budworm species, because other lepidopterous species may be present and cause similar feeding injury. Infestations are monitored by aerially mapping affected areas, by examining foliage samples for populations and leaf injury, and by counting the adult moths in pheromone (sex attractant) traps.

For the most recent information on chemicals available for control of this pest, call Agriculture Canada's Pesticide Directorate in Ottawa (toll-free) at 1-800-267-6315.

Chemical pesticides are toxic to humans, animals, birds, fish, and beneficial insects. Follow all instructions and precautions listed by the manufacturer.

Forest Leaflet 9: Spruce budworm
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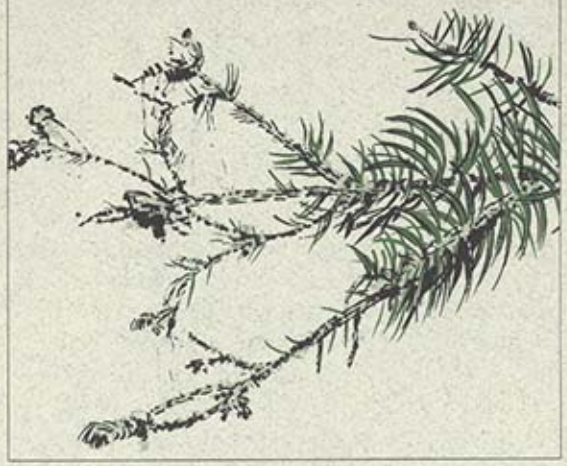
Spruce budworm



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Distribution and Hosts

The spruce budworm (*Choristoneura fumiferana* [Clemens]) is a destructive defoliator insect that is native to spruce and spruce–fir forests in North America. In the prairie provinces and Northwest Territories its larvae feed mostly on white spruce and balsam fir in natural forests, but they may also feed on black spruce and tamarack. Although the mature stands of spruce and spruce–fir are most susceptible to attack, once spruce budworm populations reach high levels the spruce budworm moths migrate to other sites such as immature mixedwood stands, single planted trees, spruce plantations, and shelterbelts. In both urban and rural areas larval feeding frequently takes place on white and blue or Colorado spruces.

Symptoms and Damage

High populations of spruce budworm develop periodically and may last for several consecutive years. During such times, larval feeding is extensive, and trees are eventually killed by the resulting loss of foliage, buds, and cones, and gradual reduction in the rate of tree growth (reduced radial increment in the stem). Feeding damage begins after mid-May, when the young larvae are 2–3 mm long and start to mine and feed within old needles and new buds. The first visible signs of damage appear on the branch tips as silken webbing, which is spun around needles and shoots by the developing larvae for protection during feeding. Terminal buds that retain their bud caps longer than usual in June often indicate the presence of small larvae because of the adhesion of the caps by the silken webbing. Later the young larvae feed more openly on the foliage, staminate flowers, and cones as shoot growth develops. By mid- to late June, the larvae are in the final stage of development and are about 22 mm long; during this time they consume most of their foliage requirements. Feeding is most intense in the upper crowns of trees and on terminal branch tips, where most of the new growth occurs.

Upon completion of feeding in late June, the tree crowns appear rust-brown due to the accumulation of partly chewed needles, dead buds, and larval debris (frass) held together by the silken webbing. Normally, current-year needles and staminate flowers are the favored food, but during periods of high populations larvae may back-feed on older needles, thus increasing the visual damage. After 3 or more consecutive years of defoliation, tree vigor is reduced, top-kill of leaders and some terminal branch shoots may occur, and stem diameter growth is reduced. These effects accumulate as the infestation continues, resulting in tree mortality 5 to 7 years after the start of the outbreak.

Causal Agent

The adult of the spruce budworm species is a gray-brown moth with a wingspan of about 2 cm; it appears in late June and throughout July. During a 2-week period in July, each female moth lays up to 200 eggs after mating, in masses of 15–50 on the undersides of needles that resemble overlapping green scales; they hatch in about 10 days. The resulting small larvae seek out sites under bark scales or staminate flower scars in which to spin silken hibernation shelters for overwintering. The following spring, in late April until mid-May, the larvae come out of hibernation and may disperse on silken threads. They feed in old needles or terminal buds. Once feeding begins the larvae develop rapidly, molting several times and reaching maturity by mid- to late June. At this stage they have yellowish brown bodies with black heads and are 20–22 mm long. They then pupate on the foliage and transform into adult moths in about 10 days, completing a 1-year life cycle.

Prevention and Control

Numerous controlling agents (such as insect parasites and predators, birds, and diseases) contribute to the reduction of all stages of the spruce budworm and help to keep populations in check. In spite of the combined effects of these agents, spruce budworm populations may still build up rapidly and fluctuate dramatically over large areas, due in part to extensive areas of mature and overmature forests, as well as to consecutive dry, sunny spring and summer seasons. Late spring frosts and cool, wet weather may cause populations to decline or collapse.

The methods of control and management of spruce budworm infestation vary widely, depending upon whether the objective is to protect forest properties managed for timber, to preserve high-value recreational sites, or to protect and maintain the visual appearance of single tree plantings. Various chemicals and a bacterial insecticide (*Bacillus thuringiensis*) are registered in Canada for spruce budworm control. For optimum control, insecticidal applications should be made when larvae are 10–15 mm long (the peak of the fourth-instar larval stage), which usually occurs during early June.

On small ornamental trees, young larvae may be removed by hand or dislodged from the foliage by strong jets of water.

In areas managed primarily for timber production, various salvaging and harvesting strategies may be deployed to reduce the risk of spruce budworm population buildup and to minimize tree growth losses resulting from the accumulated effects of defoliation. All decisions to undertake control measures should be based upon identification of the