GYPSY MOTH EFFECTS ON MAST PRODUCTION

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Abstract—Gypsy moth outbreaks can have drastic effects on many forest resources and uses. Because the gypsy moth prefers oak foliage, oak stands are the most susceptible to defoliation and resultant damage. The value of oak mast for many wildlife species is high. The high carbohydrate content of acorns provides the energy necessary for winter survival. Loss of mast crops due to direct and indirect effects of gypsy moth defoliation may result in large-scale reductions in wildlife habitat and food sources.

Direct defoliation effects during years of moderate and heavy defoliation can come from three sources: direct consumption of flowers, abortion of immature acorns due to low carbohydrate supply, and lack of flower bud initiation. These effects are generally short-lived, having residual effects for only 1 or 2 years after defoliation ends. Information available suggests that abortion of immature acorns is the most significant of these three effects. As a result, it is possible to have 5 years of complete acorn failure.

Longer term indirect effects of outbreaks result from: crown dieback and poor vigor, mortality of oaks and hickories, and shifts in species composition of current and regenerated stands. These effects can reduce viable seed for regeneration and wildlife food. Crown dieback can turn productive acorn producers into nonproducers. Trees may take as long as 10 years to recover their full vigor. Mortality of mast producers in stands is distributed across a wide range from low to moderate to heavy. Estimates of the impact of mortality on stand-level acorn production show that considerable mortality (>60 percent of the basal area) must occur before significant reductions in acorn production occur. This result is due to mortality occurring primarily in intermediate and suppressed trees that are not heavy producers. This thinning from below may even stimulate production by residual trees. Many stands that were predominately oak before defoliation and mortality occurred have regenerated to red maple and black birch. This shift in composition results in a long-term reduction in mast production in these areas.

INTRODUCTION

One of the most serious gypsy moth effects on wildlife habitat and regeneration is reduction of acorn production. It is also one of the least researched areas of gypsy moth effects. A literature review and synthesis of unpublished progress reports from Pennsylvania Game Commission studies were used to summarize effects of defoliation on acorn production. The acorn production data collected by Downs and McQuilken (1944) in the late 1930's and early 1940's have been used to develop prediction equations for estimating stand-level production. These equations were then used to estimate production losses due to mortality.

METHODS

Tree mortality data were used to estimate the long-term effects of gypsy moth defoliation on mast production. Linear regression equations were calculated for northern red, black, scarlet, chestnut, and white oak based on data in Downs (1944). The equations use diameter breast height (dbh) and dbh^2 to predict pounds of acorns produced per tree (R^2=0.93 to 0.99, n=8). Tree data from 22 of the 600 central Pennsylvania risk rating plots (Herrick and Gansner 1987) were used for calculation of acorn production capacity using the regression equations. The plots covered a wide range in mortality rates. Original acorn production was calculated for every oak tree that was present on the plot in 1978 (prior to gypsy moth). Mortality data for 1985 (after gypsy moth outbreak) were used with the 1978 dbh measurements to estimate the reduction in mast production. Diameters from 1985 were used to calculate any compensatory production from increased growth of the surviving trees. Each 1/10-acre plot was expanded to represent per acre values. The 22 stands were stratified into 4 mortality classes and average percent reductions from the original 1978 values were determined for each class.

RESULTS AND DISCUSSION

Defoliation Effects During Outbreaks

Gypsy moth defoliation can affect acorn production at several places in the production cycle (Fig. 1). Published data and unpublished reports from the Pennsylvania Game Commission were used to determine the relative importance of these various effects. The three major effects considered are: direct consumption of acorns and flowers, abortion of acorns due to reduced carbohydrate supply, and reduced flower bud production due to reduced carbohydrate supply. McConnell (1988) showed that defoliation level strongly influenced sound acorn production (Fig. 2). Moderate defoliation reduced production by about 50 percent and heavy defoliation resulted in almost complete loss of production. The question of whether this reduction was due to actual consumption of flowers or due to abortion of developing seeds due to low carbohydrate supply was answered by analyzing the developmental stage of acorns. There was a 30 percent reduction in seed set due to defoliation (Fig. 3). This reduction is due to either loss of flowers to consumption or loss of pollination (male flowers) or both.

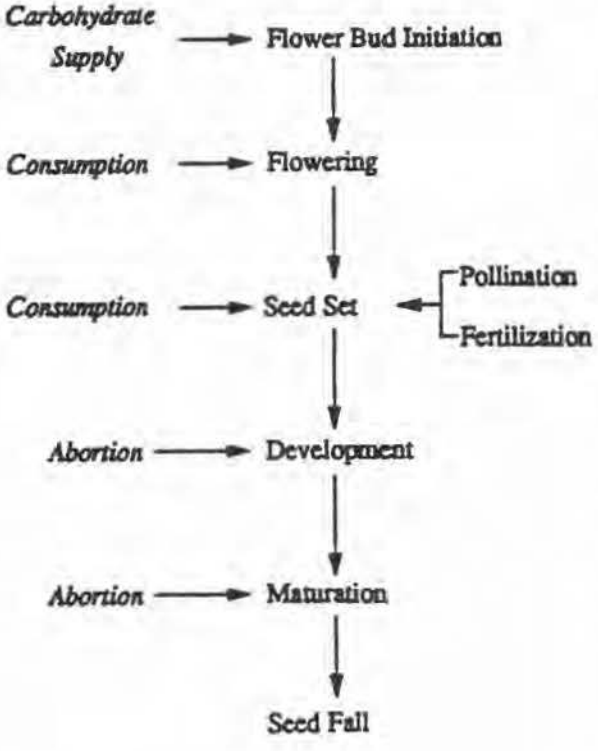

Figure 1. –Potential effects of gypsy moth on the seed production cycle of oaks.

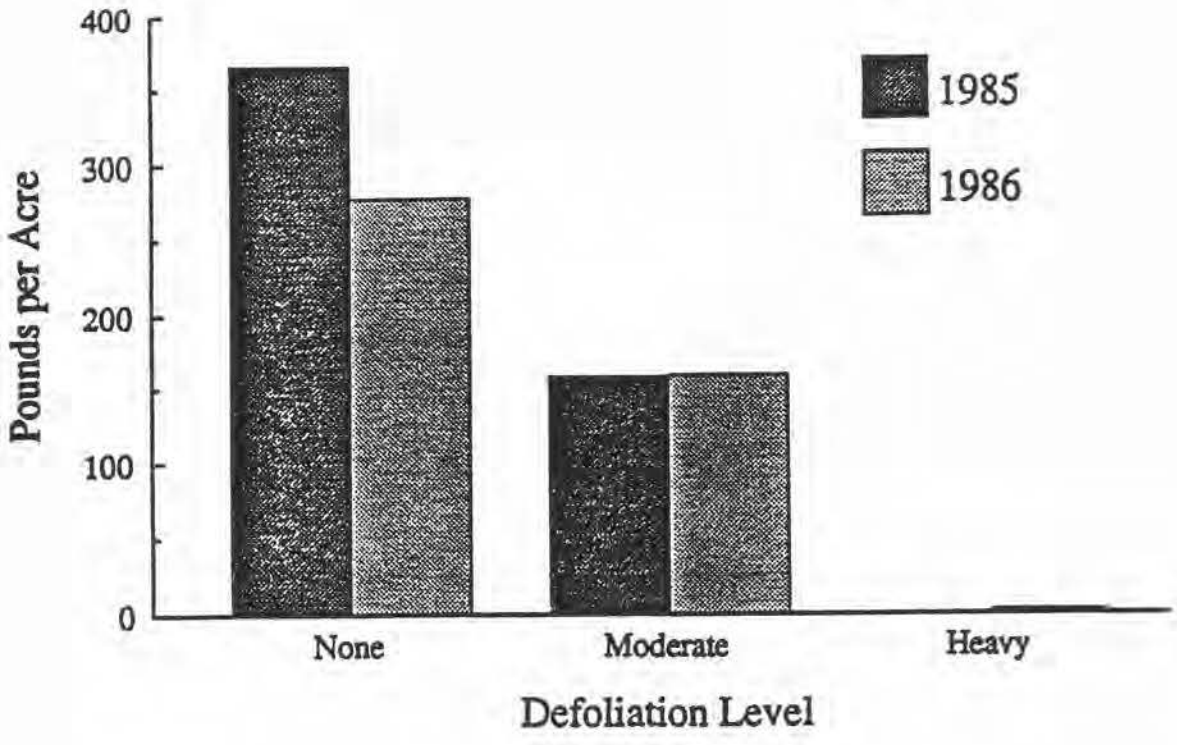

Figure 2.–Effect of gypsy moth defoliation level on sound acorn production in Maryland and Virginia (McConnell 1988).

The large proportion of fully developed acorns in moderately defoliated stands suggest that carbohydrate supply only affects about 40 percent of the reduction in acorns compared to 60 percent for loss of flowers. In heavily defoliated stands flower losses were the same as moderate stands, but development losses comprised over 90 percent of the fertilized flowers. Abortion due to loss of carbohydrate supply is the dominant effect in the near complete seed failures in heavily defoliated stands. Pennsylvania Game Commission studies show similar results. Moderate and heavy defoliation in a Centre County stand resulted in production failures in those years (Fig. 4). Similar results for a Huntingdon County stand show that both the red and white oak groups are affected (Fig. 5). Production remains low for 1 to 2 years after defoliation ends. This time lag of recovery may be due to weather conditions, but it also may be due to a lack of flower bud production until the tree can rebuild its carbohydrate reserves to the level where bud production resumes.

Post Outbreak Effects

The major indirect effects on acorn production following outbreaks are: crown dieback and poor vigor resulting in fewer producers, tree mortality removing producers, and species composition shifts that reduce the amount of oak in present and future stands. Recovery of acorn production after defoliation (see Figures 4 and 5) means that either poor vigor trees do not have a major effect or recovery occurs in 1 to 2 years. There is no specific data on how quickly individual trees recover acorn production relative to their vigor.

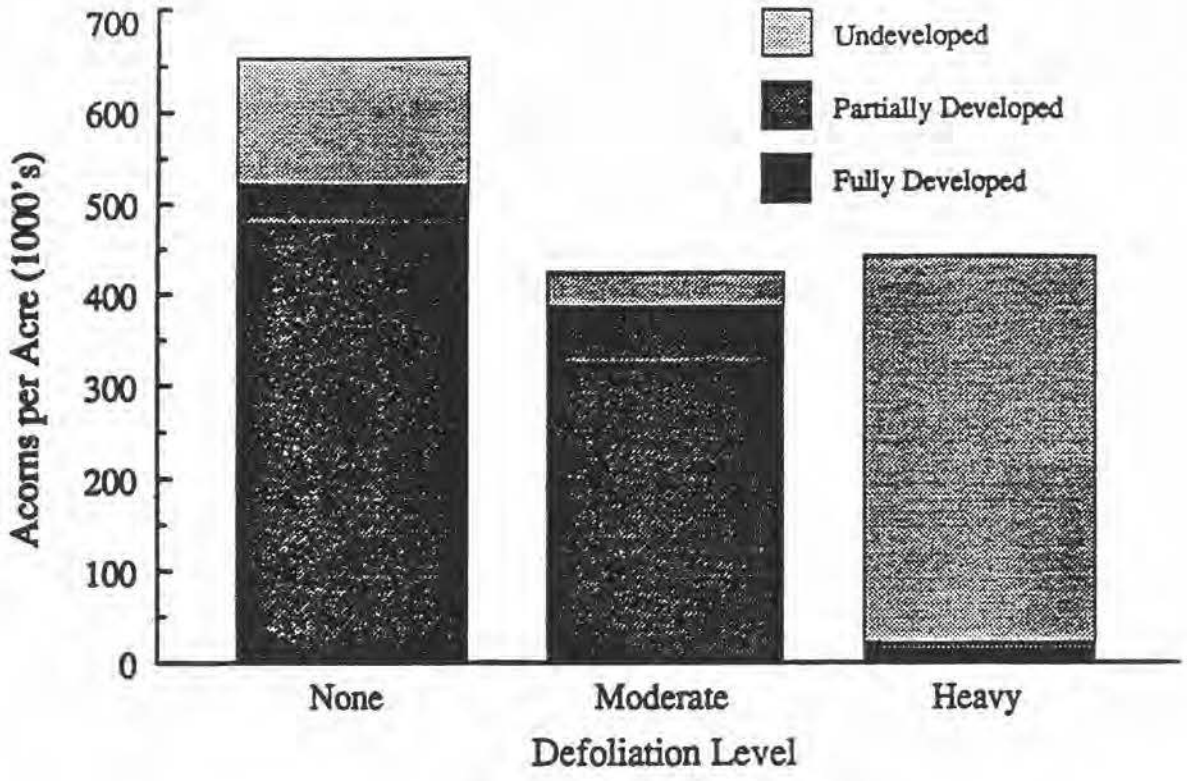

Figure 3.–Effects of gypsy moth defoliation level on total acorn production in Maryland and Virginia (McConnell 1988).

Despite 20 to 30 percent mortality in these stands, average production levels are attained in later years (Figs. 4 and 5). One potential reason for this result is that acorn production in a stand is concentrated in the dominant and codominant trees and very few of the intermediate and suppressed trees contribute (Table 1).

Table 1.–Influence of crown dominance on acorn production of individual trees in three mixed-oak stands in Centre County, PA (Pennsylvania Game Commission, Drake 1987).

Crown class	Non-productive trees (percent)
Dominant	04
Codominant	25
Intermediate	62
Suppressed	91

Dieback, loss of vigor, and mortality usually occur first in these weaker intermediate and suppressed trees so little production capacity is lost. Figure 6 provides even more support for this hypothesis. Stands with less than 25 percent mortality lost less than 10 percent of their original acorn production capacity and growth compensated for that loss providing a 20 percent increase in capacity. Losses in the next two mortality classes (up to 60 percent) were similar; about 20 to 30 percent of original acorn production capacity and growth compensation reduced it to 10 to 20 percent. Significant losses in production occurred only in stands that lost more than 60 percent of their basal area. Loss of original production was 80 percent and there was little growth compensation. These results provided a more favorable long-term outlook for many stands than I originally hypothesized, since only about 5 to 10 percent of infested stands suffer this level of mortality (Herrick and Gansner 1987).

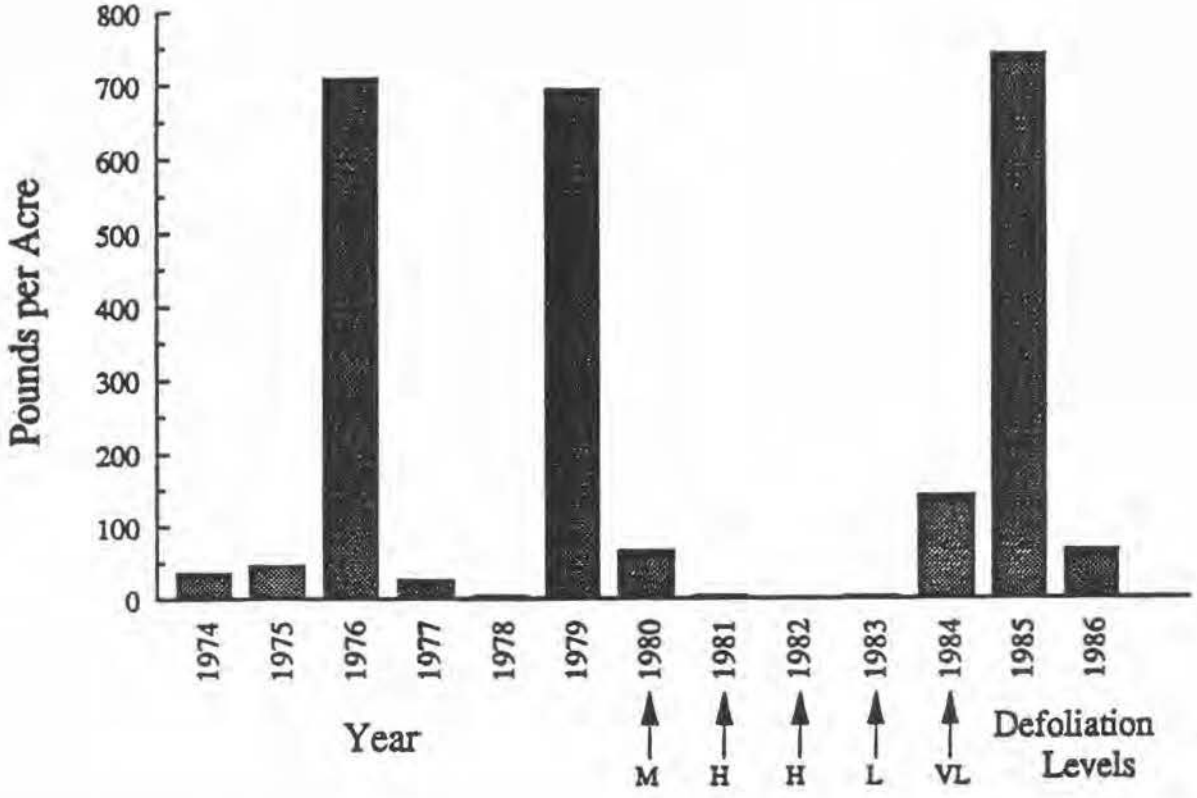

Figure 4.–Average acorn production of three mixed-oak stands in Centre County, Pennsylvania (Pennsylvania Game Commission, Drake 1987).

Allen and Bowersox (1989) have shown a large shift in regeneration composition away from oak toward red maple and black birch. This shift could result in many future stands having a much lower proportion of oak than present stands. The long-term outlook could be a much lower acorn production potential in these stands without an increase in alternate mast species. The development of regeneration after gypsy moth defoliation will need to be followed for many years before we will know if this trend is significant.

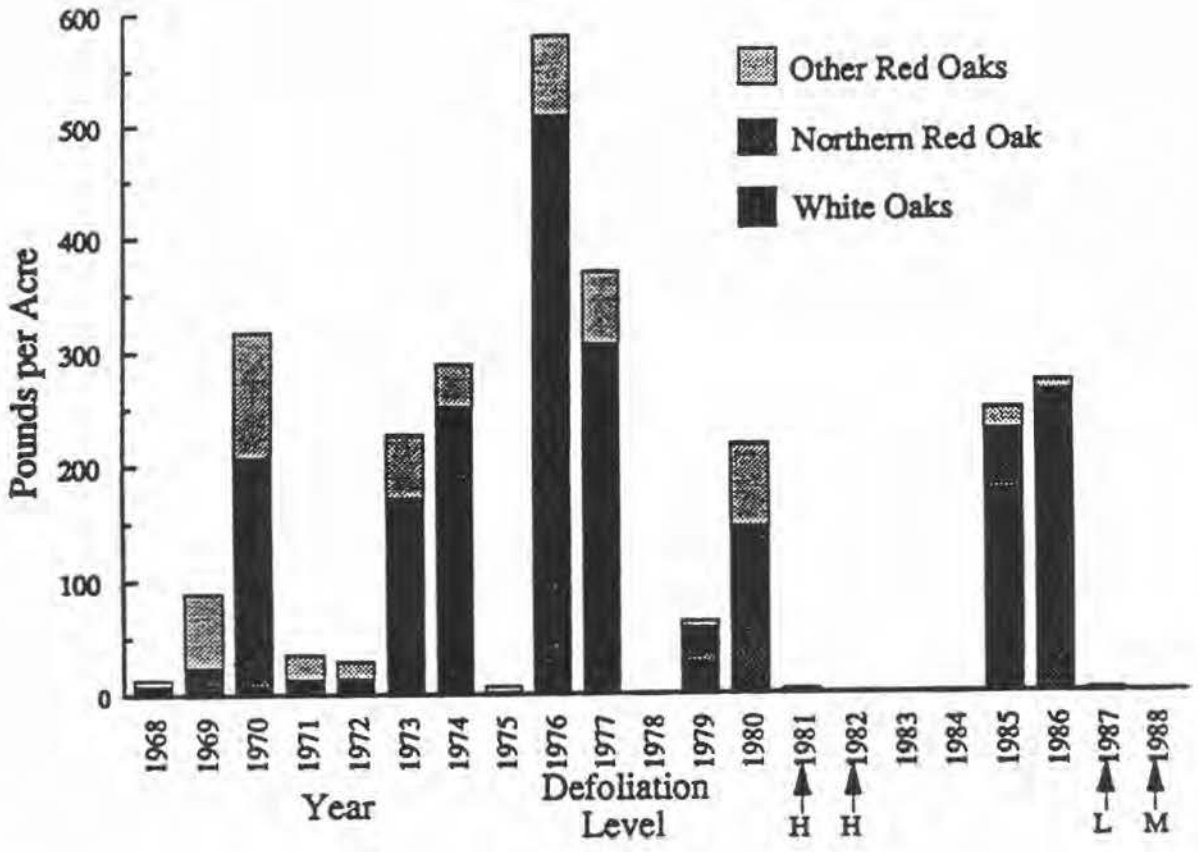

Figure 5.–Acorn production of a mixed-oak stand in Huntingdon County, Pennsylvania (Pennsylvania Game Commission, Liscinsky 1984, Palmer 1989).

MANAGEMENT RECOMMENDATIONS

Reduce Oak Component To Maintenance Level

In areas where gypsy moth attack is imminent and where sites will allow conversion to other species, the oak component of the stand can be reduced to a level where it can be maintained even with gypsy moth infestation. This level will generally be around 15 to 20 percent of the basal area. If these are healthy, dominant oaks, they will possibly survive the attack and still produce a significant amount of mast.

Favor Nonpreferred Mast Species

Wherever possible, favor mast species that are less preferred by the gypsy moth. Hickories, walnut, butternut, and beech are hard mast species that are less preferred (although they can be defoliated in heavy outbreaks). Many soft mast species are also low in gypsy moth preference.

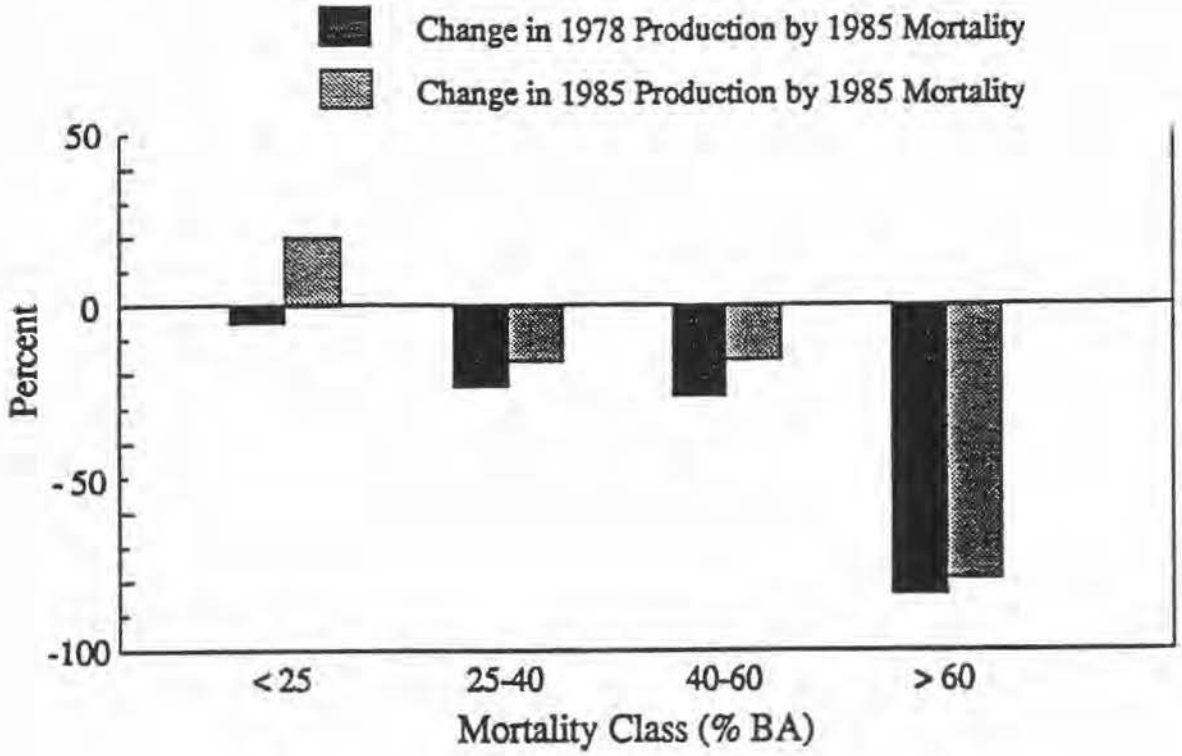

Figure 6.–Change in acorn production capacity due to stem mortality and growth from 1978 to 1985 in central Pennsylvania.

Thin To Develop Large, Healthy Crowns

Where the site and stand conditions do not warrant diversification of mast, the best strategy is to thin oak stands to develop large, healthy crowns. Not only will these trees be the best mast producers, they will also be more likely to survive defoliation and recover production. This situation will reduce postoutbreak effects, but will not prevent defoliation effects on mast crops.

Protect High Value Mast Stands

If certain oak stands have a high value for producing mast, then direct protection may be feasible. Aerial applications of pesticides or microbial agents can protect stands that have been good producers.

RESEARCH NEEDS

Determine Critical Defoliation Threshold For Abortion of Acorns

One of the major gaps in our knowledge is the critical defoliation level that causes large scale abortion of acorns. This level can then be used as a threshold for protecting mast producing stands.

Determine Recovery Response of Surviving Trees

The degree of dieback or vigor loss that will prevent acorn production and affect the recovery speed of production is not known. Development of these data will allow better stand treatment and protection decisions.

Determine "Thinning Response" From Light to Moderate Mortality

It has been proposed that thinning stands to promote increased crown size and vigor will increase mast production. The same result could occur from light to moderate mortality following gypsy moth defoliation. Need more definitive data on effect of thinning on acorn production.

SUMMARY

Defoliation effects on acorn production range from reductions of 50 to 100 percent in the years during outbreaks. Losses are due to decreased flowers and abortion of seed due to low carbohydrate supply.

The effect of oak mortality on acorn production ranges from small increases to large losses depending upon mortality level. Mortality levels of >60 percent significantly reduce acorn production. Shifts in species composition reduces mast yields in the long-term.

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