Research in the future will study more intensively the relation of bark beetles to their forest environment, what causes them to become epidemic, why innocuous bark beetles sometimes suddenly become aggressive, and how beetles can be kept in their proper place through regulation of their host trees and environment, for we are dealing with native forest inhabitants that are just as much at home in the forest as the trees themselves. We must assume that Nature had a purpose in putting them there. Rather than upset the balance of Nature by attempting to eliminate them, we should try to find out what purpose they serve and work with Nature to keep them in their proper role. Foresters and timber owners will not object to bark beetles acting as Nature's caretaker in thinning the forest of a few old decadent trees to make room for new ones. All they ask is that the beetles not be allowed to go on a rampage and kill vast quantities of timber before it can be harvested and utilized. The job ahead challenges the insight and resourcefulness of research foresters and entomologists, who will need to work together to solve this forestry problem.

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An illustration of Ips engraver beetles appears in the section of color drawings.

The Gypsy Moth

John M. Corliss

The gypsy moth is a leaf-eating insect, native to Europe and Japan, that was accidentally introduced into this country in 1869. It was brought from France to Medford, Mass., by a French scientist for experimental purposes but escaped and became established there. It gradually spread through most of New England.

It feeds on many fruit, shade, forest, and ornamental trees. In epidemic outbreaks few species of trees are untouched. Evergreen trees, on which only the larger caterpillars feed, are particularly susceptible to attack and damage when grown near oak and other hardwood trees that the insect favors. Defoliation caused by the gypsy moth has retarded growth and killed trees over extensive areas.

The gypsy moth has four stages in its life history: The egg, larva or caterpillar, pupa or resting stage, and adult or moth. During late July and August the female moth deposits about 400 eggs in a cluster, and the insect overwinters in this stage. The eggs hatch in May and the caterpillars feed on foliage for about 6 weeks. This is the stage when the insect may be most effectively controlled. When full-grown, the caterpillars change into pupae, and the adult moths emerge from the middle of July until the middle of August. A new generation is then started. The male gypsy moth is brown with black wing markings and is a strong flier. The female is nearly white, with black wing markings, but cannot fly because of her heavy body.

In Europe and Japan the gypsy moth has many natural enemies, which contribute toward its control, but when it was introduced into this country
none of these was present. In 1905 the State of Massachusetts and the Federal Government began to introduce parasites and other natural enemies of the gypsy moth. Much parasitized material has been received since then and several natural enemies have become established in this country.

But control of the gypsy moth by its natural enemies was less effective than people expected because some of the most important parasites from Europe could not be established—alternate host insects were not available here for the second or succeeding generations of the parasite. The wilt disease, caused by a polyhedral virus, attacks the gypsy moth in the larval stage and often kills large concentrations of caterpillars.

Congress first provided funds for Federal work on the gypsy moth in 1906 after the insect had spread through eastern Massachusetts and southern New Hampshire. The aim was to control and prevent the spread of the insect and eradicate outlying infestations. In 1923 a barrier zone was established where clean-up operations to prevent the further westward spread would be centered. The zone extended along the New England-New York State line from Canada to Long Island. The zone was replaced by a suppressive area in 1945 because the infestation had spread beyond the zone in New York after the hurricane of 1938.

Isolated infestations were found from time to time in New York, New Jersey, Pennsylvania, and Ohio. The smaller infestations were rapidly cleaned up.

In 1920 a well-established infestation was found in New Jersey near Somerville. It eventually covered some 1,450 square miles. Investigations traced the outbreak to blue spruce seedlings, which were imported from Europe and contained gypsy moth egg clusters. By 1935 complete eradication was effected by New Jersey and Federal cooperation, funds, and men. Spraying was done with hydraulic sprayers. Arsenate of lead was the insecticide.

In 1932 an infestation over 1,000 square miles was located near Pittston, Pa. In 1948 an infestation over 250 square miles was discovered at Quakertown, Pa. Both were sprayed with DDT by airplane. In 1951 only one isolation was known to exist in Pennsylvania. It was discovered near Pittston in August 1951, following the capture of male gypsy moths in two nearby traps.

The infested area in New England and New York is regulated by Federal Quarantine No. 45. The purpose is to prevent spread of the gypsy moth to uninfested sections of the country. Shipments of regulated plant material to points outside the infested area must be accompanied by a certificate of inspection.

Defoliation by the gypsy moth causes economic damage by ultimately killing the trees, retarding their growth, or creating other conditions that impair land value. The amount of defoliation varies from year to year.

The death of trees may be caused by single or repeated defoliations and is more extensive when partially developed deciduous foliage from primary buds has been killed by heavy frost earlier in the same season and when defoliation occurs during long periods of drought. White pine trees and some other conifers die almost always after a single stripping of the foliage.

Estimates based on a 20-year study of some 200 representative observation points in eastern New England put the value of all hardwood trees killed in those areas at 16 million dollars. Further estimates for the remainder of the infested area during that period placed the loss at 10 million dollars. No evaluation was placed on the accompanying mortality of young white pine trees, which has continued since the studies were made and is hard to estimate because the trees are usually killed before they have obtained sufficient growth to have any more than potential value.

A significant effect of defoliation is the loss in increment of tree growth.
Apparently the loss of growth in trees varies proportionately with the amount of defoliation—a tree defoliated 75 percent generally will put on only 25 percent of its annual normal growth. Estimates place the monetary loss of growth of trees from defoliation and consequent loss of lumber in the infested area at an average of 1.5 million dollars yearly.

The death of trees in woodland creates several problems. One is the opening of the forest stand, which affects the remaining growth so that the subsequently developing trees may be unsuitable or of inferior quality for timber. It also eliminates the good forest cover that helps to regulate stream flow and minimize floods. The loss of trees in recreation areas lowers land values and the production of wildlife. Heavy infestations of the caterpillars can make a place unpleasant to visitors and increase the hazard of spread of the pest by the traveling public.

Effectively planned spray operations must be preceded by surveys to delimit areas of infestation. Before establishing priorities for spraying one must know whether the growth is conducive to rapid build-up of infestation and determine whether the physical features of the forest are such as to increase the hazard of spread.

Special traps are an effective and economical way to survey extensive areas to find out if gypsy moth infestation exists and to check on the effectiveness of spraying operations. The traps are baited with a substance that attracts adult male gypsy moths in a radius of one-half mile or more. The substance is obtained by clipping the last two abdominal segments or tip of the virgin female adult and putting them in benzol, which extracts the material from the sex glands. The tips are then processed at Beltsville, Md., in order to stabilize and increase the potency of the attractant. They are then used at the rate of 15 tips to a trap. The material has been obtained by collecting large numbers of female pupae in heavily infested areas, but the spraying of extensive areas has reduced the numbers of pupae available in the United States.

The most satisfactory traps are made of salvaged cans, about 7 inches long and 4 inches in diameter, and are known as the Graham trap. The sex attractant is placed inside in a cardboard cartridge. The inside of the trap is lined with a sticky material that catches the moths. The ends of the can have cone-shaped screens with holes at the center to allow the moths to enter.

The traps are hung by wires to trees and spaced uniformly throughout the zone to be surveyed. They are placed in the field not later than early July, before the beginning of the moth flight, and removed the latter part of August or first of September. The traps are inspected every 7 to 10 days to remove moths in them and to renew the sticky material.

During the summer of 1950 trapping was done in New York, Pennsylvania, New Jersey, Vermont, Massachusetts, Rhode Island, and Connecticut. A total of 19,608 traps were placed in areas aggregating nearly 7,194,000 acres. No moths were caught in Pennsylvania and New Jersey.

In the fall and winter, scouting surveys are conducted in the vicinity of traps where moths were caught during the summer and in areas not trapped where infestation is known to occur in order to determine extent and intensity of infestation. Scouting is also carried on at points where infestation could be started by the importation of egg masses or living larvae by vehicles of all types. The latter work is largely confined to through highways, population centers, recreation areas, carrier terminals, State parks, and other locations of similar character. During the fall and winter of 1949-1950, more than 1,837,000 acres were scouted and 888 infestations were located.

Spraying is done in spring. Priorities are given to areas where surveys
The Gypsy Moth

have indicated the hazard of spread of the pest is greatest.

DDT has been used exclusively against the gypsy moth since 1946. The use of an oil solution of DDT at a concentration of 12 percent, applied at the rate of 1 gallon per acre, is most effective. During the spring of 1950 more than 600,000 acres of infested territory were sprayed by aircraft and specially designed ground mist blowers.

During the early years of the work, hydraulic sprayers were used to spray infested places with lead arsenate. Now Federal workers use the more effective and economical aircraft and blower equipment, but hydraulic equipment is still used in small commercial spraying operations. One Government-owned C-47 equipped for dispensing DDT solution can spray in an hour an area that formerly would take nine hydraulic units a whole season. Federal costs of operating hydraulic equipment averaged 25 dollars an acre. DDT-oil solution can be applied by airplane or mist blower for less than a dollar an acre. The gypsy moth is eradicated entirely when the solution is applied properly. Small single-engine biplanes of the N3N-3 type and multiple-engine types such as the C-47 have been adapted for the spraying.

The small biplanes are equipped with 90- and 110-gallon insecticide tanks located in the forward cockpit. The insecticide is pumped under pressure from the tank to the dispensing nozzle by a small gear-type pump hung beneath the fuselage just aft of the landing wheels. The pump is powered by a propeller connected with it which is mounted in suitable ball bearings and equipped with a braking mechanism. Forward motion of the plane turns the propeller at approximately 2,500 revolutions per minute, which in turn actuates the pump. The flow of insecticide is controlled by solenoid valves suitably located and operated electrically from a switch in the pilot’s cockpit. The airplanes fly approximately 50 feet above the tree tops at about 80 miles an hour, pumping out insecticide solution at the rate of 20 gallons a minute and laying down a swath 100 to 110 feet wide.

The C-47 carries two cylindrical oil-resistant rubber-lined aluminum tanks with a capacity of 922 gallons of insecticide. A centrifugal-type pump and gasoline unit mounted aft of the tanks forces the insecticide solution out through aluminum piping and hose connections to streamlined booms mounted beneath the wings and fuselage. Electric motor-operated valves control the flow of insecticide to the booms. Nozzles with small check valves are spaced along the booms to deliver the proper amount of insecticide material. This plane flies 150 miles an hour at 150 to 200 feet above the trees. The output of insecticide is 150 gallons a minute. The effective swath width is about 600 feet. The dosage is applied at the standard rate of 1 gallon of solution per acre. In a normal operating
season, 15,000 acres can be treated by a small biplane and 80,000 acres by a G-47.

In order to supply the aircraft with insecticide in large-scale spraying operations, large storage and mixing facilities are needed. Mixing tanks are equipped with heating units so that the insecticide can be heated to 80° F. to facilitate dissolving the technical grade DDT powder in the oil.

Ground mist blowers are effective for roadside spraying of woodlands. They are also used for spraying locations such as junk yards to prevent artificial spread of the insect. Blower units are mounted on trucks suitable for traveling along back roads and trails. The speed of the truck and the output of the blower are regulated so that the DDT-oil solution is applied at the rate of a gallon an acre.

Large-scale spraying operations require a great deal of planning. Maps are prepared showing areas to be treated. Just before the spraying season, windsocks are erected at specified locations for the guidance of aircraft. Property owners, as well as city, town, and other officials, including water commissioners, fish and game authorities, and the police are interviewed. Before and during the operations, radio stations and newspapers inform the citizens about the purpose and progress of the program.

Before the start of aerial spraying each day, small glass plates are placed on the ground in a line at right angles to the line of flight in order to check on the distribution of spray deposit. Plates not adequately covered give indication of areas that must be resprayed.

Six-foot-long helium-inflated dirigible-shaped balloons have proved effective as a guide for the large multi-engine airplanes, as they are visible for 2 to 5 miles.

In New Jersey and Pennsylvania, funds and manpower were furnished to supplement Federal efforts. Since 1935, surveys in New Jersey have been conducted by the State. In Pennsylvania trapping has been cooperative, with the Federal Government providing technical supervision. In New York State, in addition to supervision of the work programs, the New York Conservation Department has provided the manpower and most of the insecticides and solvents used in extensive spraying operations.

Cooperation among the Conservation Department of the Commonwealth of Massachusetts, the counties of Barnstable and Plymouth, and municipalities therein, assisted by the Federal Government, made it possible to spray the two counties completely in 1949 and 1950.

The principal long-time objective is the eventual eradication of the gypsy moth from the United States.

CURRENT OBJECTIVES are: To conduct trapping and scouting surveys in Pennsylvania until extermination there is assured; eliminate general infestation in New York by 1953 with only mop-up of isolated incipient infestations remaining in succeeding years; reduce the intensity of infestation in western New England and minimize the hazard of westward spread of the pest; continue the large-scale coordinated cooperative eradication program in southeastern Massachusetts; and to furnish technical advice and limited assistance to States, counties, cities, and towns engaged in control in the New England States.

JOHN M. CORLISS has been connected with plant-disease and insect-control projects since he joined the Department of Agriculture in 1917. In the program to prevent the spread of the white pine blister rust disease in 1928, he was in charge of transit inspection at Chicago. He was assigned to the division of gypsy moth control in 1943 and was in charge of the control measures against that insect in New Jersey, New York, and Pennsylvania until 1947, when he was made chief of the division of gypsy and brown-tail moth control.