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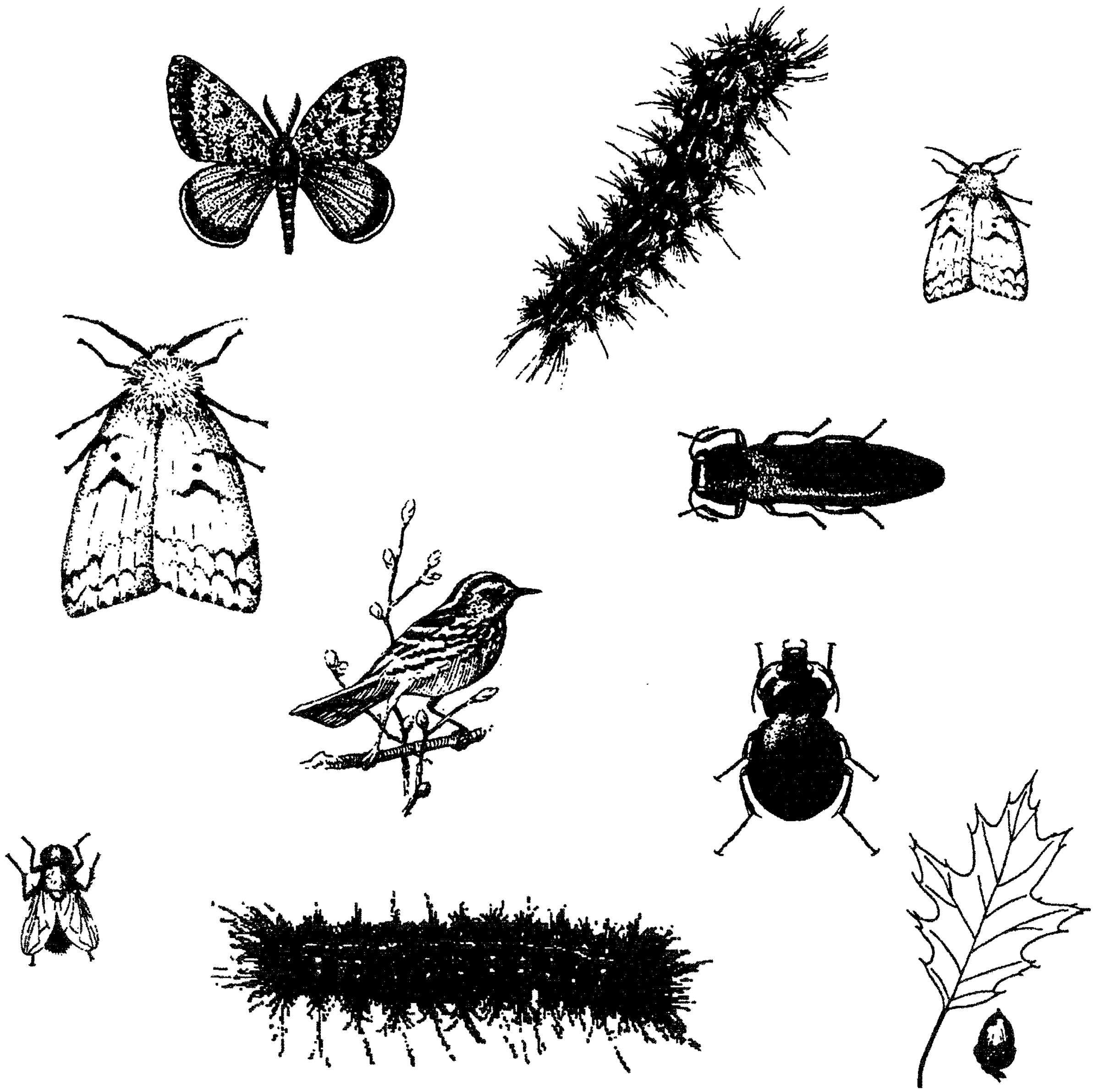

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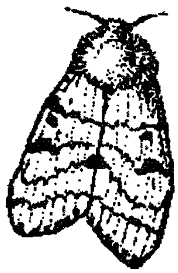

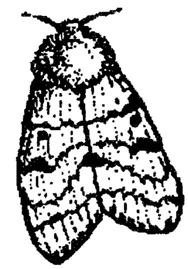

January 22-25, 1990
East Windsor, CT

Edited by
Kurt W. Gottschalk, Mark J. Twery, and Shirley I. Smith

Sponsored by:

Forest Service Research

Forest Service State and Private Forestry

Agricultural Research Service

Animal and Plant Health Inspection Service

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FOREWORD

In July of 1989 representatives of Forest Service-Research (FS-R), Animal and Plant Health Inspection Service (APHIS), and Agricultural Research Service (ARS) began regular meetings to discuss opportunities for improving cooperation among the agencies conducting research on gypsy moth. Representatives from the Cooperative State Research Service (CSRS) and Forest Service-State & Private Forestry (FS-S&PF) were added over the next few months. The group is known as the USDA Gypsy Moth Research and Development Coordinating Group and has the following objectives:

a. To monitor the progress of Service programs and any breakthroughs which may influence USDA policies;

b. To keep the Services and the Gypsy Moth Working Group appraised of progress in research and methods development;

c. To identify research and methods development issues and concerns;

d. To set priorities;

e. To maximize use of current resources as well as to provide appropriate rationale to justify increased resources.

The Coordinating Group resolved at its initial meeting that a combined interagency review of gypsy moth research and development activities would add immeasurably to better communication as well as provide a comprehensive overview of ongoing research. Members of the Coordinating Group also agreed that a proceedings should be published following the meeting.

These proceedings document the efforts of many individuals: those who made the meeting possible, those who made presentations, and those who compiled and edited the proceedings. But more than that, the proceedings illustrate the depth and breadth of studies being supported by the agencies and it is satisfying, indeed, that all of this can be accomplished in a cooperative spirit.

USDA Gypsy Moth Research and Development Coordinating Group
R. Bram, ARS
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USDA Interagency Gypsy Moth Research Review
January 22-25, 1990
Ramada Inn
East Windsor, Connecticut

CONTENTS

HAZARD RATING FOREST STANDS FOR GYPSY MOTH[1]

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ABSTRACT

A gypsy moth hazard exists when forest conditions prevail that are conducive to extensive damage from gypsy moth. Combining forest hazard rating with information on insect population trends provides the basis for predicting the probability (risk) of an event occurring. The likelihood of defoliation is termed susceptibility and the probability of damage (mortality, growth loss, reduced aesthetics, etc.) is called vulnerability. Hazard rating systems are usually developed by making empirical observations of forest stands that are exposed to a gypsy moth outbreak and formulating a prediction model that can be used to estimate susceptibility and/or vulnerability of other stands.

The value of hazard rating is in forecasting where the problem is likely to be most severe and how severe it is likely to be. Using this information, forest managers can target gypsy moth population monitoring in stands that have high hazard and high value. When potentially damaging population levels are detected, the manager can then deploy one of several intervention strategies in the appropriate stands.

INTRODUCTION

The term hazard is given several definitions in the dictionary, but the one which most closely approximates my use of the word in pest management is "something causing danger, risk, or peril". Risk can be further defined as "the degree of probability of loss". Thus hazard rating helps establish conditions where a damaging event is most likely to occur and how extensive the damage is likely to be (Hicks and others 1987). Risk assigns a probability to these likelihoods and is determined by the dynamic relationship between forest conditions and insect population levels. For example, a high hazard can exist in combination with a low risk when insect populations are absent or low. This situation is particularly appropriate to an introduced pest like gypsy moth as it moves into previously unexposed areas.

When a defoliator like gypsy moth consumes the leaves of a tree, the direct effect is a lowered amount of total photosynthesis for the tree, thus less carbohydrate is available for metabolism and storage. Heavy defoliations trigger a refoliation response of trees which further depletes starch reserves from the roots. This physiological stress results in lowered vigor. Multiple years of defoliation tend to compound the problem and defoliation coupled with any other stresses that are normally experienced by trees (drought, heat, cold, shade) often predisposes trees to attack by secondary organisms such as two-lined chestnut borer and *Armillaria* root disease. Either of these organisms directly causes tree mortality (Fig. 1). Because defoliation *per se* doesn't directly cause tree death and because not all trees are equally likely to be defoliated or to die, hazard rating systems to predict "susceptibility" (likelihood of defoliation) and "vulnerability" (likelihood of death or damage) to gypsy moth have been developed (Campbell and Standaert 1974; Valentine and Houston 1979; Herrick and others 1979).

[1]Funding for this research was provided to West Virginia University by the USDA, Forest Service, Northeastern Forest Experiment Station.

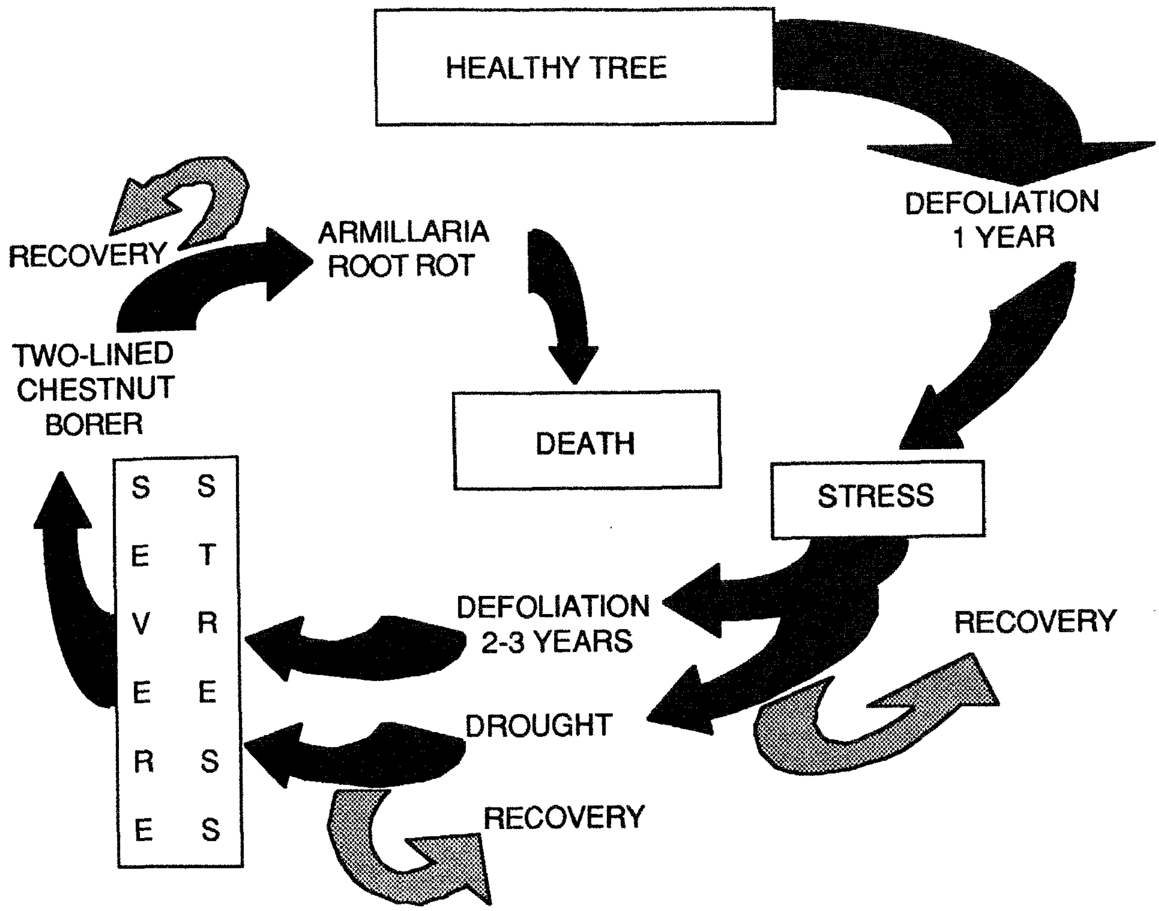

Figure 1. Mortality spiral for trees defoliated by gypsy moth (after Manion 1981).

Insect hazard rating is widely promoted among researchers as a means of targeting activities such as survey and detection, intervention and insect suppression. Unfortunately, many forest managers are slow to implement insect hazard rating as a normal component of their management activities, even though hazard rating systems are available that require standard inventory data, and in some cases have been integrated into total management packages such as SILVAH (Marquis and others 1984). It is the purpose of this paper to develop an appreciation for and an understanding of gypsy moth hazard rating and to illustrate how it can be used in an integrated forest management program.[1]

Developing a Hazard Rating System

Researchers attempting to understand the functioning of natural systems usually have some sort of conceptual model of the system. In the case of gypsy moth hazard rating for vulnerability, that model might be expressed as: Gypsy moth defoliation results in stress to trees which in turn predisposes them to secondary mortality agents; the magnitude of stress can be quantified using measurable variables.

[1]For more on hazard-rating terminology, see "The Revelation" that follows the conclusion of this paper.

Jeffers (1982) refers to this as a "word model". He further discusses "diagram models" which help to organize the problem into a structured form. I have adapted Manion's (1981) "disease spiral" to this purpose (Fig. 1). A primary purpose of modelling is predictions,in this case to forecast hazard or risk of an event happening. Thus to facilitate prediction, some type of quantitative model is required. The dependent variable is some measure of hazard or risk and the independent variables are measures of the state of the system. For example, if we assume that a stressed tree is more susceptible to mortality than a healthy tree, the independent variables we choose should be those that directly or indirectly affect or measure the impact of stress. The variables measured should also be things that are measurable and precise. For example, xylem moisture potential may meet the criterion of being indicative of stress and may be measurable at any point in time, but due to the dynamic fluctuations of tree water balance, it may change drastically in a short period of time and therefore would not be a useful variable for hazard rating. Soil moisture or monthly rainfall, although not direct measures of drought stress would be related to potential for drought stress and could be more useful than the direct measure of xylem water potential.

Once a list of dependent and predictor (independent) variables has been selected, a sampling scheme must be developed. No matter how conscientious one is about sampling, at best only a very small proportion of the total area can realistically be sampled. For example, our study of gypsy moth mortality involves some 400 tenth-acre plots in southwestern Pennsylvania, western Maryland and eastern West Virginia (roughly a circle containing 5 million acres). That works out to about one acre sampled per one hundred twenty thousand acres or a sampling intensity of 0.0008%.

The population of samples should include plots representing the principal forest cover types and sites and should include both defoliated and undefoliated forests. In our study we divided the sample plots roughly evenly between the Appalachian Plateau and Ridge and Valley physiographic provinces since these provinces represent clearly different environments (forest types, soils, geology and climate). It is also important to accurately record the defoliation history of plots since stands receiving different levels of defoliation would be expected to respond differently even when other factors are equal. After a sufficient post-defoliation time period has elapsed for the effects of defoliation to be manifested, tree mortality, growth, development of understory, etc. should be assessed. These are the dependent variables to use in subsequent analyses.

The final step in the model development process is the generation of a mathematical model. Since such sample data generally contain a good deal of variation, the appropriate technique is one which produces a "best fit". Examples are multiple regression and stepwise discriminant analysis. The goal of a model is prediction. In the case of hazard prediction, it can be accomplished as the classification (or probability of classification) of individual trees in a particular state (e.g. dead v. alive). Discriminant analysis or logistic regression are useful techniques for accomplishing this (Valentine and Houston 1979). Predicting hazard for a stand of trees in terms of such dependent variables as number of dead trees or percent dead basal area, etc. can be accomplished by using multiple regression or automatic interaction detection (Herrick and others 1979).

Testing and validation is an often overlooked aspect of model development. Certain techniques can be employed using the sample data. For example, an independent data set can be withheld from the analysis (regression, etc.) and the model developed from the other data can be applied to the independent set to see how well the model predicts. Another statistical validation technique which allows the use of the whole data set for model development is the leave-one-out method. Each observation (plot, stand, tree) is systematically excluded from the data set. The model is developed using all the others and tested against the one left out. These statistical procedures are useful as far as they go, but the true test of a model is whether or not it will work on other stands, in other environments and at other times. Such validation is an on-going and necessary process to determine where, when and if a model provides acceptably reliable predictions.

Applying Hazard Rating.

Hazard rating is a component of integrated pest management and IPM is a component of forest resource management. All too often, the tendency to become specialized makes us myopic and so it is with forest pest managers. Although outbreaks of forest pests like gypsy moth become the proverbial "tail that wags the dog" it is still necessary for pest management to be kept in perspective as a component of forest resource management. Figure 2 is a diagram from Gansner and others (1987) outlining an example of how IPM decisions are made. Hazard rating is a key element in this process which enables the manager to target many of the subsequent activities.

Application of hazard rating, as with all forest management, requires knowledge about the forest. The fundamental unit of management is the stand. Once stands have been delineated, data needed for hazard rating can be collected. In many cases the data needed for hazard rating are the same as needed for other facets of forest management (e. g. tree species, site quality, tree size, crown condition, etc.). Programs like SILVAH (Marquis and others 1984) may facilitate stand data collection and processing.

We have been engaged in gypsy moth hazard rating at the West Virginia University (WVU) Forest during the last year and this experience has been helpful in identifying some of the problems of hazard rating. We selected two compartments at the WVU Forest, each of approximately 450 acres (Fig. 3). Stands were located from point samples taken on a l x 2 chain grid using a 10 BAF prism. We used the Society of American Foresters cover type designations and descriptions to define the cover types and set a minimum of 10 acres for stand size (smaller stands became inclusions in surrounding stands). The stands identified in these two compartments are indicated in Figure 3. An interesting adjunct to this is the fact that using student labor, the cost of stand mapping and collection of stand data for the two compartments was accomplished at about $1.15 per acre.

We applied several hazard rating equations and methods to the stand data. Table 1 compares the results of these ratings for Compartment 4 of the West Block. The most striking aspect to these numbers is how much they differ, both in magnitude and in relative terms. For example, the equation of Gansner and Herrick (1984) produced very low estimates of percent mortality. Looking at their equation it is apparent that percentage of trees with poor crowns (> 50% dead limbs) is the most important driving variable for predicting mortality. Trees with poor crowns are manifesting pre-existing stress and defoliation simply adds to the stress state of the tree until some threshold is exceeded that allows secondary agents to gain a foothold. Since Gansner and Herrick's sample data were collected from the Pocono Mt. region of Pennsylvania, it is easy to visualize how trees may be under stress in this droughty and poor site region. However, at the WVU Forest where annual rainfall averages about 55 inches and oak site index averages around 72 ft., it is not surprising that the percentage of trees showing poor crowns is generally below 5%. The question is; Does Gansner and Herrick's equation accurately project the rate of mortality that might be expected due to 3 years of heavy defoliation at the WVU Forest? My guess is that it doesn't because we have observed very high levels of mortality in stands that were similar to those at the WVU Forest after heavy defoliation. In-other-words, pre-existing stress may hasten the mortality of trees, but the stress threshold for secondary organism attack can be achieved by defoliation alone. Looking farther at Table 1 reveals that the equation of Crow (1985) gives predicted mortality rates of 20-30%, which is fairly consistent with average rates of mortality we have observed in the Ridge and Valley and Appalachian Plateau of western Pennsylvania and Maryland. However a stand mapped as northern red oak type had a lower projected rate of mortality than one mapped as Yellow-poplar-red oak-white oak. When examining Crow's equation, it can be seen that presence of oaks in the white oak group tends to increase the projected rate of mortality while oaks other than white oaks tend to decrease it. To appreciate how this occurred, one must look at the data base from which Crow's equation was derived. All his stands were from the Ridge and Valley region of eastern West Virginia and were essentially pure oak stands. Thus among the oaks, the trees in the white oak group were most vulnerable.

Table 1. Stand data and hazard rating for stands in Compartment 4, Western Block of the WVU Forest.

STAND	S.A.F. COVER TYPE		OAK S.I.	B.A. OF OAK.
1	55	(NRO)	78	67.2
2	44	(CO)	63	76.2
3	44	(CO)	68	65.1
4	28	(BC/M)	75	20.4
5	59	(YP/WO/RO)	80	25.8

SUSCEPTIBILITY RATINGS

STAND	HOUSTON/ VALENTINE DEFOLIATION	GANSNER, ET AL POTENTIAL DEFOLIATION	GANSNER, ET AL PROJECTED 1990 DEFOLIATION
1	resistant	24%	20% approx
2	"	24	"
3	"	24	"
4	"	9	"
5	"	9	"

VULNERABILITY RATINGS

STAND	REGRESSION GANSNER/HERRICK (# of trees)	A.I.D. GANSNER/HERRICK (# of trees)	CROW (B.A.)
1	3.54%	4.07%	29.2%
2	4.62	--	21.8
3	3.87	4.29	20.0
4	3.50	--	32.1
5	3.50	--	35.6

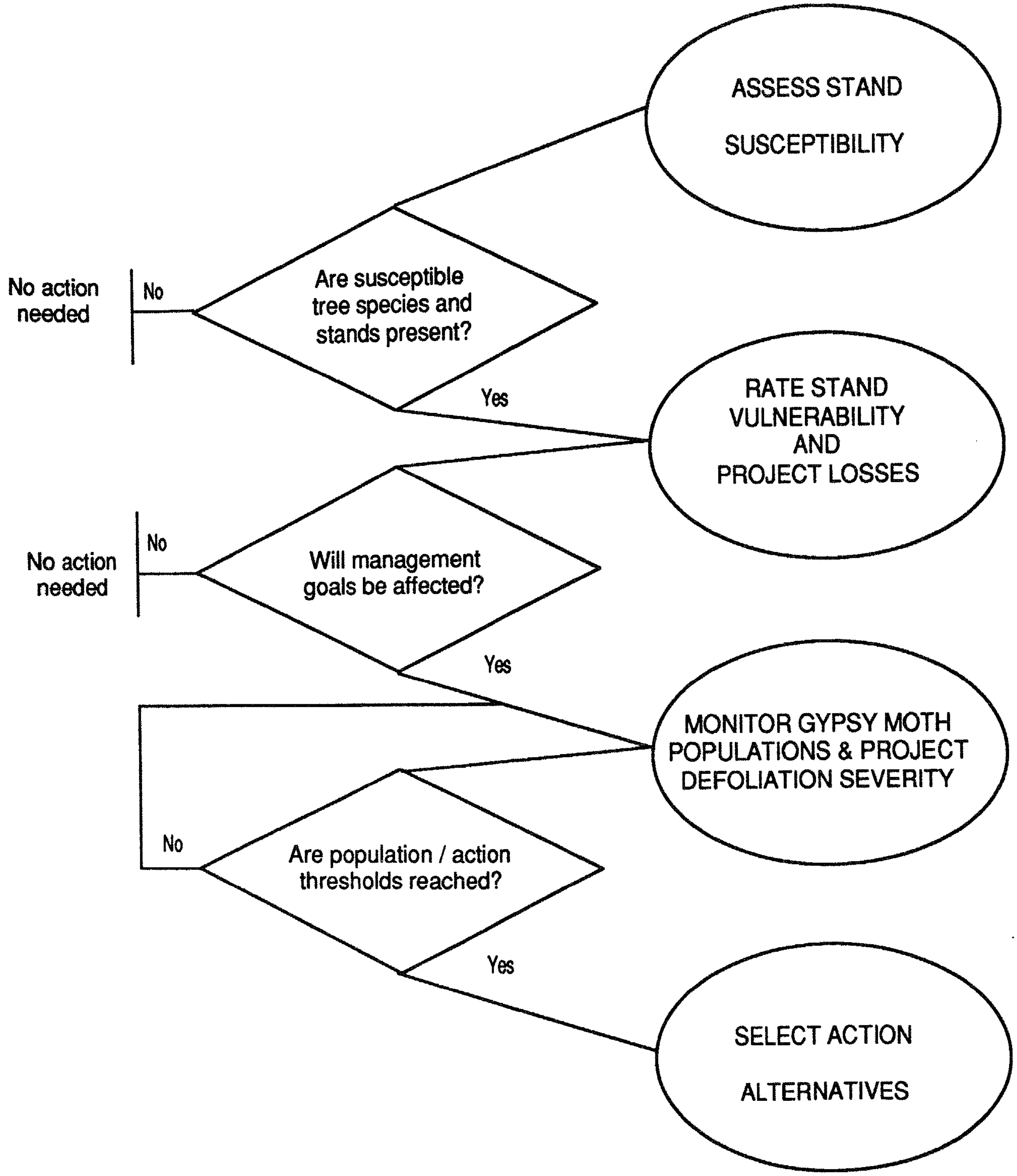

Figure 2. Flow chart of decisions for integrated pest management (from Gansner and others 1987).

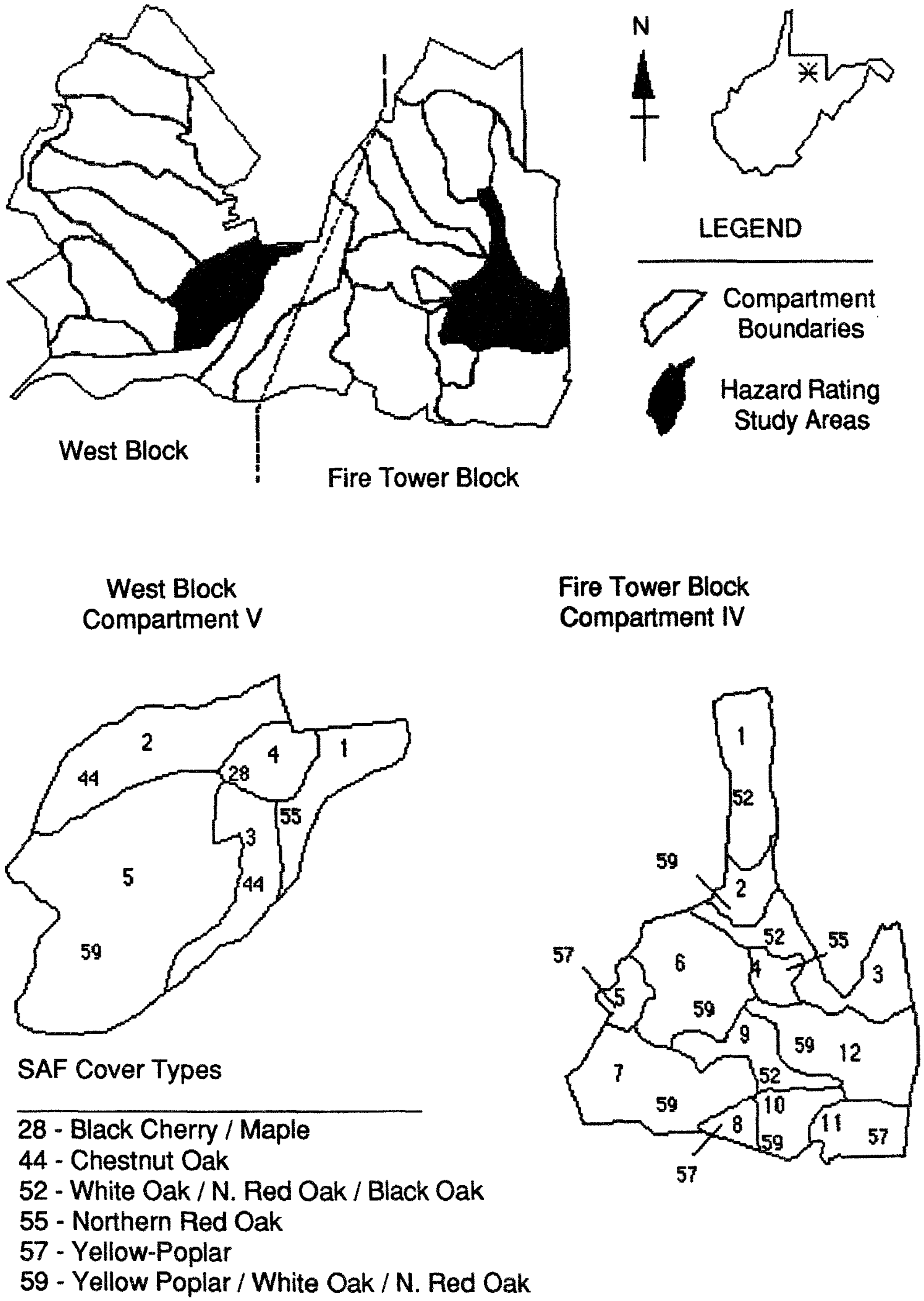

Figure 3. Study sites at the WVU Forest.

The point of all this is that one should be very careful to use hazard rating equations that were developed under conditions similar to those where they are being applied.

A final note concerning the application of IPM and hazard rating concerns the timing of these actions. IPM is not a good system to employ during "crisis management". That is to say, IPM should be an on-going component of resource management and should be implemented to give adequate time to use long-term preventative measures such as silvicultural control. The aim is to prevent the need for crisis management, a situation where forest management is subjugated to gypsy moth and not the landowners objectives.

CONCLUSIONS

Hazard rating is a component of integrated pest management, which in turn is a component of integrated resource management. This paper discusses the relationships of hazard rating to IPM and resource management. Methods of developing hazard rating systems are discussed and further discussions elaborate on the application of hazard rating within the context of resource management. Through the course of these discussions a number of needs have been identified or implied. These needs are as follows:

• Data incorporated in hazard rating systems should, to the extent possible, be standard forest inventory data so that special data collection is avoided.

• Hazard rating and IPM should be included as a normal component of forest management.

• Hazard rating should be applied at the stand level, but may also be applied at the landscape level. In both these applications, use of geographic information systems (GIS) will facilitate application and integration into management.

• Hazard rating equations must be applied only to appropriate areas with similar climatic, site and forest cover types to the conditions under which the models were developed.

• Hazard rating equations need to be validated by comparing predicted with actual susceptibility and vulnerability. This validation process should lead to updating and revision of equations to improve predictability.

Finally, several extensive reviews of insect hazard rating have been published recently. An overview of hazard rating was supplied by Hedden (1981) as a part of a conference devoted to the subject. Mason (1987) and Hicks and Fosbroke (1987) reviewed hazard rating in the proceedings of a conference dealing with gypsy moth. Hicks and others (1987) reviewed hazard rating and compared its application to gypsy moth and southern pine beetle. These and other references are useful in orienting managers to the subject of insect hazard rating.

LITERATURE CITED

Campbell, R. W. and Standaert, J. P. 1974. Forecasting defoliation by gypsy moth in oak stands. USDA For. Serv. Res. Note NE-193. 7 p.

Crow, G. R. 1985. Factors influencing tree mortality in mixed-oak stands following spring insect defoliation. M.S. Thesis, West Virginia University, Morgantown, WV. 128 p.

Gansner, D. A. and Herrick, O. W. 1984. Guides for estimating forest stand losses to gypsy moth. North. J. Appl. For. 1: 21-23.

Gansner, D. A., Herrick, O. W., Mason, G. N. and Gottschalk, K. W. 1987. Coping with the gypsy moth on the new frontiers of infestation. South. J. Appl. For. 11 (4): 201-209.

Hedden, R. L. 1981. Hazard-rating systems development and validation : an overview. in Hazard Rating Systems in Forest Insect Pest Management : Symposium Proceedings. USDA Forest Serv. Gen. Tech. Rep. WO-27. 8-11.

Herrick, O. W., Gansner, D. A. and DeBald, P. S. 1989. Predicting forest stand losses from the gypsy moth: an application of automatic interaction detection (AID). J. For. 77 (2): 91-94.

Hicks, R. R., Jr. and Fosbroke, D. E. 1987. Stand vulnerability: Can gypsy moth damage be predicted? *In* Proc. Coping with the Gypsy Moth in the New Frontier. West Virginia Univ. Books. 73-80.

Hicks, R. R., Jr., Coster, J. E., and Mason, G. N. 1987. Forest insect hazard rating. J. For. 85(10): 20-25.

Jeffers, J. N. R. 1982. Outline Studies in Ecology (Modelling). Chapman and Hall, N.Y. 80 pp.

Manion, P. D. Tree Disease Concepts. Prentice Hall, Englewood, Cliffs, NJ.

Marquis, D. A., Ernst, R. L. and Stout, S.L. 1984. Prescribing silvicultural treatments in hardwood stands of the Alleghenies. USDA, Forest Serv. Northeastern Station, Gen. Tech. Rept. NE-96. 89 pp.

Mason, G. N. 1987. Rating stand susceptibility to gypsy moth defoliation. *In* Proc. Coping With the Gypsy Moth in the New Frontier, West Virginia Univ. Books. 65-72.

Valentine, H. T. and Houston, D. R. 1979. A discriminant function for identifying mixed-oak stand susceptibility to gypsy moth defoliation. For. Sci. 25(3):468-474.

The Revelation
by Ray Hicks

Truth is seldom ever revealed
but a glimpse I got as north I wheeled,
from East Windsor on Tuesday eve,
a sign from heaven I perceived.
While heading up the Interstate
The vision came at exit 48
And slowly I began to smile
The sign said "Hazardville 1/2 mile".
I looked about the lonely scape
Expecting oaks, abundance great,
But all I saw was maple trees,
"There is no hazard here to see".
And so my thoughts began to gel,
If this is really Hazardville,
Then hazard ain't what I thought, why fight
For Once! perhaps the economists are right!
And so it is we must design
New terms that will define
Those most basic concepts
And parameterize our model steps.
I can think of quite a few
That express them to me, maybe you?
What about phytoentoprobabilistic
Or stochiometriceccentristic?

But you must have much better terms
That tell why trees are eat by worms
And so I leave this job to you
And wish you luck, you'll need it too!

WHAT CAUSES THE PATTERNS OF GYPSY MOTH DEFOLIATION?

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ABSTRACT

Gypsy moth defoliation is typically observed to occur on xeric ridge tops before more mesic, lowland forest, in oak-dominated habitats in the Northeast. In subsequent years defoliation may also occur in mesic forests. What causes this pattern of defoliation? Differences in the degree of defoliation may be due to differences in the density of gypsy moth populations in these "defoliation-susceptible" and "defoliation-resistant" habitats, with higher densities on ridge tops -- the "focal area hypothesis." It is also possible that ridge tops have a lower foliage biomass than mesic forests, such that the same density of gypsy moth results in a proportionately greater removal of foliage -- the "foliage biomass hypothesis."

The results of a long-term study in Vermont, where these classic defoliation patterns were observed in the first year of defoliation (1989) are discussed with regard to these alternative, but non-exclusive "focal area" and "foliage biomass" hypotheses. Percent defoliation was 17 x greater on the ridge top than in the surrounding mesic forest. Egg mass densities in 1988 and 1989 were not significantly different between habitats and the number of eclosed female pupae did not differ in 1989. However, total pupal density and larval densities were significantly greater on ridge tops in 1989 (approx. 1.3 to 3-fold higher). Leaf area removed was greater on the ridge top supporting the "focal area hypothesis." However foliage biomass, as indicated by tree and canopy height, and leaf area index was also lower on the ridge top, supporting the "foliage biomass hypothesis." It would appear that the patterns of the first year of defoliation are explained by both higher larval densities and lower foliage biomass on ridge tops compared to mesic forests.

The implications of these findings to the potential for ridge tops to act as focal areas in subsequent years is discussed. The data suggest that this will be unlikely, even though densities and defoliation may be higher on ridge tops. From a management standpoint the data indicate that suppression of ridge top populations will have little impact on defoliation in the surrounding areas, but future monitoring is necessary to ascertain whether or not this is the case. The data suggest that inclusion of estimates of foliage biomass in different forest habitats will markedly improve the prediction of local defoliation based on egg mass densities, and may enhance regional-scale rating of stand susceptibility to defoliation.

DEVELOPMENT OF A SAMPLING SYSTEM FOR *ARMILLARIA* RHIZOMORPHS IN MIXED OAK STANDS: A PROGRESS REPORT

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ABSTRACT

The assessment of the problems caused by gypsy moth is dependent on a number of characteristics of a forest stand. One of the main impacts of defoliation is the mortality of standing trees. Mortality is seldom caused directly by defoliation, but is usually associated with a secondary agent which attacks the tree in its weakened condition. The shoestring root rot organism, *Armillaria* spp. (probably *A. gallica*), is one of the most important of the secondary agents after defoliation . *Armillaria* is present in large quantities after defoliation episodes. Its abundance is correlated with tree mortality in defoliated stands. Preliminary studies found differences in the presence and abundance of rhizomorphs in the soil between undisturbed stands and stands defoliated previously by insects. Rhizomorph distribution within the plots was uniform in the undisturbed stand, but was significantly greater near dead trees in the defoliated stands. Greater rhizomorph abundance near recently dead trees or stumps may have important implications for management decisions in the presence of gypsy moth infestations. Total rhizomorph abundance was greater on plots defoliated 5 years before sampling than on more recently defoliated plots, and least on undefoliated plots. Overall rhizomorph density was highly correlated to rhizomorph density near dead trees.

This study was designed to test a sampling procedure to estimate the abundance of *Armillaria* rhizomorphs in forest stands and predict the vulnerability of the stand to *Armillaria* root disease after defoliation. It was superimposed on a silvicultural treatment designed to test the effectiveness of partial cutting on reducing the impact of gypsy moth defoliation on forest stands.

Eight stands of approximately 50 acres (20 ha) each have been selected for the silvicultural treatments, four with moderate susceptibility to defoliation and four with high susceptibility. Half of each stand will be thinned during the winter of 1989-90 in a manner which will reduce the susceptibility or vulnerability of that portion of the stand, producing four replications of each of four treatments, including the unthinned control stands. No stands have yet received defoliation, but gypsy moth is present, and defoliation is anticipated within one to three years. In the current study we established a systematic grid with ropes over each plot. At each grid point a judgment of the likelihood of high or low rhizomorph abundance was recorded, random samples of soil were removed from each of the strata for extraction of rhizomorphs, and estimates of rhizomorph abundance and sampling variance are being computed for each stratum and the plot.

SHORT-TERM EFFECTS OF GYPSY MOTH DEFOLIATION ON NONGAME BIRDS

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ABSTRACT

The response of a nongame bird community to tree defoliation and mortality caused by gypsy moths was studied during the summers of 1984, 1985, 1987, and 1988 in deciduous forest habitat of eastern West Virginia. Birds and structural vegetation characteristics were sampled on 42 permanent stations. The 1984 and 1985 stations were considered undefoliated because whole tree defoliation did not occur until 1986. The 1987 and 1988 stations were categorized as defoliated or undefoliated based on canopy coverage and snag density values when compared to the pooled 1984 and 1985 station values. Some bird species showed higher frequencies of presence at defoliated compared to undefoliated stations, but no species showed lower frequencies of presence at defoliated stations.

For each of 32 bird species, two-group discriminant analyses were used to construct a bird presence gradient and a defoliation gradient based on vegetation characteristics at each station. Regression analyses were used to examine the dependency of canonical variable scores along the presence gradient and canonical variable scores along the defoliation gradient. Results showed that 17 species responded positively, 4 species responded negatively, and 11 species displayed no response to gypsy moth induced defoliation and tree mortality.

We suggest the short-term pattern of generally positive effects of gypsy moth defoliation on nongame birds is related to the increased amount of suitable habitat, increased habitat diversity, and increased food supply. However, a potential exists for the future reduction in reproductive success of many species because of increased nest predation and brood parasitism. Therefore, we caution that the long term responses of bird species to heavy defoliation and subsequent tree mortality remain unknown.

THE EFFECTS OF GYPSY MOTH INFESTATION ON GRAY SQUIRREL HABITAT AND POPULATIONS

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ABSTRACT

The overall objective of this project was to determine the effects of defoliation on gray squirrel habitat. We will evaluate the existing Habitat Suitability Index (HSI) Model for gray squirrels on the University Forest and determine the effects of thinning on HSI values computed for thinned and unthinned stands. Habitat variables used in the U. S. Fish and Wildlife Service gray squirrel model were measured on 8 10-12 ha treatment (to be thinned in spring 1990) and 8 unthinned stands on the University Forest, Morgantown, WV, and 3 other nearby hardwood tracts. Six different habitat variables were measured on 112 0.04-ha plots using standard forest measurement techniques. Squirrel abundance was measured on these same stands from 6:00-9:00 AM from June-October 1989 using time-area counts.

Habitat Suitability Indices for each stand varied from 0.13 to 0.54. Pearson's correlation was used to test the association between habitat variables and HSI values to determine what variables were needed in the regression model. Four of six habitat variables were significant, but all six variables were put into the model. Multiple regression analysis was used to determine if HSI values were dependent on the habitat variables. The analysis showed that HSI values were dependent on hard mast copy, total canopy closure, mean dbh of overstory trees, and hard mast species diversity ($R^2 = 0.97$, $n = 19$, $P<0.0001$).

Fifty-nine squirrels were counted during 154 morning counts. No relationship was found between squirrel counts and HSI values ($R^2 = 0.15$, $P = 0.235$). Causes might be too few squirrel counts, low numbers of squirrels, too few den trees, too few mature mast producing trees, or poor mast production in previous year. In general, good squirrel habitat was clumped within the stands. It was in these areas that higher HSI values were obtained and squirrels were seen. Thus, we had higher squirrel counts, while the overall HSI values were low and few squirrels were counted there.

EFFECTS OF GYPSY MOTH INFESTATION ON AESTHETIC PREFERENCES AND BEHAVIOR INTENTIONS

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Using the Scenic Beauty Estimator (SBE) approach, within-stand color photographs were taken of 27 forested sites representative of the Central Appalachian Plateau. These sites had been repeatedly infested by gypsy moth (*Lymantria dispar*) (GM) to varying degrees since 1985, with resulting tree mortality from 6% - 97%. Eighty-one slides (3 slides/site) were randomly arranged and presented to 415 subjects. Subjects were composed of professional foresters, forestry students, recreation students, members of the Izaak Walton League, and a pool of general students. Within each group, half of the respondents were told the damage was caused by GM and the other half were not told. In order to evaluate the effect of GM on recreation visitation, half the subjects rated the slides for scenic beauty (SBE) and the other half for likelihood of visiting (LOV).

Analysis of the ratings revealed no differences in the ratings according to group membership, knowledge of the presence of GM, or which questionnaire (SBE or LOV) respondents received. All respondents were therefore pooled in order to develop a single predictive model. Potential predictor variables included % basal area dead, mean tree height, mean DBH, % oak basal area, stand age, and total basal area. Since mountain laurel (*Kalmia latifolia*) flowers tend to be more abundant in sites with high mortality, additional potential predictor variables included the number of slides/site with visible mountain laurel flowers and the % of mountain laurel regrowth above 1 foot.

A quadratic function of tree mortality by preference rating best described the variablity in ratings ($R^2 = .60$). The effect of flowering Mountain Laurel was also significant with the covariate "slides/site with visible flowers" increasing the R^2 to .74. Scenic preferences and appeal for visitation increased initially as mortality approaches 20-30%. Up to this point, increased sunlight, visual penetration, and undergrowth may have mitigated the negative effects of mortality. As mortality exceeded 20-30%, however, ratings dropped sharply.

Consistent with past studies, college students appear to provide a good representation of the general public in regard to reaction to forest insect damage. The potential for bias resulting from a group's views of proper forest management does not seem to be a factor in regard to preference ratings. In addition, basic awareness of the presence of insect damage did not significantly influence ratings, suggesting the limited usefulness of information or education efforts aimed at shaping public responses to GM damage. Finally, scenic beauty preferences appear to be closely linked to recreation behavior intentions, thus providing managers with a relatively simple and inexpensive surrogate measure of visitor behavioral responses to insect damage.

USING SILVICULTURE TO MINIMIZE GYPSY MOTH IMPACTS

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ABSTRACT

Several studies are underway to test and evaluate the use of silvicultural treatments to minimize gypsy moth impacts. Treatment objectives are to change stand susceptibility to gypsy moth defoliation or stand vulnerability to damage after defoliation. Decision charts have been developed to help forest and land managers to select the appropriate treatment for their forest and insect conditions. Extensive plots to test silvicultural manipulations have been and are being established by several state organizations including the West Virginia Division of Forestry, Ohio Division of Forestry, Pennsylvania Bureau of Forestry, and several private companies and consulting foresters. Other states (Michigan, Indiana, Virginia) are close to establishing plots. These extensive plots will be monitored for gypsy moth defoliation and mortality which will be used to compare with control stands in the same areas.

Intensive plots are established on the West Virginia University Forest in cooperation with the WVU Division of Forestry. Two treatments, presalvage thinning and sanitation thinning, are being tested against paired control stands. In addition to measures of defoliation and mortality, regeneration, seed production, gypsy moth life stages and mortality sources, predators, and secondary organisms are being measured in the plots. A research and demonstration area has been established in the Arnold's Valley Opportunity Area, Glenwood Ranger District, Jefferson National Forest as part of the AIPM Project. Silvicultural treatments will be established and followed in conjunction with control stands and stands treated with low- and high-level insect control tactics.

The use of both intensive and extensive plots to evaluate silvicultural treatments maximizes the amount of information that can be obtained from a limited funding base. As the installed treatments are defoliated and mortality is documented, the effectiveness of using silvicultural treatments can be determined.

EFFECTS OF GYPSY MOTH-ORIENTED SILVICULTURAL TREATMENTS ON VERTEBRATE PREDATOR COMMUNITIES

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ABSTRACT

The impact of forest thinning, as an alternative gypsy moth management technique, on insectivorous birds and small mammals is being investigated in the West Virginia University Forest. The effects of thinning on predation of gypsy moth larvae and pupae by vertebrates are also being examined. Pre-thinning studies were conducted during the spring, summer, and fall of 1989 in 8 control stands and in 8 stands scheduled to be thinned during the winter of 1989-1990. Insectivorous birds were spot-mapped, and small mammals were pitfall and snap trapped to estimate abundance per stand. Mast traps were erected to estimate seed production per stand.

Cage exclosures of gypsy moth larvae and pupae were distributed to determine sources and magnitudes of predation. The three exclosure types were a control allowing all sources of predation, 1 inch screen excluding predation by birds, and 1/2 inch screen excluding predation by birds and small mammals. Exclosures were located at ground, trunk, and foliage levels. Results for the larvae trial showed that small mammals and invertebrates were important ground predators, invertebrates were important trunk predators, and predation was low from all sources in the foliage. For the pupae trial, small mammals were the dominant predators on the ground, and predation was low at trunk and foliage locations.

A tracking technique was developed to examine differential predation of larvae and pupae by small mammals. The circumferences of styrofoam plates were painted with a mixture of fluorescent powder and petroleum jelly. The plates were baited with either a larva or pupa and collected after 1 week exposure periods. The tracks on plates with a preyed larva or pupa are currently being examined under ultraviolet light to discriminate predation by mice and shrews.