UNIVERSITY of NEW HAMPSHIRE
COOPERATIVE EXTENSION

Landscapes, Nurseries and Woodlots

Gypsy Moth

Introduction

The gypsy moth is the most important defoliating insect of hardwoods in New Hampshire. A native of Europe and Asia, the gypsy moth was introduced into North America in 1869 when specimens were accidentally released in Medford, Massachusetts.

Gypsy moth feeds on the leaves of many tree species, often defoliating them completely. In New Hampshire, most defoliation occurs south of the White Mountains. Unhealthy trees weakened by defoliation are vulnerable to attack by secondary organisms and may die as a result. In addition, swarming caterpillars and their droppings are a nuisance for homeowners.

Unfortunately, there's no practical way to eradicate the gypsy moth. However, by using several control tactics, it's possible to reduce the impacts of a gypsy moth outbreak.

Description

Adults: Females are mostly white with a wingspread of 2 inches; male moths are light tan to dark brown with a wingspread of 1½ inches. The males are good flyers and are often seen flying about in large numbers. Moths are found from early July through August. They don't feed on foliage.

Eggs: Egg masses are buff-colored, velvet-textured and 1½ by ¾ inches in size. Clusters are mostly deposited on tree trunks and branches, but can also be found on stone walls, furniture, houses and cars.

Larvae: Caterpillars are brown-black and hairy, with six pairs of red dots and five pairs of blue dots on the back when mature. Full-grown larvae are 2 inches long.

Pupae: Pupae are dark brown conical cylinders ¾ to 1½ inches long. They may be attached to many objects including trees, buildings, rocks and logs.

Gypsy moth caterpillars prefer oak, apple, birch, poplar and willow. Less preferred species are maples, cherries, elm, beech and softwoods. Heavy defoliation usually occurs where oaks are most abundant. Caterpillars will feed on many kinds of plants once the preferred trees in an area or stand are defoliated.

Healthy hardwoods generally require two or more years of heavy defoliation (greater than 50%) before they die. Defoliation weakens the tree and increases attack by fungi and other insects. Bad weather (especially drought), poor soil type and low tree vigor also lead to decline. As a result, trees may not die until years after defoliation.

Softwoods like hemlock and pine are often killed after a single defoliation. Hardwoods with more than 50% defoliation will usually refoliate before fall. Refoliation uses food reserves needed for growth the following year. Don't remove defoliated plants unless they fail to leaf out in the spring following a defoliation.

Life Cycle

The female moth deposits her egg mass of 300-500 eggs in July-August. The eggs overwinter on trees, rocks, stumps, in crevices and on buildings. The eggs hatch in May and tiny caterpillars spin fine silken threads which help in wind dispersal.

The larvae feed mainly at night and crawl down the tree to seek shade during the day. Larvae feed until late June or early July and pupate. In 10-14 days, the adult moth emerges from the pupal stage. The male moth flies to the flightless female, usually on tree trunks, and mates. The female deposits her egg mass shortly after mating. There's only one generation per year. After several years of defoliation, the population collapses, usually due to a viral disease. It will then remain at low levels until populations build and erupt again. In New Hampshire, outbreaks have occurred, on the average, every 7-10 years since 1924.

Natural Controls

Parasites and predators are active throughout the gypsy moth life cycle. Enemies include rodents, birds, parasitic wasps, spiders and ground beetles, fungi and virus. Although they may destroy many insects, none of these natural predators can prevent a gypsy moth outbreak. However, they help maintain populations at low levels, and lengthen the time between outbreaks.

Once the outbreak has peaked, starving caterpillars are quickly killed by wilt disease. Virus-infected larvae are shiny and hang limply in an inverted "V" position. Their skin is fragile and will rupture easily, emitting a brownish, foul-smelling liquid.

Entomophaga maimaiga, a fungus that attacks gypsy moth larvae, was imported from Japan and released in Boston in 1910 and 1911 as a possible control. The experiment seemed to have failed, since extensive surveys found no evidence of its survival. Then, in 1989, scientists discovered the fungus in dead gypsy moth larvae in New Hampshire, Vermont and Connecticut. *E. maimaiga* is today considered an important part of the natural arsenal that helps keep gypsy moth populations in check.

Occasionally, weather adversely affects gypsy moth. Prolonged, extreme cold (-26F) will kill most egg masses. Wet, cold springs are detrimental to larvae.

Damage

Mortality

Defoliation, and hence growth loss and tree mortality, is directly related to the percent of oak, the preferred host, in the stand. Though pure stands of softwoods are practically immune to defoliation, hemlock and pine are especially vulnerable to mortality when mixed with oak. Suppressed softwoods, often in the understory of hardwood stands, are much more likely to die than dominant trees. Overstory pines often escape complete defoliation and survive. Softwoods are more likely to die after defoliation than hardwoods. It takes softwoods several years to grow a full complement of needles, whereas hardwoods grow a full crown of leaves each year.

Healthy hardwoods generally require two or more years of heavy defoliation (61-100%) before they're killed. Defoliation weakens the tree and increases the likelihood of attack by fungi and other insects (secondary invaders). Hardwoods with more than 50% defoliation will usually refoliate before fall. This new flush of leaves uses most of the food reserves necessary for growth the following year. Defoliated trees enter enter dormancy later, and are thus more prone to winter injury. Drought increases tree mortality. Among the hardwoods, oaks receive the greatest mortality because they're the preferred host and suffer the most defoliation.

Oak mortality after heavy defoliation depends on crown condition, crown position in the forest canopy and species, in that order. Suppressed trees with small or sparse crowns are more likely to die than large, full crowned dominant trees. Chestnut oak, black oak and white oak are more likely to die than red oak. New Hampshire red oaks tend to be resilient, perhaps because repeated outbreaks lead to natural selection of resistant trees. In a study by the author

after the last outbreak (1981), average red oak mortality (DBH=10 inches or greater) was only 6% However, this is an average and some stands received greater mortality. Better sites sometimes have higher mortality because there are often more insects and diseases to act as secondary invaders. Also, dry, shallow sites, "select" for hardy trees are more capable of withstanding defoliation.

Growth Loss

In a typical outbreak cycle in New Hampshire, a susceptible oak stand will receive one year of light (1-30%) to moderate (31-30%) defoliation and 1-2 years of heavy defoliation (61-100%). Based on our studies, the first year of light defoliation reduced annual growth an average of 29%; first year moderate defoliation reduced growth about 40%; in the second year (heavy defoliation) growth is reduced about 50%; in the third year (heavy defoliation) growth is reduced 75% compared to "normal" predefoliation growth rates. After the outbreak, trees will increase annual growth during each year of the recovery until normal growth rates are attained. Healthy stands recover to normal growth within 2-3 years after the last defoliation. Highly stressed stands may take up to 10 years to recover.

Acorn Production

Even light defoliation of oak can reduce acorn (mast) production substantially. Gypsy moth outbreaks thus have a negative impact on New Hampshire's woodland wildlife, as many species of birds and mammals (turkey and deer, for example) depend on this fall food source. Lack of acorn production will also delay natural regeneration of oak seedlings.

Reduction of Timber Value

Even though the gypsy moth may not kill a tree, defoliation often reduces timber value by causing epicormic branching (sprouting), wood stain and increased secondary insect damage (ambrosia beetle and wood borers). Various decay fungi also readily invade weakened or damaged tree, diminishing timber value.

Diagnosing the Problem

The easiest method to determine likely defoliation is the 10-minute egg mass count. Take a five-minute walk into the woods and follow a straight line for about 500 feet counting visible fresh egg masses on tree boles. Then walk back to where you started. Average the counts from your two five-minute walks. If the average of the two counts is 12, there are about 250 egg masses per acre, and light defoliation is expected. An average count of 50 equals about 1,000 egg masses per acre, forecasting heavy defoliation. Factors such as species composition, human error and egg mass size contribute to the imprecision of this technique.However, the 10-minute walk will quickly determine which stands are at high risk. Egg mass surveys should be done in the fall when leaves are off the trees, making egg masses more visible. By late winter, even new egg masses are weathered and indistinguishable from old egg masses.

Impractical Techniques for Woodlots

Tree Bands -Using tree bands to capture caterpillars may be of some value to an isolated urban tree with low level populations. This technique in a forest situation is useless, as it's impractical to band every tree and only a very small percentage of the larvae would be caught. Many of the petroleum-based sticky products used to repel or capture larvae are in fact harmful to trees, and shouldn't be placed on the bark.

Pheromone Traps - Pheromone traps are useful as a monitoring tool for tracking moth populations from year to year. These traps use a sex lure to trap the male moths. By the time the male moths are flying, however, defoliation has already occurred. Also, these traps can't capture enough male moths to reduce the number of egg masses for the next year. They may increase the number of male moths in an area.

Scraping or Poisoning Egg Masses - In a forest situation, a landowner can't scrape off or poison enough egg masses to make any practical difference, as most egg masses are in the tree crowns or hidden where they can't be reached. Creosote was once used to paint egg masses but it's now a pesticide restricted by the EPA and NH Department of Agriculture and is illegal to use for that purpose.

Fertilizing - Fertilizing forest trees is a somewhat controversial issue. It may be beneficial for individual shade tree vigor. However, the expense and logistical problems render fertilization of forest stands impractical. Furthermore, research on forest tree fertilization is inconclusive, so we cannot currently recommend the practice.

Management Options

There's a range of management options depending on the goals of the landowner, the value of the stand and its vulnerability to mortality. These are the three principle options for landowners with stands of oak.

Do Nothing and Salvage

Doing nothing is a reasonable option for many woodlot owners. Red oak mortality isn't excessive (5-8%) in most stands defoliated by gypsy moth. Many owners are willing to accept the risk of mortality and the 5-6 years of growth reduction that occurs. If mortality is significant, salvaging dead and dying trees following the outbreak is always an option. Prompt salvage is recommended because timber values decline significantly due to log degrade. A sawlog tree dead for three years or more is worth very little. Most tree death will occur within two years after defoliation, but mortality can occur up to 10 years later. Predicting declining timber values and continued mortality is tricky. Before salvaging, consult with a professional forester for sound advice. UNH Cooperative Extension maintains a list of consulting foresters.

Cutting Between Outbreaks

A range of cutting practices apply to oak forests, such as intermediate treatments (weeding and thinning) and regeneration cuttings (group selection and shelterwood cuts). All these cutting practices cause stress to stands. Heavy removal of the overstory trees (greater than 1/3 of stems) are particularly stressful to the remaining trees. With proper cutting the stress is short lived. It usually takes a stand at least three years to recover following a harvest. Ideally, harvestings should be done between outbreaks, and not less than three years before anticipated defoliation. Harvesting also causes some mechanical damage to roots and trees themselves, and may increase incidence of secondary diseases (such as the root-rot fungus, *Armillaria*) which feed on stumps. Harvesting just prior to or during an outbreak will cause higher mortality of overstory trees due to stress, secondary diseases and increased defoliation due to less available foliage (food) per acre.

Maintaining a healthy stand of trees is the best option available for minimizing impacts of gypsy moth for forest landowners. Proper thinning in advance of an outbreak can reduce stand mortality by removing tree is poor health which are most likely to die, and increasing the vigor of remaining trees. Before beginning a cutting operation, consult with a competent professional forester to obtain sound advice on proper harvesting techniques.

Chemical Control

Pesticides can be used to reduce gypsy moth damage when applied by ground equipment or aircraft (fixed wing or helicopter).

Ground application is impractical for most woodlot owners because the dense forest isn't readily accessible. However, ground equipment can do an adequate job on roadside or shade trees. Due to the migration of larvae from unsprayed trees, multiple applications are often necessary. Pesticide applicators must have a Commercial Pesticide License from the NH Division of Pesticide Control (NHDPC). A list of applicators can be obtained from NHDPC or your UNH Cooperative Extension County Office.

Aerial application of insecticides is a much more complicated procedure than ground spraying. The decision and responsibility for aerial spraying rests with the landowner. The State of New Hampshire may provide technical assistance for aerial spraying of forests on private and public lands. In response to environmental concerns, a rigorous protocol must be followed to obtain the necessary spray permit from the NHPDC. This protocol includes: 1) submittal of original and three copies of the completed application to the NHDPC at least 90 days in advance of proposed spraying; 2) a possible public hearing; 3) notification of beekeepers, town officials, and abutters of the

intent to spray; 4) mapping in detail of all environmentally sensitive areas within or near the proposed spray area, including but not limited to streams, ponds, residences, buildings and wells; 5) hiring a licensed aerial applicator; 6) adequately marking spray boundaries for the pilot; and 7) a risk analysis to prove there are sufficient egg masses and stand susceptibility to warrant spraying. Spray buffers are required around abutters who don't wish to be sprayed and in many cases, around environmentally sensitive areas (a typical buffer may be 300 feet). The minimum size area practical to aerially spray is 15 contiguous acres.

Economic Considerations

Protecting a forest used for its recreational value (e.g. campground) will readily pay back the cost of aerial spraying. It's more difficult to recognize the economic benefit when applied to timber values. Studies performed by the author after the last outbreak (1981) showed that growth and mortality losses (in sawlog stands of medium quality red oak) exceeded the costs of an aerial application. If you're considering an aerial spray program, consult, your UNH Cooperative Extension educator in forestry or another professional forester to discuss the value of the timber and the economic and environmental feasibility of a spray program. Be sure to allow adequate time for planning; you may need six months before the proposed spray date in May.

Environmental Concerns

The safest commercially available pesticides to use for gypsy moth control are the biologicals, which use the bacterium *Bacillus thuringiensis* (*B.t.*). *B.t.* requires an early season spray application (just after egg hatch) in order to be effective. By the time the larvae reach the third stage (0.4inches), the bacteria aren't effective. *B.t.* is more expensive and has less residual effect than other insecticides. However, the advantages of using biologicals include: 1) least harm to nontarget organisms and the environment; 2) less requirement for buffers; and 3) less public opposition. There are several non-biological insecticides that can be used in New Hampshire, but because of potential negative environmental impacts, their use will be limited and they will receive greater public scrutiny.

Integrated Pest Management (IPM)

IPM is a term used more frequently as we try to reduce our dependence on pesticides. IPM is the use of a variety of techniques (chemical, biological, silvicultural, mechanical, etc.) to reduce pests below economically damaging levels. Biological controls such as parasites and predators can't prevent or control outbreaks. We need more research to develop effective non-chemical controls for gypsy moth.

Therefore, in forestry the primary IPM technique is good silviculture: vigorous well-tended stands are more resistant to economic loss from gypsy moth outbreaks. Insecticides should only be used as a last resort, selecting the safest pesticide that meets management objectives.

For more information, contact your county UNH Cooperative Extension forest resources educator (see list of county Extension office telephone numbers below).

UNH Cooperative Extension County Office Telephone Numbers

Belknap (603) 527-5475	**Carroll** (603) 539-3331	**Cheshire** (603) 352-4550	**Coos** (603) 788-4961	**Grafton** (603) 787-6944
Hillsborough Goffstown (603) 641-6060	**Merrimack** (603) 796-2151	**Rockingham** (603) 679-5616	**Strafford** (603) 749-4445	**Sullivan** (603) 863-9200

(over)

Stop! *This publication contains pesticide recommendations that are subject to change at any time. UNH Cooperative Extension provides these recommendations only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Because of constantly changing labels and product registration, some of the recommendations offered in this publication may be outdated by the time you read them.*

Contact the NH Division of Pesticide Control at (603) 271-3550 to check registration status. If any information in these recommendations disagrees with the label, you must disregard the recommendations and follow the label directions. No endorsement is intended for products mentioned, nor criticism intended for products not mentioned.

Store pesticides in their original containers in a locked cabinet or shed away from food. Dispose of unused pesticides or empty containers safely, according to NH regulations. If you suspect pesticide poisoning, call the New Hampshire Poison Control Center at ***1-800-562-8236.***

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