UT Extension
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Professional Hardwood Notes
Technical Information on Hardwood Silviculture for Foresters

Forest Management Strategies to Minimize the Impact of Gypsy Moth

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Gypsy Moth Spread

Gypsy moth (*Lymantria dispar* L.) is an exotic insect that was introduced into the United States (Boston, MA) in 1869 from Europe as part of a silk-making experiment. Some larvae escaped and the moth spread throughout New England. Today the moth has migrated west and south to the Midwest (Ohio), the Lake states (Michigan and Wisconsin), the Mid-Atlantic states and through the southern Appalachians in Virginia and North Carolina.

Gypsy moths extend the areas of infestation by "ballooning." Newly hatched caterpillars climb to tree crowns, where they hang from strands of their spun silk until the wind carries them to other trees. Female moths are flightless, so infestations rarely spread more than a few miles each year. However, the host range (oak-dominated forests) is extensive and the artificial spread of the insect has increased the rate of dispersion. Gypsy moths make long-distance moves by "hitchhiking" – laying their eggs on portable objects such as vehicles, nursery stock, firewood, mobile homes or lawn furniture that carry them miles away (McManus et al. 1989).

Gypsy Moth Hosts

Gypsy moth is a devastating defoliating insect affecting many hardwood trees in the eastern United States. The caterpillars feed on the leaves of many woody plants. Susceptible forest stands are those most likely to experience defoliation from a large buildup of gypsy moths. Some tree species are more susceptible to gypsy moth than others. The major factor associated with susceptibility is the presence of tree species most favored by the gypsy

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A summer scene of gypsy moth defoliation of an oak-dominated forest on a highly vulnerable site on a southern aspect. The individual green crowns remaining are yellow-poplar.

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moth. Table 1 lists tree species and their susceptibility to gypsy moth defoliation in each of the three categories: favored, not favored and avoided. Trees listed as favored are highly vulnerable. Vulnerability refers to the likelihood of tree mortality if a population buildup occurs. The condition or health of the trees in the forest affects vulnerability. Trees not favored are those fed upon when favored foliage is not available. Those trees that are rarely fed upon by gypsy moths are known as avoided species. Generally, white oaks followed by other oaks are among the most favored by gypsy moths and those species rarely fed upon include ash and yellow-poplar.

Effects of Gypsy Moth on Trees

One complete defoliation normally will not kill healthy hardwood trees. Leaves produce the food required for the growth and development of a tree. Most trees normally produce more food than they need. The excess is stored in the roots as starch. The loss of as much as 50 percent of the foliage usually results in a small reduction of growth. However, when more than half of the leaves are consumed, not enough food and other substances required for growth are produced. The tree must subsist on its stored reserves until new leaves are formed. Gypsy moth defoliation is especially detrimental because it occurs when growth is most active (May and June) and when food reserves are at their lowest levels (Abrahamson and Klass 1985).

Refoliation following defoliation reduces the amount of food reserves that the tree needs to maintain itself during the winter dormant season and to produce buds and twigs the following spring. The refoliation process puts a tremendous strain on the tree and usually results in death of buds, twigs, branches and feeder roots during the winter months. If no defoliation occurs the following year or two, most trees, except those in poor condition, should survive and regain their former growth and appearance. Defoliation, even at low levels, can be harmful if repeated for several years. Even healthy trees may become stressed and die if they go through the defoliation-refoliation process for two or more years in succession (Abrahamson and Klass 1985).

Gypsy moth outbreaks are cyclic and can last one to five years in oak-dominated stands. Outbreak populations then decline and collapse because of the buildup of disease, natural enemies and starvation. Populations then remain low for four to 12 years before increasing again (McCullough et al. 1995).

Table 1. Gypsy moth host preferences (adapted from Gottschalk 1993).

Favored:
Species readily eaten or preferred by gypsy moth larvae during all larval stages.

Apple, basswood, river and white birch, hawthorn, hazelnut, hophornbeam, hornbeam, most oaks, serviceberry, sweetgum, willows, witch-hazel

Not Favored:
Species fed upon by some larval stages when favored or preferred foliage is not available.

American beech, sweet and yellow birch, blackgum, boxelder, buckeyes, butternut, black cherry, chestnut, elms, cottonwood, cucumbertree, elms, hackberry, hemlock, most hickories, most maples, pawpaw, pear, persimmon, most spruces, most pines, redbud, sassafras, sourwood, black walnut

Avoided:
Species rarely fed upon by gypsy moth larvae.

Most ash, most azaleas, baldcypress, catalpa, dogwood, eastern redcedar, American holly, horsechestnut, Kentucky coffee-tree, black and honeylocust, mountain laurel, mulberry, rhododendrons, sycamore, yellow-poplar

Ridgetops and steep south- and west-facing slopes are sites favored by gypsy moth. Many of the tree species preferred by gypsy moth occur on these sites. These are the poorer productivity sites where moisture stress is common. In contrast, lower slopes and those with northerly and easterly aspects are the better productivity sites. These sites contain more tree species that are not as highly favored by gypsy moth. Even the species favored by gypsy moth stand a higher chance of surviving because they are usually healthier and more vigorous on these better sites (fertile soils and little drought stress).

Potential Gypsy Moth Damage

A major variable in determining the susceptibility to defoliation is the species composition of the stand, particularly the percentage of oaks in

the stand that are highly favored by gypsy moths (Figure 1) (USDA Forest Service 1990). Stands that have high percentages of species favored by gypsy moths are much more likely to undergo some degree of defoliation. Figure 2 shows forest types in the eastern United States with species that are favored by gypsy moths: oaks, sweetgum, elms, aspen and birch. Although Figure 2 is not a gypsy moth risk assessment map because it does not take into account different stand ages and site conditions and productivities, it is apparent that southern Appalachian Mountains and Cumberland and Allegheny Plateaus are areas with substantial gypsy moth habitats due to favorable species composition.

The severity of gypsy moth outbreaks will determine defoliation levels. Defoliation levels will vary from light to severe during outbreaks. Highly favored species with poor crowns (small size and less dense), dead branches, low vigor and advanced ages will likely experience heavy mortality. Species not favored by gypsy moth are moderately affected during outbreaks when mixed with favored species, although the mortality rates are relatively low. Gypsy moth defoliation and mortality of favored and non-favored species on sites that are overstocked are usually severe if measures are not taken to improve tree health.

Trees can survive heavy gypsy moth defoliation if they have healthy crowns. Trees with crowns in good condition (less than 25 percent dead branches) have the lowest mortality rates after gypsy moth defoliation. In contrast, trees with more than 50 percent dead branches (poor crowns) are more likely to succumb and suffer the greatest mortality.

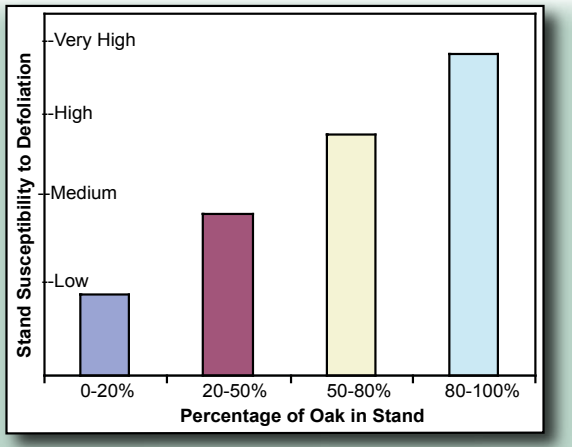

Figure 1. Guide for determining stand susceptibility to gypsy moth defoliation based on the percentage of oak species in the stand (USDA Forest Service 1990).

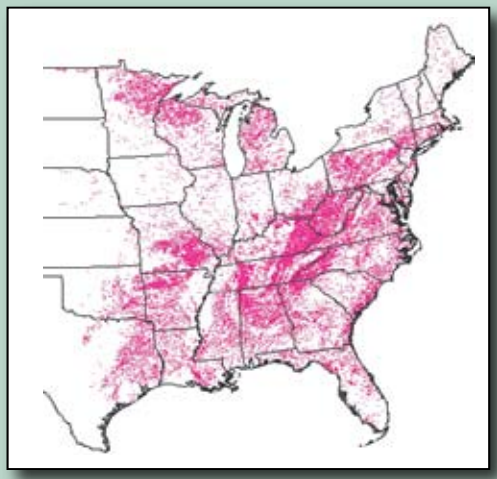

Figure 2. Eastern United States map showing forest types (oak-hickory, oak-pine, oak-gum-cypress, elm-ash-cotton-wood, and aspen-birch) that are susceptible to gypsy moth defoliation (Liebhold and Luzader 2003).

Good, fair and poor crowns (left to right) of northern red oak used in determining susceptibility to mortality from gypsy moth defoliation.

Older-aged stands are more susceptible to mortality from repeated gypsy moth defoliation than are younger, thrifty stands. There also appears to be strong relationships between age, drought, oak decline and gypsy moth defoliation (USDA Forest Service 1990). As trees age, they are more likely to exhibit the crown symptoms of decline. Oaks expressing decline are more likely to die from gypsy moth defoliation than trees with relatively healthy crowns. In Pennsylvania, drought coupled with gypsy moth defoliation increased oak mortality (Fosbroke and Hicks 1989). Thus, these underlying factors of oak drought, decline and advanced ages tend to increase the susceptibility of the stand to gypsy moth defoliation. Often, one defoliation from gypsy moth in these declining and stressed stands is enough for trees to succumb.

The effects of gypsy moth defoliation weaken the tree by depleting food reserves, making it more susceptible to attack from other pests such as two-lined chestnut oak borer, red oak borer and Armillaria root rot. Healthy trees can tolerate these secondary attacks better than trees that are in poor health.

Significant changes in the vegetation composition and structure of the stand may occur, depending on the amount of tree mortality, size of opening and site productivity. Oaks may be replaced by red maple, yellow-poplar, blackgum, white pine and other species. However, research in Pennsylvania (Feicht et al. 1993) indicated that after two gypsy moth defoliations, mixed oak forests remained intact, but the amount (basal area) of oak declined. Non-oak species were replacing dead oaks and increasing in frequency within the stands. These changes in species composition usually result in reduced hard mast production (fewer oaks) that may have impacts on wildlife populations.

Management Options

Three options are available to manage stands that are susceptible to gypsy moth.

- **No Active Forest Management** – Allows the natural selection process and the resilience of the forest stand to determine the outcome of gypsy moth infestations.

- **Insecticide Application** – Used in areas of high recreational value and occasionally in stands that have high-value timber.

- **Active Forest Management** – Decreases the likelihood and severity of defoliation and improves the health of forest stands, thereby increasing tree survival following gypsy moth defoliation.

The most effective control for gypsy moth is active forest management before the gypsy moth arrives. Otherwise, all prescriptions and treatments are reactionary after gypsy moth infestations. The remainder of this publication is in two sections. The first section is the potential silvicultural options associated with forests susceptible to gypsy moth or where gypsy moth defoliation has already occurred. The second section describes various forest management options to make forest stands less susceptible to gypsy moth and reduce the risk of gypsy moth damage in a proactive manner. These guidelines are adapted for Tennessee and Kentucky following recommendations from Brooks and Hall (1997) and Gottschalk (1993).

Silvicultural Alternatives

(adapted from McCullough et al. 1995)

Timber: In high-hazard stands nearing financial maturity, log harvestable trees or stands before gypsy moth defoliation occurs. Harvesting can realize economic benefits while reducing stand susceptibility and vulnerability to gypsy moth defoliation. Regeneration after harvesting is usually plentiful from stump sprouts, advance regeneration and seeds.

Remove suppressed and low-vigor trees that will be highly vulnerable to damage from gypsy moth. Leave healthy trees with large crowns that are likely to survive defoliation.

Tree damage in stands can be reduced by diversifying the composition of trees to species that the gypsy moth does not prefer. Harvest favored trees, leaving a greater proportion of not-favored or avoided trees.

Thinnings and TSI (Timber Stand Improvement): Thinning to reduce stand density can improve the health of residual trees and reduce stand risk and hazard. Thinning is most appropriate on medium- to high-quality sites where costs are justified. Thinning is rarely justified or practical on poor-quality sites. Consider managing

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Thinning and TSI harvest in a gypsy moth-infected stand.

for conifers or conifer-hardwood mixtures after harvest on poor sites.

To reduce stand hazard, cut suppressed, wounded, diseased or low-vigor trees with poor crowns. Thin to stocking levels appropriate for the species composition and the quality of the site. Consult stocking guides to determine residual stocking level (Gingrich 1967).

Prevent soil compaction, wounds and other injuries during the harvest operation to reduce the amount of stress of residual trees.

Following defoliation, increased exposure to sun and wind may cause residual trees to be stressed for several years after thinning. Allow trees to recover from defoliation, severe drought or other stress before beginning TSI activities.

Convert to Less-Favored Species: Selecting against tree species that are favored by gypsy moth will reduce long-term risk of defoliation. Altering the species mix can result in healthier hardwood stands. Favoring ash, yellow-poplar and maple on the more mesic sites and conifers on the poor sites will increase stand diversity while reducing the risk of defoliation. Oaks can still be a component of the stand, but at a much lower levels (< 30 percent basal area).

Do Nothing: Sometimes, taking no action is a good alternative. No action may also be the best option when stands are at or near optimal stocking. Young, vigorous growing stands are likely to tolerate even severe defoliation for two to three years. Gypsy moth may also act to "thin from below," eliminating suppressed and other low-vigor trees that would have eventually died. Stands with a mixture of species are less likely to sustain severe, repeated defoliation.

Salvage: Salvage stands damaged during gypsy moth outbreaks. Salvage logging should occur within six to 12 months after tree death before wood value is substantially reduced by stain or decay. Salvage cutting can be used to modify species composition. Avoid damage to residual trees and advance regeneration.

Management Prescriptions

1. On Poor Sites (Site index less than 60 feet at 50 years)

a. Rarely are forest operations cost-effective on poor sites. If possible, reduce stocking and/or stand density to improve the health of residual trees and increase their ability to withstand gypsy moth defoliation.

b. Convert to a conifer (shortleaf pine), a conifer-hardwood mixture or a non-forest cover-type such as a pasture.

c. Increase the proportion of non-preferred or non-favored species during forest operations.

2. On Poor to Medium Sites (Site index from 60 to 75 feet)

a. Reduce basal area (stand stocking) in gypsy moth-favored species to less than 50 percent.

3. On Medium to Higher-Quality Sites (Site index greater than 75 feet)

a. Conduct intermediate thinnings, such as crop tree release, to enlarge crowns and improve the health of highly favored and non-favored species, therefore improving their ability to survive defoliation. Favor dominant and codominant trees.

b. Maintain a mixture of healthy gypsy moth-favored and non-favored tree species when harvesting to limit gypsy moth population increases.

USDA Forest Service

Gypsy moth defoliation of an oak-hickory stand. The foliated tree in the background is a yellow-poplar, a tree that is rarely fed upon by gypsy moth.

4. All Sites

a. Remove gypsy moth-highly favored species that are small in diameter or larger trees that are degraded or of poor quality. These trees can be girdled to create wildlife snags, if needed.

b. Remove trees that could create habitat favorable for gypsy moth, such as trees with a large number of dead branches, trunk cavities and rough and peeling bark.

c. In oak-dominated stands, increase the proportion and health of non-favored species such as maples, yellow-poplar, black cherry and ash.

d. Encourage regeneration of non-favored species.

e. Create age diversity. Consider two-aged stands and patch clearcuts to invigorate older oak stands.

5. Timing of Thinnings

a. In stands that are degraded or of poor quality, overstocked and/or contain overmature favored species, a thinning may be performed to reduce the vulnerability of the stand to gypsy moth. The resulting stand should be in a healthier condition that can better survive an outbreak.

b. In stands that are healthy and approaching an overstocked condition, a thinning should be conducted to alter composition toward non-favored species and to ensure maintenance of stand health before or just after a gypsy moth outbreak.

c. Thinning treatments are especially useful in stands with a high composition of favored species and whose susceptibility to gypsy moth cannot be changed quickly. Thinning generally increases the vigor and improves the health of residual trees.

6. Regeneration Considerations

a. Seedlings and saplings of oak and other favored species will have the highest defoliation and mortality rates during outbreaks. Large oak advance reproduction (> 4 feet) will resprout several times and will probably survive several defoliation events.

b. Stump sprouts of gypsy moth-favored species should be thinned to one stem per stump to improve health and resistance.

c. Gypsy moth usually has little impact on young pines.

d. Most silvicultural intermediate treatments in stands susceptible to gypsy moth preserve some seed production, encourage advance regeneration and allow stump-sprouting potential.

Regional Concerns

The woodlots in Kentucky and Tennessee are often isolated by agricultural land as well as developed land. This isolation should reduce gypsy moth populations. During the dispersal stage, if the larvae are blown onto non-forest land rather than a woodlot, their likelihood of survival is extremely low since their favored food is not available. Isolation can also lead to a wide variation in gypsy moth defoliation levels. For example, one woodlot may be severely defoliated, while another nearby woodlot may have little or no defoliation.

The Cumberland Plateau, southern Appalachians and the Western Highland Rim/Pennyroyal regions are considered favorable for supporting large gypsy moth populations: favored species with a majority of oaks; ridgetops with shallow, rocky soils; and steep south- and west-facing slopes and frequent stress (primarily droughts) that weaken trees. These

USDA Forest Service

Gypsy moth caterpillars can be identified by their long hairs and red and blue spots.

factors are expected to promote heavy gypsy moth defoliation if and when gypsy moths become established in the area. With increases in population, the moth will disperse and affect favored trees on the better sites (lower north- and east-facing slopes).

Wildlife Considerations

1. Favored species on ridgetops and steep south- and west-facing slopes can be maintained if management practices are implemented to improve tree conditions such as reducing stand stocking or density to encourage widely spaced, large tree crowns.

2. Reduce the percentage of favored species and create and maintain agricultural crop openings.

3. Within high-risk stands, increase the proportion of non-favored species that will benefit wildlife and minimize defoliation, i.e., hickory, walnut, ash, pine and redcedar.

4. Create a stratified structure for wildlife forage and cover. For example, increase the pine component on ridgetops, increase the non-favored conifer and hardwood species on mid-slopes and increase non-favored hardwood species on the lower slopes and stream valleys. Generally, gypsy moth susceptibility decreases with an increasing soil moisture gradient from the ridgetops to the stream valleys.

Landscape Considerations

1. The fragmentation of forests in Tennessee and Kentucky may assist in the management of gypsy moth populations. During the dispersal stage, the caterpillars are unlikely to survive in openings where favored species are not available.

2. Where a single habitat type exists over large areas, a diverse arrangement of oak with non-favored species such as hickory, ash, yellow-poplar and pine can reduce the likelihood of damage from gypsy moth and other defoliators.

3. Take advantage of the available diversity of habitat types and current cover types across the landscape to reduce short-term and long-term pest threats.

4. Decrease the oak component and increase the conifer component on ridgetops and other susceptible sites.

5. Increase the percentage of non-favored species over the landscape to decrease the probability of gypsy moth population increases.

Summary

Use of silviculture to manage gypsy moth effects gives foresters additional tools for developing integrated pest management programs. Silvicultural actions should be taken prior to gypsy moth outbreaks to reduce or minimize the potential damage that arises in stands vulnerable to gypsy moth. Three approaches to reduce stand susceptibility to gypsy moth are applicable. First, change the stand composition by reducing the proportion of favored species and increasing the number of non-favored species in the stand. This can be accomplished through intermediate thinning treatments. The percentage of favored species that remain should be less than 30 percent of total composition.

Second, improve the growing conditions for residual trees. The more vigorous the tree, usually indicated by crown condition (size and density), the more likely it is to survive defoliation whether a favored or non-favored species. Intermediate thinnings create more space for crown expansion of residual trees. The released trees will grow larger with more vigorous crowns.

Third, between gypsy moth outbreaks, in situations where defoliation and mortality have already occurred, salvage dead trees and thin live trees as needed. The increased growing space for the remaining trees should create a healthier stand that can better withstand the next outbreak of gypsy moth.

References

Abrahamson, L. and C. Klass, compilers. 1985. Gypsy moth. Publication 1153. Knoxville, TN: University of Tennessee, Agricultural Extension Service. 13 p.

Brooks, C. and D. Hall. 1997. Gypsy moth silvicultural guidelines for Wisconsin. PUB-FR-123 97. Madison, WI: Wisconsin Dept. of Natural Resources. 11 p.

Feicht, D.L., S.L.C. Fosbroke, M.J. Twery. 1993. Forest stand conditions after 13 years of gypsy moth infestation. Proceedings, 9th Central Hardwood Forest Conference (A.R. Gillespie, G.R. Parker, P.E. Pope, G. Rink, eds.). Gen. Tech. Rep. NC-161. St. Paul, MN: U.S. Dept. of Agriculture, Forest Service, North Central Experiment Station: 130-144.

Fosbroke, D.E. and R.R. Hicks, Jr. 1989. Tree mortality following gypsy moth defoliation in southwestern Pennsylvania. Proceedings, 7th Central Hardwood Forest Conference (G. Rink and C.A. Budelsky, eds.). Gen. Tech. Rep. NC-132. St. Paul, MN: U.S. Dept. of Agriculture, Forest Service, North Central Experiment Station: 74-80.

Gingrich, S.F. 1967. Measuring and evaluating stocking and stand density in upland hardwood forests in the central states. Forest Science 13(1): 38-53.

Gottschalk, K.W. 1993. Silvicultural guidelines for forest stands threatened by gypsy moth. General Technical Report NE-171. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 50 p.

Liebhold, S. and G. Luzader. 2003. How gypsy moth risk map was constructed. Morgantown, WV: U.S. Dept. of Agriculture, Forest Service, Northeastern Forest Experiment Station: (http://www.fs.fed.us/ne/morgantown/4557/gmoth/risk).

McCullough, D.G., R.A. Haack, D.J. Hall, J. Niese. 1995. Gypsy moth and oak silviculture in the North Central Region. Northern Hardwood Notes 7.12. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 6 p.

McManus, M., N Schneeberger, R. Reardon, G. Mason. 1989. Gypsy moth. Forest Insect & Disease Leaflet 162. Washington, DC: U.S. Department of Agriculture, Forest Service. 13 p.

USDA Forest Service. 1990. Gypsy moth research and development program. Radnor, PA: U.S. Dept. of Agriculture, Forest Service, Northeastern Forest Experiment Station. 29 p.

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