

Using GIS to Assess Potential Impacts Of Gypsy Moth Infestations at Great Smoky Mountains NP

By Hope R. Barrett and Stephen C. Nodvin

The gypsy moth (*Lymantria dispar*) (Fig. 1) is an insect pest whose larvae feed on tree foliage. Populations of gypsy moths often cause extensive defoliation of forests which sometimes results in tree mortality. Over the past 100 years, gypsy moth populations have spread south and westward from Massachusetts, the site of accidental release, and have produced one of the most serious forest pest management problems in United States history. By early next century, the expanding portion of North America that is infested with gypsy moth populations is expected to include the Great Smoky Mountains National Park (GRSM). The park, a 207,500 ha natural area on the border of North Carolina and Tennessee, serves as a center of biodiversity and is the most visited national park in the United States.

This study to assess the forests of GRSM for potential impacts from the inevitable moth invasion. A personal computer version of Earth Resources Data Analysis System (ERDAS) was the geographic information system (GIS) used to model forest defoliation and tree mortality events in the park. The three objectives of this study were to rate forests of GRSM for: 1) defoliation potential, 2) sensitivity to environmental stress, and 3) tree mortality potential. Evaluations of forest susceptibility, sensitivity, and vulnerability were completed during the rating process.

The term "susceptibility" refers to the potential that a forest will become defoliated given gypsy moth invasion. The assessment of susceptibility in GRSM forested areas was achieved using a three step modeling approach. The first step involved the development of a selection index. Forest types in the park were classified and mapped using satellite data and image processing (MacKenzie 1991). Forest types were then ranked for their likelihood of defoliation according to their tree species composition relative to spe-

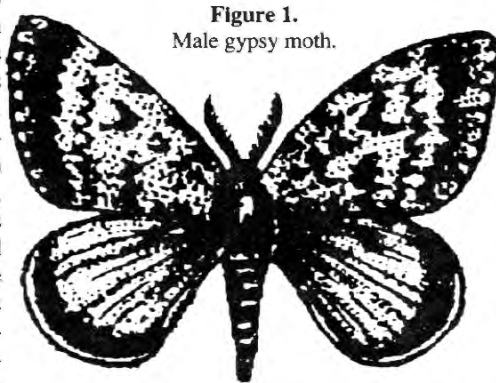


Figure 1.
Male gypsy moth.

cies preference of gypsy moths (Table 1). Rankings were based on published studies of gypsy moth susceptibility in the northeastern United States.

The second step was initiated by delimiting sites in the park where gypsy moth introduction would be influenced by humans. These sites include: developed campgrounds, environmental education centers, visitor centers, picnic areas, and heavy or medium duty roads. A GIS was then used to delineate a zone around the sites which indicated expected gypsy moth expansion and defoliation within the first two years after their introduction into the park.

The third step involved using a GIS modeling program to ascertain susceptibility ratings for each forest type. Areas of susceptibility to defoliation within two years after gypsy moth introduction were delineated by finding forest types that were ranked for gypsy moth preference within the zone of gypsy moth expansion. The results of the susceptibility evaluation indicated that 64 percent of the park (131,972 ha) is projected to experience some tree defoliation within the first two years after gypsy moth introduction.

Forest sensitivity is the relative likelihood of tree death after forests are disturbed. It was assumed that forest types would be most sensitive to disturbances (e.g., gypsy moth defoliation) at the extremes of their ranges along the topographic gradients of elevation, slope, and aspect. These three topographic variables were used to create map layers from a digital elevation model. Each map layer was cross tabulated with the nine forest types which generated frequency distributions of elevation, slope, and aspect for each forest type. The distributions were then evaluated for normality, and confidence intervals were located on each Gaussian distribution. Forest sites outside of the 95 percent confidence intervals of fitted Gaussian distributions were classified as sub-optimal. Forested areas of high, moderate, and low forest sensitivity to disturbance were identified by combining the sub-optimal sites of the elevation, slope, and aspect map layers (Table 2). A high sensitivity rating represented sites that were determined to be sub-optimal in all three map layers, while a moderate sensitivity rating represented sites that were sub-optimal in any pair of the three map layers, and a rating of low represents sub-optimal sites in a single map layer.

Vulnerability is the relative risk of forest mortality following defoliation. Vulnerability ratings of forest types were ascertained by finding every possible combination of susceptibility and sensitivity. The combinations were then assigned a descriptor that indicated a significance value (vulnerability rating) of high, moderate, or low. The results of the vulnerability evaluation indicated that 15 percent (30,416 ha) of the park is projected to be at some risk to stand mortality within two years after gypsy moth defoliation (Table 3).

Results from these evaluations are being provided to NPS staff to assist in development of management strategies prior to gypsy

Continued on page 27

Table 1

Gypsy moth preference ratings for forest types of the Great Smoky Mountains National Park

Preference	Forest Type
Highest	Mesic oak
High	Pine-Oak
High	Pine
High	Xeric Oak
Moderate	Northern Hardwood
Moderate	Cove Hardwood
Moderate	Spruce-Fir
Low	Mixed Mesic Hardwood
Lowest	Tulip Poplar

Table 2

Sensitivity ratings, and their hectares and percent composition of the Great Smoky Mountains National Park

Sensitivity Rating	Hectares	Percentage of GRSM
High	662	0.3
Moderate	8,852	4.3
Low	38,293	18.4
Total	47,807	23.0

Table 3

Hectares and land percentages of GRSM forests that are either high, moderate, or low in vulnerability to mortality within two years of gypsy moth introduction

Vulnerability Rating	Hectares	Percentage of GRSM
high	349	0.17
moderate	18,279	8.81
low	11,788	5.68
total	30,416	14.7

moth infestations. Strategies can be developed to protect against early infestations, and to focus protection efforts on those stands that are both vulnerable to mortality and considered critical natural resource areas. In addition, interpretive materials and programs can be developed from the results of this study to educate the public on the inevitable consequences of this exotic insect moving into the region and the efforts that the National Park Service will take to minimize the resulting damage.

Barrett is a Research Ecologist with the USFS at Morgantown, WV; Nodvin is with the NPS/CPSU at U/TN, Knoxville.

Literature Cited

MacKenzie, M.D. 1991. Vegetation map of Great Smoky Mountains NP based on LANDSAT thematic mapper data: accuracy assessment and numerical descriptions of vegetation types. A Report to the National Park Service - Southeast Region.