Spruce Budworm
Choristoneura fumiferana (Clemens)
Lepidoptera: Tortricidae

ABSTRACT: The spruce budworm, *Choristoneura fumiferana* (Clemens), is the most destructive defoliator of balsam fir, *Abies balsamea* (L.) Mill., and white spruce, *Picea glauca* (Moench) Voss, in eastern North America. The last three larval instars cause most of the defoliation. Periodic outbreaks occur every 30 years and epidemics can last 5-10 years. A study was conducted near Black Sturgeon Lake, Ontario, Canada to determine the sample size needed to estimate the population density of 3rd, 4th, and 5th instar *C. fumiferana* larvae on 45 cm branch tips of balsam fir and white spruce.

The distribution of larvae at densities <0.1 larvae per branch tip was nearly random but became aggregated at densities >0.2 larvae per tip for both host species. This method of estimation works well up to a density of 50 larvae per tip. The suitability of this sampling method for estimating late instar larval density is discussed.

OBJECTIVE: To determine the sample size required to estimate larval populations of *C. fumiferana* at 65% and 95% confidence levels and at various precision levels.

SAMPLING PROCEDURE: To determine the number of samples needed, given the budworm density per 45 cm branch tip and the desired precision level, refer to Table 1. Select dominant and codominant balsam fir or white spruce in the most representative area(s) of the area of concern. With a set of pole pruners, cut a 45 cm branch tip from the mid-crown of each sample tree when larvae are 3rd, 4th, and 5th instar. Place and store each branch in a brown paper bag. In the laboratory, examine the buds (and shoots) and record the number of larvae.

The sample size needed to achieve a given degree of precision is based on the estimates of the mean ($\overline{X}$), variance (S^2) and the level of precision desired. When precision is expressed in terms of a confidence interval at the (1-α) probability level, the half-width of which is selected as a constant proportion (C) of the mean, the optimal sample size (n) is given by

$$n = \left(\frac{Z_{\alpha/2}}{C}\right)^2 \frac{2.08}{\overline{X}^{0.75}}$$

where $z_{\alpha/2}$ is the upper $\alpha/2$ point of the standard normal distribution (under the assumption that the sample sizes involved are >30). When sample sizes are small (<30), t can be used as the standard deviate corresponding to the desired probability level (Student's t).

NOTES: The execution of this sampling plan requires that the user has prior knowledge of the larval density in the area(s) to be sampled. The distribution of

larvae at higher densities (>50 larvae per 45 cm tip) approximates the negative binomial distribution, indicating that the 45 cm branch tip is either not a particularly appropriate sample unit or that a different expression of density is required to reduce sample variance.

TABLE:

Table 1. Sample sizes required to achieve various levels of precision relative to the mean, based on the standard error of the mean (65% confidence intervals) or on 95% confidence intervals at various densities of spruce budworm larvae.

Density per 45-cm tip	Standard error of the mean			95% confidence interval		
	15%	20%	25%	15%	20%	25%
0.01	2923	1644	1052	11230	6317	4043
0.1	874	492	315	3359	1889	1209
0.25	520	292	187	1997	1123	719
0.5	156	88	56	597	336	215
1.0	92	52	33	355	200	128
2.5	47	26	17	179	101	64
5.0	28	16	10	106	60	38
10.0	16	9	6	63	36	23

Table 1 reprinted with permission from the Canadian Entomologist, January 15, 2001.