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Eastern Spruce Budworm: Management Approaches in Minnesota's Forests

Matthew Russell (Extension Specialist-Forestry) and Michael Albers (Minnesota Department of Natural Resources, retired)

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The eastern spruce budworm (*Choristoneura fumiferana*) is a native forest insect of concern across Minnesota's coniferous forests. Spruce budworm is responsible for defoliating and/or killing vast acreages of balsam fir and spruce annually in Minnesota. Despite its name, balsam fir trees are most susceptible to budworm while spruces are moderately susceptible. Fortunately, these important conifer species can be protected through effective forest management.

Large-scale outbreaks of spruce budworm in the eastern Canadian provinces and northern New England typically occur cyclically every 30 to 40 years. In Minnesota, budworm activity has been observed every year since at least 1954, representing an endemic budworm population for over 60 years. Budworm outbreaks in Minnesota typically occur in the same area every 25 to 40 years. Estimates from the Department of Natural Resources suggest that annual budworm defoliation averaged 94,500 acres of Minnesota's forests from 2010 through 2014.

SYMPTOMS

Life cycle

The eastern spruce budworm is a native insect that has evolved with forests across the US Lake States. Moths lay up to 10 egg masses on spruce and balsam fir needles in July. Larvae soon hatch from the eggs and spin down on a silk tread which can blow a considerable distance by wind. After overwintering, young larvae emerge just before balsam fir budbreak in the spring (Fig. 1).

Fig. 1. Eastern spruce budworm larvae (photo: Max McCormack).

Budworm larvae feed on new foliage growth through May and June then pupate and emerge as moths by mid-July. These adult moths will mate, lay eggs, and eventually die in the summer. Moths are effective fliers and use wind currents to disperse over long distances.

Populations remain in outbreak stage in a forest stand until much of its food source, i.e., mature and overmature balsam fir and spruce, is killed. When an outbreak of budworm occurs, it typically will remain in that area defoliating trees for the next eight to ten years.

Tree symptoms and vulnerability

Budworm feeding damage is first noticed on outer branch shoots in the upper crowns of spruce and fir trees. Partially eaten needles are webbed onto branch tips and turn a reddish-brown color (Fig. 2). Long-term damage of budworm defoliation can result in top kill in two to three years for balsam fir or three to five years in white spruce (Table 1). Additional years of feeding cause tree mortality.

Fig. 2. Eastern spruce budworm damage to new foliage of white spruce (photo: Mike Albers).

Complete stand mortality is rare following a budworm outbreak, but can occur in patches located within stands. Although trees can tolerate repeated defoliations (white spruce more so than balsam fir), tree growth is reduced. When mortality occurs, it is initially concentrated on smaller-diameter trees that are in an intermediate or suppressed crown position within the stand. Many years of repeated defoliation can result in death of the majority of overstory and understory fir trees.

Table 1: Species susceptibility to eastern spruce budworm.

TYPE	BALSAM FIR	WHITE SPRUCE
Top kill	2 to 3 years	3 to 5 years
Mortality	3 to 5 years	5 to 7 years
Survival under repeated defoliation	Low	Moderate (higher than fir)

Dense stands with high basal area in balsam fir and low proportions of non-host species are most vulnerable to budworm damage (Table 2). When a spruce budworm outbreak begins, less susceptible stands include those that have high proportion of density in non-host species and are comprised of healthy and vigorous trees as indicated by large live crown ratios (e.g., in excess of 40% in white spruce).

Table 2: Vulnerability to spruce budworm in spruce-fir stands (Batzer and Hastings 1980). Values in the table represent the percentage of balsam fir likely to die in the stand as a result of defoliation. The shaded region indicates potential balsam fir mortality greater than 75%.

	PRETREATMENT BALSAM FIR BASAL AREA (FT^2/AC)					
Stand basal area in non-host species (%)	20	40	60	80	100	120
0	75%	88%	90%	91%	93%	93%
10	55%	75%	83%	86%	89%	90%
20	35%	65%	77%	81%	84%	87%
30	15%	55%	68%	76%	80%	83%
40	-	45%	62%	71%	76%	79%
50	-	35%	55%	65%	72%	76%
60	-	23%	48%	60%	68%	73%

MANAGEMENT STRATEGIES

Forest management actions can be taken to mitigate losses in the spruce-fir resource from budworm damage. When budworm populations begin to be noticed in stands with high merchantable volumes of balsam fir, the landowner should make plans to have them harvested as soon as possible. Given there are few markets for dead and dying spruce or balsam fir, waiting to harvest trees is not recommended. A dark bluish-gray discoloration may be observed on the wood surface when bark is peeled back from a branch with wilting leaves.

Thinning strategies

In white spruce stands, both pre-commercial and commercial thinning strategies can be used to promote healthy and vigorous trees that can be less susceptible to spruce budworm damage. In white spruce plantations, pre-commercial thinning should be considered in stands with greater than 800 trees per acre.

For commercial thinnings, plantations between 35 and 45 years are most likely to respond well to thinnings (Fig. 3). Thinning from above, i.e., removing trees from dominant and codominant trees to favor the best trees in those crown classes, should be avoided. Seek to retain trees with greater than 40% live crown ratio (the ratio of the size of a tree's live crown to its total height). Plantations greater than 55 years old that have never been thinned are not likely to respond to thinning (Table 3). Any stand and especially older stands thinned during a budworm outbreak will not respond favorably to thinning. Thinning adds additional stress to trees already stressed by budworm defoliation.

Fig. 3. A 43-year-old white spruce plantation that has been recently thinned (photo: Matt Russell).

It is not uncommon to experience some tree mortality following thinning. In particular, as white spruce is a shallow-rooted tree, injuries to roots, debarking, and breakage can be experienced. Thinning can also lead to windthrow if too much basal area is removed.

If a stand is in a merchantable condition and experiencing the beginning of a budworm outbreak, a pre-salvage harvest operation should be considered.

Table 3: Considerations for thinning in white spruce plantations to offset spruce budworm damage.

Scenario	Should you thin?	Considerations
Pre-commercial thinning		
Young stands with greater than 800 trees per acre	YES	Remove 50% of trees. Retain trees with greater than 40% live crown ratios to promote a vigorous and healthy stand.
Commercial thinning		
35 to 45-year old stands in a healthy condition	YES	Commercially thin to basal area of 90 to 110 ft^2/ac, or 50% of basal area. Retain trees with greater than 40% live crown ratios.
Stands greater than 55 years old that have never been thinned	NO	Trees are unlikely to respond to thinning. Consider clearcutting.
Older stands currently experiencing a spruce budworm outbreak		

Harvest operator considerations

Commercial thinning operations should occur on frozen soils with snow cover to minimize damage to roots. Thinning operations on wet soils should be avoided. Orienting skid trails perpendicular to planted trees can allow harvesting equipment to keep a distance from the base of the tree. Leaving three feet or more between equipment and trees can help to prevent root damage.

Chemical control

The limited demand for balsam fir as a wood product has precluded the use of pesticides across large regions in Minnesota. Insecticides such as the bacterial pathogen *Bacillus thuringiensis* (Bt) have been successful in maintaining productivity in stands experiencing moderate infestations of spruce budworm. Spraying forests can be used to keep trees alive in anticipation of a harvest that will soon occur. However, the cost of multiple sprayings and the minimal success of treatments have led managers to seek less costly management strategies (e.g., thinning).

Yard trees can be sprayed to protect foliage and kill spruce budworm. Pesticides must be applied early in the year prior to budworm needle feeding that begins in June. Applications will need to occur in each year during the budworm outbreak. Because the spray has to reach to the tops of tall trees, it is usually difficult for homeowners to get adequate spray coverage. The Minnesota Department of Agriculture has a list of licensed pesticide applicators if a homeowner is considering pesticide application. Otherwise, keeping yard trees healthy by protecting root systems from damage, watering during dry periods, and mulching around trees will help to retain soil moisture.

Fire risk

If dead and dying trees are not removed, they become a fire hazard around homes and buildings and contribute to increased fire risk.

SUMMARY

- Spruce budworm activity has been observed in Minnesota every year since at least 1954.
- Management strategies include commercially thinning healthy stands to retain trees with greater the 40% live crown ratio.
- Costs and limited success has precluded the use of pesticide for spruce budworm across Minnesota's forests, but is an option for saving yard trees.

ADDITIONAL RESOURCES

Albers, J. and M. Albers. Spruce problem diagnosis for yard trees (Minnesota Department of Natural Resources): http://files.dnr.state.mn.us/assistance/backyard/treecare/forest_health/whitesprucediagnosis.pdf

Anderson, D.P. and B.R. Sturtevant. 2001. Pattern analysis of eastern spruce budworm *Choristoneura fumiferana* dispersal. *Ecography* 34:488-497.

Batzer, H.O. and A.R. Hastings. 1980. How to rate spruce-fir vulnerability to budworm in Minnesota. US Department of Agriculture Forest Service, North Central Forest Experiment Station, St. Paul, MN.

D'Amato, A.W., S.J. Troumbly, M.R. Saunders, K.J. Puettmann, and M.A. Albers. 2011. Growth and survival of *Picea glauca* following thinning of plantations affected by eastern spruce budworm. *Northern Journal of Applied Forestry* 28:72-78.

Firewise in Minnesota (MN Department of Natural Resources): http://www.dnr.state.mn.us/firewise/index.html

Kucera, D.R. and P.W. Orr. Spruce budworm in the eastern United States. Forest Insect and Disease Leaflet 160. US Department of Agriculture Forest Service: http://na.fs.fed.us/spfo/pubs/fidls/sbw/budworm.htm

Minnesota Department of Agriculture Pesticide Program: http://www.mda.state.mn.us/chemicals/pesticides.aspx

What's wrong with my plant? Evergreens (University of Minnesota Extension): http://www.extension.umn.edu/garden/diagnose/plant/evergreen/

Photo credits: Max McCormack, Mike Albers, and Matt Russell

This publication was reviewed by Jeff Hahn (University of Minnesota, Extension Entomologist).

For more information:
www.myminnesotawoods.umn.edu