Western Spruce Budworm

Choristoneura occidentalis Freeman
Lepidoptera: Tortricidae

Twardus, D. B. 1985. Surveys and sampling methods for population and damage assessment. In: Brookes, M. H.; Bolbert, J. J.; Mitchell, R. G.; Stark, R. W., editors. Managing trees and stands susceptible to western spruce budworm. Tech. Bull. 1695. Washington, DC: *U.S. Department of Agriculture, Forest Service*; 27-40.

Objective: To provide a comprehensive review of sampling techniques used to describe *C. occidentalis* populations and defoliation levels.

Abstract: The western spruce budworm, *Choristoneura occidentalis* Freeman, is an important pest of Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, true firs, *Abies* spp., Englemann spruce, *Picea englemannii* Parry ex. Englem., and larch, *Larix occidentalis* Nutt., in the western USA and Canada. Infestations in mature stands cause growth loss, top kill, and occasional tree mortality. Douglas-fir that is defoliated severely or top-killed is often subsequently attacked by the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins. A review of sampling techniques used to describe *C. occidentalis* populations and defoliation levels is presented. Defoliation estimates are based on aerial surveys, ground based surveys with binoculars, and mid-crown branch samples. The sampling of egg masses, third and fourth instar larvae, late instar larvae, and pupae provided reliable estimates of population density.

Sampling Procedure:

Defoliation assessments:

Sketch-map surveys: This is the most common aerial survey method used to detect, delineate, and provide crude estimates of defoliation levels. Time surveys to occur during peak damage expression, which is typically during late July through early August. Surveys are conducted by fixed-wing aircraft at speeds of 130-180 km/h several hundred meters above ground. Reference the table below to connect the appearance of defoliated stands to actual defoliation from ground surveys.

Aerial defoliation class	**Appearance from the air**	**Ground defoliation (%)**
None	No visible change in foliage	<10%
Light	Light browning of crown	20-40%
Moderate-Heavy	Orange to light brown cast to foliage	50-100%
Severe	Entire crown appears gray;	50-100%

	top kill and tree mortality observed	

Aerial photography: This method is used to map and evaluate budworm-caused defoliation, which is evident as color changes on the photograph.

Whole-tree or binocular assessment: This method is a ground-based estimate that is subjective, but allows for rapid classification of defoliation levels. Divide the tree crown visually into thirds, and assign a defoliation code to each level (lower, mid-, upper):

Class	Percent defoliation
1	0
2	1-25
3	26-50
4	51-75
5	76-99
6	100

Express defoliation for each tree as an average of the three levels.

Mid-crown branch samples: This is the most common method used to estimate branch defoliation. Clip 46-cm branch samples from the mid-crown of trees 7-14 m tall. Each of 25 apical shoots per branch is rated using the six-class system described above. Estimates are based only on current year's defoliation.

Population assessments:

Egg-mass sampling: This method is one of the most common techniques used for estimating populations, and can be conducted over large areas without excessive time restrictions. Planning insecticide treatments requires considerable advanced notice, and egg mass densities are used to predict subsequent defoliation for decision-making procedures. The positive linear relationship between egg mass density and subsequent infestation class allows egg mass densities to be used to predict population density the following year (Carolin and Coulter 1972). Density increases with crown height, but equations are available for estimating whole-plot density based on mid-crown samples (Srivastava and others 1984).

A sequential sampling plan is available that predicts subsequent defoliation based on new egg mass counts obtained from 61-cm branch samples (McKnight and others 1970). Sample a minimum of 25 Douglas-fir trees, 15-21 m in height, and without top kill or severe defoliation. Collect two branches from each tree, and count all new egg masses.

After 25 trees have been sampled (50 branches), reference the sequential sampling table (McKnight and others 1970), and continue sampling until a decision is met and populations are classified in one of four categories:

Class	New egg masses per 61-cm branch	Defoliation prediction
1	≤0.250	Undetectable (<5%)
2	0.275-1.0	Undetectable to light (5-35%)
3	1.5–5.0	Light to moderate (35-65%)
4	≥5.5	Moderate to heavy (>65%)

<u>Sampling overwintering larvae:</u> Several methods have been developed, but none receive significant application.

<u>Sampling early-instar larvae</u>: Time surveys to coincide with the predicted peak of the third and fourth instar stages. Select a minimum of 15 trees randomly, 7-14 m in height, within a 5-ha plot. Remove two sample branches from the mid-crown. Branch length should be measured from the base of the foliage to the tip. Branch width is measured perpendicular from the midrib to the outermost edge. Estimate foliage surface area per branch by dividing the product of length and width by two. After measuring each branch, remove a 45-cm terminal tip, and count and record the number of larvae present. Srivastava and others (1984) found that whole-plot density (WS_L) per square meter of foliage was related positively to average density of *C. occidentalis* per plot (X_M) (WS_L + 0.238 (X_M), R^2 = 0.98).

To conduct a quick sample, collect 45-cm terminal tips sequentially from the mid-crown of each tree. Density is classified relative to a predetermined threshold:

Larvae per 45-cm tip	Infestation class
0-3	Light
4-7	Moderate
≥8	Heavy

Alternative sampling plans distinguish between light and moderate-to-heavy infestations (Table 5-5), and light-to-moderate and heavy infestations (Table 5-6).

<u>Sampling late instar larvae:</u> This is the most common method used for evaluating the efficacy of insecticide treatment, which is timed near the predicted peak of the fifth instar stage of *C. occidentalis*. Sample three 45-cm branches at the bottom of the crown on each of 25 trees per plot.

Beat each branch against a hand-held cloth to dislodge larvae, and count and record the number of larvae. Refer to Figure 5-5 to relate beat sample counts to the number of larvae per square meter of foliage.

Sampling pupae: Pupae are most vulnerable to predation, and therefore samples should be conducted after natural mortality has occurred. Select a minimum of 15 trees randomly, 7-14 m in height, within a 5-ha plot. Remove two sample branches from the lower crown. Measure branch area as described above. After measuring each branch, remove a 45-cm terminal tip, and count and record the number of pupae present. Whole plot density (WS_P) per square meter foliage is related positively to the average density per plot (X_L) ($WS_P = 0.629\ (X_L)$, $R^2 = 0.89$) (Srivastava and others 1984).

Sampling Adults: The attraction of moths to light traps is used to monitor population changes in low density infestations. Pheromone-baited sticky traps may have promise for forecasting future stand risks.

Note: This review describes briefly several techniques available for monitoring *C. occidentalis* populations. We refer you to the original publication if more detailed information is desired.

References:

*Carolin, V. M.; Coulter, W. K. 1972. Sampling populations of western spruce budworm and predicting defoliation on Douglas-fir in eastern Oregon. Res. Pap. PNW-149. Portland, OR: *U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station*; 38 p.

*McKnight, M. E.; Chansler, J. F.; Cahill, D. B.; Flake, H. W., Jr. 1970. Sequential plan for western budworm egg mass surveys in the central and southern Rocky Mountains. Res. Note RM-174. Fort Collins, CO: *U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station*; 8 p.

*Srivastava, N.; Campbell, R. W.; Torgersen, T. R.; Beckwith, R. C. 1984. Sampling the western spruce budworm: fourth instars, pupae, and egg masses. *Forest Science* 30: 883-892.

Figure and Tables:

Table 5-5. Sequential classification scheme for separating light from moderate-to-heavy populations of fourth instars at 95 percent confidence level (adapted from Srivastava and Campbell 1983 unpubl.)

Number of trees	Cumulative number of budworm larvae[1]	
	Light	Moderate to heavy
5	<1	>37
10	<10	>64
15	<20	>90
20	<31	>114
25	<43	>138
100	<235	>477

[1]If a count falls between the limits in the two columns, continue sampling.

Table 5-6. Sequential classification scheme for separating light-to-moderate from heavy populations of fourth instars at 95 percent confidence level (adapted from Srivastava and Campbell 1983, unpublished)

Number of trees	Cumulative number of budworm larvae[1]	
	Light to Moderate	Heavy
5	< 11	> 51
10	< 36	> 117
15	< 64	> 165

20	< 92	> 212
25	< 121	> 258
100	< 592	> 917

[1]If a count falls between the limits in the two columns, continue sampling.

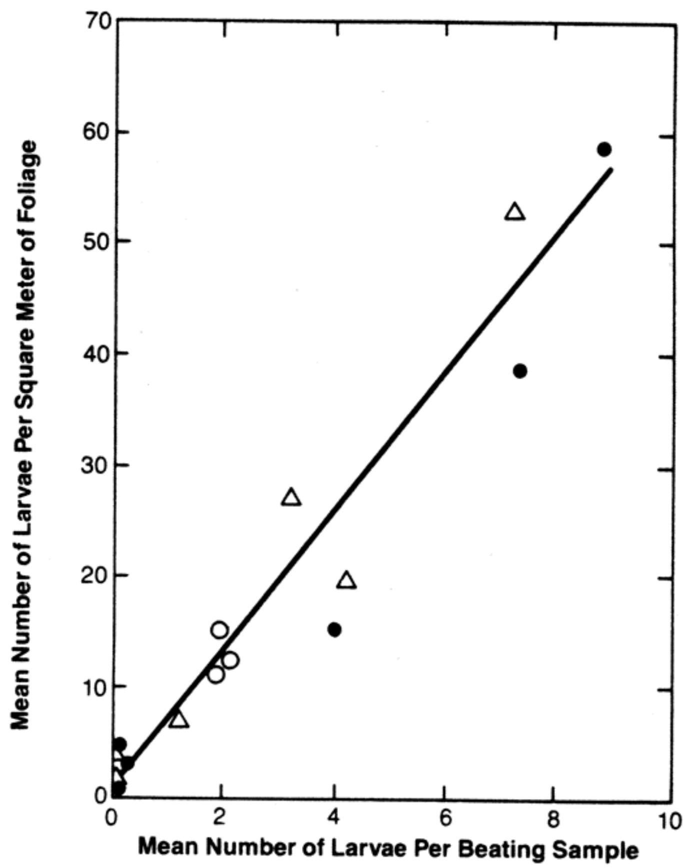

Figure 5-5—Relation of larvae from lower crown branch beating to larvae from midcrown branch samples.