United States
Department of
Agriculture

Forest Service

**Northeastern Forest
Experiment Station**

Research Paper NE-690

Tracking Changes in the Susceptibility of Forest Land Infested with Gypsy Moth

David A. Gansner
John W. Quimby
Susan L. King
Stanford L. Arner
David A. Drake

Abstract

Does forest land subjected to intensive outbreaks of gypsy moth (*Lymantria dispar* L.) become less susceptible to defoliation? A model for estimating the likelihood of gypsy moth defoliation has been developed and validated. It was applied to forest-inventory plot data to quantify trends in the susceptibility of forest land in south-central Pennsylvania during a period of intensive infestation. Results show that even though susceptibility of the region's forest apparently has declined, the potential for future defoliation remains relatively high.

The Authors

DAVID A. GANSNER, SUSAN L. KING, STANFORD L. ARNER, and DAVID A. DRAKE are resource analysts with the Forest Inventory and Analysis work unit at the USDA Forest Service's Northeastern Forest Experiment Station, Radnor, PA.

JOHN W. QUIMBY is a forest pest management specialist with the Division of Forest Pest Management, Pennsylvania Department of Environmental Resources, Bureau of Forestry, Middletown, PA.

Manuscript received for publication 22 April 1994

USDA FOREST SERVICE
5 RADNOR CORP CTR STE 200
PO BOX 6775
RADNOR PA 19087-8775

August 1994

Introduction

Resource and pest managers are constantly being challenged to show that the benefits of gypsy moth (*Lymantria dispar* L.) control outweigh the costs. To deal objectively with this issue, they need a better understanding of the consequences of doing nothing—what happens to infested woodlands if you don't control the pest? In this regard, Jim Nelson (State Forester of Pennsylvania) asked us to help answer a specific question: Does forest land that has been subjected to intensive outbreaks become less susceptible to gypsy moth defoliation?

The forests of south-central Pennsylvania (Fig.1) provide an excellent contemporary example of a resource that came under heavy attack from the gypsy moth during the 1980's. Infestation cycles were typical of the gypsy moth's traditional modus operandi, that is, noticeable defoliation during 1981-83 and again during 1985-87 with peak levels in 1982 and 1986.

Defoliation combined with drought, cutting, deer browsing, and other stresses took a heavy toll on the region's oak resource. During the 1980's, mortality and cutting removed about 40 percent of the original inventory of oak growing stock. Growth on residual oak trees offset much of the loss, but not enough to keep the volume of oak from declining between inventories (Gansner et al. 1993). Losses were especially noticeable in smaller size trees. At the same time, other species such as red maple, pine, hemlock, birch, blackgum, ash and yellow-poplar, which are less susceptible to gypsy moth, prospered. Certainly, these trends would suggest a change in susceptibility.

We are fortunate that a comprehensive reinventory of forest land in south-central Pennsylvania was completed for 1989 (Alerich 1993). A model that estimates defoliation potential can be applied to data from 415 plots remeasured in that survey. This allows us to quantify and analyze shifts in susceptibility that have occurred in the region since the last inventory in 1978.

Guide For Estimating Susceptibility

One model for gauging the likelihood of gypsy moth defoliation was developed in central Pennsylvania by Herrick and Gansner (1986). It links defoliation potential (expressed as average defoliation expected during a 3-year outbreak) to key forest-stand characteristics as predictor variables. The model can be used to rate the relative susceptibility of forest stands. For example, stands with the highest potential for defoliation have at least 80 percent basal area in oak species, at least 70 percent in chestnut and black oaks, and at least 60 percent in trees with good crowns. Stands with the lowest rating have less than 20 percent basal area in oaks.

Checking on Model Performance

Does the guide for estimating susceptibility work? To find out, we ran a test of validity on the 415 remeasured inventory plots in south-central Pennsylvania. First, we used the model to predict the defoliation potential of each plot, employing plot characteristics recorded in 1978. That was before the gypsy moth got into high gear in this region. Only three of the four variables included in the defoliation potential model could be used in the analysis. Crown condition was not measured by forest inventory crews and

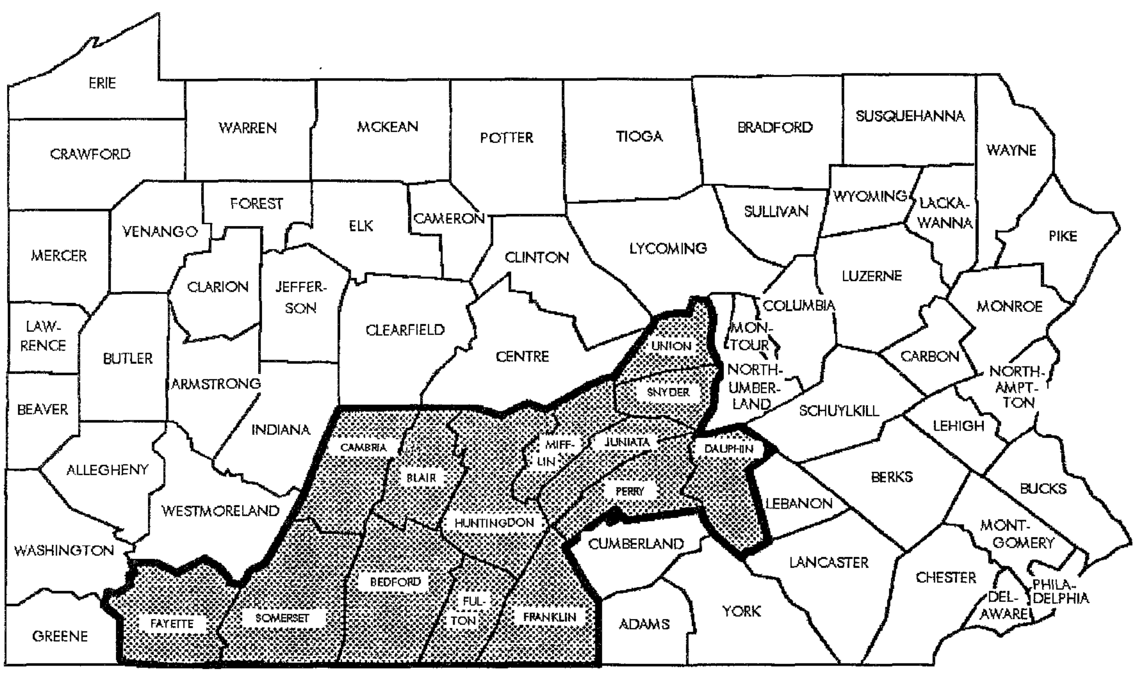

Figure 1.--The study area in south-central Pennsylvania.

Abstract

Does forest land subjected to intensive outbreaks of gypsy moth (*Lymantria dispar* L.) become less susceptible to defoliation? A model for estimating the likelihood of gypsy moth defoliation has been developed and validated. It was applied to forest-inventory plot data to quantify trends in the susceptibility of forest land in south-central Pennsylvania during a period of intensive infestation. Results show that even though susceptibility of the region's forest apparently has declined, the potential for future defoliation remains relatively high.

The Authors

DAVID A. GANSNER, SUSAN L. KING, STANFORD L. ARNER, and DAVID A. DRAKE are resource analysts with the Forest Inventory and Analysis work unit at the USDA Forest Service's Northeastern Forest Experiment Station, Radnor, PA.

JOHN W. QUIMBY is a forest pest management specialist with the Division of Forest Pest Management, Pennsylvania Department of Environmental Resources, Bureau of Forestry, Middletown, PA.

Manuscript received for publication 22 April 1994

USDA FOREST SERVICE
5 RADNOR CORP CTR STE 200
PO BOX 6775
RADNOR PA 19087-8775

August 1994

Introduction

Resource and pest managers are constantly being challenged to show that the benefits of gypsy moth (*Lymantria dispar* L.) control outweigh the costs. To deal objectively with this issue, they need a better understanding of the consequences of doing nothing—what happens to infested woodlands if you don't control the pest? In this regard, Jim Nelson (State Forester of Pennsylvania) asked us to help answer a specific question: Does forest land that has been subjected to intensive outbreaks become less susceptible to gypsy moth defoliation?

The forests of south-central Pennsylvania (Fig.1) provide an excellent contemporary example of a resource that came under heavy attack from the gypsy moth during the 1980's. Infestation cycles were typical of the gypsy moth's traditional modus operandi, that is, noticeable defoliation during 1981-83 and again during 1985-87 with peak levels in 1982 and 1986.

Defoliation combined with drought, cutting, deer browsing, and other stresses took a heavy toll on the region's oak resource. During the 1980's, mortality and cutting removed about 40 percent of the original inventory of oak growing stock. Growth on residual oak trees offset much of the loss, but not enough to keep the volume of oak from declining between inventories (Gansner et al. 1993). Losses were especially noticeable in smaller size trees. At the same time, other species such as red maple, pine, hemlock, birch, blackgum, ash and yellow-poplar, which are less susceptible to gypsy moth, prospered. Certainly, these trends would suggest a change in susceptibility.

We are fortunate that a comprehensive reinventory of forest land in south-central Pennsylvania was completed for 1989 (Alerich 1993). A model that estimates defoliation potential can be applied to data from 415 plots remeasured in that survey. This allows us to quantify and analyze shifts in susceptibility that have occurred in the region since the last inventory in 1978.

Guide For Estimating Susceptibility

One model for gauging the likelihood of gypsy moth defoliation was developed in central Pennsylvania by Herrick and Gansner (1986). It links defoliation potential (expressed as average defoliation expected during a 3-year outbreak) to key forest-stand characteristics as predictor variables. The model can be used to rate the relative susceptibility of forest stands. For example, stands with the highest potential for defoliation have at least 80 percent basal area in oak species, at least 70 percent in chestnut and black oaks, and at least 60 percent in trees with good crowns. Stands with the lowest rating have less than 20 percent basal area in oaks.

Checking on Model Performance

Does the guide for estimating susceptibility work? To find out, we ran a test of validity on the 415 remeasured inventory plots in south-central Pennsylvania. First, we used the model to predict the defoliation potential of each plot, employing plot characteristics recorded in 1978. That was before the gypsy moth got into high gear in this region. Only three of the four variables included in the defoliation potential model could be used in the analysis. Crown condition was not measured by forest inventory crews and

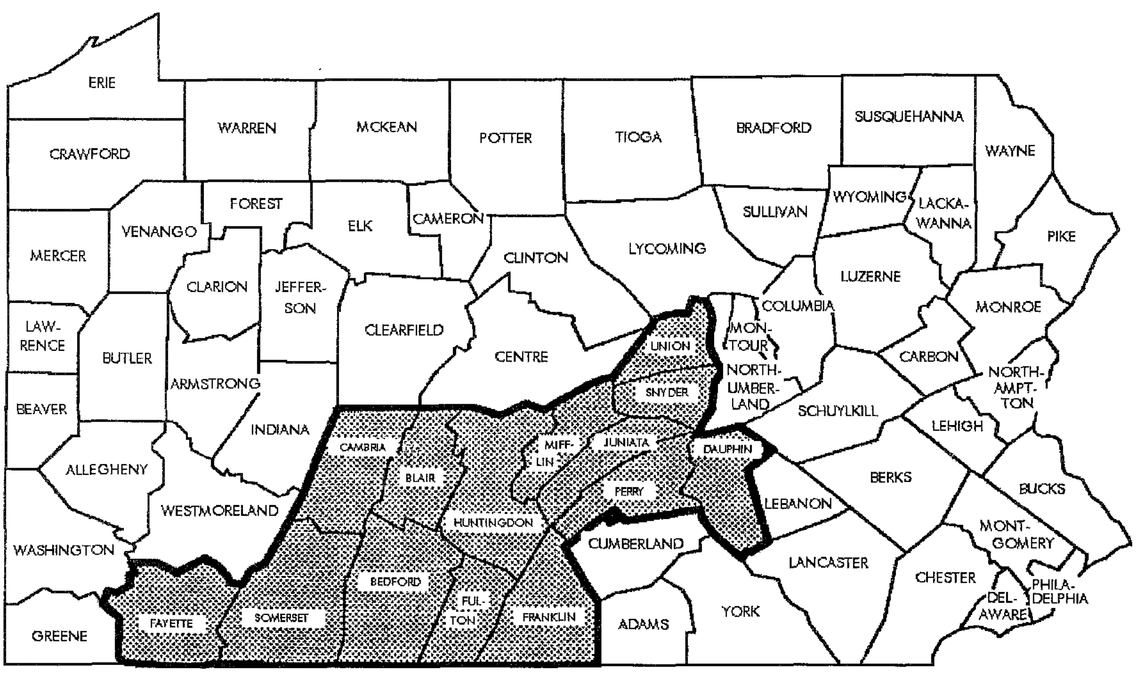

Figure 1.--The study area in south-central Pennsylvania.

no appropriate surrogates for the crown condition variable are available. This is not a serious concern because crown condition does not account for a large amount of the variation in defoliation. The 415 plots were classified and sorted into six distinct groups of defoliation potential (in percent):

Group	Defoliation potential (1978)	Number of plots
1	9	140
2	18	96
3	24	52
4	27	62
5	28	30
6	35	35

Next, estimates of *actual* defoliation occurring from 1978 through 1989 were recorded for plots in each of the six groups of defoliation potential. To obtain these estimates, optical bar photography and sketch maps showing amounts and intensity of actual annual defoliation were overlayed on plot locations.

Finally, averages of actual defoliation for the plots in each defoliation potential group were compared with predicted values for the groups (Fig. 2). Averages of actual defoliation for 1985 through 1987 were used. These 3 years encompassed a period of intensive defoliation in the region. Use of average defoliation for a 3-year period of outbreak is consistent with the procedure used to develop the defoliation potential model.

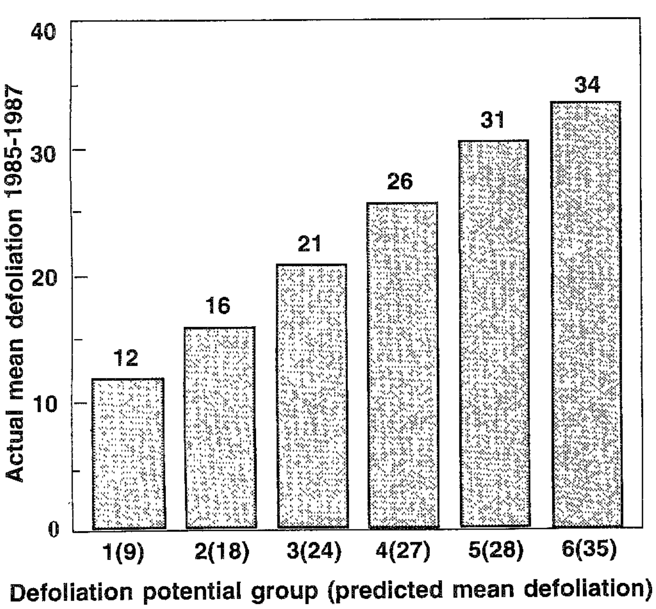

Figure 2.--Comparison of actual mean defoliation (1985-87) with predicted potential--south-central Pennsylvania.

Results of this test indicate that, as a measure of relative susceptibility, the model appears to work well. For example, the model assigned 140 plots to Group 1, which had a mean defoliation potential of only 9 percent. Actual defoliation recorded for the 140 plots in Group 1 averaged only 12 percent. At the other end of the scale, 35 plots were assigned to Group 6, which had a relatively high mean defoliation potential of 35 percent. Actual defoliation for these 35 plots averaged 34 percent.

There was a significant amount of variation in actual mean defoliation for plots within each group. For example, actual defoliation for 2 of the 30 plots in Group 5 averaged 62 percent, while no noticeable defoliation was recorded for 2 other plots in this group. For half of the plots in Group 5, actual mean defoliation ranged from 15 to 47 percent. Actual defoliation for all plots in Group 5 averaged 31 percent. The predicted mean was 28 percent.

Fosbroke and Hicks (1993) evaluated the performance of this same model on plots in the Ridge and Valley province of Maryland and in the Appalachian Plateau of Pennsylvania. Our findings are in basic agreement with theirs. The model's best use is for rating relative susceptibility, that is, for separating stands at risk of heavy defoliation from those where defoliation is likely to be light—and not for predicting actual defoliation in a given stand.

The Region's Forest is Less Susceptible

Application of the defoliation potential model to forest-inventory plot data for 1978 and 1989 allowed us to quantify trends in the susceptibility of south-central Pennsylvania's forest resource during a period of intensive infestation by the gypsy moth. By design, each plot represents a proportional share of the forest area in a county, so appropriate weights could be applied to susceptibility ratings for individual plots to derive average ratings for each county. Results of this analysis show that defoliation potential is down in all of the region's 14 counties:

County	Susceptibility rating 1978	Susceptibility rating 1989	Percent change
Bedford	20.2	17.2	-15
Blair	19.8	19.2	-3
Cambria	14.5	11.9	-18
Dauphin	23.3	19.4	-17
Fayette	15.2	15.1	-1
Franklin	21.7	18.3	-16
Fulton	20.0	18.7	-7
Huntingdon	18.3	16.7	-9
Juniata	21.2	17.7	-17
Mifflin	25.7	21.8	-15
Perry	21.9	20.4	-7
Somerset	14.9	13.6	-9
Snyder	18.3	17.6	-4
Union	20.7	18.3	-12

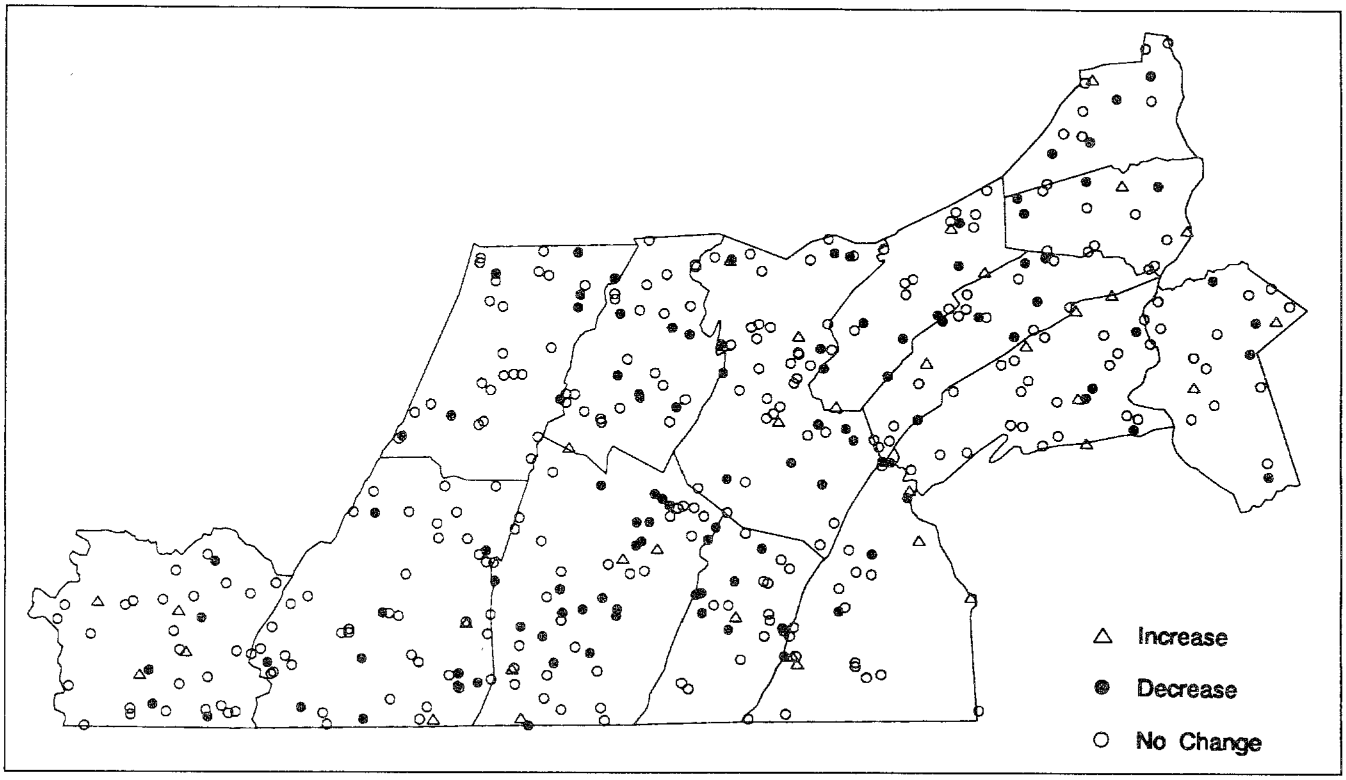

Figure 3.—Change in defoliation potential for plots in south-central Pennsylvania, 1978-89.

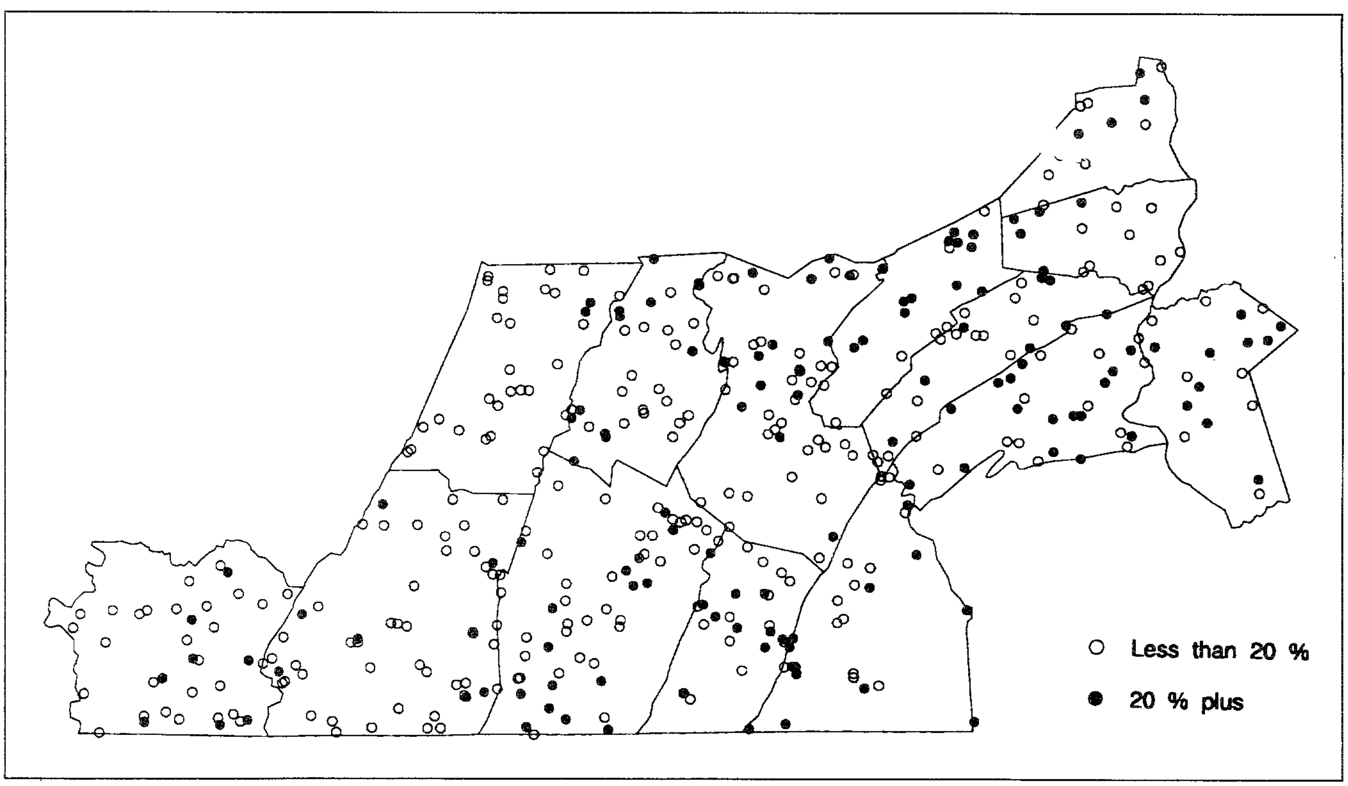

Figure 4.—Defoliation potential of south-central Pennsylvania plots, 1989.

This is not to say that gypsy moth is no longer a threat here. In fact, despite the declines in potential, susceptibility ratings for the region's counties remain relatively high. By comparison, Erie, McKean, Sullivan, and Susquehanna Counties, in parts of the state where oaks are not so plentiful, had average ratings of less than 10 in 1989.

Locations of the 415 forest inventory plots have been digitized, so changes in defoliation potential for individual plots can be mapped. This map provides a more specific view of trends in susceptibility (Fig. 3). Two-thirds of the plots remained in the same defoliation potential class between inventories. However, 26 percent shifted to a lower ratings while 8 percent shifted to a higher one. So on a plot basis, losers in susceptibility outnumbered gainers by more than 3 to 1. In 1978, more than 40 percent of the plots had ratings of 20 or more. By 1989, one-third of them were still in this category (Fig. 4). This reinforces the notion that, even though susceptibility of the region's forest has declined, the potential for future defoliation remains relatively high.

Implications

Does forest land subjected to intensive defoliation by gypsy moth become less susceptible to the pest? Results of this analysis would indicate that indeed it does. And there is other related news--some good and some bad, depending on your perspective. The species composition of south-central Pennsylvania's forest resource is more diverse now than it was 15 years ago. Also, many areas that were decimated by heavy mortality and cutting are regenerating to provide badly needed habitat for wildlife species that require early successional ecosystems. On the down side, there is less oak than there used to be and much of the timber that died cannot be salvaged. This is bad news for wood-producing interests.

Some care should be taken in extending specific results of this case study to other regions. Factors other than the gypsy moth such as drought, cutting, bark beetles, root rot, and deer browsing contributed to the declines in oak that led to reductions in the susceptibility of south-central Pennsylvania's forests. Effects of these other factors will vary from place to place. Also, characteristics of the region's forests are somewhat different from those on new frontiers of infestation. Who can say whether a post oak in the Ozarks of Missouri or sweetgum on the Coastal Plain of South Carolina will hold the same attraction for gypsy moth as a chestnut oak on a ridge in south-central Pennsylvania.

Literature Cited

Alerich, Carol L. 1993. **Forest statistics for Pennsylvania, 1978-1989.** Resour. Bull. NE-126. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 244 p.

Fosbroke, David E.; Hicks, Ray R., Jr. 1993. **Predictability of gypsy moth defoliation in central hardwoods: a validation study.** In: Proceedings of the 9th central hardwood forest conference; 1993 March 8-10; West Lafayette, IN. Gen. Tech Rep. NC-161. St Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 156-170.

Gansner, David A; Arner, Stanford L; Widmann, Richard H.; Alerich, Carol L. 1993. **What's happening to Pennsylvania's oaks?** In: Finley, James C.; Jones, Stephen B., eds. Penn's Woods--change and challenge: proceedings of the 1993 Penn State forest resources issues conference; 1993 April 1-2; State College, PA. State College, PA: Pennsylvania State University: 15-22.

Herrick, Owen W.; Gansner, David A. 1986. **Rating forest stands for gypsy moth defoliation.** Res. Pap. NE-583. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

Gansner, David A.; Quimby, John W.; King, Susan L.; Arner, Stanford L.; Drake, David A. 1994. **Tracking changes in the susceptibility of forest land infested with gypsy moth.** Res. Pap. NE-690. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

Does forest land subject to intensive outbreaks of gypsy moth (*Lymantria dispar* L.) become less susceptible to defoliation? A model for estimating the likelihood of gypsy moth defoliation has been developed and validated. It was applied to forest-inventory plot data to quantify trends in the susceptibility of forest land in south-central Pennsylvania during a period of intensive infestation. Results show that even though susceptibility of the region's forest apparently has declined, the potential for future infestations remains relatively high.

Keywords: Forest health, defoliation, susceptibility, hazard classification, *Lymantria dispar* L.

Headquarters of the Northeastern Forest Experiment station is in Radnor, Pennsylvania. Field laboratories are maintained at:

Amherst, Massachusetts, in cooperation with the University of Massachusetts

Burlington, Vermont, in cooperation with the University of Vermont

Delaware, Ohio

Durham, New Hampshire, in cooperation with the University of New Hampshire

Hamden, Connecticut, in cooperation with Yale University

Morgantown, West Virginia, in cooperation with West Virginia University

Orono, Maine, in cooperation with the University of Maine

Parsons, West Virginia

Princeton, West Virginia

Syracuse, New York, in cooperation with the State University of New York, College of Environmental Sciences and Forestry at Syracuse University

University Park, Pennsylvania, in cooperation with The Pennsylvania State University

Warren, Pennsylvania

"Caring for the Land and Serving People Through Research"