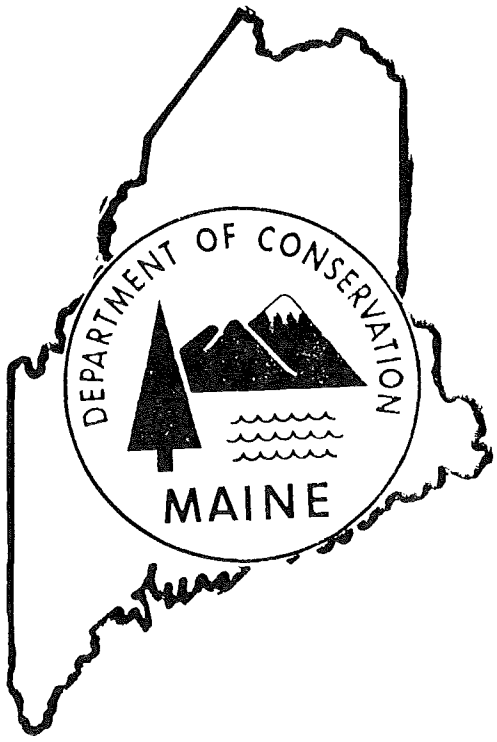
FIELD TRIALS FOR CONTROL OF SPRUCE BUDWORM IN MAINE: A HISTORY AND BIBLIOGRAPHY



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Entomology Division
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INTRODUCTION

The 1910-1919 spruce budworm outbreak caused substantial damage to the fir-spruce resources in Maine (1). Little or no research was done on the budworm during that period. However, the memory of the losses, and the realization that budworm outbreaks were likely to recur, caused research on control to begin a few years later. Research trials were infrequent until the impending 1940's outbreak, when interest in the new classes of synthetic chemicals, especially DDT, became strong. Control trials were still sporadic in Maine, however, until the most recent resurgence of budworm, which began to affect Maine in 1971 or 1972. Since that time, field research trials have been carried out every year and with increased intensity each year.

The following sections review all field trials of procedures for spruce budworm control that have taken place in Maine or have involved Maine scientists.

The control procedures are grouped into forest management practices, biological control, and chemical control for convenience. We have not reviewed laboratory studies, including techniques still in preliminary laboratory phases, nor field research other than studies concerned with direct control of the budworm.

FOREST MANAGEMENT PRACTICES

The earliest experimental attempt at controlling spruce budworm through forest management practices involved the State of Maine Forest Service. In the spring of 1924, spruce and fir were girdled in several different ways, at different seasons of the year, to determine the feasibility of girdling infested areas. The idea was to dry up the foliage and thus starve out the larvae (3). While observations could not be made on the budworm, there being no outbreak at the time, data were taken on condition of the foliage and subsequent deterioration of the wood of killed trees. Observations were made on this experiment through the 1920's and it was concluded that a budworm outbreak could be checked by girdling the trees in a localized infested stand by means of a "V" notch or deep hack in April or August (4,5).

Very little work was done in the following decade because the budworm infestation had collapsed and control measures were no longer urgent. However, by the early 1940's the Maine Forest Service was recommending that forest land owners check susceptibility of stands and lower the percentage of fir (mature) therein before future outbreak conditions existed (6). Experimental work was started to determine how to avoid losses from impending attacks and build up the resistance of spruce-fir stands to future budworm outbreaks (41). Recommendations for pre-salvage cutting, removal of old growth and defective balsam fir, and conversion of mixed spruce-fir stands to predominantly spruce were given. These practices would lead to stand improvement and increase vigor and resistance (43). Following this work classification systems were developed to aid in mapping of high hazard areas and guide in selecting trees to be cut or retained (38,44). The assumptions that removal of mature fir could reduce losses from impending attack and that selective cutting practices could increase stand vigor and resistance to future attack were studied in further tests in the mid-forties (31). The experimental cuttings did not become infested with budworm until the 1970's, however, by which time most had been commercially cut or otherwise modified. Recent evaluations suggest that while proper forest management practices are beneficial, silviculture alone may not provide adequate control of the budworm (39). However, the present strong interest in silvicultural control suggests that new, longterm field trials will soon be initiated.

BIOLOGICAL CONTROL

Attempts at controlling spruce budworm infestations through biological control methods started in the late forties. These were mainly parasitoid rearing and release projects carried out by the Maine Forest Service (8,9,10,28). Work with the western budworm parasite, Phytodietus fumiferana, appeared to be the most promising, but was discontinued in 1957 due to lack of positive results (12). More recent work involving the parasitoid Brachymeria intermedia, which attacks gyspy moth in Maine, showed that it will also parasitize spruce budworm (35). In this 1975 study, percent mortality was considerably higher in release areas than the total native pupal parasitoid complex would cause. The parasitoid has not, however, been recovered after the first year of release.

The second type of biological control experimented within Maine deals with the bacterium Bacillus thuringiensis. In 1963, the Northeastern Forest Experimental Station, USFS and the Maine Forest Service started preliminary tests to investigate some of the operational and biological characteristics of the microbial insecticide to determine its feasibility for field use (32,33). The control level was not high enough to be considered successful. In the early seventies testing of Bt was resumed. Bt was used at a rate of 4 billion international units (BIU) per acre and was accompanied by the enzyme chitinase (18). Levels of population control were only moderate but a major protective effect on current foliage was demonstrated for the Bt plus chitinase treatment. Because of this partial control, Bt tests were conducted the following year under simulated operational conditions (19). The application did not provide tree protection or population reduction. It was recommended that the research be continued to discover alternate materials to provide stress in budworm population, enhancing the activity of Bt. Several experiments followed in an attempt to determine effective additives and proper dosages for control of spruce budworm (22, 23, 24). Tests in 1975 against extremely high larval populations of the budworm showed some efficacy of the higher dosages, 8-12 BIU per acre, and of a mixture with the chemical insecticide, Orthene (23). However, repetition of these tests in 1976 proved a failure (24).

Nevertheless, the several years of tests combined with extensive Canadian data, led to registration of Bt for spruce budworm control. It was used operationally at 8 BIU per acre over 20,000 acres in 1978 with considerable success. A report on the project has not been issued at this writing.

CHEMICAL INSECTICIDES

In the mid-forties Maine started to investigate the possibility of chemical control of spruce budworm, first as observers in Canadian experiments with DDT in Ontario and Quebec (7). Due to the success of Canadian and western U.S. spray programs against budworm, Maine planned to spray in 1949 (8). Because of problems in obtaining funding, however, the 1949 spray program was abandoned.

Preliminary experimental spraying was carried out in 1949 and 1950 to determine the effectiveness of DDT formulations (9,41). The test showed that DDT solution applied as a relatively fine spray at a rate of 1 lb./acre during the 4th - 5th instar was most effective. Maine observed additional Canadian experiments designed to determine proper timing and dosage (10) and first sprayed operationally in 1954 (11).

By the mid-sixties the environmentally harmful effects of DDT were recognized, and an attempt to find a suitable alternative was started. In 1964 malathion was tested and found unsatisfactory as a substitute for DDT, although further trials with concentrate applications were recommended (17). The next material tested was Zectran (36). Using criteria accepted at that time, the Zectran treatment did not achieve satisfactory control. Further study was recommended to provide more information on the operating characteristics of Zectran when applied as a fine spray at low volume.

Because of experimental work done in Canada, the insecticide Accothion (fenitrothion) was used both operationally and experimentally in Maine, 1970, as a double application of 2 oz./acre (16). The results of the operational program showed that it was possible to keep the forest alive with the material and methods used. The experimental study indicated that the first application aids in foliage preservation while the second application contributes most to budworm population reduction. This agreed with Canadian experience.

Further testing of Zectran took place in 1971 and 1973 to determine the optimum dosage and application rate (14, 37). The results of these tests indicated that a single application of a finished spray of Zectran and kerosene applied at a rate of 0.25 gal./acre containing 0.15 lbs. of actual insecticide (A.I.) will reduce budworm populations and minimize defoliation on balsam fir. Zectran became a principal operational chemical in Maine in the next several projects. Sevin was first tested for budworm control in 1974 (21) and compared to Zectran at conventional spray timing and in early application timings. Sevin-4-oil provided effective protection and became registered for budworm control at a rate of 1 lb./acre. Several experiments were conducted in 1975 testing the chemicals: Orthene, Sevin-4-oil, Reldan, FMC-33297, Lannate, Dylox, Matacil, and Sumithion (23,25,34). The results of these tests indicated that Orthene at 0.5 lb. A.I./acre, and Dylox at 1 lb. A.I./acre could give adequate foliage protection and population reduction. As a result of these and subsequent tests, both chemicals were registered.

Experimental study continued in the 1976 season testing the conventional insecticides Sevin-4-oil, Dylox, Matacil, Lannate,

Imidan, Cygon and Orthene (15,24,39,40). The U. S. Forest Service tested Orthene, Dylox, and Sevin-4-oil (45). An elaborate comparison of .75 lb. and 1.0 lb. rates of Sevin-4-oil in operational use was conducted by the U.S.F.S. and M.F.S. (46). In helicopter tests involving control of spruce budworm in Christmas tree plantations, Dylox gave the best results and was registered for this purpose. For control of forest infestations, Matacil provided the highest degree of control and further testing of the material was advised. In addition to the above tests, experimental work was started with new classes of insecticides, the insect growth regulators (30). Insect growth regulators are chemicals used to disrupt vital physiological activity specific to the insect's development or metamorphosis. The two types of I.G.R. tested were juvenile hormone analogues, and Dimilin which interferes with chitin formation in the insect body wall. Although neither material provided satisfactory control, recommendations for continued study of possible use of I.G.R.'s in budworm control were made.

Experiments run in the 1977 seasons tested both chemicals and application methods. Double applications of Sumithion and Sevin-4-oil, and single application of Reldan, and Matacil were evaluated (26). Again, Matacil produced the best levels of population reduction and foliage preservation. Further testing to obtain all data required for registration for spruce budworm control was recommended. Sumithion Premix and Sevin-4-oil applied in split applications gave favorable results and seemed to warrant additional testing. The Maine Bureau of Forestry tested insecticide dosages and spray emission volumes of Orthene that were below the registered 1/2 lb. in 1/2 gallon of water per acre. Due to poor spray deposit, control was poor and no report has been issued on this test.

In addition to aerial tests, there was a series of ground tests using a back-mounted mist blower in a white-spruce plantation. (27). This evaluated two experimental numbered compounds developed by Union Carbide Corporation and a new, water miscible formulation of Sevin. Both the new formulated Sevin and one of the numbered compounds, a carbamate insecticide, produced favorable results compared to a conventional Sevin formulation.

The 1978 season saw a similar array of chemical tests carried out by several agencies. The Maine Bureau of Forestry continued tests of reduced dosages of Orthene and tested several combinations of split applications of Sevin-4-oil. A test by the U. S. Forest Service also studied reduced dosages of Orthene. A private consultant, J. H. Krall, working with Stauffer Chemical Co., tested low volume applications of a new formulation of Sumithion. And, the University of Maine, working in cooperation with private consultant H. L. Brown and several chemical companies, tested Matacil once more with emphasis on environmental monitoring, Lannate at two dosages, 2 oz. and 4 oz. A.I. per acre, and the new, water-miscible formulation of Sevin at three dosages and five spray emission rates. There was also a continuation of ground testing with the new Union Carbide carbamate insecticide, UC51762.

Reports on the 1978 tests had not been issued at this writing. A summary of insecticides, dosages, and acreages treated in Maine is presented in Table 1.

Table 1. Summary of experimental aerial insecticide + applications for spruce budworm control in Maine.

Year	Chemical and Dosage	Acreage	
1949	DDT,1 lb/acre in fuel oil	200	1,2
1950	DDT,1 lb/acre in fuel oil	160	1,2
1964	Malathion, 1/2 - 1 lb/acre	1,100	1,3
1967	Zectran, 2.4 oz/acre	500	1,2
1970	Accothion, 2 oz plus 2 oz/acre	210,000	1,2,3
1971	Zectran, 2.4 oz/acre	8,700	1,2
1973	Zectran, 2.4 oz/acre (incl. split dosage)	42,200	1,2
1974	Sevin-4-oil, 1 lb/acre	16,700	1,3
1974	Zectran, 2.4 oz/acre (early timing)	8,738	1,3
1975	Orthene, 1/2 lb/acre	900	2,3
1975	Sevin-4-oil, 1/2 - 1 lb/acre	3,000	1,3
1975	Reldan, 2 - 4 oz/acre	160	1,3
1975	FMC - 33297*, 0.1 - 0.4 oz/acre	200	1,3
1975	Lannate, 1/2 lb/acre	200	1,3
1975	Dylox, 1 lb/acre	3,000	2
1975	Matacil, 2.4 oz/acre	3,000	2
1975	Sumithion, 3 oz/acre	3,000	2
1976	Sevin-4-oil, 1/2 lb/acre	13,500	1,3,4
1976	Dylox, 1/2 - 1 lb/acre	16,500	1,3,4
1976	Matacil, 2.4 oz/acre	150	1,3,4
1976	Lannate, 1.5 - 2 oz/acre	1,400	1,3,4
1976	Imidan, 1/2 lb/acre	1,800	3,4
1976	Orthene, 1/2 lb/acre	4,500	2
1976	Dylox, 3/4 lb/acre	4,500	2

Table 1. (Continued)

1976	Sevin-4-oil, 3/4 lb/acre	4,500	2
1976	Dimilin, 1 - 2 oz/acre	1,800	1,3,4
1976	RO 10-3108/0.8,** 4.4 - 8.5 oz/acre	400	1,3,4
1977	Sumithion, 3 - 4 oz/acre (incl. split dosage)	450	3,4
1977	Sevin-4-oil, 1/2 - 3/4 lb/acre (incl. split dosage)	5,800	3,4
1977	Reldan, 1 - 3 oz/acre	400	3,4
1977	Matacil, 2.4 oz/acre	300	3,4
1977	Orthene, 6 - 8 oz/acre (reduced spray emission)	12,000	1
1978	Sevin UCSL,*** 1/2 - 1 lb/acre	1,000	3,4
1978	Lannate LV, 2 - 4 oz/acre	4,000	3,4
1978	Matacil, 2.4 oz/acre	3,000	3,4
1978	Sumithion, 3 oz/acre (new formulation)	1,000	4
1978	Orthene, 6 - 8 oz/acre (reduced spray emission)	10,000	1
1978	Orthene, 6 oz/acre	6,000	2
1978	Sevin-4-oil, 0.62 - 1 lb/acre	200,000	1

\+ does not include biological insecticides; B.t. was tested in Maine in 1963, '72, '73, '74, '75 and '76 on various acreage.
* a synthetic pyrethroid
** a juvenile hormone-type insect growth regulator
*** a water miscible formulation

1. responsible agency the Maine Forest Service
2. responsible agency the U. S. Forest Service
3. responsible agency the University of Maine
4. responsible agency the insecticide industry

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