Susceptibility of Oak Regeneration in Clearcuts to Defoliation by Gypsy Moth

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Abstract: In 1991 and 1992, we observed gypsy moth defoliation of oak regeneration in clearcuts of varying sizes and ages. We established plots in the surrounding mature forests to document ambient gypsy moth population levels and placed subplots within the clearcuts designed to examine the effect of location relative to the clearcut edge. We found that the levels of defoliation on oak regeneration in the clearcuts closely approximated that of the adjacent mature forests. Clearcut age seemed to have little effect on rate of defoliation, but larger clearcuts (> 25 acres) had somewhat lower average defoliation, particularly in the subplots near the center. We established a more intensive sample in 3 large clearcut (> 25 acres) and found that the larvae appeared to originate from the surrounding stands.

INTRODUCTION

Harvesting is a viable silvicultural option for mature oak stands that are about to come under attack by gypsy moth (Gottschalk 1987). Heavy tree mortality is commonplace following defoliation in stands with a large proportion of oak (Hicks and Fosbroke 1987) and harvesting is one way to avoid such losses.

In addition to advoiding tree mortality due to gypsy moth, harvesting before an outbreak preserves the sprouting potential of oak stumps, thereby contributing to better oak regeneration. In the absence of sprouting, oak stands with heavy gypsy moth-induced mortality have a very low number of oak seedlings in the understory (Hix and others 1990). Clearcutting is a recommended method of regenerating oaks (USDA 1983) and has been applied to mature oak stands in the National Forests of the Appalachian region for a number of years. In addition to the benefits cited above, clearcutting may have other benefits to forests that are coming under gypsy moth attack. It has been speculated that oak seedlings are less susceptible and/or vulnerable to gypsy moth attack than mature trees. Susceptibility is a measure of the likelihood that gypsy moth will defoliate a tree or species whereas vulnerability has to do with the likelihood of damage occurring as a result of defoliation.

The basis for the speculation regarding response of seedlings versus mature trees is in part derived from casual observations (Gottschalk, 1988). Observers have noted that vegetation in clearcuts often remains green even when surrounded by mature stands that are 100% defoliated. Our study was conducted to quantify these casual observations and to determine if indeed young trees in clearcuts were less susceptible and/or vulnerable than their mature counterparts.

METHODS

Our study was conducted in the George Washington National Forest along the West Virginia-Virginia border (Figure 1). This is an area that is along the so-called leading edge of gypsy moth

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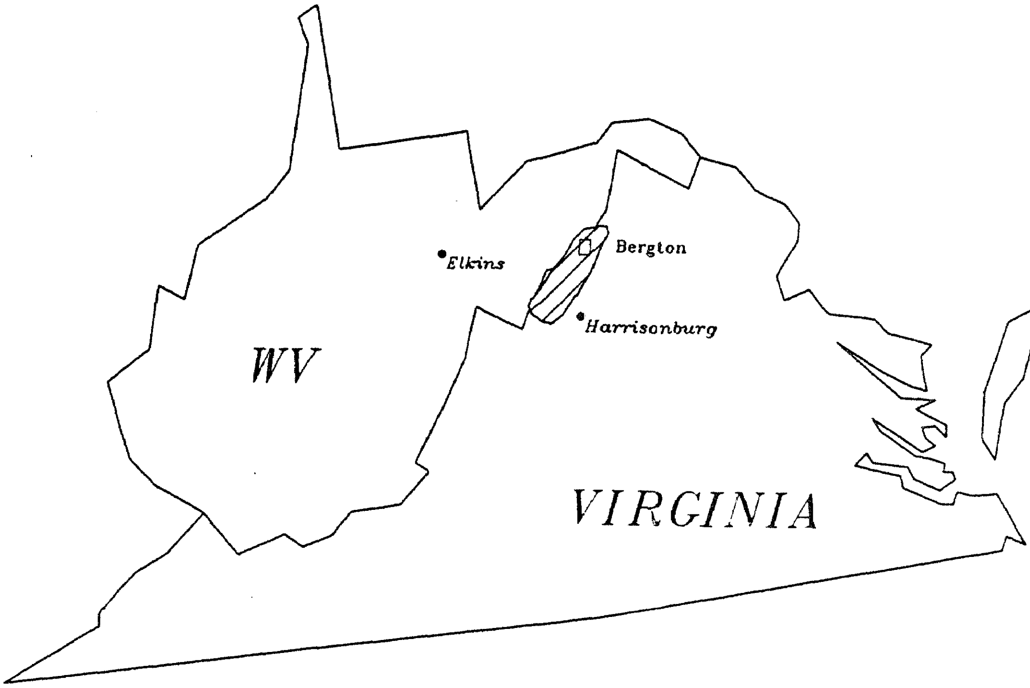


Figure 1.—Location of study area.

invasion and is in an area of predominantly oak forests (the Ridge and Valley Physiographic Province). The George Washington National Forest has conducted a number of small to medium sized clearcuts over the past decades, therefore all the ingredients needed for our study were present (oak forests, a gypsy moth population and clearcuts of varying size).

We used a heirarchial experimental design with three levels of age (time since clearcutting) and three levels of size of clearcuts. There were 5 replications within each age/size cell for a total of 45 observations in all. A diagram of the design is as follows:

		Clearcut Age		
		0-5 yrs.	5-15 yrs.	> 15 yrs.
Clearcut size	0-15 acres	5 reps	5 reps	5 reps
	15-25 acres	5 reps	5 reps	5 reps
	> 25 acres	5 reps	5 reps	5 reps
			Total -	45 reps

In each clearcut, a standard sampling procedure was conducted. First, two baselines were laid out in the cardinal directions. The north-south line was installed initially and at the mid-point of this line an east-west line was installed. Four 6-ft.-radius subplots were established along each line and a subplot was placed at the intersection of the baselines for a total of 9 subplots per clearcut.

Four of the subplots were positioned 100ft. from the edge of the clearcut (outer) and four were placed equidistant from the outer subplots and the center (mid) subplot (Figure 2). The purpose of this arrangement was to examine the effect of the exterior forest on defoliation within the clearcut. It is well documented that gypsy moths disperse by "ballooning" of small first instar larvae and if the principal source of larvae in the clearcuts is from adjacent stands this should be evident in the difference between inner and outer subplots.

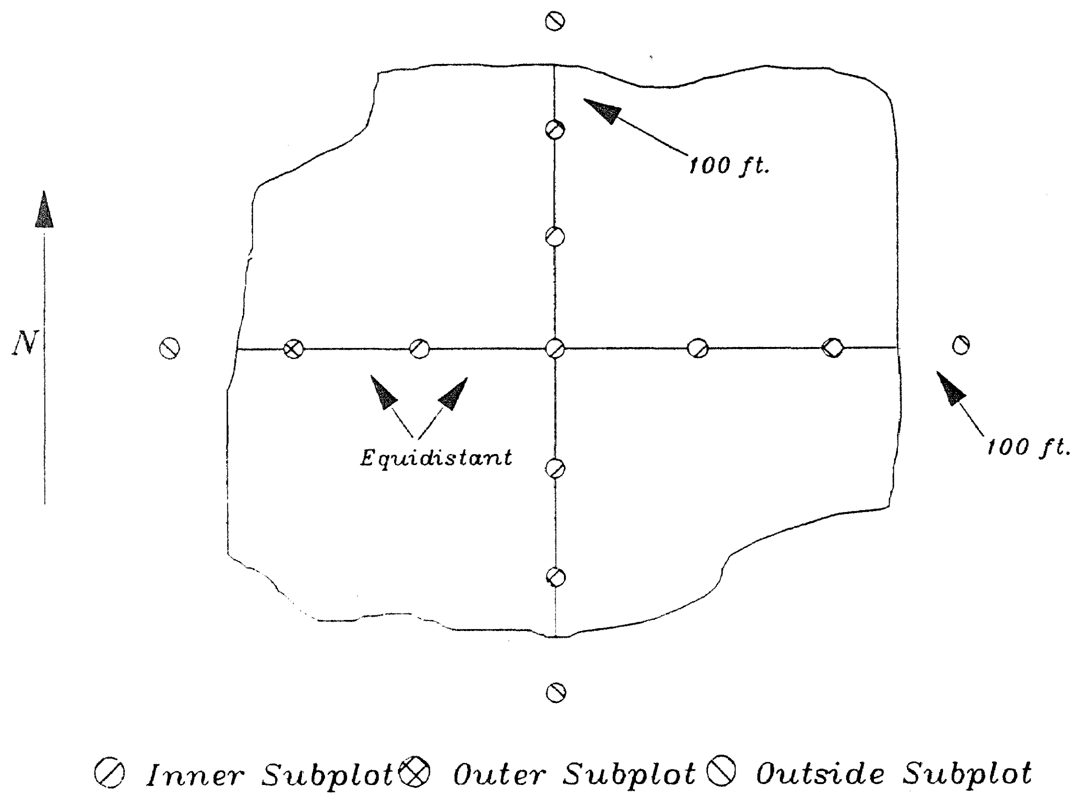


Figure 2.—Diagram of subplot positions on clearcut study areas.

The subplots were installed during May and June of 1991 and all tree seedlings were tallied by height and species. Percent ground cover was also estimated and the dominant species were listed. During the peak defoliation season (mid to late June), all clearcuts were visited in both 1991 and 1992 and percent defoliation was estimated for every tree seedling. In addition, 4 one-tenth-acre plots were established in the surrounding forest, at locations 100 ft. from the edge of the clearcuts on an extension of the baselines. These plots were used to document the ambient levels of gypsy moth in the surrounding forest and to serve as a base of comparison for the defoliation levels found within the clearcuts.

RESULTS

Although we observed defoliation of trees and seedlings of all species, it was the oaks that were most heavily defoliated and are typically among the most susceptible species in the forest (Gansner and Herrick 1985). The data reported here include only the oak defoliation results.

The general result that seems most significant, and somewhat surprising, is the fact that oak seedlings in clearcuts were generally defoliated at a level very similar to that of oaks in surrounding stands (Figs. 3 and 4). Mean oak defoliation among all subplots within clearcuts averaged 42% in 1991 while oak defoliation on surrounding stands averaged 49%. In 1992 these results were 13% and 20% respectively.

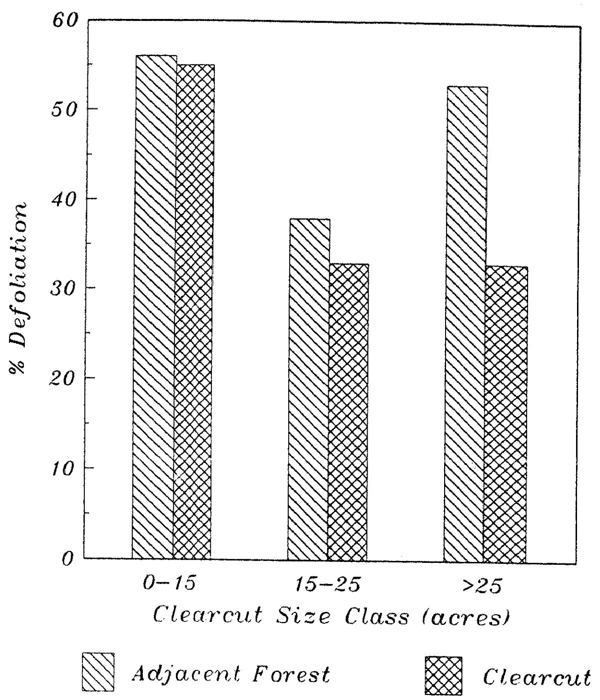


Figure 3.—Percent oak defoliation by clearcut size for 1991.

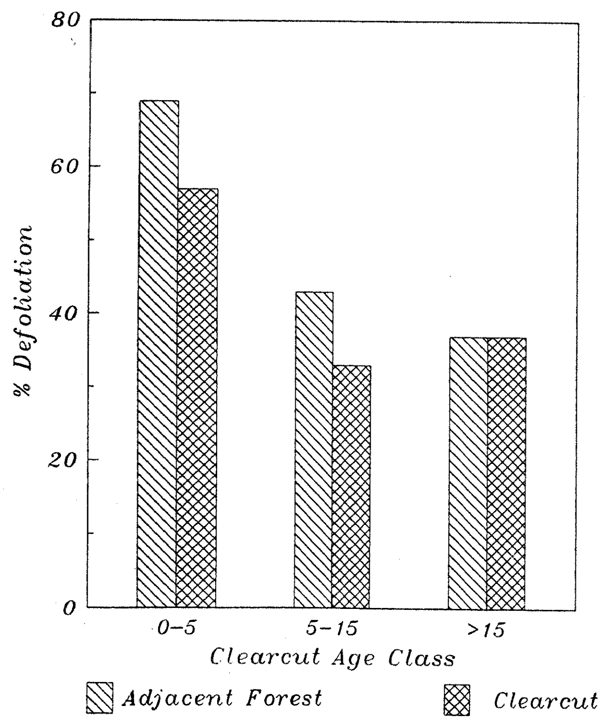


Figure 4.—Percent oak defoliation by clearcut age for 1991.

The effects of clearcut age and size were not dramatic and as yet no tests of significance have been performed on these data, but it seems unlikely that significant effects will be found. In Figure 3, it can be seen that clearcuts had a somewhat lower percentage of oak defoliation than adjacent stands and this relationship seemed to be more noticeable for larger clearcuts than for smaller ones. Logically this should be the case, particularly if the surrounding stands serve as a reservoir for caterpillars that drop into the clearcuts. The effect of clearcut age is illustrated by Figure 4, where it can be seen that younger clearcuts differed from their adjacent stands by a greater degree than older ones, and in general clearcuts had a slightly lower percentage oak defoliation than surrounding stands.

In comparing the inner versus outer subplots of clearcuts, the outer subplots had slightly higher levels of defoliation (Figure 5). But when clearcuts were selected for analysis that had 50% or greater oak defoliation in the surrounding stands (those with large resident gypsy moth populations), the difference between inner and outer subplots was greatly magnified. In Figure 5 it can be seen that outer subplots, in clearcuts where the adjacent forests were defoliated 50% or greater, had about 71% defoliation whereas inner subplots in these same clearcuts had only 52% defoliation. This is evidence affirming the hypothesis that adjacent stands serve as reservoirs for caterpillars to infest young trees in clearcuts.

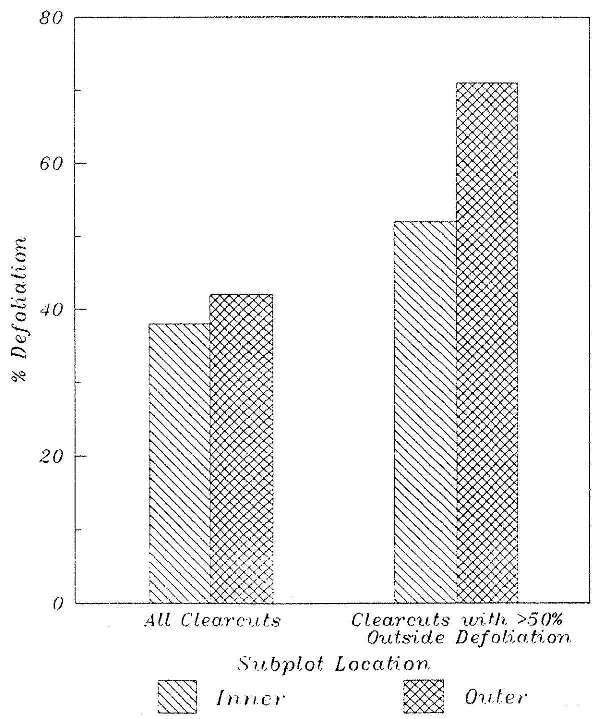


Figure 5.—Percent oak defoliation in clearcuts for inner vs. outer subplots for 1991.

In order to further investigate the effect of clearcut size on the dispersal of caterpillars into the clearcut, three larger clearcuts (> 25 acres), were selected near Bergton, Virginia (star on Figure 1). These clearcuts ranged from 30-35 acres, and age class 0-5 years old. A total of 8 transects were laid out in these clearcuts with subplots spaced equally distant from one another (Figure 6), for a total of 41 subplots for each clearcut (31 interior, 8 exterior).

During the peak defoliation season of 1991, defoliation levels along these transects and the surrounding forest were observed. Exterior forest defoliation was measured at 81.0%, while interior

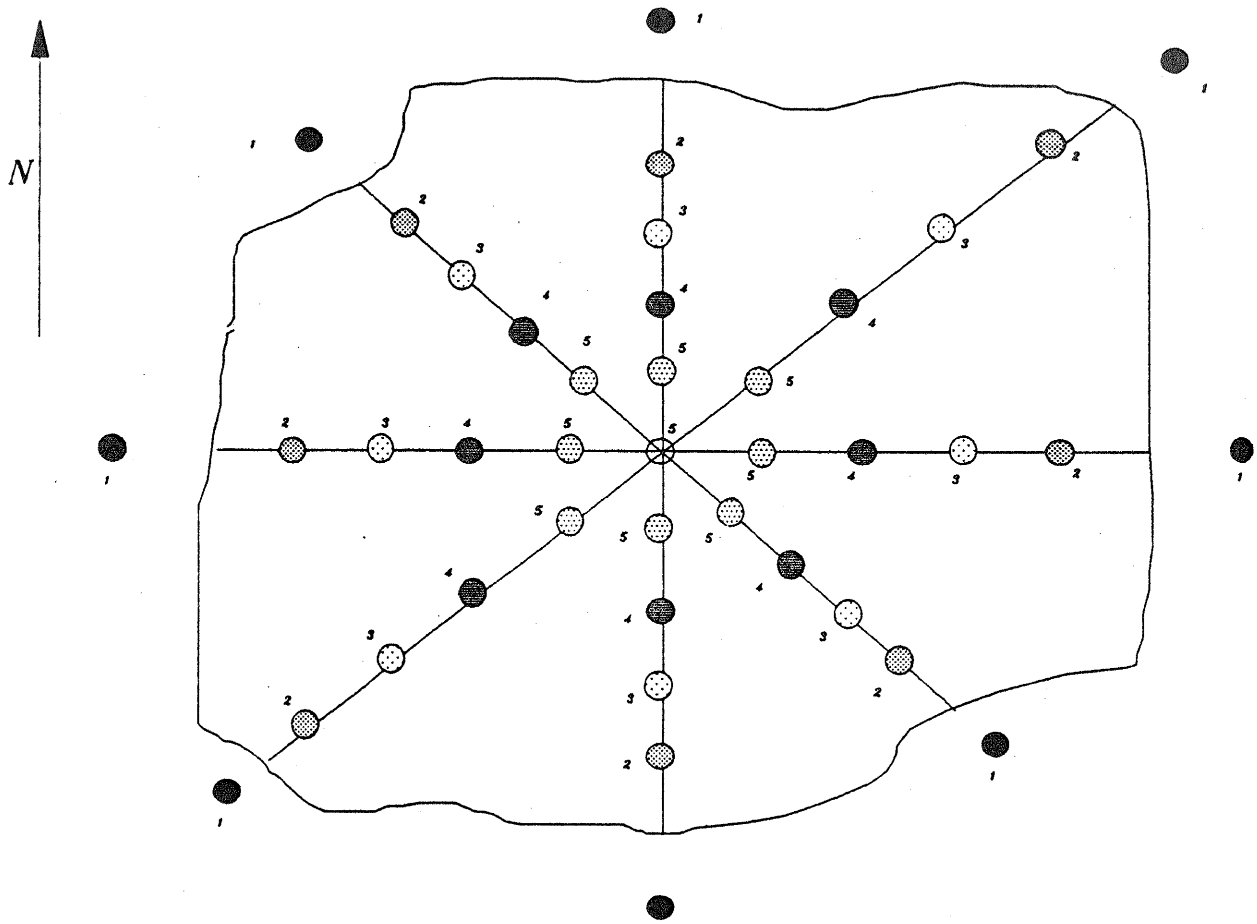
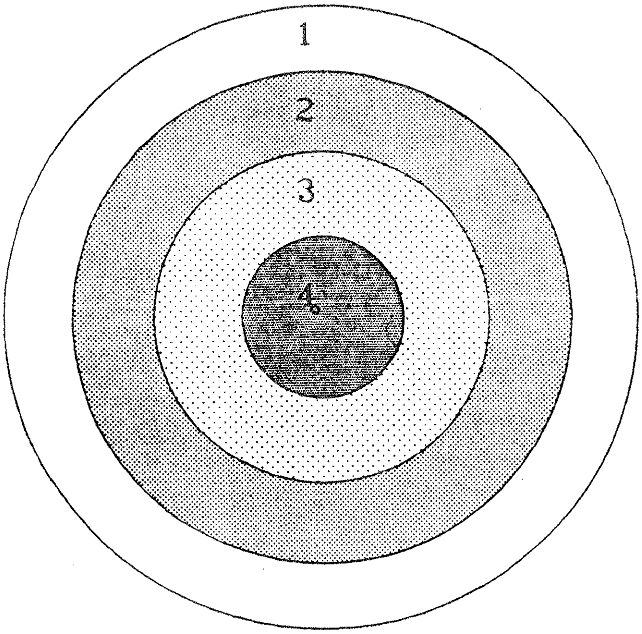


Figure 6.—Diagram of subplot positions on clearcut study area for egg mass location.

defoliation levels steadily decreased by zones (Figure 7), for an average interior rate of 41.0%. Defoliation levels for 1992 show a substantial decrease both within and outside these clearcuts indicating a gypsy moth population crash. The average exterior defoliation level decreased by 70.0% for a rate of 24.0%, while interior levels averaged 14.0% (Figure 7).

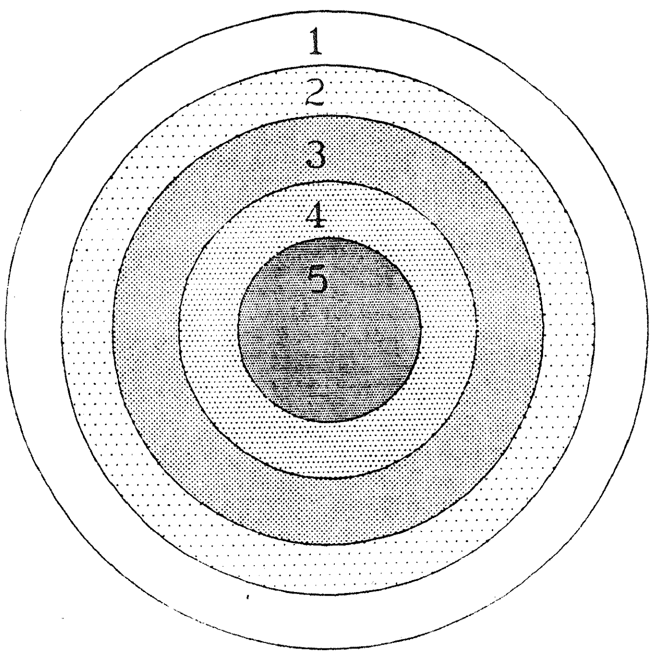
Clearcuts were also visited during March and November of 1992 to conduct egg mass counts on both interior and exterior subplots. These counts were taken in order to establish whether or not ovipositing was occurring within the cut to the same extent as they were in the surrounding forest. If so, theoretically, many defoliating larvae would have come from within the clearcut as opposed to coming from the surrounding forest.

Results of egg mass sampling in the clearcuts showed that on the average, egg mass density within the cut was generally very low, one-forth that of the exterior subplots. Data for 1990 indicate a ratio of 3:1 (exterior-310.0 E.M./acre compared to an interior average of 100.0 E.M./acre). These figures were obtained as the leading edge of gypsy moth defoliation entered the study area, while the 1991 egg mass data reflect the peak season of caterpillar activity with a ratio of 8:1 (exterior-710.0 E.M./acre compared to an interior average of 80.0 E.M./acre. Lastly, 1992 egg mass density corresponds to gypsy moth population levels with a significant decrease in density at a rate of 4:1, (exterior-370.0 E.M./acre compared to an interior average of 20.0 E.M./acre) (Figure 8).



ZONE 1-(4 PLOTS)= 82.0 %
ZONE 2-(4 PLOTS)= 65.0 %
ZONE 3-(4 PLOTS)= 49.0 %
ZONE 4-(1 PLOT)= 10.0 %

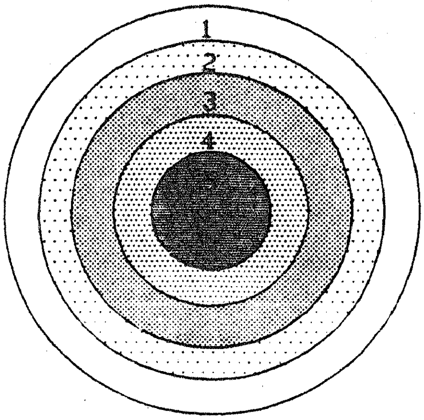
1991



ZONE 1-(8 PLOTS)= 24.0 %
ZONE 2-(8 PLOTS)= 15.0 %
ZONE 3-(8 PLOTS)= 15.0 %
ZONE 4-(8 PLOTS)= 13.0 %
ZONE 5-(9 PLOTS)= 11.0 %

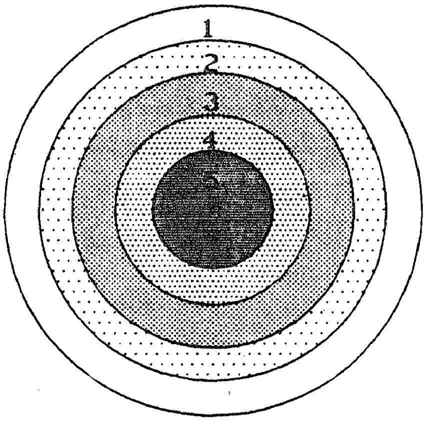
1992

Figure 7.—Average oak defoliation by zones for three clearcuts near Bergton, VA.



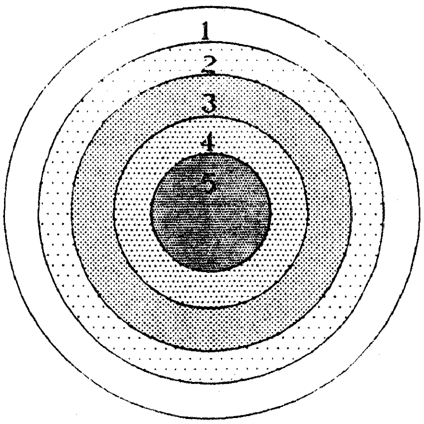
ZONE 1–(8 PLOTS)=310.0 E.M./ACRE
ZONE 2–(8 PLOTS)=110.0 E.M./ACRE
ZONE 3–(8 PLOTS)= 80.0 E.M./ACRE
ZONE 4–(8 PLOTS)= 50.0 E.M./ACRE
ZONE 5–(9 PLOTS)=160.0 E.M./ACRE

1990



ZONE 1–(8 PLOTS)=710.0 E.M./ACRE
ZONE 2–(8 PLOTS)=100.0 E.M./ACRE
ZONE 3–(8 PLOTS)= 20.0 E.M./ACRE
ZONE 4–(8 PLOTS)=100.0 E.M./ACRE
ZONE 5–(9 PLOTS)=110.0 E.M./ACRE

1991



ZONE 1–(8 PLOTS)=370.0 E.M./ACRE
ZONE 2–(8 PLOTS)= 20.0 E.M./ACRE
ZONE 3–(8 PLOTS)= 0.0 E.M./ACRE
ZONE 4–(8 PLOTS)= 50.0 E.M./ACRE
ZONE 5–(9 PLOTS)= 10.0 E.M./ACRE

1992

Figure 8.—Average egg mass density by zones for three clearcuts near Bergton, VA.

An assessment has not been conducted on the relationship of gypsy moth population to the host foliage biomass present. For example, mature oak forest probably contain substantially more oak foliage biomass than do clearcuts. As Figure 9 indicates, egg mass location appears to be a function of the population density. During the peak season, 1991, exterior and interior subplots both exhibited proportionately higher levels of egg masses on woody stems present. By 1992, egg mass concentrations on all substrates began decreasing due to the apparent crash of the gypsy moth population.

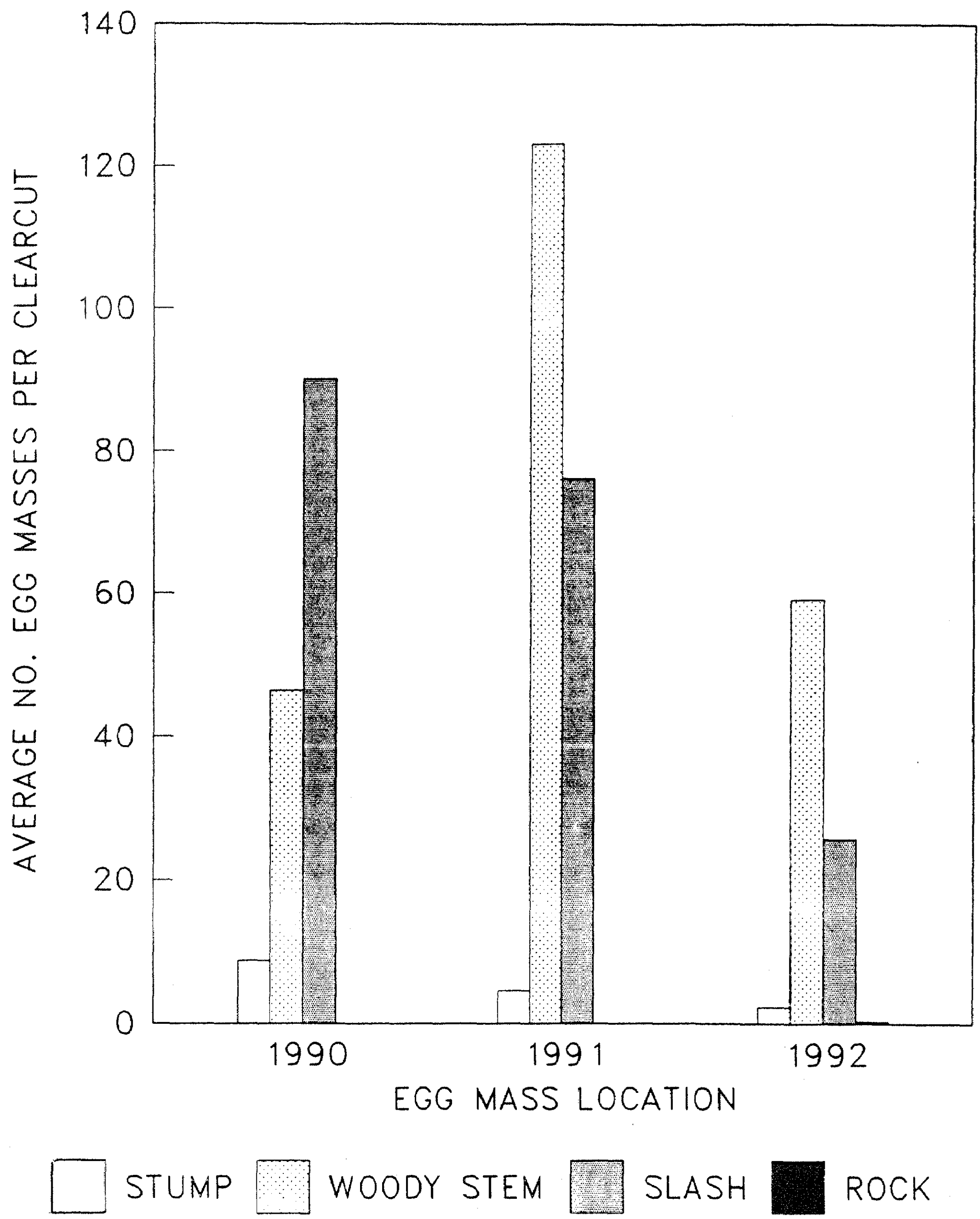


Figure 9.—Location of egg masses by years for cleatcuts

DISCUSSION

Our data indicate that oak seedlings in clearcuts are indeed susceptible to defoliation by gypsy moth and are defoliated to a degree that closely resembles that of adjacent surrounding forests. However, the facts that larger clearcuts had comparatively lower defoliation than small ones and that outer subplots in clearcuts had higher defoliation than interior ones suggest that many caterpillars are entering clearcuts from adjacent stands. This suggestion was born out when we looked both at the distribution of defoliation and egg masses in larger clearcuts, where we found higher levels of defoliation and higher egg mass densities around the periphery of large clearcuts as compared to the inner subplots. An implication of this result is that larger clearings might insulate oaks in the interior from gypsy moth defoliation. Our examination of larger clearcuts near Bergton, Virginia seems to bear this out.

The question of why casual observations find clearcuts to be undefoliated even when surrounded by heavily defoliated forests can be answered based upon the species composition of the clearcuts versus the surrounding forest. In our study, we found that 76% of the tree seedlings in clearcuts were non-oaks such as red maple. In the surrounding forests the ratio was almost exactly reversed with 75% of the trees being the highly preferred oak species.

Clearcutting of mature oak stands about to come under gypsy moth attack may have several advantages such as presalvaging anticipated losses, retaining oak sprouting potential and reducing food available for gypsy moth. But, oak seedlings do not appear to have any intrinsic resistance to gypsy moth defoliation as compared to older trees. The question of vulnerability of young oaks in clearcuts is as yet unanswered. We will continue to monitor the oak seedlings in these same clearcuts and document their defoliation, growth and mortality levels as compared to similar data collected from adjacent surrounding forests.

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