

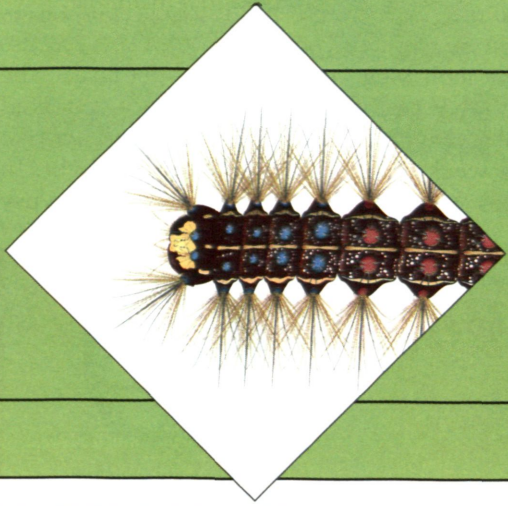
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Gypsy Moth in Michigan Homeowner's Guide
Michigan State University Extension
Department of Entomology, MSU, and the Michigan Department of Agriculture
Major Revision April 1993
8 pages

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GYPSEY MOTH IN MICHIGAN HOMEOWNER'S GUIDE

Major Revision April 1993 (First printing 1991) ♦ EXTENSION BULLETIN E-2302

Gypsy Moth Management Starts At Home

You are the first line of defense for protecting your trees and shrubs from damage by gypsy moth, other insects, nematodes and diseases. Being knowledgeable about the life cycle of the gypsy moth will pay off in money saved, labor expended and peace of mind.

Depending upon where you live in Michigan, gypsy moth outbreaks may last from two to several years or may never occur. Why gypsy moth populations explode from time to time is not entirely clear. Outbreaks will eventually collapse, usually from natural causes.

Until a local gypsy moth population crashes, however, there are several techniques that homeowners can employ to keep damage and nuisance to an affordable minimum.

Monitoring

Hopefully, the mind set of dragging the sprayer out of the garage and spraying insecticide on trees and shrubs just because something might be out there lurking is no longer a part of the Michigander mentality. Years ago this was called "insurance spraying" when everybody was spraying chlorinated hydrocarbon insecticides (e.g., DDT) on everything that moved. We all know where that got us!

Take time to inspect your trees and shrubs periodically for the various life forms of gypsy moth. Especially look for the caterpillars when they begin to hatch, usually in early May.

Contrary to popular belief, population explosions in a locality do not happen suddenly! An area will undergo a gradual population buildup for a time before the population goes into a phase of rapid release. This gives vigilant homeowners, neighborhoods and communities time to assess local conditions and take appropriate action.

The gypsy moth is in the egg mass form for nearly nine months, plenty of time to find and destroy them before they hatch in the spring. While it may not be possible to find and destroy all of the egg masses in and around your backyard, this activity will complement management activity taken in the spring.

Management

Non-Pesticide Techniques

Water and Fertilize

We often take trees and shrubs for granted, figuring that they are indestructible and meant to last forever. Trees and shrubs have specific nutrient and water requirements. Take the time to determine what they need, and water and fertilize properly. There are bulletins available at all county extension offices and garden centers. Most insects and diseases select trees and shrubs that are being stressed. Keeping your trees and shrubs healthy will reduce the pests and diseases attracted to your foliage and lessen the damage done if they are attacked.

Sanitation

Keep your yard as clean as possible. Remove discarded items, dead branches (from the ground and out of the trees), stumps, etc., where the adult female moth is likely to lay egg masses. It is very important that homeowners be watchful when obtaining firewood from areas infested by the gypsy moth. A good rule of thumb is to never get more firewood in the summer or fall than you can burn by spring.

Each fall, check recreation vehicles (boats, trailers, campers, etc.) for gypsy moth egg masses. Vehicular movement is how gypsy moth came to Michigan.

Destroy Egg Masses

As mentioned, gypsy moth egg masses are around for nearly nine months before they hatch. Homeowners can help reduce gypsy moth populations on their property and in their neighborhood by seeking out and destroying egg masses each year.

When a gypsy moth caterpillar is about to pupate, it will look for a protected area such as a loose flap of bark, something flat nailed to a tree, woodpile of the underside of branches, etc. Once a suitable location is found, it weaves a loose net of silk around itself and transforms into a pupa. This is the resting state where the caterpillar undergoes the miracle transformation from caterpillar to moth. This takes about two weeks.

Upon emergence, the female gypsy moth is creamy white and has a wingspan of about two inches. The male moth is smaller in size and camouflage brown with black mottling. Both have a distinguishing mark on their forewings: an inverted black V often referred to as a chevron marking.

The female generally deposits egg masses from early July to mid-August depending upon local weather conditions. The female cannot fly, so she will lay egg masses near where she was in the pupal (cocoon) stage.

The adult female lives about a week. Her only purpose in life is to breed as quickly as possible and lay her eggs. She cannot fly, so she emits a chemical odor to attract the nearest male for mating. This chemical is called a pheromone. After mating, the male flies off to mate several more times before dying. After mating, the female spends about a day depositing her egg mass, falls to the ground and dies. Neither the male or female moth feed.

Each egg mass can contain from 50 - 1,500 eggs. The eggs are intertwined in a matting of hair from the body of the female. The hair is a tan-buff color. It is also very water repellent and a good insulator.

The egg masses begin hatching the following May. Hatching coincides with the bud break of aspen and the flowering of serviceberry.

Homeowners are encouraged to search out and destroy egg masses. This is accomplished by scrap-

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Gypsy Moth Life Cycle

1) Small Larvae. This stage lasts for 7-10 days after eggs hatch in early May (or sooner in warmer weather). Larvae are less than 1.2 inch long and usually black. They linger around the egg cluster for several days if the weather is cool or rainy, then climb trees or other objects, trailing silken threads as they move. When the larvae reach the top of the tree, they do not feed but drop on silken threads and are dispersed by the wind.

2) Large Larvae. Feeding at night for 4 to 6 weeks, large larvae generally rest during the day unless populations are very large, then they wander constantly. They grow until they are about 2 inches long.



1. Small Larvae—May



2. Large Larva—June



3. Pupae—July



4. Adults—August



5. Egg masses—August

3) Pupae. During this stationary stage the larvae are changing into moths. This generally occurs from the end of July until early August. After about 10 days in the dark colored pupal cases, the adult moths emerge, leaving the pupal cases behind.

4) Adults. The female moth is creamy white and does not fly but emits a chemical called a pheromone to attract a male moth. The male is brownish and flies in a zigzag pattern looking for the female. A single male can mate with many females. Both sexes have chevron markings (V or notch-shaped marking) on each forewing.

5) Egg masses. The buff-colored egg masses contain between 50 and 1,500 eggs. The female deposits the eggs on any convenient surface. The masses are usually covered with hairs from the female's abdomen. The egg masses are quite cold resistant and can survive temperatures as low as -20 degrees F. Egg masses hatch during May.

Management...

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ing them from the surface to which they are attached into a coffee can or similar receptacle. They can be buried or burned. Remember that each egg mass destroyed probably eliminates 400-500 caterpillars. Destroying egg masses is not a cure all. Many times egg masses are overlooked or inaccessible. However, it is a very good and certainly very cheap way to significantly impact the gypsy moth population in your yard and neighborhood.

Barrier Bands

Sticky, or slippery bands can be placed around tree trunks to help curtail, though not necessarily prevent, the caterpillars movement into and out of the tree canopy.

Sticky bands can be purchased or made using a nonporous material that can be wrapped around a tree trunk, then coated with a commercially made, vegetable-based sticky material. **Never put sticky material directly on the tree trunk.** This will permanently stain the bark and may harm the tree.

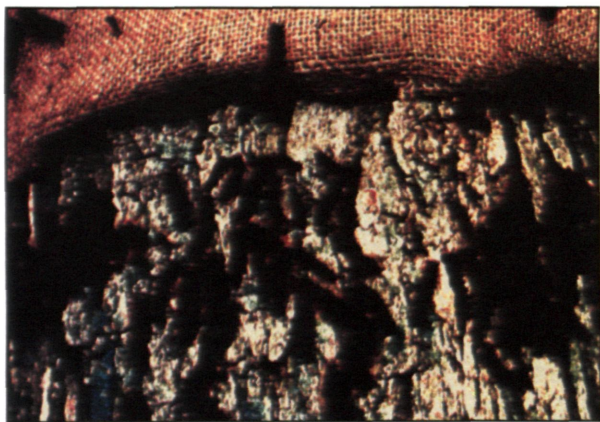
Sticky bands should not be put on the tree until the caterpillars are about an inch long. Smaller caterpillars usually stay in the tree canopy. Because sticky bands eventually lose their effectiveness due to rain and other weather factors, the sticky material has to be reapplied periodically. Bands covered completely with caterpillars need to be cleaned or replaced.

Slippery bands are also intended to interrupt the daily migration of the caterpillar. They prevent the caterpillar from climbing up into the canopy.

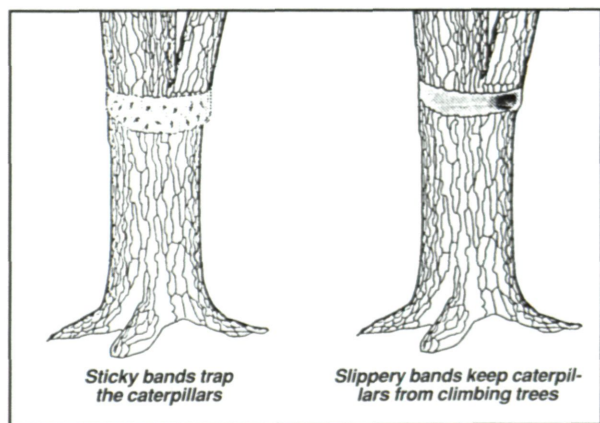
Hiding Bands

Cloth, or hiding bands, can be homemade from medium weight dark cloth about 12 to 18 inches wide and long enough to completely wrap around the tree. Fasten each band at about chest height around the tree with twine, cord or wire about midway from the bottom of the cloth. Then fold the top part of the cloth down over the bottom half.

Some of the caterpillars descending the tree in the morning hours in search of a secluded daytime resting spot will hide under the flap of the band. Remove and destroy the caterpillars each day by scraping them into a bucket of soapy water.



Gypsy moth caterpillars use cloth bands to hide during daylight hours. Scrape the caterpillars into a bucket of soapy water



Pesticide Techniques

Biological Pesticide

There are many pesticides registered for use against gypsy moth in Michigan. The **only** pesticides used in the the Michigan Voluntary Cooperative Suppression Program are products that contain B.t.k. *Bacillus thuringiensis* var. *kurstaki* as the active ingredient. B.t. is a common soil bacteria. It is commercially formulated and sold under various labels (e.g., Dipel, Foray, Thuricide and Bactur to name a few). B.t. can be

applied from the ground or by aerial spraying.

B.t. formulations are quite safe to humans. There is no apparent human toxicity, although there have been rare cases of allergic reaction by humans to certain formulations of B.t. In fact, B.t. is only known to be toxic to the caterpillars of moths and butterflies. While there are many species of caterpillars affected by B.t., this pesti-

cide is the most "selective" product available.

To be most effective in minimizing defoliation, B.t. must be applied when the caterpillars are less than one inch long. As caterpillars get larger, the efficacy of B.t. diminishes. B.t. has a reported residual activity (i.e. how long it remains potent) of about a week. It is broken down by sunlight. In instances where there are extremely high gypsy

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Be careful with pesticides!



Use proper recycling procedures for disposing of pesticide containers.

This publication contains pesticide recommendations based on research and pesticide regulations. However, changes in pesticide regulations occur constantly. Some pesticides mentioned may no longer be available, and some may no longer be legal. If you have questions about the legality and/or registration status for using pesticides, contact your MSU Extension county office.

To protect yourself and others and the environment, always read the label before applying any pesticide. For information about pesticide labels see Extension Bulletin E-2182 *Reading a Pesticide Product Label*.

For more information about pesticide safety, see Extension Bulletin E-2215, *Using Pesticides Safely: A Guide for the Applicator*; Extension Bulletin E-1546 *Take Cover! Protect Yourself from Exposure. (Pesticides)*.

For more information about safe disposal of pesticide containers see Extension Bulletin AM-95 *Rinsing and Recycling Pesticide containers*.

Dozens of other Extension bulletins on safe application of pesticides are also available.

WOODLOT MANAGEMENT and THE GYPSY MOTH

According to experts at MSU, the appearance of gypsy moth has caused foresters to rethink their approach to timber management. In stands that are composed of a large percentage of trees that are preferred hosts for gypsy moth, the potential effects from defoliation and tree mortality must be considered in the planning of any timber management operation.

"Gypsy moth is a relatively new disturbance to the forests of Michigan," states Russell Kidd, District Forestry Agent for MSU Extension in Roscommon. "Consequently, scientists have only been able to study its impact for just a few years. Therefore, it is difficult to predict all the long-term changes that gypsy moth will cause in Michigan's forests," says Kidd.

Michigan has large areas of oak and aspen forests that are extremely susceptible to defoliation by gypsy moth. Additionally, many parcels have been weakened by old age or are too dense for optimum growth. These parcels are at some risk to tree mortality because of all the stress they are under.

Generally speaking, good traditional timber management recommendations that keep stands healthy and vigorous are the best approach to minimizing impacts from defoliation. Depending upon the stand, recommendations for thinning younger stands to optimum densities, and harvesting overage stands to regenerate them, would be appropriate management.

Timing is Critical

The timing of thinning and harvest operations must be planned carefully in relation to gypsy moth population outbreaks. If an outbreak of gypsy moth caterpillars (i.e. heavy defoliation) is taking place or is expected in the next year or two, then landowners should wait before cutting down any trees. Instead, such stands should be watched

to see what mortality, if any, occurs. Any tree that dies can be harvested promptly with little loss of value.

If heavy defoliation is not expected in the near future, landowners should proceed with thinning or harvesting. However, landowners should monitor gypsy moth activity in their woodlots for 2-3 years after the completed thinning or harvesting operation has taken place.

According to Kidd, thinning and selective harvesting causes some short-lived stresses to a forest as it adjusts to both the demand for increased growth and to the small openings created during these operations. Timing these operations for those years when populations of gypsy moth are at low levels avoids adding another stress to the stand.

In carrying out the thinning or harvest operation, the forester or landowner managing the stand should concentrate on the following guidelines in selecting trees for removal:

1. Reduce the number of poor-quality, high-risk species.
2. Remove trees of any species with poorly developed crowns.
3. Give strong consideration to removing trees that provide good egg laying habitat for gypsy moth (e.g. rough bark, small cavities, and large, overhanging branches). However, if such trees are also being actively used by wildlife, which may include gypsy moth predators, those trees should not be removed.

A question that is often raised by landowners is whether spraying their woodlot with pesticide to manage gypsy moth is justified. "In most cases," says Kidd, "aerial spraying of woodlots is not justifiable. When you compare the cost of aerial spraying against the value of timber that may be lost, it's probably not worthwhile. This is especially true in stands that have not been well-tended by the landowner or are growing on poor-quality, droughty sites."

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Trees and shrubs defoliated by gypsy moth

Although gypsy moth caterpillars feed primarily on deciduous tree species such as oak or aspen, this insect is known for its wide-ranging appetite. When populations of gypsy moth are very high, the caterpillars quickly devour the leaves of their preferred host tree species. Once their favored food source disappears, the hungry caterpillars do not hesitate to seek out new sources of food. When this occurs, almost any deciduous or conifer tree, shrub or other landscape plant may be at risk of suffering some amount of defoliation.

Consequently, it is difficult to state exactly how susceptible a tree or shrub species is to defoliation by gypsy moth caterpillars. Therefore, the following list is offered only as a guide to homeowners. This list does not guarantee that any species listed as minimally at risk will never be defoliated by the gypsy moth.

More importantly, homeowners need to recognize that gypsy moth caterpillars do have preferences for certain types of trees and thrive best on those species. Typically these favored food sources are usually the first ones attacked in a homeowner's yard, especially tall, large crowned trees. These are the trees most likely at risk to defoliation.

Generally speaking, when gypsy moth caterpillars move into less preferable food sources, the caterpillars do not thrive as well and often only cause minor damage.

However, regardless of this insect's food preferences, close inspection of yard trees and outdoor fixtures and prompt action by the homeowner to destroy egg masses and small caterpillars is crucial (see related articles). This is the real key to minimizing the discomfort and, to some degree, the defoliation caused by large numbers of gypsy moth caterpillars.

If a homeowner is able to minimize the amount of defoliation from the gypsy moth, it will lessen the overall impact on tree health. When a hardwood tree is heavily defoliated, the needed energy to regrow a new set of leaves causes stress. This

stress often weakens a tree which may lead to additional tree health problems. Moreover, conifer species, such as spruce or pine, are at greater risk than hardwoods because conifers are not able to regrow needles lost to defoliation. Thus complete defoliation of conifers by gypsy moth is usually fatal.

Trees and Shrubs Most at Risk to Defoliation

- All oak (*Quercus*).
- All aspen and poplar (*Populus*).
- Gray, paper (white), and river birch (*Betula*).
- All willow (*Salix*).
- All apple and crabapple (*Malus*).
- All thornapple and hawthorne (*Craetagus*).
- White pine (*Pinus*).
- Blue spruce (*Picea*).
- American beech (*Fagus*).
- Basswood (*Tilia*).
- Sweetgum (*Liquidambar*).
- Juneberry or serviceberry (*Amelanchier*).
- Witch hazel (*Hamamelis*).
- Hazelnut (*Cornus*).
- Mountain ash (*Sorbus*).

Trees and Shrubs Somewhat at Risk to Defoliation

- Black walnut and butternut (*Juglans*).
- All cherry and plum (*Prunus*).
- Norway, red and sugar maple (*Acer*).
- Hophornbeam or ironwood (*Ostrya*).
- Hornbeam or blue beech (*Carpinus*).
- Alder (*Alnus*).
- Elm (*Ulmus*).
- Hickory (*Carya*).
- Eastern redbud (*Cercis*).
- Sassafras (*Sassafras*).
- Paw paw (*Asimina*).
- White and Norway spruce (*Picea*).
- Balsam fir (*Abies*).
- Eastern hemlock (*Tsuga*).
- Red, jack, scotch and Austrian Pine (*Pinus*).

Trees and Shrubs at Minimal Risk to Defoliation

- Ash (*Fraxinus*).
- Tulip tree or yellow poplar (*Liriodendron*).
- Sycamore and London plane tree (*Platanus*).



Gypsy moth caterpillars prefer to eat leaves of certain tree species, including poplar.

- Northern catalpa (*Catalpa*).
- Honey locust (*Gleditsia*).
- Black locust (*Robinia*).
- Horsechestnut (*Aesculus*).
- Dogwood (*Cornus*).
- Eastern redcedar (*Juniperus*).
- Juniper (*Juniperus*).
- Yew (*Taxus*).
- Lilac (*Syringa*).
- Azalea (*Azalea*).
- Rhododendron (*Rhododendron*).
- Arborvitae (*Thuja*).
- Viburnum (*Viburnum*).

Homeowners considering planting trees or shrubs in areas prone to high gypsy moth population build-ups should choose species that are at minimal risk to defoliation. Contact your local MSU Extension office for bulletins and information on tree selection, planting and care.

Be careful about quick fixes for your gypsy moth problem

Struggling with the effects of the gypsy moth can be frustrating enough without unscrupulous people trying to take advantage of the homeowner by offering quick fixes.

There are no quick fixes, declares Russell Kidd, MSU Extension district forestry agent in Roscommon County.

He advises homeowners to be wary of products or services that promise or imply they can end gypsy moth problems in the backyard or woodlot.

Be careful of salespeople who want to spray your trees with chemicals that are "guaranteed" to control the gypsy moth. In some cases, these may be worthless or even dangerous.

Homeowners should ask what chemical is to be used, its hazard, what its effect will be and what precautions will be taken to minimize spray drift to nearby objects.

Homeowners should also ask to see proof that the company and the individual are certified and licensed to apply such a material. Michigan law requires that commercial pesticide spraying companies be certified and licensed by the Michigan Department of Agriculture.

Remember that chemical sprays are effective only during the caterpillar stage of the gypsy moth. Spraying trees before the eggs hatch or after the caterpillars have pupated or emerged as adult

moths is worthless. (See the gypsy moth life cycle chart on Page 1.)

Be wary of unrealistic claims about products or techniques to rid your property of the gypsy moth by themselves.

Some products, such as sticky bands, are indeed useful, but they will not control the gypsy moth completely, especially when used alone. Only a combination of control treatments, used diligently by the homeowner, will achieve satisfactory control of the gypsy moth.

Other products may not do what their names imply. Take, for instance, the gypsy moth trap. The purpose of the trap is to attract and capture the adult gypsy moth. Traps are used to monitor gypsy moth populations. They will not control or eliminate next year's gypsy moth problem in your yard because one adult male moth can mate with many female moths and one or two traps will not capture enough males to interfere with mating or cause the population to decline significantly next year.

Be very careful about timber buyers who offer to buy standing trees that have been defoliated. Unscrupulous timber buyers may use gypsy moth infestations in an area as a scare tactic to persuade people to sell valuable timber at low prices before the trees die.

Timber owners should always consult with professional foresters before they decide to sell any standing timber.

Your county MSU Extension office can provide the names of professional foresters in your area.

Woodlot Management...

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"Spraying is only justifiable under certain conditions such as in high value, large diameter oak stands that are very close to harvest or in stands that are under severe stress from other factors," advises Kidd. "Landowners should not fool themselves into thinking that spraying is a panacea to the gypsy moth problem or that it is a substitute for good forest management. In fact under certain conditions, spraying could actually prolong defoliation if it eliminates the buildup of predators," says Kidd.

More research is needed before foresters and others working with gypsy moth can answer most of the questions and concerns about the ultimate impact of gypsy moth in Michigan. To date, the bulk of the research done on gypsy moth has been

in the eastern states and Europe. Michigan is different in terms of soil, climate and forest types. Therefore, it is not always easy to apply what happened elsewhere to our state.

Over the past several years, MSU extension specialists have held workshops for professional foresters and other natural resource managers to help them learn more about gypsy moth and how to manage timber stands to minimize the negative affects.

"Private landowners should seek out professional help if they are unsure as to how to manage their timber, given gypsy moth as a new development," advises Kidd. "The best place to start for further information would be your local MSU Extension office."



GYPSY MOTH QUESTIONS AND ANSWERS

Management on state lands

The battle to rid Michigan of the gypsy moth was lost long ago. The gypsy moth is an established resident of our state's forests. Spraying in most areas of the state will only temporarily reduce the numbers of caterpillars. For most areas, this effect will last for only one year.

Gypsy moth numbers are controlled by many predators, parasites and diseases. Like most leaf-eating insects, the number of gypsy moth caterpillars cycle with time. Periods of bad years will be followed by periods of time when gypsy moth will hardly be noticed.

The key to this cycle is the rapid drop in gypsy moth numbers often referred to as a "population crash." A virus that kills only the gypsy moth is the main reason for these crashes. This remarkable phenomenon, when gypsy moth numbers return to low levels, is the basis for the Michigan Department of Natural Resources (DNR) management strategy for gypsy moth.

The DNR does not use insecticides against gypsy moth on vast areas of the forest. Small areas are treated if it is appropriate to do so. Gypsy moth on state land do not cause outbreaks on private lands, just as those insects on private lands do not cause outbreaks on state forest lands. In fact, spraying large areas of state land may actually help prolong outbreaks by altering natural mortality. While we understand that gypsy moth periodically rises to levels that create a problem, this in itself is not reason enough to spray. The benefits from using any pesticide must be carefully weighed against the risks and costs of that use.

A Few Commonly Asked Questions and Answers:

Q. What is the DNR doing about gypsy moths?

A. The DNR is responsible for protecting state land from gypsy moths and other tree pests. Through forest management practices, the department is striving to make our forests less vulnerable to gypsy moth. The gypsy moth is monitored to determine if the insect will kill valuable timber or become a serious nuisance in recreation areas. This information is used to ensure that we spray only where it is most appropriate.

Q. When and where is it appropriate to spray gypsy moths on state lands?

A. Put simply, it's appropriate where and when the benefits outweigh the costs, which is not always easy to determine. Generally, it makes sense to spray recreational areas, such as campgrounds and parks, with an appropriate insecticide. A well-used campground relatively free of caterpillars creates benefits that outweigh the small environmental and economic costs of treatment. On the other hand, it seldom makes economic sense to spray state-owned timber lands. The cost of treating those lands usually is greater than the timber value we would lose if we choose not to spray.

Q. How does the state know what areas to treat?

A. Areas of high recreational value or timber value are routinely surveyed for gypsy moth egg masses. A count of these egg masses tells us whether or not to expect a problem.

Q. What would happen if the state did not treat recreational areas such as campgrounds or parks?

A. If there are sufficient egg masses in the area, it is likely that most visitors would find the experience intolerable

because of the large number of caterpillars. Some trees may die, although this may not happen until several years after the outbreak. Visitors to an infested area may unknowingly transport gypsy moths back to areas that were previously not infested.

Q. If state lands are not sprayed what will be the long term effects on the forest?

A. A forest's first encounter with gypsy moth defoliation will cause some change, which can be thought of as the forest's way of fighting back. In some areas some trees will die, weakened by repeated gypsy moth attacks. Certain susceptible species will be replaced to some extent by more resistant ones. In those areas the forest makeup will change slightly creating a forest type that is more resistant to future mortality. This means that after the first outbreak, future defoliation will have much less impact. This change may be quite noticeable in a few areas, while in others, the change will be hard to see. Although a few trees will die, the forest will survive.

Q. Isn't it worth spraying to avoid changing the forest?

A. Forests are always in a state of change; this is normal. Spraying for gypsy moth on a large scale may have the effect of prolonging the outbreak and delaying population collapse. This is because large-scale spraying may alter naturally occurring organisms that regulate gypsy moth populations. Spraying on a large scale to prevent a problem may actually cause a bigger one in the long run.

Q. What happens environmentally in an area that is treated for gypsy moth?

A. When an area is treated for gypsy moth, the safest material possible is used. The name of the material used will be posted on a sign on the site. Generally it is *Bacillus thuringiensis* (Bt), a bacterial insecticide that has little effect on other organisms or the environment. The smallest area possible, usually 50 acres or less, is treated so we do not interfere with the pending gypsy moth population crash.

Q. What method of spraying is used?

A. The DNR uses the most up to date aerial application techniques, either by airplane or helicopter.

Management on private lands

Q. Will county-administered suppression spray programs eradicate this pest?

No. Community suppression spray programs are designed to help homeowners cope with the gypsy moth until natural controls (predators, diseases, etc.) cause the population to fall to levels that people can tolerate without spraying.

Q. Once the county begins to spray, will my property have to be treated every year?

Not likely. Only small blocks of land are sprayed as part of any suppression program. Highly infested, unsprayed blocks bordering these areas are allowed to follow the course of nature. After three of four years of large outbreaks, natural controls such as disease-causing viruses and predators cause populations to crash or fall dramatically in the unsprayed areas. When this occurs, properties sprayed in previous years do not require spraying because the population crash usually extends into these areas.

Q. Will the trees in my yard or woodlot die once the leaves are completely chewed off by the gypsy moth?

Most trees survive, but survival depends on tree vigor before defoliation and the species of tree being attacked. Healthy, vigorous trees are generally able to withstand two or three years of heavy feeding by the gypsy moth. However, yard trees that are weakened by old age, drought, competition from other trees, or insects and diseases may die after one defoliation.

In addition, coniferous trees, such as pine or spruce, cannot produce new needles after defoliation. Thus complete defoliation by the gypsy moth can kill these trees.

Q. What may happen if my neighbors and I do not have our properties sprayed as part of a gypsy moth suppression spray program?

Left on their own, gypsy moth populations generally continue to increase until trees are completely stripped of foliage and then natural causes, such as predators and virus diseases, reduce the population.

However, during multiyear outbreaks, droppings (frass) fall from trees in large quantities; masses of migrating larvae in search of new food or places to pupate climb on houses and other objects and become a nuisance that most people (or communities) whose properties qualify for a suppression spray program choose to participate to avoid the many uncomfortable aspects of large gypsy moth outbreaks.

Q. There are tents and webs in the cherry and crabapple trees in my yard. Is this gypsy moth?

No. The gypsy moth does not spin webs or tents as it feeds. Silken tents in the crotches of trees are made by the eastern tent caterpillar. This insect feeds primarily on fruit trees such as cherry and apple and the ornamental varieties of these species. Because this insect's hosts are more limited, the eastern tent caterpillar is not considered as threatening as the gypsy moth. Eastern tent caterpillar outbreaks occur periodically, and after a few years they crash or decline once predators and other natural diseases build up in the population.

Q. Is there anything I can do around my home to control gypsy moth without using pesticides?

Homeowners can use several nonpesticide methods that are effective, to some degree, in coping with the gypsy moth. For example, physical barriers can be placed around tree trunks. These include sticky bands that trap gypsy moth larvae or folded fabric bands that attract larvae which then can be easily destroyed. Scraping egg masses off of trees and manmade objects before they hatch also helps. Some measure of control can also be accomplished by spraying newly hatched larvae with a weak solution of hand soap mixed with water (1–2 fl. oz. per gal. of water).

In addition, insecticidal soaps (similar to dishwashing or hand soap) or *Bacillus thuringiensis*, a bacterial disease of caterpillars (tradenames: B.t., Dipel, Biotrol, and others) effectively control gypsy moth when larvae are about one inch long. B.t. is not toxic to animals or people. It is only lethal to the larvae of insects in the moth and butterfly family. This material has a low impact on the environment.

Q. How much does a caterpillar eat?

During the caterpillar stage, each gypsy moth eats about one square meter of foliage.

Management starts at home

Continued from page 2

moth populations, two applications five days apart might be needed.

Most chemical pesticides are 95% – 99% effective. B.t.k. is probably is 80% – 85% efficient in field applications. This is actually a desirable attribute of B.t.k.. That may sound like a contradiction, but it isn't. Pesticides that are highly efficient will eventually work against the pest manager. Insects, through natural selection, will develop resistance to the pesticide. By leaving 15% of the population intact, selection for resistance is slowed. B.t.k. has been used against gypsy moth for over fifteen years and no resistance has been discovered.

There is, quite naturally, a trade off. When B.t.k. is applied there are still some caterpillars crawling around. However, nuisance is reduced to a minimum, defoliation lowered below damaging levels, and B.t.k. remains effective.

Soap and Water

In addition to destroying egg masses, homeowners can use a number of other non-pesticide methods to reduce defoliation of their yard trees.

Watch for the appearance of the small caterpillars in the spring. A garden hose has sufficient water pressure to knock them off the foliage. Spraying them with water under pressure kills many of them.

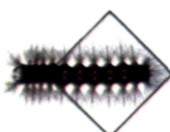
Garden centers carry various brands of "insecticidal soap." An insecticidal soap is not a soap containing a synthetic insecticide but instead refers to the ability of the soap to kill certain insects. Spraying gypsy moth caterpillars with a hose with an attachment to dispense soap can be very effective. Be sure to follow label directions on the insecticidal soap container. Small and large caterpillars can easily be drowned when submerged into a bucket of soapy water.

Chemical Insecticides

A number of chemical pesticides are registered against gypsy moth in Michigan. Many are available at your local garden center or nursery. Some of the most common are formulations of acephate, carbaryl, and malathion.

If you choose to use chemical insecticides to control gypsy moth, apply them judiciously and wisely. Besides gypsy moth they can have a potential impact on a variety of beneficial insects, including valuable predators, parasites and honeybees.

Regardless of what insecticide you choose, read the label instructions and follow them exactly. If you have any potential personal health concerns regarding pesticides, discuss them with your family physician or contact your local health department.



By 1990, gypsy moth had a firm grip on the Lower Peninsula. By this time it was accepted that this would cause episodes of serious defoliation by the end of the decade wherever suitable host plants existed in sufficient numbers (most of both peninsulas).

The state legislature, keenly aware of the potential for misuse of insecticides that could occur, provided funds to Michigan State University Extension to put into place the Michigan Gypsy Moth Education Program (MGMEP).

MGMEP provides a variety of educational material and programs to all counties that are now or will soon be affected by gypsy moth defoliation. The goal of the program is to provide the information necessary for the citizens of the state to make correct management decisions when confronted with gypsy moth.

"Once people have a solid understanding of what gypsy moth can and cannot do, they will

MICHIGAN GYPSY MOTH EDUCATION PROGRAM

make good management decisions," states Tom Ellis, Gypsy Moth Education Coordinator for Southern Michigan. "Our unstated goal," Ellis goes on to say, "is to learn to live with the gypsy moth, to avoid the knee-jerk reaction of spraying everything and anything with pesticides, and to teach everyone a little ecology along the way."

"Initially, the program concentrated efforts in those counties in central northern Michigan that

were the first to be affected severely by gypsy moth," says Cora Gorsuch, education coordinator for Northern Michigan. As the program gained momentum, the scope of the activity has expanded to include programs for lake associations, the recreational industry, elementary and secondary education, the landscape and forestry industries, municipal grounds and forestry personnel, and community service organizations.

The MGMEP provides the vital link between regulatory activities and the people of Michigan. It also is the mechanism by which university researchers can discuss their role in searching out and implementing environmentally compatible, economically viable and socially acceptable management strategies to control this insect pest.

For more information regarding the role the Michigan Gypsy Moth Education Program plays in your locality, contact your county MSU Extension office.

❖ Gypsy Moth Educational Materials ❖

Workbooks:

The Gypsy Moth in the Classroom; by Eric Mullenbauer, published in cooperation with USDA Forest Service and others; available from Dr. Norman Dill, Delaware State College, 1200 N. Dupont highway, Dover, Delaware 19901; 92-page notebook with gypsy moth related activities aimed at elementary through junior high school. Includes lesson plans, ten minute introductory video and some graphics and teaching tips. Fee of \$5 to cover shipping and handling (S&H).

Gypsy Moth Workbook; published by American Forestry Association in cooperation with the USDA Forest Service; available from American Forests, P.O. Box 2000, Washington, D.C. 20013 for \$6.95, including S&H; 1-800-368-5748; 80-page booklet of classroom projects divided by age level (4-8, 9-12, and 13 and over), suitable for photocopying.

The Gypsy Moth...A Workbook About Michigan's Newest Insect; 1987, updated; by Clare County Gypsy Moth Task Force Education Committee; available through Michigan legislators; 24-page paperback, plus teaching guide, addresses basic insect study and gypsy moth activities.

The Gypsy Moth Activity Book; 1991; by Midland County Gypsy Moth Suppression Program; available from Gypsy Moth Suppression Program; Midland County Services Bldg. 220 West Ellsworth St., Midland, MI 48640-5194; (517) 832-6785, 20-page activity book aimed at early elementary grades, mostly identify and color pages. Cost \$1.15 (including S&H).

Videos:

Living With the Gypsy Moth in Michigan MSU Extension Video VT-33; 1991; 23 minutes; Available through Michigan State University Extension offices; Complete study of the gypsy moth life cycle and demonstration of population suppression techniques.

A Balanced Perspective 1992; USDA/Forest Service; 18 minutes; available from Irene M. Borak, USFS Forest Health Protection, 1992 Folwell Ave., St. Paul, MN 55108; Focuses on living with gypsy moth infestations and nature's methods of reducing gypsy moth populations.

Gypsy Moth...the Way West 1991; USDA/Forest Service; 18 minutes; available from USDA Forest Service, Northern Region Public Affairs Office, P.O. Box 7669, Missoula, MT 59807; Good historical review of introduction in eastern United States and travel westward.

MSU Extension Bulletins:

Available through your county MSU Extension office.

E-2299 "Comparison of the Gypsy Moth, Eastern Tent and Forest Tent Caterpillars." One page, color drawings. Free.

E-2300 "Cloth Banding Trees to Suppress the Gypsy Moth." One page with how-to graphics and explanation of gypsy moth caterpillar feeding and wandering behaviors. Free.

E-2301 "Barrier Bands to Suppress the Gypsy Moth." Illustrates the use of bands to trap or repel gypsy moth caterpillars. Free.

E-2281 "Gypsy Moth Homeowners Guide." Two pages, on what to look for and how to deal with the problem if your locality is affected. Free.

E-1983 "The Gypsy Moth in Michigan: A Guide for Homeowners and Small Woodlot Owners." Eight page color bulletin on recognizing and managing the gypsy moth. Excellent photos of life stages and life cycle and extensive management recommendations. 50 cents.

GYPSY MOTH GLOSSARY OF TERMS

Btk. *Bacillus thuringiensis* var. *kurstaki*. A common soil bacterium that produces a toxin deadly to gypsy moth caterpillars. Commercial formulations of Btk are used exclusively in the Michigan Cooperative Suppression Program. While not 100% specific to gypsy moth, Btk is the most selective and human safe pesticide registered for use against gypsy moth.

Caterpillar. The larva (immature form) of moths and butterflies.

Defoliate. Remove leaves from plants. One gypsy moth caterpillar can remove over a square yard of leaves in its lifetime.

Egg mass. A cluster of eggs. A gypsy moth egg mass consists of eggs and body hair from the female moth. The buff-colored egg masses range in size from 1/2" x 1/4" to 2" x 3/4" and contains from 50 to 1,500 eggs.

Eradication. Elimination of an organism from a geographical area. To date, gypsy moth has proven to be impossible to eradicate from Michigan and eastern states.

Exoskeleton. Insects do not have an internal skeleton. Instead, they have evolved an outer shell (exoskeleton) that provides structural strength and protection

Frass. Insect droppings (excrement).

Instar. Growth stages of immature insect forms. As immature insects grow (in this case caterpillars) they outgrow their exoskeleton and must shed it. The life stages between molts are called instars. The gypsy moth may complete 5 - 7 instars before forming a pupa.

IPM. Integrated Pest Management is the use of a variety of management strategies and techniques to limit insect pest populations to tolerable levels. It involves taking tree-directed actions, insect directed actions and no action depending

upon the circumstances. The management strategy selected is based on sound ecological, economic and sociological principals.

Michigan Voluntary Cooperative Gypsy Moth Suppression Program. A management partnership available to all counties. Up to 50% of the cost of aerial application of Bt may qualify for cost-sharing funds from the U.S. Forest Service. The program is managed at the state level by the Michigan Department of Agriculture. For more information contact your county extension office or MDA.

Molt. As the gypsy moth caterpillar grows, it must periodically shed its skin to allow for additional growth. It will molt four to six times.

NPV. Nucleopolyhedrovirus. NPV is a virus disease that is present in our gypsy moth population. It is most virulent when populations are high and food becomes scarce, weakening the caterpillars. At this time over 99% of the population will become sick, stop feeding and die (population crash). It is commonly referred to as wilt disease. Only caterpillars are affected.

Outbreak. Local gypsy moth populations will be innocuous for several years. When conditions are right, a population explosion (outbreak) will occur causing widespread, severe defoliation. Population densities of one half million to six million feeding caterpillars per acre are not uncommon during these outbreak episodes.

Parasite. An organism that lives on or in the body of another organism. There are several organisms (mostly other insects) that parasitize gypsy moth egg, caterpillar and pupa. A parasitoid is an important population regulator.

Predator. Organisms that eat other organisms. Many different kinds of mammals, insects and birds prey on all gypsy moth life forms. A predator is an important population regulator.

Pheromone. A scent the flightless female emits to attract and induce male gypsy moth for mating.

Pheromone trap. A trap that resembles a rectangular 1/2 gallon milk container with a roof. The trap is "baited" with a synthetic form of the gypsy moth pheromone. The Michigan Department of Agriculture has been monitoring male moth activity throughout Michigan since 1985 from a permanent array of traps. Two traps are set and collected each summer from each township in Michigan. Pheromone traps are not recommended for backyard control.

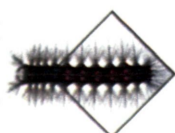
Population crash. The collapse of a large population of gypsy moth caterpillars. It is brought on by starvation which triggers naturally occurring diseases to disseminate a local population.

Population monitoring. Keeping track of the presence, population density and rate of spread of the gypsy moth. Traps baited with synthetic pheromone are used to monitor male moths. Egg mass and defoliation surveys are also important components of gypsy moth monitoring programs.

Pupa. The development stage that occurs between the caterpillar and adult stages. This is the resting state where the caterpillar transforms into an adult moth.

Refoliation. When deciduous trees lose more than 60% of their leaves they will "flush" a new set of leaves. This is called refoliation. The new leaves are usually smaller and not quite as green as the first set. Trees that refoliate are weakened somewhat due to stored energy used to produce the new leaves.

Stress. The negative effect on plants caused by poor growing conditions or damage caused by poor soil, too much or too little water, insects and diseases. Gypsy moth is only one of many causes of stress to trees in Michigan.



Researchers in Michigan have taken aim at the gypsy moth. Their goal is to provide new tools to the integrated pest management toolbox.

Integrated pest management (IPM) is nothing more than a common sense approach to managing pests within the context of the ecological, economic and social structures they affect. Nothing new. Put together a toolbox of technologies and use them properly. Manage the target beast in a way that doesn't throw the overall biological framework out of whack; do it in such a way that it doesn't cause an economic burden to the taxpayer or the crop producer; do not introduce pesticides that persist in the water, air or animal body fat or cause cancers; and, finally, implement a management program that makes everybody happy.

While this seems like an impossible task, that is very difficult and painstaking, it is not impossible.

In Michigan, scientists at Michigan State University, the University of Michigan, other universities, colleges, and the U.S. Forest Service have accepted the challenge presented by the gypsy moth. They are looking at it from many angles depending upon their specific expertise.

Is sick better than dead?

Dr. Leah Bauer is a part of a group of U.S. Forest Service research entomologists who are headquartered and share lab space at Michigan State University.

"Since the introduction of the gypsy moth, entomologists have been trying to reinstate the balance of nature in our eastern forests," Bauer said, "Many natural enemies of gypsy moth are now established and have gradually begun to moderate the dramatic population swings that occur in newly infested areas such as Michigan."

Dr. Bauer has been working with a group of protozoan pathogens called microsporidia. "We hope to introduce a full complement of pathogens to keep these insects as unhealthy as possible." These one-celled animals, together with NPV, play an important role in stabilizing gypsy moth populations in its native Europe range.

A caterpillar infected with NPV, Nucleopolyhedrovirus, dies fairly quickly, usually within a week or two. One infected with microsporidia may take three or four weeks to succumb. Some just get sick and stay sick. The sick caterpillars pupate and turn into a female moth that lays a greatly reduced number of eggs. Many of these hatching caterpillars are sick also.

What is manifested, over time, is the spread of a long, lingering illness throughout a large portion of a local or regional population. Sick begets sick. These individuals eat less, reproduce less and are more susceptible to other pathogens and parasites.

"As a result of natural enemy introductions, we can expect that gypsy moth populations will become more stable over time—similar to some of our native pests like spruce budworm or forest tent caterpillar that flare up only occasionally."

Dr. Suzanne Thiem of the Department of Entomology and the Pesticide Research Center is exploring the gypsy moth virus at the genetic level. Dr. Thiem has just received a grant to try and identify the genes of the gypsy moth virus that make the disease so host specific. Additionally, she will be looking at the genetics of other similar virus diseases that affect other insects, but not gypsy moth.

The forgotten fungus

For the last couple of years Dr. Leah Bauer has been collaborating with Dr. Dave Smitley of the Department of Entomology at MSU to determine the feasibility of introducing the fungal pathogen

Entomophaga maimaiga into Michigan's gypsy moth population.

The pathogen was successfully introduced into Crawford and Lake counties in 1991 and was still viable at these locations in 1992. Smitley will be monitoring the establishment of this organism over the next several years.

Ants in the plants!

In certain situations ants may be a valuable ally against gypsy moth. While many research projects look for an organism or pesticide to provide that big knockout punch, Dr. Cathy Bristow has been studying the potential of mound ants in the biological control of gypsy moth in Michigan.

Mound ants are fairly common in jack pine forests and plantations in northern Michigan. In her study plots in Crawford County she noted that no gypsy moth egg masses were deposited in areas with high mound ant activity while adjacent areas with low or no mound ant activity contained ovipositing female moths.

MICHIGAN RESEARCHERS TAKE AIM AT THE GYPSY MOTH

Bristow's group at MSU is currently assessing how ants affect gypsy moth behavior and survival and how ant density correlates with gypsy moth density and damage.

The exception to the rule dilemma

Dr. Dan Herms from Dow Gardens also holds the position of adjunct assistant professor in the Department of Entomology at MSU.

Dan is collaborating with Dr. James Nitao, a research associate in the Department of Entomology and Dr. Muraleedhan Nair, a natural products chemist in the Department of Horticulture. They are trying to unravel one of the many "exceptions to the rule."

Paper birch is a highly favored host of gypsy moth. However, some paper birch trees seem to be highly resistant to defoliation. Herms, Nitao and Nair hypothesize that leaves of resistant birch may contain compounds that cause this resistance. They are trying to identify and isolate the compounds responsible for this resistance.

Ripples in the pond

The introduction of an insect like gypsy moth into a previously gypsy moth free forest causes massive changes. This phenomena may make far-reaching changes in the behavior of other leaf feeding insects in the way they select hosts to feed and lay eggs upon, how they select habitats and even behavioral changes in mating. These changes, in turn, may affect the way their predators and parasites relate to them. And so on.

Dr. Mark Scriber, chairman of the Department of Entomology, has been researching these questions for quite some time.

Scriber's group discovered recently that there has been an apparent shift of feeding and egg laying preference of the tiger swallowtail butterfly from quaking aspen to white ash in areas with gypsy moth activity. This "ash shift" will be examined at various distances ahead of gypsy moth "fronts" to try and determine what is responsible for this major ecological host shift.

Dr. Deborah McCullough is the newest faculty member in the Department of Entomology at MSU. McCullough's area of specialization is forest entomology. Like Scriber's efforts, McCullough will be looking at the impact that gypsy moth and suppression activities have on other foliage-feeding insects in the forest, and on impacts of defoliation in relation to nitrogen cycling in our forest ecosystems.

McCullough also plans to look at the importance of gypsy moth defoliation relative to two-lined chestnut borer and shoe-string root rot in northern pin oak forests. Many of these stands have high mortality rates, but the causal agent is not known.

Plans are also underway to develop a hazard rating system to predict what kinds of aspen stands are most vulnerable to gypsy moth defoliation; habitat typing and ecological attributes of aspen stands will be related to gypsy moth-caused mortality.

Where are they and how many are there?

Dr. Stuart Gage of the Department of Entomology at MSU uses sophisticated computer technology to track the incidence and spread of gypsy moth throughout Michigan. Gage, in cooperation with Ron Priest of the Michigan Department of Agriculture, has developed a permanent network of pheromone traps throughout the state. Using a geographic information system (GIS), trap catch data are analyzed each year to monitor gypsy moth distribution and estimate population size. Spatial analysis and maps produced on the GIS can be used by other agencies and programs to target areas likely to experience defoliation. This information allows resource managers to initiate education and suppression efforts in a proactive, timely manner.

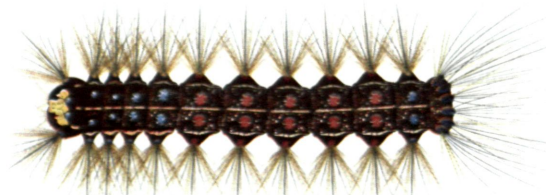
Dr. Charley Chilcote, a research associate in the Department of Entomology at MSU, is working to develop an egg mass sampling technique that is more accurate and may be as easy to execute as the five minute walk technique that is currently used in Michigan.

So what's happening to the trees?

Dr. John Witter and his current graduate assistant, Jennifer Stoyenoff, (Charley Chilcote before her) from the School of Natural Resources at UM have been examining the impact of gypsy moth on the forested landscapes of Michigan. Working closely with the Michigan Department of Natural Resources they have been attempting to document and evaluate the impact of gypsy moth on stand mortality, changes in stand density, stand composition, and understory and groundcover vegetation.

Comparison of the gypsy moth, eastern tent, and forest tent caterpillars

The identity of three common caterpillars that may be present early each year could be confusing. These illustrations will help identify which caterpillar is feeding on your trees.



Gypsy Moth Caterpillar



Eastern Tent Caterpillar

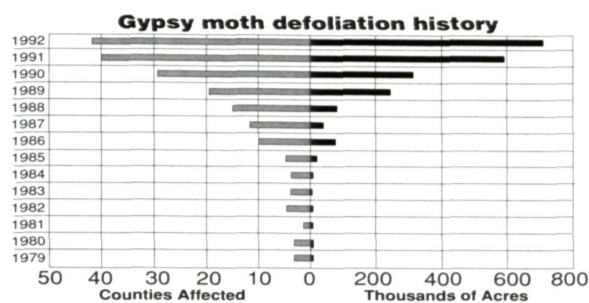


Forest Tent Caterpillar

Illustrations by Peter Carrington



Defoliation Survey, an Evolution of Technologies



Courtesy Michigan Department of Natural Resources

Since 1985, the Forest Management Division of the Michigan Department of Natural Resources (DNR) has made many improvements in its annual gypsy moth defoliation survey techniques and is now turning to technology from the space program for even better data.

Facing decreasing fiscal resources and an ever-increasing area of defoliation, the DNR is investigating new technologies to help meet a commitment of providing a complete defoliation history of the gypsy moth in Michigan.

There have been many changes since 1985 when the first survey was completed in two hours by one sketch mapper flying over Midland county. Since that original mission, the survey has grown to more than 40 counties, taking up to five weeks, three aircraft and sketch mappers from both the DNR and the Michigan Department of Agriculture (MDA).

The early technology using one or two observers to sketch defoliation damage on topographic maps was quickly outgrown as the gypsy moth began to affect larger expanses of susceptible forest type. In 1986, a cooperative effort between the DNR and Dr. David Lusch at the Center for Remote Sensing, Michigan State University, in 1986 led to the use of an infra red video camera to record defoliation. In 1987, the

DNR purchased its first Biovision camera which was installed in an aircraft. In 1989, the MDA added a second camera and deck which the DNR installed in another aircraft.

Frank Sapio, Manager of the DNR's Forest Health Program explained, "We've contracted with the Center for Remote Sensing to develop a survey approach using low cost satellite imagery. We hope this project will yield a readily available method that will decrease our reliance on airplanes."

If successful, the DNR plans to use the satellite imagery over large expanses of forest to free up valuable resources during each field season. The monies for the project have been provided through a grant from the Northeastern Area State and Private Forestry branch of the U.S. Forest Service.

With a future 50-county scope of statewide gypsy moth impact likely, the DNR continues to look for the most practical, accurate, and cost effective methods of continuing the survey of gypsy moth defoliation in Michigan.

Michigan's Gypsy Moth Struggle Dates to 1954

Immediately following the discovery of the gypsy moth in 1954, the Michigan Department of Agriculture (MDA) and other agencies became involved in a continuing effort to first eradicate and later to control the spread of the insect.

During the late 1950s and the 1960s, it appeared that the gypsy moth had been eliminated with surveillance and targeted spray programs. No spray programs were conducted in 1958, 1961, 1963-66 or 1968-72 because no infestations could be found.

In 1971, it was discovered that the synthetic pheromone (chemical sex attractant) that had been used in traps in various locations in the state was not very attractive to the male gypsy moths. Traps baited with a more alluring scent revealed that the gypsy moth was alive and well in Michigan.

Since that time populations have grown steadily in the Lower Peninsula wherever suitable vegetation is abundant. In 1992 serious defoliation occurred across nearly 750,000 acres in the state.

Problem Spreading to the U.P.

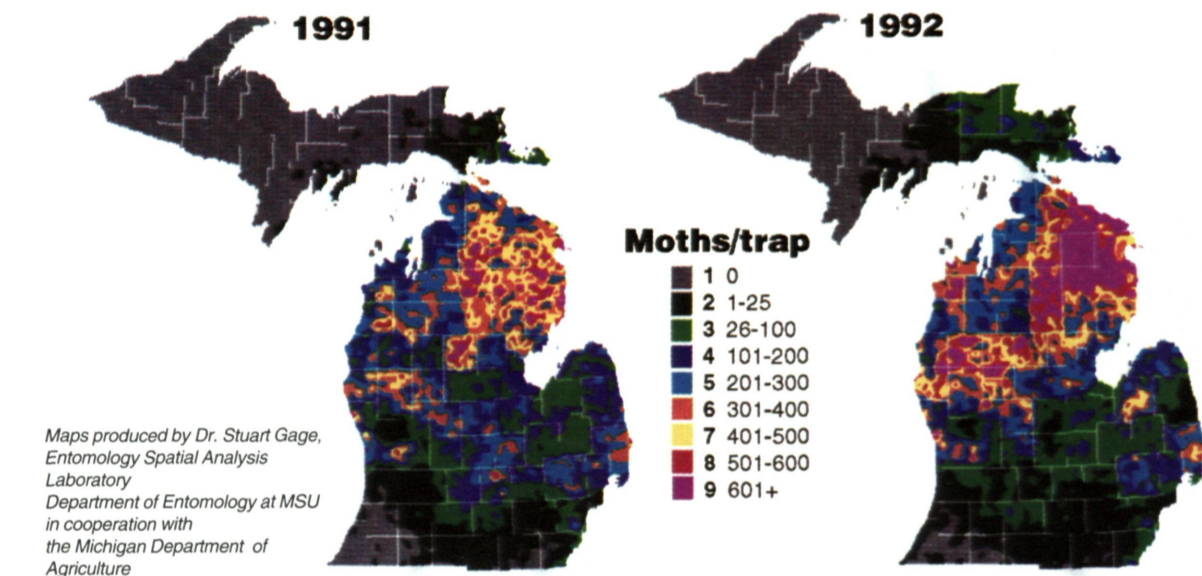
Gypsy moth populations are starting to build in the U.P. also. Male moths are now routinely caught in surveillance traps as far west as Delta County. A program has been proposed to "slow the spread" of the gypsy moth in the U.P. If supported, the program will be a cooperative effort by the U.S. Forest Service, MDA, DNR and Michigan State University to use non-pesticide technology to slow the spread of the gypsy moth across the U.P. to northern Wisconsin, Minnesota and western Ontario. State-of-the-art GIS (Geographical Information System) computer technology will be employed to interpret population trends and aid in management decisions.

Michigan Voluntary Cooperative Suppression Program

Even though gypsy moth cannot be eradicated in Michigan, selective spraying of insecticides can be used to bring relief to homeowners that are severely affected by high populations of the pest. The MDA is the central coordinator of the Michigan Voluntary Cooperative Gypsy Moth Suppression Program.

A key aspect of the suppression program is cooperation between state government and local communities. Aerially applied sprays used today are biological and applied through the program when gypsy moth populations become intolerably high.

The voluntary suppression program does not attempt to eliminate the gypsy moth, but rather to reduce population levels in forested residential and recreational areas. The program requires public involvement through county government (the local coordinator in the program), in local decision making, and it provides financial assistance to communities experiencing intolerably high gypsy moth populations.



Ronald Priest, of MDA's Pesticide and Plant Management Division, is the program coordinator at the state level. In 1992, two-dozen counties were enrolled and nearly 300,000 acres were protected under the program.

Areas within a community that are eligible for treatment include: forested residential areas (communities and individual dwellings, both permanent and seasonal); forested recreational areas and public campgrounds (public parks, public picnic areas); and commercial campgrounds, resorts and golf courses.

MDA defines the term "forested" as tree covered, with a tree canopy covering half or more of the ground when seen from the air. There must also be 300 healthy gypsy moth egg masses per acre in the affected area.

Priest explains that the role of the MDA is to function as the administrator of the suppression program in Michigan. The costs of the local aerial suppression program are shared by local county government and the U.S. Forest Service.

Priest says the Michigan suppression program is designed to focus on the major trouble spots in the state. He believes that an orderly procedure based on research and objectivity is the best way to approach what will eventually be a pervasive problem in Michigan.

The MDA is not, however, limited to just an administrative role. Priest says that the MDA, in cooperation with the Michigan Department of Natural Resources and other state and federal agencies and universities, is trying to augment the natural forces in the woodlands that could contribute to more effective gypsy moth control. For example, the MDA since 1979 has introduced five natural enemies, including a gypsy moth egg parasite *Ooencyrtus kuvanae*, a tiny wasp, into Michigan. The program has been very successful. Most areas that have gypsy moth also have established populations of the egg parasite. MDA personnel routinely introduce the wasp into new locations each year.

The Future:

Tolerance, Involvement and Education

Like cancer or AIDS, finding a "cure" for gypsy moth in Michigan may be around the corner or it may be beyond our scope of understanding. "We will continue to implement new technology to find a way to rid Michigan of the gypsy moth," Priest says. "But for the foreseeable future, we will have to learn to live with it. Our challenge right now is to hold the gypsy moth population to a tolerable level. Our program is like an umbrella that we want to raise over homes and communities to make living conditions tolerable for the couple of years that the infestation is severe," Priest points out.

For success, the gypsy moth suppression program in Michigan needs citizen involvement, he believes.

Priest encourages local residents to become acquainted with and active in local county gypsy moth management programs and to attend educational meetings whenever they are offered by MSU Extension, the DNR, or local county and civic groups.

Gypsy Moth in Michigan

HOMEOWNER'S GUIDE

MICHIGAN STATE UNIVERSITY EXTENSION

Produced by Michigan State University Extension in cooperation with the Department of Entomology. Funded by the Michigan Department of Agriculture.

For more information about the gypsy moth or other insect pests, contact the MSU Extension county office nearest you.

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Built-in controls of gypsy moth—the 3 Ps

Living with the gypsy moth in Michigan is easier thanks to a little help from the 3 Ps—the Predators, Parasitoids and Pathogens of gypsy moth. These natural enemies take their toll on all stages of the gypsy moth life cycle.

P Number One—Predators

Birds, insects, mice and shrews — all are important predators of gypsy moth.

Although many birds don't like feeding on gypsy moth caterpillars, a few species such as the yellow-billed cuckoo, seem to relish the big, hairy caterpillars. Small rodents like white-footed mice, shrews and voles feed on large caterpillars and pupae. Mice seem to prefer the larger female pupae to smaller male pupae. This selective munching may have an even greater impact on gypsy moth populations than random dining. Calosoma beetles also actively seek out and devour young gypsy moth caterpillars. Calosoma beetles are large, attractive ground beetles. Some species were imported into North America specifically for gypsy moth control. Both the larval and adult stages of this beetle are predaceous.



Small gypsy moth larvae are parasitized by the Braconid wasp *Cotesia melanoscelus*.

P Number Two—Parasitoids

Parasitoids are small wasp-like insects and specialized flies that live by feeding in the body of another insect. Gypsy moth eggs, caterpillars and pupae are attacked by many different kinds of parasitoids. Some parasitoids are native, while others have been imported from overseas in hopes of finding the “silver bullet” to control gypsy moth.

One parasitoid that is very important in Michigan is *Ooencyrtus kuvanae*. This insect is a tiny wasp and was imported into Michigan by the Department of Agriculture. The young wasps feed on the developing caterpillars inside gypsy moth eggs. When the adult wasps emerge, they are attracted to the scent of gypsy moth females or new egg masses. Once they find an egg mass, they lay their eggs inside the gypsy moth eggs. Estimates made by Cora Gorsuch showed that an average of 35 percent of the eggs in an egg mass are parasitized. Other parasitoids may also feed in gypsy moth eggs, or in caterpillars or pupae. Although parasitoids won't control a gypsy moth outbreak by themselves, they certainly help.

P Number Three—Pathogens

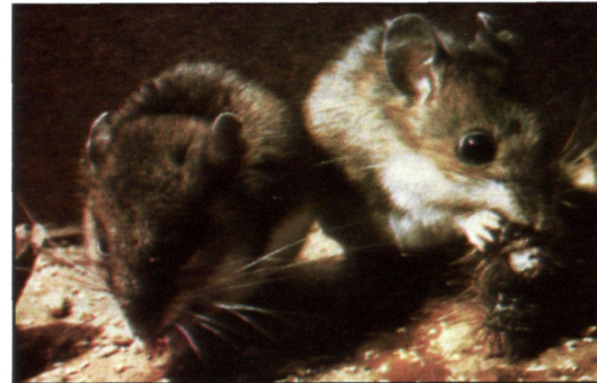
Pathogens, or insect diseases, are the most important of the 3 Ps. One especially interesting pathogen is an organism that causes a virus disease in caterpillars. The virus disease Neucleopolyhedralosis virus (usually referred to as NPV) is the major factor that causes gypsy moth outbreaks to collapse. When caterpillars are killed by this virus, they hang in an upside-down V, turn a dark color and appear to melt as they decompose over leaves and branches.

NPV, always present in gypsy moth populations, is seldom noticed except during gypsy moth outbreaks. During a gypsy moth outbreak, there are usually two waves of disease in the gypsy moth population. Adult females can pass the virus to some of their offspring when they lay eggs. Young caterpillars may then pick up the virus as they chew their way out of the eggs. When these young larvae die (the first wave), they can spread the virus around foliage, tree trunks, and other areas.

Older larvae may eventually pick up the virus and die before pupating (the second “wave”). NPV is known to affect only gypsy moth caterpillars and does not affect other insects or other animals.

Gypsy Moth Populations — Boom and Bust

Although the gypsy moth has many natural enemies, predators, parasitoids and most diseases can't keep up with a gypsy moth population explosion. In healthy gypsy moth populations, one female moth will lay 400–1500 eggs in one egg



White-footed mice, as well as shrews and voles, are rodents that feed on gypsy moth caterpillars and pupae.

mass. Even if 90 percent of the eggs are killed by natural enemies, the ones that are left can build up populations in a single year. Because the virus disease is the major factor causing gypsy moth populations to collapse, gypsy moth managers must be careful not to interfere too much with the natural build-up of virus in the population. Gypsy moth populations usually have to build to high levels before the virus kicks in and drives populations down. At high population levels, caterpillars must compete with each other for food and space. Caterpillars get stressed, which makes them more susceptible to the virus disease. As more caterpillars get sick and die, the disease spreads through the whole population.

When insecticides are used, many gypsy moths are killed. However, there are always some gypsy moths that survive and populations can rise back to outbreak levels within a year. If insecticides are applied repeatedly, larvae won't get stressed and the virus may not kick in. This could cause high gypsy moth populations to occur year after year.

Gypsy moth managers in Michigan use *Bacillus thuringiensis* var. *kurstaki* (Btk) rather than broad spectrum chemical insecticides. Even Btk is only applied in residential areas and high-use recreation areas. The goal of gypsy moth management is to reduce the discomfort of people living in infested areas, without disrupting the virus disease and other natural controls.

Gypsy Moth — Changing the Face of Michigan Forests

What will be the long-term impact of gypsy moth on Michigan forests? Will our woodlands cease to exist? “Not at all,” says Deborah McCullough, MSU Forest Entomologist. “Impacts of gypsy moth are likely to be subtle and occur over a period of several years. To understand how gypsy moth will change Michigan forests, we need to understand how defoliation affects forest trees.”

Certain trees are more affected by gypsy moth than other trees. Oak trees and other species that gypsy moth caterpillars prefer to feed on are more likely to be affected than trees like red maple and ash, which gypsy moth caterpillars avoid.

Most hardwood trees, including oaks, can recover from even complete defoliation. Severely defoliated trees will “refoliate” and use reserve energy to produce a second set of leaves later in the summer. Healthy trees can refoliate and tolerate defoliation for two or three, perhaps even four years. Eventually, however, the reserve energy the tree has stored is depleted. Diseases or other insects such as wood-borers may then attack trees with low energy reserves, eventually killing them.

Mortality occurs more rapidly when trees are diseased, suffering from drought or other stresses,

or when trees are very old and growing slowly. Trees on dry or shallow soils, or trees with injured root systems are often very vulnerable to gypsy moth defoliation and may also be killed quickly.

Unlike hardwood trees, conifer (evergreen) trees cannot refoliate and cannot tolerate complete defoliation. Conifers store most of their energy reserves in the needles, rather than in their roots like hardwood trees. When needles are consumed by gypsy moth caterpillars, no energy reserves are available to produce more foliage, and the tree will die.

Like hardwoods, conifer species differ in their vulnerability to gypsy moth defoliation and mortality. For example, hemlock trees are often killed during gypsy moth outbreaks. Gypsy moth caterpillars feed on new foliage of hemlock, which severely stresses the trees. White pine trees, on the other hand, often survive heavy defoliation. This is because gypsy moth caterpillars prefer to feed on older white pine foliage, which is less damaging to the trees. As is the case with hardwood trees,



NPV is an important virus disease that can cause gypsy moth populations to collapse.

conifers that are stressed, wounded, diseased or on poor sites are more likely to die than healthy trees.

Based on what we know about gypsy moth and what we've seen in northeastern states where gypsy moth has long been established, we can



Calosoma beetles actively seek out and devour young gypsy moth caterpillars.

make some predictions about how gypsy moth will change Michigan forests.

Gypsy moth has been established in northeastern forests for over 100 years. Over this time, there has been a shift in the species of trees in the forest. Northeastern forests tend to have less oak and more species like red maple that gypsy moth generally does poorly on. A similar type of shift occurred across much of the eastern U.S. when chestnut blight disease began killing chestnut trees in the early 1900s. Chestnut trees were once a major part of eastern forests, but today, can hardly be found. Northeastern forests are still there, though, and the forests still provide the wildlife, beauty and recreation that we all value.

The situation is likely to be the same in Michigan over the next 100-150 years. Oaks may become less common, while red maples may become more common. This shift in species composition should make our forests more resistant to gypsy moth. Although outbreaks will continue, gypsy moth caterpillars may be less abundant during outbreaks.

The gypsy moth may change the face of Michigan forests, but it will not destroy them. With continued good management, we will all enjoy Michigan forests for a long time to come.

