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Rating Forest Stands for Gypsy Moth Defoliation

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Abstract.

The severity of future defoliation can be estimated from the percentages of basal area in oaks (Quercus), black oak (Q. velutina) and chestnut oak (Q. prinus), and in trees with good crowns, along with the average diameter of the stand. With information on these variables, the defoliation potential of any hardwood forest stand in an approaching gypsy moth (Lymantria dispar) infestation can be rated.

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Because the levels of defoliation vary widely within areas infested by gypsy moth, the ability to identify critical locations (i.e., those most likely to suffer heavy defoliation during an infestation) is important to resource management. The purpose of this work is to evaluate the relationship between defoliation and forest stand characteristics and develop guidelines for rating the defoliation potential of forest stands on new frontiers of infestation.

Approach

Measurements have been taken each year since 1978 to monitor and evaluate impacts of the gypsy moth on forest trees in central Pennsylvania. The project (a cooperative venture of the Pennsylvania Bureau of Forestry and the U. S. Forest Service) uses a network of some six hundred 1/10-acre field plots located between Carlisle and State College, Pennsylvania. This was the leading edge of gypsy moth infestation in 1978 when the plots were established, before the stands were infested.

Defoliation Data

Ocular estimates of defoliation for all trees 3.0 inches dbh and larger were recorded each year at peak periods of defoliation (June or July). The percentage of foliage stripped from each tree was estimated to the nearest 10 percent. Defoliation averages ($\overline{DF}$) for each plot were derived from the defoliation estimates for each tree (DF_i), weighted by the tree's diameter squared (D_i^2) to account for differences in tree crown size:

$$\overline{DF} = \sum_{i=1}^{n} D_i^2 * DF_i \; / \; \sum_{i=1}^{n} D_i^2$$

Average defoliation on each plot was used to assign it to a light (<30%), moderate (30-59%), or heavy (60+%) defoliation category each year (Gansner and Herrick 1985). The peak year for defoliation was 1981; nearly half the plots had moderate or heavy defoliation that year, and plot defoliation averaged 39 percent (Fig. 1). The next highest defoliation years were 1980 and 1982, with averages at 17 percent and 22 percent, respectively. One-fourth of the plots had heavy defoliation at least once during these 3 years (only 2 percent received as much as 2 years of heavy defoliation). Another third of the plots received moderate defoliation at least once.

The bulk of gypsy moth defoliation activity in central Pennsylvania occurred during the 3-year period from 1980 to 1982. To make allowance for the progressive but uneven nature of gypsy moth infestations we averaged each plot's defoliation measurements for these 3 years. Clearly, more locations in a sample area are likely to be defoliated sometime during several years of gypsy moth buildup than in any single year. Thus, the 3-year average provided a more comprehensive measure of defoliation at any one location during the outbreak.

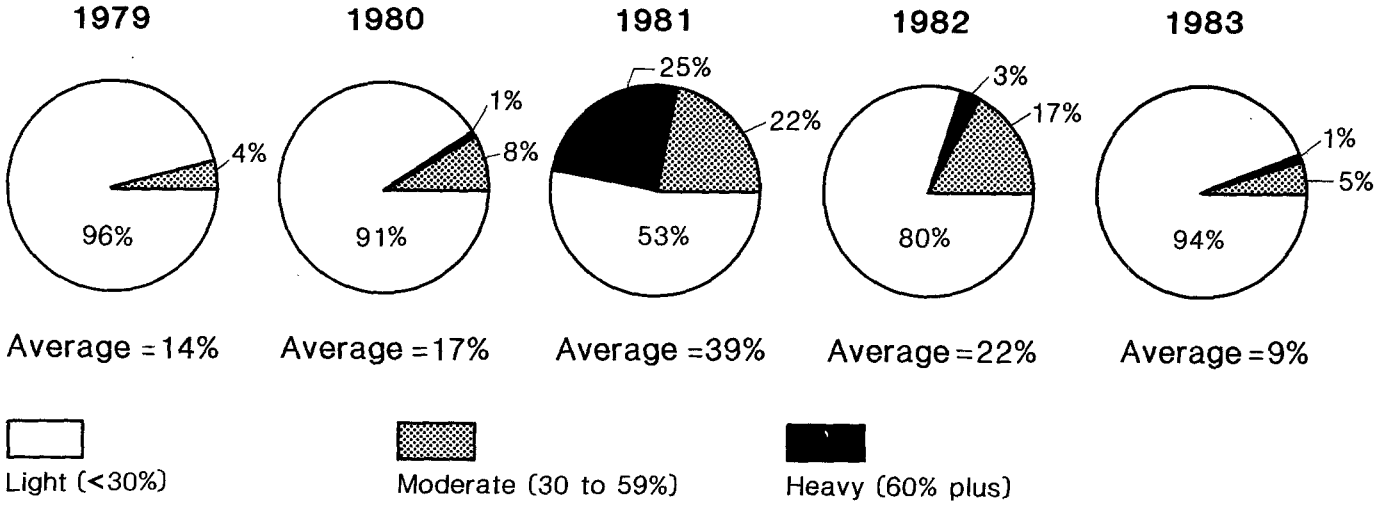

Figure 1.--Gypsy moth defoliation in central Pennsylvania, 1979-83.

Predictor Variables

Many forestland characteristics are potential candidates for gauging the amount of defoliation an area is likely sustain in an infestation. Tree species, size, crown condition, crown position, stocking density, site quality, elevation, and aspect are some prominent attributes that many people associate with gypsy moth defoliation (Bess et al. 1947, Campbell and Sloan 1977, Campbell 1979). More detailed data, such as the prevalence of bark flaps and rock outcrops and egg mass viability may be useful as well (Houston and Valentine 1977, Wilson et al. 1981). As a practical matter, however, only easy-to-measure timber stand characteristics that would be useful in prediction were entered into our analyses. It would be of little help in planning, for example, to have to rely on predicting weather conditions during an infestation to gauge potential defoliation. Also, it is assumed that some indicator of imminent infestation has raised enough concern to warrant rating an area; e.g., to identify forest areas that are candidates for treatment because of their likelihood of being defoliated to unacceptable levels.

The data-plot network covers a full range of values representing preoutbreak conditions (1978) in the infested area. Selected plot variables provide a general description of the coverage area:

	Mean	Range
Basal area/acre (ft^2)	90	15-190
Basal area in oaks (%)	68	0-100
Basal area in black and chestnut oaks (%)	47	0-100
Basal area in dominant and codominant trees (%)	77	14-99
Basal area in trees with good crown condition[1](%)	55	0-100
Average dbh (inches)	7.4	3.8-13.4
Site index (ft., upland oaks)	61	25-100
Stand age (years)	71	15-175
Trees/acre (no.)	255	80-650
Stocking (%)	81	20-158
Slope (%)	24	0-67
Elevation (ft.)	1535	575-2450

[1]A good crown is healthy, with few dead branches and normal foliage density, color, and size.

Analysis

The combined influence that 38 variables have on the 3-year defoliation average was studied by Automatic Interaction Detection (Sonquist et al. 1973). This statistical technique searched characteristics of the trees and timber stands for the best predictors of defoliation. Starting with the entire sample in one group, the plots were partitioned through successive two-way splits into a series of subgroups. The splits occur so that, at each step, the chosen predictor variable forms two new groups that cause the greatest reduction of variance in the dependent variable (average defoliation). The result is a set of best predictors selected by the AID algorithm, and presented as a branching diagram that details the configuration of 3-year defoliation averages from forest stands subjected to the gypsy moth episode in central Pennsylvania.

Results

From 1980 through 1982, the 3-year defoliation average was 26 percent, with a range from 0.3 percent to 70 percent. Plots that were heavily defoliated in any of the 3 years averaged 43 percent. The 3-year average was 27 percent for plots with no more than moderate defoliation; for plots that had only light defoliation, it was 14 percent.

Automatic interaction detection analysis of the 3-year defoliation averages generated 10 final classification groups and the average defoliation percentage for each group (Fig. 2). Each sample plot is a member of one of the groups. Only four of the many tree and timber stand characteristics analyzed as predictor variables were retained in this defoliation classification system: percentage of basal area in oaks, percentage of basal area in black and chestnut oaks, percentage of basal area in trees with good crowns, and average diameter of the stand.

Forest stands represented by the sample plots in the group with the highest average defoliation--40 percent, as compared to 26 percent for the total sample--are identified as Group 1. They have at least 80 percent of their basal area in oak species, at least 70 percent of their basal area in black and chestnut oaks, and at least 60 percent of basal area in trees with good crowns. This group comprised 10 percent of the total sample.

The average defoliation dropped to 31 percent if a timber stand met the first two criteria for Group 1 but had less than 60 percent of its basal area in trees with good crowns (Group 2). Average defoliation was 32 percent when 50 to 79 percent of basal area was in oak species, at least 40 percent of the basal area was in black and chestnut oaks, and at least 40 percent of the basal area was in trees with good crowns (Group 5). These three groups with the highest defoliation averages included 38 percent of the sample. On the

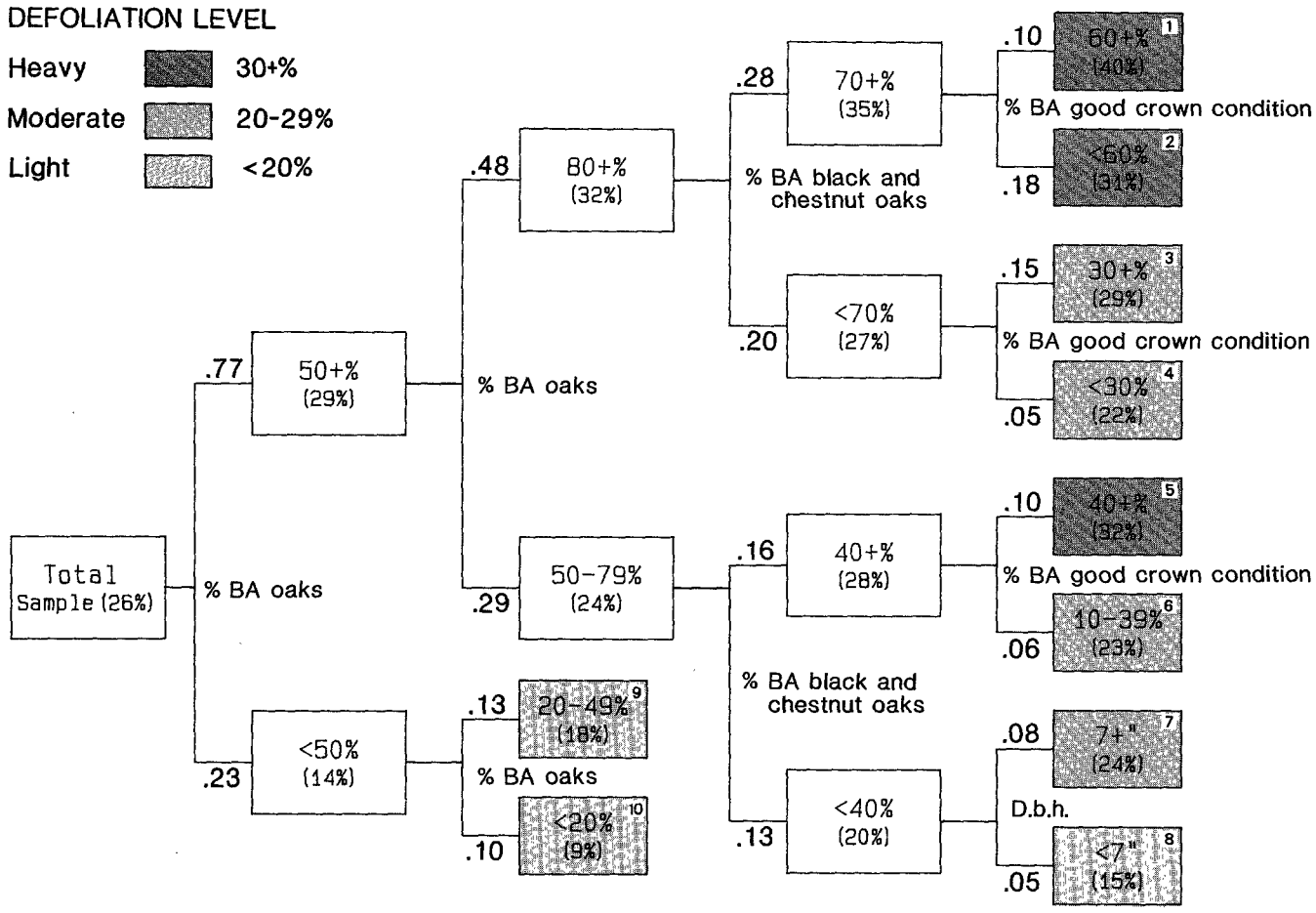

Figure 2.--Guide for estimating gypsy moth defoliation potential. Any hardwood stand can be assigned to a defoliation group on the basis of characteristics of the stand. The 3-year average defoliation percentage is shown in parentheses for each group. Fractions on each line between groups show the portion of the Pennsylvania sample that is in that group.

other hand, as testimony to the strength of host species as a key indicator, stands with less than 20 percent of their basal area in oak species had the lowest defoliation average--9 percent (Group 10).

This study describes a fairly simple structure that can be used to assign potential rates of defoliation to forest stands. It is likely to be most accurate when applied to areas with stand characteristics similar to those of the central Pennsylvania study area. Nevertheless, it is the only available model that links defoliation severity to key forest stand characteristics as predictor variables. Of the many elements of stand condition analyzed as independent variables, the four retained in the model make good sense. Oaks are a favored food of gypsy moth, and black and chestnut oak are highly preferred (Gansner and Herrick 1985); thus species is a strong indicator of stand attractiveness for gypsy moth activity: over half the group-identifying splits in the model were keyed to species alone. Trees with good crowns support abundant foliage which presents attractive insect feeding sites. Likewise, large-diameter trees often support large dominant crowns that are attractive gypsy moth feeding sites.

Perhaps the model's most useful contribution lies in making it possible to separate stands at risk of heavy defoliation from those where defoliation is likely to be light. From the distribution of the 3-year averages we have arbitrarily defined heavy defoliation as above 30 percent and light defoliation as less than 20 percent (Fig. 2). The model gives a basis for rating and mapping the potential severity of forest defoliation. Once the stands are rated, management decisions can be directed toward protecting highly valued forest resources among those identified as most threatened with defoliation in an approaching gypsy moth infestation.

This model's performance will be further validated as the gypsy moth invades new territory. Meanwhile, we are developing measurements that will describe tree mortality and changes in stand condition on this same plot network. These data will be the basis for impact analyses to provide further understanding of defoliation and subsequent tree mortality and loss relationships in forest stands infested by gypsy moth. As was the case in this study, the entire sequence of analyses will focus on the development of more effective guides to help forest resource managers cope with the pest.

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