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Spruce Budworm in the Eastern United States

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The spruce budworm *Choristoneura fumiferana* (Clemens) is one of the most destructive native insects in the northern spruce and fir forests of the Eastern United States and Canada. Periodic outbreaks of the spruce budworm are a part of the natural cycle of events associated with the maturing of balsam fir.

The first recorded outbreak of the spruce budworm in the United States occurred in Maine about 1807. Another outbreak followed in 1878. Since 1909 there have been waves of budworm outbreaks throughout the Eastern United States and Canada. The States most often affected are Maine, New Hampshire, New York, Michigan, Minnesota, and Wisconsin. These outbreaks have resulted in the loss of millions of cords of spruce and fir.

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Figure 1.—Mature larva of the spruce budworm.

Balsam fir is the species most severely damaged by the budworm in the Eastern United States. White, red, and black spruce are suitable host trees and some feeding may occur on tamarack, pine, and hemlock. Spruce mixed with balsam fir is more likely to suffer budworm damage than spruce in pure stands.

The range of the spruce budworm includes the Northern States east of Montana but the budworm is found wherever host species grow (fig. 2).

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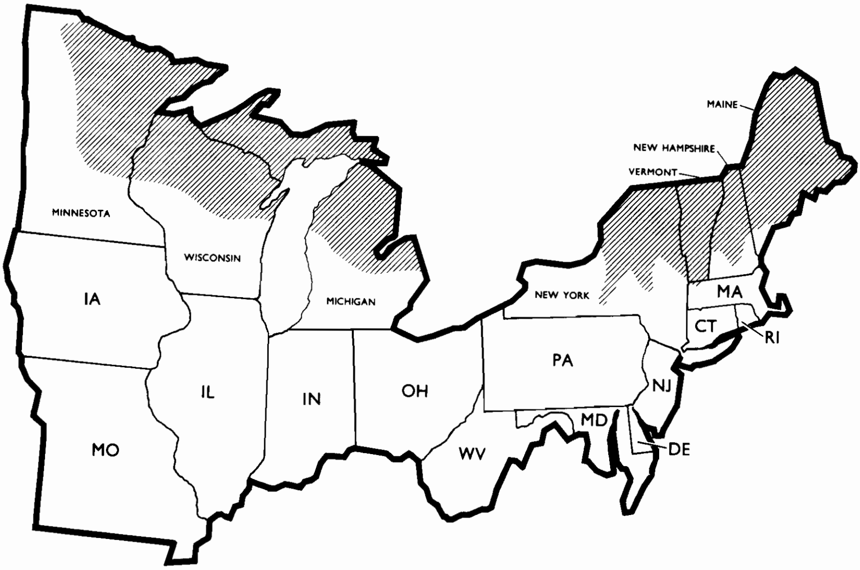

Figure 2.—Distribution of the Spruce budworm in the Eastern United States coincides with the range of balsam fir and spruce.

Damage and Evidence of Infestation

The newly hatched budworm larva is very small and difficult to find because it bores into and feeds on needles or expanding buds. These larvae can cause severe damage to the expanding buds. As the larva grows, needles are severed at the base and left hanging in a thin silken web. The severed needles turn brown, giving the defoliated tree a scorched appearance (fig. 3). This condition is apparent from about mid-June until late August, depending on the weather and latitude.

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Figure 3.—Balsam fir needles mined by spruce budworm larvae.

Early in an epidemic, defoliation is usually most noticeable in the top portion of the crown. After several years of heavy defoliation, the forest turns gray as dead tops become conspicuous (fig. 4). Individual trees die after 1 or more years of heavy defoliation, depending on their general vigor.

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Figure 4.—Severely defoliated balsam fir (left); red spruce with slight defoliation (right).

Description

The adult moth has a wing span of 2 centimeters. It is usually grayish with dark brown markings (fig. 5). Some moths are brown or reddish with gray markings. Males and females occur in about equal numbers.

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Figure 5.—An adult spruce budworm.

The light green eggs are about 1 millimeter long by 0.2 millimeter wide. The eggs, laid in elongate masses of 2 to 60—averaging about 20, overlap one another (fig. 6).

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Figure 6.—Egg mass of the spruce budworm.

Larvae go through six instars. The first larval instar, about 2 millimeters long, is yellowish green with a light- to medium-brown head. The second instar is yellow with a dark brown or black head. During the next four instars, the body of the larva changes from a pale yellow to a dark brown with light-colored spots along the back. In the sixth instar, the larva is about 2.5 centimeters long and the head is dark brown or shiny black. The pupa is pale green at first, later changing to reddish brown. It is marked with darkened bands and spots (fig. 7).

Life History and Habits

There is one generation of the spruce budworm each year. The female moth lays eggs on the flat undersurface of balsam fir or spruce needles, generally within 3

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Figure 7.—Pupa of the spruce budworm.

inches of the buds or defoliated area. In extremely high populations, eggs may be laid on almost any surface. Eggs are distributed more evenly on foliage of host trees in the Northeastern United States and eastern Canada than on those of western species. The eggs hatch in about 2 weeks. Usually, newly hatched larvae immediately seek a suitable place to spin their hibernacula or cocoon-like shelters. However, during warm periods, larvae may move about and feed on needles before spinning a hibernaculum. In doing so, they may spin down from a branch on a silken thread and be carried away by air currents. Larval dispersal at this stage is one means of spread within and beyond the infested stands. The young larva transforms into the second instar or stage within the hibernaculum and remains dormant over the winter. Old staminate flower bracts are preferred as overwintering sites, but bud scales and bark crevices are also used.

In the spring—after several days of warm weather, but before the balsam fir buds begin to expand—the larva emerges from hibernation and begins feeding. Early feeding is first confined to the new buds of staminate flowers if present, or the larva mines the previous year's needles if staminate flowers are scarce. The new flower buds provide a ready source of food before the vegetative buds expand. The early emerging larvae that feed on staminate flower buds grow much more rapidly and have a higher survival rate than those that feed on old needles.

The larva migrates to the end of a twig and bores into a needle or an expanding vegetative bud. Some larvae spin down on silken threads and, as first instar larvae, may be dispersed by air currents. The larvae feeding on staminate flower buds and flowers stay in place until the immediate food supply is depleted. Later, the larva feeds on the new foliage of developing shoots. When the larva is in the fifth instar, it begins tying the tips of twigs together with silk, forming a small nest. The new foliage is eaten first. In epidemic situations, old needles and bark (near branch tips) may also be consumed to such a degree that branch tips and terminal shoots are destroyed. During late June through mid-July, depending on the weather, the larva completes development and stops feeding.

The larva then transforms to a pupa, generally within the last-formed webbing. Some pupae are found at the axils (needle base) of the twigs. The moth emerges about 10 days later (in late June through mid-July). Peak moth flight activity occurs from about 7:30 p.m. to 11:30 p.m. Moths may be carried up to 10 miles or more by winds and can be transported hundreds of miles by storm fronts.

Natural Control

The spruce budworm has a high reproductive capacity, but natural factors such as adverse weather, diseases, predators, and parasites play an important part in holding budworm populations in check. For example, high rates of parasitism of mature larvae by tiny parasitic wasps such as *Meteorus trachynotus* Viereck and *Phaeogenes hariolus* (Cresson) and by a tiny parasitic fly, *Lypha setifacies* (West), were seen in a declining budworm population in Maine and New York. But several successive years of favorable weather (warm, dry springs), adequate food, and suitable hibernation sites can lead to an outbreak beyond the control of these and other natural agents. Once a spruce budworm outbreak begins, it usually continues until the larvae consume much of the available foliage. As a result, the use of biological and chemical insecticides may be necessary to supplement natural control agents.

Integrated Pest Management

The use of various tactics, such as biological insecticides, silvicultural practices, and chemical insecticides, in combination, is termed integrated pest management. For forest landowners, several tactics may be available, while the homeowner with only one or two trees has more limited options. A discussion of various management and control techniques follows.

Biological control agents—Recent developments in the use of diseases as biological control agents hold some promise for spruce budworm control. At the present time, biological insecticides are more expensive than conventional chemical insecticides. In 1948, a polyhedral virus disease was reportedly found in budworm populations. The infectious nature of this disease was later demonstrated. With few exceptions, budworm larvae that were fed polyhedra showed effects of the disease within 72 hours. However, many larvae survived, indicating that the virus was not particularly deadly. At least four viruses are known to be endemic in North America (nucleopolyhedrosis, granulosis, cyloptasmic polyhedrosis, and entomopox). However, the current cost of applying a virus such as the nucleopolyhedrosis virus is about 30 times as expensive as applying chemical insecticides.

A microsporidian disease, *Perezia fumiferanae* Thomson, slows the rate of budworm development during the larval and pupal stages. The lifespan of infected adults is shortened. Females are affected more than males. To date, neither viruses nor fungi have provided sufficient control in field trials.

Both field tests and operational applications of the bacterial pathogen *Bacillus thuringiensis (B.t.)* effectively controlled moderate populations of less than 50 larvae per 18-inch branch. However, in extreme populations of more than 8,000 egg masses per 100 square feet of foliage, *B.t.* did not protect foliage or reduce the population significantly.

Indirect control—Budworm outbreaks develop and gain momentum in the Northeastern United States only when there is a large proportion of mature and overmature balsam fir in the forest. Management practices including a greater use of balsam fir, regulating age classes to prevent the occurrence of overmature balsam fir over large areas, and favoring or planting less susceptible species such as spruce make conditions generally unfavorable to the budworm and may materially reduce the risk of an outbreak.

In the Lake States, young balsam fir trees (1.5- to 4.6-m tall) growing next to mature balsam fir or white spruce stands often support heavy overwintering populations of the budworm. Vegetative buds, mined by spruce budworm larvae previously blown in or dropped from the overstory balsam fir, provide suitable hibernation sites for the next generation. Larvae are able to survive the winter and continue the infestation on these young trees the following year. One way to prevent infestations in young trees growing under a mature balsam fir and white spruce overstory is to remove the overstory trees and replant the stand with nonsusceptible species such as white pine. Insecticides can be applied to adjoining mature stands to protect the young stands nearby.

Direct control—Application of chemical or biological insecticides is the most economical way to prevent widespread damage caused by heavy budworm populations. Aerial spraying of registered insecticides satisfactorily controls larvae and, when applied against early instars, provides effective foliage protection. Among the registered insecticides in addition to *B.t.* are carbaryl, trichlorfon, acephate, malathion, and fenitrothion. Several insecticides are registered for use under the supervision of licensed applicators. *B.t.* and fenitrothion are registered for use only in the Eastern United States. Therefore, appropriate State forestry agencies or the U.S. Department of Agriculture, Forest Service, should be consulted for further details before applying insecticides for budworm control. Special care must be taken when treating infested stands near streams and lakes or other environmentally sensitive areas.

Spraying does not kill all the larvae because some are protected by the webbed foliage within which they are feeding. An accurately performed application of a registered insecticide will reduce larval populations sufficiently to retain 35 or more percent of the foliage (fig. 8). This is enough to keep trees alive, or until they can be harvested.

Caution: Pesticides used improperly can be injurious to man,

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Figure 8.—Color infrared photo of a treated white spruce plantation: the spray swath is next to the road in left of photo.

animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or when they may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary landfill dump or crush and bury them in a level, isolated place.

Note: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure the intended use is still registered.

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