Gypsy Moth References:

The Conservation District is not responsible for the funding that Montmorency county has received in millage. We have assisted when possible to coordinate and educate on gypsy moth issues. We are currently working with the county to help address the gypsy moth issue. We don't believe spraying chemicals is the solution to control and/or eradication of the gypsy moth. There are many alternatives to the management of gypsy moth and we would like to pursue them. Our goal as the CD is to educate private landowners on what they can do to help on their own property when gypsy moths are an issue. They are not going away anytime soon and education is always the best option for ecological sustainability.

Instructions on checking for egg masses:

https://www.canr.msu.edu/ipm/invasive_species/Gypsy-Moth/surveying-egg-masses

There is an MSU CANR news article coming out about gypsy moth. A couple of links to the MSU ENviroWeather GM maps are being added, even as I write this. I know you folks are dealing with GM, so I thought I'd mention it.

There is a lot of info on the GM web page on the MSU IPM site at :
https://www.canr.msu.edu/ipm/invasive_species/Gypsy-Moth/
Feel free to share, copy, print or otherwise make use of the information

Here is the link to the news article, and it's also on the newsfeed on the Gypsy Moth page:
https://www.canr.msu.edu/news/gypsy-moth-caterpillars-are-out-and-about

Possible backyard treatment options:
There is a Bt one can purchase at a big box store, I've not used it and am not sure of its effectiveness. One thing I do know is that the caterpillars are very likely past the stage where the Bt will affect them, and multiple applications may be in order. Application to the leaves, not the caterpillars. Please read and follow label directions when using any kind of chemical treatment.

Finally, it may be wise to act this year if you are considering spraying next year. A fall survey of egg masses (September – November) would let you know exactly what to expect next year and would inform your decision whether to spray next year (need to start lining up contracts and permits in February). There are established survey protocols available on the web or from the DNR.

Information from DNR:
We do not have any plans to do any spraying of state forest land. We have never sprayed state forest land and have not sprayed any state recreation areas since the 1990's. GM populations will fluctuate and will go through periods of outbreak followed by periods of collapse under pressure from viral and fungal pathogens. Mortality of caterpillars occurs in later instars, a couple of weeks from now. GM are rarely tree killers and spraying forested areas is not economically reasonable.

[Bulletin about the natural pathogens of gypsy moth, found below. Might help for people to know that chances are good that these pathogens will cause the population to decrease this year, thus decreasing numbers for next year.]

[Bulletin on natural enemies of gypsy moth, also found below. Even though they are native to Europe, and not the US, many of our wildlife species have come to enjoy eating them over the year.]

Extension Bulletin E-2700, April 1999 (New)

Natural Enemies of Gypsy Moth: The GoodGuys!

Michigan State University Extension

Dr. Deborah G. McCullough
Associate Professor
Dept. of Entomology and Dept. of Forestry
Michigan State University

Dr. Kenneth A. Raffa
Professor
Dept. of Entomology
University of Wisconsin-Madison

Dr. R. Chris Williamson
Extension Entomologist
Dept. of Entomology
University of Wisconsin-Madison

"Natural enemies" refers to the predators, parasitoids and pathogens that affect pest insects such as the gypsy moth (*Lymantria dispar* L.). These natural enemies are important in helping to control gypsy moth outbreaks and in keeping populations low in the years between outbreaks. One reason why gypsy moth is a much greater problem in North America than in its native lands is that many of its important natural enemies were left behind when gypsy moth became established here.

Some natural enemies of gypsy moth will be familiar to you; others, such as insect parasitoids and pathogens, may be less well known. They all play important roles, however, in helping to limit the damage and annoyance caused by gypsy moth. Some of the natural enemies that affect gypsy moth are native to North America. Others were deliberately introduced from Europe, Asia, India and northern Africa, where gypsy moth is native, by federal agencies involved in biological control programs.

The goal of this bulletin is to help you learn to recognize some of the important natural enemies that may help control gypsy moth in your area. This bulletin will also give you suggestions on tactics to conserve or protect natural enemies of gypsy moth on your property.

Predators

Predators of gypsy moth are important in keeping gypsy moth populations low in years between outbreaks. A diverse group of bird, mammal, amphibian and insect predators will feed on gypsy moth eggs, caterpillars and pupae. Woodlots, urban forests and landscapes that include a diverse mix of forest trees, shrubs and herbaceous vegetation will provide cover and other resources for predators. Restrict use of broad-spectrum insecticides to avoid harm to populations of predatory insects. The microbial insecticide known as B.t. or B.t.k. *(Bacillus thuringiensis* var. *kurstaki)* is often used to protect tree foliage in residential areas during gypsy moth outbreaks. Unlike conventional insecticides, B.t.k. will not harm vertebrate or insect predators.

Birds

Many birds do not like to feed on large, hairy gypsy moth caterpillars, but other species seem to relish them! Yellow-billed and black-billed cuckoos, blue jays, orioles and rufous-sided towhees are among the species that feed on gypsy moth caterpillars. Some birds, such as the black-capped chickadee, will also feed on egg masses and can sometimes cause substantial egg mortality.

Mammals

Shrews, mice, voles and other small mammals often feed on gypsy moth caterpillars and pupae that they encounter on the ground and around the bases of trees. Mice (Fig. 1) seem to prefer the large female pupae to the smaller male pupae. This selective feeding can have a greater impact on the overall gypsy moth population than random feeding. Chipmunks, skunks and racoons will also feed on gypsy moth larvae and pupae, and squirrels will feed on pupae.

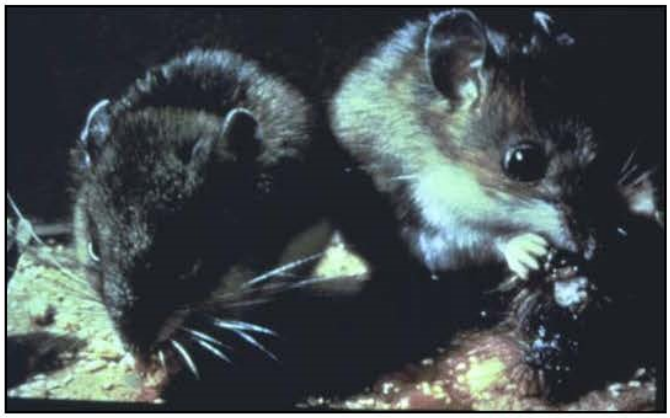


Fig. 1. Mice are important predators of gypsy moth caterpillars and pupae.

Insect predators

Fig. 2. The adult *Calosoma sycophanta* beetle is a gypsy moth predator.

Some insects are also important predators of gypsy moth. For example, the Calosoma beetle *(Calosoma sycophanta)* is a "specialist," in that it feeds almost entirely on gypsy moth (Fig. 2). It was introduced into the northeastern United States and, more recently, into Michigan in the Great Lakes region, specifically to help provide long-term control of gypsy moth populations. Adults and larval stages of this brightly colored beetle feed on gypsy moth caterpillars and pupae (Fig. 3).

Fig. 3. Calosoma beetles will climb trees to prey on gypsy moth larvae.

Several native insects are also good predators and will attack gypsy moth, as well as other plant-feeding insects. For example, in Fig. 4, a predatory stinkbug is feeding on a gypsy moth caterpillar. Ants can also be important predators of young caterpillars. Many other insect predators and spiders are opportunistic feeders and will consume gypsy moth larvae or pupae when they are available.

Fig. 4. A predatory stinkbug attacks a gypsy moth caterpillar. *Photo by Lyle Buss.*

Parasitoids

The term "parasitoid" refers to certain species of wasps and flies that have a very specialized life cycle. Parasitoids lay their eggs inside, on or near the body of a host insect, such as a gypsy moth caterpillar (Fig. 5). The larval stages of most parasitoids resemble maggots. Parasitoid larvae live by feeding on tissues in the body of the host insect, killing it in the process. Once the parasitoid has completed its development, it emerges from the host insect. Several parasitoids are important natural enemies of gypsy moth. A few examples are described here.

Fig. 5. A parasitoid fly laid the white egg on this gypsy moth caterpillar. *Photo by Ron Weseloh.*

Ooencyrtus kuvanae

This little wasp is a specialist that parasitizes the eggs of gypsy moth (Fig. 6). It was introduced into the United States for biological control of gypsy moth many years ago and is now well established in most of the region infested by gypsy moth. Three generations of this wasp may occur in the summer and fall after egg masses are laid, and another generation may occur the following spring. The tiny, dark adult wasps can often be observed if you look closely at gypsy moth egg masses. You may also see the small, round holes in the egg mass where the adult wasps emerged (Fig. 7). Because the wasp is small, it can usually attack only the eggs in the upper layer of a gypsy moth egg mass. In many years, however, it is able to kill 20 to 30 percent of the eggs in an egg mass.

Fig. 6. *Ooencyrtus kuvanae* is an important egg parasitoid of gypsy moth. *Photo by Michael Higgins.*

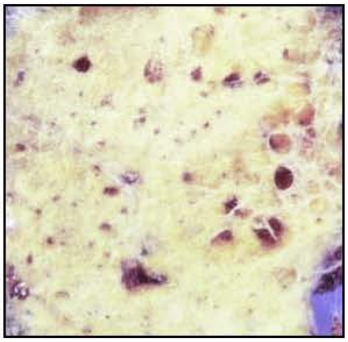


Fig. 7. Holes in a gypsy moth egg mass where *Ooencyrtus kuvanae* wasps emerged after parasitizing gypsy moth eggs. *Photo by Michael Higgins.*

Although *Ooencyrtus* wasps are rarely available from commercial suppliers, you can help to protect populations that are established in your area. For example, if you intend to scrape off and destroy egg masses as part of your gypsy moth management program, it is best to wait until winter. This will give the egg parasitoids a chance to complete their development and find overwintering sites in the litter below trees. Limit use of insecticides in mid- and late summer to avoid killing this beneficial species. The microbial insecticide B.t.k. will not harm parasitic wasps or flies.

Cotesia melanoscelus

Fig. 8. A *Cotesia melanoscelus* wasp parasitizes a young gypsy moth caterpillar.

This is another specialized wasp that was introduced specifically for biological control of gypsy moth. The first generation of the wasp will attack very young gypsy moth caterpillars (Fig. 8) and is often successful in subduing the young host caterpillar. A second generation of the wasp can attack larger gypsy moth caterpillars, those that are about halfway through their development.

Fig. 9. A white *Cotesia melanoscelus* cocoon near parasitized gypsy moth caterpillars.

This parasitoid pupates in a small, oblong yellowish cocoon (Fig. 9). These cocoons are frequently observed near a dead gypsy moth caterpillar or attached to the bark of an infested tree. In some cases, this parasitoid can be an important source of mortality. However, the small wasps sometimes have difficulty attacking larger gypsy moth caterpillars, and the wasp has its own natural enemies that may limit its effectiveness.

Avoiding applications of broad-spectrum chemical insecticides in early and midsummer will help protect this species. Application of the microbial insecticide B.t.k. may slow the development of gypsy moth caterpillars. This can benefit the *Cotesia melanoscelus* wasps and may increase the rate of parasitism. If you use burlap "hiding bands" on your trees and then mechanically remove

Fig. 10. Gypsy moth caterpillars hide under burlap bands and can be removed. *Photo by Lyle Buss.*

gypsy moth caterpillars (Fig. 10), you should avoid removing any caterpillars with the yellow or white *Cotesia melanoscelus* cocoons still attached (Fig. 11).

Fig. 11. This gypsy moth cadaver with the white *Cotesia melanoscelus* cocoon should be left on the burlap band to allow the parasitoid wasp to emerge. *Photo by Lyle Buss.*

Compsilura coccinnata

This fly attacks gypsy moth caterpillars, as well as the caterpillars of more than 100 other moth and butterfly species. It was introduced for gypsy moth control many years ago and is well established throughout much of the northeastern and north central United States. It has three generations a year, although only one of these generations attacks gypsy moth caterpillars. After feeding in the body of a gypsy moth caterpillar, this parasitoid pupates in a reddish brown puparium, often seen on or near the body of the dead caterpillar (Fig. 12). This parasitoid may be important in helping to keep gypsy moth populations in check and prolonging the period between outbreaks.

Fig. 12. The reddish brown puparium indicates that this gypsy moth caterpillar was killed by a parasitic fly such as *Compsilura coccinnata*. *Photo by Lyle Buss.*

Pathogens

Gypsy moth and other insects are affected by a variety of organisms that cause disease, including fungi, bacteria, viruses and protozoans. Two diseases are especially important in controlling gypsy moth outbreaks.

NPV - The Virus Disease

NPV is a nucleopolyhedrosis virus, and is a disease that affects only gypsy moth. The NPV disease is usually the most important factor in the collapse of gypsy moth outbreaks in North America. The virus is always present in a gypsy moth population and can be transmitted from the female moth to her offspring. It spreads naturally through the gypsy moth population, especially when caterpillars are abundant. During a gypsy moth outbreak, caterpillars become more susceptible to this virus disease because they are stressed from competing with one another for food and space. Typically, 1 to 2 years after an outbreak begins, the NPV disease causes a major die-off of caterpillars.

Caterpillars killed by the NPV disease hang in an upside-down V shape from trees (Fig. 13). The bodies of the dead caterpillars liquefy (Fig. 14) and rapidly disintegrate. A limited amount of the gypsy moth NPV disease is produced annually and distributed by the state and federal agencies that oversee gypsy moth suppression programs.

Fig. 13. Gypsy moth caterpillars that die from the NPV disease hang from trees in an upside-down V shape.

Fig. 14. Caterpillars killed by the NPV pathogen liquefy rapidly.

Entomophaga maimaiga - The Fungus Disease

This fungus has recently attracted much interest in the northeastern and north central states. It was introduced from Japan in 1910 but did not affect gypsy moth populations until the late 1980s. What happened to the fungus in the years between its introduction and 1988-89 is a mystery. Since 1989, the fungus has been widely released in states with gypsy moth populations.

Fungal spores that overwinter in the soil will infect young caterpillars early in the summer. When the young caterpillars die, their bodies produce windblown spores (Fig. 15) that can spread and infect older caterpillars. Large caterpillars killed by the fungus will hang head-down from the tree trunk, and the bodies of the dead caterpillars (cadavers) appear dry, stiff and brittle (Fig. 16). Within several days, the cadavers fall to the soil and disintegrate, releasing the spores that will overwinter back into the soil.

Fig. 15. Spores of the *Entomophaga maimaiga* fungus on a gypsy moth caterpillar. *Photo by Darwin Dale.*

Fig. 16. Gypsy moth caterpillars killed by the *Entomophaga maimaiga* fungus hang from the tree and are dry and brittle. *Photo by Lyle Buss.*

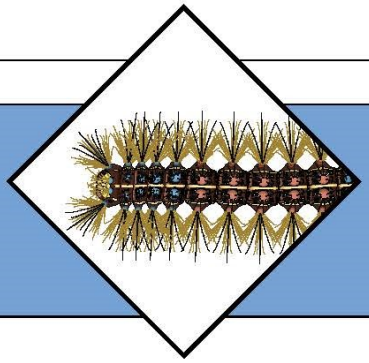
Like all fungi, *Entomophaga maimaiga* is strongly affected by temperature and moisture. Cool, rainy weather in the spring and early summer probably favors the fungus, but the specific conditions needed for good control are not yet known. When conditions are right, however, it can be an important source of mortality in both low and high gypsy moth populations.

MICHIGAN STATE UNIVERSITY EXTENSION

MSU is an Affirmative-Action/Equal-Opportunity Institution. Extension programs and materials are available to all without regard to race, color, national origin, sex, disability, age or religion. n Issued in furtherance of Extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Arlen Leholm, extension director, Michigan State University, E. Lansing, MI 48824. n This information is for educational purposes only. References to commercial products or trade names does not imply endorsement by MSU Extension or bias against those not mentioned. This bulletin becomes public property upon publication and may be printed verbatim with credit to MSU. Reprinting cannot be used to endorse or advertise a commercial product or company.

Produced by Outreach Communications and printed on recycled paper using vegetable-based inks. New 4:99-5M-Price: 50¢, single copy free to Michigan residents.

Extension Bulletin E-2604, Reprinted May 2001



Entomophaga maimaiga - A Natural Enemy of Gypsy Moth

Michigan State University Extension

Lyle Buss
M.S. Research Assistant
Dept. of Entomology
Dept. of Forestry
Michigan State University

Dr. Deborah McCullough
Assistant Professor
Dept. of Entomology
Dept. of Forestry
Michigan State University

Dr. David R. Smitley
Associate Professor
Dept. of Entomology
Michigan State University

The gypsy moth (*Lymantria dispar L.*) is an exotic pest of urban and forest trees. Gypsy moth caterpillars feed on the leaves of oaks, aspens, and many other hardwood and conifer trees. During gypsy moth outbreaks, trees may be completely stripped of leaves. Although gypsy moth caterpillars rarely kill trees by themselves, trees weakened by heavy defoliation may become more susceptible to drought, disease or other insect pests. In addition, the large hairy caterpillars annoy people living or recreating in outbreak areas.

Managing gypsy moth requires the integration of a variety of control tactics. Biological control, the use of natural enemies to control a pest, can be an important part of an integrated pest management program for gypsy moth. One biocontrol agent that has recently shown much promise is a fungal pathogen, *Entomophaga maimaiga*.

Origin of *Entomophaga maimaiga*

Entomophaga maimaiga is a common disease in gypsy moth populations in its native country of Japan. The fungus was first released into the United States near Boston in 1910 as part of a program to introduce natural enemies of gypsy moth. Scientists could find no evidence that the fungus had become established and the project was abandoned a few years later. However, the fungus appeared unexpectedly in several northeastern states in 1989 and caused high mortality in many gypsy moth populations. Although scientists have several theories, the strange reappearance of the fungus is still a mystery.

Entomophaga maimaiga was first brought into Michigan in 1991 by scientists at Michigan State University and the USDA Forest Service. It was released in three sites in northern lower Michigan and monitored closely.

Additional introductions have since occurred and the fungus also is spreading naturally. *Entomophaga maimaiga* has now been found throughout most of Lower Michigan.

Life history of *Entomophaga maimaiga*

Entomophaga maimaiga passes the winter as a tough, thick-walled "resting spore" in the soil and on tree bark. In May and June, resting spores germinate and produce sticky spores at the end of a stalk that grows just above the soil surface. Gypsy moth caterpillars come into contact with these spores in the spring as they search for suitable leaves to feed on. The fungus digests its way through the exoskeleton of the caterpillar and grows inside the body of the caterpillar. Infected caterpillars may die within one week.

When young caterpillars are affected early in the summer, the fungus will produce a second type of spore called conidia. These microscopic spores are spread by the wind and can infect other caterpillars. The cycle of conidia production and infection may occur four to nine times during the summer. When the fungus develops in large caterpillars, it produces the overwintering resting spores.

Weather plays an important role in determining how effective *Entomophaga maimaiga* will be. Like most fungi, its spores need moisture and high humidity to germinate. Frequent rainfall during May and June contributes to the start and spread of *Entomophaga maimaiga* through a gypsy moth population. Temperatures of 50 to 80 degrees F enhance fungal growth.

Figure 1. Gypsy moth larva killed by NPV hanging in an inverted "V" position.

Figure 2. Dead larva covered with conidia of *Entomophaga maimaiga*.

Figure 3. Larvae killed by *Entomophaga maimaiga* often remain attached to trees.

Distinguishing *Entomophaga maimaiga* from NPV

Another disease is common in outbreak populations of gypsy moth. NPV (nuclearpolyhedrosis virus) is a virus disease that often causes gypsy moth outbreak populations to collapse. One important difference between the two diseases is that NPV is seldom prevalent until gypsy moth populations reach very high levels. In contrast, *Entomophaga maimaiga* may be found even when gypsy moth populations are low.

Caterpillars killed by NPV often remain attached to the stem or branches of trees. The bodies of the dead caterpillars are soft, filled with a brown liquid and disintegrate rapidly. Usually they hang limply in an upside-down `V` position (Fig. 1).

Caterpillars killed by *Entomophaga maimaiga* will also remain attached to tree stems or branches. However, the bodies tend to be stiff and straight, and the legs extend stiffly from the body. Some of the dead caterpillars may have tiny white conidia attached to the hairs on the body (Fig. 2). The cadavers may remain on the stem well into autumn (Fig. 3).

The future of *Entomophaga maimaiga*

Entomophaga maimaiga may become an important biological control of gypsy moth in both low and high populations. Infections may be more common in years with rainy spring weather than in years with dry spring weather. Scientists have found that the fungus is established in a number of areas in Michigan. Laboratory and field studies have shown that *Entomophaga maimaiga* is host specific and poses little risk to other insect populations. It will not affect other animals or humans. Introductions and evaluation will continue. Although there is not likely to be any `silver bullet` for gypsy moth, *Entomophaga maimaiga* should improve our ability to manage this pest in Michigan.

MICHIGAN STATE UNIVERSITY EXTENSION

MSU is an Affirmative-Action Equal-Opportunity Institution. MSU Extension programs are available to all without regard to race, color, national origin, sex, disability, age or religion.

Issued in furtherance of MSU Extension work in agriculture and home economics, acts of May 8, and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Margaret A. Bethel, acting Extension director, Michigan State University Extension, E. Lansing, MI 48824.

Rep. 5.0M–5M–MS–CP–Price $ 5.0. Single copy free to Michigan residents.
File 27.55 (Pests and Management)

Article from the CD Forester, Dr. Greg Corace:

Thoughts on Gypsy Moth

The gypsy moth is a non-native (exotic), invasive insect from Europe. The gypsy moth, like all moths and butterflies, undergoes "complete metamorphosis." Within one year these insects change from an egg (found in 1" beige, furry, masses on trees), to a larva (caterpillar), to a pupa, to a reproducing adult. Eggs begin to hatch mid-April and the ¼" black caterpillars eat and grow and undergo a change in appearance over the next 40 days.

Gypsy moth caterpillars are voracious eaters. In high numbers, they can cause defoliations of deciduous trees. Because trees produce their energy through photosynthesis in green leaves, gypsy moth caterpillars stress many forests, especially those dominated by oaks and aspens. However, trees store energy in their roots and have other evolutionary responses to defoliation by native insects. Thus, the caterpillars of gypsy moth do not often cause wide-spread direct tree mortality as does the emerald ash borer (another exotic/ invasive forest insect). Gypsy moth caterpillars do cause trees to look unsightly and are a pest in many other ways, but trees that die during gypsy moth outbreaks are often of reduced vigor already.

According to a paper in the journal The Great Lake Entomologist (1983), gypsy moths were first documented in Michigan in 1952. Early management attempts aimed for eradication using DDT, the same chemical that prompted Rachel Carson's Silent Spring. Subsequently, a naturally occurring bacterium (Bt) has been aerially sprayed to suppress populations. Eradication is rarely discussed by professionals now.

Gypsy moth management is complicated. First, as discussed in Pest Management and Sampling (1991), a monitoring program must be devised and systemically applied so that treatment efficacy can be quantified. The need for monitoring is essential because populations of gypsy moth and many other forests insects fluctuate (cycle) over time. Moreover, population fluctuations can occur in a discontinuous, patchy fashion; some areas may experience more moths than other areas in the same year. It is during times when the gypsy moth population is high that tree defoliation is most easily observed and most management actions occur. In effect, however, gypsy moths are always around, but the moth population is low. As discussed in an article in the journal TREE (1996) gypsy moth populations may be held in check in most years by parasitic organisms that prey on the moth's eggs, larvae, and pupae. When the populations of the parasites are low the gypsy moth populations erupt for a couple years on approximately 10-yr cycles.

Another issue that must be considered is the non-target impacts of Bt, the commonly applied bacterium used to kill gypsy moths. In another study in The Great Lakes Entomologist (1997) researchers demonstrated that Bt also kills the Endangered Karner blue butterfly. Researchers surmise that other members of our native moth and butterfly community in Michigan are also susceptible. Thus, like many forest management actions, there are collateral issues that must be considered.

So, what can landowners do to manage or mitigate for gypsy moths without spraying?

Techniques suitable for backyard trees are dissimilar from what a landowner with 40 acres should do. For backyard situations, keep trees well-watered, but do not fertilize. Reduce the number of egg masses by scraping them off trees in late winter or early spring. Place the egg masses in a soap water solution for a couple of hours or burn them. Later in the spring, emergent caterpillars can be impeded and collected by a combination of tree "barrier and collection bands" as discussed by the Wisconsin DNR (google search).

Forest landowners should take a step back and consider their property from the perspective of its capabilities based on soils, climate, seed sources, and past management. Gypsy moths impact oak and aspen forests more so than deciduous-coniferous mixed forests. As demonstrated by a number of studies, past forest management actions have generally increased the dominance of oak and aspen relative to historic conditions in northern Michigan. Thus, as stated before in this column, landowners are well served by promoting forest tree diversity within the context of known successional pathways on a given soil type. On many northern Michigan sites now dominated by oak and aspen, irregular planting of conifers, such as white spruce or eastern white pine on better sites with partial sun or red pine or jack pine on drier sites with full sun, may be a simple and cost-effective way of promoting diversity.

Gypsy moths are here to stay for the foreseeable future. Making our forests less susceptible may be the most time and cost-effective way of mitigating the impacts of gypsy moth. Managing for resistance and resilience in our forests is key.

Greg Corace is the forester for the Alpena-Montmorency Conservation District. For more information, including sources used in this article, Greg can be contacted via email (greg.corace@macd.org) or phone (989.356.3596 x102).