SAMPLING LOW-DENSITY GYPSY MOTH POPULATIONS

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ABSTRACT

The techniques and methodology for sampling gypsy moth, *Lymantria dispar* L., at low densities, less than 100 egg masses/ha (EM/ha), are compared. Forest managers have constraints of time and cost, and need a useful, simple predictable means to assist them in sampling gypsy moth populations. A comparison of various techniques coupled with results of recent habitat research studies indicates that a series of burlap banded trees can be utilized to monitor egg-mass density change over time. Egg masses beneath bands accurately reflect densities on unbanded trees, yet are easier to deploy and use as well as being less costly than other conventional methods. Habitat does not seem to be a major factor in determining the distribution of gypsy moth egg masses; however, forest stands selected for banding should have a major oak component. Predicting a 2-year lead time to outbreak is possible based upon two consecutive years with an increase of one order of magnitude or greater of egg-mass density beneath bands.

INTRODUCTION

Gypsy moth is capable of an increase of more than 1-1/2 orders of magnitude in a generation. The problem for managers in assessing egg-mass density counts is the inability to track increase trends and predict 1-2 years in advance the need for suppression. Successful forecasting of pest densities, whether for management or research purposes, relies on dependable sampling methodology. For the gypsy moth, *Lymantria dispar* L., we do not know enough about its dynamics to be able to predict outbreak occurrences. This has necessitated reliance on sampling, with a lead time of no more than one generation to provide the necessary information. For example, if gypsy moth is capable of increasing 1-2 orders of magnitude/year and if defoliation can occur at 10^4 egg masses/ha (EM/ha) or higher, then it is necessary to detect 10^{-1} to 10 EM/ha in order to predict defoliation during the next 2-3 year period. Trend prediction at low densities (<100 EM/ha) to detect population change requires more intensive sampling with inherent higher costs. The researcher has different demands for sampling than the forest manager and will utilize a technique or combination of techniques to suit the research. The forest manager, on the other hand, generally requires less detailed information, must assess populations over large areas of variable habitat, and sampling activity is constrained by economics. Several methods for population estimation have been developed but no consistent approach has been utilized by managers that permits comparisons and evaluation over a broad geographic region. Recent research indicates that such a procedure is feasible for the manager and may or may not be useful for the researcher.

For a sampling regimen to be acceptable to the forest manager as a successful forecasting tool, it must be simple, inexpensive, reliable and useful. A comparison of current sampling methods provides insights into their relative usefulness to meet these criteria. The comparative features of each method (Table 1) are based on specific studies (Kolodny-Hirsch 1986, Liebhold and Elkinton 1988, Wallner and others 1989, Wilson and Fontaine 1978) as well as our consensus assessment of their past performance and accepted use. Sensitivity reflects the ability to detect gypsy moth life stages at densities less than 100 EM/ha. Reliability of a method connotes its ability to consistently perform in measuring a life stage. The cost of methodology includes both deployment of the technique and subsequent observations, counting, and soon. Since the manager depends upon predictability for planning and allocating resources, a chosen sampling approach should provide not only insect density but also an assessment of defoliation prognosis. The greater the prediction in time (that is, N + 2, N + 3), the more useful the method.

The pheromone trap has consistently demonstrated the highest level of male moth detection sensitivity at minimal cost. However, it has not been possible to relate adult male capture to subsequent egg-mass and larval densities or defoliation. Hence, its use for population monitoring in generally infested regions is limited and is best suited for detecting and delimiting new, potential infestations. Sampling egg masses has been the most accepted method for expressing population densities, a luxury not provided by sampling adults or larvae. Additionally, egg masses can furnish information on fecundity, density change between generations, phenology, and levels of parasitism. Techniques such as fixed-radius and prism plots are most often used; their sensitivity and reliability are good, but high cost and use in predicting defoliation are limitations. Other means of quantifying egg masses such as timed walks and masses/stem are "quick fixes" lacking the necessary essentials such as sensitivity, reliability, and defoliation prediction. The larval stage is most difficult to sample at low densities and, with the exception of using burlap bands, tends to be costly and provide limited predictive information beyond the current year. Frass and head capsule counts are best suited to research on larval population dynamics because of cost of deployment, collection and evaluation, and lack of sensitivity at the lower density ranges of gypsy moth. From this comparison of methods, we conclude that egg-mass sampling is the method for predicting long-term population trends by managers but a new modification should be used.

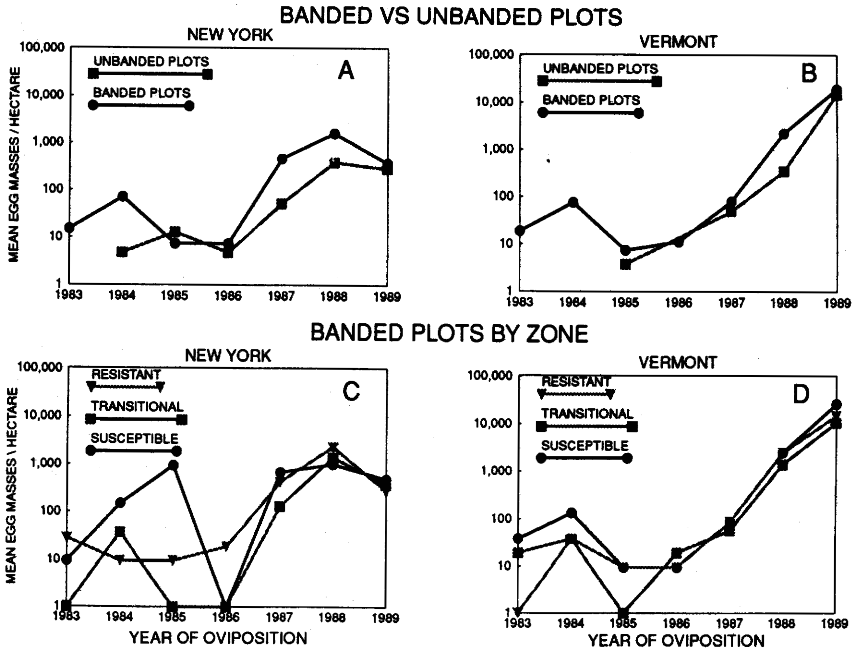

Figure 1. Mean egg-mass densities over time in burlap banded plots and adjacent unbanded plots (A, B), and mean egg-mass densities in susceptible, transitional, and resistant forests (C, D).

Table 1.--Comparison of techniques for sampling gypsy moth at low (<100 EM/HA) densities

Method	Sensitivity	Reliability	Cost	Predictability Density	Predictability Defoliation
Pheromone traps	+++	++	+	+	+
Egg mass					
fixed radius	+++	+++	+++	++	+++
prism	++	+++	+++	+	++
burlap band	+++	+++	+	+++	++
stem	+	++	++	+	++
timed walk	+	+	+	+	+
Larvae					
burlap band	+++	+++	+	++	++
branch	+	+	+++	+	+
dislodgement	+	+	+++	+	+
head capsule	+	+	++	+	+
frass	++	++	++	+	+

Lowest = +; Moderate = ++; Highest = +++

During the past 6 years, we conducted collaborative research on low-density gypsy moth populations at the Harvard Black Rock Forest (New York), Bryant Mountain (Vermont), Cape Cod Military Reservation (Massachusetts), and North Stonington, Connecticut, which provided us with a new approach. It was essential that we quantify gypsy moth in different habitats at these sites to verify the dynamics of low-density populations. Forests can be classified based upon their susceptibility to defoliation by gypsy moth (Houston and Valentine 1977); we used this system in selecting and classifying our plots. Using a series of 15-m-dia burlap banded plots and adjacent unbanded plots, we measured density changes from less than 10 EM/ha in 1983 to greater than 10,000 EM/ha in 1989.

Burlap bands consistently mirrored egg-mass densities of unbanded plots. While bands tended to give higher values of masses/ha, they did accurately reflect density trends (Fig. 1A, B). Habitat potential (susceptible, transition, resistant forests) has been used to classify potential forest stand defoliation (Houston and Valentine 1977). Irrespective of habitat, equal numbers of egg masses were found in all habitats (Fig. 1C, D). Thus, burlap banded trees (> 7 cm) gave accurate, yearly estimates of egg masses and permitted us to predict defoliation in 1989 based on the dramatic increase in egg-mass density from 1986 through 1988. While we have not evaluated different sampling schemes for the manager, we believe that a series of burlap-banded oaks in clusters of 10 trees, with each cluster separated from the next by 100 m, can provide a reasonable estimate (<10% error). Arraying burlap-banded tree clusters on a square grid is recommended. This permits starting and ending at the same point, thus saving time and maximizing effort.

Figure 2 illustrates that larval densities beneath bands do not necessarily predict subsequent egg-mass densities. New York had a relatively consistent 10 mean larvae/tree from 1984 to 1989, yet egg masses and eggs/tree were extremely low in 1985 and 1986 but accelerated for two consecutive years in 1987 and 1988. Conversely, in Vermont the larval/egg-mass values appeared to track one another more closely. Explanations for these differences include larval immigration from adjacent infestations in New York and not in Vermont and differences, between sites in rates of predation or parasitism.

These same burlap-band counts of egg masses in New York and Vermont showed increases in density of more than one order of magnitude for two consecutive years. This presaged defoliation in 1989, which was forestalled only by an epizootic of *Entomophaga maimaiga.* We believe that managers can use this burlap banding of trees on a permanent basis to monitor density changes over time. Given two consecutive years of egg-mass density, increases of more than one order of magnitude should alert managers to expand sampling to other forested regions. It is not clear what role fecundity plays in such a prediction scheme. A simple method based on measuring the lengths of egg masses can be used to compute fecundity (Moore and Jones 1987). Our data suggest fecundity plays an important role at very low densities (<20 EM/ha) but may be unimportant as densities increase.

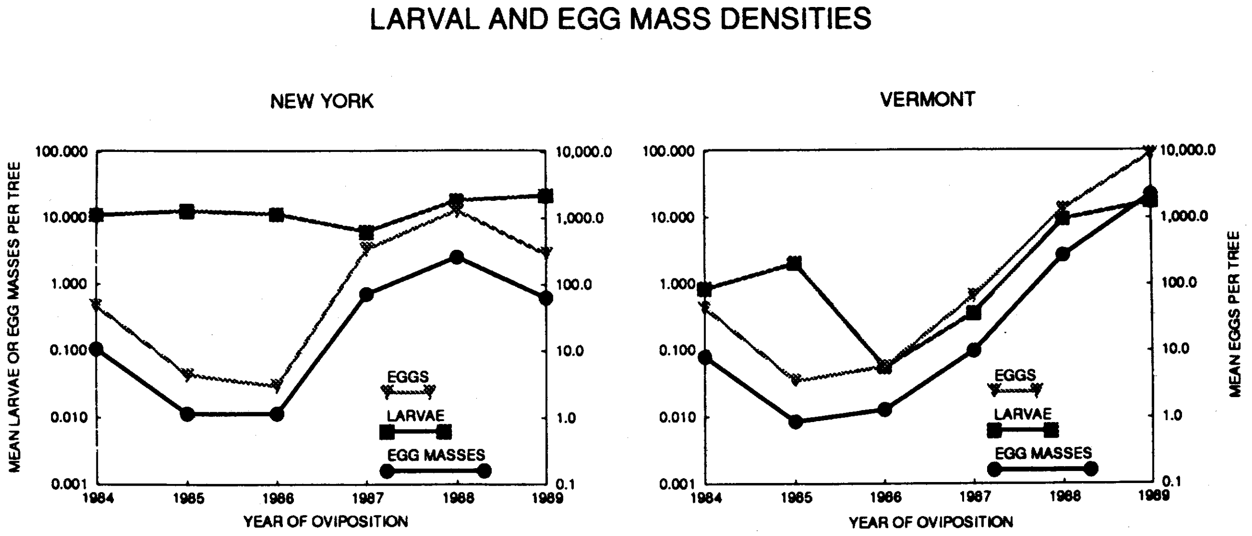

Figure 2. Mean number of eggs, larvae, and egg masses per tree for fifteen 15-m-dia plots in Vermont and New York for the period 1984-1989.

The possibility of using a series of individually burlap-banded trees (oaks, 20-30 m apart) or clusters of trees (20/cluster) on a permanent sentinel basis is suggested. The advantages of transects of individual trees is that it permits extensive sampling across heterogeneous habitat at minimal cost for set up and monitoring. It is not clear whether single-tree transects will be more efficient than transects containing clusters of trees. Egg-mass counts from the same tree clusters in Massachusetts, 15-m-dia plots in Vermont, and individually burlapped trees in New York have been used for several years with good success. However, we need to evaluate this further, not only in regions of general infestation but also in areas recently infested.

Past experience with egg mass density as a predictor of defoliation has been erratic. In most instances, samples were not taken in the same area year after year nor did they consider forest susceptibility to defoliation. The intent in using long term monitoring of egg masses under burlap banded trees is to detect shifts in density and predict the length of time before a defoliation event likely will occur. In our studies, the low-density equilibrium point is about 10 EM/ha. Campbell and Sloan (1978) state that at <25 EM/ha gypsy moth is in the innocuous phase and that once the population exceeds 25 EM/ha it is in the outbreak phase. We determined that gypsy moth was in an outbreak mode once densities exceeded 100 EM/ha. The outbreak was triggered when densities were 10 to 25 EM/ha. If we could identify more accurately the causal mechanism(s), our ability to predict outbreaks would increase. The most plausible explanation of the release mechanism is small mammal predators, which are important regulating mechanisms at low densities (Smith 1988). At the time when gypsy moth populations were lowest (1985-86, Fig. 2), small mammal densities were at a 20-year high for New England (Smith, personal communication). Certainly this relationship requires further clarification. However, we believe that managers should not delay using permanent burlap banded trees since they will provide useful information in assessing management decisions for gypsy moth.

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