that continuation of the case causes Bell officials. A heightened desire to end the case is no doubt encouraged by the soft antitrust positions taken by top officials of the Reagan Administration and the recent wave of corporate mergers across the nation. The entry of the Pentagon into the massive antitrust case also highlights divisions within the Reagan Administration over telecommunications policy. However, the national security tactic itself is not surprising. For decades the Bell System and the Pentagon have worked together on a variety of top secret projects. In addition, Bell has provided the Pentagon with many telecommunication services (*Science*, 5 June, p. 1118). The strength of that relationship has been fading in recent years, however, and the irony of the current court action is that DOD's defense of Ma Bell is based more on loyalty than need. Although the Bell System has no communication satellites, the Pentagon now relies on satellites for 70 percent of its long-haul communications needs.

—WILLIAM J. BROAD

# The Summer of the Gypsy Moth

## *Entomologists who made bets on its destructive power never guessed it would strip 10 million acres this year*

What the Mediterranean fruit fly tried and failed to do this summer near San Francisco, the gypsy moth did more than 100 years ago in Boston's harsher climate. It made its way across the ocean from Europe, established a colony, and spread through the New World. Unlike the Medfly, the gypsy moth has overcome every obstacle thrown in its path. It is well on its way to colonizing the entire eastern United States. This summer, in fact, has been a banner season for the moth. Every entomologist who spoke with *Science* said the insect (*Lymantria dispar*) has covered far more ground in 1981 than anyone could have predicted.

Some see in this a graphic warning of what can happen with insect pests if they are not dispatched quickly and thoroughly, as California is now trying to dispatch the Medfly. The difference between the gypsy moth and the Medfly, however, is that the moth does not attack cultivated crops. It prefers forests, and has never posed a direct threat to farming. But for people who live near infested woods, it is an overpowering nuisance, and it does kill trees. As one U.S. Department of Agriculture (USDA) official put it, living in territory overrun by the moth can be like "living in an Alfred Hitchcock movie."

According to Gary Moorehead, director of the gypsy moth quarantine program for the USDA's Animal and Plant Health Inspection Service (APHIS), scientists at an APHIS laboratory on Cape Cod organized a betting pool last year to see who could come closest to guessing the number of acres the moth would strip bare in 1981. The number in the previous season, a record breaker, was 5 million acres. The results for 1981 are now coming in, and, according to Moorehead, even the highest guesses are short of the mark. It looks as though the total will be 9 to 10 million acres, maybe more. Next year is expected to be worse.

The number of defoliated acres rises and falls periodically, but the area held by the moth grows steadily larger. The USDA and state agricultural officials have had several massive confrontations with the insect, most notably in 1957, when 3 million acres were sprayed with DDT. The public reaction against this tactic was loud and effective. Shortly afterwards, following the publication in 1962 of *Silent Spring*, Rachel Carson's book on the dangers of pesticides, DDT spraying was stopped. USDA officials speak nostalgically of the weapon they have lost, but concede that DDT appeared to be doing long-term damage as it accumulated in the food chain. Chemical residues were found in birds and fish.

Since the 1960's, aerial spraying with less potent pesticides has been continued on a smaller scale. The pest fighters' ambitions are now reduced. All they really hope to do is slow the rate of spread and keep the moth out of backyards, parks, and campgrounds. The front line of the advancing colony is now said to be in Maryland and Virginia, moving west and south.

The federal government's forces are divided into two groups: APHIS, which enforces the quarantine on products and camping vehicles moving out of the Northeast, and the Forest Service, which runs a "cooperative suppression" program with state governments in the worst-hit areas. Moorehead essentially agrees that the insect has won the war. Holding the latest environmental impact statement for the gypsy moth program in his lap, Moorehead put his left thumb over one corner of the document. "This is what APHIS covers," he said. Then he put his right thumb over another corner: "And this is what the Forest Service covers." All the rest of the space belongs to the moth.

John Kegg, New Jersey's commander in the battle against the moth, says he has been on the losing side for 18 years. "We can keep a green island here and there, but by the end of May with the caterpillars hatching and blowing into new areas, we cannot prevent their spreading."

The moth's tactics are eccentric. After hatching in April or May, the tiny caterpillars weighing less than a milligram climb the nearest tree. Before feeding, or later in the season if food is scarce, they spin down and hang from the upper branches on silken threads. Winds carry them aloft quite easily and drop them up to half a mile from the hatching point. Strong winds carry them farther, and in the Appalachian Mountains, the insect can hop from ridge to ridge in this fashion. Since the female moth cannot fly, this is the way the population migrates. The moths also travel by laying eggs on logs, cars, trucks, and campers that move through an infested area at laying time. Their favorite food is oak leaves, although when desperate they devour almost any foliage. In recent tests, they have shown a keen interest in salads of manzanita leaves from the West Coast.

Containment has been abandoned as a credible policy. The gypsy moths, Kegg says, are "having a ball out there; it's like introducing houseflies into a house full of honey." He does not expect the exploding population to stabilize until all the eastern U.S. oak forests have been infested.

Some state officials like Kegg expect the level of defoliation to reach a plateau


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when the moth population has expanded to the full extent of its habitat. Others disagree. They point to Massachusetts, which has been infested since the turn of the century, and had its worst outbreak and highest defoliation level this year. Despite 100 years of research, USDA scientists cannot say with certainty why the moth has done so well this summer. They think it may be the result of mild winter weather, which may permit more eggs to survive until spring.

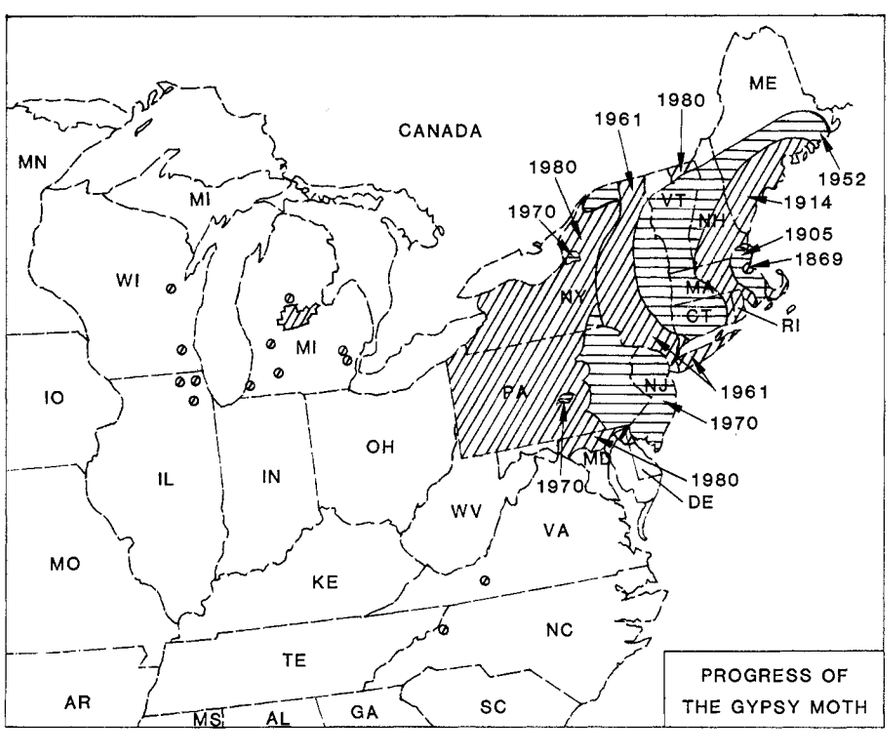
The damage, as one forester says, is more a social than an economic insult. By stripping the leaves from trees in several successive summers, the moths can kill some weak hardwood trees and healthy evergreens. They stunt the growth of many more. But the losses are not great in statistical terms. According to one recent study, a severe outbreak of caterpillars kills about 13 percent of the trees in a stand, at an average cost of $14 an acre. Yet if the victim is the favorite oak or apple in a suburban backyard, the loss seems much larger.

More important is the rank indifference gypsy moths have shown toward human society and its threats. Although humans are rapacious colonizers, they are not tolerant of other species with tendencies like their own. The feeling of disgust expressed by people living in moth-infested areas today is no different from that recorded by the residents of Massachusetts in the first outbreak in 1889.

The moth was introduced by accident to Medford, Massachusetts, and to the continent in 1869 by a French entomologist named Leopold Trouvelot. He had hoped to cross this European insect with oriental silkworms and produce a hybrid that would spin silk and thrive on American oaks. No doubt he hoped to make a lasting contribution to the silk industry, if not a fortune for himself. He failed in this, although he did make a name for himself. A windstorm one day in 1869 blew over a cage of his imported caterpillars, and they crawled out the window. The result, 20 years later, was recorded by Sylvester Lacy of Medford:

> I lived on Spring Street when the caterpillars were thickest there. The place simply teemed with them, and I used to fairly dread going down the street to the station. It was like running a gantlet. I used to turn up my coat collar and run down the middle of the street. One morning, in particular, I remember that I was completely covered with caterpillars, inside my coat as well as out. The street trees were completely stripped down to the bark. . . . The fronts of these houses were black with caterpillars, and the sidewalks were a sickening sight, covered as they were with the crushed bodies of the pest.*

Massachusetts organized a campaign against the moth, and after 10 years of concerted effort, nearly eradicated it. As the moths disappeared, the appropriations dwindled, and the volunteers became scarce. Soon the infestation reappeared. This set the pattern of man-moth interactions for another 80 years.




*The moth marches south, looking for oak forests.*

In the early days, pest fighters went after the insect with torches, creosote paint, scrapers, sticky paper, and sprays of lead arsenate and other general poisons. The chemical assault became the most frequently used, eventually reaching a crescendo in the aerial DDT spraying of the 1950's. Since that high point, the campaign has tapered off to a sporadic application of pesticides now considered safe: malathion, Sevin, Dylox, and Orthene.

At the same time, entomologists who believed in the efficacy of biological control—the use of "friendly" insects to fight pests—were importing the natural enemies of the gypsy moth from all over the world. Most of these are small wasps and flies that attack the eggs or larvae.

According to Roger Fuester, an entomologist at the USDA's Beneficial Insects Research Laboratory in Newark, Delaware, 47 species of natural enemies have been imported and released since the turn of the century, and about 10 have established themselves in this country. One of the latest arrivals, for example, is the Calosoma beetle from Japan, which has done well in New England but has not yet crossed the Delaware River into the front line area. Fuester thinks the friendly insects have done a valiant job, but he does not make any great boasts for them. At best, he says, they seem to have lengthened the time between peak outbreaks in the repeating cycle of infestations. He guesses that without the natural enemies, the worst outbreaks would come every 2nd or 3rd year, rather than every 5th or 6th. Biological control has worked well against some pests, notably the cereal leaf beetle in the Midwest and the alfalfa weevil in the Northeast, reducing farmers' use of chemicals. But the USDA has found nothing strong enough to stop the gypsy moth, even though an official of the Beneficial Insects lab says, "We've scoured the world" for a superbug.

The inherent weakness of most natural enemies is a corollary of their strength: they prey on, and thus depend on, a healthy moth population. When the population expands to the breaking point, a virus in the moth asserts itself, wiping out millions of larvae in a cataclysmic plague. Carcasses hang from every tree, filling the forest with a stench. After a population collapses like this, the natural enemies go without food. Then they likewise die off cataclysmically. The moth population rebuilds in a few years from a band of survivors, but the enemies take longer to recover. They cannot keep pace with the moth.

Chemical sprays also disrupt the pattern, for pesticides are often more lethal to parasites than to the moth itself. This is true, for example, of the commonly used insecticide, Sevin. (It kills honey bees, and for that reason is being used less now than it was a few years ago.) The impact on friendly insects may be lessened by spraying at just the right moment, when the moth larvae are freshly hatched and weak, before most of the parasites have come out. But as Fuester notes, the people who do the spraying often do not know or care about biological control. Newcastle County, Delaware, home of the Beneficial Insects lab, decided to attack the gypsy moth in mid-June this year—a "perfect case of spraying at the wrong time," according to Fuester. He thinks the spray probably had a minimal effect on caterpillars and a significant impact on parasitic flies.

New technology has produced several other ingenious weapons for the battle against the moth, but none has proved effective on a large scale. After many years without success, USDA researchers now think they have developed a way to produce sterile male moths that will compete with wild males. When released in large numbers, the laboratory-bred insects overwhelm and mate with an isolated population, producing sterile eggs. The USDA was releasing about 9000 of these saboteur moths each day in Michigan during July in an attack on a small infestation there. The results will not be known until next summer. The logistics of this method make it useless in the Northeast, where the moth has been known to produce millions of larvae per acre, over millions of acres.

A synthetic gypsy moth sex pheromone, distributed under the name Disparlure, is used occasionally against small infestations to disrupt mating. USDA researchers say they are not quite sure how it works, but if a breeding area is saturated with Disparlure, the male moths seem to be confused by the profusion of female scent. In addition, two liquid biological pesticides are now used as sprays: *Bacillus thuringiensis*, a bacterium that attacks many lepidoptera, and nucleopolyhedrosis virus, which attacks only the gypsy moth. They are somewhat less toxic than Sevin and two or three times more expensive. State officials tend to use them only when a neighborhood refuses to allow chemical spraying.

The moth clearly has won the battle against 20th-century technology, unless the agricultural labs produce a miracle weapon in the next decade. That seems unlikely. As with eradication campaigns, funding for research on the gypsy moth moves along in fits and starts, and achievements come slowly. James Nichols, director of Pennsylvania's forest pest control program, has compared the ups and downs in appropriations with the peaks and valleys of moth outbreaks and found a neat correlation. The problem, according to Nichols, is that the funds always arrive after the armies of moths have laid eggs (50 to 1000 each) for the next season. The government's entomologists may simply be the most successful species of gypsy moth predator, for, like the moth's insect enemies, the humans always follow a few years behind their quarry.

The federal establishment seems to have lost its enthusiasm for battle after losing its heavy gun, DDT. The last big federal effort ended in 1979 with the termination of a 5-year accelerated research program. (The stepped-up funding covered work on two other forest pests as well: the southern pine beetle and the Douglas fir tussock moth.) One USDA scientist involved in the research says: "There was a little spurt of activity. We went through the paces. Some good things came of it, and then it stopped. That's all I can say." According to David Graham, assistant director of the Forest Service's suppression program, the main accomplishments of this research were (i) registering the gypsy moth virus with the Environmental Protection Agency as a safe pesticide, (ii) finding and releasing new parasites, and (iii) learning to synthesize the sex attractant, Disparlure.

If the past is a guide, the funds available for fighting the moth will increase this fall as a result of this year's devastation. In fact, Graham already says that he expects the Forest Service will be asked to help spray three times as much land next year as in 1981, or about 1 million acres. But there is really no expectation of stopping the moth's progress. Indeed, Moorehead, who runs the quarantine program, voices doubts about the government's ability to control even the 20 outlying patches of infestation now blossoming in the far West and Midwest. He says he once planned to have a house in the Ozarks, but now he wonders if he wants to retire to this potential moth nest.

"Cremation is a cleansing process," wrote one of the leaders of Massachusetts' early campaign against the gypsy moth: "Bonfires mark the progress of civilization. Such work will not only aid in disposing of the moth, but will remove harboring places for other insects and render the locality more healthful and wholesome." * This Victorian outlook inspired many decades of pest fighters. But it is being replaced with a more accommodating view of nature. The federal government, in any case, has recognized in fact if not in form that the gypsy moth is a nuisance that must be tolerated.—ELIOT MARSHALL

**Home of the first family**

*In 1869, the first caterpillars crawled out the window of this house in Medford, Massachusetts.*

*From *The Gypsy Moth*, by E. H. Forbush and C. H. Furnald (Wright & Potter, Boston, 1896).