, and quality of forest stands. Can include basic silviculture (e.g., planting and seeding) and intensive silviculture (e.g., site rehabilitation, spacing, and fertilization).

Site: A land area based on its climatic, physiographic, edaphic, and biotic factors that determine its suitability and productivity for particular species and silvicultural alternatives.

Soil-borne root diseases: Diseases transmitted or spread through the soil that adversely affect the roots of plants.

Sooty mold: Black fungi that develops on the honeydew that aphids deposit on plants.

Sp.: Abbreviation (singular) of species; used after a genus name when referring to one species.

Species: In biological classification, a group of related organisms capable of interbreeding. In the scientific name of an organism, the first name is its genus and the second, its species (for example, *Abies balsamea*, balsam fir).

Spore: A spore is a single-celled reproductive unit of mushrooms, ferns, and mosses; it is similar to a seed but it does not contain an embryo.

Spp.: Abbreviation (plural) of species; used after a genus name when referring to more than one species.

Stem: The axis of a plant.

Systemic insecticide: A chemical that, when applied either externally or internally to various parts of a tree, is absorbed and translocated to untreated plant tissue, rendering the tissue toxic to insects.

Terminal leader: See “Leader.”

Thoracic shield: A protective covering of the central portion of an insect’s body, the thorax.

Top kill: A condition caused by the balsam woolly adelgid in which the top portion of a tree dies completely or partially.

Toxic: Poisonous or injurious to animals or plants through contact or systemic action.

Toxicity: Degree to which something is poisonous; the ability of a material to interfere adversely with the vital processes or an organism.

Tussock moth: A moth that defoliates most hardwoods and softwoods. Most of the foliage is eaten by the larvae, starting at the top of tree and working downward.

Vigor: The health of a tree based on observation of the foliage.

Whorl: The arrangement of branches (or leaves) in a circle around a point on the stem.

Appendix 2.
Taxonomy of pests and diseases

All life forms are classified into a taxonomic scheme in which each living thing belongs to one of six kingdoms: Plant, Animal, Fungus—the more commonly known—and Protista, Eubacteria, and Archaebacteria. All insects, spiders, and mites belong to the Animal kingdom. All diseases belong to the Fungus kingdom.

A phylum is a major subdivision of a kingdom; one of the main groups (or phyla) of animals is the Phylum Arthropoda. The Phylum Arthropoda (or arthropods) is divided into several classes, two of which are the Class Insecta (insects) and the Class Arachnida (spiders). A class is a group of animals that share similar characteristics. Each of the classes is divided into several orders or groups of closely related families, each of which is a group of closely related species. The Class Insecta contains 29 orders.

This is a simplified listing of the pests and diseases mentioned in this manual.

The Animal Kingdom

CLASS ARACHNIDA

- Order Araneae – Spiders (101 families)
- Order Acari – Ticks and Mites (300 families)
  - Spruce spider mite, Family Tetranichydae
  - Predatory mites, Family Anystidae

CLASS INSECTA

- Order Hemiptera – Bugs (134 families)
  - Stink bugs, Family Pentatomidae
  - Assassin bugs, Family Reduviidae
  - Balsam twig aphid, Family Mindaridae
  - Balsam woolly adelgid, Family Adelgidae
  - Cinara aphids, Family Aphididae
- Order Neuroptera – Lacewings (17 families)
  - Green and brown lacewings, Family Chrysopidae
- Order Coleoptera – Beetles (166 families)
  - Soldier beetles, Family Cantharidae
  - Ground beetles, Family Carabidae
  - Whitespotted sawyer beetle, Family Cerambycidae
  - Ladybird beetles, Family Coccinellidae
  - Fireflies, Family Lampyridae
  - June bugs, Family Scarabaeidae
  - Rove beetles, Family Staphylinidae
- Order Diptera – Two-winged flies (130 families)
  - Balsam gall midge, Family Cecidomyiidae
  - Robber flies, Family Asilidae
  - Hover flies, Family Syrphidae
  - Parasitic flies, Family Tachinidae
- Order Lepidoptera – Butterflies and Moths (127 families)
  - Hemlock looper, Family Geometridae
  - Whitemarked tussock moth, Gypsy moth, Family Lymantridae
  - Blackheaded budworm, Spruce budworm, Family Tortricidae

Order Hymenoptera – Bees, Wasps, Sawflies and Ants (91 families)
- Mound ants, Family Formicidae
- Hornets, Stinging wasps, Family Vespidae
- Parasitic wasps, families Braconidae, Chalcidae, Ichneumonidae
- Trichogramma (Red-eyed bee), Family Trichogrammatidae
- Balsam shootboring sawfly, Balsam fir sawfly, Family Xyelidae

The Fungus Kingdom

This is a very complex group, and the taxonomy has changed a great deal over the years. The following is a list of the fungi mentioned in the manual.

Phylum ASCOMYCOTINA

Order Diaporthales – Cytospora dieback

Order Rhytismatales – Needlecasts

Order Dothideales – Balsam fir tip blight

Order Capnodiales – Sooty mold

Order Helotiales – Snow blight (*Phacidium*)

Phylum BASIDIOMYCOTINA

Order Agaricales – Armillaria root rot

Order Uredinales – Yellow witches' broom
- Needle rusts of firs

Phylum EUMYCOTA

Order Sphaeropsidales – Red flag fungus (*Fusicoccum*)

Appendix 3.
List of common and scientific names

English – Latin

Ants – *Formica* spp.

Armillaria root rot – *Armillaria* spp.

Balsam fir - *Abies balsamea* (L.) Mill.

Balsam fir sawfly – *Neodiprion abietis* (Harr.)

Balsam fir tip blight – *Delphinella balsameae* (Waterm.) E. Müller

Balsam gall midge – *Paradiplosis tumifex* Gagné

Balsam shootboring sawfly – *Pleuroneura brunneicornis* Rohwer

Balsam twig aphid – *Mindarus abietinus* Koch

Balsam woolly adelgid – *Adelges picea* Ratzeburg

Blackheaded budworm – *Acleris variana* Fernald

Black spruce – *Picea mariana* (Mill.) B.S.P.

Bracken fern – *Pteridium aquilinum* (L.) Kuhn

Branch canker – *Valsa abietis* Nitschke

Cattle (cows) – *Bos* spp.

Common chickweed – *Stellaria media* (L.) Vill.

Common fir–bracken rust – *Uredinopsis pteridis* Dietel & Holw.

Common stitchwort (starwort) – *Stellaria graminea* L.

Cytospora dieback – *Valsa friesii* (Duby) Fuckel

Deer – *Odocoileus virginianus* Zimmermann

Field or mouse-ear chickweed – *Cerastium arvense* L.

Fir–fireweed rust – *Pucciniastrum epilobii* G.H. Otth

Fireweed – *Epilobium angustifolium* (L.)

Fir–blueberry rust – *Pucciniastrum goeppertianum* (Kuehn) Kleb.

Fraser fir – *Abies fraseri* (Pursh) Poir.)

Fusicoccum canker – *Fusicoccum abietinum* (R. Hartig) Prill. & Delacr.

Grouse – *Bonasa umbellus* L.

Gypsy moth – *Lymantria dispar* L.

Hares – *Lepus* spp.

Hemlock – *Tsuga canadensis* (L.) Carr.

Hemlock looper – *Lambdina fiscellaria fiscellaria* Guenée

Horse – *Equus ferus caballus* L.

Latin – English

Abies balsamea (L.) Mill. – balsam fir

Abies fraseri (Pursh) Poir.) – fraser fir

Acleris variana Fernald – blackheaded budworm

Adelges picea Ratzeburg – balsam woolly adelgid

Alces alces L. – moose

Armillaria spp. – armillaria root rot

Bonasa umbellus L. – grouse

Bos spp.– cattle (cows)

Cerastium arvense L. – field or mouse-ear chickweed

Choristoneura fumiferana Clemens – spruce budworm

Delphinella balsameae (Waterm.) E. Müller – balsam fir tip blight

Equus ferus caballus L. – horse

Epilobium angustifolium (L.) – fireweed

Erethizon dorsatum L. – porcupine

Formica spp. – ants

Fusicoccum abietinum (R. Hartig) Prill. & Delacr. – fusicoccum canker

Lambdina fiscellaria fiscellaria Guenée – hemlock looper

Larix decidua Mill. – European larch

Lepus americana Erxleben – snowshoe hare

Lepus spp. – hares

Lirula mirabilis, L. nervata, Isthmiella faulli – needle casts

Lymantria dispar L. – gypsy moth

Microtus pennsylvanicus Ord – meadow voles

Mindarus abietinus Koch – balsam twig aphid

Monochamus scutellatus (Say) – whitespotted sawyer beetle

Mus spp. – mice

Neodiprion abietis (Harr.) – balsam fir sawfly

Odocoileus virginianus Zimmermann – deer

Oligonychus spp. – spider mites

Oligonychus ununguis (Jacobi) – spruce spider mite

Orgyia leucostigma Fitch – whitemarked tussock moth

Paradiplosis tumifex Gagné – balsam gall midge

Phyllophaga spp. – white grubs

Larch – *Larix decidua* Mill.

Lowbush blueberry – *Vaccinium angustifolium* Ait.

Meadow voles – *Microtus pennsylvanicus* Ord

Mice – *Mus* spp.

Moose – *Alces alces* L.

Needle casts – *Lirula mirabilis, L. nervata, Isthmiella faulli*

Pine – *Pinus* spp.

Pine grosbeak – *Pinicola enucleator* L.

Porcupine – *Erethizon dorsatum* L.

Red squirrel – *Sciurus vulgaris* L.

Smothering disease – *Thelephora terrestris* Ehrh.

Snowshoe hare – *Lepus americana* Erxleben

Spider mites – *Oligonychus* spp.

Spruce – *Picea* spp.

Spruce budworm – *Choristoneura fumiferana* Clemens

Spruce spider mite – *Oligonychus ununguis* (Jacobi)

White grubs – *Phyllophaga* spp.

Whitemarked tussock moth – *Orgyia leucostigma* Fitch

White spruce – *Picea glauca* (Moench) Voss

Whitespotted sawyer beetle – *Monochamus scutellatus* (Say)

Yellow-bellied sapsucker – *Sphyrapicus varius* L.

Picea glauca (Moench) Voss – white spruce

Picea mariana (Mill.) B.S.P. – black spruce

Picea spp. – spruce

Pinicola enucleator L. – pine grosbeak

Pinus spp. – pine

Pleuroneura brunneicornis Rohwer – balsam shootboring sawfly

Pteridium aquilinum (L.) Kuhn – bracken fern

Pucciniastrum epilobii G.H. Otth – fir–fireweed rust

Pucciniastrum goeppertianum (Kuehn) Kleb. – fir–blueberry rust

Sciurus vulgaris L. – red squirrel

Sphyrapicus varius L. – yellow-bellied sapsucker

Stellaria graminea L. – common stitchwort, starwort

Stellaria media (L.) Vill. – common chickweed

Thelephora terrestris Ehrh. – smothering disease

Tsuga canadensis (L.) Carr. – hemlock

Uredinopsis pteridis Dietel & Holw. – common fir–bracken rust

Vaccinium angustifolium Ait. – lowbush blueberry

Valsa abietis Nitschke – branch canker

Valsa friesii (Duby) Fuckel – cytospora dieback