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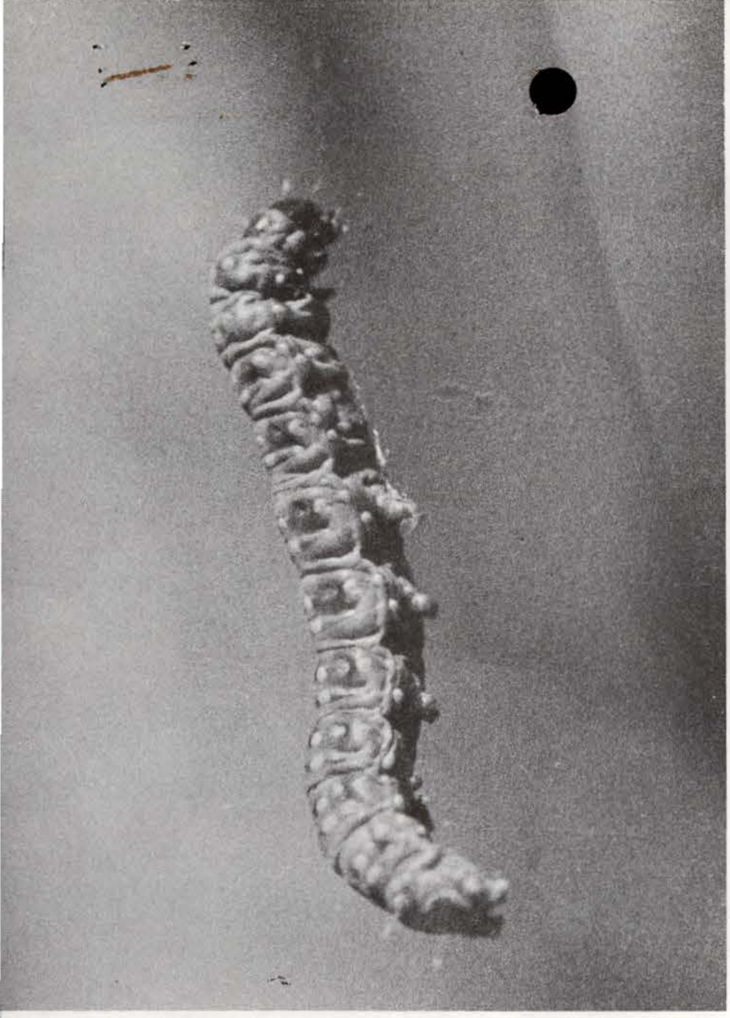


Spruce budworm, when hit with insecticide, falls from the tree in a 'death dance,' riding a silvery spider-like web. (Photo IEP-110)

ZECTRAN — for Control of Spruce Budworm

Only a small fraction of the pesticides used in the United States are applied to forest lands. Yet forests are an especially important part of the total environment. They are the source of major water supplies and home for most of our wildlife. The application of pesticides to forest lands must be done with great care, and with as little effect as possible on other insects, fish, birds, and other animals.

Pesticides provide a quick, effective and economical means of suppressing outbreaks of many insects. Sometimes they are the only known means of control. But pesticides also pose the problem of environmental contamination.

There is no question that small amounts of some insecticides such as DDT, get in the soil, water, or on plants, and because of their persistence remain for a relatively long time. Some ultimately finds its way into animal tissues. DDT, in minute amounts, is almost universally present in the fatty tissues of mammals, including man. DDT's persistence, its ability to accumulate in animal fat, and its wide range of activity against many insect species, are the main arguments against widespread use of this otherwise safe and very effective insecticide.

Today, many people are concerned about pesticide residues; some would ban use of DDT and other persistent chemicals. But until substitutes are found, careful use of DDT is far better than a dead forest. In the meantime, foresters are seeking new, safer, more effective sprays.

Insecticide Evaluation Research

In 1964, a research program in Insecticide Evaluation was begun at the U.S. Forest Service Experiment Station in Berkeley, California. Its goal, under the direction of Dr. Arthur D. Moore, is to develop safer chemical treatments for control of forest insects. Moore's staff now totals 30, and includes the special skills of entomologists, chemists, a plant physiologist, an insect biochemist, a statistician-programer, an ecologist, and a meteorologist, plus laboratory technicians and other specialists.

Working closely with the insecticide group on related research are 17 post doctorate fellows, research assistants, and graduate students under the direction of Dr. John E. Casida, a professor of Entomology at the University of California, Berkeley. Casida's group does basic laboratory research on pathways of metabolism and breakdown of chemicals in plants and animals.

The research team was joined in 1966 by Dr. Julius Hyman, a noted chemist responsible for development of several widely used agricultural insecticides. Some Forest Service scientists, and the University of California group share facilities at Hyman's laboratory in Berkeley.

The Research Goal

The research goal is to develop and help get into use, safe and short-lived chemical treatments for use against forest pests. A national steering committee sets priorities. The number one job now is to develop new treatments for use against tree defoliators previously controlled by aerial applications of DDT. On the list are the spruce budworm, hemlock looper, pandora moth, and the Douglas-fir tussock moth. All pose serious threats to North American forests.

Target Number One

Target number one is the spruce budworm, the most widely distributed and destructive forest tree defoliator in North America. More aggressive than its name implies, the budworm attacks spruce, Douglas-fir, and true firs. It was first recognized as a serious forest pest in the Western United States in 1922, when two outbreaks occurred in Idaho. Widespread epidemics have since been recorded in many forests in the Rocky Mountains and in the Pacific Northwest. Since 1944, epidemics have occurred in Idaho, Montana, Oregon, New Mexico, Arizona, and Colorado.

Finding New Insecticides

In looking for new insecticide treatments, scientists seek chemicals that will be (1) effective, (2) selective, and (3) non-persistent. Treatments should kill the target insect, but not other organisms. Chemicals should break down as soon as they do the job, and not linger weeks or months after spraying or "build-up" in plants and animals.

The first step in research is a process called "screening," in which carefully selected chemicals are tested in the laboratory. Early tests turned up several insecticides that were effective against spruce budworm. One carbamate—Zectran—was especially promising. Zectran, chemically 4-dimethyl-amino-3,5-xylyl methyl-carbamate, is a product of the Dow Chemical Company. It has been used against snails and insects on ornamental plants.

Why Zectran?

In laboratory tests, Zectran showed many of the characteristics sought in the basic chemical. It is more toxic to spruce budworm than DDT, especially in the sixth larval instar (that stage of insect development when the larva is nearing pupation).

Though Zectran does not have the total degree of selectivity researchers hope to develop, it is more toxic to budworm and some other defoliators than to most other organisms.

Zectran is especially safe to fish. It is one of the least toxic chemicals tested on game fish by the U.S. Fish and Wildlife Service at their Fish Pesticide Laboratory in Denver.

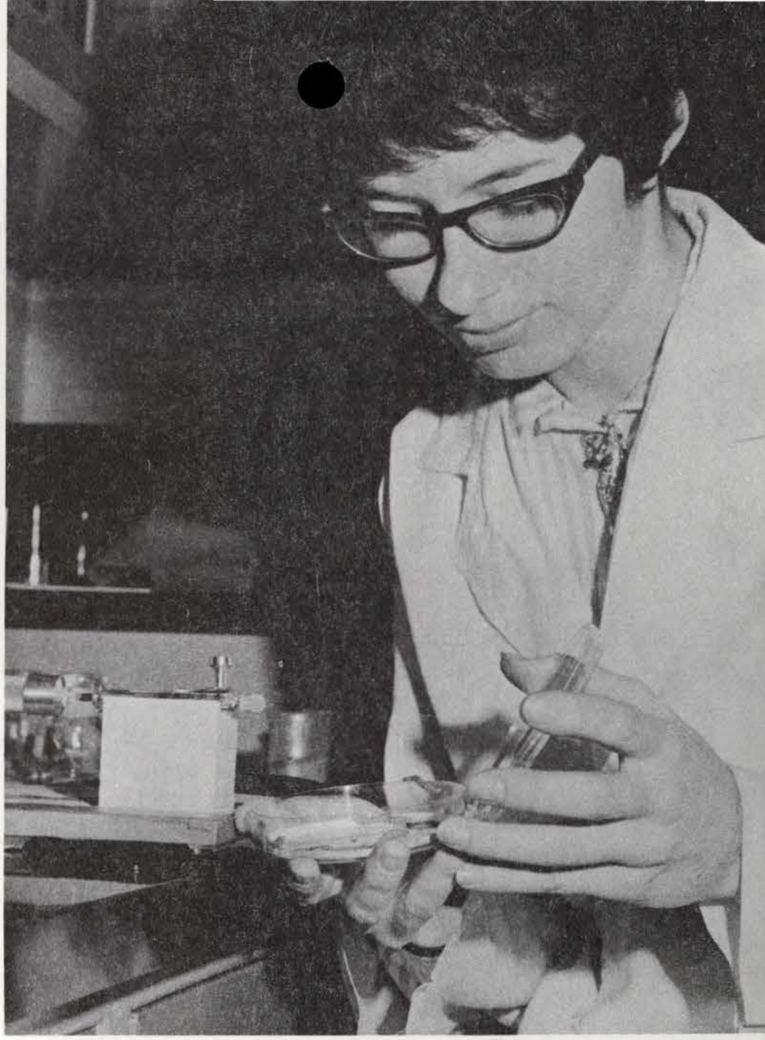
Because of its high toxicity to budworm, it can be applied in small amounts not hazardous to other forms of life.

Zectran is also nonpersistent; it breaks down in sunlight within a few hours and is rapidly degraded by biological systems.

Field Tests

The first step in field testing was to find out if Zectran would last long enough in forest spraying to kill the budworm. A field test near Salmon, Idaho, in 1964, indicated that it probably would—but not in the formulation tested.

In 1965, Zectran was used again near Darby, Montana, in a new type of formulation. It was highly effective, achieving a 98 percent reduction in budworm populations in one area. No adverse effects were found on fish, birds, or mammals and no lasting effects on beneficial insect populations were reported.



ABOVE: In the laboratory, the toxicity of chemicals is tested on spruce budworm larvae. Work with the insect, not native to California, is done in quarantine rooms where insects are raised for experimental purposes. (Photo IEP-113)

BELOW: A micro-applicator is used to apply tiny drops of chemical to the insect. (Photo IEP-114)

In 1966, tests were conducted in the Bitterroot National Forest in Montana and the Salmon National Forest in Idaho. The purpose was to test its effectiveness against the budworm and to study the effects of the insecticide on other insects, fish and mammals. For this work, Station scientists called in other specialists—the U.S. Fish and Wildlife Service, the Montana Fish and Game Department, and the U.S. Bureau of Sport Fisheries working with the University of Idaho.

In Montana, the U.S. Fish and Wildlife Service studied the effects on small mammals, fish and aquatic insects. Biologists trapped and marked squirrels, mice, chipmunks, and songbirds, and kept records of wildlife behavior, both before and after spraying.

In a 200-acre plot sprayed with five times the dosage applied elsewhere, Montana State biologists are studying the effects of the insecticide on blue grouse. They used tiny radio transmitters attached to the birds to follow their movements. They noted behavior and checked for accumulations of Zectran in the birds' systems. Tests on blue grouse will continue until spring of 1967.

In Idaho, fisheries biologists searched for effects of Zectran on trout and salmon in Bear Valley Creek, and on their aquatic insect food source. No adverse effects have been reported to date; however, the final tabulation on aquatic insects has not been completed.

Results

In the past three years, Zectran has been intensively tested on forest lands. All this work adds up to an insecticide treatment that is both effective and safe. Though budworm mortality was high, entomologists found no adverse effects on wildlife and little or no reduction of insect populations other than budworm and some associated defoliators.

what's high?

Foliage from sprayed areas was analyzed to determine its persistence on plants browsed by deer and elk. Researchers learned that Zectran deteriorated to insignificant levels within four weeks after spraying. After eight days, residue on most plant material was less than one part per million. (One-hundred parts per million is generally considered to be the "minimum no effect" level.)

And there is no evidence yet to indicate that it will persist in plant and animal systems.

Application Techniques

The research team not only screens and conducts basic research on prospective chemicals, but also studies application techniques...spray formulations, timing, equipment, and insecticide distribution.

One of the toughest problems has been to learn where, and in what quantity, spray is distributed through the forest. Researchers first used conventional dye sensitive cards set out to pick up spray droplets. However, these did not show where the smallest droplets were going or how much spray was reaching the target. For the 1965 and 1966 tests, a new method was devised. Dr. Chester Himel, a research professor at the University of Georgia, is primarily responsible. By use of tiny fluorescent particles mixed in the spray, he determined the size of the spray drops that killed individual budworm.

The largest drop found on a dead insect was 107 microns in size; most (97 percent) were below 50 microns (a micron is 0.000039 inch). But researchers knew that drops released from the plane ranged in size from 1-400 microns. Thus the larger drops were largely ineffective. The forest cover and dense webbing surrounding the budworm shielded them from all but the smallest spray particles.

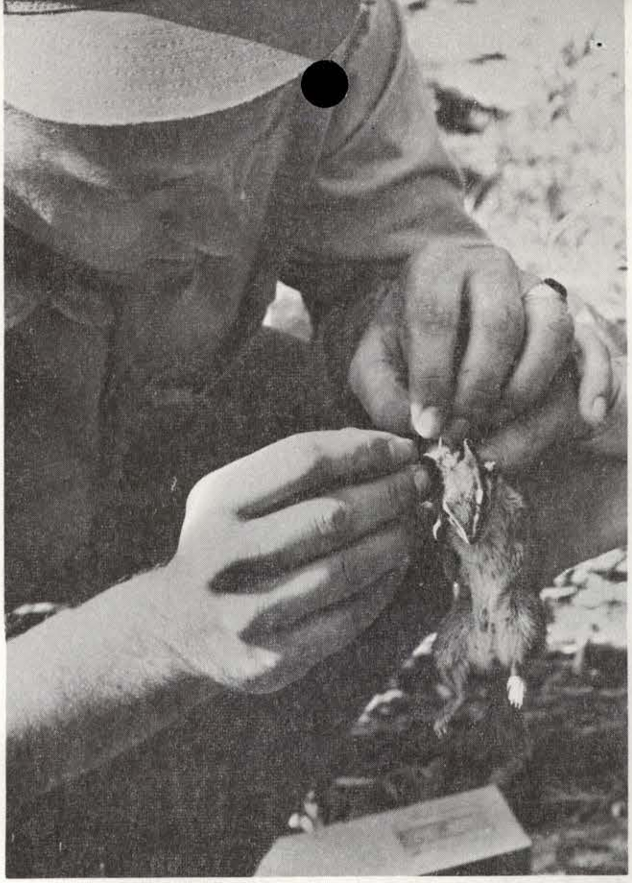
For future spray work, scientists will use an "aerosol" spray—or a fine spray mist of very small droplets. New equipment needed for "aerosol" spraying is being developed at the U.S. Forest Service Equipment Development and Testing Center in Missoula, Montana.

Tracking the spray will be increasingly difficult as drops get smaller. Previous methods aren't good enough. Scientists have found that lidar...a marriage of radar and laser developed by Stanford Research Institute, can keep track of even the smallest drops. The lidar shoots a laser beam into the spray cloud and the reflected beam is measured on an oscilloscope and recorded by camera. Two lidar guns tested by SRI and the Forest Service during the summer of 1966 traced the tiny droplets as long as 15-20 minutes after spraying.

Knowledge obtained from these tests will be used to help direct spray to target areas by natural air movement.

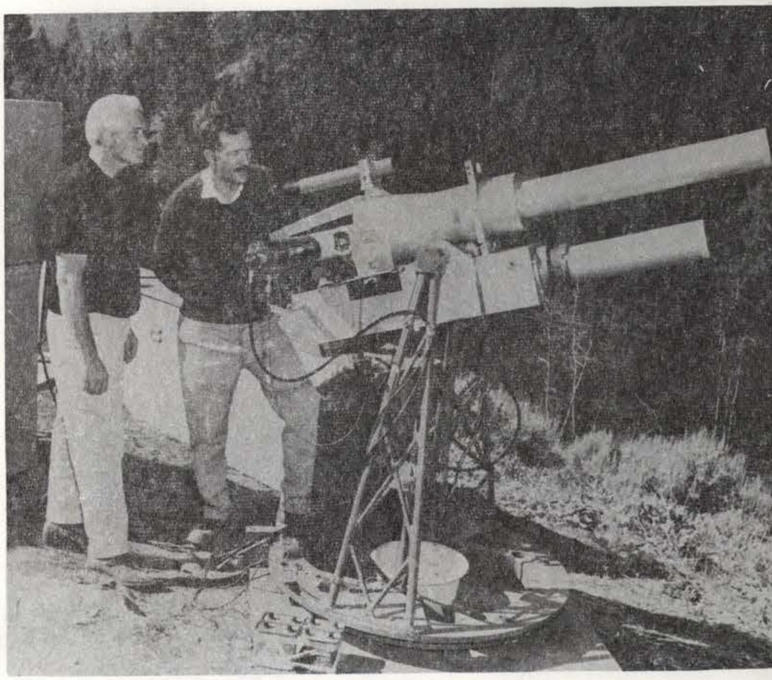
Field Tests 1967

By the end of the 1966 field season, the insecticide research team felt they had learned enough about Zectran to warrant a full operational test. This will be done in the summer of 1967 on some 60,000 acres in the Sawtooth National Forest, Idaho. The test will be done along the South Fork of the Boise River and tributaries in an area infested with spruce budworm since 1952.



ABOVE: Cooperative tests have turned up no adverse effects on fish or wildlife from use of Zectran. There has also been little or no reduction of insect populations other than budworm and some associated defoliators. (Photo IEP-111)

BELOW: Lidar gun--a marriage of radar and laser--is used to track small spray particles.



The goal of 1967 tests will be to:

- Test the effectiveness of Zectran applied in an aerosol spray at the rate of one half ounce per acre.
- Determine to what extent this type of treatment reduces environmental contamination.
- Determine the most effective means of applying low volume, micro-size droplets, by using atmospheric transport and diffusion in spray operations.
- Test mechanical air samplers for checking spray distribution.

The test will be carried out by U.S. Forest Service personnel from the Regional Office in Ogden, Utah, and the Sawtooth National Forest, Twin Falls, Idaho, under technical guidance of the Insecticide Evaluation group and with assistance from the U.S. Fish and Wildlife Service and other cooperators.

Alternatives to Use of Insecticides

The forest is a complex community. Disruption of its natural patterns must be undertaken only after thorough study of alternatives and their consequences. The use of insecticides is only one approach to forest insect control. There are several others. Sometimes a strategic harvest of timber can halt the spread of epidemics. Where this is not possible, a controlled application of insecticides may be necessary. Someday, research may give us methods for natural control by predators, by use of sex attractants, or other biological methods. The goal is a wide range of choices from which the land manager can select those that best suit his purpose. Most important is control in the safest possible manner, and with consideration for other forest resources.

Research Cooperators

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Ford Tri-Motor plane spreads Zectran in the Trapper Creek basin, Bitterroot National Forest, Montana, 1966. Goal of 1967 tests will be to reduce droplets to a fine mist, or 'aerosol' spray. New spray equipment will be used. (Photo IEP-112)