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Gypsy Moth in the Southeastern U.S.: Biology, Ecology, and Forest Management Strategies

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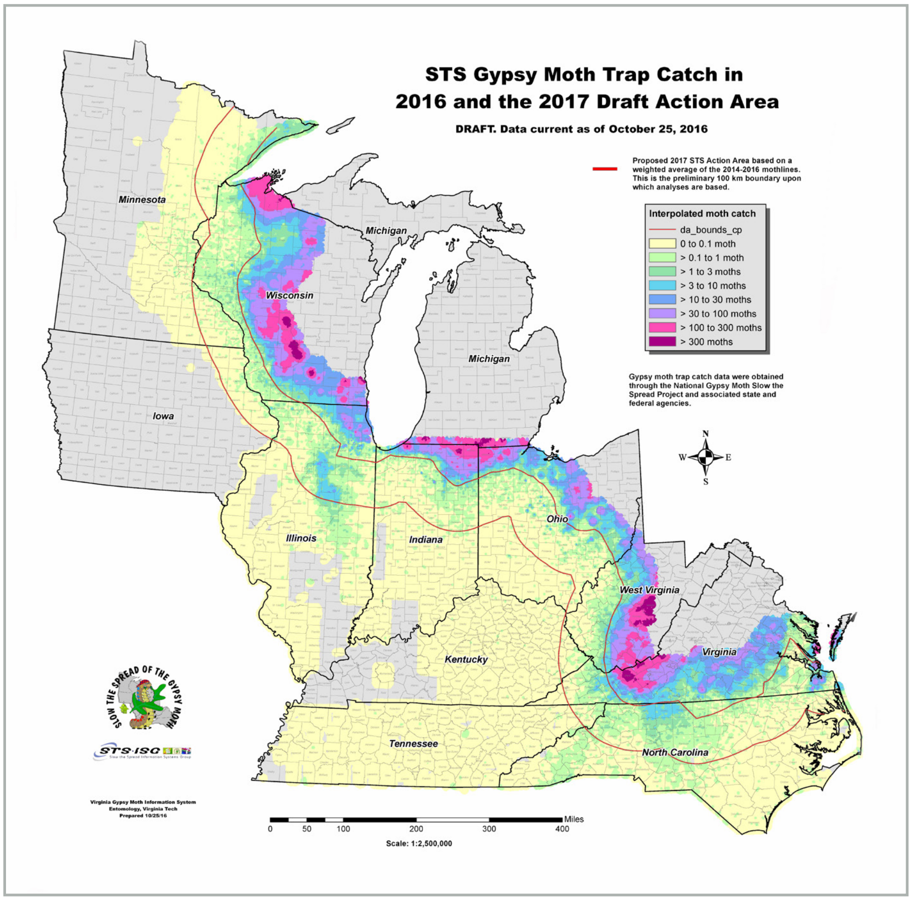

Figure 1. In the southeastern U.S., the gypsy moth is established throughout most of Virginia, and moths are regularly captured in eastern Kentucky, eastern Tennessee, and much of North Carolina. The Slow the Spread (i.e. Containment) area is a band that extends from northern North Carolina through the Virginias, Ohio, Indiana, Illinois, and north to western Wisconsin / eastern Minnesota. The gypsy moth is established in the entire northeastern U.S.

The European gypsy moth (*Lymantria dispar* L.) is a non-native insect that was accidentally introduced to North America in 1869 when it escaped cultivation by a French amateur entomologist living near Boston, MA. Despite early efforts to eradicate the species, it became established throughout eastern Massachusetts. Since then, the gypsy moth has expanded its range throughout the Northeast and Mid-Atlantic regions, west to the Lake States (Minnesota, Wisconsin, and Illinois), Indiana, Ohio, and into the central Appalachian Mountains (West Virginia and Virginia). Gypsy moth populations have recently established in North Carolina, and moths are annually captured in Kentucky and eastern Tennessee, though no established populations exist (Fig. 1). Adult gypsy moths are occasionally captured in Georgia and South Carolina.

Gypsy moth eggs hatch in the spring, and newly hatched caterpillars begin feeding on recently expanded leaves. Gypsy moths can disperse into areas by "ballooning," whereby newly hatched caterpillars climb into tree crowns and spin down on strands of silk until the wind carries them to other trees (Fig. 2). Caterpillars mostly feed during the night, but may feed during the day when populations are high. Gypsy moth caterpillars are distinct in that they have five pairs of blue spots beginning at the head followed by six pairs of red spots ending at their posterior (Fig. 3), though these spots are less obvious in younger caterpillars. After feeding for about 6-8 weeks (adult moths do not eat - all the eating takes place during the caterpillar life stage), caterpillars pupate, and emerge as adult moths (Fig. 4). Following mating, the flightless females lay their eggs in a single mass usually on the side of tree trunks, and especially on the undersides of branches. Egg masses can also be laid on picnic tables, firewood, automobiles,

Figure 2. Young gypsy moth larvae can travel long distances by "ballooning", where they produce a long strand of silk that gets carried by the wind.

Figure 3. Gypsy moth larvae have five pairs of blue dots starting just behind the head, followed by six pairs of red dots.

Figure 4. Adult female gypsy moths are mostly white and do not fly, and adult males are a dull brown color.

logging equipment, or any other object that is stationary. Because of the variation in elevation and latitude in the southeastern U.S., timing of the gypsy moth life cycle differs depending on location (Fig. 5).

Because females do not fly (but see Box 1), established populations spread rather slowly - usually only 5-10 miles per year. Given the gypsy moth's broad host range, large portions of the natural and urban environments throughout the eastern U.S. provide suitable habitat where the species could eventually establish (Fig. 6). Spread of the gypsy moth into uninfested regions is facilitated by accidental movement of life stages, typically by transport of egg masses on objects such as vehicles, nursery stock, firewood, mobile homes, or lawn furniture that are moved long distances[13] (Fig. 7).

Natural enemies can help regulate established gypsy moth populations, especially when populations are at low densities. Small mammal predators, such as the white-footed mouse (*Peromyscus leucopus*), are known to find and consume gypsy moth pupae, and many different bird species can eat gypsy moth caterpillars[5]. Insect predators like large caterpillar hunter beetles (*Calosoma* spp.) readily feed on gypsy moth caterpillars, and parasitoids (usually tiny wasps or flies) will use gypsy moth eggs or caterpillars as hosts[5]. Microbes are also important factors limiting gypsy moth populations. The fungal pathogen *Entomophaga maimaiga*, originally from Japan, is present throughout the range of gypsy moths in the U.S. and plays a major role in gypsy moth population regulation. This fungus thrives in hot humid environments[17], and will likely be particularly important should the southeastern U.S. become infested with gypsy moth. However, extremely dry weather is often associated with increased adult gypsy moth captures, as fewer caterpillars may be killed by *E. maimaiga* under these conditions. A nucleopolyhedrovirus (NPV) can also be an important regulator of gypsy moth populations[5]. Unlike *E. maimaiga*, which can be present even when gypsy moth larvae populations are low, impacts from NPV are usually only noticeable when larval populations are high.

Gypsy Moth Hosts

Gypsy moth caterpillars feed on the leaves of many woody plants, although some species are more susceptible than others. The major factor associated with susceptible forest stands - those most likely to experience defoliation from a large density of gypsy moth caterpillars - is the presence of tree species favored by the gypsy moth. Table 1 lists tree species and their susceptibility

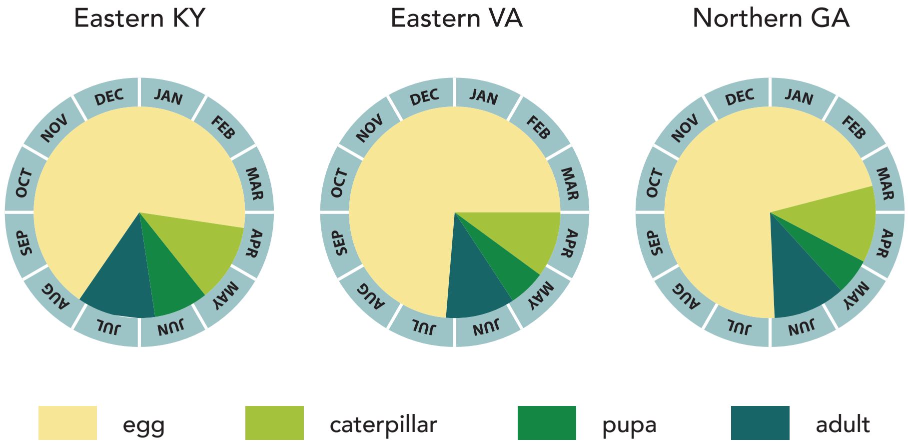

Figure 5. Phenology of the gypsy moth in three areas of the southeastern U.S. In general, overwintering eggs hatch in early spring, caterpillars feed for several weeks, spin cocoons and pupate, then emerge as adults in early to mid-summer.

to gypsy moth defoliation in each of 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** may be fed upon when favored foliage is not available. Those trees that are rarely fed upon by gypsy moths are known as **avoided** species. Generally, all oaks are favored by gypsy moths, and species rarely fed upon include most pines and yellow-poplar.

Box 1. Asian gypsy moth is very similar to European gypsy moth, but adult female Asian gypsy moths can fly. These are occasionally captured in the southeastern U.S., but no established populations exist.

Effects of Gypsy Moth on Trees

One complete defoliation will not normally kill healthy hardwood trees. Leaves produce the energy required for the growth and development of a tree, and most healthy trees produce more energy than they need. The excess energy is stored as starch in the roots, and the tree uses this energy to maintain itself during the dormant winter season, and to produce buds and twigs the following spring. Gypsy moth defoliation is especially detrimental because it occurs when growth is most active (spring and early summer) and when starch reserves are at their lowest levels[1]. The loss of as much as 50% of the foliage usually results in little more than a reduction of growth. However, when more than half of the leaves are consumed, the tree cannot produce enough energy and other resources required for growth, and must subsist on its stored reserves until new leaves are formed. This process, called refoliation, 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[1]. When defoliation coincides with drought or other stressors, trees are much more likely to die.

Gypsy moth outbreaks are cyclic and typically last one to three years in oak-dominated stands. Outbreak populations then decline and

Table 1. Gypsy moth host preferences (adapted from [7,11])

Preference level	Description	Tree species
Favored	Species readily eaten or preferred by gypsy moth larvae during all larval stages	Apple, basswood, river and white birch, hawthorn, hazelnut,hophornbeam, hornbeam, larch, most oaks, pear, 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, most eucalyptus, hackberry, hemlock, most hickories, locust, most maples, pawpaw, pear, persimmon, most spruces, most pines, redbay, redbud, sassafras, sourwood, black walnut
Avoided	Species rarely fed upon by gypsy moth larvae	Most ash, most azaleas, baldcypress, buckthorn, catalpa, dogwood, eastern redcedar, ginkgo, American holly, horsechestnut, Kentucky coffee-tree, juniper, black and honeylocust, magnolia, mountain laurel, mulberry, rhododendrons, sycamore, most viburnum, water tupelo, yellow-poplar

collapse because of the buildup of disease, parasitoids, and starvation. Populations often remain low for four to 12 years before increasing again[5].

Gypsy Moth Damage

With very few exceptions (e.g. extreme southern Florida, certain coastal areas in Louisiana and Texas, and parts of the Mississippi River Delta) the entire southeastern U.S. – even northern Florida[2] – contains suitable forest habitat for gypsy moth establishment. 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[22]. Stands that have high percentages of tree species favored by gypsy moths are much more likely to undergo some degree of defoliation. The southeastern U.S. has a large number of oak species growing throughout the region, and many of these forests are considered susceptible to the gypsy moth.

Site quality does not appear to directly influence tree mortality following gypsy moth defoliation, but site quality does influence the tree species that grow on a site, which indirectly influences defoliation levels[4]. Ridgetops and steep south- and west-facing slopes are particularly favored by the gypsy moth, because many of the preferred tree species occur on these sites. These are generally drier sites with poorer productivity, which may also lead to poorer habitat for small mammal predators. In contrast, lower slopes and those with northerly and easterly aspects are typically more productive sites that contain more tree species that are less favored by the gypsy moth.

Defoliation levels vary from light to severe during outbreaks, with favored tree species often being severely defoliated. The occurrence of massive levels of tree mortality as a result of gypsy moth defoliation is patchy and difficult to predict, though it tends to be associated with drought and other factors that may contribute to declines in tree vigor. Gypsy moth defoliation usually does not directly kill trees, but instead weakens them, making them more susceptible to attack from secondary pests such as two-lined chestnut borer, red oak borer, and *Armillaria* root rot. Outbreaks that occur across large regions may result in many weak or dying trees, and may trigger outbreaks of secondary pests that result in even more tree mortality[16]. Healthy trees (those with <25% dead branches) can tolerate these secondary attacks better than trees that are in poor health. In contrast, trees with poor crowns (>50 percent dead branches) or older/weaker trees are more likely to suffer the greatest mortality.

Figure 7. These gypsy moth egg masses were discovered on the underside of a camper near Fort Wayne, Indiana. The owner was driving to Florida.

Gypsy moth outbreaks can have wide-ranging impacts. They are associated with increased tree mortality and declines in growth of host trees, which can ultimately lead to changes in stand composition[15] and structure, depending on the amount of tree mortality, size of opening and the site productivity. Highly susceptible oaks may be replaced by red maple, yellow-poplar, blackgum, white pine, and other species. Forest inventory data indicates that gypsy moth defoliation during a 15-year time period was associated with declines in the net growth of host species. These impacts may combine with other factors, such as increased levels of

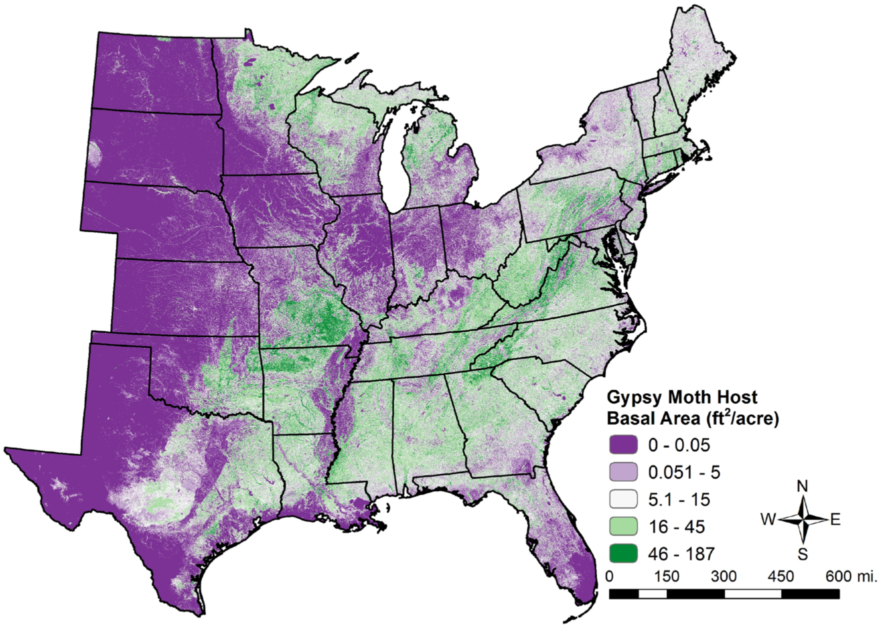

Figure 6. The eastern U.S., and especially the Southeast, has a large quantity of gypsy moth-preferred host trees (shown in green).

grazing by deer populations, and contribute to long-term declines in regional oak dominance. Defoliation of dominant trees also opens up the canopy, allowing increased light to reach the forest floor. In areas with populations of non-native plants, these conditions are very conducive to increases in non-native plant growth, as these plants can usually outcompete native vegetation for the new light resource. Gypsy moth defoliation may also cause reduced hard mast production[6] that may negatively impact wildlife populations[8]. Gypsy moth defoliation may also result in improved habitat conditions for certain wildlife species, particularly when defoliation or tree mortality creates greater light penetration through the canopy and subsequent understory growth[3].

The impacts of the gypsy moth on market forest resources (e.g., timber) are generally small compared to non-market impacts[9]. In particular, when outbreaks occur in residential areas, homeowners often become very upset by the large number of caterpillars, excrement and defoliation. As a consequence, such property owners are typically willing to pay considerable sums of money to locally suppress gypsy moth populations during outbreaks.

Gypsy Moth Management

Gypsy moth management consists of three different approaches with very different objectives: eradication, containment and suppression. We highly advise contacting a federal, state, or local professional if you think you have a gypsy moth infestation on your land.

ERADICATION

Gypsy moth has currently invaded an estimated 1/3 of forests that may potentially support outbreaks of the species[14]. Consequently, there is considerable value in preventing the species from invading new areas. The lead Federal agency in charge of preventing gypsy moth invasion of new states is the USDA APHIS, which in partnership with State governments deploys about 100,000 pheromone-baited traps every year to detect new, isolated gypsy moth colonies in otherwise uninfested areas. Once detected, more traps are deployed in the surrounding area the following year to determine if a reproducing population is present and delimit the potential extent of infestation. This may also be confirmed by the presence of life stages (usually egg masses) detected during winter surveys. Delimiting trapping is also used to target treatments applied to eradicate the population. Currently, the most common treatment used to eradicate gypsy moth populations is an aerial application of the pesticide *Bacillus thuringiensis* var. *kurstaki* (also called Btk; trade names include Foray® or Gypchek®). The "Bt" part of Btk is a bacteria discovered in soil in 1902, and the "k" refers to the variant which is specific to Lepidoptera (e.g. butterflies and moths) – once consumed by a caterpillar, the bacteria basically poisons the digestive system of the insect, leading to a halt in feeding and eventually death. Mating disruption (i.e. the use of synthetically-made female moth scents to prevent male moths from finding mates) is also used a gypsy moth management tactic. Over the course of the last 40 years, there have been hundreds of such eradication projects in uninfested states. Because pheromone traps are highly effective at locating and delimiting newly established populations, every one of these projects has been successful at eliminating gypsy moth from previously uninfested regions.

CONTAINMENT

In the early 1900's attempts were made to stop the spread of gypsy moth into uninfested parts of the U.S., but these projects ultimately failed and the species has continued to slowly expand its range[10]. Though eradication of isolated populations is a realistic goal, completely stopping spread into adjoining areas may be impossible, as there is a close link between human populations and movement and gypsy moth detections (Fig. 8). In 1999, the U.S. Forest Service implemented the gypsy moth "Slow the Spread" (STS) program (http://www.gmsts.org/) aimed at slowing, rather than stopping, the spread of the gypsy moth. This program has succeeded in reducing gypsy moth spread by over 60%[18,20,21]. The STS program accomplishes this by placing a base-grid of traps across an approximately 62 mile wide band along the species expanding population front ranging from the Atlantic coast in North Carolina to the border with Canada in Minnesota. Catch data are used to build frontal models of gypsy moth expansion, inform treatment decisions, and separate the front into priority treatment zones. Base-grid densities range from approximately ¾ of a mile in the Action Zone at the head of the front to 5 miles at the tail end of the front in the Monitoring Zone. As with eradication, these traps are used to identify and delimit newly established isolated populations that are then targeted for treatment. While the goal of eradication is the total elimination of these populations, in STS the goal is to retard population growth such that range expansion occurs at a slower speed. Slowing the rate of gypsy moth spread is cost effective because reduced spread postpones when residents and communities become impacted and delays the start of gypsy moth outbreak suppression programs in that area[9,19]. Also in contrast to eradication, most STS treatments utilize mating disruption, though Btk may be used in high-density populations.

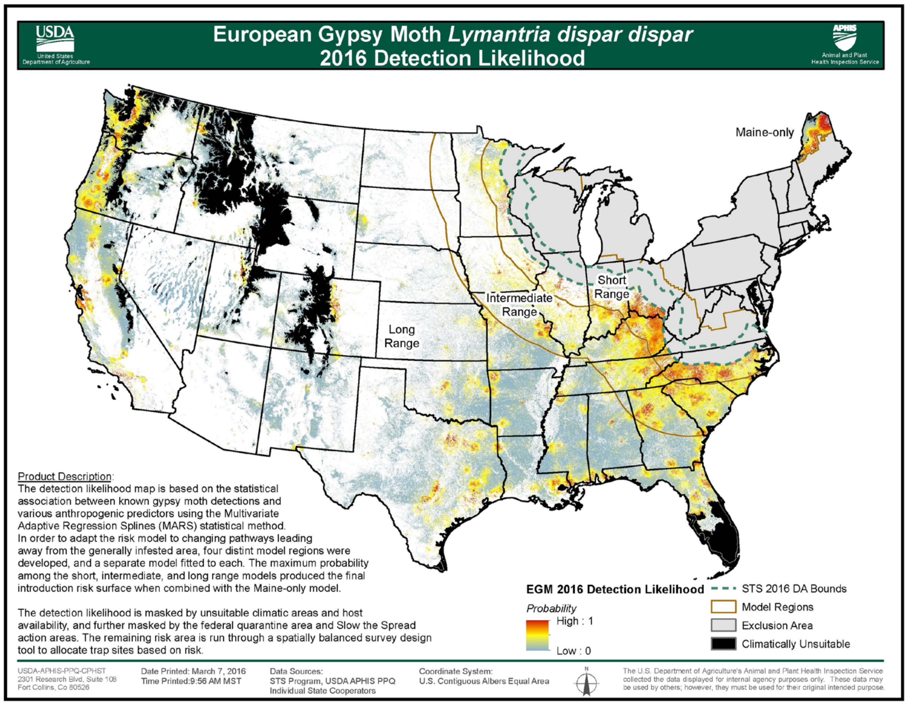

Figure 8. Red areas are those in which new gypsy moth discoveries are most likely to occur, and these are closely linked with both the current gypsy moth distribution and human population/movement (i.e. cities).

SUPPRESSION

Once gypsy moth becomes established in a region, recurrent outbreaks may occur every few years. In order to prevent these outbreaks and lessen their impacts (including both tree mortality and nuisance impacts), landowners may opt to protect forests using aerial pesticide applications. Again, most suppression treatments are conducted using Btk (Fig. 9), though synthetic pesticides are used to a lesser extent. The decision as to whether to treat a stand is based in part on densities of over-wintering egg masses. These counts are made visually in circular plots (typically 1/40th acre) and thresholds (e.g., 400 egg masses / acre) are used to predict the occurrence of defoliation. The decision to suppress populations is also based on land use with forested residential land typically considered to be the highest priority for treatment, though land managed for recreation or high-value timber may also be considered for suppression.

Silvicultural Alternatives for Gypsy Moth

Forest susceptibility to gypsy moth defoliation can be reduced with preventative silvicultural treatments, provided these treatments are conducted well before gypsy moth invades the region. Silvicultural prescriptions and treatments implemented after gypsy moth arrives in an area are not likely to be effective. We strongly advise consulting with a professional forester when putting together a forest management plan. Details for finding a professional forester are located on the last page of this document.

Silvicultural options are:

- Pre-salvage harvest
- Thinning and/or timber stand improvement (TSI)
- Post-salvage harvest
- Convert to less-favored species
- Do nothing

Pre-salvage harvests or thinning are most appropriate on medium- to high-quality sites where costs are justified; these activities are rarely justified or practical on poor-quality sites. Depending upon the site, consider managing for conifers or conifer-hardwood mixtures after harvest on poor sites. In high-hazard stands nearing financial maturity, harvesting merchantable trees or stands before gypsy moth defoliation occurs can help the landowner realize economic benefits while reducing stand susceptibility and vulnerability to gypsy moth defoliation. In stands that are not yet mature, leave healthy trees with large crowns that are likely to survive defoliation, and removing suppressed and low-vigor trees that will be highly vulnerable to damage from gypsy moth. Salvage logging in stands damaged during gypsy moth outbreaks should occur six to 12 months after tree death, but before wood value is substantially reduced by stain or decay. During any harvest operation, take care to prevent soil compaction, wounds and other injuries to reduce the amount of stress of residual trees. Regeneration after harvesting is usually plentiful from stump sprouts, advance regeneration, and seeds.

Pre-salvage harvests, thinning, and TSI all selectively remove trees from the forest and allow an opportunity to shape future forest composition. 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 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). However, in certain areas (e.g. those with oak decline or low natural oak regeneration) it may not be prudent to remove oaks from a stand.

Figure 9. Gypsy moth defoliation in Pennsylvania in an area treated with pesticide and untreated.

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 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.

Management Prescriptions

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

- Rarely are forest operations cost effective on poor sites. If possible, reduce stand stocking and density to improve the health of residual trees and increase their ability to withstand gypsy moth defoliation.
- Convert to a conifer (e.g. shortleaf pine), a conifer-hardwood mixture, or a non-forest cover type such as a pasture.
- Increase the proportion of non preferred or non-favored species during forest operations.

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

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

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

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

All Sites:

- Remove 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.
- Remove trees that could create favorable habitat for gypsy moth, such as trees with a large number of dead branches, trunk cavities and rough and peeling bark.
- In oak-dominated stands, increase the proportion and health of non-favored species such as maples, yellow-poplar, and black cherry.
- Encourage regeneration of non-favored species.
- Create age diversity. Consider two-aged stands and patch clearcuts to invigorate older oak stands.

Timing of Thinnings:

- In stands that are degraded or of poor quality, overstocked or contain overmature favored species, a thinning may be performed to reduce the vulnerability of the stand to gypsy moth. Dead trees should be salvaged and live trees thinned in infected stands within two years after the outbreak. The resulting stands after these practices should be in a healthier condition that can better survive the next gypsy moth outbreak.
- 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.
- 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.

Regeneration Considerations:

- Seedlings and saplings of oak and other favored species will have the greatest defoliation and mortality rates during outbreaks. Large oak advance reproduction (> 4 feet) will resprout several times and will probably survive several defoliation events.
- Stump sprouts of gypsy moth-favored species should be thinned to one stem per stump to improve health and resistance.
- Gypsy moth usually has little impact on young pines.
- Most intermediate silvicultural treatments in stands susceptible to gypsy moth allows some potential regeneration from seeding of remaining trees,

advance reproduction, and stump sprouting of cut trees.

Wildlife Considerations:

- Favored species 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.
- Reduce the percentage of favored species and create and maintain agricultural crop openings.
- Within high-risk stands, increase the proportion of non-favored species that will benefit wildlife and minimize defoliation, i.e., hickory, walnut, pine and red cedar.
- 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.

Summary

Although current efforts to deter the establishment of gypsy moth populations in new areas have been quite effective, the species can be expected to continue to gradually extend its range into the southeastern U.S. (particularly in the mountain regions). Some impacts of the gypsy moth in forest and residential settings can be mitigated via suppression of outbreak populations. In forested regions, silvicultural treatments can be implemented prior to gypsy moth establishment 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.

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Resources

For the location and phone numbers of state agencies in the southeastern U.S. providing forestry assistance and information, see the following websites:

Alabama Forestry Commission: http://www.forestry.alabama.gov/

Arkansas Forestry Commission:
http://forestry.arkansas.gov/Pages/default.aspx

Florida Forest Service: http://www.floridaforestservice.com/

Georgia Forestry Commission: http://www.gatrees.org/

Kentucky Division of Forestry:
http://forestry.ky.gov/Pages/default.aspx

Louisiana Department of Agriculture and Forestry:
http://www.ldaf.state.la.us/

Mississippi Forestry Commission: http://www.mfc.ms.gov/

North Carolina Forest Service: http://www.ncforestservice.gov/

Oklahoma Forestry Services: http://www.forestry.ok.gov/

South Carolina Forestry Commission:
http://www.state.sc.us/forest/

Tennessee Division of Forestry:
https://www.tn.gov/agriculture/section/forests

Texas A&M Forest Service: http://texasforestservice.tamu.edu/

Virginia Department of Forestry: http://www.dof.virginia.gov/

For the location and phone numbers of University Extension personnel in the southeastern U.S. providing forestry assistance and information, see the following websites:

Alabama Cooperative Extension System:
http://www.aces.edu/main/

University of Arkansas Cooperative Extension Service:
http://www.uaex.edu/

University of Florida's Institute of Food and Agricultural Sciences (UF/IFAS):
http://solutionsforyourlife.ufl.edu/

University of Georgia Extension: http://extension.uga.edu/

Kentucky Cooperative Extension Service:
https://extension.ca.uky.edu/

Louisiana Cooperative Extension Service:
http://www.lsuagcenter.com/

Mississippi State University Extension Service:
http://extension.msstate.edu/

North Carolina Cooperative Extension:
https://www.ces.ncsu.edu/

Oklahoma Cooperative Extension Service:
http://www.oces.okstate.edu/

Clemson Cooperative Extension (South Carolina):
http://www.clemson.edu/extension/

University of Tennessee Extension:
https://extension.tennessee.edu/

Texas A&M AgriLife Extension: http://agrilifeextension.tamu.edu/

Virginia Cooperative Extension: http://www.ext.vt.edu/

To locate a consulting forester:

Association of Consulting Foresters:
http://www.acf-foresters.org/acfweb.

Click on "Find a Forester", then select your state in the "People Search – Public" search page.

For more information on how to select a consulting forester, go to:

http://msucares.com/pubs/publications/p2718.pdf

http://texashelp.tamu.edu/011-disaster-by-stage/pdfs/recovery/ER-038-Selecting-a-Consulting-Forester.pdf

http://www.uaex.edu/environment-nature/forestry/FSA-5019.pdf

Additional information on the gypsy moth is available at::

http://southernforesthealth.net/

http://www.fs.fed.us/ne/morgantown/4557/gmoth/

http://www.gmsts.org/

http://protecttnforests.org/gypsy_moth.html

Photo Credits

Box 1: USDA APHIS PPQ, Bugwood.org.

Figure 1: Map from http://www.gmsts.org/library.html.

Figure 2: A. Steven Munson, USDA Forest Service, Bugwood.org.

Figure 3: Didier Descouens, https://commons.wikimedia.org/wiki/File:Lymantria_dispar_MHNT_Chenille.jpg.

Figure 4: USDA APHIS PPQ, Bugwood.org.

Figure 5: Laura Costa and David Coyle, SREF

Figure 6: L.M. Blackburn, U.S. Forest Service Forest Inventory and Analysis Database

Figure 7: Vince Burkle, Indiana DNR.

Figure 8: Gericke Cook, USDA APHIS.

Figure 7: Pennsylvania Department of Conservation and Natural Resources – Forestry, Bugwood.org.