

EFFECTS OF GYPSY MOTH INFESTATION ON NEAR-VIEW AESTHETIC PREFERENCES AND RECREATION BEHAVIOR INTENTIONS

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Abstract: Using the Scenic Beauty Estimator (SBE) approach, near-view color photographs were taken of 25 forested sites exhibiting gypsy moth induced tree mortality from 6% - 97%. A quadratic function of tree mortality by preference rating best described the variability in ratings ($R^2 = .60$). The effect of flowering mountain laurel flowers was also significant with the covariate "presence of flowers" increasing the R^2 to .74. Scenic preferences and appeal for visitation increased initially as mortality approached 20-30%. Up to this point, increased sunlight, visual penetration, and understory regrowth may have mitigated the negative effects of mortality. As mortality exceeded 20-30%, ratings dropped sharply. Attitudes regarding proper forest management were not a factor in preference ratings. 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 gypsy moth damage. Scenic beauty preferences were closely linked to recreation behavior intentions, thus providing managers with a relatively simple and inexpensive surrogate measure of visitor behavioral responses to insect damage. We conclude that if near-view aesthetics or recreation visitation are the only consideration, except where tree mortality is expected to be unusually high, suppression is not justifiable.

INTRODUCTION

Legislative mandate and growing public concern for preserving beauty in natural landscapes necessitate formal consideration of aesthetic merit in the public resource allocation process. The "visual landscape" has, in fact, secured recognition as a basic resource warranting equal consideration among more established forest resource values. As a result, measurement methods have been developed that can produce valid and reliable indices of scenic beauty (Daniel and Boster 1976; Buhyoff and others 1981; Zube 1982; Anderson and Schroeder 1984; Ribe 1989). By determining the effects of different resource conditions or management alternatives on aesthetic qualities, these methods provide explicit quantitative values based on people's perceptions or judgments of stimuli (i.e. the visual quality of a

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forest stand). The application of these methods has generally focused on estimating changes in aesthetic quality resulting from alternative resource conditions that policy makers and managers can at least partially influence (Hull and Buhyoff 1986).

Since its introduction in the Boston area in 1869, the range of the gypsy moth *Lymantria dispar* L. has expanded from the Northeast to the Central Appalachian Plateau region and promises to continue moving south and west. Despite being arguably the most thoroughly studied forest insect and the target of the most intensive control and eradication effort (McManus 1987) the gypsy moth persists, periodically erupts, and continues to expand its range. Along with the more tangible forms of damage caused by the gypsy moth (e.g. loss of saw timber volume and change in forest composition), the continuing spread of the gypsy moth poses a serious threat to aesthetic values.

There is no published empirical work on the aesthetic impact of gypsy moth damage. Anecdotal evidence suggests that recreational participation during high defoliation periods may be curtailed by as much as 20% (Goebel 1987). More enduring visual impact may occur as a result of tree mortality and changes in forest composition. This may be particularly true at intensively used recreation areas, along scenic byways, or where private landowners place high value on the scenic qualities of their property. Resource policy and management responses to gypsy moth (e.g. aerial spraying, silvicultural treatments, "let-infest" policies, public education and information) may also have significant aesthetic impacts.

Study Objectives

The goal of this study was to provide resource policy makers, public land managers, tourism interests, and private landowners with useful information for making decisions regarding the gypsy moth. This was accomplished under three primary objectives. First, the study sought to determine whether gypsy moth-induced tree mortality results in aesthetic impacts. We chose to look at the long-term aesthetic impacts that may result from gypsy moth induced tree mortality and forest compositional change; as opposed to the more intermittent and transient effects of defoliation. It has been consistently proven that insect damage affects the scenic quality of within stand sites and scenic vistas. Buhyoff and Leuschner (1978) found that visual preferences decreased rapidly as forest damage from southern pine beetle *Dendroctonus frontalis* Z. approached 10%. Declines in preference ratings were slight thereafter. Of primary concern in this study was whether this relationship would prove true with gypsy moth damage.

Second, we were interested in determining the relationship between aesthetic assessments and recreation behavior intentions. Preferences such as perceived security and perceived enjoyment have been successfully measured using scenic beauty assessment methods (Schroeder and Anderson 1983, 1984; Schroeder 1983) These efforts demonstrated that amenity preferences other than aesthetic quality can be quantified. In this study, we examined the behavior intention "Likelihood of Visiting" (LOV) in relation to gypsy moth damage.

When knowledge of the presence of insect damage has been provided to the respondents, preference ratings have typically been more critical (Riesenman 1977, Buhyoff and others 1979, 1980, 1982; Schroeder and Daniel 1981). Conversely, information and education may also be a factor managers can use to moderate aesthetic or recreation impacts of the gypsy moth. Therefore, a third objective of this study was to examine the effect knowledge of the presence of gypsy moth on preference ratings.

METHODS

Study Site Selection

The sites were located in Somerset county of southwestern Pennsylvania and are representative of the Central Appalachian Plateau region. Forest measurement data available on the sites back to 1985 allowed us to select sites with a broad spectrum of tree mortality (Fosbroke and Hicks 1989). Twenty-five sites were selected from a population of 181 sites. The sample sites depict a range of gypsy moth related tree mortality from 6.1% to 97.9%. The mean and median dead basal area of the population sites were 27.9% and 19.97% respectively. Topography of the sites ranges from very steep to relatively flat. The mean basal area was 103 ft²/acre and ranged from 57-149 ft²/acre. The average percentage of oak on the sites prior to mortality was 93.5%. The mean stand age was 83.9 years with a standard deviation of 21.3 years.

Photo Sampling

During the month of June, 1989, three 35mm color near-view photos were taken of the sites in random directions. The camera was held vertically and the angle of view was maintained at consistent levels. It should be pointed out that the photos were all taken in June and 42% of the slides contained a noticeable amount of flowering mountain laurel *Kalmia latifolia* L. and thus do not represent seasonal differences. The effects of the flowers are adjusted for in a covariate analysis but the appearance of the sites is delimited to May through July when mountain laurel is flowering.

Subjects

The slides were randomly sorted into a slide carousel and presented to 400 individuals. Comparison of differing user groups is common in aesthetic preference research. Past studies have typically shown a lack of intergroup differences in preference ratings (Ribe 1989; McCool 1986). In this research effort, we attempted to represent a wide spectrum of resource management interests. The groups chosen for this study were members of the Izaak Walton

League (n=16), representing moderate preservationist interests, and professional foresters (n=31) representing utilitarian interests. The remaining three groups were drawn from students at West Virginia University and were composed of recreation students (n=61), forestry students (n=91), and a pool of general students (n=201). These three groups theoretically fall between the Izaak Walton league and the foresters on the preservation/utilization spectrum.

Scenic Beauty and Likelihood of Visiting Estimates

Tree mortality and scenic assessments may not be related in a linear fashion (Buhyoff and Leuschner 1978). Gypsy moth-related tree mortality also varies widely from site to site (Fosbroke and Hicks 1989a). It therefore was necessary to adopt a methodology whereby changes in aesthetic quality could be assessed across incremental changes in forest composition and tree mortality. An adaptation of the Scenic Beauty Estimation (SBE) method developed by Daniel and Boster (1976) was used to examine this relationship. The SBE method has emerged as the most sophisticated and commonly used visual assessment techniques (Ribe 1989). A derivative of signal detection theory, widely used in the field of psychophysics, the procedure yields standardized difference scores indicating the perceived scenic beauty of each site for each observer. The SBE method has been proven repeatedly to be a highly reliable and valid means of obtaining preference judgments (Daniel and Boster 1986; Brown and Daniel 1984; Schroeder and Anderson 1984).

We used the method to generate viewers' ratings for both the scenic quality and their likelihood of visiting the study sites. Within each subject group, half of the respondents rated the slides in regard to scenic beauty (SBE) and the other half rated the slides by the likelihood they would visit (LOV) the area represented by the slide. Additionally, half of the respondents were informed of the presence of Gypsy Moth through written instructions. The other half remained unaware while rating the slides.

Ratings were converted to Scenic Beauty and Likelihood of Visiting Estimates (SBE's and LOV's) using the "by slide" method developed by Daniel and Boster (1976). The method converts ratings of each slide to standard normal deviates which place all respondents on a common scale. The distance of each rating was then measured from a common baseline. A site which had been sprayed to prevent gypsy moth infestation served as this baseline. This site was assigned a scale value of '0' and all other sites were measured relative to this origin. The scores were multiplied by 100 to remove the decimal point, and the scores for each site were averaged for each group. Thus, the resulting score was not an individual preference, but a combination of preferences of several people for a variety of slides representing a site.

RESULTS

Intergroup Preferences

Similar to past research, the preference ratings of the five subject groups were quite similar. Correlations ranged from .94 between recreation students and foresters, to .99 between forestry students and general students ($p < .001$ in all cases). Analysis of variance between groups showed no significant differences between the means ($f = .0012$; $df = 4$; $p = .999$). The groups were pooled for further analysis.

Analysis of Treatment Effects

Pearson's sample correlation coefficients and t-tests were used to compare the ratings for scenic beauty and the likelihood of visitation and to compare the ratings of those who were aware and unaware of gypsy moth presence. Scenic beauty and likelihood of visiting ratings correlated at .99 ($p < .0001$) and had essentially equal means ($\text{prob} > |t| = .99$). The ratings of the aware and unaware respondents correlated at .97 ($p < .0001$) and also had similar means ($\text{prob} > |t| = .98$). Results of a 2x2 factorial analysis of variance indicated that neither variable had a significant effect on ratings, and no interactive effect was present (Table 1).

Table 1.--Factorial analysis of variance showing no effect of LOV vs. SBE., aware vs. naive, or their interactions. Gypsy Moth Aesthetics Study, Morgantown, West Virginia, 1989-90.

| Source | DF | SS | F Ratio | Prob > F | R ² |
|----------------------------------|----|-------|---------|----------|----------------|
| SBE vs. LOV | 1 | 4.188 | 0.0012 | 0.97 | .000243 |
| Aware vs. Naive | 1 | 1.246 | 0.0004 | 0.98 | |
| SBE vs. LOV x Aware vs. Naive | 1 | 3.471 | 0.0010 | 0.97 | |

Effects of Gypsy Moth Caused Tree Mortality

With the lack of treatment effect by respondent group, knowledge, or whether respondents rated the slides for scenic beauty or likelihood of visitation, we felt justified in combining respondents for the purpose developing of a single predictive model. Percent tree mortality served as the experimentally manipulated variable. Other potential predictor variables included: mean DBH, mean height, stand age, plot tree volume, plot basal area, site index, and the percentage of each plot comprised of oak.

Visual examination of the scatter plots suggested a quadratic function might best explain the relationship between preference ratings and the percent tree mortality present on each site (Figure 1). Indeed, by fitting a quadratic polynomial to percent mortality, the R^2 of the model was increased from .50 to .60. This quadratic function produced the following model for predicting preference rating by the amount of tree mortality (t-values of coefficients are in brackets):

$$\begin{aligned}
 \text{RATING} = & -30.41 + 1.50(\%DEAD) - .029(\%DEAD)^2 \\
 & [-.82] \quad [1.08] \quad [-2.19] \\
 R^2 = & .60 \quad \text{Adjusted } R^2 = .56
 \end{aligned}
 \tag{1}$$

where: RATING = rating for either scenic beauty (SBE) or likelihood of visiting (LOV); %DEAD = percent dead basal area per site. Only the quadratic term made significant contributions to the R^2 . Contrary to past investigations of aesthetic damage from insects, the scenic preference and appeal for visitation may increase slightly as gypsy moth induced tree mortality reaches 20-30% (Figure 1). When mortality exceeds these levels, however, ratings sharply decrease. The relatively high R^2 (.60) suggests that mortality serves as a good predictor of scenic preference and likelihood of visitation. None of the other previously mentioned site measurements contributed significantly to the model.

Mitigating Effects of Understory

Throughout implementation of this study, we were concerned about how the presence of flowering mountain laurel in 42% of the slides affected preference ratings. Two tactics were used to address this concern. First, through the use of available data, it was possible to calculate the percentage of mountain laurel understory in each site. An initial regression analysis suggested no linear relationship between ratings and the percent of mountain laurel understory.

Second, a cursory look at the slides suggested a relationship existed between mountain laurel flowers and percent tree mortality. By comparing sites with and without noticeable flowers, it was possible to develop a covariate model in which the presence of flowers (present or not present) were the categories and percent tree mortality was the regressor. Adjustment for the covariate "flowers" increased the R^2 of our model to .74 ($F = 13.61$; $df = 4, 19$; $p < .0001$). The final model is as follows (t-values are in brackets):

$$\begin{aligned}
 \text{RATING} = & -57.13 + 1.75(\%DEAD) - .025(\%DEAD)^2 - 20.69(\text{FLOWERS}) \\
 & [-1.51] \quad [1.23] \quad [-1.96] \quad [-1.86] \\
 R^2 = & .74 \quad \text{Adjusted } R^2 = .69
 \end{aligned}
 \tag{2}$$

where: RATING = rating for either scenic beauty (SBE) or likelihood of visiting (LOV); %DEAD = percent dead basal area per site; FLOWERS = presence of visible mountain laurel flowers (present or not present).

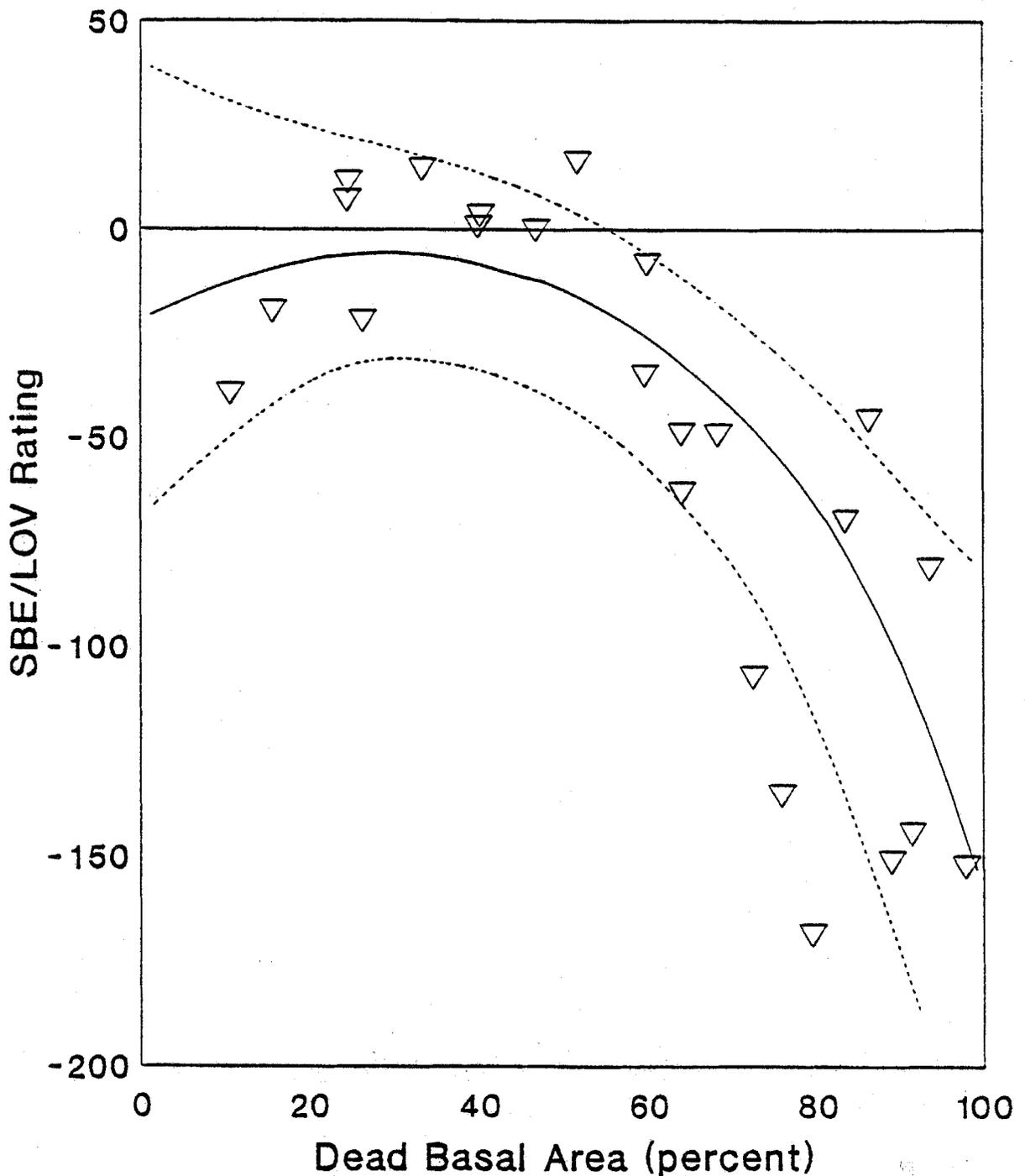


Figure 1. The effect of tree mortality caused by Gypsy Moth infestation on scenic beauty (SBE) and likelihood of visiting (LOV) preference ratings. Gypsy Moth Aesthetics Study, Morgantown, West Virginia, 1989-90. Dotted lines represent approximate 95% confidence intervals.

A comparison of the least square means (mean preference ratings adjusted for the presence of flowers) with the unadjusted means illustrate the mitigating influence of mountain laurel flowers (Table 2). The unadjusted means represent most closely the ratings of sites when

mountain laurel is not in bloom while the least squares means represent the ratings when the flowers are in bloom. It can be seen that sites with flowers were viewed much less critically. The covariate model also suggests that the sites without flowers were viewed more critically than the original regression model suggests, while the intercept is also closer to being significant.

Table 2.--Effects of covariate "flowers" on mean SBE/LOV ratings. Least square means reflect ratings when flowers are in bloom. Gypsy Moth Aesthetics Study, Morgantown, West Virginia, 1989-90.

| Presence of flowers | # of Sites | Average Mortality | Mean Rating | Least Sq Mean | Standard Error |
|---------------------|------------|-------------------|-------------|---------------|----------------|
| Not Present | 14 | 42.5% | -18.88 | -36.43 | 11.92 |
| Present | 10 | 80.4% | -102.38 | -77.80 | 14.98 |

SUMMARY AND DISCUSSION

The percent of dead trees in a hardwood forest site is an outstanding predictor of the appeal a site will have regarding near-view scenic beauty or likelihood of visitation. A quadratic equation fit to the percentage of gypsy moth-caused tree mortality is the single best predictor of aesthetic damage (R^2 .60). Contrary to past studies in which preference ratings decreased rapidly as damage reached 10% and then leveled, we found that both scenic beauty and likelihood of visitation ratings may actually increase slightly until mortality reaches 20-30%. Up to this point, increased sunlight, a reduction in stand density, and changes in understory may mitigate the negative effects of mortality. Beyond 30% mortality, preference ratings drop drastically. It should also be pointed out that since our slides represented "near-view" interactions with the forest as opposed to distant vistas, the mitigating effects of understory regrowth and other subtle changes in forest composition may be more pronounced than was found in previous studies.

With the exception of the control sites (5% of the population and 12% of the sample), gypsy moth had not been suppressed on the study sites during the years of 1985-1988. Of the 181 sites in the population, the mean gypsy moth-caused tree mortality was 27.9%. The distribution of mortality, however, was not normal. With the large portion of sites (67%) with less than 34% mortality, the median of 19.97% is a more accurate statistic. In either case, this is well under the critical threshold of 30% regarding aesthetic quality and visitor displacement ratings.

If these mortality rates are in keeping with the entire Central Appalachian Plateau region, as is suggested by several studies (Fosbroke and Hicks 1989a, 1989b), suppression does not seem warranted from the standpoint of long-term near-view aesthetic qualities or recreation visitation. Recreation areas at risk of high mortality (greater than 30-40%), however, might be considered for suppression efforts. When considered in concert with the lack of difference

in the preferences ratings of the various user types, homogeneous management approaches would be appropriate for most near-view forested sites, regardless of the type of recreation users.

It also seems apparent that changes in forest composition must be considered when predicting aesthetic changes to an area in the path of gypsy moth. In this study, the presence of flowering mountain laurel was significantly correlated with gypsy moth-induced tree mortality. This relationship mitigated some of the negative effect on preference ratings, and led to a model explaining 74% of the variance in preference ratings.

The extent to which the general public should be informed about specific management policies is an important concern of forest managers. The results of past research suggest that respondents who were aware of the presence of forest insect damage were more critical of the scenery. Although that may be the case during defoliation periods, the results of this study indicate that there is no negative effect of knowledge regarding the long term effects of Gypsy Moth infestation to near-view sites. It is not likely that managers will be able to positively influence visitor perceptions by informing them (i.e. signs and brochures) of the presence of gypsy moth. The effectiveness of more intensive information and education efforts is a question for further research.

The high correlation between scenic beauty ratings and likelihood of visitation ratings suggest that the scenic beauty estimation method can be used to predict visitor behavior intentions. This finding is supported further by the results of an additional question asked of respondents: how much gypsy moth-induced tree mortality would cause you to choose another outdoor recreation area? In close agreement with the predictive model, 79% of the respondents replied that 30% or more tree mortality in a forest stand would cause them to seek an alternative area for outdoor recreation. We suggest that future research tests this finding on actual visitation rates.

The tree mortality and changes in forest composition that result from gypsy moth infestation have important influences on both scenic beauty and the recreation behavior intentions of potential visitors. However, it appears that most viewers will be tolerant, possibly even positively disposed towards, the level of long-term gypsy moth damage expected on most sites. Forest managers and resource policy managers must still use professional judgment in developing strategies for dealing with the gypsy moth. Aesthetic and recreation qualities are but two factors that must be considered. Estimates of scenic beauty and recreation behavior intentions should, however, provide useful information for making these decisions.

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