SUMMARY OF IMIDAN 1E®
WESTERN SPRUCE BUDWORM
EFFICACY TRIALS: 1975-77.

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OCTOBER 30, 1977

FINAL REPORT

FORESTRY RESEARCH REPORT NO. 121-D

ABSTRACT

THE RESULTS OF EXTENSIVE FIELD TESTING OVER THREE SEASONS INDICATE THAT IMIDAN 1E CAN BE SUCCESSFULLY APPLIED FOR CONTROL OF EPIDEMIC POPULATIONS OF THE WESTERN SPRUCE BUDWORM, CHORISTONEURA OCCIDENTALIS, AND TO LIMIT THE LOSS OF CURRENT YEAR'S FOLIAGE GROWTH.

MINIMUM EFFICACY CRITERIA WERE JUDGED TO BE A GREATER THAN 95% REDUCTION IN LARVAL POPULATIONS AND MORE THAN 40% FOLIAGE PROTECTION.

IMIDAN 1E MAY BE APPLIED WITHOUT A CARRIER, OR DILUTED WITH WATER OR OIL. APPLICATIONS IN WATER ARE, IN GENERAL, MORE EFFICACIOUS THAN EITHER DIRECT APPLICATIONS OR USING AN OIL CARRIER. ESSENTIALLY IDENTICAL EFFICACY WAS OBTAINED AFTER APPLICATIONS WITH BEECOMIST EQUIPPED HELICOPTERS AND WITH FIXED-WING AIRCRAFT WITH CONVENTIONAL TEEJET NOZZLES.

THE RECOMMENDED APPLICATION FOR CONTROL OF WESTERN SPRUCE BUDWORM IS 0.25 LBS A.I. IMIDAN 1E APPLIED IN WATER AT ONE GALLON TOTAL SPRAY MIXTURE PER ACRE WHEN THE MAJORITY OF BUDWORM LARVAE ARE IN THE 4TH INSTAR. SUCH APPLICATION WILL EFFECTIVELY REDUCE LARVAL DENSITY TO BELOW FOREST SERVICE CRITERIA OF 3 LARVAE/100 BUDS AND ALSO RESULT IN SUBSTANTIAL FOLIAGE PROTECTION.

FURTHER STUDIES ARE RECOMMENDED WITH STICKER/SPREADER AGENTS WHICH MAY SIGNIFICANTLY REDUCE THE REQUIRED DOSE BELOW 0.25 LBS/ACRE.

INTRODUCTION

THIS REPORT PRESENTS THE RESULTS OF A SERIES OF FIELD TESTS CONDUCTED IN WASHINGTON AND MONTANA TO DETERMINE THE EFFICACY OF IMIDAN 1E AGAINST THE WESTERN SPRUCE BUDWORM, CHORISTONEURA OCCIDENTALIS FREEMAN. A WIDE VARIETY OF CONCENTRATIONS, GALLONAGE RATES, CARRIERS AND SPRAY SYSTEMS WERE EXAMINED TO ESTABLISH THE MOST EFFICACIOUS COMBINATION OF SPRAY PARAMETERS.

EFFICACY AGAINST THE BUDWORM WAS MEASURED BY BOTH THE DECREASE IN LARVAL POPULATIONS AND BY THE AMOUNT OF FOLIAGE PROTECTION DEMONSTRATED BY EACH TREATMENT. THE CRITERIA FOR EFFICACY MEET OR EXCEED FOREST SERVICE STANDARDS FOR THE PACIFIC NORTHWEST, UNDER WHICH REDUCTION TO LESS THAN 3 LARVAE/100 BUDS OF NEW FOLIAGE IS THE MINIMUM EFFECTIVE THRESHHOLD.

TREATMENT AND CONTROL PLOTS IN WASHINGTON WERE LOCATED IN THE WENATCHEE NATIONAL FOREST, NEAR THE VILLAGE OF LEAVENWORTH IN CENTRAL WASHINGTON (SEE FIGURE 1.). FOREST LAND AND TECHNICAL ASSISTANCE WAS PROVIDED BY PESHASTIN FOREST PRODUCTS, INC., A DIVISION OF THE PACK RIVER COMPANY. THE PLOTS IN MONTANA WERE LOCATED ABOUT FIVE MILES NORTH OF YELLOWSTONE NATIONAL PARK, WITHIN THE RANCHES OF LEONARD SARGENT AND MALCOLM FORBES, NEAR CORWIN SPRINGS, MONTANA.

EXPERIMENTAL DESIGN

THESE FIELD TRIALS WERE CONDUCTED OVER A THREE YEAR PERIOD BEGINNING IN 1975. THE FIRST SET OF APPLICATIONS WERE MADE TO DETERMINE WHETHER THE IMIDAN 1E FORMULATION MERITED

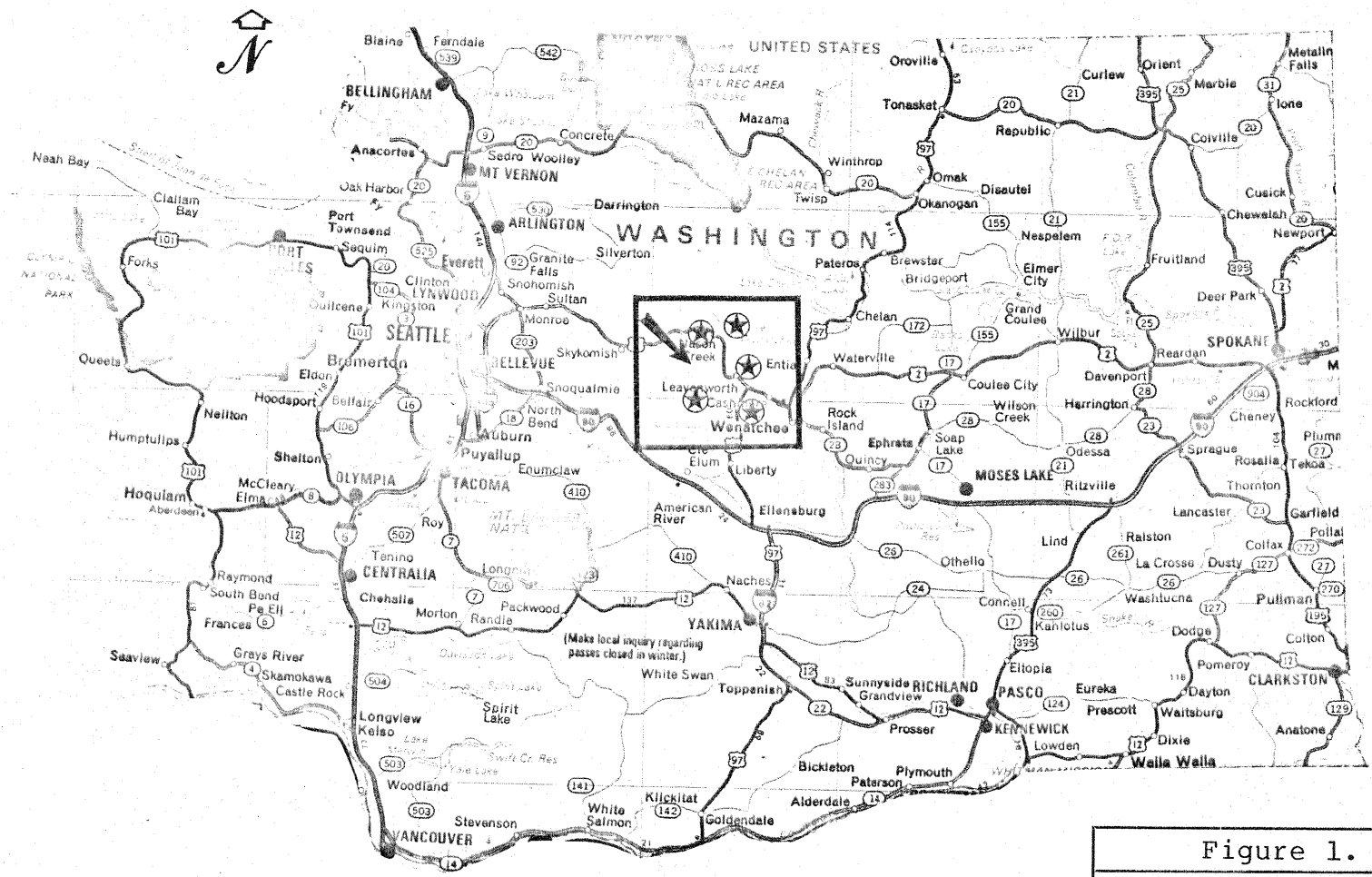

Figure 1.

TEST PLOT LOCATIONS

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FURTHER DEVELOPMENT FOR USE AGAINST THE SPRUCE BUDWORM. SINCE THESE TESTS SHOWED A HIGH ACTIVITY, SUBSEQUENT FIELD TRIALS WERE UNDERTAKEN TO EXAMINE THE EFFECT OF VARYING THE APPLICATION PARAMETERS WITH THE AIM OF DETERMINING THE MINIMUM TOTAL DOSE WHICH COULD BE APPLIED TO MEET THE EFFICACY CRITERIA.

DURING THE 1975 SUMMER SEASON, THREE 60 ACRE BLOCKS WERE TREATED BY AN AERIAL APPLICATION OF 1.0, 0.75, AND 0.5 LBS A.I./ACRE IMIDAN 1E. THESE TRIALS WERE CONDUCTED WITH A HELICOPTER EQUIPPED WITH BEECOMIST® #80 SPRAY SLEEVES, AND APPLIED A 1.0 GALLON/ACRE TOTAL SPRAY VOLUME USING WATER AS A DILUTANT.

EXPANDING ON THESE PRELIMINARY TESTS, TWO SEPARATE SETS OF FIELD TRIALS WERE CONDUCTED DURING 1976. THE FIRST CONSISTED OF 12 APPLICATIONS, EACH A DIFFERENT COMBINATION OF CONCENTRATION, CARRIER, AND SPRAY NOZZLE, AND EACH APPLIED TO A 60 ACRE BLOCK. THEN THE TWO MOST EFFECTIVE COMBINATIONS WERE APPLIED TO 600 ACRE BLOCKS TO SIMULATE A LARGE-SCALE, ACTUAL FIELD USE APPLICATION. BECAUSE OF THE TIME LAG NEEDED TO EVALUATE THE FIRST SERIES OF TESTS, THE LARGE ACREAGE APPLICATIONS WERE CONDUCTED IN CENTRAL MONTANA, SOME 500 MILES TO THE EAST. THE INSECT POPULATIONS THERE WERE APPROXIMATELY THREE WEEKS BEHIND IN DEVELOPMENT.

FOUR CONCENTRATIONS OF IMIDAN WERE APPLIED IN THE FIRST SERIES: 0.75, 0.50, 0.25 AND 0.125 LBS A.I./ACRE. AT EACH OF THESE RATES, APPLICATIONS WERE MADE USING EITHER AN OIL CARRIER OR NO CARRIER AT ALL (STRAIGHT FORMULATED

MATERIAL). IN ADDITION, EACH OF THE HALF-POUND AND QUARTER-POUND APPLICATIONS WAS DUPLICATED USING EITHER THE #40 OR #80 BEECOMIST SPRAY SLEEVES. THIS YIELDED TWELVE COMBINATIONS FOR TESTING:

0.75 LBS AT 4 QTS/ACRE IN OIL WITH #80 NOZZLES
0.75 LBS AT 3 QTS/ACRE NO CARRIER #80 NOZZLES

0.50 LBS AT 4 QTS/ACRE IN OIL WITH #80 NOZZLES
0.50 LBS AT 2 QTS/ACRE NO CARRIER #80 NOZZLES
0.50 LBS AT 4 QTS/ACRE IN OIL WITH #40 NOZZLES
0.50 LBS AT 2 QTS/ACRE NO CARRIER #40 NOZZLES

0.25 LBS AT 2 QTS/ACRE IN OIL WITH #80 NOZZLES
0.25 LBS AT 1 QT/ACRE NO CARRIER #80 NOZZLES
0.25 LBS AT 2 QTS/ACRE IN OIL WITH #40 NOZZLES
0.25 LBS AT 1 QT/ACRE NO CARRIER #40 NOZZLES

0.12 LBS AT 1 QT/ACRE IN OIL WITH #80 NOZZLES
0.12 LBS AT 1 PT/ACRE NO CARRIER #80 NOZZLES

IN ALL OF THESE TESTS, THE IMIDAN 1E WAS DILUTED WITH DIESEL OIL AS A CARRIER (OR NO CARRIER WAS USED) SINCE THE WATER EMULSIFIERS USED IN THE PREVIOUS YEAR'S STUDY HAD BEEN REMOVED FROM THE BASIC FORMULATION. IN ADDITION, DUE TO AN UNEXPECTED SOLUBILITY LIMITATION, THE MAXIMUM DILUTION OF IMIDAN 1E IN THE OIL CARRIER WAS 1:1. SO THAT ONLY THE 0.5 AND 0.75 LB/ACRE RATES COULD BE TESTED AT THE PREFERRED RATE OF 4 QUARTS/ACRE.

THE HALF-POUND APPLICATIONS WERE JUDGED THE LOWEST EFFECTIVE RATE. THEREFORE, THE TWO 600 ACRE BLOCKS IN

MONTANA WERE TREATED WITH 0.5 LBS/ACRE IN OIL AT ONE GALLON/ACRE AND WITH 0.5 LBS/ACRE AT 2 QTS/ACRE WITH NO CARRIER. BOTH TREATMENTS WERE APPLIED BY AIRPLANE USING CONVENTIONAL TEEJET NOZZLES.

IT SHOULD BE NOTED THAT A FIXED-WING AIRCRAFT WAS USED IN MONTANA RATHER THAN A HELICOPTER AS THIS IS THE TYPICAL VEHICLE USED BY FOREST SERVICE IN ACTUAL SUPPRESSION PROJECTS IN THE MONTANA REGION. THE ROLLING TERRAIN, EVEN IN MOUNTAINOUS AREAS, ALLOWS THE USE OF LOW FLYING PLANES. IN WASHINGTON THE TERRAIN IS FAR TOO STEEP. THE FOREST SERVICE IN THIS REGION USES HELICOPTERS EXCLUSIVELY IN PEST CONTROL PROJECTS. THE CONVENTIONAL SPRAY DELIVERY SYSTEM WAS USED SIMPLY BECAUSE THAT WAS ALL THAT WAS AVAILABLE IN THE AREA.

A SINGLE 10 ACRE PLOT WAS ALSO TREATED IN MONTANA USING IMIDAN AT 0.5 LBS/ACRE IN WATER WITH TRITON X-190 EMULSIFIER.

FOLLOWING THESE 1976 FIELD TRIALS, THE ORIGINAL WATER EMULSIFIERS WERE REPLACED IN THE BASIC IMIDAN 1E FORMULATION, AND ANOTHER SERIES OF TESTS CONDUCTED IN 1977.

IMIDAN 1E WAS APPLIED IN A WATER CARRIER TO 60 ACRE PLOTS AT 0.75, 0.50, 0.25 AND 0.125 LBS A.I./ACRE, AND TO 600 ACRE BLOCKS AT THE HALF-POUND AND QUARTER-POUND RATES. ONCE AGAIN, THE LARGE ACREAGE BLOCKS WERE INCLUDED TO SIMULATE ACTUAL FIELD USE CONDITION. IN ADDITION, 0.50 AND 0.25 LBS/ACRE WERE APPLIED IN OIL TO 60 ACRE BLOCKS

TO PROVIDE A COMPARISON WITH THE PREVIOUS YEAR'S TESTS. ALL OF THESE APPLICATIONS WERE MADE AT A TOTAL SPRAY VOLUME OF ONE GALLON/ACRE, USING A HELICOPTER OUTFITTED WITH BEECOMIST #80 SPRAY SLEEVES. THE FOLLOWING WERE THE 1977 FIELD TRIALS:

0.75 LBS IN WATER	#80 NOZZLES	60 ACRE BLOCK
0.50 LBS IN WATER	#80 NOZZLES	60 ACRE BLOCK
0.50 LBS IN WATER	#80 NOZZLES	600 ACRE BLOCK
0.25 LBS IN WATER	#80 NOZZLES	60 ACRE BLOCK
0.25 LBS IN WATER	#80 NOZZLES	600 ACRE BLOCK
*0.25 LBS IN WATER	#80 NOZZLES	500 ACRE BLOCK
0.125 LB IN WATER	#80 NOZZLES	60 ACRE BLOCK
*0.125 LB WATER+NL	#80 NOZZLES	100 ACRE BLOCK
0.50 LBS IN OIL	#80 NOZZLES	60 ACRE BLOCK
0.25 LBS IN OIL	#80 NOZZLE	60 ACRE BLOCK

THE TWO APPLICATIONS MARKED (*) WERE ADDED DURING THE COURSE OF THE FIELD TRIALS: A DUPLICATE LARGE ACREAGE TEST OF THE 0.25 LB RATE AND A SMALL PLOT APPLICATION OF 0.125 LBS IMIDAN WITH A 2% SOLUTION OF AGWAY® TARGET NL STICKER SPREADER AGENT IN THE WATER CARRIER.

IN ADDITION TO THE PREVIOUSLY DESCRIBED TREATMENT PLOTS, DURING EACH OF THE THREE SEASONS, 60 ACRE POSITIVE AND NEGATIVE CONTROL PLOTS WERE ESTABLISHED. SEVIN 4-OIL WAS

APPLIED AT 2 QUARTS/ACRE IN DIESEL OIL FOR COMPARISON WITH A "STANDARD" CHEMICAL. THREE 20 ACRE PLOTS, LEFT UNTREATED, WERE LOCATED IN THE VICINITY OF THE TREATMENT PLOTS, BUT NOT CLOSER THAN 0.25 MILES TO MINIMIZE CONTAMINATION BY AERIAL DRIFT.

WITHIN EACH TREATMENT AND CONTROL BLOCK, REGARDLESS OF SIZE, THREE PLOTS CONSISTING OF 15 TREES EACH, WERE SAMPLED PERIODICALLY FOR BUDWORM DENSITY AND HOST TREE DEFOLIATION.

METHODS-PROCEDURES

AERIAL APPLICATION

ALL TEST TREATMENTS IN WASHINGTON WERE APPLIED BY CASCADE HELICOPTERS, INC. OF CASHMERE, WA USING BELL B-1 HELICOPTERS OUTFITTED WITH THREE BEECOMIST 350 NOZZLES AND A PRESSURIZED DELIVERY SYSTEM AT 40 PSI. THE BEECOMIST NOZZLES WERE FITTED WITH EITHER #80 PERFORATED METAL, WETTABLE POWDER SLEEVES OR #40 POROUS SINTERED METAL, FLUID SPRAY SLEEVES. SWATH WIDTH WAS A CONSTANT 100 FEET; HOWEVER, AIRSPEED WAS VARIED FROM 40 TO 60 MPH. THE FIVE GALLONAGE RATES, FROM ONE GALLON TO ONE PINT PER ACRE, WERE REGULATED BY INSERING METERING DISCS IN THE DELIVERY SYSTEM AND CHANGING THE AIRSPEED ACCORDINGLY.

THE TWO TREATMENTS IN MONTANA WERE APPLIED BY THE YELLOWSTONE AIR SERVICE OF LIVINGSTON, MT USING A CESSNA AGWAGON OUTFITTED WITH TWENTY-TWO D-6 TEEJET NOZZLES AND A HYDRAULIC PUMPING SYSTEM. SWATH WIDTH WAS 60 FEET AND AIRSPEED A CONSTANT 120 MPH. THE ONE GALLON/ACRE RATE WAS APPLIED UNDER 60 PSI; THE HALF-GALLON RATE AT 45 PSI.

THE CARRIERS USED WERE EITHER NO. 2 FUEL OIL, WITH SUFFICIENT RHODAMINE EXTRA S RED DYE TO MAKE A 0.3% SOLUTION IN THE FINAL TANK MIXTURE, OR WATER WITH NIGROSINE OPG BLACK DYE TO MAKE A 0.5% SOLUTION. THE DYES WERE ADDED TO FACILITATE DEPOSIT ASSESSMENT.

DEPOSIT ASSESSMENT

KROMOKOTE SPRAY CARDS WERE PLACED NEAR THE BASE OF EACH SAMPLE TREE IN ALL TEST BLOCKS, MOUNTED IN WIRE HOLDERS ABOUT 0.5 M. ABOVE GROUND LEVEL.

THE SPRAY CARDS FOR THE 1975 WATER-BASED APPLICATIONS WERE SENT TO THE FORESTRY SCIENCES LABORATORY, US FOREST SERVICE AT CORVALLIS, OREGON FOR PROCESSING AND ANALYSIS. THE 1976 OIL APPLICATION CARDS WERE ANALYZED AT THE FLIGHT RESEARCH LABORATORY OF THE NATIONAL AERONAUTICAL ESTABLISHMENT, NATIONAL RESEARCH COUNCIL OF CANADA AT OTTAWA. BOTH FACILITIES USE ROUGHLY SIMILAR METHODS INVOLVING AUTOMATED SCANNING DEVICES WHICH CATEGORIZE DROPLETS ACCORDING TO SIZE, DETERMINE THE TOTAL AREA OF DROPLETS, AND USING AN EMPIRICAL SPREAD FACTOR FOR EACH SPRAY SOLUTION, CALCULATE THE TOTAL VOLUME OF MATERIAL ON EACH CARD.

IT SHOULD BE CAUTIONED THAT WHILE THE NAE/NRC ANALYTICAL METHODS REPRESENT THE VERY LATEST IN STATE-OF-THE-ART FOR SPRAY DEPOSIT ASSESSMENT, CONSIDERABLE LATITUDE SHOULD BE GIVEN THE RESULTS OF ANY SPRAY CARD ANALYSIS. SUCH VARIABLES

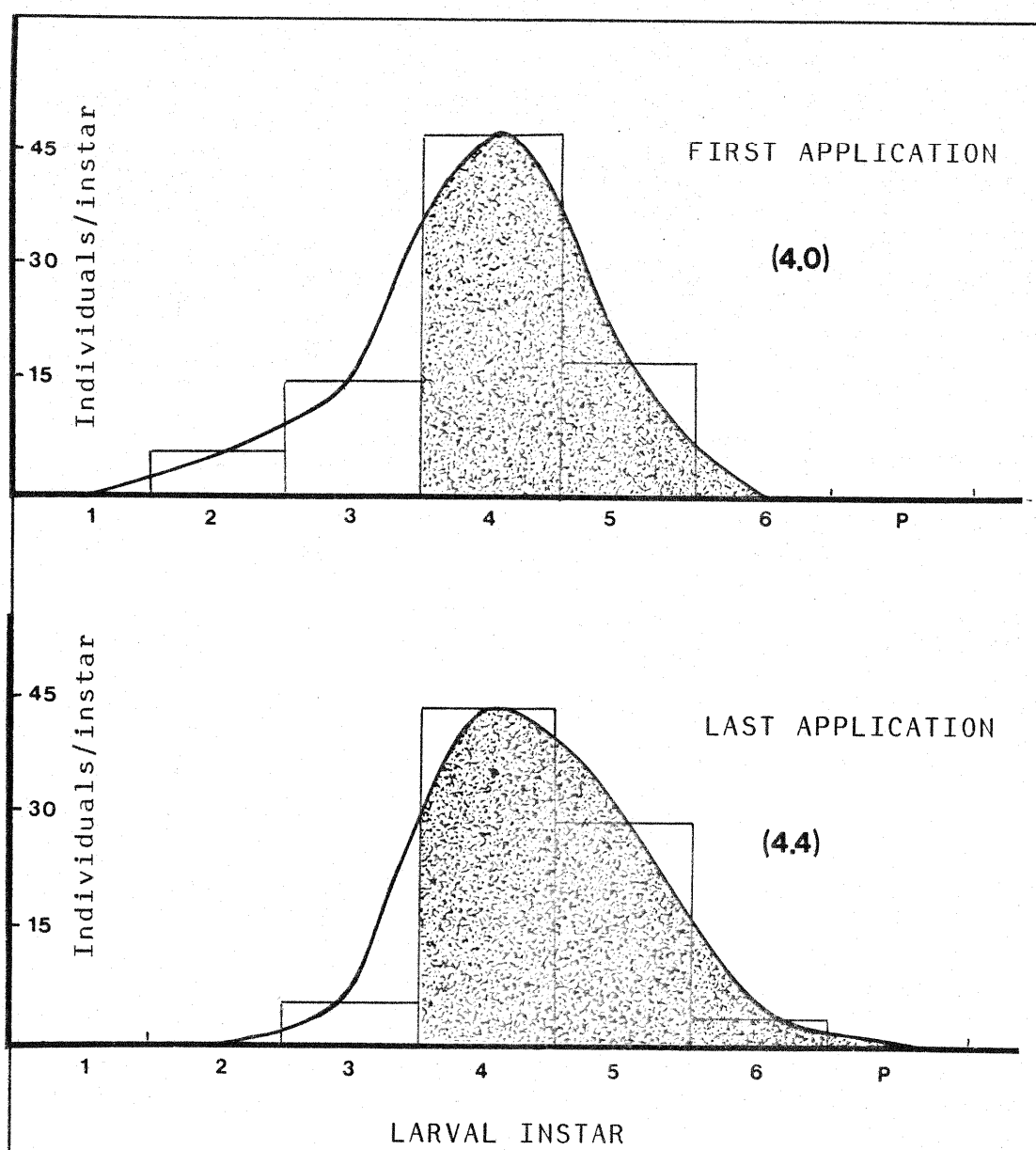
AS TEMPERATURE, HUMIDITY, PREVAILING WIND DIRECTION, EXACT PLACEMENT OF THE CARDS AND SURROUNDING TREE COVER HAVE A RATHER GREAT EFFECT ON THE MICRO-SCALE AIR CURRENTS WHICH DETERMINE THE AMOUNT OF SPRAY REACHING GROUND LEVEL.

TIMING

THE SPRAY APPLICATIONS WERE TIMED SO THAT THE MAJORITY OF BUDWORM LARVAE WERE IN THE 4TH INSTAR OR LATER. TO DETERMINE THE PROPER TIMING, BRANCH SAMPLES WERE TAKEN AT THREE DAY INTERVALS AND THE LARVAE PRESENT EXAMINED FOR INSTAR DEVELOPMENT USING HEAD CAPSULE WIDTH. FIGURE 2 SHOWS THE LARVAL POPULATIONS IMMEDIATELY BEFORE THE FIRST AND LAST TREATMENTS IN WASHINGTON DURING 1976. THE WEIGHTED AVERAGE RANGED FROM 4.0 TO 4.4 INSTAR; THE PORTION OF THE POPULATION EXPOSED TO THE AERIAL SPRAY IS SHOWN BY STIPPLING. THE BUDWORM POPULATION IN MONTANA WAS SOMEWHAT MORE ADVANCED BY THE TIME OF TREATMENT, AT 5.3 INSTAR. THE AVERAGE IN 1977 WAS 4.0 INSTAR FOR THE FIRST, AND 5.2 FOR THE LAST APPLICATION.

LARVAL COUNTS

THE EXTENT OF LARVAL MORTALITY WAS DETERMINED BY MEASURING THE NUMBER OF LARVAE PRESENT BEFORE AND AT INTERVALS AFTER EACH TREATMENT. A TOTAL OF 45 TREES WERE SAMPLED ON EACH TEST AND CONTROL BLOCK, 15 EACH FROM THREE PLOTS. THE SAMPLE TREES SELECTED WERE DOUGLAS-FIR, 20 TO 40 FEET TALL, WITH OBVIOUS BUDWORM INFESTATION OR FEEDING DAMAGE VISIBLE.



Portion of Population Exposed to Aerial Spray

FIGURE 2.

POPULATION DEVELOPMENT

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THREE BRANCHES WERE CLIPPED FROM THE MIDCROWN OF EACH TREE USING EXTENDABLE POLE PRUNERS FITTED WITH CLOTH CATCH BASKETS. EACH BRANCH WAS CAREFULLY EXAMINED AND THE NUMBER OF BUDWORM LARVAE OR PUPAE AND THE NUMBER OF NEW BUDS OR SHOOTS ON EACH WAS RECORDED. THESE VALUES WERE THEN CONVERTED TO THE NUMBER OF BUDWORMS PER 100 BUDS, OR THE PERCENT INFESTATION OF NEW FOLIAGE FOR EACH BRANCH.

BRANCH SAMPLES WERE COLLECTED ON BOTH TEST AND CONTROL BLOCKS ONE DAY BEFORE AND 2, 5, 10 AND 15 DAYS FOLLOWING EACH APPLICATION.

FOLIAGE PROTECTION

THE AMOUNT OF CURRENT YEAR'S FOLIAGE SAVED BY TREATMENT WAS DETERMINED BY MEASURING THE DIFFERENCE BETWEEN THE DEFOLIATION PRESENT BEFORE AND AFTER EACH TREATMENT.

THE PERCENT DEFOLIATION ON SAMPLE TREES WAS ESTIMATED VISUALLY, IN 10% INCREMENTS, BY EXAMINING EACH OF 10 APICAL BUDS ON EACH BRANCH, THREE BRANCHES PER TREE. THE FIRST DEFOLIATION MEASUREMENTS WERE MADE WITH THE PRESPRAY LARVAL COUNTS, ONE DAY BEFORE TREATMENT, AND THE FINAL DEFOLIATION MEASUREMENTS AFTER THE FINAL LARVAL COUNTS.

THE AMOUNT OF FOLIAGE PROTECTION RESULTING FROM A PARTICULAR TREATMENT IS CONSIDERED TO BE THE NET DEFOLIATION WHICH HAS OCCURRED ON THE UNTREATED CONTROL PLOTS MINUS THE NET DEFOLIATION ON THE TREATMENT BLOCK. OF COURSE, THIS TAKES INTO CONSIDERATION ONLY THE CURRENT YEAR'S

FOLIAGE, NOT EXISTING NEEDLES, AND COMPARES ONLY THE ADDITIONAL DEFOLIATION FROM THE TIME OF TREATMENT ONWARD. SO THAT CONSIDERABLE FEEDING DAMAGE CAN, AND DOES, OCCUR EVEN ON TREATMENT PLOTS WITH EXCELLENT FOLIAGE PROTECTION.

RESULTS

DATA RECORDED FROM THE 1975 PRELIMINARY FIELD TRIALS ARE DISPLAYED IN TABLE 1. AT THE TOP OF THE TABLE, THE PERCENT REDUCTION IN THE NUMBER OF BUDWORM LARVAE FOUND ON EACH OF THE FOUR POSTSPRAY SAMPLING DATES IS LISTED. PLEASE NOTE THAT THE 1.0 LB/ACRE APPLICATION RESULTED IN SLIGHTLY, BUT SIGNIFICANTLY LESS MORTALITY THAN EITHER THE 0.75 OR 0.5 LB PER ACRE APPLICATIONS. ALSO LISTED ARE THE AVERAGE NUMBERS OF LARVAE PER 100 BUDS FOR EACH PLOT REMAINING ALIVE ON THE LAST SAMPLING DATE. ON AVERAGE, EACH OF THESE APPLICATIONS REDUCED THE LARVAL POPULATIONS BY 95%, LEAVING LESS THAN 2 LARVAE PER 100 BUDS.

THE LOWER PART OF THE TABLE SHOWS THE RESULTS OF SPRAY CARD ANALYSES PERFORMED BY THE FOREST SERVICE LABORATORY AT CORVALLIS. LISTED ARE THE AVERAGE VALUES FOR THE AMOUNT OF SPRAY MATERIAL DEPOSITED ON THE CARDS, THE PERCENT THAT THAT REPRESENTS OF THE TOTAL AMOUNT APPLIED, AND THE AVERAGE VMD DROPLET SIZE. IN GENERAL, 19% OF THE TOTAL TANK MIXTURE REACHED THE SPRAY CARDS, WITH AN AVERAGE DIAMETER SIZE OF 146 MICRONS.

LARVAL MORTALITY

RATE	PERCENT (%) BUDWORM REDUCTION +1	+5	+10	+15	No. LARVAE PER 100 BUD REMAINING
1.00	77.5	83.3	88.1	91.8	2.7
0.75	81.8	93.8	98.0	98.0	0.7
0.50	72.2	89.0	92.1	95.8	1.9
0.00	3.3	27.2	39.5	65.5	9.5

SPRAY CARD ANALYSES

RATE LB/A	No. CARDS	FL OZ/ACRE CALCULATED	PERCENT(%) OF APPLIED	VMD SIZE (MICRON)
1.00	35	20.5	16	167
0.75	39	28.2	22	137
0.50	38	25.6	20	134

TABLE 1.

1975 FIELD TESTS

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THE REDUCTIONS IN BUDWORM LARVAE RESULTING FROM EACH OF THE MANY 1976 APPLICATIONS ARE LISTED IN TABLE 2. PLEASE TAKE SPECIAL NOTICE OF THE 0.75 LB-NO CARRIER AND 0.125 LB-OIL APPLICATIONS. IN THE LATTER CASE, THE UNUSUALLY HIGH LARVAL MORTALITY CAN BE EXPLAINED BY THE PLOT TOPOGRAPHY. A STEEP RAVINE TRAVERSED THE PLOT; DURING APPLICATION, THE SPRAY CLOUD ON SUCCESSIVE PASSES WAS OBSERVED TO DRIFT TOWARD THE CENTER OF THE RAVINE. EFFECTIVELY, THIS FUNNELLING RESULTED IN A 2 OR 3 FOLD APPLICATION TO THE CANYON BOTTON WHERE THE SAMPLING STATIONS WERE LOCATED. SPRAY CARD ANALYSIS BEARS THIS OUT. IN THE FORMER CASE, THERE IS SIMPLY NO REASONABLE EXPLANATION FOR THE SUDDEN INCREASE IN LIVE LARVAE BETWEEN SAMPLING DAY 5 AND 10. HOWEVER, THIS PHENOMENON WAS REAL; THE PLOT WAS IMMEDIATELY RE-SAMPLED WITH THE SAME RESULTS.

OTHER THAN THESE TWO ANAMOLIES, THE REMAINING TRIALS PRODUCED SURPRISINGLY CONSISTENT LARVAL REDUCTIONS; THE LARGER THE APPLIED CONCENTRATION OF IMIDAN, THE GREATER THE BUDWORM MORTALITY. THE FOUR 0.5 LB APPLICATIONS AVERAGED AN 82% REDUCTION, WHILE THE FOUR 0.25 LB APPLICATIONS AVERAGED 67%.

EXAMINATION OF THE DATA ALSO SHOWS A LACK OF CONSISTENT PATTERN BETWEEN THE #40 AND #80 NOZZLES. STATISTICAL ANALYSES SUPPORT THIS; IN TERMS OF LARVAL MORTALITY, THERE IS NO SIGNIFICANT DIFFERENCE BETWEEN THE USE OF #40 OR #80 NOZZLE SLEEVES.

TABLE 3 SHOWS THE RESULTS OF THE DEFOLIATION MEASUREMENTS FOR THE 1976 FIELD TRIALS; BECAUSE OF THE PRELIMINARY

LARVAL MORTALITY

APPLICATION			PERCENT (%) BUDWORM REDUCTION				NO. LARVAE/100 BUDS REMAINING
CONC	CARRIER	NZL	+2	+5	+10	+15	
0.75	oil	80	36	82	83	94	1.8
0.75	---	80	64	69	1	14	1.3
0.50	oil	80	26	66	69	88	1.8
0.50	---	80	7	47	95	95	11.8
0.50	oil	40	41	50	59	65	15.7
0.50	---	40	19	36	63	81	10.4
0.25	oil	80	35	36	49	61	8.4
0.25	---	80	16	45	48	51	20.1
0.25	oil	40	41	47	71	83	8.9
0.25	---	40	20	45	50	74	14.5
0.125	oil	80	60	67	54	89	1.9
0.125	---	80	23	7	31	53	11.3
1.00	SEVIN	80	53	67	94	94	2.1
0.00	CONTROLS		23	9	26	42	17.5

TABLE 2.

IMIDAN EFFICACY-1976

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NATURE OF THE ORIGINAL 1975 TESTS, THERE WERE NO FOLIAGE PROTECTION ESTIMATES MADE THAT YEAR. THE NET PERCENT DEFOLIATION REPRESENTS THE AMOUNT OF ADDITIONAL FEEDING DAMAGE FOLLOWING EACH OF THE TEST APPLICATIONS. LISTED IN THE NEXT COLUMN, LABELLED "AVG", ARE THE AVERAGE NET DEFOLIATION VALUES FOR EACH DOSE LEVEL. THE STANDARD ERROR FOR THIS SAMPLING TECHNIQUE IS ABOUT ±5% OF THE LISTED VALUES.

THE PERCENT FOLIAGE PROTECTION IS THE DIFFERENCE BETWEEN THE NET DEFOLIATION ON THE CONTROL PLOTS AND THE NET DEFOLIATION ON EACH TEST PLOT. THIS REPRESENTS THE ADDITIONAL DEFOLIATION WHICH MIGHT HAVE OCCURRED IF EACH OF THE TEST PLOTS HAD NOT BEEN TREATED, OR CONVERSELY, THE AMOUNT OF DEFOLIATION WHICH DID NOT OCCUR BECAUSE OF THE TREATMENT. ALTHOUGH THE VALUES ARE EXPRESSED IN TERMS OF PERCENT, THEY DO NOT REPRESENT A PERCENT OF THE NEW FOLIAGE SAVED FROM LOSS. FOR EXAMPLE, THE SEVIN 4-OIL APPLICATION YIELDED 33% FOLIAGE PROTECTION; HOWEVER, THIS DOES NOT MEAN 67% OF THE FOLIAGE WAS LOST AND 33% SAVED. IT MEANS THAT EVEN THOUGH A TOTAL OF 40% OF THE NEW FOLIAGE ON THE PLOT WAS ACTUALLY EATEN, AN ADDITIONAL 33% WOULD HAVE BEEN DEFOLIATED, AS COMPARED TO THE CONTROL PLOT, IF THE APPLICATION HAD NOT BEEN MADE. ACTUALLY, 60% OF THE NEW FOLIAGE WAS NOT LOST. THIS METHOD, ALTHOUGH CONFUSING IF NOT PROPERLY DEFINED, IS THE STANDARD FOREST SERVICE MANNER OF DISPLAYING DEFOLIATION MEASUREMENTS, AND IS INCLUDED FOR THAT REASON. IT MAY BE SIMPLIER TO REFER TO NET DEFOLIATION RATHER THAN FOLIAGE PROTECTION, ESPECIALLY FOR COMPARISONS FROM YEAR TO YEAR.

APPLICATION			PERCENT DEFOLIATION				(%) FOLIAGE PROTECTION	
CONC	CARRIER	NZL	PRE-	POST-	NET	(AVG)		(AVG)
0.75	oil	80	19	25	6	3	38	41
0.75	---	80	12	12	0.2		44	
0.50	oil	80	17	15	-2	17	46	27
0.50	---	80	19	32	13		31	
0.50	oil	40	35	52	17		27	
0.50	---	40	58	97	39		5	
0.25	oil	80	8	21	13	42	31	2
0.25	---	80	42	88	46		-2	
0.25	oil	40	40	78	38		6	
0.25	---	40	30	98	68		24	
0.125	oil	80	13	22	9	16	35	28
0.125	---	80	33	56	23		21	
1.00	SEVIN	80	29	40	11		33	
0.00	CONTROLS		21	65	44		--	

TABLE 3.

FOLIAGE PROTECTION-1976

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AGAIN, THE FINAL COLUMN IN TABLE 3 LISTS THE AVERAGE PERCENT FOLIAGE PROTECTION VALUES FOR EACH DOSE LEVEL. AND AS WITH THE LARVAL MORTALITY, THE DATA EXHIBITS A CLEAR DOSE-EFFECT. THE LARGER THE APPLIED CONCENTRATION OF IMIDAN, THE GREATER THE FOLIAGE PROTECTION. INDEED, THE 0.75 LB/ACRE APPLICATIONS RESULTED IN VIRTUALLY NO ADDITIONAL DEFOLIATION, ONLY 3%.

THE NAE/NRC SPRAY CARD ANALYSES FOR THE 1976 APPLICATIONS ARE PRESENTED IN TABLE 4. TWO THINGS ARE APPARENT FROM THIS TABLE: FIRST, THE AVERAGE AMOUNT OF SPRAY MATERIAL REACHING THE CARDS WAS 21%, WITH REMARKABLE UNIFORMITY AMONG THE TWELVE TEST APPLICATIONS. THERE ARE TWO NOTABLE EXCEPTIONS. THE 0.125 LB/ACRE OIL-BASED TRIAL SHOWED 68% DEPOSITION. AS PREVIOUSLY MENTIONED, THIS WAS DUE TO AN ACCIDENTAL THREE FOLD APPLICATION. THE SEVIN APPLICATION YIELDED ONLY A 3% DEPOSITION IN SPITE OF THE REASONABLY HIGH LARVAL MORTALITY AND FOLIAGE PROTECTION SHOWN IN TABLES 2 AND 3. IN THIS PLOT, WHICH HAD VERY DIFFICULT TERRAIN, THE SPRAY CARDS WERE NOT PLACED AT THE BASE OF EACH SAMPLE TREE, BUT WERE STRUNG ALONG AN ACCESS ROAD TRAVERSING THE PLOT. EVIDENTLY THE ACTUAL SAMPLING PLOTS WERE PROPERLY TREATED, BUT THE SPRAY CARDS WERE LOCATED IN A SKIPPED SWATH.

SECONDLY, THE AVERAGE VMD DROPLET SIZE FOR THE #40 AND #80 NOZZLE APPLICATIONS WERE VERY SIMILAR: 117 MICRONS VERSUS 114. FURTHERMORE, THIS DIFFERENCE IS NOT STATISTICALLY SIGNIFICANT. IT HAD BEEN ASSUMED THAT THE #40 NOZZLES WOULD RESULT IN AVERAGE DROPLETS IN THE 80 TO 100 MICRON SIZE,

Application			No. Cards	FL OZ/ACRE CALCULATED	FL OZ/A APPLIED	PERCENT ON CARD	VOLUME MEAN DIAMETER (u)
0.75	oil	80	38	29.6	128	23	124
0.75	---	80	40	21.1	96	22	109
0.50	oil	80	28	26.7	128	21	106
0.50	---	80	28	12.4	64	19	128
0.50	oil	40	32	22.2	128	17	119
0.50	---	40	17	7.4	64	12	115
0.25	oil	80	40	12.1	64	19	104
0.25	---	80	36	5.4	32	17	103
0.25	oil	40	38	13.6	64	21	119
0.25	---	40	8	8.1	32	25	116
0.125	oil	80	40	21.9	32	68	119
0.125	---	80	40	3.7	16	23	118
1.00	SEVIN	80	20	2.0	64	3	82

TABLE 4.

1976
SPRAY CARD ANALYSES

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WHICH IS SOMEWHAT SMALLER THAN THE 110-130 MICRON SIZE TYPICAL FOR #80 NOZZLES.

IT SHOULD ALSO BE OBSERVED THAT THE MORE SENSITIVE AND SOPHISTICATED NAE/NRC ANALYTICAL METHODS YIELDED DATA COMPARABLE TO THE PREVIOUS FOREST SERVICE ANALYSES. THE AVERAGE DEPOSITION FOR ALL 1976 TESTS WAS 21% AS COMPARED TO 19% FOR THE 1975 TESTS, WHILE THE AVERAGE DROPLET SIZE WAS 114 MICRONS AS COMPARED TO 146 FOR THE PREVIOUS YEAR. IF ALLOWANCE IS MADE FOR THE FACT THAT OIL TENDS TO FORM SLIGHTLY SMALLER DROPLETS THAN WATER BECAUSE OF ITS GREATER VISCOSITY AND SURFACE TENSION, THEN THESE RESULTS INDICATE VIRTUALLY IDENTICAL AERIAL APPLICATIONS IN 1975 AND 1976.

TABLE 5 SHOWS THE RESULTS OF THE LARGE ACREAGE APPLICATIONS IN MONTANA. THE TWO RATES CHOSEN FOR TESTING WERE 0.5 LBS IN OIL AND 0.5 LBS APPLIED DIRECTLY. LISTED ARE THE LARVAL MORTALITY AND DEFOLIATION MEASUREMENTS FOR EACH PLOT, AS WELL AS FOR A SMALL-SCALE TEST OF 0.5 LBS IN WATER.

OVERALL, THE LARGE-SCALE, ACTUAL-USE APPLICATIONS PRODUCED RESULTS VERY SIMILAR TO THE SMALL ACREAGE TESTS JUST COMPLETED IN WASHINGTON. IN THE 60 ACRE TESTS, LARVAL MORTALITY WAS 82% AND NET DEFOLIATION WAS 17% AS THE AVERAGE OF THE FOUR 0.5 LB/ACRE APPLICATIONS. IN MONTANA, ON 600 ACRE BLOCKS, THE COMPARABLE VALUES WERE 83-81% LARVAL MORTALITY AND 13-16% NET DEFOLIATION. AGAIN, THE DIFFERENCES BETWEEN THE TWO APPLICATIONS, OIL-BASED AND NO CARRIER, WERE NOT STATISTICALLY SIGNIFICANT.

LARGE ACREAGE FIELD-USE EFFICACY RESULTS

APPLICATION		PERCENT MORTALITY				PERCENT DEFOLIATION			FOLIAGE
RATE	CARRIER	+2	+5	+10	+15	PRE-	POST-	NET	PROTECTION
0.5	Oil	33	43	81	83	11	24	13	19
0.5	---	51	72	71	81	13	29	16	16
0.5	Water*	35	54	63	84	15	38	23	9
0.00	Control	31	58	60	67	13	45	32	--

*Single 10 acre plot.

TABLE 5.

1976 MONTANA TRIALS

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THE EFFICACY RESULTS OF THE 1977 FIELD TRIALS ARE SHOWN IN TABLES 6 AND 7. THE PERCENT LARVAL MORTALITY ON EACH SAMPLING DATE AND THE AVERAGE NUMBER OF LARVAE REMAINING ALIVE AFTER THE FINAL SAMPLING ARE LISTED FOR EACH OF THE SEPARATE APPLICATIONS IN TABLE 6. THE DEFOLIATION MEASUREMENTS AND PERCENT FOLIAGE PROTECTION VALUES FOR THESE SAME APPLICATIONS ARE DISPLAYED IN TABLE 7. IN THESE TEST RESULTS, A CLEAR DOSE-EFFECT WAS NOT OBSERVED, FOR EITHER THE LARVAL MORTALITY OR FOLIAGE PROTECTION DATA. IN GENERAL, THE 0.25 LB APPLICATIONS OUTPERFORMED THE 0.5 LB, AND THE 0.75 LB APPLICATION WAS NOT AS EFFECTIVE AS THE 0.5 LB TESTS.

THE PARTICULARLY POOR PERFORMANCE OF THE 0.75 LB APPLICATION AS SHOWN IN THE TABLES MAY BE EXPLAINED BY MARGINAL AERIAL APPLICATION. THE SCHEDULED APPLICATION HAD BEEN TWICE CANCELLED BECAUSE OF HIGH WINDS WHICH ALSO GROUNDED THE FOREST SERVICE CONTROL PROGRAM IN WASHINGTON. AFTER MORE THAN 10 DAYS IT BECAME IMPERATIVE TO SPRAY IMMEDIATELY OR THE LARVAE WOULD BE TOO FAR DEVELOPED. SO THE APPLICATION WAS MADE UNDER GUSTY 9-12 MPH WINDS. EVEN WITH A TREE TOP APPLICATION, IT CAN BE ASSUMED THAT A LARGE PERCENT OF THE SPRAY MATERIAL NEVER REACHED THE TARGET PLOT.

HOWEVER, THERE IS NO SIMILAR EXPLANATION FOR THE GOOD PERFORMANCE OF THE 0.25 LB APPLICATIONS. ON THE AVERAGE, THESE THREE APPLICATIONS OUTPERFORMED THE 0.5 LB/ACRE TESTS INBOTH LARVAL MORTALITY AND NET DEFOLIATION. THIS ACTIVITY WAS SO UNEXPECTED THAT A SECOND LARGE ACREAGE PLOT WAS ESTABLISHED AND TREATED WITH 0.25 LBS TO INSURE THAT THE FIRST RESULTS WERE NOT A FLUKE. IT WOULD APPEAR THAT, IN A WATER CARRIER, THE 0.25 LB RATE IS MORE EFFICACIOUS THAN THE 0.5 LB RATE.

LARVAL MORTALITY

APPLICATION			PERCENT (%) BUDWORM REDUCTION				NO. LARVAE/100 BUDS REMAINING
CONC	CARRIER	PLOT	+2	+5	+10	+15	
0.75	water	60	58	76	67	87	2.1
0.50	water	600	50	68	80	94	1.3
0.50	water	60	59	71	73	78	4.2
0.25	water	600	82	95	92	96	1.3
0.25	water	500	51	73	68	81	2.1
0.25	water	60	65	86	89	91	2.9
0.125	water	60	2	30	44	40	14.0
0.125	+NL	100	65	72	73	85	2.1
0.50	oil	60	52	64	81	87	1.7
0.25	oil	60	23	30	51	57	4.8
1.00	SEVIN	60	49	64	89	94	2.0
0.00	CONTROLS	60	9	18	34	54	8.6

TABLE 6.

IMIDAN EFFICACY-1977

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APPLICATION			PERCENT DEFOLIATION			(%) FOLIAGE PROTECTION
CONC	CARRIER	PLOT	PRE-	POST-	NET	
0.75	water	60	68.1	91.5	23.4	26.4
0.50	water	600	35.9	58.1	22.2	27.6
0.50	water	60	15.8	36.6	20.8	29.0
0.25	water	600	61.5	68.5	7.0	42.8
0.25	water	500	37.3	55.9	18.6	31.2
0.25	water	60	62.0	76.2	14.2	35.6
0.125	water	60	49.8	78.7	28.9	20.9
0.125	+NL	100	81.5	78.9	-2.6	52.4
0.50	oil	60	18.4	28.7	10.3	39.5
0.25	oil	60	24.4	56.4	32.0	17.8
1.00	SEVIN	60	29.7	53.4	23.7	26.1
0.00	CONTROLS	60	46.4	96.2	49.8	----

TABLE 7.

FOLIAGE PROTECTION-1977

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ALSO NOTE THE REMARKABLE DIFFERENCE BETWEEN THE 0.125 LB TEST AND THE 0.125 LB TEST WITH THE STICKER/SPREADER AGENT: LARVAL MORTALITY WAS DOUBLED AND POST-TREATMENT DEFOLIATION WAS COMPLETELY ARRESTED. THE NEGATIVE 2.6% NET DEFOLIATION VALUE LISTED IS WITHIN THE ±5% SAMPLING ERROR, AND REPRESENTS ESSENTIALLY ZERO NET DEFOLIATION.

FINALLY, THE TWO 1977 OIL-BASED APPLICATIONS IN TABLE 6 SHOULD BE COMPARED WITH THEIR COUNTERPARTS FROM 1976 IN TABLE 2. IN TERMS OF BUDWORM REDUCTION, THE 0.5 LB TEST RESULTED IN 87% MORTALITY IN 1977, AND 88% IN 1976; THE 0.25 LB RESULTS WERE 57% IN 1977, AND 61% IN 1976. BOTH RATES GAVE ESSENTIALLY THE SAME RESULTS IN BOTH YEARS.

DISCUSSION

THERE IS A STRIKING DIFFERENCE BETWEEN THE EFFICACY OF IMIDAN APPLIED WITH A WATER CARRIER AND WITH AN OIL CARRIER. THE 1975 FIELD TESTS, APPLIED IN WATER, ARE DISPLAYED IN FIGURE 3. THE 1.0 LB/ACRE APPLICATION IS NOT SHOWN IN THIS GRAPH SINCE IT WAS APPLIED WITHOUT ANY CARRIER: THE 1.0 LB/GAL EC FORMULATION CANNOT BE DILUTED IF IT IS TO BE APPLIED AT 1.0 GAL/ACRE. COMPARE THESE RESULTS WITH FIGURE 4 WHICH SHOWS THE #80 NOZZLE-OIL BASED TESTS FROM 1976. THE DOTTED LINE IN BOTH GRAPHS IS THE 90% LARVAL MORTALITY LEVEL. OBSERVE THAT IN THE WATER-BASED TESTS, THE RATE OF MORTALITY (THE SLOPE OF THE LINES) IS QUITE STEEP INITIALLY, WHILE IN THE OIL-BASED TESTS THE OVERALL RATE OF MORTALITY IS MUCH MORE GRADUAL. THIS DIFFERENCE CAN BE SEEN MORE

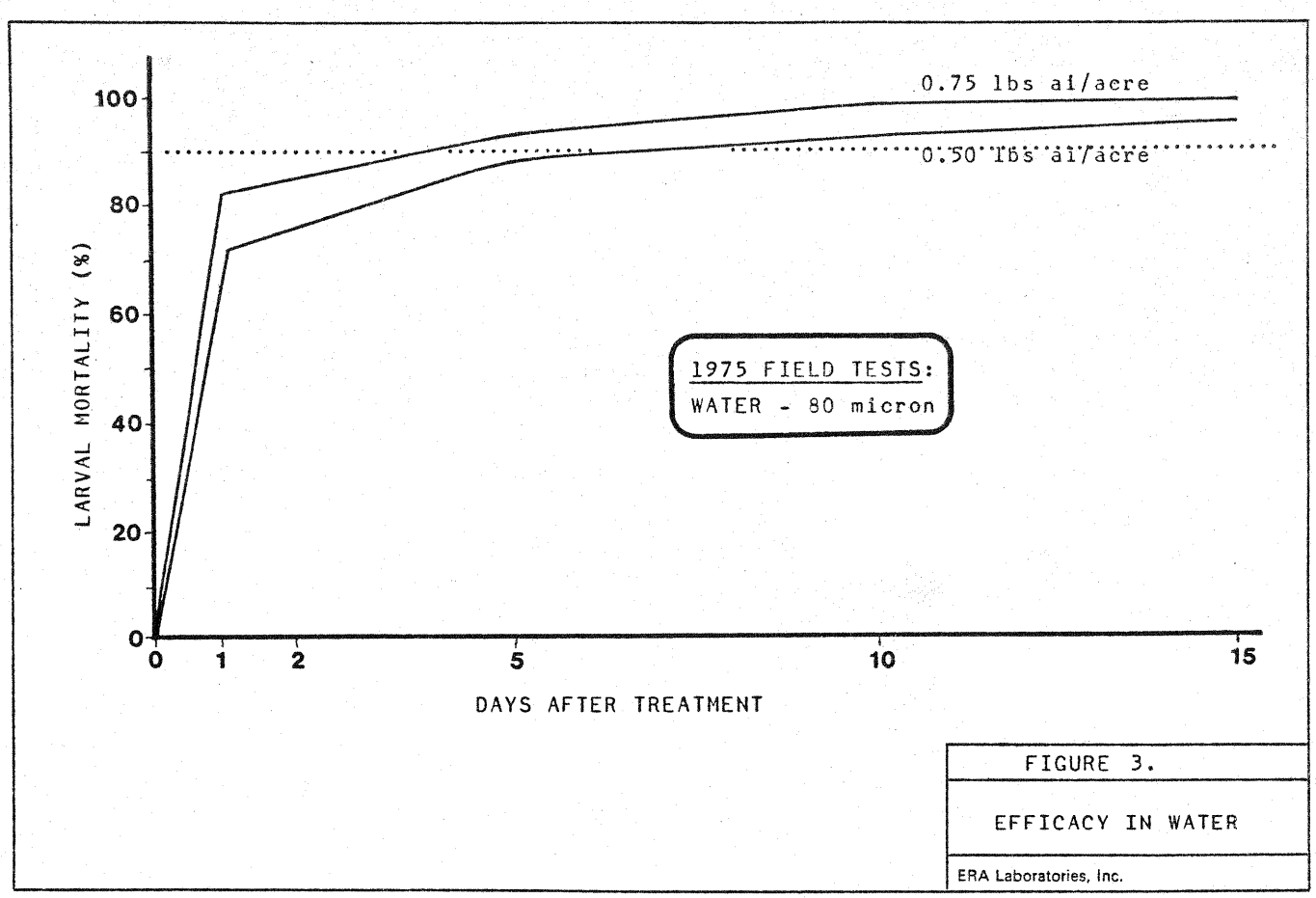

FIGURE 3.

EFFICACY IN WATER

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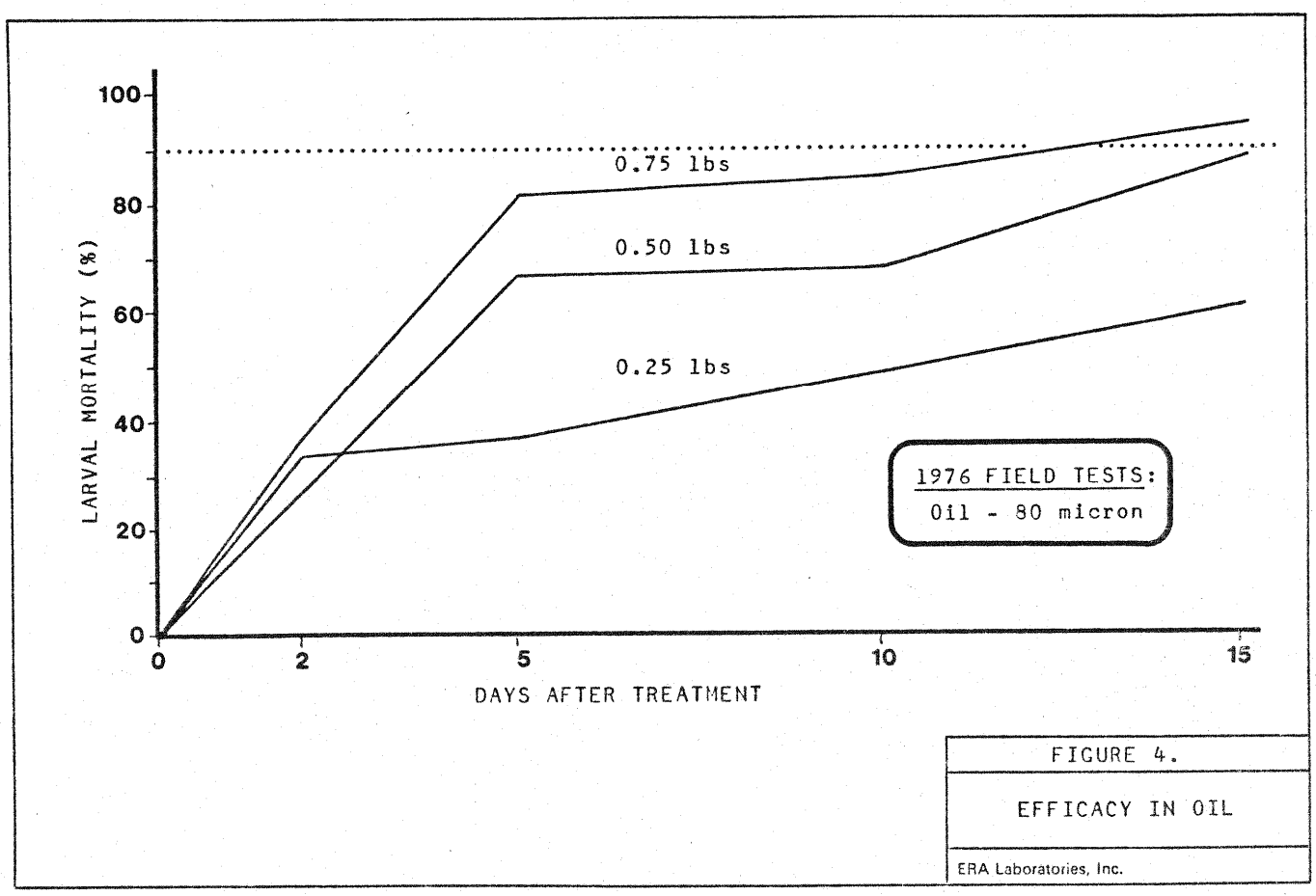

FIGURE 4.

EFFICACY IN OIL

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CLEARLY IN FIGURE 5 WHICH PLOTS ONLY THE LARVAL MORTALITY RESULTS FOR THE 0.75 LB APPLICATIONS FROM 1975 (WATER) AND 1976 (OIL). THE SHADED AREA BETWEEN THE CURVES REPRESENTS THE APPARENT ACTIVITY THAT IS LOST WHEN GOING FROM WATER TO OIL AS A DILUENT. ALTHOUGH BOTH APPLICATIONS EVENTUALLY RESULT IN SIMILAR TOTAL MORTALITY (98 VERSUS 94%), THE WATER-BASED APPLICATION REDUCES THE BUDWORM POPULATION MUCH MORE RAPIDLY. ONE ADVANTAGEOUS EFFECT OF THIS RAPID RATE OF MORTALITY MAY BE INCREASED FOLIAGE PROTECTION, SINCE FEWER LARVAE ARE ABLE TO EAT, AND FOR A SHORTER TIME.

ALTHOUGH THE 1976 OIL-BASED APPLICATIONS WERE NOT AS A GROUP AS EFFECTIVE AS THE 1975 WATER-BASED TRIALS, THEY DID PRODUCE A MUCH CLEARER DOSE-MORTALITY RELATIONSHIP. AS PREVIOUSLY MENTIONED, THE GREATER THE APPLIED DOSAGE, THE GREATER THE LARVAL MORTALITY. THIS IS DEMONSTRATED IN FIGURE 6. THE RESULTS FROM TWO 0.75, FOUR 0.5 AND FOUR 0.25 LB/ACRE TESTS HAVE BEEN AVERAGED TO SHOW THE EFFECT OF CONCENTRATION REGARDLESS OF NOZZLE OR CARRIER. THE SLOPE OF THESE CURVES FLATTENS NOTICEABLY WITH DECREASING CONCENTRATION.

THE EFFECT OF USING DIFFERENT CARRIERS ON LARVAL MORTALITY IS SHOWN IN FIGURE 7. IN THIS GRAPH, LINES 1, 2 AND 3 ARE THE 1975 APPLICATIONS; ALL OTHERS ARE FROM 1976. ALL TESTS SHOWN WERE APPLIED USING #80 NOZZLES ONLY. PLEASE NOTE THAT LINES 1 AND 3 WERE ALSO SHOWN IN FIGURE 3; LINES 4, 5 AND 6 WERE SHOWN IN FIGURE 4.

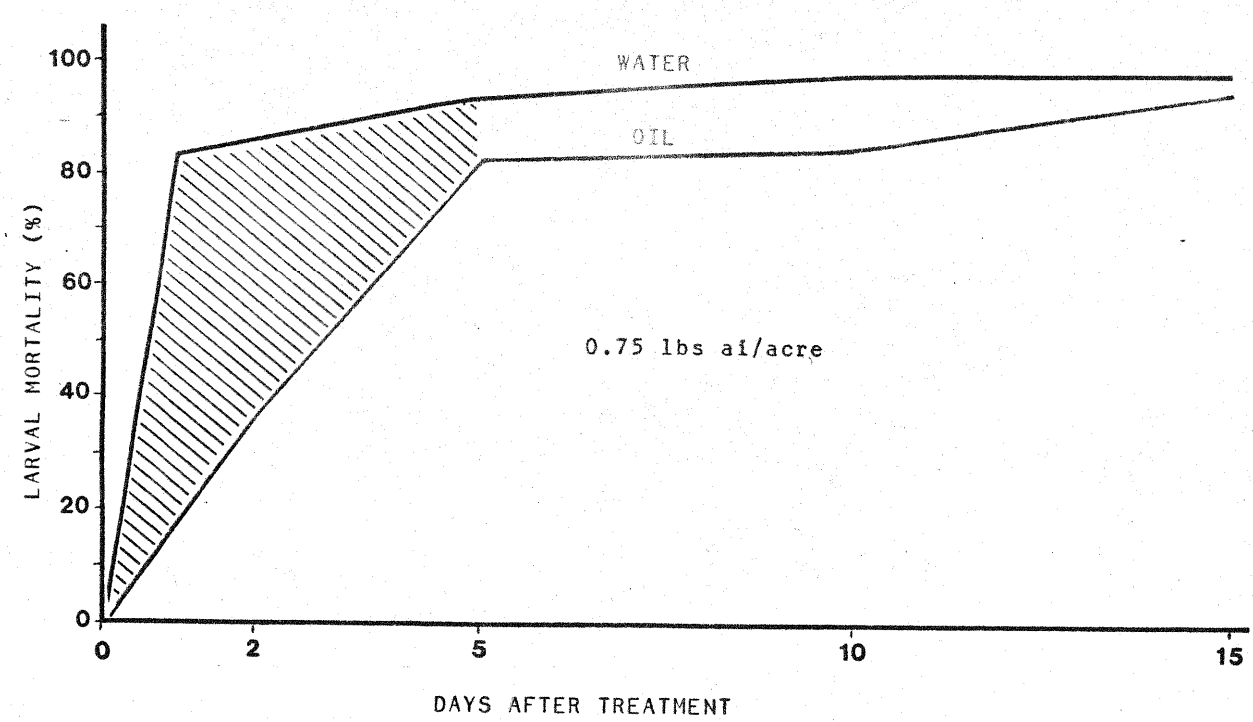

FIGURE 5.

OIL/WATER COMPARISON

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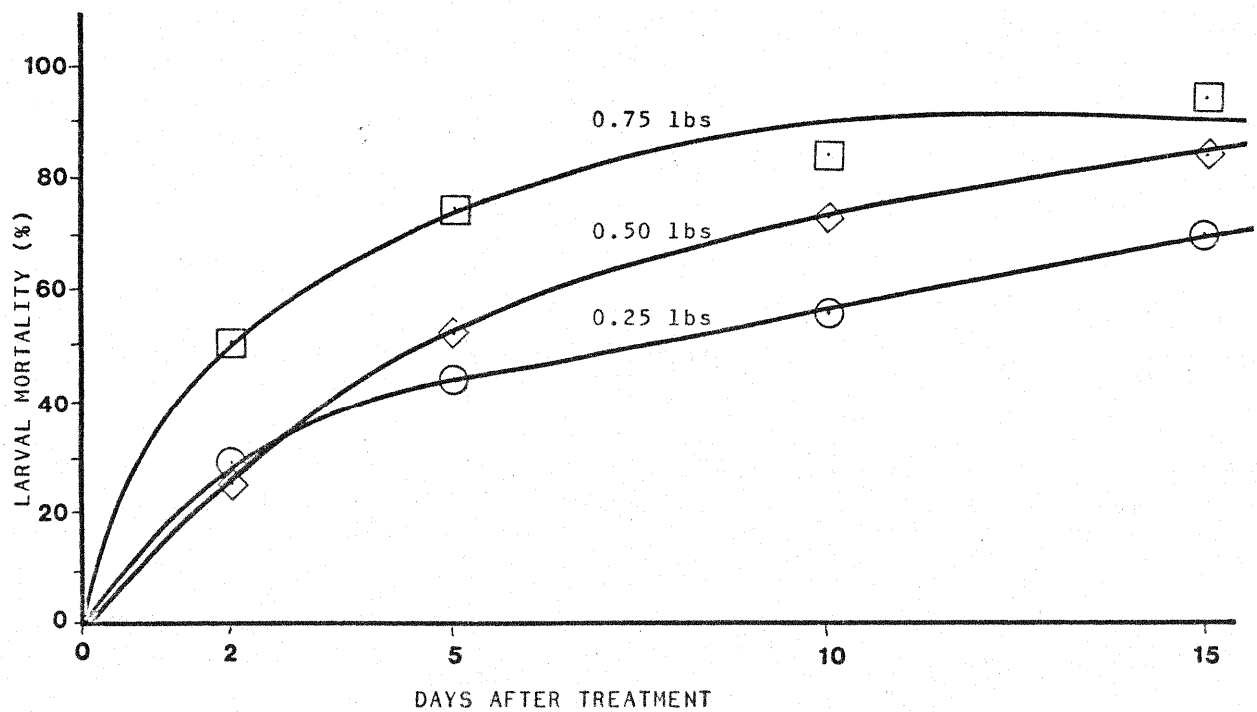

FIGURE 6.

AVERAGE DOSE EFFICACY

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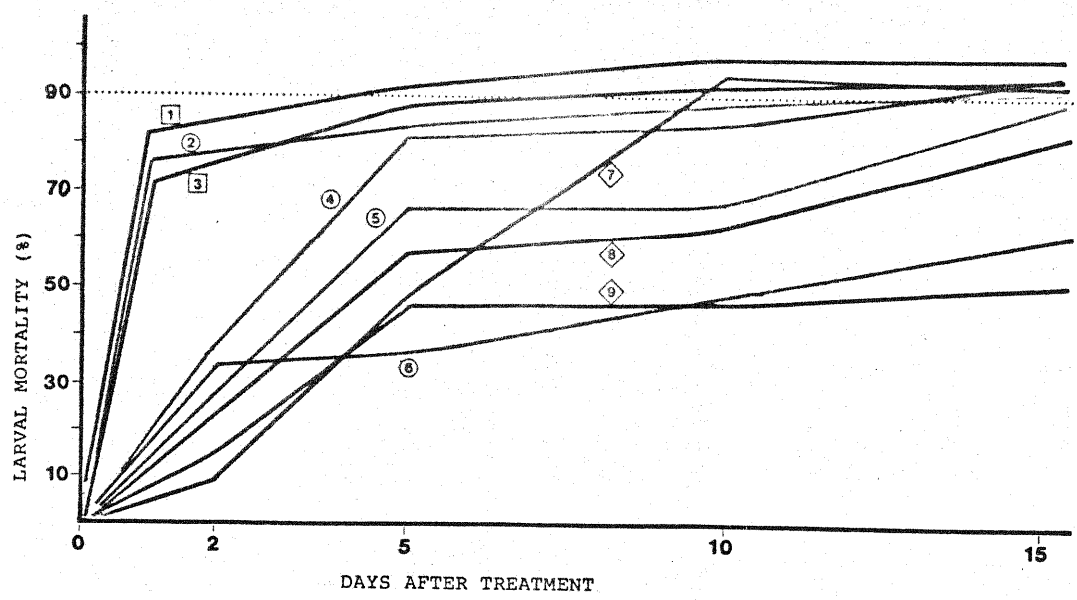

FIGURE 7.

EFFECT OF CARRIER ON RATE OF MORTALITY

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THE LINES NUMBERED IN BOXES WERE WATER-BASED APPLICATIONS; THOSE IN CIRCLES WERE OIL-BASED; AND THOSE IN DIAMONDS WERE APPLIED WITHOUT A CARRIER. A KEY TO EACH FOLLOWS:

1. 0.75 LB - WATER	4. 0.75 LB - OIL	7. 0.75 - NONE
2. 1.00 LB - NONE	5. 0.50 LB - OIL	8. 0.50 - NONE
3. 0.50 LB - WATER	6. 0.25 LB - OIL	9. 0.25 - NONE

THREE DISTINCT GROUPINGS BECOME APPARENT IN THESE PLOTS OF LARVAL MORTALITY, EACH WITH A DIFFERENT INITIAL SLOPE. LINES 7, 8 AND 9 SHOW THE RATE OF MORTALITY FOR THREE CONCENTRATIONS OF IMIDAN APPLIED AS STRAIGHT FORMULATED MATERIAL. LINES 4, 5 AND 6, WHICH ARE DILUTED 1:1 WITH OIL FORM THE NEXT GROUP WITH SIMILAR SLOPES; AND LINES 1 AND 3 FORM THE LAST GROUP, THOSE WITH THE GREATEST INITIAL LARVAL MORTALITY. IT IS RELATIVELY CLEAR THAT USING AN OIL CARRIER WILL RESULT IN MORE ACTIVITY THAN A DIRECT APPLICATION, AND THAT USING WATER AS A CARRIER INCREASES THIS RATE OF ACTIVITY EVEN MORE.

HOWEVER, AT ANY GIVEN CONCENTRATION THE TYPE OF CARRIER USED WILL AFFECT ONLY THE RATE OF ACTIVITY, NOT THE TOTAL LARVAL REDUCTION. FOR EXAMPLE, LINES 1, 4 AND 7 EACH REPRESENT A 0.75 LB/ACRE APPLICATION IN A DIFFERENT CARRIER. BUT ALL THREE RESULT IN 93-96% MORTALITY BY DAY 15. SIMILARLY, LINES 3, 5 AND 8 ARE EACH 0.5 LB/ACRE APPLICATIONS, AND EACH RESULTS IN ABOUT 85% OVERALL MORTALITY.

PERHAPS THIS EFFECT OF CARRIER ON IMIDAN EFFICACY CAN BE MORE CLEARLY EXPRESSED BY PRESENTATION IN A DIFFERENT FORMAT. FIGURE 8 IS A PROBIT ANALYSIS GRAPH OF LARVAL MORTALITY VALUES FOR EACH OF THE 1975 WATER AND 1976 OIL TESTS. ALSO INCLUDED ARE THE 1977 RESULTS FOR BOTH WATER AND OIL CARRIERS. THESE DATA POINTS ARRANGE THEMSELVES ALONG TWO SEPARATE DOSE-MORTALITY CURVES, ONE FOR WATER, AND ONE FOR OIL-BASED APPLICATIONS. THE 1977 0.75 LB/ACRE APPLICATION VALUE WHICH IS CONSIDERABLY BELOW THE WATER LINE SHOULD BE IGNORED. THIS WAS THE SPRAY APPLIED UNDER WINDY CONDITIONS AND DOES NOT REPRESENT THE TRUE EFFICACY OF THAT CONCENTRATION. ALSO NOTICE THAT THE TWO 0.50 LB APPLICATIONS IN WATER FROM 1975 AND 1977 ARE QUITE SIMILAR, AS ARE THE 0.5 AND 0.25 OIL-BASED TESTS FROM 1976 AND 1977.

THE EFFECT ON EFFICACY OF USING DIFFERENT SPRAY DELIVERY SYSTEMS CAN BE BRIEFLY EXAMINED BY COMPARING FIGURES 9 AND 10. FIGURE 9 SHOWS THE LARVAL MORTALITY CURVES FOR THE TWO 0.5 LB TESTS IN MONTANA, ONE APPLIED DIRECT, THE OTHER

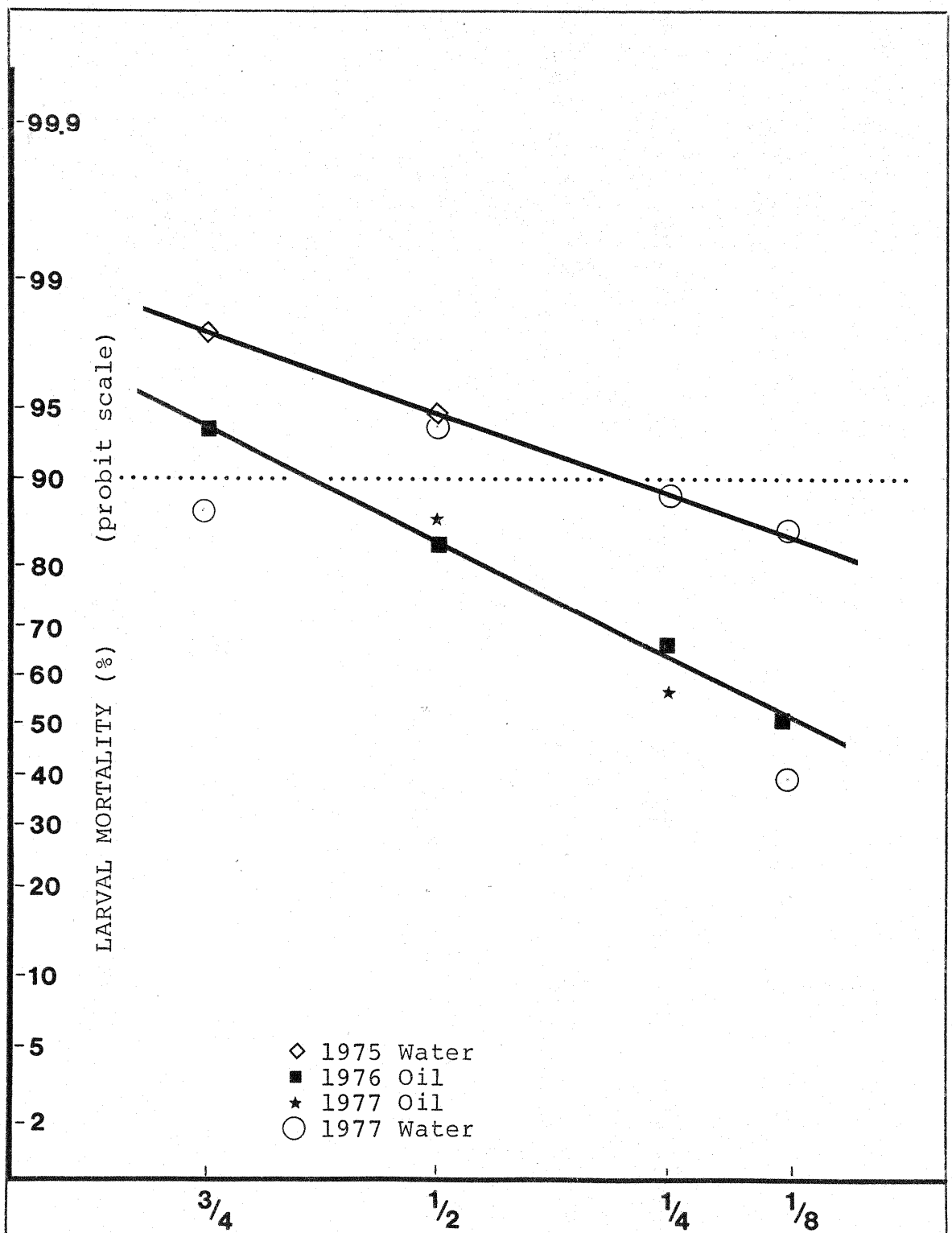

Figure 8.

15 DAY MORTALITY

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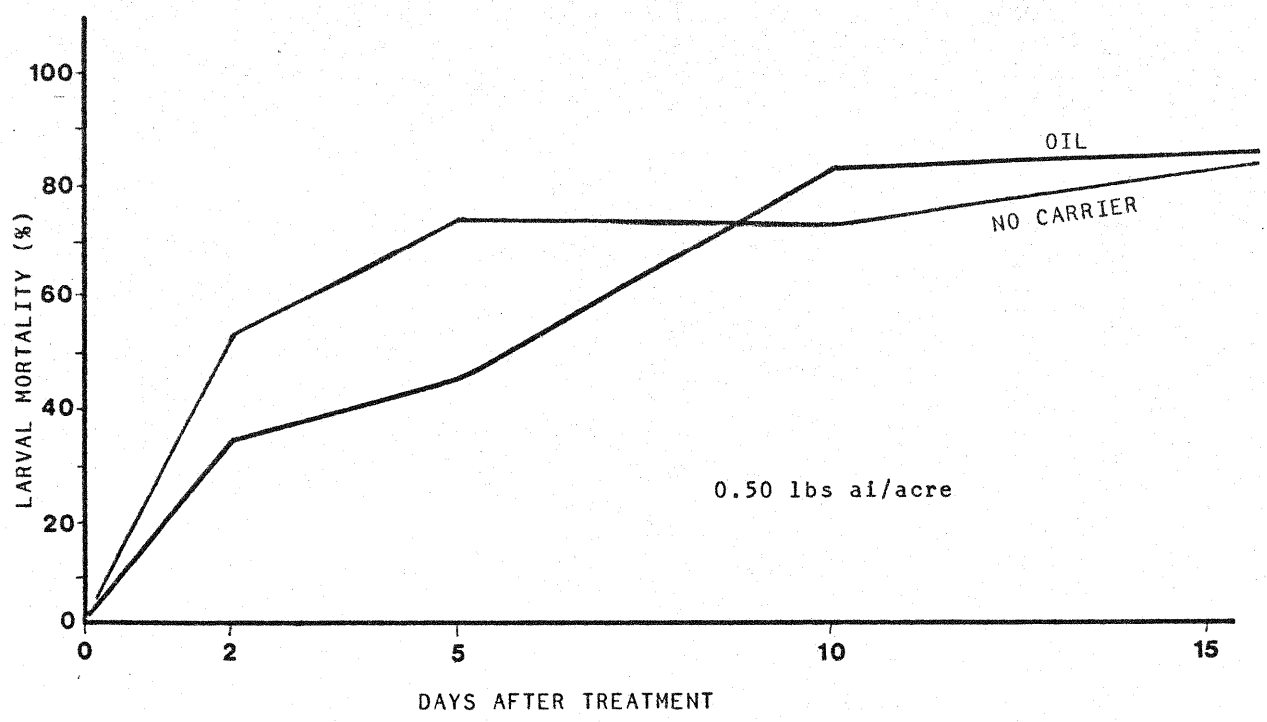

Figure 9.

HALF POUND EFFICACY: MONTANA TESTS

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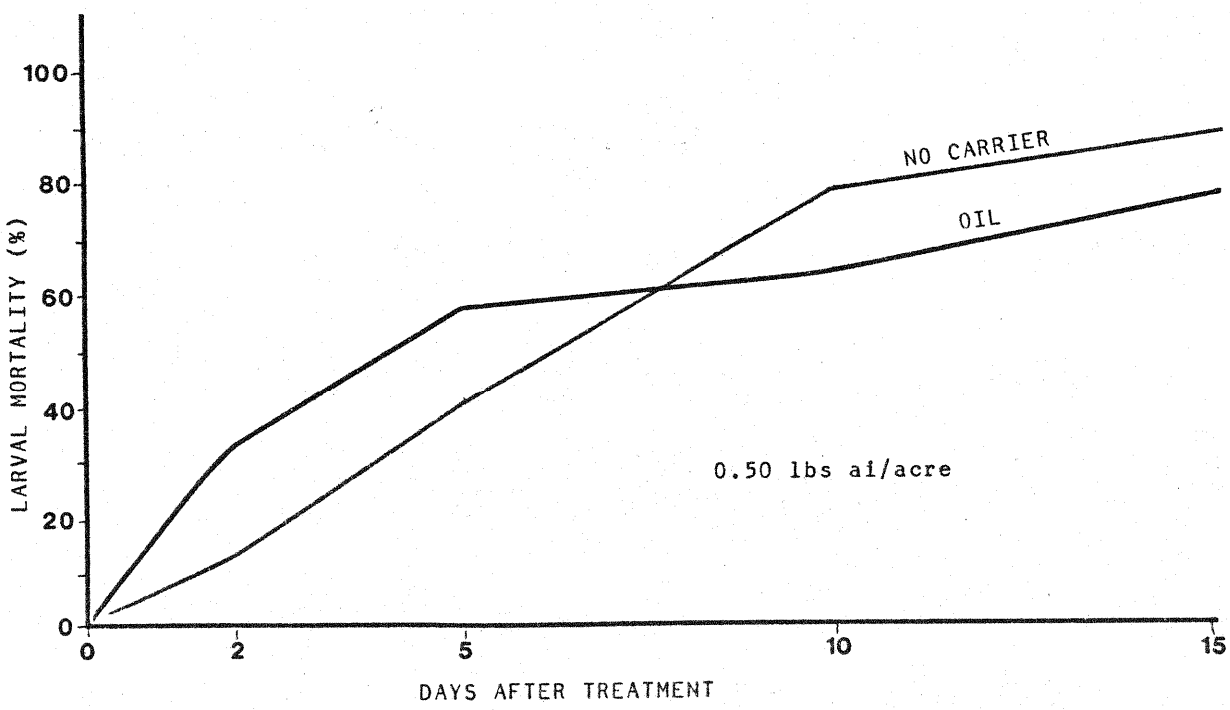

FIGURE 10.

HALF POUND EFFICACY: WASHINGTON TESTS

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IN OIL. BOTH WERE APPLIED BY AIRPLANE USING CONVENTIONAL TEEJET D-6 NOZZLES. FIGURE 10 SHOWS THE EQUIVALENT TESTS IN WASHINGTON WHICH WERE APPLIED BY HELICOPTER WITH BEECOMIST SPINNING NOZZLES. OTHER THAN SMALL VARIATIONS, EACH TYPE OF APPLICATION PRODUCED THE SAME MORTALITY CURVE. THIS CERTAINLY SEEMS TO INDICATE THAT CONVENTIONAL SPRAY EQUIPMENT, AND FIXED-WING AIRCRAFT, CAN BE USED JUST AS EFFECTIVELY AS BEECOMIST EQUIPPED HELICOPTERS IF NECESSARY.

THERE ARE A NUMBER OF ASSUMPTIONS UNDERLYING THE BASIC EXPERIMENTAL DESIGN OF THESE FIELD TRIALS. ONE OF THESE IS THAT THE BUDWORM POPULATIONS WHICH WERE USED EACH YEAR WOULD YIELD REPRODUCIBLE RESULTS; THAT IS, THAT THEY MAINTAINED THE SAME TYPE OF POPULATION DYNAMICS OVER EACH OF THE THREE YEARS. FIGURE 11 PLOTS THE LARVAL MORTALITY THROUGHOUT THE TRIAL PERIODS FOR EACH OF THE THREE YEARS. OBVIOUSLY, THEY ARE QUITE SIMILAR, AND DO NOT DISPLAY THE CHARACTERISTIC COLLAPSE WHICH FOLLOWS THE BUILDING, OUTBREAK PHASE OF AN EPIDEMIC INFESTATION. ANOTHER ASSUMPTION IS THAT TEST APPLICATIONS FROM YEAR TO YEAR WILL BE SIMILAR ENOUGH FOR VALID COMPARISON. AS PREVIOUSLY MENTIONED, THE AVERAGE SPRAY DEPOSIT FOR THE 1975 TRIALS WAS 19% OF THE APPLIED MATERIAL, WHILE THE AVERAGE FOR ALL 1976 TRIALS WAS 21%. SIMILARLY, WHEN IDENTICAL TREATMENTS ARE COMPARED IN DIFFERENT YEARS, THE LARVAL MORTALITY VALUES ARE VERY CLOSE. NOTE PARTICULARLY THE 0.5 AND 0.25 LB/ACRE OIL-BASED APPLICATIONS IN 1976 AND 1977, AND THE 1975 AND 1977 0.5 LB/ACRE WATER APPLICATIONS. ALL THREE COMPARISONS SUPPORT THE THESIS THAT, WHEN APPLIED BY IDENTICAL MEANS, A TEST TREATMENT WILL PRODUCE THE SAME RESULTS, ALLOWING A VALID

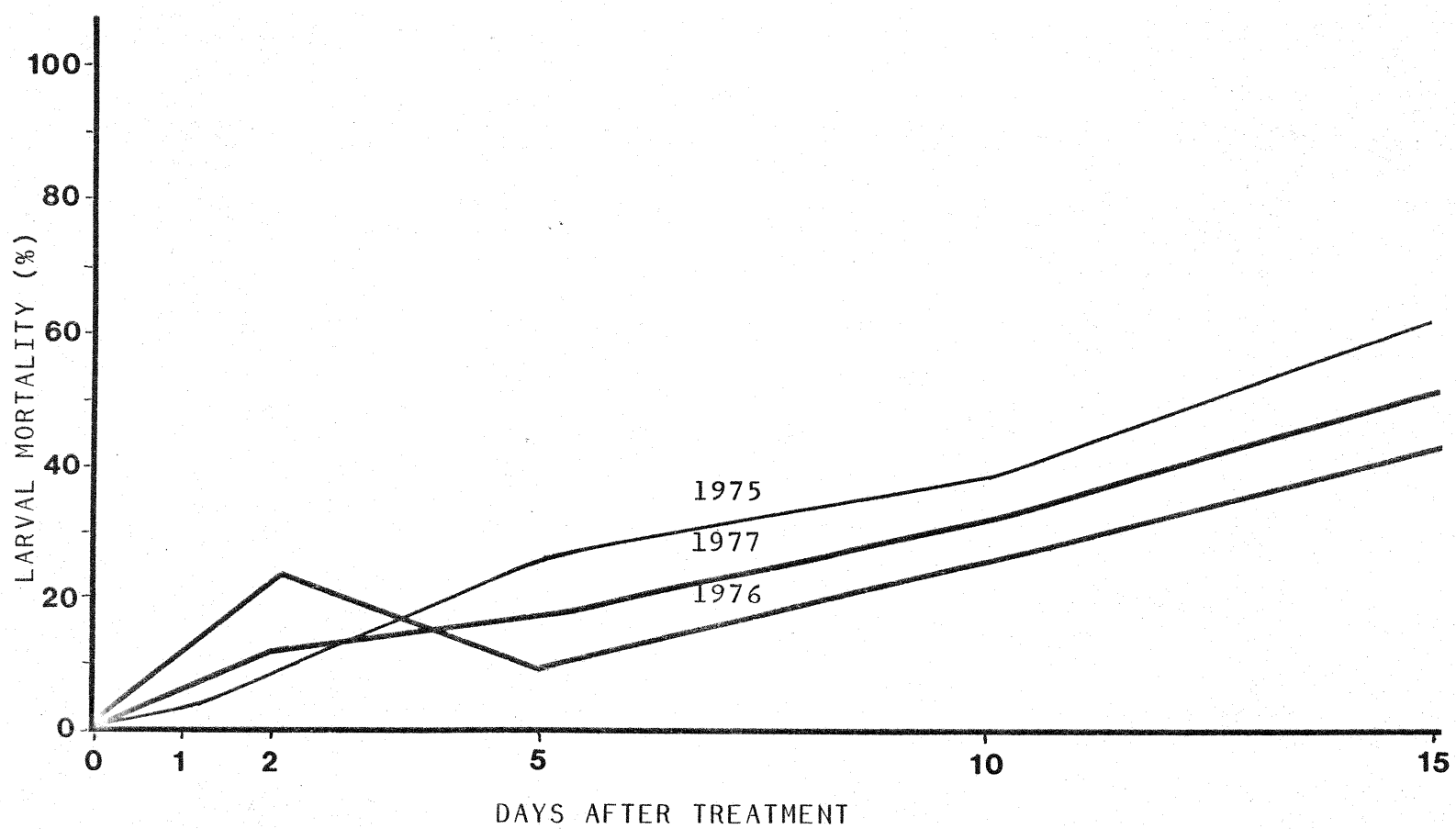

FIGURE 11.

WESTERN SPRUCE BUDWORM CONTROL POPULATIONS

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COMAPRISON FROM ONE YEAR TO THE NEXT. ONE FURTHER ASSUMPTION IS THAT TESTING ON 60 ACRE BLOCKS WILL YIELD DATA WHICH CAN BE EXTRAPOLATED TO THE LARGER BLOCKS WHICH WOULD BE USED IN AN ACTUAL SPRUCE BUDWORM SUPPRESSION PROGRAM. FIGURES 9 AND 10 CAN ALSO BE USED TO SUPPORT THIS ASSUMPTION. THE 0.5 LB TESTS IN FIGURE 9 WERE APPLIED AND EVALUATED ON 60 ACRE BLOCKS; THE 0.5 LB TESTS IN FIGURE 10 ON 600 ACRE BLOCKS. THE LARGE ACREAGE RESULTS ARE VIRTUALLY THE SAME AS FOR THE SMALLER BLOCK RESULTS. LIKEWISE, FROM TABLES 6 AND 7, SIMILAR EFFICACY RESULTS CAN BE OBTAINED BY COMPARING THE 60 ACRE 0.5 AND 0.25 LB TESTS AND THE 600 ACRE 0.5 AND 0.25 LB TESTS. ALL OF THESE COMPARISONS INDICATE THAT THE BASIC DESIGN OF THESE TESTS, THAT IS, USING 60 ACRE BLOCKS TO TEST A LARGE NUMBER OF COMBINATIONS OVER A NUMBER OF YEARS, IS SOUND.

IT WAS PREVIOUSLY MENTIONED THAT THE OIL-CARRIED APPLICATIONS RESULTED IN A CLEAR DOSE RELATED EFFECT WHILE THE WATER-BASED TESTS DID NOT. THIS HOLDS TRUE FOR FOLIAGE PROTECTION AS WELL AS LARVAL MORTALITY. THIS RELATIONSHIP BETWEEN APPLIED DOSE AND NET DEFOLIATION IS SHOWN IN FIGURE 12, FOR BOTH THE 1976 AND 1977 OIL-CARRIED TESTS. AS IS CLEAR FROM THE GRAPH, TO OBTAIN A REASONABLE DEGREE OF FOLIAGE PROTECTION USING AN OIL CARRIER, 0.5 LBS/ACRE OR MORE OF IMIDAN WOULD BE NECESSARY. HOWEVER, FROM TABLE 7, ONLY 0.25 LBS/ACRE OR LESS IN WATER WOULD YIELD THE SAME RESULTS, AS WITH LARVAL MORTALITY, THE FOLIAGE PROTECTION OFFERED BY WATER-BASED APPLICATIONS IS GREATER THAN OIL-BASED. INDEED, THE 0.125 LB/ACRE APPLICATION WITH THE TARGET NL STICKER/SPREADER AGENT ADDED TO THE WATER

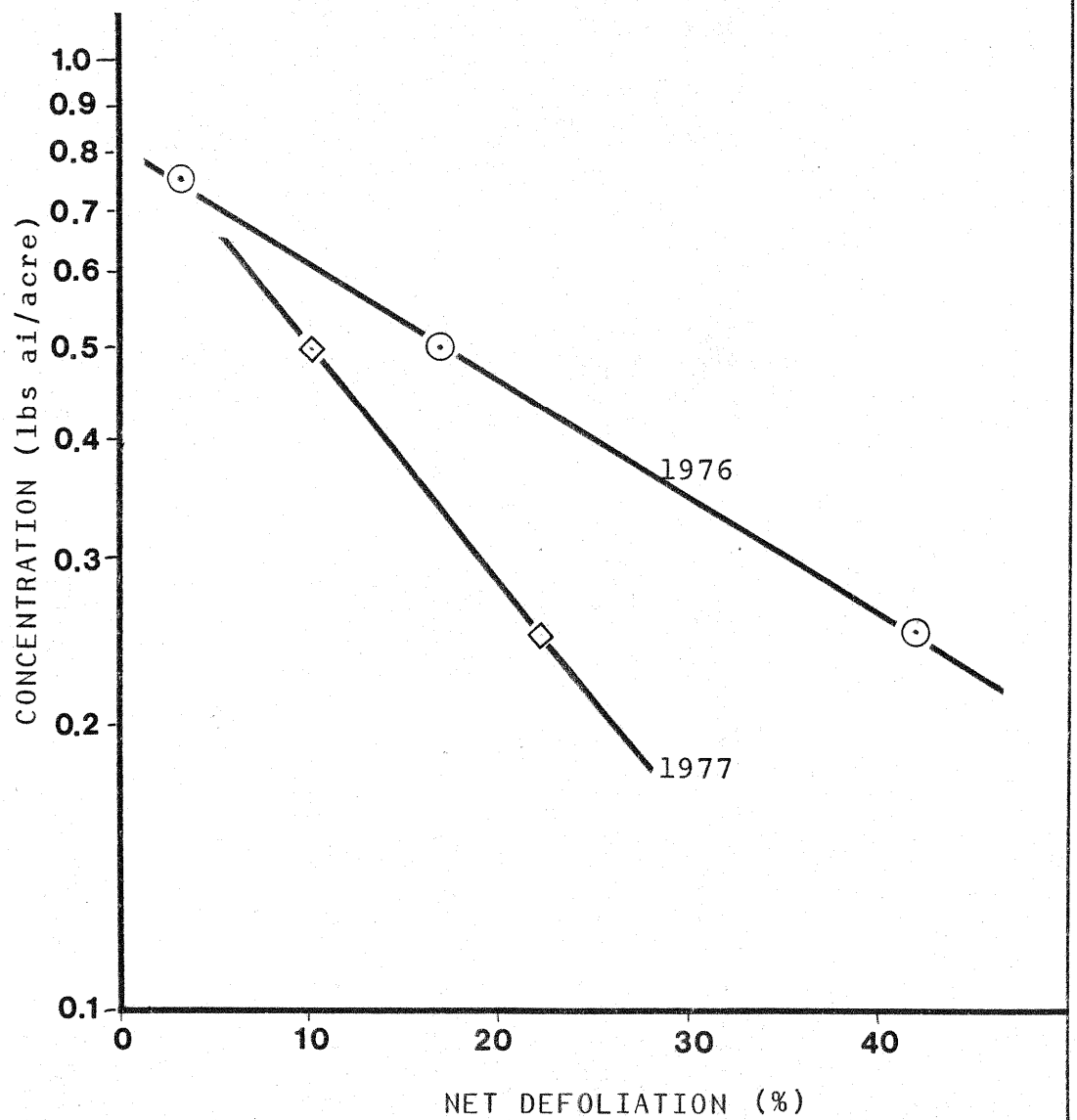

FIGURE 12.

FOLIAGE PROTECTION

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CARRIER ACTUALLY RESULTED IN ZERO NET DEFOLIATION.

THIS STICKER/SPREADER AGENT NOT ONLY RESULTED IN EXCELLENT FOLIAGE PROTECTION, BUT APPARENTLY DOUBLED THE ACTIVITY OF THE 0.125 LB DOSE. FIGURE 13 SHOWS THE COMPARISON OF THE TWO 0.125 LB TRIALS FROM 1977; THE UPPER LINE IS WITH THE TARGET NL, THE LOWER LINE IS WITHOUT. OTHERWISE, THE TWO APPLICATIONS WERE IDENTICAL: BOTH USED #80 NOZZLES, WERE DILUTED IN WATER, AND APPLIED TO SMALL BLOCKS. THE DIFFERENCE IN ACTIVITY, SHOWN IN FIGURE 13 AND IN TABLES 6 AND 7, SPEAKS FOR ITSELF. IT SHOULD BE CAUTIONED HOWEVER, THAT WHILE THE FOLIAGE PROTECTION WAS IMPRESSIVE, THE LARVAL MORTALITY, EVEN THOUGH DOUBLED, WAS STILL ONLY MARGINAL.

THE PURPOSE OF THIS SERIES OF FIELD TRIALS WAS TO DETERMINE THE LOWEST CONCENTRATION OF IMIDAN WHICH WOULD RESULT IN EFFICACY DATA ACCEPTABLE FOR BUDWORM CONTROL. FROM THE DATA PRESENTED, EITHER 0.5 A.I./ACRE IN OIL OR 0.25 LBS A.I./ACRE IN WATER WILL ACHIEVE A REDUCTION IN LARVAL POPULATIONS OF 95%, LEAVING LESS THAN 2 LARVAE/100 BUDS, AND ALSO ACHIEVE SUBSTANTIAL FOLIAGE PROTECTION. EITHER APPLICATION WILL MATCH OR EXCEED THE RESULTS OF A 1.0 LB/ACRE APPLICATION OF SEVIN 4-OIL.

FURTHERMORE, DOSES AS LOW AS 0.125 LBS A.I./ACRE MAY ACHIEVE SUFFICIENT FOLIAGE PROTECTION TO WARRANT REGISTRATION ON THAT BASIS ALONE.

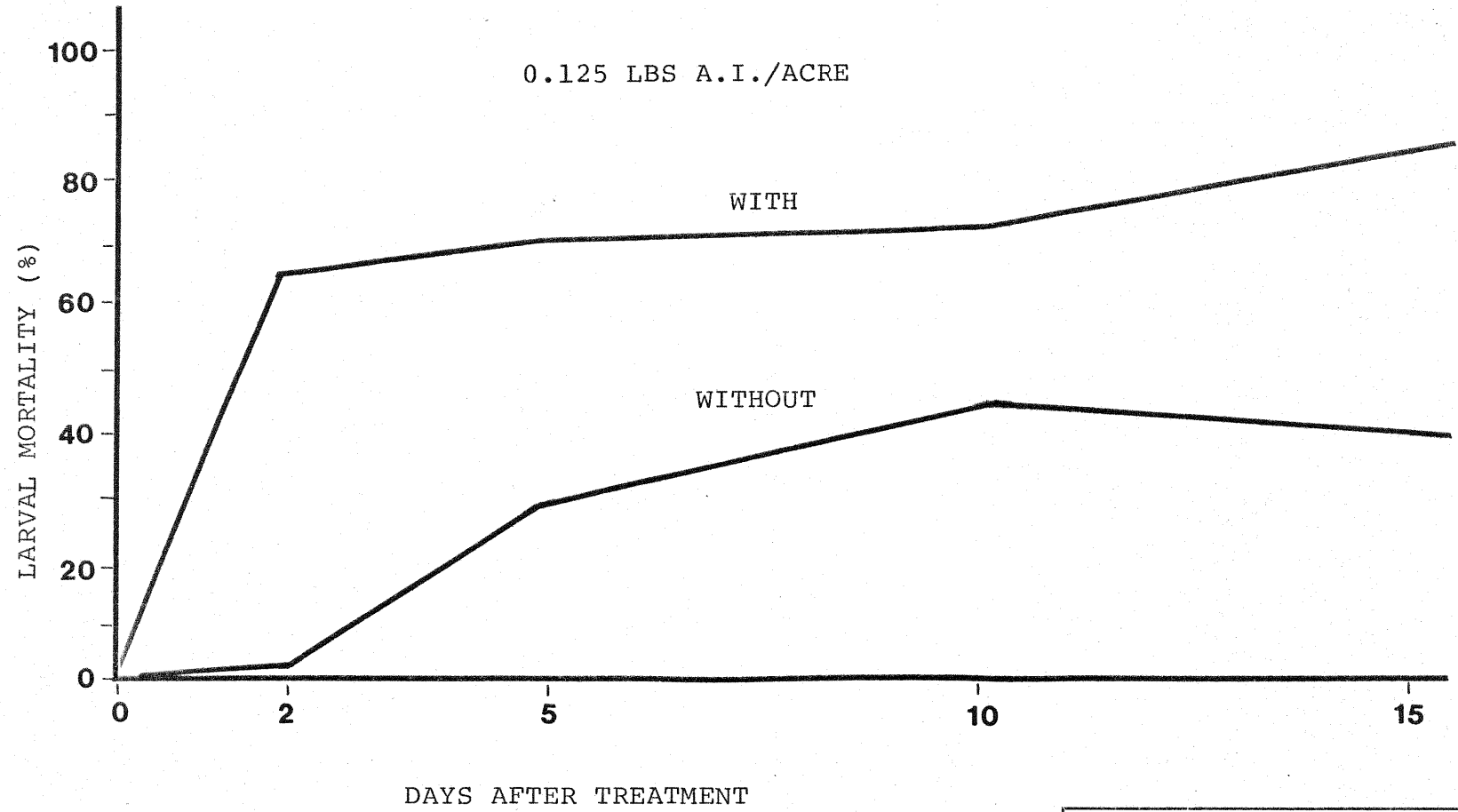

Figure 13.

STICKER/SPREADER AGENT

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