Frontline

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FORECASTING DEFOLIATION BY THE JACK PINE BUDWORM

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CATEGORY: Pest management
KEY WORDS: Jack pine budworm, jack pine, defoliation

INTRODUCTION

The jack pine budworm (*Choristoneura pinus pinus* Free.) is a native defoliator of jack pine (*Pinus banksiana* Lamb.) in North America, and outbreaks of this pest can cause severe damage in mature stands. Such defoliation causes measurable growth loss in the year immediately following infestation. Repeated defoliation causes mortality of suppressed or understory trees as well as topkill of dominant or codominant trees. The jack pine budworm caused average annual losses of nearly 2 million cubic meters of jack pine in Ontario forests between 1982 and 1987.

The aerial application of insecticides to suppress outbreak populations of this budworm has been utilized in Ontario repeatedly since 1968. These control operations require accurate forecasts indicating where intolerable defoliation is likely to occur. Historically, the methods used for predicting defoliation by the jack pine budworm have been the same as those developed for the closely related spruce budworm—sampling egg masses and/or overwintering larvae. When applied to the jack pine budworm, however, these methods of forecasting have proven to be inadequate because simple relationships between estimated densities of egg masses or overwintering budworm larvae and subsequent defoliation are not consistent. This note describes a method to improve conventional forecasts using either egg-mass or overwintering budworm larvae density by incorporating estimates of pollen-cone abundance. The method should permit improved forecasting of defoliation by the jack pine budworm at the stand level.

SAMPLING AND THE JACK PINE BUDWORM

The jack pine budworm has one generation per year. The female moth lays masses of 30 to 40 eggs on the foliage of jack pine trees. In Ontario, the total number of egg masses found on one 60-cm branch tip sampled from the mid-crown of six trees is used to forecast defoliation classes.

Budworm larvae hatching from these eggs move to sheltered positions under bark scales and spin hibernation sites. They remain in these sites, and can therefore be sampled from late summer until emergence the following spring. Sampling methods, and the size of sample required for fixed levels of precision of this overwintering stage, have been developed. In Ontario, at least ten 1-m branches from the mid-crown of codominant trees constitutes a point sample of overwintering jack pine budworm.

Budworm emerging in the spring feed first on the pollen cones (microstrobili) of jack pine, but eventually move to feed on current-year vegetative shoots. Survival of these budworms is strongly related to the abundance of pollen cones in the stand (Fig. 1). Quantification of this relationship is the basis for the modified approach described here.

Jack pine budworm complete a total of seven instars and then pupate on the tree. Once feeding stops and the entire population has pupated, an estimate of defoliation can be made. In most areas, including Ontario, broad categories representing light,

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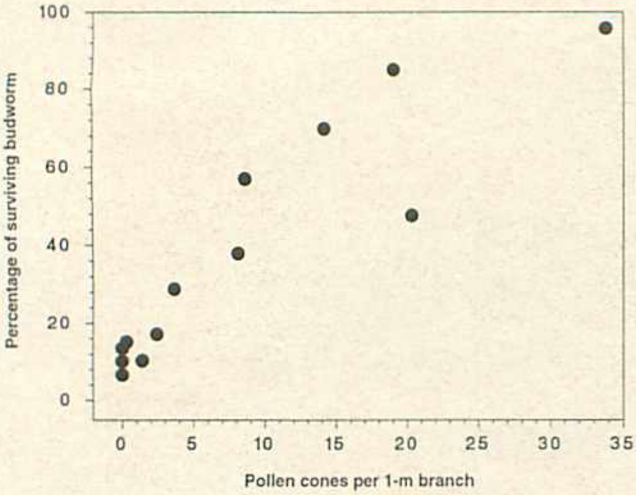

Figure 1. Percentage of emerging overwintered budworm that survive to establish feeding sites as a function of pollen-cone abundance in the stand.

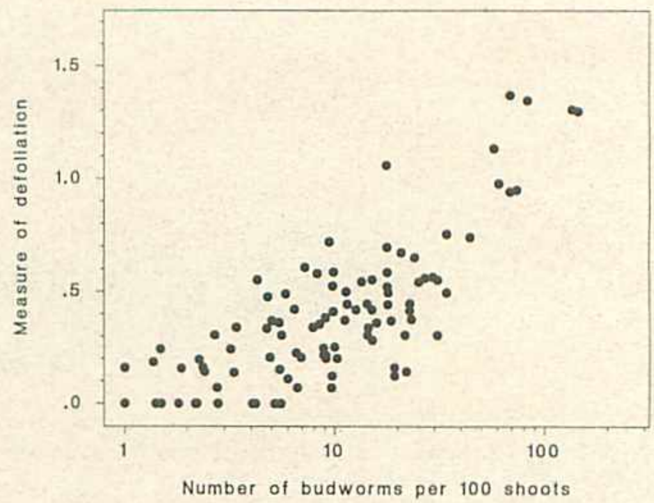

Figure 2. Defoliation of jack pine as a function of the number of feeding jack pine budworm per 100 shoots. Defoliation is measured as a percentage, but expressed here as a transformed value (arcsine) in order to satisfy the conditions for regression analyses.

moderate, or severe defoliation (roughly less than 25 percent, 25 to 75 percent, and greater than 75 percent, respectively, of the current-year shoots removed) are determined by visual inspection by experienced observers. Typically, defoliation is assessed on a single 60-cm branch taken from the mid-crown of a codominant tree. Each sample point represents a total of six to ten such branches.

Recent field data gathered with these sampling elements were combined in a series of regression models. The resulting model was assessed for its ability to predict defoliation in an independent data set.

MODEL DEVELOPMENT

Estimates of the density of various life stages of the jack pine budworm, and of defoliation, were obtained for several sites in northeastern Ontario and adjacent Michigan. The authors first identified the life stage of the jack pine budworm for which the density was best correlated with defoliation. As expected, neither egg-mass nor overwintering budworm densities by themselves were well correlated to subsequent defoliation. However, the density of feeding budworm could be used to predict defoliation with an acceptable degree of confidence (Fig. 2).

Estimation of the density of even the early stages of feeding jack pine budworm occurs too late in the season to be useful for planning control operations. It is necessary to find a way of linking density estimates for earlier life stages, such as eggs or overwintering budworm, to the density of feeding insects and hence to defoliation. The relationship between the abundance of overwintering and feeding budworm is determined by the survival rate between those two stages. Survival to the feeding stage is a direct function of the abundance of pollen cones in the stand (Fig. 1). This relationship between early spring survival and density of pollen cones provides an explicit link between the densities of overwintering and feeding budworms. Densities of both overwintering budworm and pollen cones occurring on the trees can be estimated in the previous autumn or winter. Hence, estimates of defoliation can be made available by the late autumn or early winter of the year preceding the expected defoliation.

The time frame to plan control programs can be further increased because the density of overwintering jack pine budworm can, in turn, be calculated from an estimate of egg-mass density (Fig. 3). There are several operational advantages to sampling egg masses. In addition to the increased time frame for decision making, the same branch sample taken for egg masses can be used to estimate current-year defoliation and next year's pollen crop. Thus, the reduction in sampling and handling of foliage is considerable.

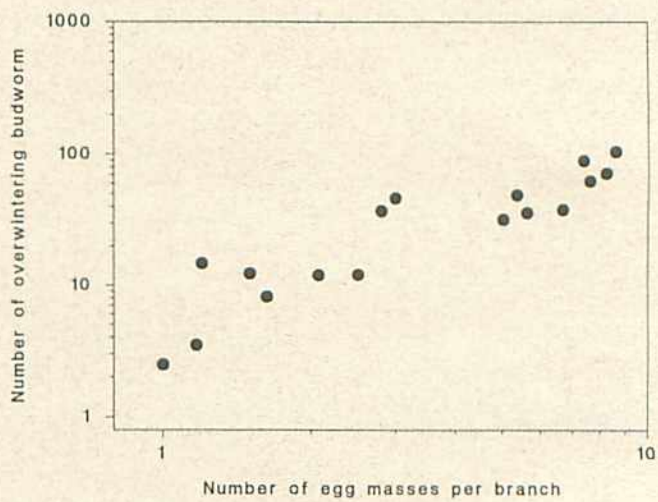

Figure 3. Number of overwintering jack pine budworm as a function of the number of egg masses per branch.

A schematic diagram showing the sequence of prediction and an estimate of predictability (as expressed by the coefficient of determination, R^2) is given in Figure 4. The predictive model can be summarized as:

$$N_{t+1} = \frac{10^{(1.31 * EGG + 0.70)}}{10^{(-.60 * CONE + 0.94)}} \quad [1]$$

where:

N_{t+1} is the predicted number of feeding jack pine budworm per 100 shoots,

EGG is the $\log_{10}$ density of egg masses per 1-m branch, and CONE is the $\log_{10}$ number of pollen cones per 1-m branch.

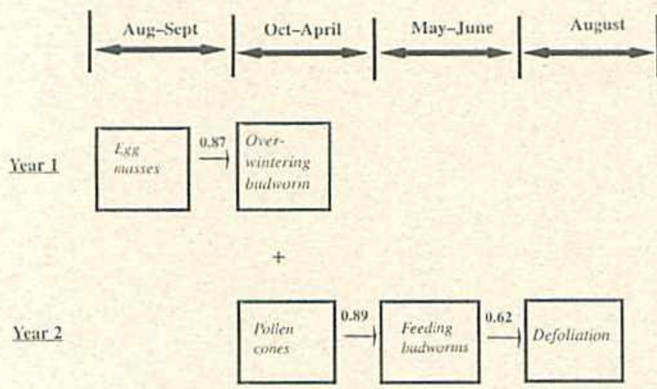

Figure 4. Algorithm showing the time line and sampling sequence used to forecast defoliation by the jack pine budworm. Numbers over the arrows between boxes represent the coefficient of determination (R^2). This is a measure of the amount of variation in one variable explained by its relationship to another variable.

USING THE MODEL

To use the model, a pest manager would first set the level of defoliation to be detected and then determine the number of budworm that would produce this degree of damage. Using the relationship shown in Figure 2, for example, >30 percent, >50 percent, or >75 percent defoliation would result from >6.1, >16.8, or >55.2 feeding jack pine budworms per 100 shoots, respectively.

The pest manager can then either 1) estimate by sampling the number of egg masses present and solve Equation 1 for the density of pollen cones, which would result in a given level of defoliation, or 2) estimate the number of pollen cones present and solve for the number of egg masses required for damage to exceed the given threshold. Either density estimate can be made using fixed-size or sequential sampling schemes.

To test the model, independent data from 35 sampling points in Ontario were used. Each site had information on the number of egg masses, pollen-cone density, and defoliation as determined by the sampling methods described above. The model was evaluated by first solving for the number of expected feeding budworm and then predicting the level of defoliation that should result. The number of times the actual defoliation was correctly identified by these preselected defoliation thresholds was scored for each of the 35 sites. The model correctly forecasts actual defoliation greater than the preselected thresholds 77 percent of the time for the lowest defoliation threshold (>30 percent) and 89 percent of the time for the highest defoliation threshold (>75 percent).

MANAGEMENT IMPLICATIONS

This investigation shows that defoliation thresholds for the jack pine budworm can be predicted from information on the number of egg masses and the abundance of pollen cones in the stand. Using a simple model the pest manager can, with an acceptable degree of confidence, obtain earlier estimations of defoliation. Improvements in both the accuracy and efficiency of egg-mass and pollen-cone sampling techniques will undoubtedly further advance the precision of the forecasts. The use of sequential sample plans, currently under development for egg masses and pollen cones, should maximize the efficiency of categorizing stands infested by the jack pine budworm. Pest managers will be able to track high-hazard stands and identify where unacceptable damage is likely to occur. This information can be available several months prior to the actual defoliation and should permit adequate time for planning control operations.

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Gordon Howse, Joe Meating, and the Forest Insect and Disease Survey Unit, Canadian Forest Service–Sault Ste. Marie, provided data for much of this study.

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