SPRUCE BUDWORM IN MAINE

The

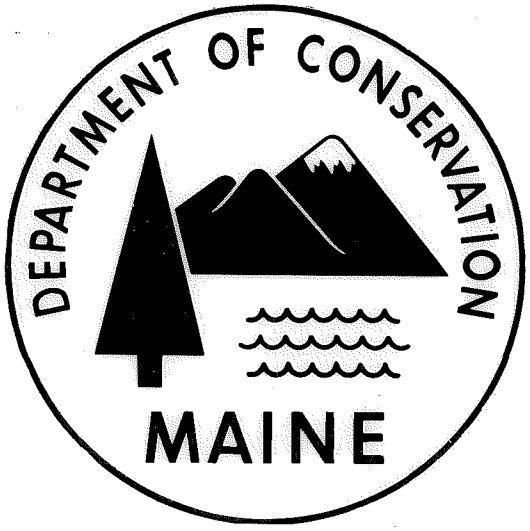
1979

Cooperative Spruce Budworm Suppression Project

and

Expected Infestation Conditions For

1980



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Authors
Henry Trial, Jr.
Ancyl S. Thurston

Maine Forest Service
Maine Dept. of Conservation
Augusta, Maine 04333

SPRUCE BUDWORM IN MAINE: 1979

The 1979 Cooperative Spruce Budworm Suppression Project and Expected Infestation Conditions for 1980

By

Henry Trial, Jr. and Ancyl S. Thurston

Entomology Division

TECHNICAL REPORT NO. 14

Maine Forest Service

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

INTRODUCTION

In May and June 1979, the Maine Forest Service conducted its Cooperative Spruce Budworm Suppression Project. The project was a cooperative venture of the State of Maine, the State's forest landowners, and the U.S. Forest Service, which supplied technical advice and financial assistance.

This report summarizes operational details of implementing the spray project and reports its effectiveness in population reduction and foliage protection. The forest condition, expected budworm populations, and tree hazard estimates for 1980 are also presented.

I. REVIEW OF SPRAY OPERATIONS

A. Introduction

Preparations for the 1979 Spruce Budworm Spray Operation (SBSO) began in late summer, 1978. High hazard areas were located in the field, plotted on U.S. Geological maps, and developed into spray blocks. Project headquarters were established in January of 1979 and personnel and equipment needs identified. Plans were developed to use two (2) major airport locations, Presque Isle and Millinocket, for fixed-wing operations. Satellite operations were established in Lincoln, Old Town, Frenchville, Red Pine, Jackman, and Greenville. Heliport sites were located in Eustis, Spencer Stream, Alder Stream, T6 R11 near Baxter Park, and Rangeley.

On May 21, 1979, all personnel, equipment, insecticide, and aircraft were assembled at Millinocket for the Millinocket airport operation and a project briefing was held. On May 28, 1979, the Presque Isle operation was ready and an assembly was held. The earliest spray date, May 19, 1979, was realized by the fixed-wing operation working from Old Town. The final date of treatment occurred at the Presque Isle operation on June 19, 1979.

Weather during the project was variable. (See Tables 1 & 2 for daily spray/no-spray information). A summary of spray days and spray periods is shown below:

LOCATION	NO. OF SPRAY DAYS*	NO. OF SPRAY PERIODS
Eustis	4	4
Spencer Stream	2	3
Alder Stream	1	1
T6 R11	2	3
Rangeley	1	1
Old Town	5	5
Lincoln	5	7
Millinocket	9	11
Greenville	2	2
Jackman	9	12
Presque Isle	12	15
Red Pine	7	10
Frenchville	3	3

* Day = Morning period and evening period

TABLE 1
DAILY SPRAY - NO SPRAY SUMMARY BY LOCATION

DATE	OLD TOWN	LINCOLN MILL.	GRNVLE	JACKMAN	PI	RED PINE	FRNVLE
May 19 AM							
PM	S						
20 AM	NS,R						
PM	NS,W						
21 AM	NS,W						
PM	S						
22 AM	NS,R						
PM	S						
23 AM	S	S					
PM	NS,W	NS,W,R	NS,W				
24 AM	NS,R	NS,W,R,	NW,R				
PM	NS,R	NS,R	NS,R				
25 AM	NS,R	NS,R	NS,R				
PM	NS,R	NS,R	NS,R				
26 AM	NS,R	NS,R	NS,R				
PM	NS,R	NS,R	NS,R				
27 AM	S,F	NS,R	NS,R				
PM		NS,R	S			NS,V	
28 AM	5 spray	S	NS,W,T	NS,V		NS,R,V	NS,R
PM	periods	NS,V,T	NS,V	NS,V		NS,R,V	NS,R
29 AM		NS,R	NS,W,T	NS,R		NS,R,W	NS,R
PM		S	NS,W,T	NS,R		NS,R,V	NS,R
30 AM		NS,R	NS,R,V	NS,R		NS,R,V	NS,R
PM		NS,R	NS,R,V	NS,R		NS,R,V	NS,R
31 AM		S	NS,V	NS,V		NS,V	NS,R
PM		S	NS,R	NS,V		S	NS,R
Jun 1 AM		S	S	NS,V		S	NS,R
PM		S,F	S	S		S	S
2 AM			S	NS,W	NS,W	S	S
PM		7 spray	NS,W	NS,W	S	NS,W	NS,W
3 AM		periods	NS,W,T	NS,W	S	NS,R	NS,V
PM			NSW,T	NS,W	S	NS,W	NS,W
4 AM			S	S	S	S	S
PM			NS,W,T	NS,W	NS,W	NS,W	S
5 AM			NS,V	NS,V	S	S	S
PM			NS,R,W	NS,V	NS,W	NS,W,R	S
6 AM			NS,W	NS,V	NS,W	NS,W	NS,W
PM			NS,W		S	S	S
7 AM			S	2 spray	S	S	S
PM			S	periods	S	S	S
8 AM			S		S	S	S,F
PM			NS,W		S	NS,W	
9 AM			NS,R		NS,R	NS,R,V	10 spray
PM			NS,R,V		NS,R,V	NS,R,V	periods

(Cont'd.)

Key: S = Spray W = Wind
NS = No Spray V = Visibility F = Finished Job
R = Rain T = Temperature

TABLE 1
DAILY SPRAY - NO SPRAY SUMMARY BY LOCATION (Cont'd.)

DATE	OLD TOWN	LINCOLN	MILL.	GRNVLE	JACKMAN	PI	RED PINE	FRNVLE
Jun 10 AM			NS,W,V		NS,W	NS,R,V		
PM			NS,W,V		NS,W	NS,V,W		
11 AM			NS,W		NS,W	NS,W		
PM			NS,W,V		S	NS,V,W		NS,W
12 AM			NS,W		NS,V	NS,R,V		NS,R
PM			NS,W		NS,W	NS,V		NS,R
13 AM			NS,R,W		NS,R,W	NS,R,W		NS,R
PM			NS,W		NS,W	NS,W		NS,W
14 AM			S		S	S		S
PM			NS,W		S,F	NS,W		NS,W
15 AM			NS,W			NS,W		NS,W
PM			NS,W		12 spray	NS,T,W		NS,W
16 AM			S		periods	NS,V,W		NS,W
PM			NS,W			NS,R,W		S
17 AM			S,F			S		S,F
PM						S		
18 AM			11 spray			S		3 spray
PM			periods			NS,W		periods
19 AM						S,F		
						15 spray		
						periods		

Key: S = Spray
NS = No Spray
R = Rain
F = Finished Job
W = Wind
V = Visibility
T = Temperature

TABLE 2. DAILY SPRAY - NO SPRAY SUMMARY BY LOCATION

HELIPORTS

Date	Eustis	Spencer Stream	Alder Stream	T6R11	Rangeley
Jun 1 AM				S	
PM				S	
Jun 2 AM				S,F	
PM				3 spray periods	
Jun 3 AM					
PM					
Jun 4 AM	S				
PM	NS,R				
Jun 5 AM	NS,W,R				
PM	NS,W,R				
Jun 6 AM	NS,W,V				
PM	S				
Jun 7 AM	S				
PM		S			S,F
					1 spray period
Jun 8 AM	S,F	S			
	4 spray periods				
PM		S,F			
		3 spray periods			
Jun 9 AM			S,F		
PM			1 spray period		

Key: S = Spray, NS = No Spray, R = Rain, W = Wind, V = Visibility, T = Temperature, F = Finished Job

Rain, wind, temperature, and visibility were the major factors influencing spray feasibility during various periods.

The personnel organization for the 1979 SBSO is shown in Figure 1. Approximately 435 people were employed by the 1979 SBSO, including 75 from the Entomological Division of the Maine Forest Service, 60 Maine Forest Service employees working on the operational aspects of the project, and 300 contractor employees which included temporary help.

B. Bases of Operation

The following locations were employed:

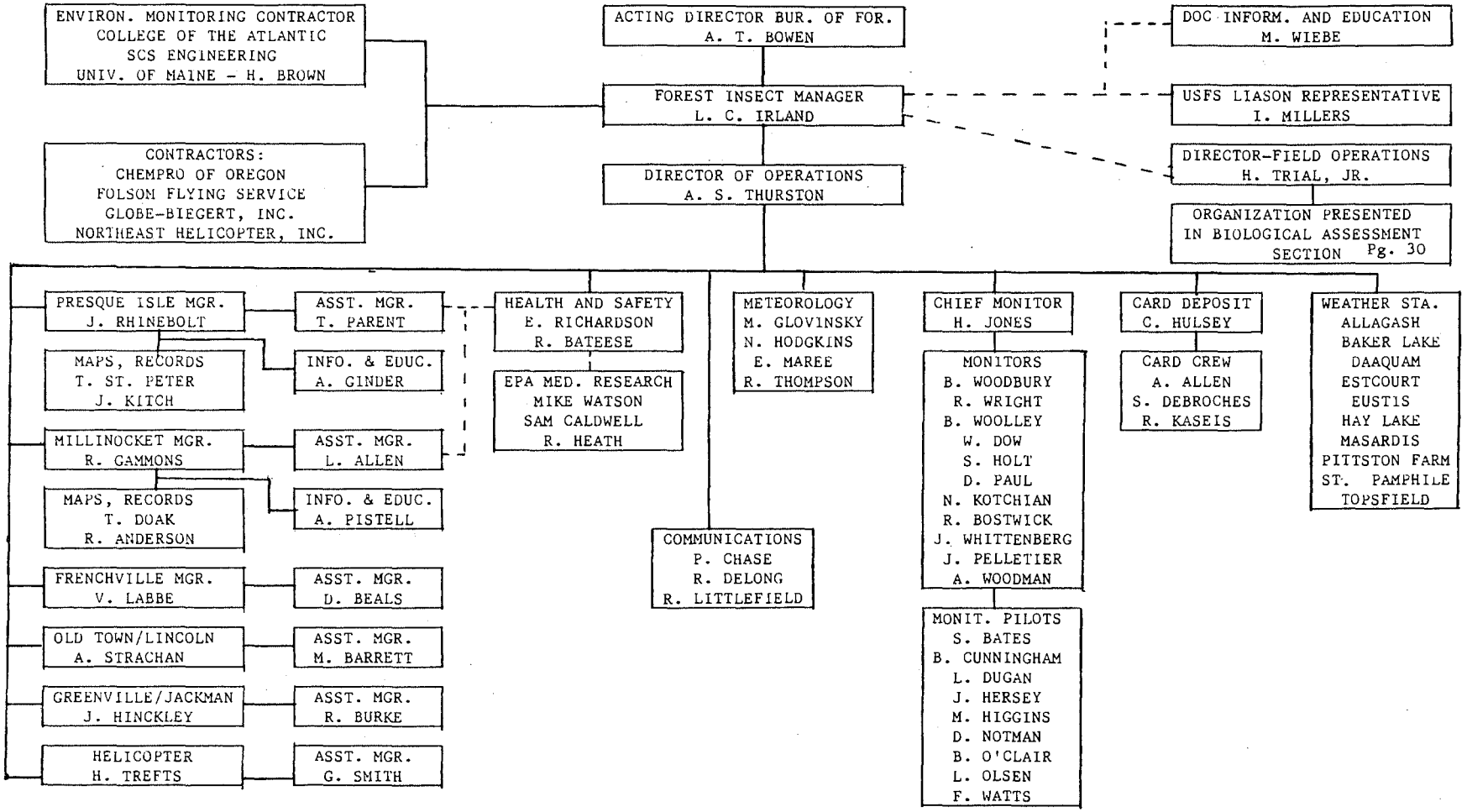
Presque Isle	-	Project headquarters and the major base operation for fixed-wing aircraft, both single and multi-engine.
Millinocket	-	Single-engine and multi-engine fixed-wing operation.
Lincoln	-	Satellite operation to the Millinocket operation for single-engine, fixed-wing.
Old Town	-	Satellite to the Millinocket operation for single-engine, fixed-wing.
Jackman	-	Single-engine, fixed-wing aircraft.
Greenville	-	Single-engine, fixed-wing aircraft.
Frenchville	-	Single-engine, fixed-wing aircraft.
Red Pine	-	Single-engine, fixed-wing aircraft.
Eustis, Spencer Stream, Alder Stream T6 R11, Rangeley	-	Rotary-wing aircraft.

The above locations were chosen as bases of operation due to the proximity of the blocks to be sprayed and facilities available for feeding and housing. In addition, Millinocket and Presque Isle offered railroad sidings for delivery of insecticide.

Feeding and housing services were provided by the following:

Millinocket	-	Local motels.
Presque Isle	-	Northern Maine Vocational Technical Institute.
T6 R11	-	MFS trailers, GNP camp eating facilities.

Figure 1.
1979 SPRUCE BUDWORM ORGANIZATIONAL CHART



Eustis, Rangeley Alder Stream, Spencer Stream	-	Local motel.
Frenchville	-	Local motel.
Red Pine	-	Local motel.
Old Town	-	Local motel.
Lincoln	-	Local motel.
Greenville	-	Local motel.
Jackman	-	Local motel.

C. Chemicals Used

Insecticides considered for the 1979 operation were Sevin, Dylox, Orthene, Fenitrothion, Lannate, *Bacillus thuringiensis* (BT), and Matacil. However, as in the 1978 operation, only Sevin, Dylox, Orthene, and BT were used (Table 3).

Sevin-4-Oil has performed well in Maine for spruce budworm control work. (See Spruce Budworm in Maine; 1977 Entomology Division Technical Report No. 3; March 1978). Operationally it is a mixture of 6 oz. No. 1 fuel oil and 24 oz. Sevin-4-Oil to the acre. The Sevin was delivered to Millinocket and Presque Isle by rail where it was then mixed with the oil for application at the operational dosage of 3/4 lb. AI per acre in 30 oz. finished spray.

In 1979 the SBSO became involved with applying Sevin-4-Oil at the dosage rate operationally as noted above and at other rates and applications as summarized in Table 3. This resulted in changes of formulations and/or changes in spray booms on the aircraft.

Dylox 4 was chosen for use primarily because of its safety around bees in such places as the lower Penobscot River area and in Washington County where bees are used to pollinate berry crops. Dylox was applied at 3/4 lb. AI in 24 oz. finished spray per acre. It was delivered to Millinocket by railroad tank car.

Orthene was employed in areas where there existed a concentration of streams, rivers, and waterways identified by the Maine Department of Inland Fisheries and Wildlife as containing critical fisheries.

Orthene was shipped to Presque Isle in 50 lb. fiber drums and the portion scheduled for use at that airport was mixed with water. The portion of this chemical required by the Millinocket operation was mixed at Presque Isle and shipped over the road in tankers. Orthene used at heliports was shipped from Presque Isle in dry form and mixed on site for helicopter application.

TABLE 3. FORMULATION, DOSAGE, AND ACRES TREATED - BW 1979

INSECTICIDE AND DELIVERY MODE	DOSAGE (AI/A)	SPRAY VOL./ ACRE	ACRES	FORMULATION (PER ACRE)
Carbaryl (Sevin-4-Oil) (Tank Car)	0.75 lbs.	30 oz.	2,026,430	24 oz. Sevin + 6 oz. #1 Fuel Oil (4:1)
Carbaryl (Sevin-4-Oil) (Tank Car)	0.50 lbs. (Twice)	20 oz. + 20 oz.	343,159	16 oz. Sevin + 4 oz. #1 Fuel Oil (4:1)
Carbaryl (Sevin-4-Oil) (Tank Car)	0.46 lbs. (Twice)	30 oz. + 30 oz.	84,613	15 oz. Sevin + 15 oz. #1 Fuel Oil (Approx. 1:1)
Carbaryl (Sevin-4-Oil) (Tank Car)	0.50 lbs. + 0.46 lbs.	20 oz. + 30 oz.	44,479	Formulated as above
		TOTAL SEVIN	2,498,681	
Trichlorfon (Dylox 4) (Tank Car)	0.75 lbs.	24 oz.	96,902	Spray as delivered
Acephate (Orthene Forest Spray) (Fibre Drums)	0.50 lbs.	64 oz.	110,417	0.67 lbs. formulation in 2 qts. water
Bacillus thuringiensis (BT) (Metal Drums)				
16B	8 BIUs	80 oz.	37,584	64 oz. BT + 16 oz. Water + Chevron Spray Sticker
32B	8 BIUs	64 oz.	930	32 oz. BT + 19.2 oz. Water + 12.8 oz. Sorbitol + Chevron Spray Sticker
24B			2,969	Experimental - Dr. John Dimond, UMO Report later.
		TOTAL BT	41,483	
		GRAND TOTAL	2,747,483	

NOTE: The above figures do not reflect the second application of Sevin over 44,479 acres previously treated.

Orthene was applied at 8 oz. AI in 64 oz. finished spray per acre.

Bacillus thuringiensis (BT) was sprayed both operationally and experimentally in 1979. Application was by helicopters and Thrush Commanders with conventional nozzles. Dr. John Dimond of the University of Maine Entomology Department supervised the experimental application of 24B and 32B and provided the technical services needed to perform the biological evaluation of treatment results. Thuricide 16-B, applied operationally, was sprayed at a dosage rate of 8 BIU's per acre with a finished spray volume of 80 fl. oz. per acre (64 oz. Thuricide - 16B plus 16 oz. water). The BT was shipped to Maine via tractor trailer truck in 55 gallon (US) steel drums. Contractor personnel assumed the responsibility of transporting BT to work sites once within the state. Details regarding the BT project are reported in a separate MFS publication (Technical Report #13).

Insecticide cost per acre are shown in Table 4. Tables 5 and 6 show the total gallonage used and acres treated by airport location and aircraft type.

D. Area Sprayed

Figure 2 shows the blocks which were sprayed during the SBSO for 1979. As noted earlier, Dylox was sprayed in areas where bees are used as pollinators of berry crops in lower Washington County and in the lower Penobscot River area. Orthene was used in the vicinity of critical freshwater fisheries areas. BT was used in blocks near populated areas, while the remaining areas were treated with Sevin-4-Oil.

E. Contractors

Aircraft:

Fixed Wing	- Globe Air/Biegert Aviation Joint Venture 4930 East Falcon Drive Mesa, Arizona 05205
Rotary Wing & Medivac	- Northeast Helicopter RFD #1, Box 152 Bucksport, Maine 04416
Monitor/Administrative	- Folsom's Air Service Greenville, Maine 04441
Mixing & Loading	- Chempro of Oregon 11535 North Force St. Portland, Oregon 97217

TABLE 4. INSECTICIDE COST PER ACRE, 1979

Insecticide	Cost of Formulation as Delivered	Acres Per Unit of Formulation	A.I./Acres	Insecticide Cost/A	Fluid oz. Per Acre	Cost Including Carrier & Mixing/A
Sevin-4-Oil	8.69/gal.	5.33	12 oz.	1.63	30 oz.	1.78
Orthene	5.25/lb.	1.5	8 oz.	3.50	63 oz.	3.55
Dylox	16.60/gal.	5.33	12 oz.	3.11	24 oz.	3.13
Bacillus thuringiensis (BT) (Thuricide)						
16B	9.30/gal.	2	8 BIU's	4.65	80 oz.	4.69
32B	9.30/gal.	4	8 BIU's	2.33	64 oz.	3.67

NOTE: Orthene – Delivered as soluble powder and mixed with water, mixing cost nominal on a per acre basis, assume $.05/A.

Sevin – Add $.03 for fuel oil (6 oz.) per acre and $.12 for mixing costs in 1979.

Dylox – Spray as delivered. Storage cost nominal on per acre basis, assume $.02/A.

BT – 16B delivered in 55 gal. drums, mixed with water, mixing costs nominal, assume $.04/A mixing.

32B delivered in 55 gal. drums, mixed with water, mixing costs nominal, assume $.04/A mixing.

TABLE 5. 1979 SPRUCE BUDWORM PROJECT TOTAL GALLONS & ACRES TREATED

FIXED WING:	GALLONS (MIXED)	ACRES
Sevin-4-Oil		
Millinocket	160,082	590,046
Presque Isle	379,648	1,536,480
Red Pine	68,902	294,212
Frenchville	24,162	103,174
Greenville	4,812	19,248
	637,606	2,543,160
Dylox		
Presque Isle	9,110	48,556
Lincoln	10,144	48.346
	19,254	96,902
Orthene		
Presque Isle	6,379	12,758
Jackman	37,700	74,600
	44,079	87,358
BT		
Old Town	11,239	18,168
TOTAL FIXED WING:	712,178	2,745,588
ROTARY WING:		
BT		
Eustis		
Spencer Stream		
Alder Stream	14,200	23,315
T6R11		
Rangeley		
Orthene		
Eustis		
Spencer Stream		
Alder Stream	11,529	23,059
T6R11		
Rangeley		
TOTAL ROTARY WING:	25,729	46,374
TOTAL PROJECT:		
Fixed Wing and Helicopter	737,907	2,791,962

Chemicals Used During 1979 Maine Spruce Budworm Spray Project (Gallons / Acres)

Table 6.

Airport	Dylox	Orthene	Sevin					B.T.			Totals		Aircraft
			Microfine	(1) Split	(2) Double	(3) Single	(4)Other	16B	24B	32B	Gals.	Acres	Used
Presque Isle	9110 / 48556	6379 / 12758			39632* / 84613	329599 / 1407388	6950 split (Mill. 10417 double (P.I.)				395137	1597794	C-54, TBM, B-1, Thrush, Connie
Millinocket				101222* / 323911		51910 / 221656					160082	590046	PV2, TBM
Red Pine						68902 / 294212					68902	294212	Thrush
Frenchville						24162 / 103174					24162	103174	Thrush
Lincoln	10144 / 48346										10144	48346	Thrush
Old Town								10774 / 17233		465 / 930	11239	18168	Thrush
Greenville				4812 / 19248							4812	19248	TBM
Jackman		37700 / 74600									37700	74600	Thrush
Subtotals	19254 / 96902	44079 / 87358		106034 / 343159	39632 / 84613	474573 / 2026430	6950;10417 / 44479	10774 / 17233		465 / 930	712178	2745588	
Eustis Spencer Stream Alder Stream Baxter Copland Rangeley		11529 / 23059						12716 / 20346	1484 / 2969				Helicopter
Subtotals		11529 / 23059						12716 / 20346	1484 / 2969		25729	46374	
TOTALS	19254 / 96902	55608 / 110417		106034 / 343159	39632 / 84613	474573 / 2026430	6950 split 10417 double / 44479	12716 / 20346	465+1464 / 930+2969		737907	2791962	

*Note: These gallonage figures include two applications; halve this figure for gallons applied during one application.

(1) 'Split' application, 20 oz. (4:1 mix), applied twice, .5 lb./A each
(2) 'Double' application, 30 oz. (1:1 mix), applied twice, .5 lb./A each
(3) 'Single' application, 30 oz. (operational dose), applied once, .75 lb./A
(4) 'Other' = One application, 20 oz. (4:1 mix), plus 1 application 30 oz. (1:1 mix), .5 lb./A each. These were applied on the same acreage (44479 acres).

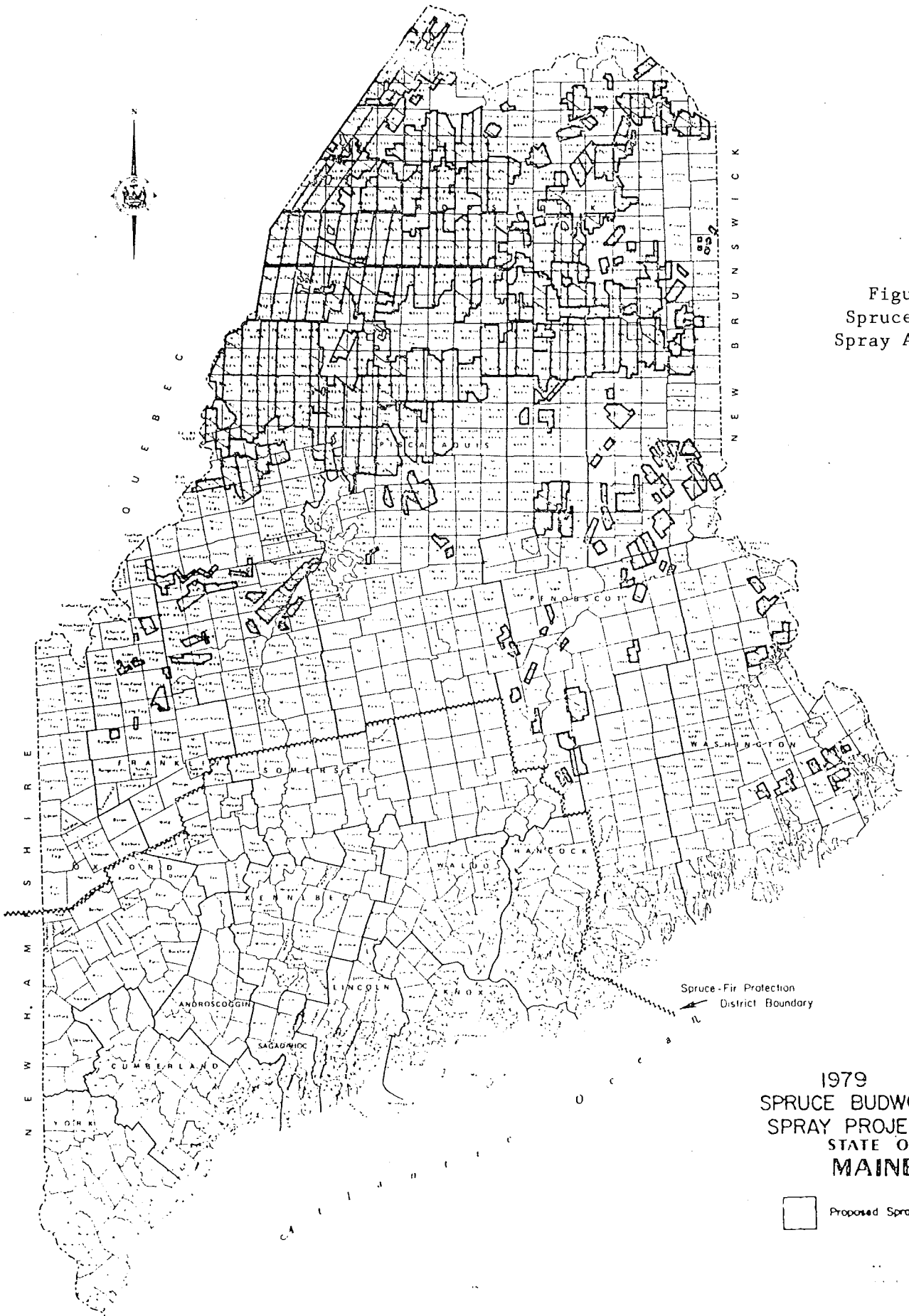


Figure 2.
Spruce Budworm
Spray Area Map

F. Guidance

Guidance was a contractor responsibility, accomplished through the use of small guide aircraft and electronic guidance systems. The basic tool used for guidance was the spray block map, prepared on multi-colored USGS topographic quadrangles at 1:62,500 scale. These maps are annotated with data pertaining to no-spray areas, streams, and operational restrictions. Pilots and monitors also used topographic 1:250,000 maps for general navigation between the airport and spray blocks. Block map reproductions used by the Maine Forest Service were produced by MFS personnel. The major contractors were given three (3) copies of all block plates and were required to supply their own reproductions.

Helicopters were worked in teams of two to four, guided by an additional helicopter flying above and slightly behind the spray teams with a contractor guideperson guiding the spray ships. The guide steered the spray ships via direct radio contact with the lead ship. The other spray aircraft aligned on the lead ship. A monitor helicopter flew above the spray teams to observe application procedures.

Small fixed-wing aircraft were guided by guide ship(s) in direct radio contact with the lead spray aircraft. When a spray team consisted of more than one spray aircraft all other spray aircraft guided on the lead spray plane.

Large fixed-wing aircraft (C-54) utilized an electronic guidance system (Loran "C") for guidance purposes.

G. Operational Monitoring

Monitoring of the SBSO was performed by Maine Forest Service personnel. Aircraft used for this operation were contracted separately from the spray contractor. The monitors' primary responsibility was to observe wind conditions and temperature over spray blocks, and to advise airport supervisors regarding initiation and conclusion of spray periods. Monitors observed spray aircraft performance, recorded deviations from block boundaries by spray aircraft, noted spraying over waterways or other "no spray areas", and recorded spray swath action (drift, irregular spray lines, etc.).

Monitors received a 5-day training course in 1979, with special emphasis on flight map orientation. Significant emphasis was placed on actual flight training and orienting monitors on the relationship of maps (USGS 1:62,500) to the ground. Particular emphasis was made on areas relatively devoid of significant topographic features.

Additional operational monitoring was conducted by a four person ground crew whose primary job was to place spray deposit cards on lines established in accessible spray blocks. The purpose of this operation was to assess spray deposit as well as a check on block coverage.

H. Weather

For the third consecutive year the SBSO employed four meteorologists from the U.S. Weather Service working in shifts; two working during the first spray periods and two working the second spray periods. One meteorologist worked the A.M. shift and the second worked the P.M. shift. These meteorologists used information sent from MFS field stations (Figure 3) and from the U.S. Weather Service. They were able to predict weather activity accurately.

I. Set-up, Mixing, and Loading

This year, as in the past few years, the SBSO contracted for the mixing, loading, and transfer of chemical (See Item E). The contractor was responsible for setting up the mix equipment, mixing and loading of the chemical, and transferring chemicals from one location to another. Major mixing facilities were located at Millinocket and Presque Isle.

J. Health and Safety

As in the past, the SBSO borrowed one person from the Maine Department of Human Services and one person from the Maine Department of Agriculture to monitor the health and safety of the crews working the project. These individuals helped to write the safety plan, checked compliance with its provisions, and advised the director of operations and the airport supervisors on health and safety problems.

K. Accidents

A C-54 aircraft carrying approximately 1200 gallons of insecticide (Sevin-4-Oil) made an emergency landing on Eagle Lake in the Allagash Wilderness Waterway. Most of the insecticide was jettisoned over forest canopy. After the aircraft was towed to the shore of the lake, the remaining insecticide and the aviation fuel in the aircraft were pumped from the plane. The aircraft was later dismantled and removed from the site.

L. Spray Progress

Figure 4 represents graphically the progress of the spray operation based on daily acreage released, sprayed, and completed. Tables 1 and 2 show the spray-no spray situation in relation to weather.

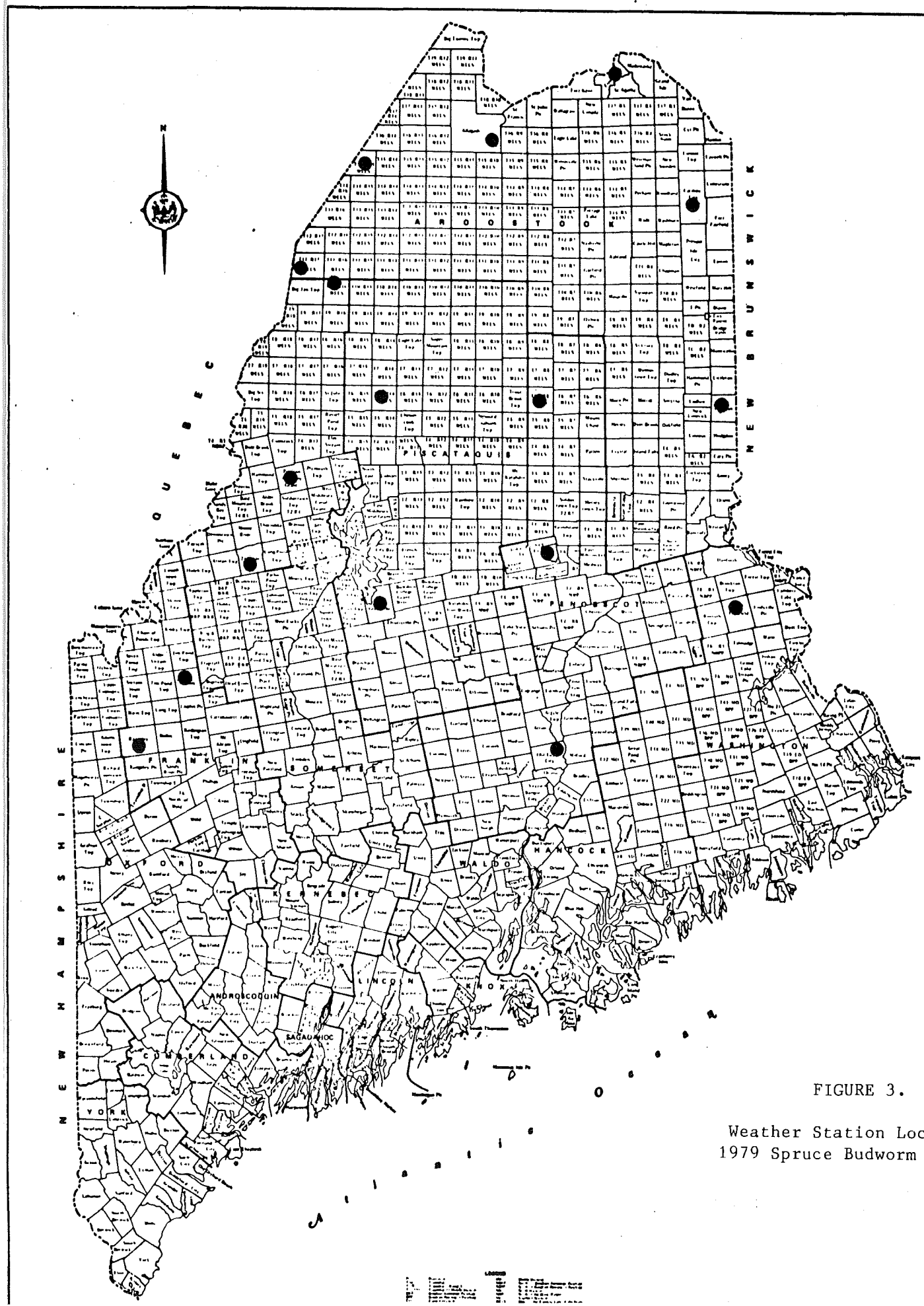


FIGURE 3.

Weather Station Locations
1979 Spruce Budworm Project.

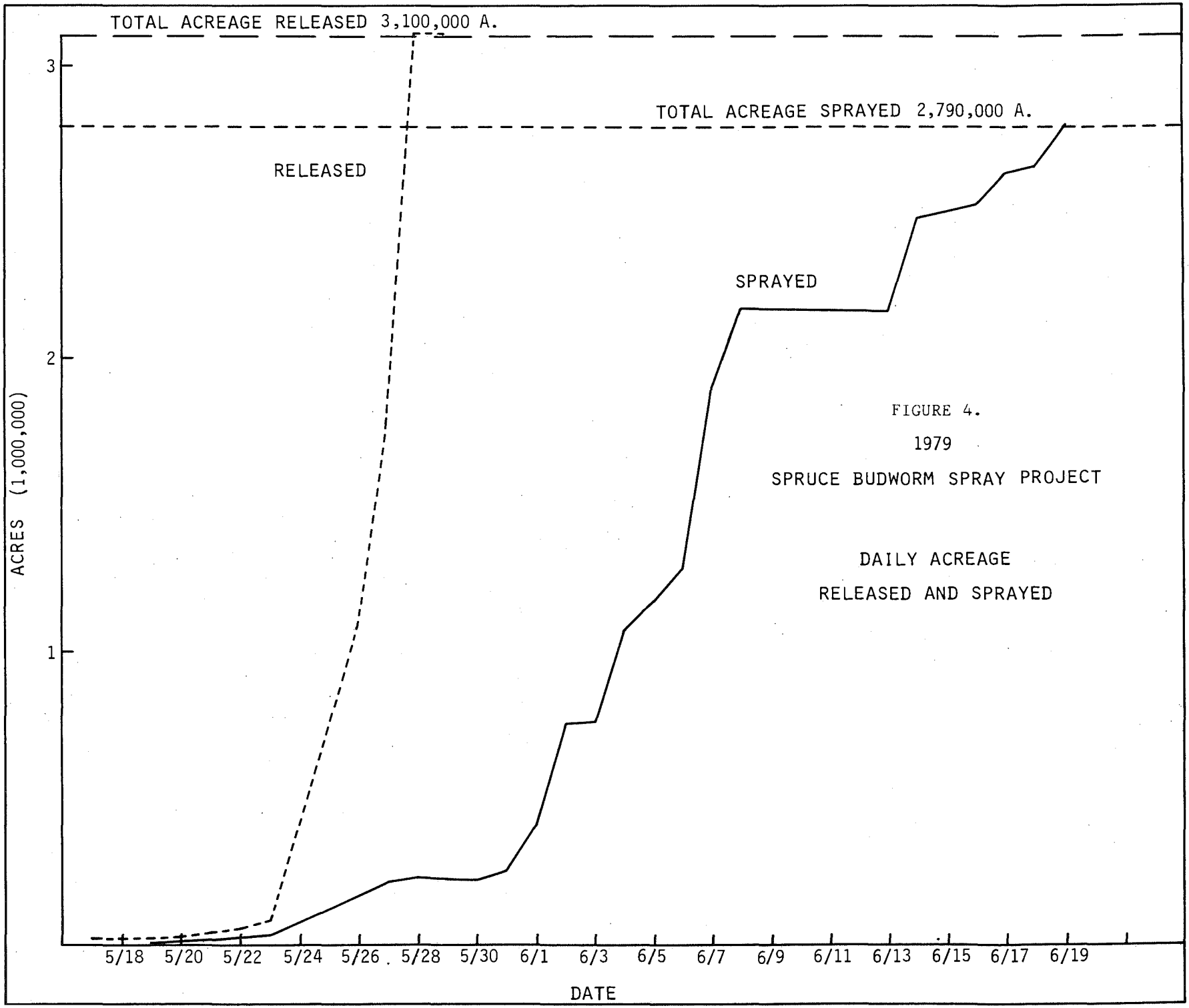


FIGURE 4.

1979

SPRUCE BUDWORM SPRAY PROJECT

DAILY ACREAGE

RELEASED AND SPRAYED

M. Aircraft Selection

In contracting for spray aircraft in 1979 the following spray plane numbers were contracted:

	Type of Aircraft	Gallon Capacity	No. of Aircraft Originally Contracted	No. of Aircraft Released From Contractor
Fixed Wing:	Constellation (Four engine)	3200	2	1
NOTE: C-54 is synonomous with DC-4 aircraft type.	C-54 (Four engine)	2400	12	11
	B-17 (Four engine)	1800	0	2
	PV-2 (Two engine)	1200	8	8
	TBM (Single engine)	800	6	6
	Thursh (Agricultural) (Single engine)	300-400	14	14
Rotary Wing:	Helicopters (Bell 47 series)	80 gals. @	8	8

(See Table 7 for aircraft characteristics). (See Table 8 for aircraft use by location).

Due to equipment malfunctions the contractor was not able to deliver one Constellation and one C-54 as requested in the original contract. These planes were replaced with two four-engine B-17 aircraft.

The number of guide aircraft was not specified in the bid specifications but had to meet the needs of the contractor based upon his proposed operation plan. This operation plan had to be approved by the contract administrator after his review.

The C-54 and Constellation aircraft were employed on large blocks at long ferry distances from the airport. Distances in access of 50 miles were common for these ships with a few as far away as 90 miles.

C-54 aircraft flew individually and in teams of two (2) and occasionally three (3). PV-2 and TBM aircraft flew as teams of two and three,

TABLE 7. AIRCRAFT CHARACTERISTICS

Aircraft Type	Nozzles	Spray Speed	Altitude	Capacity U.S. Gals.	Swath Width	Number on Project
L-749	8015	210 mph	150-200 ft.	3500	1,500	1
B-17	8015	180 mph	150-200 ft.	1800	800	2
C-54	8015	180 mph	150-200 ft.	2400	1,200	11*
PV-2	8015	175 mph	150-200 ft.	1200	600	8
TBM	8008	165 mph	150-200 ft.	800	400	6
Thrush	8006	110 mph	50	300-400	300	14
Helicopter (Bell 47)	8002	55 mph	75	75	100-150	8

* One aircraft became inoperable during the project.

TABLE 8.

FIXED WING AIRCRAFT USED BY LOCATION
(Acres Sprayed)

AIRCRAFT	GREENVILLE	JACKMAN	LINCOLN	MILLINOCKET	OLD TOWN	PRESQUE ISLE	RED PINE	FRENCHVILLE
Thrush		74,600	48,346		34,980	19,419	294,212	103,174
TBM	30,666			207,760		101,425		
PV-2				409,577				
B-17						147,528		
C-54						1,233,368		
Connie						175,924		

NOTE: Above acreages include split and double application blocks; e.g. acreage sprayed twice.

OTHER AIRCRAFT USED BY LOCATION

AIRCRAFT	ALDER STREAM	T6R11	EUSTIS	RANGELEY	SPENCER STREAM
Helicopters	X	X	X	X	X

Total Acres = 46,374

depending upon block size.

Thrush aircraft treated blocks close to the Millinocket, Lincoln, and Old Town airports (lower Penobscot River area) where minimal spray drift was demanded. These demands were placed on areas where there were high human populations and critical environmental considerations such as a high bee population. Thrush aircraft were also employed in isolated northern and western areas of Maine where small runways required small, maneuverable spray aircraft. Thrush aircraft were guided by small guide planes.

The spray system employed on the C-54, PV-2, and TBM aircraft was the boom and nozzle system. Spray pressure was adjusted (approx. 40 psi) to deliver a spray spectrum of between 80 and 150 microns with a minimum of 25 spray droplets per square centimeter. Thrush aircraft employed a boom and nozzle system with a pump pressure of approximately 40 psi to deliver the necessary spray spectrum. Helicopters used a boom and nozzle system to dispense insecticide at the desired rate.

Following the project a careful review of recent aircraft productivity was undertaken (See Appendix B for summary).

N. Project Costs

Table 9 gives a summary of the budget compared with the actual costs of the SBSO for 1979. Estimated cost was $11,212,000 and the actual costs were approximately $9,967,000. The per acre cost as shown was $3.88 per acre.

O. Radio Network

Figure 5 shows the Maine Forest Service radio network and frequencies used on the SBSO for 1979. This system proved adequate with minimum interference with the existing network.

As in 1978, the SBSO experienced some difficulty in reaching from the Presque Isle base to aircraft working the areas west of the St. John River and Moosehead Lake. This problem was solved by utilizing a monitor and monitor aircraft and a Fire Control tower as a control for radio relay purposes. Though there was some delay in forwarding messages, it did not prove to be a serious situation.

P. Environmental Monitoring

As in past years, careful field studies were conducted to monitor the environmental impact of insecticides sprayed in the forest to fill gaps existing in our knowledge of pesticide effects on the ecosystem. (See Table 10). These studies were conducted by trained scientists from

TABLE 9.

Budgeted vs. Actual Costs, 1979 Budworm Project

(In $1,000 except Actual Costs/a.)

ITEM	BUDGET	ACTUAL	BUDGET VS. ACTUAL	ACTUAL PER ACRE[2]
	In thousands	In thousands	In thousands	In dollars
Aircraft[1]	$4,077	$3,499	$578	$1.28
Insecticide	6,063	5,544	519	1.99
Fuel Oil	125	108	17	.04
Mixing	250	229	21	.08
Food & Lodging	100	198	- 98	.07
Temp. Labor	75	511	- 436	.19
Env. Monitoring	160	157	3	.06
Misc.	150	449	- 299	.16
TOTAL	$11,000	$10,795	$305	$3.88[3]

NOTES: 1. Fixed Wing Spray, Helicopter, Monitor & Administrative, and Medivac.

2. Based upon 2,791,962 acres sprayed.

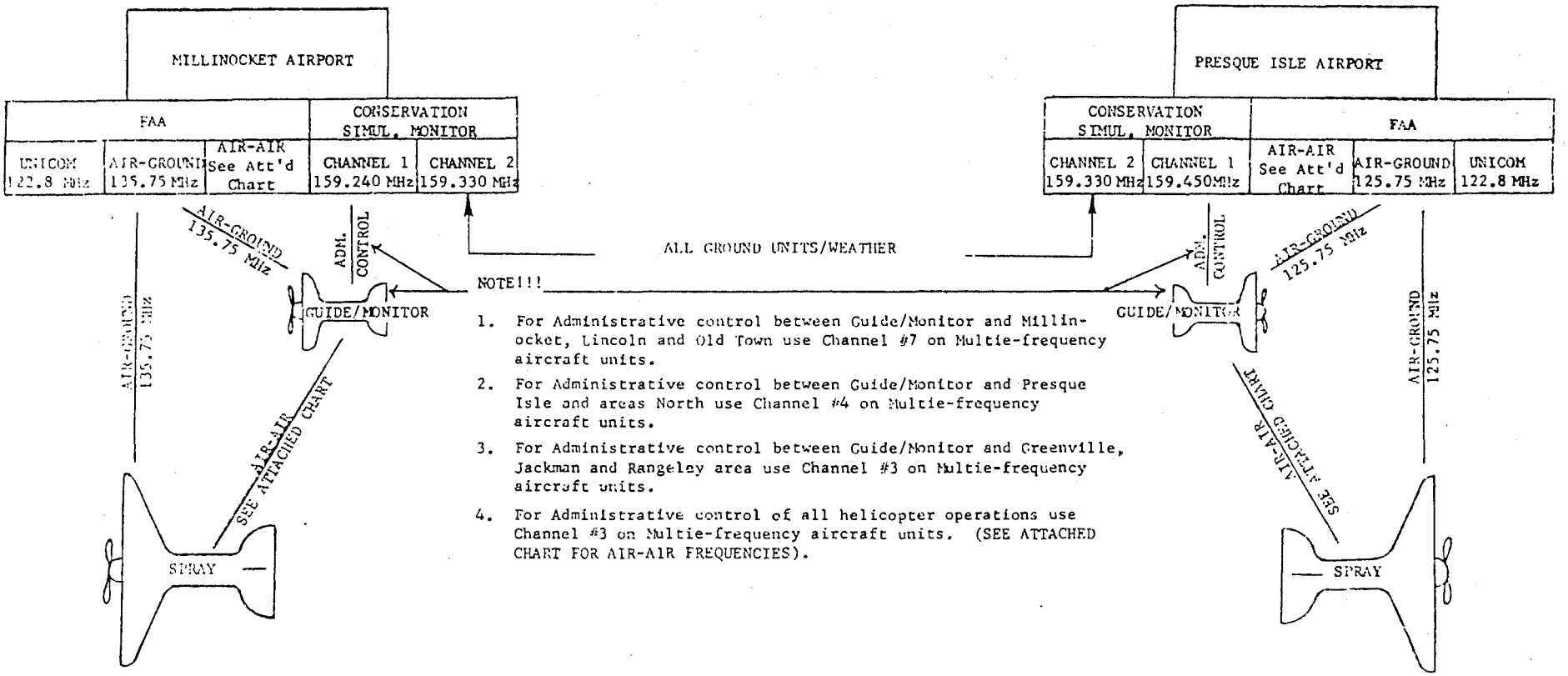
3. Figures do not add up due to rounding off.

FIGURE 5. Radio Network and Frequencies Used

1979 SPRUCE BUDWORM SPRAY PROJECT

- RADIO COMMUNICATIONS -

-- EMERGENCY 125.95 Mhz FREQUENCY --



1. For Administrative control between Guide/Monitor and Millinocket, Lincoln and Old Town use Channel #7 on Multie-frequency aircraft units.
2. For Administrative control between Guide/Monitor and Presque Isle and areas North use Channel #4 on Multie-frequency aircraft units.
3. For Administrative control between Guide/Monitor and Greenville, Jackman and Rangeley area use Channel #3 on Multie-frequency aircraft units.
4. For Administrative control of all helicopter operations use Channel #3 on Multie-frequency aircraft units. (SEE ATTACHED CHART FOR AIR-AIR FREQUENCIES).

the University of Maine, U.S. Fish and Wildlife Service, and others. These studies in most cases were conducted in cooperation with the Maine Forest Service.

Q. Acreage Adjustments

In October, 1978, the State Entomologist presented to the Forest Insect Manager maps indicating a spruce budworm high hazard area consisting of approximately 5.5 million acres. This map identified the gross area where the budworm situation was declared as needing control work done.

To arrive at the net area which would actually be sprayed (approximately 2.8 million acres) MFS personnel examined the maps and, with other sources of information, withdrew areas which would not receive spray. These areas included the following:

a. Lakes, ponds, rivers, streams.

b. Withdrawals as provided by the Statute.

c. Buffers (See Item R).

d. Industrial and residential areas.

e. Areas determined not to contain proper forest type after blocking.

f. Small blocks located great distances from bases.

R. Buffering

Zones to be left unsprayed were established along streams, rivers, and lakes, around hazard areas (bee hives, fish hatcheries, poultry houses, etc.) and around areas of human habitation (roads, towns, houses, parks and camps). Buffer rules for 1979 were more complicated than in the past. Figure 6 summarizes buffering procedures for 1979.

S. Public Information

Public awareness of the SBSO has intensified over the years. To accommodate the public desire for up-to-date information, each airport headquarters was staffed with a public relations or Information and Education (I & E) person. These people, working through the Departmental Information and Education Officer, kept the public informed through the news media (T.V., radio, and newspaper). Other methods of informing the public included posting of notices in stores, post offices, and town halls near the spray project. Posters were also located in parks, campsites, and on roads leading to spray areas.

TABLE 10.

1979 ENVIRONMENTAL MONITORING/CHEMICAL EXPERIMENTS

Investigator	Agency	Subject
Dunlap, Eaton, Bird, Madden	SCS Engineers (Augusta)	Water and air monitoring for Sevin, Orthene, and Dylox
Trial, J. G.	UMO	Assessment of no-spray buffers
Trial, J. G.	UMO	Further studies on streams in Sevin sprayed areas
Hunter, M.	UMO	Forest spraying and birds
Drury, W.	College of the Atlantic	Forest spraying and bird populations
Gibbs, K.E. et.al.	UMO	Sevin impact on ponds
Rabeni, C.F., and J. Stanley	UMO	Sevin and impact on brook trout
Mingo, T.	UMO	Impact of Sevin on Plecoptera
Brown, H.	Consultant	Ecosystem Impact of Sevin (Planned for Matacil)
Haines, T.	U.S. Fish & Wildlife Service	Split Sevin Application Impact On Fish

In addition to the above, the I & E Officer conducted tours involving college students, civic groups, and legislators through the airport operations. Working closely with the airport supervisor and the map room, the I & E Officer was constantly aware of spray progress and was able to give daily situation reports to the U.S. Forest Service in Portsmouth, N.H., and to the Department of Conservation headquarters in Augusta. This report included the areas released to the project, acres sprayed daily, per cent of the project completed daily by airport, etc..

Figure 6.

MAINE FOREST SERVICE
REMINDER SHEET FOR AIRCREWS
SAFETY BUFFERS AND PRECAUTIONS 1979 SPRUCE BUDWORM PROJECT

The following information summarizes major features of the Maine Forest Service precautions specified to prevent deposit of spray in water, settled areas, and other designated areas. This summary is not intended to include every detail regarding buffers.

I. SETTLEMENTS

A. Buffers for isolated dwellings, scattered settlements....1/2 mile.

B. Buffer for concentrated settlement (25 dwellings or more)..TBM and larger - 1 mile. Helicopter or Ag planes - 1/2 mile.

C. B.T. (*Bacillus thuringiensis*).....1/4 mile - Design blocks to minimize over - flights of homes and farms.

D. Asphalt roads and highways.....500 feet.

E. Fields and pastures.....500 feet or one swath width.

F. Avoid flying over settled areas to the maximum extent practical while enroute to and from blocks.

II. WATERWAY BUFFERS

All spray aircraft will turn off booms when crossing streams, ponds, or marshes visible from the spray aircraft itself.

A. B.T.....No buffers for waterways.

B. Orthene.....Edge of swath at edge of waterway or marsh. On St. John River, use a 200 foot no spray buffer on the mainstem.

C. Dylox

	TBM and Larger Aircraft	Ag or Helicopter
Critical Fishery	500 feet	250 feet
Major Streams	250 feet	150 feet

D. Sevin-4-Oil

1. Unsprayed with Sevin Previous Year

	TBM and Larger	Ag or Helicopter
a. Critical Fishery	600 feet	300 feet
b. Major Streams	300 feet	150 feet

2. Sprayed with Sevin Previous Year

a. Critical Fishery	1,000 feet	500 feet
b. Major Streams	500 feet	250 feet

* NOTE: Buffer Strips for logging sites is 1/2 mile.

II. BIOLOGICAL ASSESSMENT - 1979 SPRAY PROJECT

Biological assessment for the 1979 Maine Spruce Budworm suppression project was conducted in the same manner as for the 1977 and 1978 projects. Comparative efficacy was determined for 5 operational spray treatments, 5 BT variations, 4 application timing variations, and 7 untreated check areas. An attempt was made to determine spray deposit in each monitored area.

Project results were determined in general terms for the entirety of the treatment area and specific assessments were made in selected project blocks. In 1979 the selected intensively monitored blocks were those of split applications of Sevin near Telos and Umsaskis Lakes. BT treatments were also monitored intensively and were located in the Old Town and Topsfield areas.

The manpower commitment to accomplish these evaluations required the addition of project-funded labor to the standard assessment team of the Maine Forest Service, Entomology Division. Added labor consisted of 22 field assistants and 34 laboratory workers, hired for the project season. As in 1978, laboratories were operated at Portage and Greenville. The Princeton lab was relocated at Topsfield and a lab was added at Old Town. Biological assessment organization is shown in Fig. 7.

The 1979 egg mass and tree condition survey covered the entire spruce-fir protection district. Necessary manpower was obtained from the Entomology Division and from 20 hired laborers. Laboratories for egg mass counting were operated at Portage, Greenville, Old Town and Topsfield.

Survey zones have been defined to facilitate analysis and presentation of data (Table 11 and Figure 8).

FIGURE 7.

PROJECT ORGANIZATION

1979 FIELD OPERATIONS

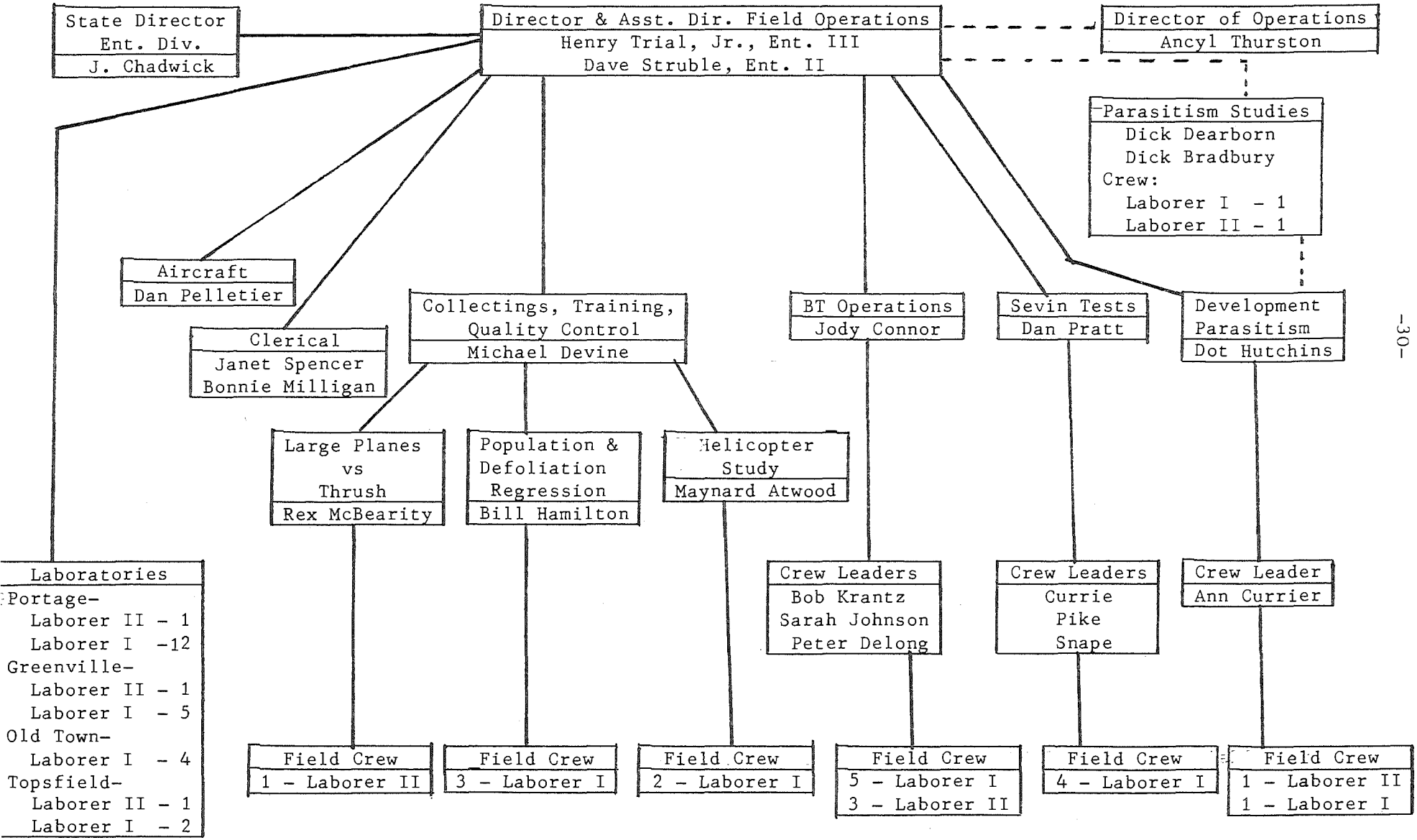


TABLE 11. SPRUCE BUDWORM SURVEY ZONES

Allagash-St. John Zone:

Geographic---Mostly flat with some rolling hills, two major river valleys, hilly in extreme north.
Forest Type---Predominantly contiguous spruce-fir.
Infestation History---Most areas with three or four years of extreme infestation, southern portion near Chamberlain Lake with four years of extreme. (1972 to 1976).
Spray History---80,000 acres near Chamberlain Lake treated in 1973; 26,000 acres in scattered spots near Chamberlain Lake in 1974; about one half of this zone treated in 1975; nearly all treated in 1976; untreated in 1977; 1,000,000 acres treated in 1978; and nearly all type sprayed in 1979.

Northeast Zone:

Geographic---Several hilly areas with two major river valleys.
Forest Type---Few large areas of contiguous spruce-fir forest, predominantly mixed wood areas, much cleared agricultural land.
Infestation History---Spotty and shifting areas of extreme infestation since early 50's.
Spray History---Scattered portions treated since early 50's; 200,000 to 500,000 acres sprayed in this since 1971; little spraying in 1977 and 1978; nearly all type treated in 1979.

Penobscot-Mattawamkeag Zone:

Geographic---Most of the area low, flat, wetland.
Forest Type---Flat wet areas heavy to softwood, ridges mostly hardwood.
Infestation History---Most of the area has had three years of very extreme infestation.
Spray History---Much of the northern portion was treated in 1976, spray areas were not contiguous. Much of the Penobscot Valley type was treated in 1977, 1978, and 1979.

Southeast Coastal Zone:

Geographic---Mostly coastal influence, shallow rocky soil.
Forest Type---Mixed softwood and scrub hardwood; softwood, heavy to spruce with pockets of fir.
Infestation History---Infestation very extreme for three years, area fir greatly influenced by balsam woolly aphid.
Spray History---25,000 acres treated in 1976; 50,000 acres treated 1977. Northeast portions sprayed 1974, 1975, 1977, 1978; no treatment in the southeast in 1978 or 1979.

TABLE 11 (Continued)

Moosehead Zone:

Geographic---Softwood flats in the northern section of the zone. Southern portion has many high mountains and rolling hills.
Forest Type---Spruce-fir flat in the north, mixed wood and hardwood in the south.
Infestation History---Most of the zone has experienced two or three years of heavy defoliation.
Spray History---Much of the northern third of the zone sprayed in 1976; much of the northern two thirds treated in 1977 and 1978; scattered blocks treated in 1979.

Western Mountains Zone:

Geographic---Very hilly with several mountain ranges.
Forest Type---Fir in the valleys with hardwood and spruce in the high areas, susceptible type broken into relatively small sections.
Infestation History---Most areas with two years of very extreme infestation sometimes causing three years defoliation.
Spray History---Sections of the northern part of the area treated in 1976, 1977, 1978, and 1979.

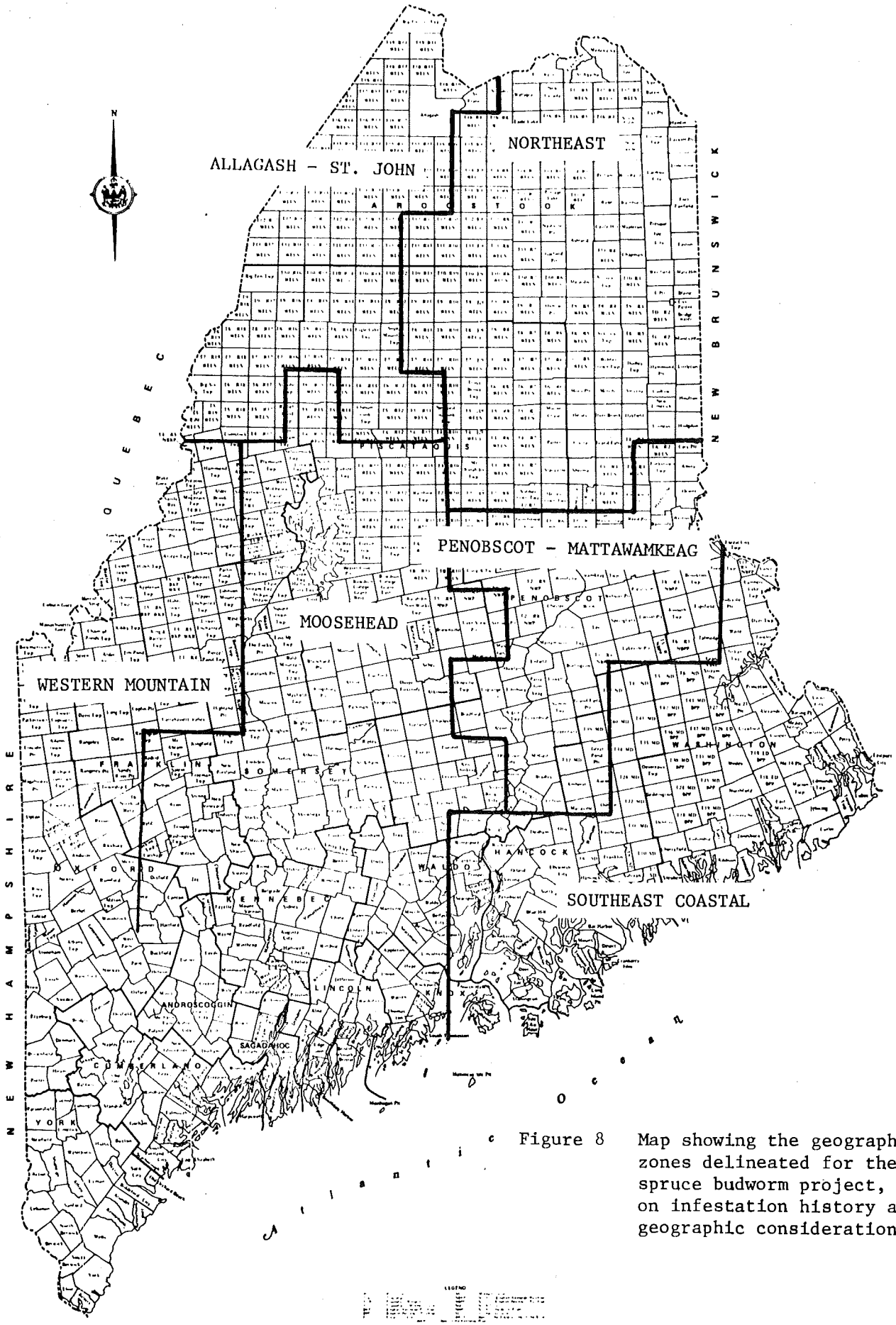


Figure 8 Map showing the geographic zones delineated for the 1979 spruce budworm project, based on infestation history and geographic considerations.

A. Larval Development

Synchronization of spray application with budworm development is necessary for the most effective results. Treatment should be applied as soon as possible to minimize defoliation but not before the young larvae are exposed. Since changes in budworm behavior occur concurrently with changes in larval instar, determination of the percentages of budworm in each instar can be used to plot their susceptability to spray treatment. In addition to insect development, an adequate spray target provided by the expansion of foliage is necessary. Bud development is also monitored and used in conjunction with insect development data.

Prior to the beginning of the budworm control project, larval and bud development sample plots were established adjacent to spray areas (Figure 9). Within these plots, dominant and codominant fir trees were periodically sampled to obtain foliage from the upper midcrown of the trees. A bud expansion index was recorded for each of 50 shoots. Foliage was then taken to one of the field laboratories where it was searched for budworm. These larvae were examined to determine the number and percentage in each instar. A development index curve was derived and plotted using the method of Quebec (Dorais 1977, personal communication). Bud flare was also plotted as an index developed in Quebec (Auger 1978, personal communication).

In addition to the permanent sample plots, as the target stages approached, numerous other samples were taken using the same method to check the budworm development in various locations.

The desired developmental stage for the start of spraying operations with Sevin was 50% to 70% in the fourth instar (index of 3.5 to 3.7). Dylox and Orthene were targeted for an index of 4.2. The desired bud index to trigger treatment was 3.8 to 4.0. When bud and insect indices conflicted, bud development was given priority.

Development of spruce budworm and fir foliage in 1979 was extremely favorable to an effective spray treatment. Foliage development in most of the state was well in advance of insect development, yielding a large food source which the small instar larvae were unable to destroy rapidly. In general, foliar development reached an index of 4.0 before insect development exceeded 3.5.

An exception to the generally favorable development conditions occurred in the southeast coastal zone. In this area, foliar development was more synchronized with the insect and in some cases the insect may have been ahead of the foliage. Both insect and foliage development in this zone were much later than the rest of the state. This condition was probably due to the coastal weather influence.

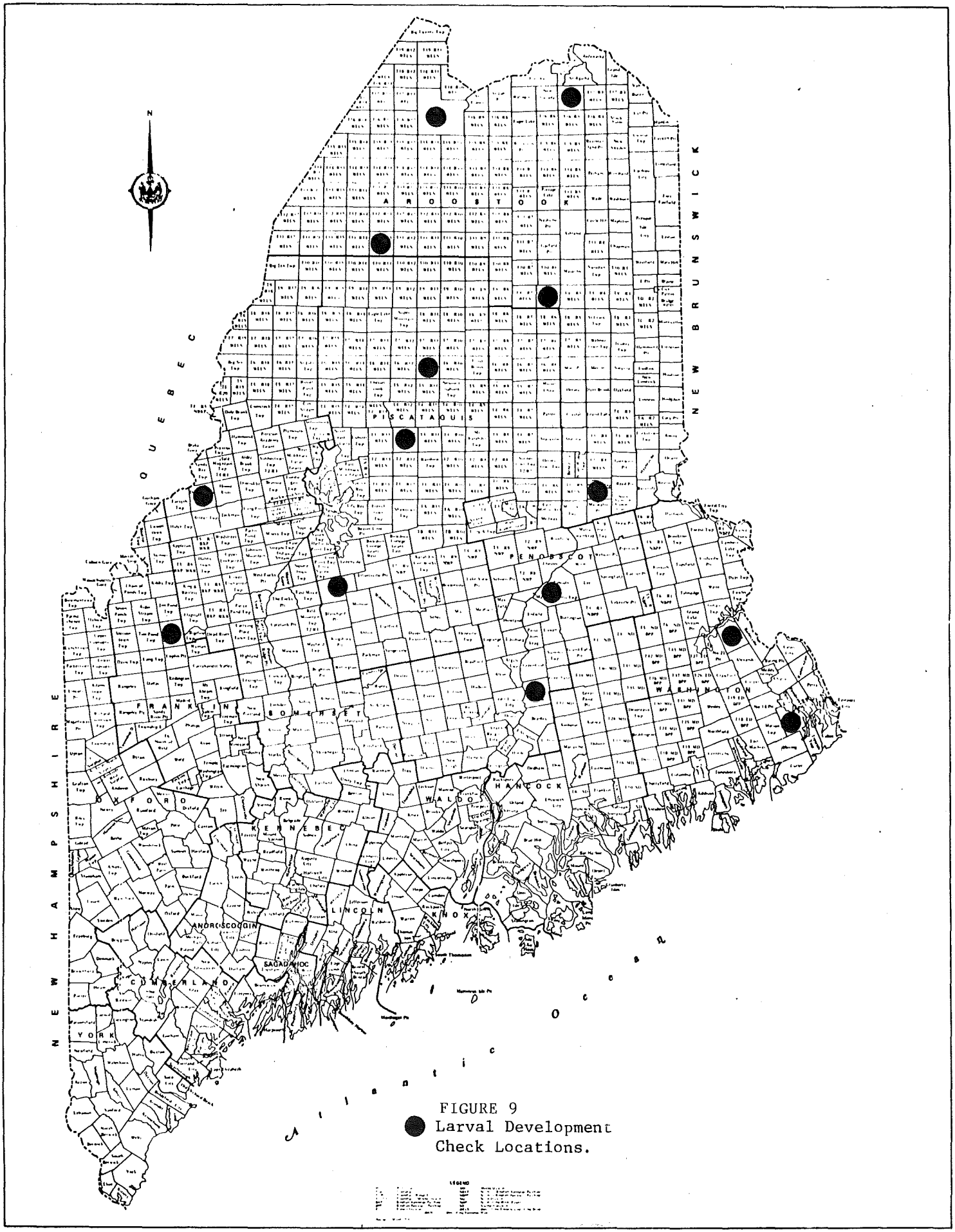


FIGURE 9
● Larval Development Check Locations.

B. Budworm Health in 1979

Early in the development cycle, larvae throughout the state seemed healthy (i.e. no appreciable numbers of undersized or apparently diseased larvae were found). Counts of early needle miners revealed expected numbers of larvae, suggesting normal winter survival.

As the larvae entered the fourth instar, May 23 to June 1, the entire state experienced a prolonged period of heavy rain. Temperatures during this period were cool but not extreme. Following the rainy period, a marked drop in larval density was noted and laboratories began to report high numbers of dead larvae. These larvae apparently drowned. Larval reduction over the rainy period ranged from 10 to 50 percent and probably far exceeded normal losses for a similar period.

The 1979 crop of pupae and moths seemed of normal size, survival, and vigor.

C. Host Condition in 1979

The condition of fir and spruce in the protection district was noted prior to the 1979 operation. The general conditions by zone were as follows:

Allagash-St. John - Because of the late spray application in the area in 1978 and the resulting low foliage protection, tree condition in the Allagash-St. John was extremely severe in the spring of 1979. The 1978 spray treatment had prevented additional wide spread mortality over the winter and did protect the 1979 bud crop. Additional mortality and complete 1979 bud loss was common in the areas not sprayed in 1978.

Northeast - In 1978, conditions in the northeast zone deteriorated sharply. Extremely heavy feeding in 1978 caused the loss of 2 to 3 years of foliage and put the trees in severe condition. Little mortality was noted.

Western Mountains - The northern portion of the zone was in very poor condition in 1979 but the 1979 bud set was good. The southern portion of the zone deteriorated in 1978 but in the spring of 1979 only patches of severe condition were found.

Patchy mortality of fir and white spruce was found throughout the northern portion of the zone.

Moosehead - Most of the area was in fair or good conditions in 1979 following two years of treatment. Severe areas were noted north of Moosehead Lake and near Lily Bay.

Penobscot-Mattawamkeag - Tree condition varied widely in the zone. Areas sprayed in 1977 and 1978 showed a high degree of recovery and good bud sets. Areas not treated were in critical condition or dead. Mor-

tality in the area includes considerable white spruce.

Southeast Coastal - Severe feeding in 1978 caused a sharp deterioration in tree condition for 1979. Areas in the northern portion of the zone were in fair condition, having received some spray in 1978. Several areas of fir and spruce mortality were found in the southern portion of the zone, mainly in areas not treated in 1976 and 1977.

D. Spray Assessment

Spray efficacy was determined for each chemical and treatment regime used in the 1979 project. Special efforts were made to assess the results of 'BT' operations (reported in Technical Report #13) and split application of Sevin. The sampling scheme was designed to yield estimates of prespray populations, survival, population reduction, and defoliation. The assessment method used for evaluation of each variation is that described in Technical Report #12, "Sampling and Analysis Design for Departmental Insecticide Monitoring."

Pre-Treatment Population Checks - As in other recent projects, populations in each treatment block were evaluated before spraying began. These pre-treatment checks were designed to determine if populations predicted for a given block by the egg mass and L-II surveys are present in the block. Blocks were sampled by collecting one branch from each of seven dominant or codominant fir trees. Samples were bagged and sent to laboratories for evaluation.

The number of samples per block varied according to block size and according to the number of larvae found. Blocks found to have low populations were resampled in other locations to determine if populations were uniformly low. Blocks found to have high or moderate counts were not resampled.

Blocks identified as having uniformly low populations were considered for deletion. Before a block was finally omitted from spray plans, population, damage, and block location were considered.

No blocks were found to have populations low enough to be dropped from the 1979 project. In general, populations throughout the spray area were as expected. Exceptions were, slightly lower population than expected in the north and slightly higher population than expected in the western mountains. Populations in each zone were in the following ranges:

Zone	Larvae per 18" Tip
Allagash - St. John	25 - 35
Northeast	40 - 60
Penobscot - Mattawamkeag	15 - 60 variable
Southeast Coastal	50 - 80
Moosehead	20 - 70 variable
Western Mountains	50 - 80

Chemicals and Spray Regimes Evaluated - A single application of 0.75 lbs. of Sevin was used on most of the 2.8 million acres treated in 1979. Approximately 250,000 acres were scheduled for various split applications of Sevin, but this acreage was reduced due to delays in the first application. As in other recent projects, Orthene and Dylox were used in selected areas. A complete listing of the variations evaluated is given in Table 12.

Methods - The sample scheme used for evaluation of the various treatments was that described in MFS Technical Report #12. In general this method involves replicated assessment of each treatment in carefully monitored portions of the sprayed area. A replicate consists of a set of twenty sample clusters. Each cluster consists of 2 fir and 2 spruce sample trees. One 18" branch was collected from each tree 2 days prior to spray and at 3, 7, and 14 days (pupation) following spray. Defoliation was assessed at each sample period by determining defoliation on 10 expanding shoots on each sample branch. All larval populations were evaluated at the 4 MFS laboratories.

Results - Treatment Variations - Spray efficacy in terms of survival, adjusted mortality, unadjusted mortality and defoliation was determined for each treatment variation. Results for fir are shown in Tables 13 and 14. These figures represent only a summary of the large volume of data gathered on the comparisons of split and single application of Sevin conducted in 1979. A complete, detailed report of these comparisons will be prepared in the near future.

Results of 'BT' usage in Maine are complicated and require explanation. These results can be found in MFS Technical Report #13.

Applications of Sevin in 1979 were, in general, extremely successful, especially in areas sprayed in 1978. Important factors leading to this success were the rapid bud expansion seen in 1979 and population reduction probably caused by the 1978 application.

Many areas in the Allagash-St. John zone which were in critical condition in 1978, now have a prominent flush of 1979 growth. These critical areas were given priority in 1979 because of their condition. Blocks in this zone which received the split application of 0.46 or 0.50 lbs. received the best protection. Protection offered by the single application of 0.75 lbs. in the Allagash-St. John zone was very good, but splits were statistically better.

Split applications were slightly earlier than the single application, but not in all cases. Earlier timing would explain some of the increase in foliage protection, but as some single and split blocks were treated at the same time, other factors are indicated. The most likely reason for the better results with splits is improved coverage of the area by two applications and a prolonged exposure of the insect to residual chemical on the foliage.

In the Northeast zone results varied with the timing of the application. Southern portions of the zone treated at the proper time with Sevin show excellent foliage protection and larval reduction. Areas in

Table 12. Treatment variation assessed; 1979 Maine Spruce Budworm Suppression Project.

Chemical	Total AI/Acre lbs.	No. App.	AI/Application	Total Vol/App.	Timing
Sevin					
1	0.75	1	0.75	30 oz.	Peak L-IV
2	1.00	2	0.50	20 oz.	50% L-IV/+5 to 7 days
3	0.92	2	0.46	30 oz.	50% L-IV/+5 to 7 days
Dylox					
	0.75	1	0.75	32 oz.	20% L-V
Orthene					
	0.375	1	0.375	64 oz.	20% L-V

Table 13. Summary of spray efficacy on fir - 1979 Maine Spruce Budworm Suppression Project.

Chemical (Treatment)	No. of Survivors per 18" Tip	% Red. Unadajusted	% Red. Adjusted
Sevin			
0.75 lbs. once (Proper timing)	0.9	95.7	88.9
0.75 lbs. once (Late)	2.8	91.7	No Check
0.50 lbs. Twice	0.4	98.1	95.1
0.46 lbs. Twice	0.4	98.8	96.9
Check (not 0.75 lbs. late)	6.9	61.3	
Dylox			
0.75 lbs. (Proper timing)	3.9	89.3	67.9
0.75 lbs. (Late)	6.4	79.2	No Check
Check	11.3	68.8	
Orthene			
(Late)	7.2	86.4	55.0

Table 14. Summary of defoliation and foliage saved on fir - 1979 Maine Spruce Budworm Suppression Project.

Chemical (Treatment)	% Def.	% Foliage Saved
Sevin		
0.75 Lbs. once (Proper timing)	33	48
0.75 lbs. once (Late)	89	No Check
0.50 lbs. Twice	32	49
0.46 lbs. Twice	22	59
Check (not 0.75 lbs. late)	81	
Dylox		
0.75 lbs. (Proper timing)	68	32
0.75 lbs. (late)	91	No Check
Check	100	
Orthene		
(Late)	88	12

the north where spray was delayed by weather show only marginal foliage protection and adequate larval kill.

Much of the treatment scheduled for the southeast coastal zone was cancelled. Larval development in this zone was very slow and spraying was delayed to a point where aircraft were needed elsewhere. Areas sprayed in the northern part of the zone were done at the proper time.

Treatment in the Penobscot-Mattawamkeag zone was generally at the proper timing, but many applications were followed closely by rain. Rainy weather in this zone at spray time resulted in a general reduction in the efficacy of all the area treatments.

The small area treated in the Moosehead Zone was generally treated somewhat late and defoliation was heavier than desired. Most delays in this zone were due to logistics.

Applications in the Western Mountains were very late and damage in many spray areas was heavy. As in the Moosehead Zone, spraying was delayed by logistics resulting from the unusual development.

Logistical problems encountered in 1979 were largely the result of uniform larval development throughout the state. Ordinarily, areas in northern Maine are later developing than areas in the south. This allows aircraft to be assigned to southern blocks and then moved north with the progression of development. Uniform development in 1979 caused a need of aircraft everywhere at once.

E. Spray Deposit Assessment

Spray deposit was monitored on all sample lines established for chemical and dosage variation assessments. Deposit monitoring methods included spray deposit cards and examination of fir foliage clipped from sample trees. Assessment was used only to determine if an area was actually sprayed and to categorize deposit in the broad groups of poor, fair, or good. This assessment was independent of that done in connection with "spray operations".

A single spray card was placed in the open at each sample cluster. Cards were put out before daylight and retrieved 2 hours after spraying. On lines showing poor deposit on spray cards and on selected lines receiving "good" coverage, branches were clipped from the mid-crown of fir trees near the sample tree and examined for deposits. This procedure was used only on lines sprayed with Sevin as only this chemical leaves a visible deposit (white spots) on the foliage.

In at least two cases, considerable variation was noted between card deposits, foliage assessment, and larval kill. In each case cards showed "poor" deposits, foliage showed numerous very small droplets, and larval kill was excellent. In all cases where cards showed good deposit, larval kill was also good.

F. Parasitism Survey

Twelve points selected in 1978 for an annual survey were again utilized in 1979 for the collection of Spruce Budworm *(Choristoneura fumiferana)* to monitor the relative abundance of parasites (See Figure 10). It was necessary to move three of the points to similar areas to avoid spray blocks. A sample point was set up in T17 R5 in place of the Great Pond Plt. plot due to low number of budworm in the Great Pond Plt. plot.

At each location the budworm population was sampled at four different developmental stages: early larval, late larval, pupal and egg stage. Samples consisted of 1 or 2 45 cm. branches from the upper mid-crown of five co-dominant balsam fir trees. Each branch was bagged separately and transported to the Entomology Laboratory in Augusta to be processed. Egg mass samples were very time consuming to search and for this reason they were processed in the Old Town Laboratory.

Early larval (3rd - 5th instars) budworm larvae were dissected in water to determine parasitism levels. Remaining budworm samples were reared individually in shell vials. Any pupae failing to emerge were opened to determine parasite species and abundance. All adult parasites were preserved dry for possible future use.

Total apparent parasitism for 1979 was lower than last year being 23.4% parasitism as opposed to 37.1% parasitism in 1978 (see Table 15). The decline was primarily due to lower levels of parasitism by hymenopterous parasites such as *Apanteles* spp. The dipterous parasites showed a small increase over last year.

An experiment was started in the Telos area to evaluate the effects of single and double applications of Sevin-4-Oil used to control budworm on the parasite complex this year. Next year's data will be necessary before any results can be reported.

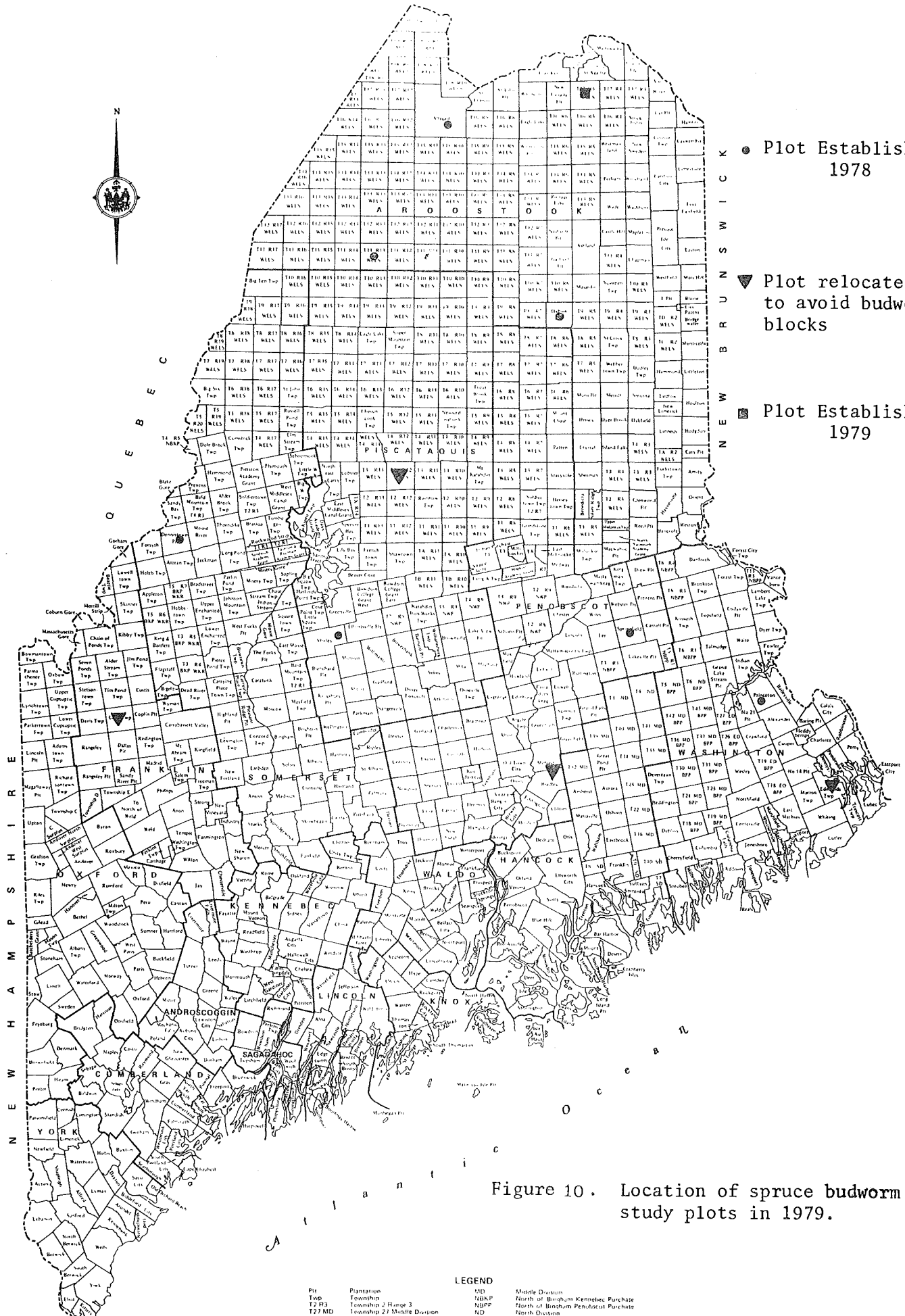


Figure 10. Location of spruce budworm parasite study plots in 1979.

TABLE 15.

1979 Percentage Parasitism of Spruce Budworm

Location	*Apanteles*	*Glypta*	*Lypha*	*Meteorus*	*Phaeogenes*	*Itoplectis*	*Ephialtes*	*Omotoma*	Misc. Hymenoptera	Misc. Diptera	Total Apparent* % Parasitism	% Egg Parasitism**
Shirley	20.3	9.4	0.7	0.0	0.0	0.0	0.0	1.4	0.7	1.4	33.1	4.3
Dennistown Plt.	18.4	2.0	0.0	0.0	0.0	0.4	0.0	3.3	0.0	0.7	24.8	1.1
Lang Plt.	15.2	3.3	7.7	3.3	0.0	0.0	0.0	1.0	0.0	1.0	31.5	28.9
T3 R12	6.7	1.2	0.0	3.8	0.0	0.0	2.5	2.5	0.0	2.5	19.2	1.2
Bradley	9.0	1.1	1.3	0.0	0.0	0.0	0.0	1.9	1.0	0.0	14.3	12.5
Springfield	10.0	2.4	2.6	0.0	1.9	0.0	0.5	0.5	0.0	1.4	19.2	2.1
Princeton	10.1	2.5	9.2	4.6	0.0	0.0	0.0	3.1	0.0	0.0	29.5	30.4
Edmunds	9.7	6.6	0.6	0.0	0.8	3.1	0.0	4.6	0.8	0.8	26.9	2.5
Allagash Plt.	9.1	1.8	0.0	0.0	1.7	0.0	0.0	4.2	2.5	0.8	20.1	0.0
T11 R13	9.1	2.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	12.0	3.7
Oxbow Plt.	6.6	0.7	6.1	0.0	3.3	0.0	1.1	7.8	0.0	2.2	27.8	2.3
T17 R5	7.8	2.8	0.0	0.0	0.0	0.8	0.8	6.3	0.0	0.0	18.4	1.2

* Parasitism rates allow only for previous loss to parasites and disregard other matural mortality.

** Egg Parasitism assumed due to *Trichogramma* spp.

III. BUDWORM - FOREST CONDITIONS AND 1980 HAZARD FORECAST

This section reports results of surveys of defoliation, budworm moth occurrence, egg mass deposit, tree damage, and L-II levels. These data were used to formulate the hazard map presented in this section.

A. Defoliation, Aerial Survey

In July of 1979, an aerial defoliation survey was conducted and the entire spruce-fir region of Maine was mapped for current budworm defoliation. The survey began during the budworm pupal stage when most of the budworm-clipped dead needles still adhered to the webbing and twigs. The survey was completed prior to loss of "browning" due to wind and rain. Brown conditions were not striking in 1979 and the survey was extremely difficult.

Trained observers surveyed the infested area from small fixed-wing aircraft and helicopters. The areas of defoliation were sketched on 1:62,500 topographic maps in the following categories: none, light to moderate and heavy to severe. Aircraft used were Cessna 180 and Cessna 185.

The area of heavy-severe defoliation are shown in Figure 11. Aerial defoliation was supplemented by ground observations within the sprayed areas and in questionable sections.

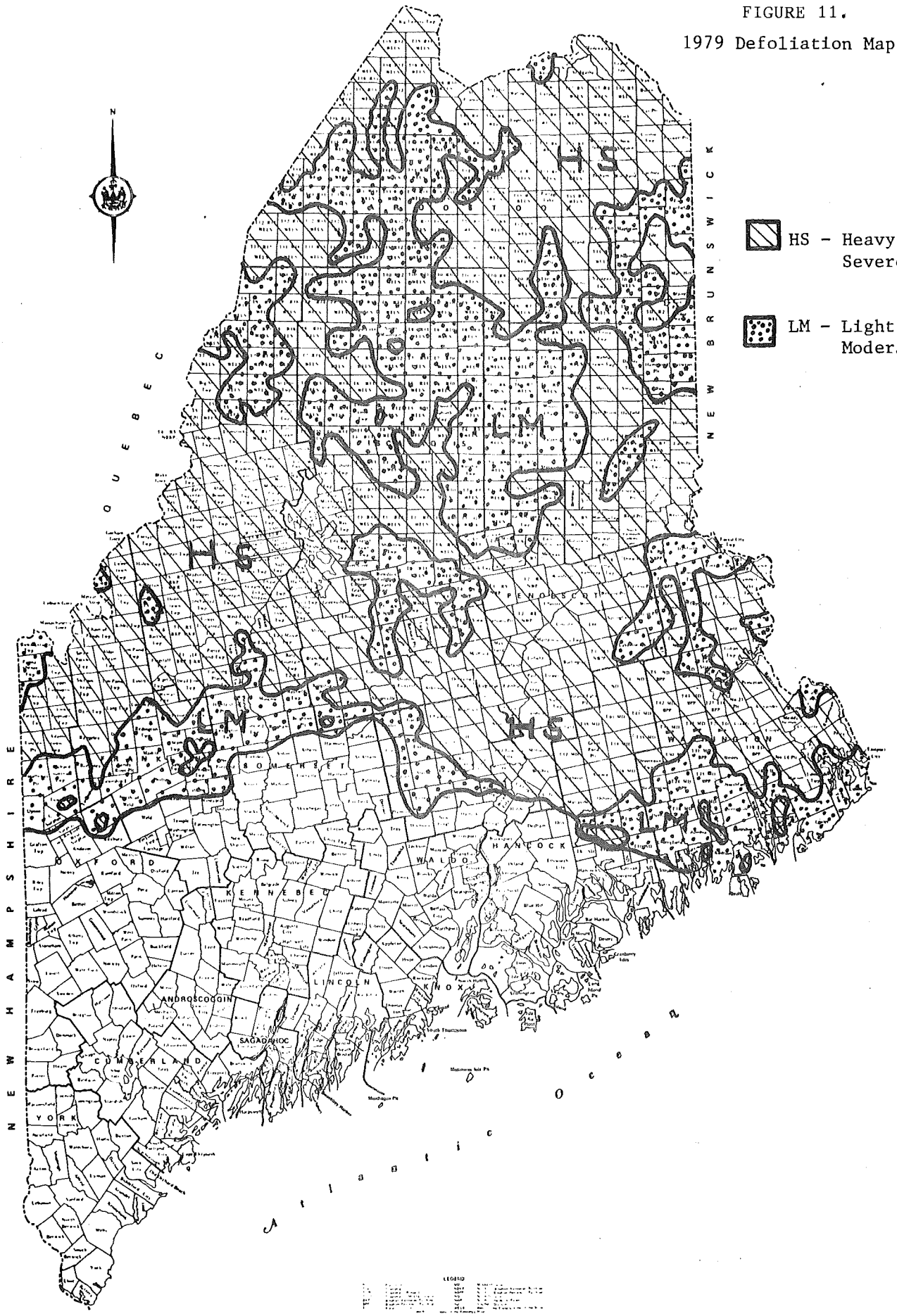
B. Forest Insect Survey (F.I.S.)

The 39th season of the F.I.S. proved again to be informative and rewarding. The recent change utilizing assigned fire control personnel to collect samples on an assigned schedule from designated tree species has proven to be useful in obtaining uniform data throughout the State. The regular budworm parasite survey was again included as part of the F.I.S. responsibility, the results of which are reported elsewhere.

Larval Collections--Collectors were again designated from fire control personnel statewide and were asked to collect insects from spruce, fir and other tree species following a carefully designed schedule using the "tree beating" method. Cooperation was very good and most of the requested collections were made according to schedule.

FIGURE 11.

1979 Defoliation Map



Year	Fire Control Collections	Collections From Other Sources	Total
1978	418	165	583
1979	401	262	663

The number of F.I.S. collections processed increased by 80 or nearly 14% from 583 in 1978 to 663 in 1979 statewide coverage and representation was excellent. Of the 683 collections received, 198 or approximately 30% yielded spruce budworm larvae or pupae (Figure 12). The number of budworm per tree sampled was 6.8 in 1979 as compared to 6.2 in 1978. These figures are conservative as collectors are asked to send in only a representative sample when numbers of larvae are high. Larvae collected in this manner generally appeared quite healthy with little disease or parasitism.

C. Moth Activity As Monitored by Light Traps

A total of 16 light traps (Fig. 13) were operated statewide during the 1979 season to determine the distribution and abundance of major lepidopterous forest insect pests, especially the spruce budworm. Table 16 summarizes the numbers of budworm moths caught during the period of moth activity.

Spruce budworm moth activity was down from 1978 especially in traps located within the spruce-fir belt (notably traps at Allagash, Clayton Lake, Garfield and T6R19). Traps in more western southeastern and southern portions of the State (notably Kingfield, Elliotsville Plt., Meddybemps, Brunswick, Hollis Center and Washington) showed much higher catches in 1979 than in 1978. The period of moth activity in 1979 was just slightly later than that experienced in 1978 but was somewhat more prolonged. The peak of activity (except for the Kingfield and Allagash traps) began around July 8 and ran through July 16. Overall catches showed a strong single peak of activity as they did in 1978 rather than the 2-4 peaks experienced in some other years. The uniformity of larval development statewide may have contributed to this. Longer range moth flights were more evident in 1979 especially in western and eastern areas of the State. One noticeable moth flight was reported from Rumford between July 13 and 14 and several inches of moths accumulated beneath lights in the area. Lesser flights occurred in eastern Maine in mid July.

It appears that we did not experience the moth inflights into spruce-fir stands in 1979 that we experienced in 1973 and 1974 but rather had fairly significant but somewhat limited outflight activity from infested stands to areas to the south and east. Most of this exodus flight activity occurred between July 10 and July 17 except in the Kingfield trap which showed a large inflight between July 22 and July 24. It is suspected that the large numbers collected in the Kingfield trap may have come from infested areas in the western mountains where larval development was retarded.

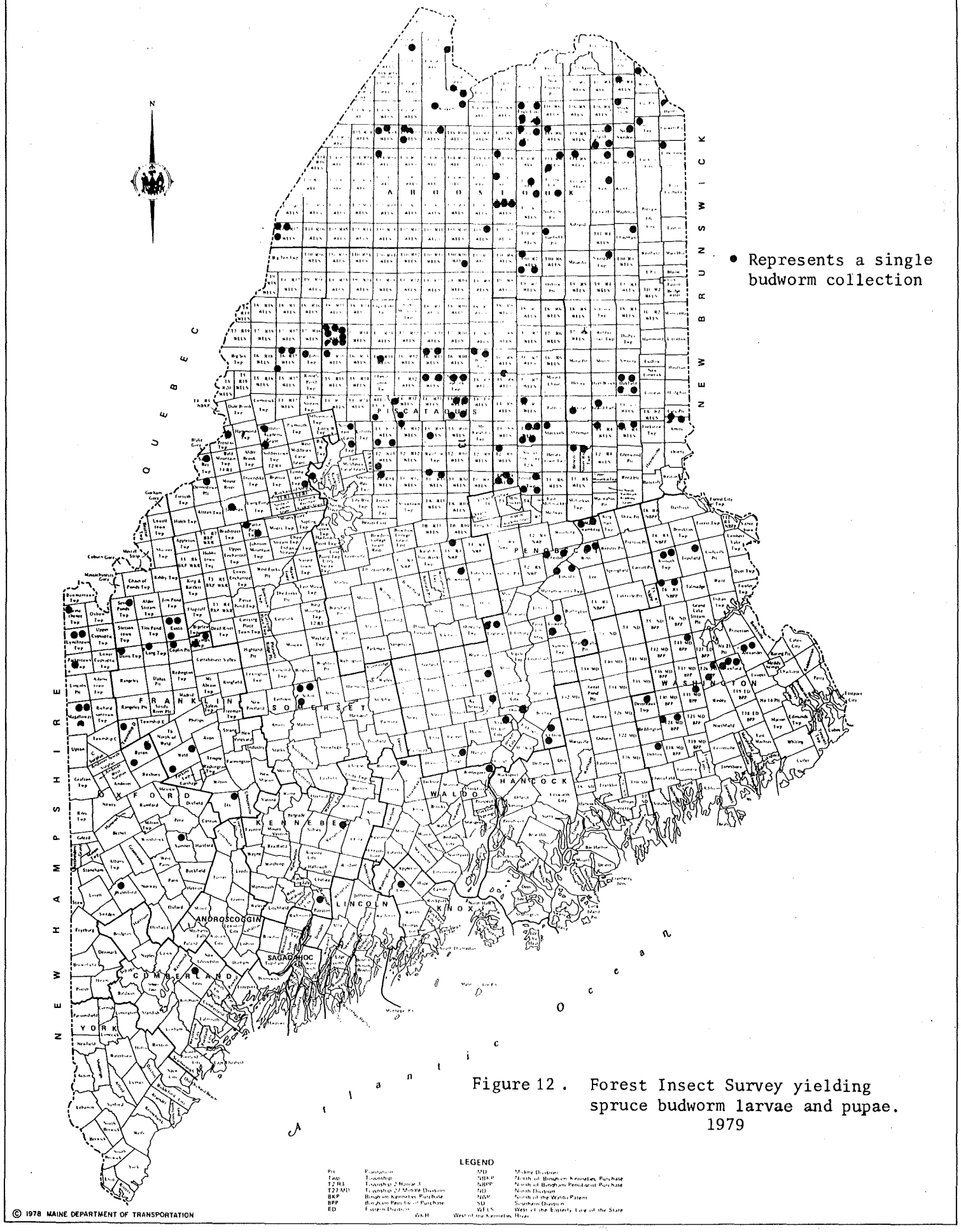


Figure 12. Forest Insect Survey yielding spruce budworm larvae and pupae. 1979

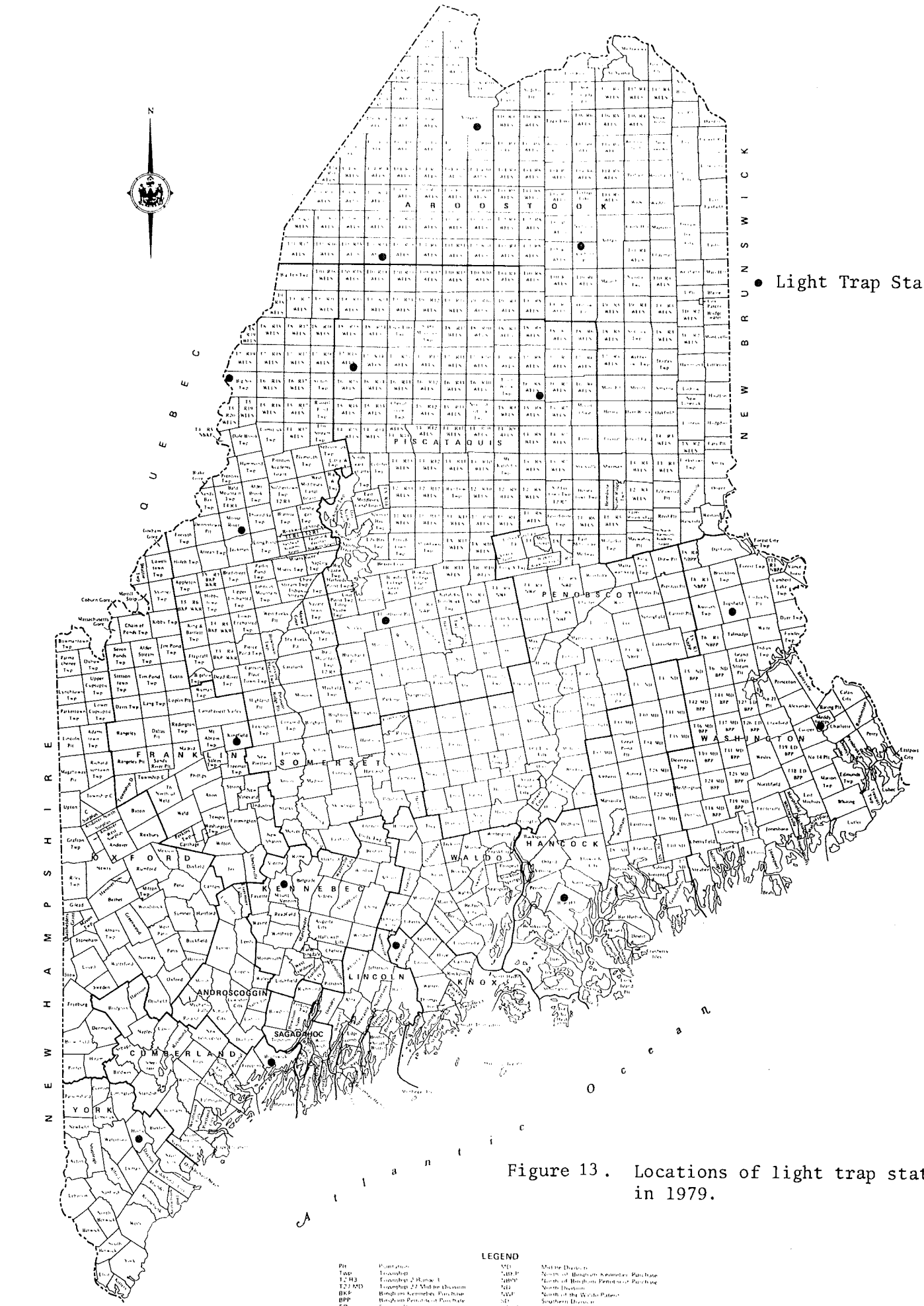


Figure 13. Locations of light trap stations in 1979.

LEGEND

Plt	Plantation	MD	Maine Division
Twp	Township	NBKP	North of Bingham Kennebec Purchase
T2 R3	Township 2 Range 3	NBPP	North of Bingham Penobscot Purchase
T2 MD	Township 2 Maine Division	ND	North Division
BKP	Bingham Kennebec Purchase	NWP	North of the White Patent
BPP	Bingham Penobscot Purchase	SD	Southern Division
ED	Eastern Division	WELS	West of the Easterly Line of the State

Table 16. Summary of the Number of Spruce Budworm Moths Collected at Light Traps In Various Locations During June and July of 1979

Trap Location	Date June 26	27	28	29	30	July 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Totals
Brunswick												4	1	1	1	1	37	27	22	30	22	31	26	29	25	42	7	12	2			320
Hollis Center			2																		485	102	14	7	7	8	1	2	6		4	638
Mt. Vernon														1		3	3	6		1						1						15
Washington								1		1		6	1		3	2	7	13	12	15	7	12	12	7	6	3	1					109
Kingfield		2	9	2	6	5	29		1		6	7	57	28	189	185	2536	3880	2376	408	2528	86	160	143	1008	848	16500	18080	1900	200	350	51529
Elliotsville	3	128	184	35	300		95	24	2	102	131	71	350		900	1500	1430	2160	3220	800	640	80	175	160	100	165		340	140	140	140	13515
Moose River	6	46	8	22	146	19	40	1				65	28	29	430	326	1140	248	966	830	1400	19	44	15	26	53	62	180	120	117		6386
Caucomagomac					4	2	4				1	21	8	15	25				11	28								4	2		125
T6 R19			2	2	75	207		1		1	57	70	264	50	516	256	368	82	1120	1632	78			9	1		4		275	48	4	5122
Topsfield		3	5	42	2	13				8	39	15	23	39	52	150	95	159	558	240	44	18	22	3	11	8	4	10	3	5	1	1572
Blue Hill		1					4		2					17	11	14	5		6			1			1			1	2	6	1	72
Meddybemps	1		9	27	21			331	57	3	29	212	362	490	500	1000	600	1365	900	450	72										6429
Allagash	24	81	40	100	1004	167	356	179	1		1	160	163	140	12	63	143	51	50	328	47		2		1	10	9	2	12	2	4	3152
Garfield	1				4	1	1	3				4	3			7			3	30	14	5										76
Hay Lake	3	9	33	240	400	27	67	37	3		46	310	400	400	210	350	600	220	350	389	58	2	26	3	35		16	32	93	50	9	4418
Clayton Lake			13	1	58	363	30	75	3			1	122	140	37	80	349	131	325		267	155	6	8	20		82	24	37	3	4	2334
Totals	38	270	305	471	2018	804	626	652	69	115	310	946	1782	1350	2886	3937	7313	8342	9919	5182	5662	511	487	384	1241	1138	16686	18683	2594	573	517	95811

D. Secondary Insect Problems

Over the years it has become evident that a number of secondary insect problems associated with budworm-infested spruce and fir can cause sufficient impact to complicate assessment of budworm damage or spray effectiveness. Of the many insects found on spruce and fir, several lepidopterous defoliators in the genus *Dioryctria* and a complex of woodboring beetles stand out as the most significant. Although these insects alone seldom cause significant damage on a broad scale, they can cause locally heavy damage in association with budworm feeding.

Dioryctria: The species of *Dioryctria* in Maine are not well understood, but it appears that at least 2 species do occur in association with the spruce budworm and may build up in numbers sufficient to produce noticeable defoliation. Over the past few years light trap collections have also indicated a buildup in numbers in the spruce-fir forest. While the significance of the feeding by *Dioryctria* spp. is still subject to questions, defoliation of spruce has often been heavier than can be explained by spruce budworm. Where such defoliation has occurred, it may have complicated the assessment of foliage protection following insecticide treatment. It appears that, due to slightly different feeding habits and development, *Dioryctria* often survives regular budworm spray operations.

Dioryctria prey upon budworm larvae and apparently have a higher level of competative ability. There is certainly a need to evaluate this relationship more closely in the future should populations of *Dioryctria* continue to increase.

Woodborers: Woodboring beetles have been recognized as a primary factor effecting the decline and deterioration of spruce and fir following attack by the spruce budworm. In earlier outbreaks several species of beetles were instrumental in destroying large numbers of host trees weakened by the budworm. In the current outbreak or series of outbreaks (since the late 1940's) there had been relatively little woodborer activity, except very locally, until approximately 1975. As the acreage of severely weakened spruce and fir increased, accompanied by amplified cutting operations which generated large volumes of slash suitable for breeding beetles, subtle and locally striking population increases of woodboring beetles were noted. Three primary groups of beetles are involved: bark beetles (*Pityokeines sparsus* on fir; *Dendroctonus obesus* on spruce); sawyer beetles (*Monochamus* spp.); and bark weevils (*Pissodes dubius*). A complex of woodborers such as this seldom causes problems in a healthy forest, but as stress on the trees increases, such opportunistic pests are enabled to exert more impact. Once woodboring beetles become established they increase slowly until they reach a population threshold. When this threshold is reached the inoculum of beetles become sufficeint to cause catastrophic mortality. There are also a number of factors which may allow only one of the species to develop to such levels (as has occurred in western Ontario in Canada where *Monochamus* is causing significant damage in spruce-fir stands).

In order to determine the status of the woodborer complex in Maine,

and to try and determine the degree of impact, a series of woodborer/deterioration/mortality plots have been planned statewide. Between 40-60 plots will be established this winter (1979-1980), each with 50 trees. Tree and insect conditions in these plots will be recorded initially and monitored for at least 5 years to determine the trends of woodborer populations and mortality. The presence and impact of disease organisms within these stands over the period will be studied.

E. Data Computerization

An increased effort was made in 1979 to computerize all egg mass and tree condition data as it became available from the laboratories. The data was processed by the MFS Planning Division using the computer mapping and digitizing capability of that unit. Using this procedure, maps of egg density and hazard (Figure 14) were produced on a weekly basis at any scale desired. These maps were made available to some industry representatives, but problems with map reproduction made complete dispersal impossible. Reproduction difficulties can be corrected by 1980, allowing a timely source of survey data to the effected landowners.

The combination of computerized data and the digitizing capability has allowed an opportunity to effectively assess many concepts such as the hazard ratings and population prediction. The mapping aspects of the current system allows the MFS to produce a map of almost any perimeter in minutes. This capability has revealed numerous areas of possible study.

To date, all data through 1973 has been added to the system and previous data is being processed as time permits.

F. Egg Mass Survey

In late July and August, an egg mass survey was conducted to provide an indicator of expected 1979 population levels. The egg mass survey was concentrated in the spruce-fir protection district of the State.

The 1979 egg mass survey was begun July 23rd and completed by August 24th. At this time, many masses were badly weathered but color differences between new and old egg masses allowed differentiation by trained observers.

An egg mass sampling density of one sample per 10,000 acres was set for areas of uniform stand type. In areas where stand types varied or where spraying was conducted, sample density was increased to as many as one sample per 3,000 acres. A total of 1,353 samples were taken and evaluated.

Egg mass samples consisted of one upper mid-crown branch from each of

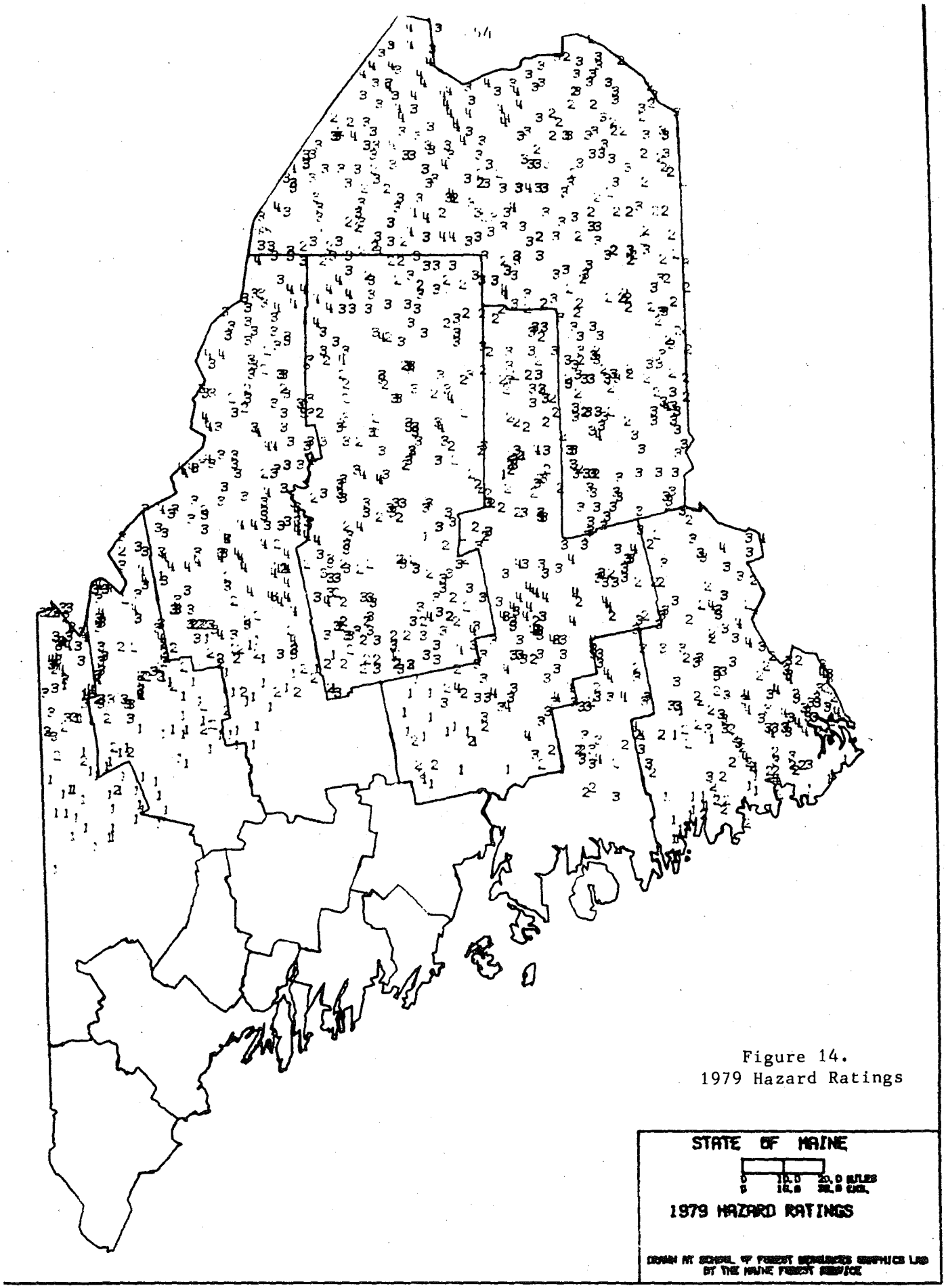


Figure 14.
1979 Hazard Ratings

four dominant or co-dominant fir trees, per sample point. Each branch was cut up and bagged separately. The dimensions of the foliated portion of each branch were recorded. Collections were sent to one of the three field laboratories where they were searched by experienced lab help. As egg masses were found, the needles on which they were attached were separated from the branch and saved. Egg masses were classed in one of the following categories:

1. Old; from previous year's populations.

2. New-healthy.

3. New-parasitized; the majority of eggs in the egg mass parasitized.

4. New, dead of other causes; the majority of eggs in the egg mass damaged or destroyed by predation, disease, etc., so as to prevent larval development.

The final determination of the egg mass category was made by an entomologist in the laboratory.

Following completion of the egg mass survey, an analysis of the viability, Table 17, of the egg masses was made. The values for the individual branches within each sample point were grouped so that each sample point was given equal statistical weight. A twenty percent sample was analyzed.

TABLE 17. VIABILITY OF SPRUCE BUDWORM EGG MASSES, INCLUDING THE RELATIVE ABUNDANCE OF OLD EGG MASSES STILL PRESENT ON FIR FOLIAGE IN 1979

Category*	Mean $\bar{X}$	Standard Deviation
% Parasitized	8.11	10.18
% Dead of Other Causes	0.03	1.38
% Old Egg Masses	19.89	19.09
% New and Viable	91.86	---

* Percentage of Parasitism, and Dead of Other Causes was based on the number of new egg masses. Percentage of Old and New Egg Masses was based on the total number of egg masses encountered.

The number of new, healthy egg masses per square foot of foliage was calculated separately for each branch of the sample and then converted to the number per 100 sq. ft. for comparison with a sequential table (Morris, 1954). Searching of additional branches ceased when

the cumulative egg mass count fell into a sequential category. The average number of egg masses per 100 sq. ft. of foliage was then calculated to an infestation level as shown in Table 18.

TABLE 18. SPRUCE BUDWORM INFESTATION LEVELS BASED ON EGG MASSES PER 100 SQ. FT. OF FOLIAGE

No. Egg Masses 100 Sq. Ft.	Infestation Level
0	None
1- 99	Light
100-239	Moderate
240-399	High
400-999	Very High
1000 +	Extreme

Egg deposit was mapped to show general features of the 1979-1980 infestation (Figure 15). The general forecast for 1980 contains many changes from the 1979 situation. The large area in northern and eastern Maine which was uniformly high and extreme in 1979 is expected to have variable population levels in 1980. Large areas which show some uniformity of population are; a high level west of Moosehead Lake to the Quebec Border; the Chesuncook and Telos Lakes area which shows low to moderate levels, an area northwest of Allagash Lake which is extreme, and the north central tip of the state around Allagash Village which is high to extreme.

In addition to the general egg assessment, geographic zones were delineated (Figure 8) for the purpose of analyzing trends in the 1980 egg deposit. The six zones used are described in Table 19.

Mean egg mass levels for the total survey area and for each zone are reported in Table 20. Egg deposit by zone is mapped in Figures 16 through 21.

Assessment of the 1980 prediction show that all zones have egg levels in the moderate to extreme range. The Allagash-St. John, Penobscot-Mattawamkeag, and Moosehead zones all showed an increase but the increase was not significant. The Northeast zone showed a sharp decrease from the extreme levels of 1978 and the Western Mountain Zone showed a sharp increase. In each case the change was greated than 100%. The southeast coastal zone showed a significant decrease in egg deposit.

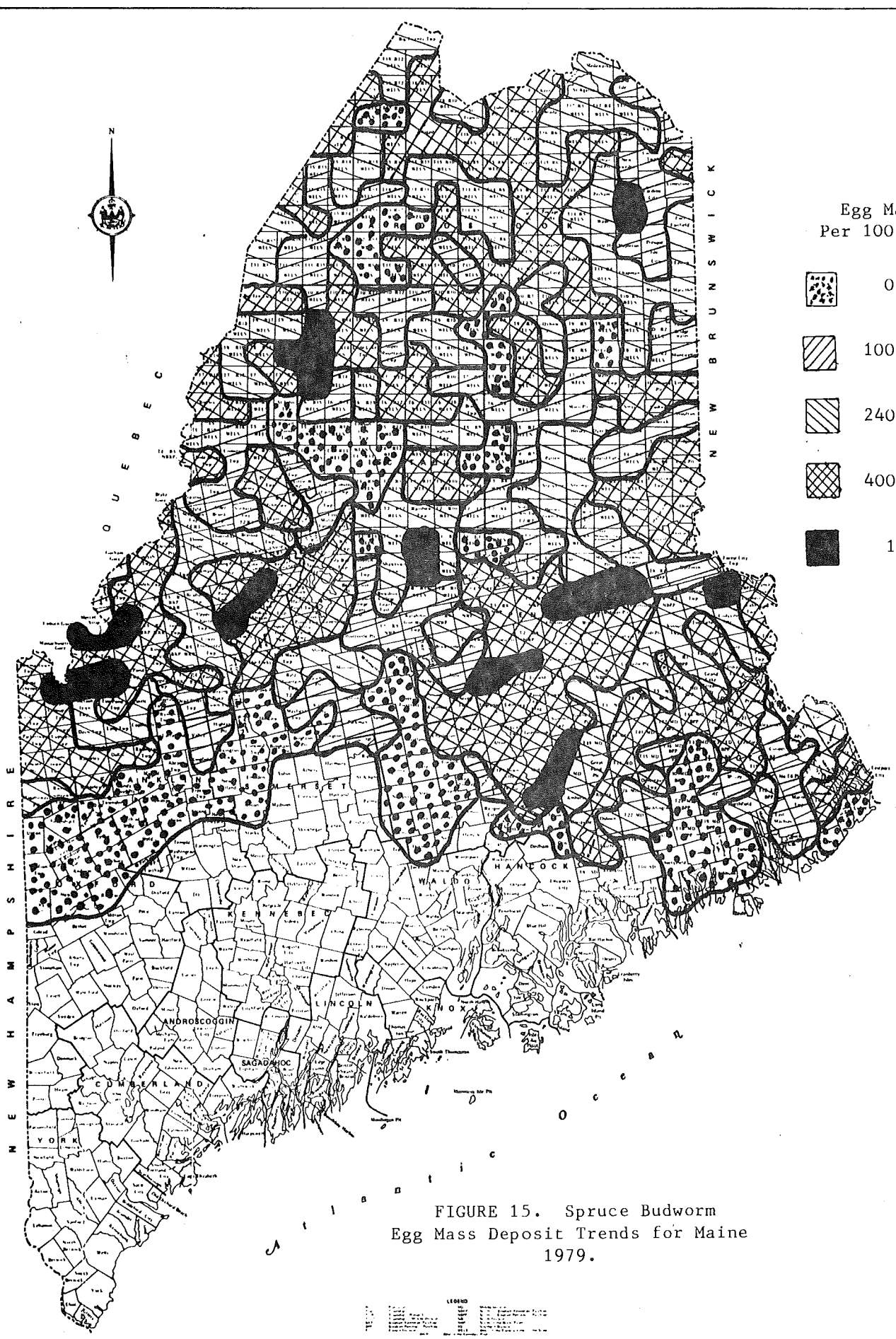


FIGURE 15. Spruce Budworm
Egg Mass Deposit Trends for Maine
1979.

TABLE 19.

EGG MASSES DEPOSITED BY THE

SPRUCE BUDWORM IN 1979, BY ZONES

Zone	N	Egg Masses/100 Sq. Ft. $\bar{X}$	Standard Deviation
Allagash-St. John	188	392.1	408.3
Northeast	323	373.8	321.9
Penobscot-Mattawamkeag	181	607.2	1362.6
Southeast Coastal	170	291.6	279.5
Moosehead	266	286.8	314.0
Western Mountains	223	416.3	451.5
Total	1351	387.1	401.1

2 points were not assigned to a zone.

TABLE 20.

MEAN EGG MASS DEPOSIT AND

POPULATION TRENDS BY ZONES

Zone	Egg Masses/100 Sq. Ft. 1976	1977	1978	1979	1978 to 1979 Trend
Allagash-St. John	86.4	331.6	331.2	392.13	No Change
Northeast	144.7	312.2	824.4	373.78	- -
Penobscot-Mattawamkeag	348.1	287.4	518.6	697.21	No Change
Southeast Coastal	721.5	154.6	469.2	291.61	-
Moosehead	252.5	110.4	209.9	286.83	No Change
Western Mountains	312.1	106.5	158.2	416.28	+ +

EGG MASS LEGEND

No. of Egg Masses/100 sq. ft. of foliage

- ○ – 0 – 99
- ⊖ – 100 – 239
- ⊕ – 240 – 399
- ◒ – 400 – 999
- ● – 1000 +

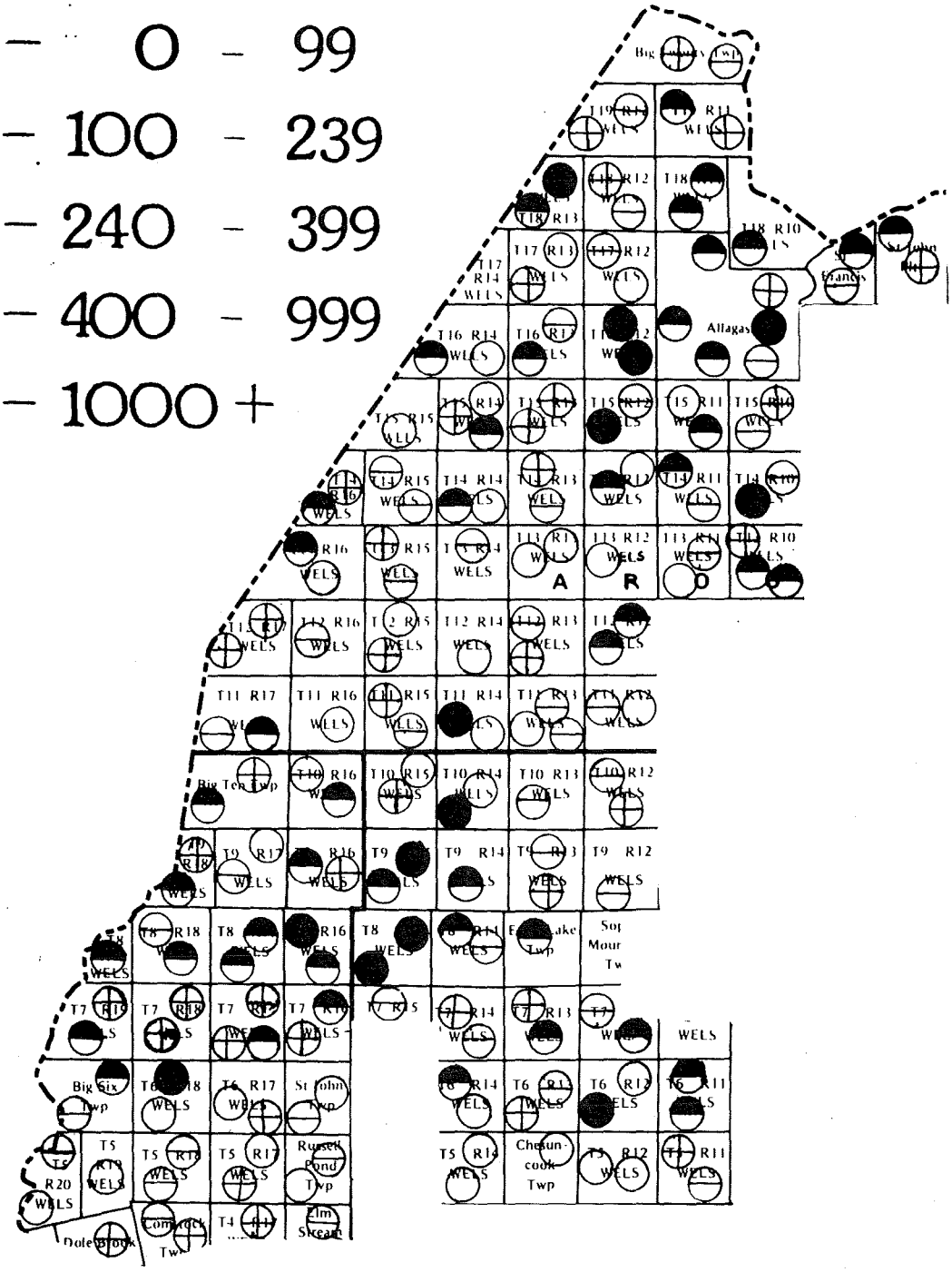


Figure 16. 1979 Spruce Budworm Egg Mass Survey Map of Allagash – St. John Zone.

EGG MASS LEGEND

No. of Egg Masses/100 sq. ft. of foliage

○ – 0 – 99

⊖ – 100 – 239

⊕ – 240 – 399

◒ – 400 – 999

● – 1000 +

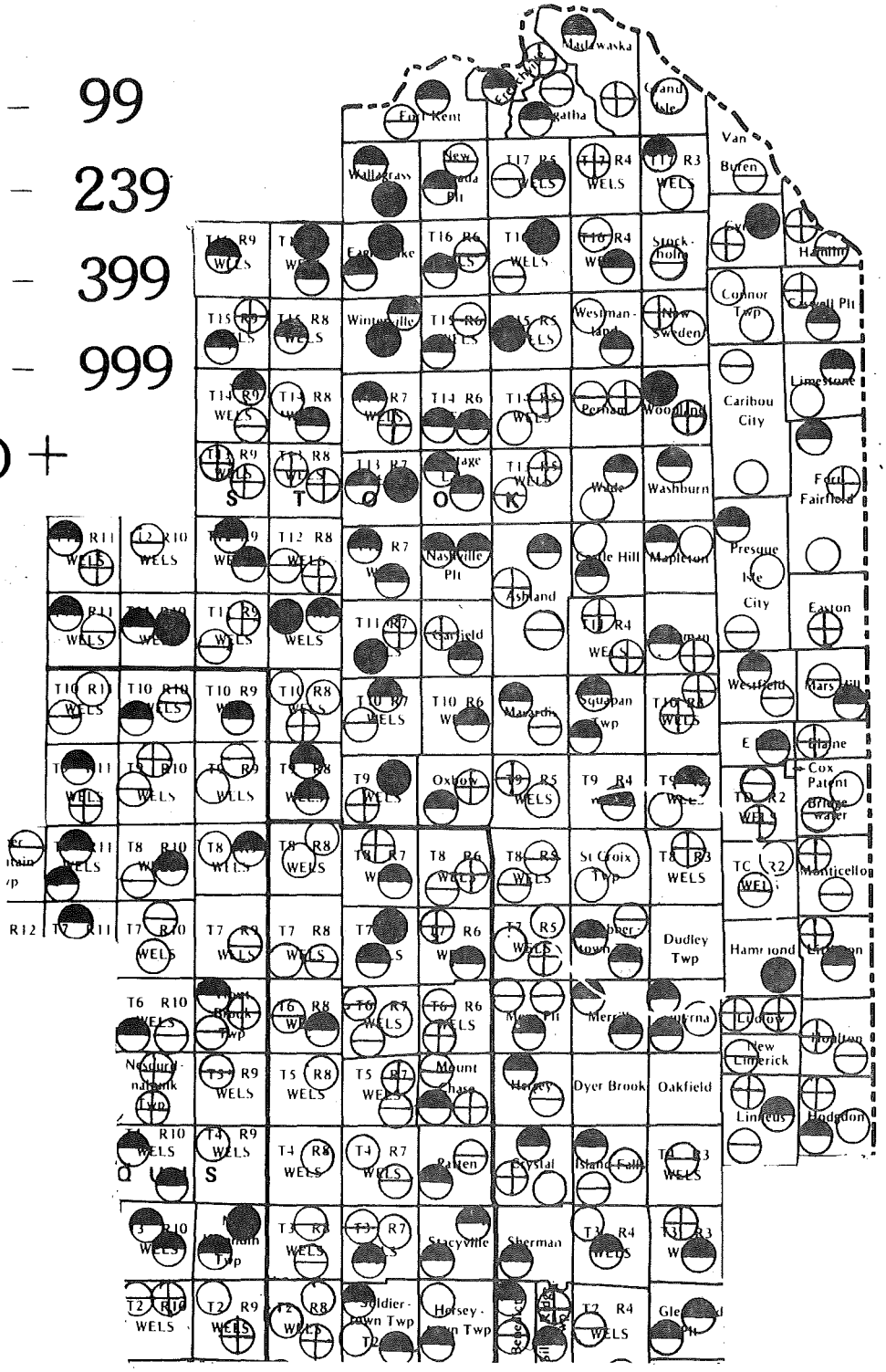


Figure 17. 1979 Spruce Budworm Egg Mass Survey Map of Northeast Zone.

EGG MASS LEGEND

No. of Egg Masses/100 sq. ft. of foliage

○ – 0 – 99

⊖ – 100 – 239

⊕ – 240 – 399

◒ – 400 – 999

● – 1000 +

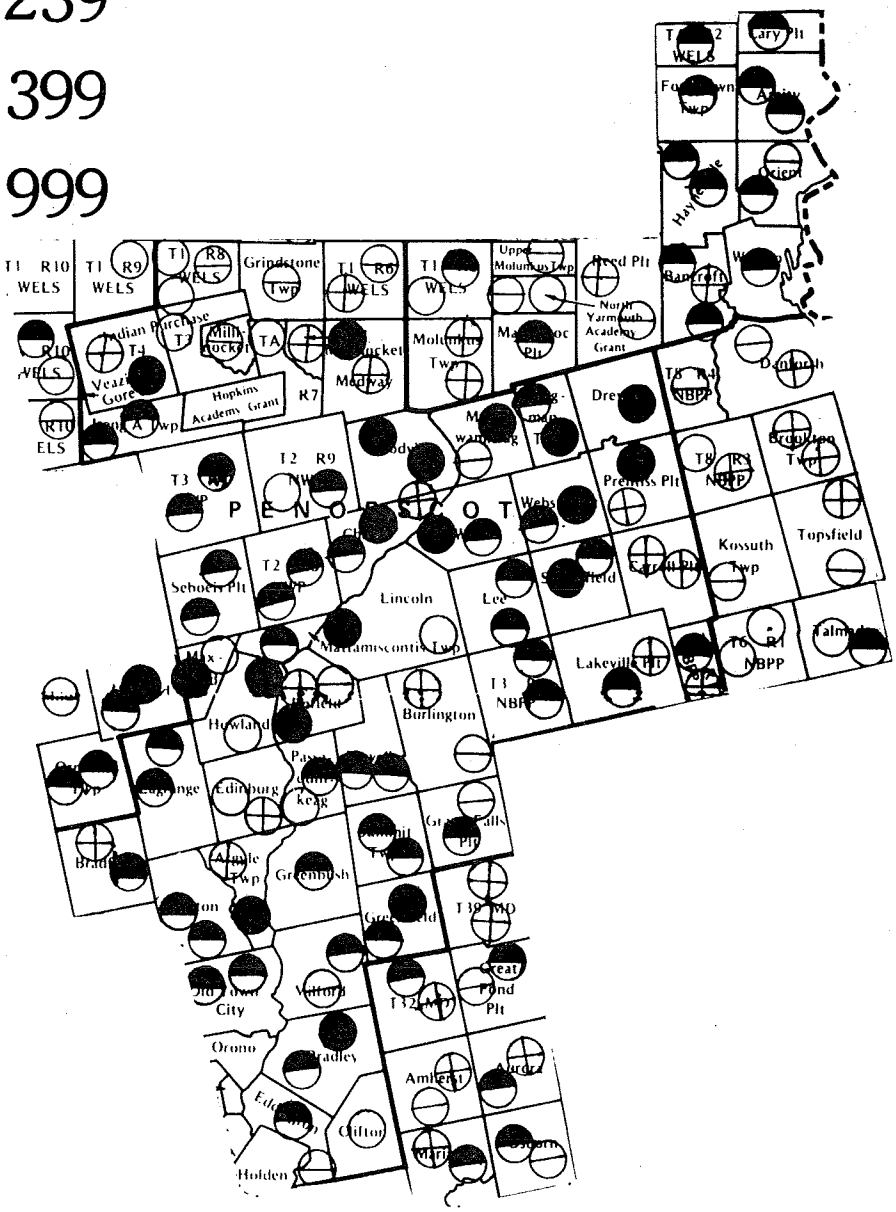


Figure 18. 1979 Spruce Budworm Egg Mass Survey Map of Penobscot - Mattawamkeag Zone.

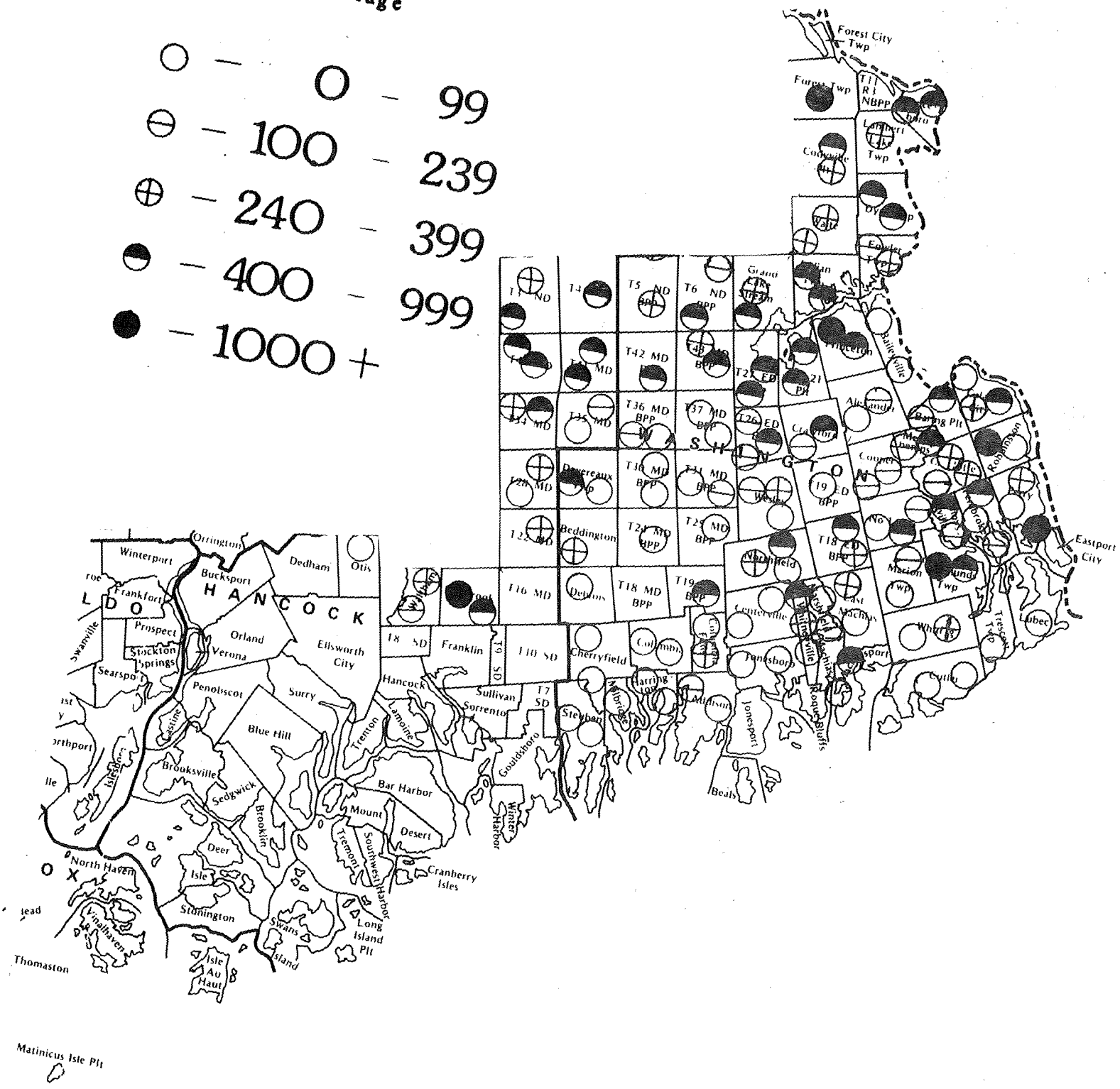


Figure 19. 1979 Spruce Budworm Egg Mass Survey Map of Southeast - Coastal Zone.

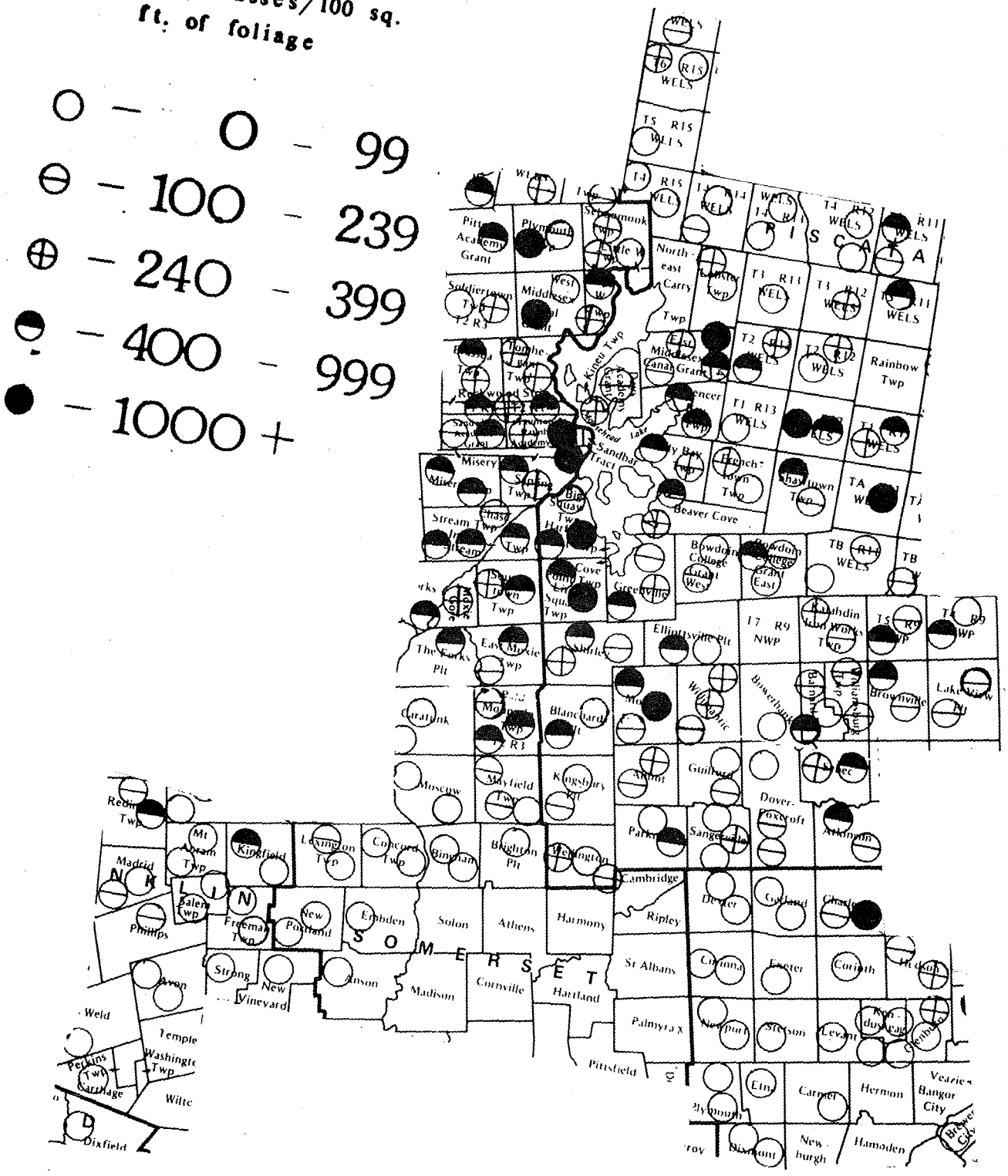


Figure 20. 1979 Spruce Budworm Egg Mass Survey Map of Moosehead Zone.

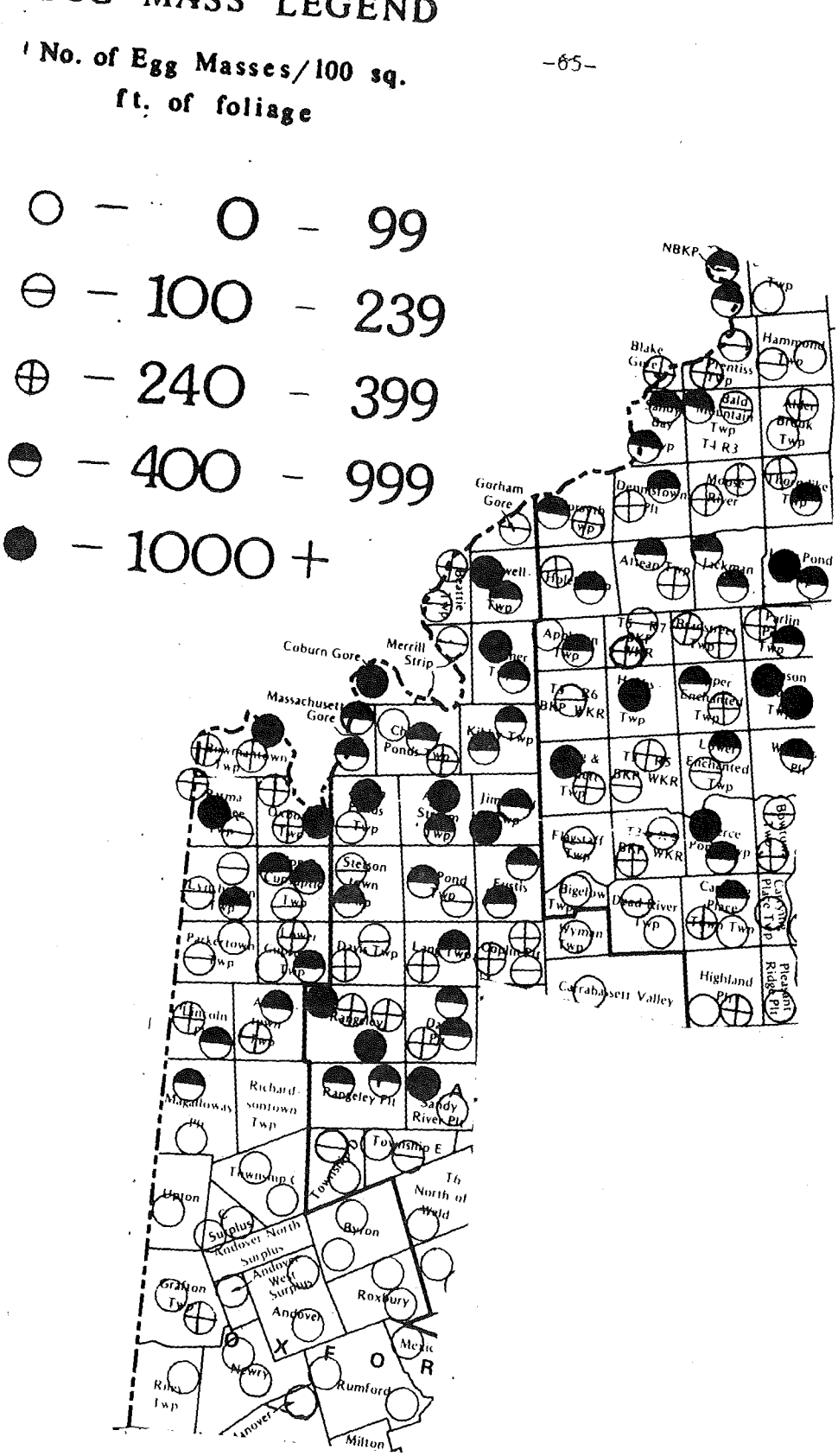


Figure 21. 1979 Spruce Budworm Egg Mass Survey Map of Western Mountain Zone.

G. Tree Damage Surveys

Ground Assessment--Concurrent with the collection of egg mass samples, a survey of tree condition in the infested areas was made. At each egg mass sample point the following data were taken from balsam fir:

Percent defoliation of current year's growth

Percent defoliation of 1978 and 1977 growth

Tree vigor

Crown ratio

Presence of dead tops

Presence of dead trees

These data were used to determine the general state of the stands. Stand condition data in conjunction with the egg mass data were then used in the determination of hazard values and potential damage to fir stands in the absence of control measures.

Aerial Assessment--A second aerial survey was conducted in September and October to map tree and stand conditions in the portion of the State which had heavy egg mass deposits or in which heavy defoliation was noted during the July aerial survey. Aerial observation of infested area after the browned needles have weathered off the trees allows an accurate estimation of tree condition which can be readily correlated with ground hazard data. This overview of tree damage allows the drawing together of areas of similar hazard on a map delineating areas requiring attention to prevent tree mortality.

In 1978 and 1979 some forest type mapping was conducted during the aerial damage survey. This typing data was used predominantly for the omission of hardwood areas from the proposed treatment areas.

The presence of tree mortality was noted, but no attempt was made to assess the percentage of dead trees. The dead and moribund trees appeared gray as opposed to less severely damaged trees which were brownish or green. The presence of dead tops was also recorded.

The actual mapping was done on 1:62,500 scale maps by one or two experienced observers per plane. Aircraft used were the Cessna 180, DeHavilland Beaver and the Bell 47 helicopter. Flying was usually done at approximately 500 feet and at 80-120 miles per hour. Flight patterns were usually keyed to roads, topography, or watersheds.

The information gathered in this survey was used extensively to delineate areas of high hazard for 1980.

In addition to results of the Maine Forest Service damage survey, information from private surveys by the various landowners was solicited. Such data are being studied to more closely delineate areas in need of further investigation.

H. Mortality Studies

During aerial surveys, areas containing patches of significant fir and spruce mortality were mapped (Figure 22). As in 1978, several 500 to 2500 acre areas of high mortality (10 to 25%) were located. The total area in this condition was approximately 25,000 acres. In addition to these "large" areas of mortality, countless patches (.5 to 5 acres) of mortality were present. Also, individual dead stems were found throughout much of the infestation.

Many of the mortality areas were found in areas not sprayed for a variety of reasons. With the exception of the larger areas, most mortality has occurred in intermediate and suppressed trees. Most of the larger mortality areas had dead trees in all classes. Most large mortality areas also have a very high fir content.

Nearly the entire increase in the size of the mortality area in 1979 (10,000 acres) occurred in Washington County. An area of approximately 50,000 acres was dropped from the project for a number of reasons and consequently heavy mortality occurred. Mortality within about 10,000 acres of this area increased from 5 to 13% in 1978 (Devine et. al., 1978) to 18 to 39% in 1979. Mortality to fir within the untreated Moosehorn Wildlife Refuge, also in Washington County, was estimated to be in excess of 60%. A detailed resurvey of the Moosehorn Wildlife Refuge will be conducted in the winter of 1979-1980.

I. Overwintering Larval Survey

During the winter of 1979-1980 an overwintering larval survey will be conducted. This survey will be used to check budworm populations in those areas which were inaccessible at the time of the egg mass survey and in those areas where additional population information is necessary. Overwintering larvae will be extracted by the methods of Miller et.al. (1971) and populations will be assessed by the rating established in New Brunswick (Miller and Kettela, 1972).

Tree condition data will be collected when overwintering larval samples are taken. The larval population estimates and tree condition data will be used to calculate hazard. Hazard values from this survey will be used to supplement the hazard values from the egg mass survey in order to better delineate proposed treatment areas.

Larval samples will also be taken from spruce during the winter of 1979-1980. These samples will be compared to samples taken from fir in the same area.

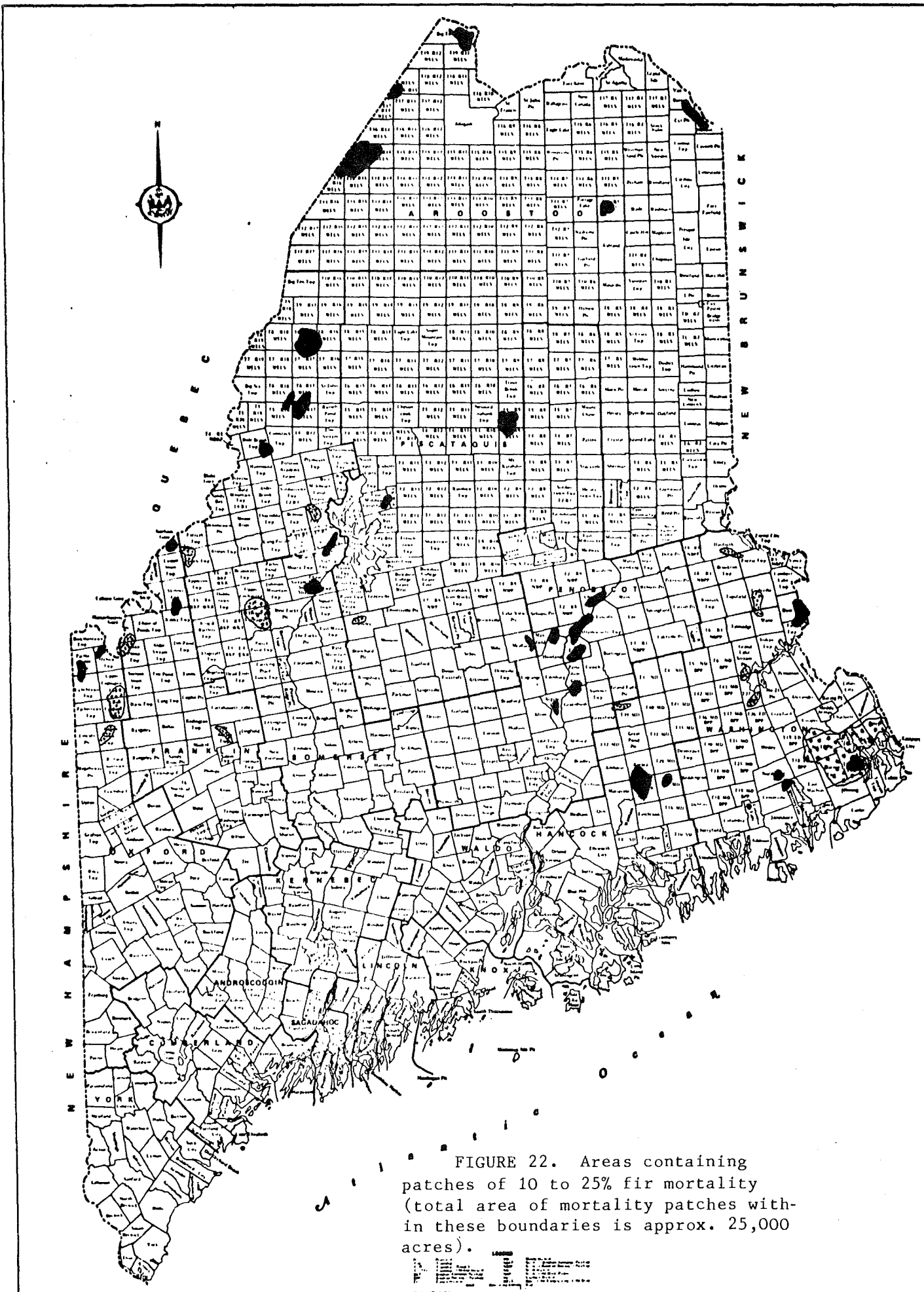


FIGURE 22. Areas containing patches of 10 to 25% fir mortality (total area of mortality patches within these boundaries is approx. 25,000 acres).

J. Forecast of Tree Condition and Hazard for 1980 in Maine

Results from the tree condition and egg mass surveys were used to establish a hazard rating for each sample point. Base maps of the 1979 hazard data were used in conjunction with an aerial damage survey conducted in September and October to delineate areas of predicted high and extreme hazard (Figure 23). Hazard data were also summarized by category in Figure 24. In 1979, the high and extreme hazard area totaled more than 5 million acres. The proposed treatment area for 1980 will be chosen from these high and extreme hazard areas. The process of selection of a treatment area from the high and extreme hazard area involves consideration of the following:

1. Forest type - selection for spray of only those areas of sufficient fir and spruce.

2. Elimination from spray of areas where non-target hazards exist.

3. Elimination of areas which are small (less than 5,000 acres) if they are isolated from other treatment areas and a great distance from airports.

4. Elimination of areas where terrain prevents a safe and effective application.

5. Elimination of areas where populations are found to be low during winter L-II samples and prespray checks.

The hazard rating system and relative values of the data are summarized in Table 21. Total hazard values were determined for each sample point and were plotted on maps (Figures 25-30).

The hazard outlook from 1979 can best be summarized in terms of the same zones as those described for egg mass analysis.

Allagash - St. John -- Hazard in this zone was extreme in 1979 following no treatment in 1977 and application problems in 1978. The treatment in 1978 did save back foliage, the 1979 buds, and reduced population. The 1979 treatment was extremely successful in this area and most areas now have a good crop of 1979 foliage. The 1979 egg deposit is essentially the same as in the 1978 coverage, but counts are reduced in sprayed areas. The combination of 1979 foliage and a reduced egg deposit in some areas has caused a mean decrease of hazard within the zone. Even though hazard is reduced, the extremely heavy past damage in the area has maintained hazard in the high range. Untreated areas remain extreme.

Northeast -- Hazard in this zone is decreased in areas of good spray results in 1979 and sharply increased in unsprayed areas. Hazard in the areas sprayed late in this zone is unchanged in general. The overall outlook for this zone is variable for 1980, but in general hazard is high.

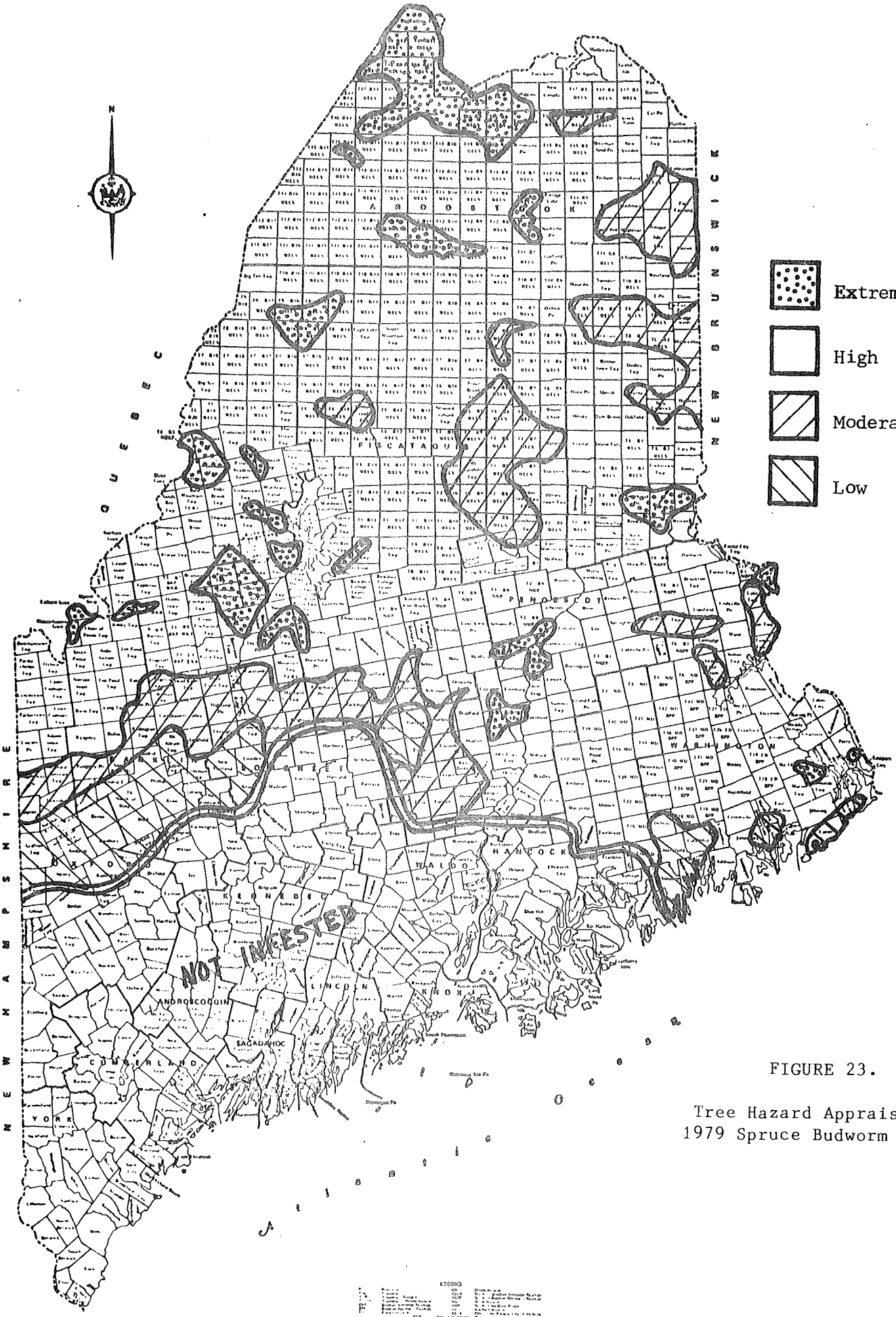


FIGURE 23.

Tree Hazard Appraisal Map
1979 Spruce Budworm Survey.

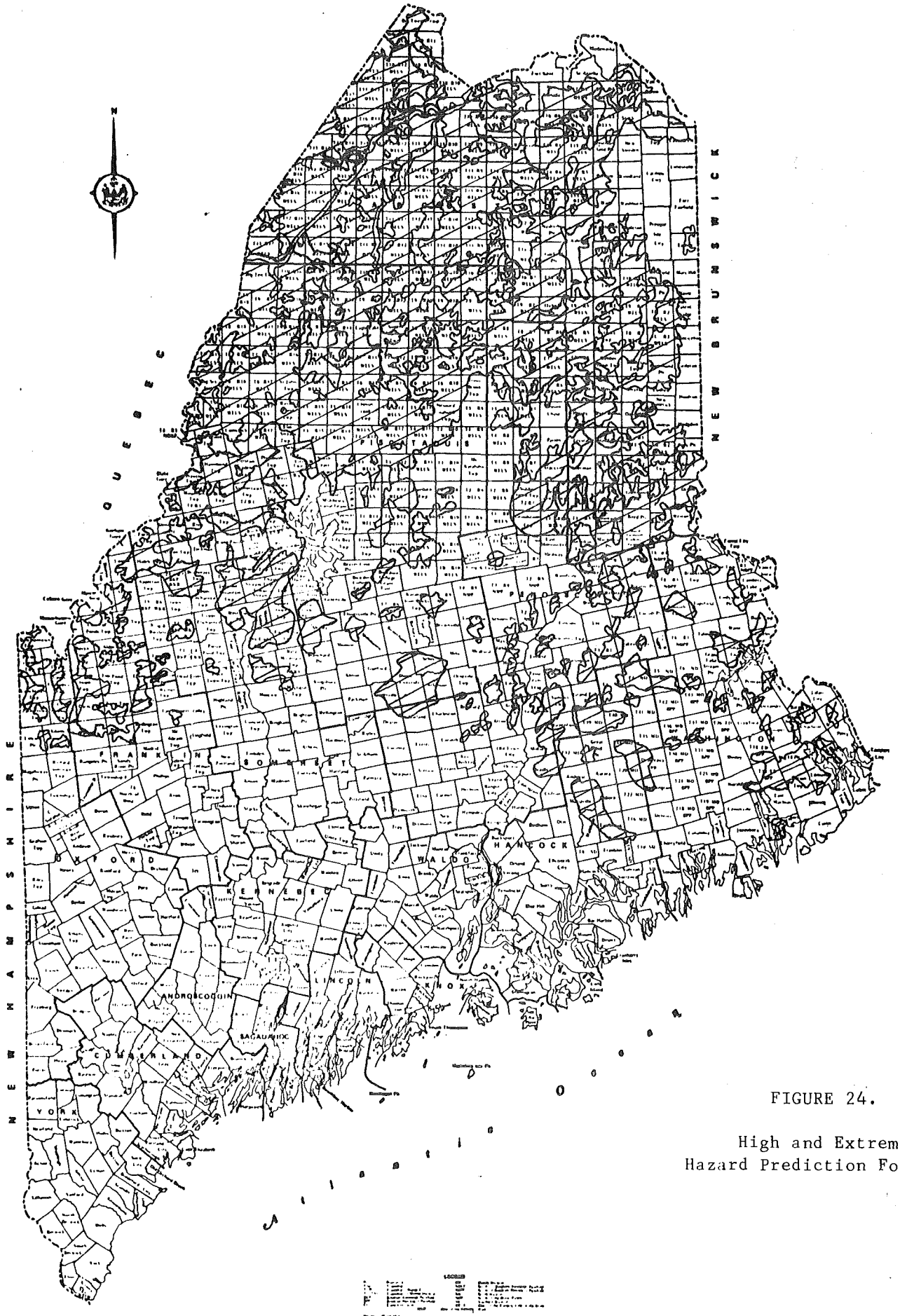


FIGURE 24.

High and Extreme
Hazard Prediction For 1980.

TABLE 21. HAZARD RATING SYSTEM USED IN 1979

Current Defoliation

Category	Values	Hazard Values
Trace	0-5 %	0
Light	6-20 %	1
Moderate	21-50 %	2
Heavy	51-80 %	4
Severe	81 + %	6

Previous Defoliation

(1978 % plus 1977 %)

Trace	0-9 %	0
Light	10-49 %	3
Moderate	50-129%	6
Heavy-Severe	130 + %	9
Dead Tops		+3

Egg Mass Deposit

Based on No./100 sq. ft. of foliage

None	0	0
Light	1-99	1
Moderate	100-239	2
High	240-399	3
Very High	400-999	4
Extreme	1000 +	5

Tree Vigor

Good	0
Fair	1
Poor	2
Very Poor (No chance of recovery)	3

Hazard

Hazard Rating	Range of Total Values
Low	0- 6
Moderate	7-15
High	16-22
Extreme	23-26

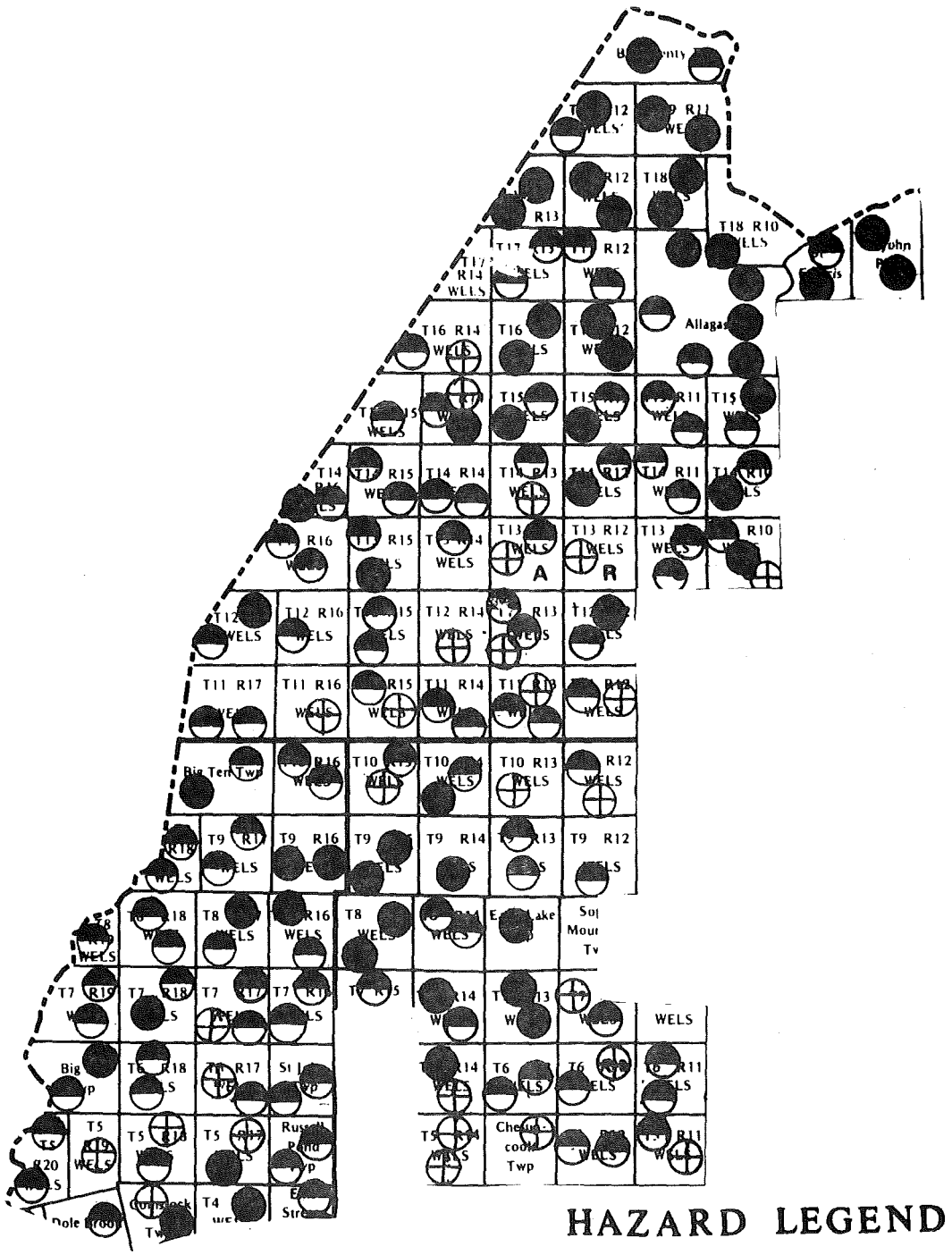


Figure 25. 1979 Spruce Budworm Hazard Appraisal Map of Allagash - St. John Zone.

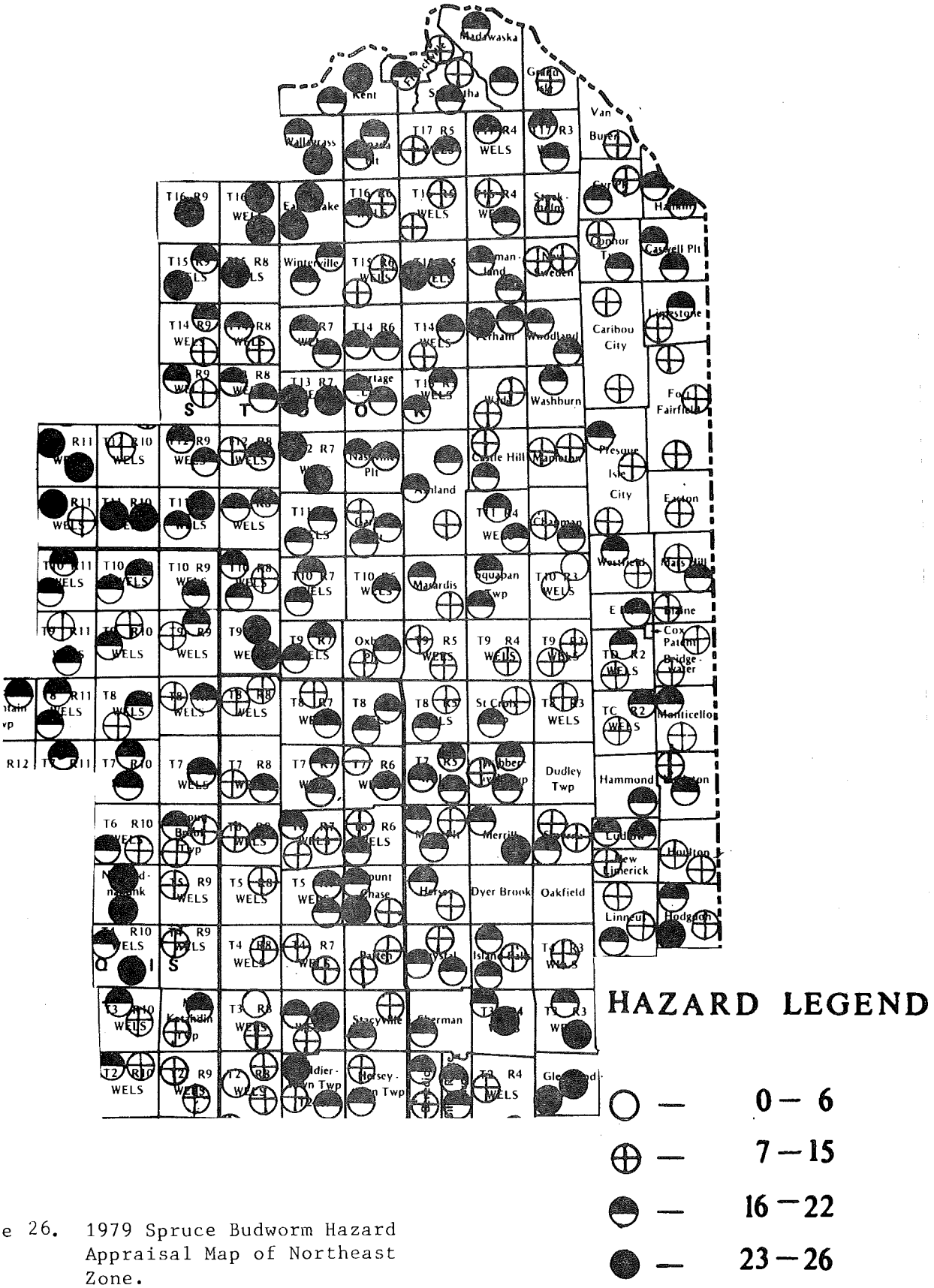


Figure 26. 1979 Spruce Budworm Hazard Appraisal Map of Northeast Zone.

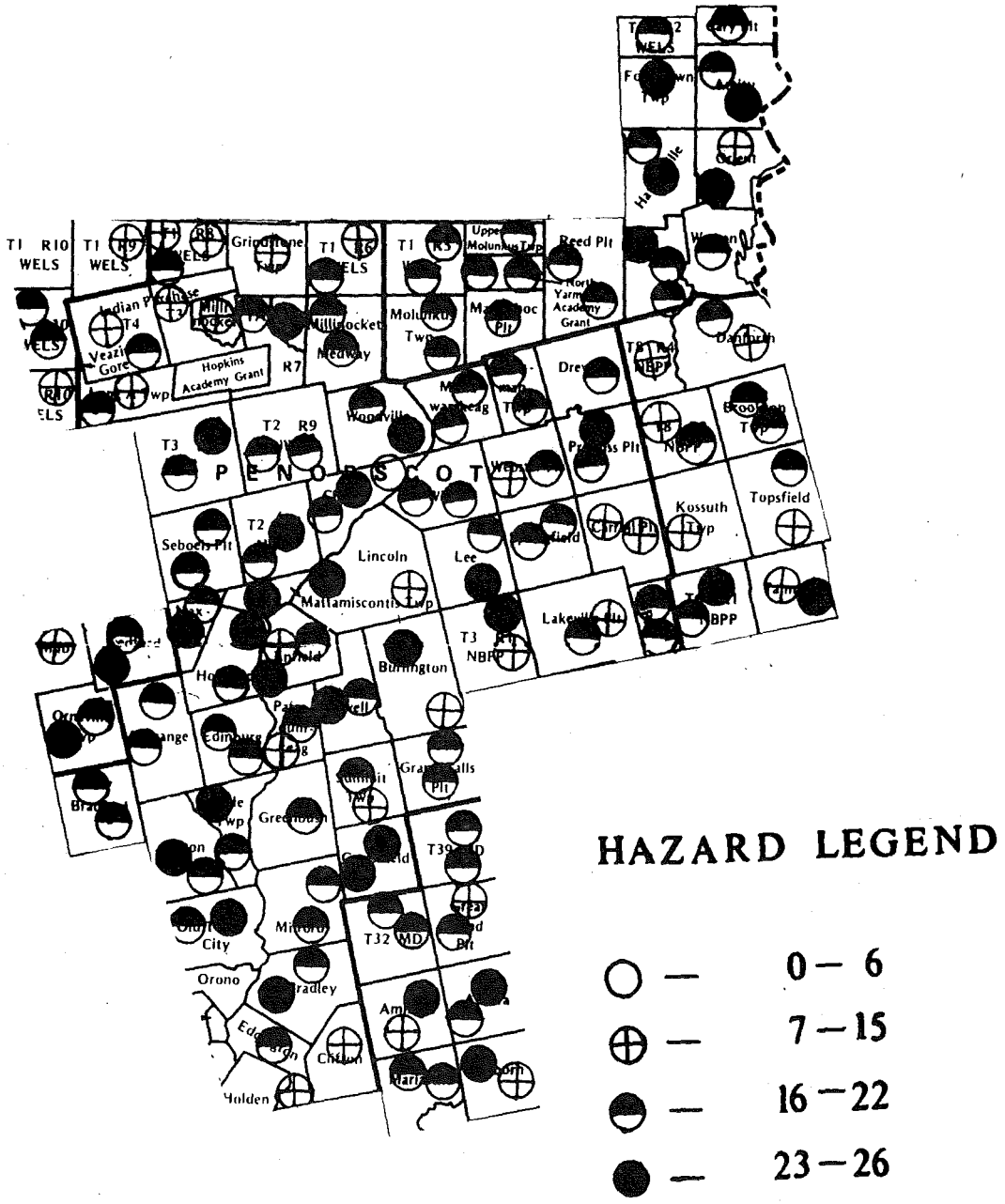


Figure 27. 1979 Spruce Budworm Hazard Appraisal Map of Penobscot - Mattawamkeag Zone.

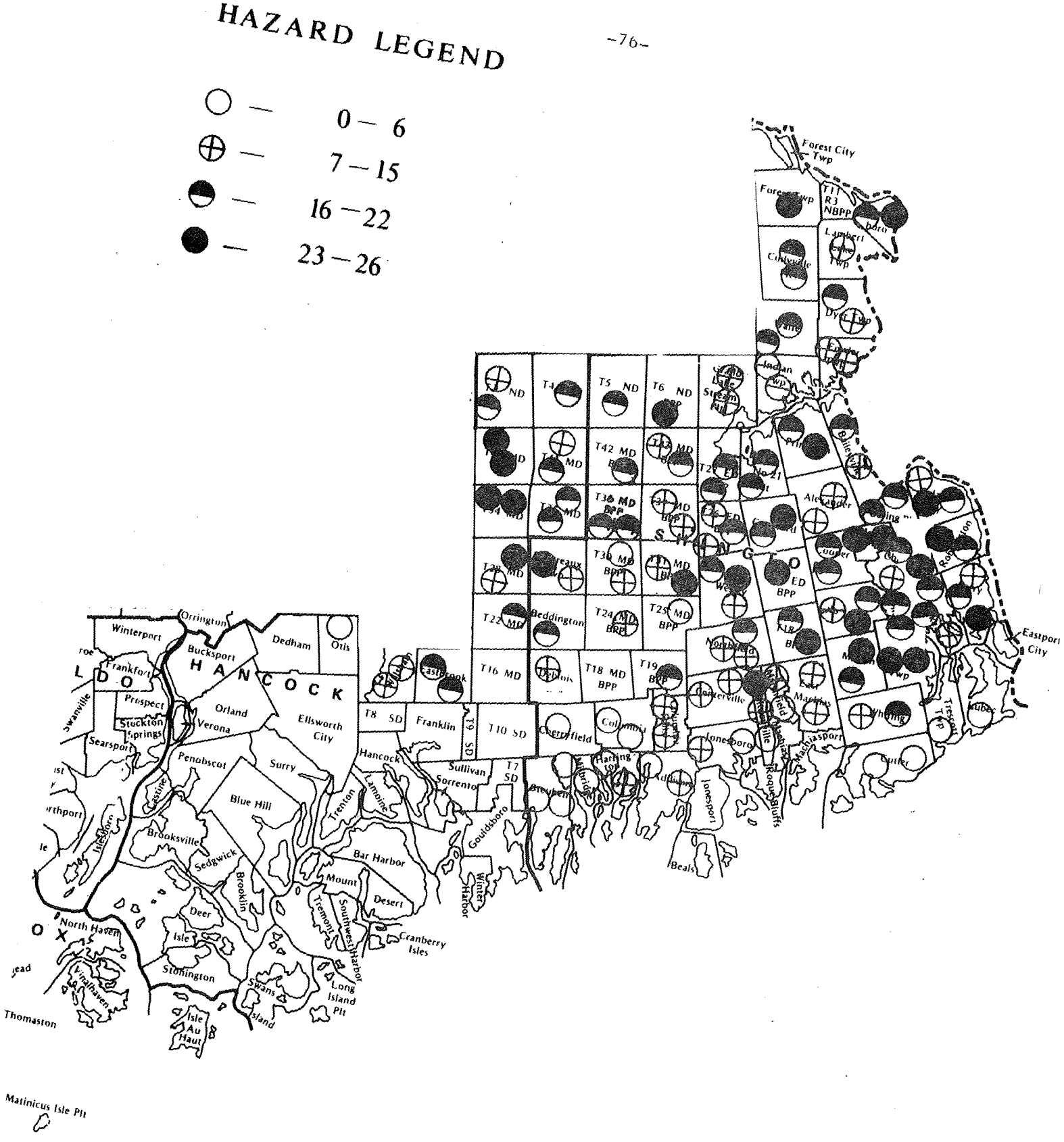


Figure 28. 1979 Spruce Budworm Hazard Appraisal Map of Southeast Coastal Zone.

HAZARD LEGEND

○ — 0 — 6

⊕ — 7 — 15

◓ — 16 — 22

● — 23 — 26

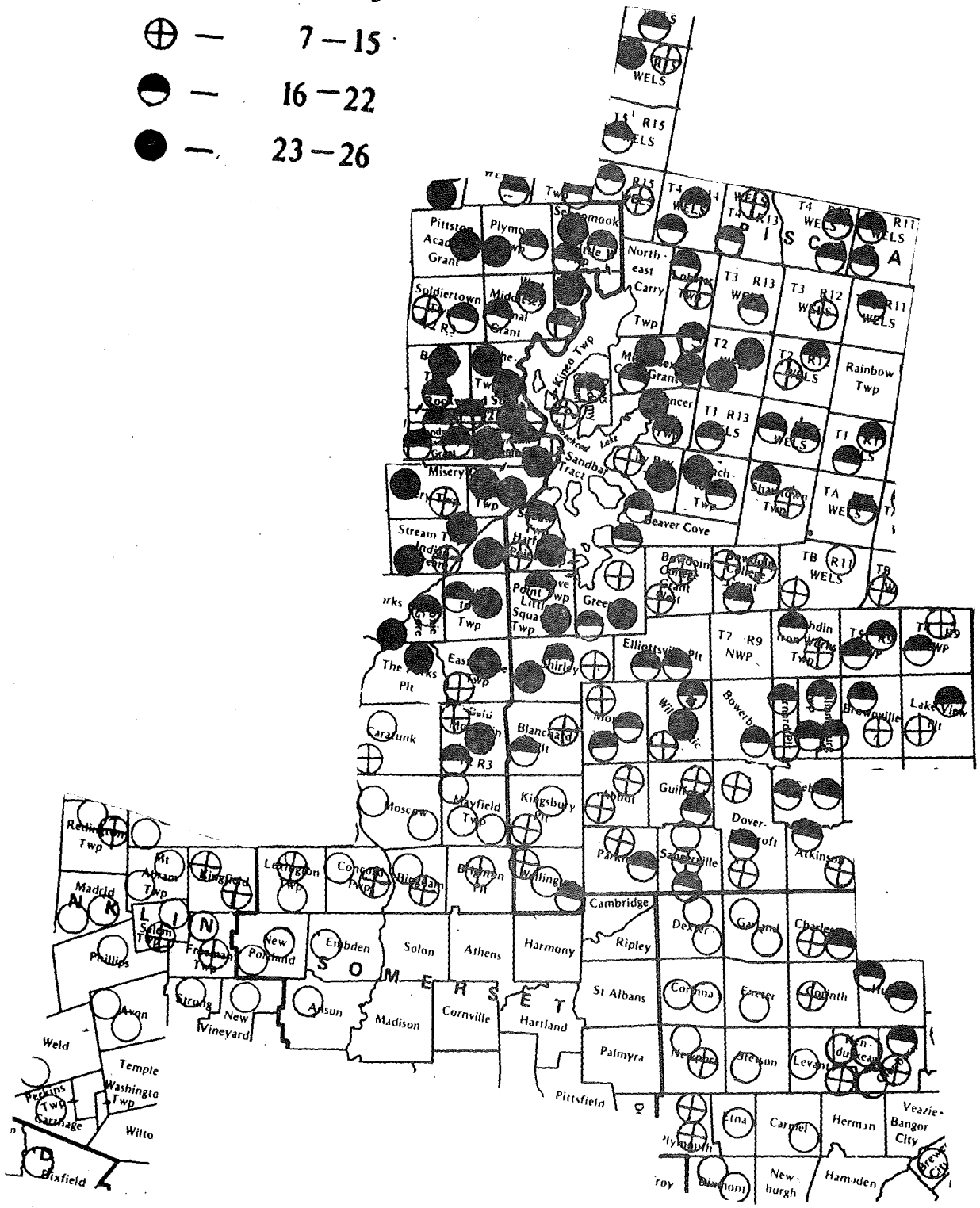


Figure 29. 1979 Spruce Budworm Hazard Appraisal Map of Moosehead Zone.

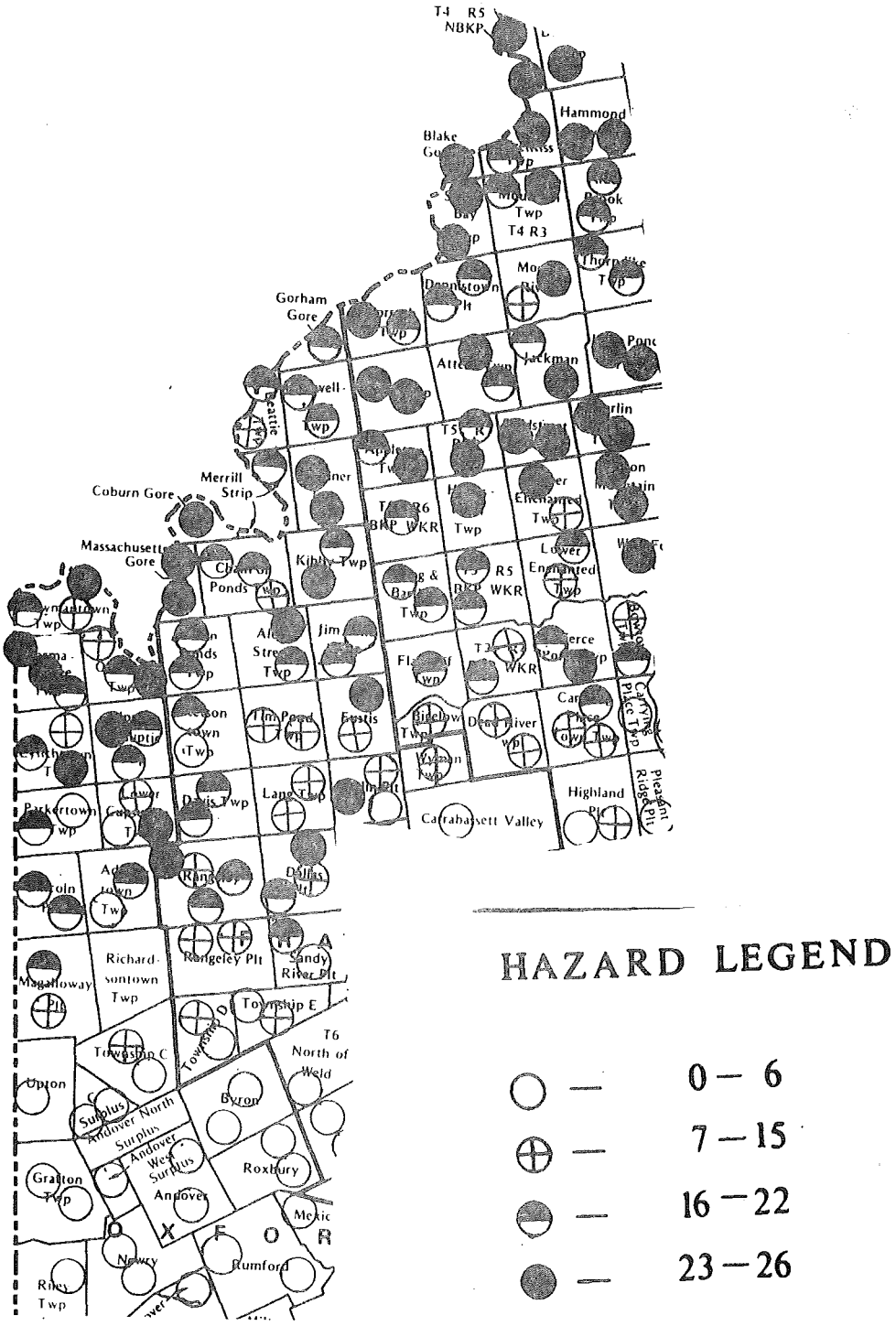


Figure 30. 1979 Spruce Budworm Hazard Appraisal Map of Western Mountain Zone.

Penobscot - Mattawamkeag--Hazard in this zone is reduced slightly in sprayed areas and is now moderate. Hazard in unsprayed areas has increased steadily in this zone and much mortality can be found in buffers. Spraying in this zone in general has not been successful in consistantly reducing hazard to the degree seen in northern Maine.

Southeast Coastal--Very little of this zone was treated in 1979 despite high and extreme hazard. As a result, much of the southern part of the zone is extreme and many areas are dead or moribund.

Hazard in the northern portion of the zone is reduced in treated areas and slightly increased in unsprayed areas.

Moosehead--Little spraying was done in this area in 1979 and as a result hazard showed a general increase. Most areas of type in this zone are now in moderate or high hazard. Much of the hazard increase is due to increased egg deposit.

Western Mountains--Rough terrain, noncontinuous type, and buffers have prevented widespread spraying in this zone and thus hazard is increasing in many areas. Sprayed areas are not showing increased hazard, but application problems have prevented success such as that seen in northern Maine.

IV. 1979 EFFORTS AND FORECAST OF CONDITIONS IN ADJACENT CANADIAN PROVINCES

Quebec and New Brunswick engaged in large scale spray projects in 1979. In Quebec, 3.1 million acres were treated in the lower St. Lawrence and a single block in the Gaspe' region. Insecticides used in Quebec were Matacil, Fenitrothion, and 'BT'. Most areas were treated twice in the fourth and fifth instars. Application was made predominantly with large 4 engine aircraft. Treatments were classified as successful in terms of population reduction and foliage protection. The last two operations in Quebec have been aided by larval population levels below those experienced in the early 70's. In 1979 larval populations were generally below 20 per 45 cm branch tip.

Predictions for 1980 suggest a further decline of the Quebec infestation both in the Gaspe' and the lower St. Lawrence areas. Egg counts in the Gaspe' remain very low and counts in the lower St. Lawrence are somewhat lower than 1979 levels. A relatively small project of .5 million acres is planned for Quebec in 1980.

In New Brunswick slightly less than 4 million acres were treated in 1979 with Matacil. Two applications were planned, but uniform development throughout the province caused a shift to a single application. The single application was at the rate of 1.35 oz. acre and was used on approximately 3 million acres. The project was classified as successful, with foliage saved around 55%. Foliage protection was better than average in areas where split applications were used and protection of spruce was better with splits. Egg density was down slightly in 1979 and, as a result, improved conditions are expected in 1980. The treatment area for 1980 is expected to be approximately 4 million acres.

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APPENDIX A

SPRUCE BUDWORM PROJECT 1979

PROGRAM CHRONOLOGY, 1978-79

APPENDIX A

SPRUCE BUDWORM PROJECT 1979

PROGRAM CHRONOLOGY, 1978-79

1978

July	20	Critique of 1978 Spray Operation
	26	Briefing of Landowners et. al. on preliminary results of the '78 operation.
August	30	To Broomall, PA - met w/USFS on preparation of Environmental statement (ES) for BW '79.
September	12	Met w/I. Millers-USFS on spray aircraft specifications and spray block design. Met w/Jim O'Brien-USFS on 1979 ES.
	22	Met w/Stauffer chemical representatives concerning use of Sumithion.
October	3	Met w/State purchasing personnel in preparation for BW '79.
	6	Met w/Entomology Division et. al. on chemicals to use during BW '79.
	10	Met w/landowners et. al. on plans for BW '79.
	11	Initial pre-bid conferences on chemical.
	17	To Quebec for meeting with Spray Technology Committee of the Eastern Spruce Budworm Council.
	23	Initial pre-bid conferences on aircraft.
	31	To USFS - Portsmouth on Draft ES.
November	9	Met w/USFS et.al. on BW demonstration areas.
	15	Met w/Spruce-Fir Silvicultural Committee.
	27	Preliminary spray block design on USGS sheets.
	29	Met w/Stauffer chemical personnel and interested parties on the environmental concerns relative to the use of Sumithion.
December	5	Completed preliminary spray block design.
	8	Unity College - Seminar on SBW Control and the Environment.
	11	Attended Union Carbide seminar on use of Sevin.
	15	To St. John N.B. - met w/D. Oxley to review J.D. Irving spray operations.

1979

January	2	Ordered Sevin through GNP for BW '79.
	8	Fixed wing specifications to GNP.
	10	Opened bids on building tank storage area at Millinocket - four bids - price higher than budget - did not accept any bids.
	31	Met w/Sandoz Chemical on 'BT;.
February	5	Attended NRC sponsored meeting on Matacil at which Dr. Wm. Thurlow was speaker.
	13	Ordered Orthene, Dylox, Matacil.
	14	Met w/Cramm on Radio requirements for BW '79.
	20	Appropriation hearing.
	21	Met w/Airport Supervisors for BW '79.
	22	Bids for Monitor/Administrative and Medivac aircraft to Bureau of Purchases.
	26-28	CANUSA B Conference and Eastern Spruce Budworm Research Conference in Bangor.
March	1	Opened fixed wing aircraft bids at GNP.
	6	Selected fixed wing aircraft contractor - Globe Air/Beigert Aviation, Mesa, Arizona.
	13	Mixing contract specs. to Bureau of Purchases.
	14	BW '79 Supervisors meeting.
	15	Met w/weather and USFS people on BW '79 weather systems.
April	2	Met w/Day and Currie on tank farm area in Millinocket.
	3	BW Supervisors meeting.
	10-12	Briefings at Old Town, Greenville, and Presque Isle to regrind personnel on BW '79.
	18	BW Supervisors meeting.
	24	With Lennington (mixing contractor) et. al. to view sites for mixing at remote airstrips.
May	7-8	BW Supervisors training meeting.
	19	First spray for season from Old Town.
	21	Assembly of spray crews at Millinocket for briefing (safety, etc.).
	27	Assembly of spray crews at Presque Isle - briefing. Environmental Monitoring contract finalized. Fitzgerald v. USDA lawsuit filed.
June	14	C-54 ditched into Eagle Lake.
	19	Last spray day - finished at Millinocket and Presque Isle.
	25	At Old Town - with key members of staff on critique of the spray project.

APPENDIX B

SPRUCE BUDWORM PROJECT 1979

AIRCRAFT PRODUCTIVITY

APPENDIX B

SPRUCE BUDWORM PROJECT 1979

AIRCRAFT PRODUCTIVITY, 1975-79

This Appendix presents a summary of a detailed evaluation of aircraft productivity done by Anthony St. Peter, covering the 1975-79 spray projects. These results will be used to guide future project planning.

In many instances, it was necessary to estimate data from fragmentary records. Users intending to rely heavily on these tables should first consult the full report, dated Augusta 1978, available from the Maine Forest Service.

It should be noted that the performance data summarized here are heavily affected by year-to-year changes in project size, block size and layout, weather, and other factors.

The years listed in the tables differ due to use of different aircraft mixes in each year. Due to lack of data, more limited information is provided for PV-2 and TBM aircraft for 1974-79.

TABLE B - 1

BELL 47 HELICOPTERS, 1976-1979

PERFORMANCE DATA

	1976	1977	1978		1979	
			Kibby-Skinner	Codyville		
Acreage Treated	24,672	48,820	5,974	21,848	23,059	23,315
Number of Helicopters	4	7	3	6	5 (ave.)	6 (ave.)
Ave. Gallons Sprayed Per Period Per Aircraft	210	249	248	253	288	592
Ave. Acres Per Hour Per Aircraft	416	45	251	99	---	---
Application Rate	24 oz./A	64 oz/A	64 oz./A	80 oz./A	64 oz/A	80 oz./A
Insecticide	Dylox	Orthene	Orthene	B.T. (16B)	Orthene	B.T. (16B)

TABLE B - 2

CONSTELLATION, PERFORMANCE DATA

1975, 1976, 1979

	1975	1976	1979
Acres Treated	484,078	267,762	175,924
Number of Aircraft	2	2	1
Acres per Aircraft per Spray Period	22,004	26,776	17,592
Total Loads Sprayed by Constellation	49	22	14
Gallons Sprayed	112,576	62,270	41,200
Number of Spray Periods	17	11	10
Insecticide	---	---	Sevin

TABLE B-3

C-54 PERFORMANCE DATA

1976 - 79

	1976	1977	1978	1979
Acres Treated	2,245,908	281,527	772,276*	1,888,889
Number of Aircraft	12	2	6	11
Acres per Aircraft per Spray Period	11,697	10,828	10,726	13,209
Total Loads Sprayed By C-54	227	35	102	136
Gallons Sprayed	517,301	65,931	180,849	288,845
Number of Spray Periods	16	13	12	13
Insecticide	---	---	---	Sevin

* Includes 134,000 acres treated with split application.

NOTE: 'DC-4' is synonymous with 'C-54'.

TABLE B - 4

B-17 PERFORMANCE DATA

1979

Acres Treated	147,528
Number of Aircraft	2
Acres per Aircraft per Spray Period	9,200
Total Loads Sprayed by B-17	20
Gallons Sprayed	34,550
Number of Spray Periods	8
Type of Insecticide	Sevin

TABLE B - 5

PV-2 PERFORMANCE

1975 - 1979

	1975	1976	1977	1978	1979
Acres Sprayed	1,040,868	821,192	260,883	401,115	409,577
Number of Aircraft	9	6	5	4	8
Total Acres per Aircraft	115,654	136,865	52,176	100,278	51,197
Acres per Aircraft per Spray Period	6,803	6,843	4,014	10,028	4,266

TABLE B - 6

TBM PERFORMANCE DATA

1975 - 1979

	1975	1976	1977	1978	1979		
					Greenville	Millinocket	Presque Isle
Acres Sprayed	722,057	101,926	333,821	51,447	19,248	180,469	101,425
Number of Aircraft	10	2	5	2	2	6	5
Total Acres per Aircraft	72,206	50,963	66,764	25,723	9,624	30,078	20,285
Acres per Aircraft per Spray Period	4,011	4,633	2,384	2,572	4,812	2,734	3,423

TABLE B - 7

THRUSH PERFORMANCE DATA

1979

	Lincoln	Old Town	Jackman	Frenchville	Presque Isle	Red Pine
Acres Treated	48,346	18,168	74,600	103,174	19,419	294,212
Number of Aircraft	12	14	8	8	6	8
Acres per Aircraft per Spray Period	576	216	1,554	4,299	1,618	5,253
Total Loads Sprayed	39	---	176	77	30	233
Gallons Sprayed	9,065	11,239	37,300	24,977	7,938	66,465
Number of Spray Periods	7	6	6	3 (spray days)	2	7 (spray days)
Type of Insecticide	Dylox	BT-16B + Dipel	Orthene	Sevin	Orthene	Sevin

APPENDIX C

SPRUCE BUDWORM PROJECT 1979

CALIBRATION REPORT

APPENDIX C

SPRUCE BUDWORM PROJECT 1979

CALIBRATION REPORT BY E. RICHARDSON

On April 22, 1979, Ernest Richardson traveled to Mesa, Arizona to calibrate Globe Air aircraft (TBM, PV-2, DC-4, Constellation) to be used in the 1979 Maine Budworm Suppression Project. Work commenced Monday, April 23, with respective aircraft types being calibrated for the dosage rates shown below. All aircraft were calibrated in Mesa except for: a) Thirteen Thrush aircraft calibrated in Millinocket, Maine; b) one DC-4 and two B-17 aircraft calibrated in Presque Isle, Maine.

Dosage Rate	AIRCRAFT TYPE				
	TBM	PV-2	B-17	DC-4	Constellation
Sevin 20 oz. 1:1		X	X	X	X
Sevin 30 oz. 4:1	X	X	X	X	X
Sevin 40 oz. 4:1	X	X	X		
Dylox 24 oz.	X	X			
Orthene 64 oz.	X				

Boom time apparatus were not operational for all aircraft at the time, and therefore, the majority of timers were not tested. However, overall maintenance of PV-2 and DC-4 aircraft appeared very satisfactory to both myself and Buzz Dyer, Fixed Wing Specialist for the USFS.

Tests of insecticide products were conducted by Union Carbide and Chevron companies under the observation of the USFS (Millers, Berry). A successful study was also conducted by myself to test a technique for monitoring Sevin deposits on 8" x 8" glass plates. Characterization tests of Dylox were performed by myself, USFS, and GNP, using a Piper Pawnee aircraft. Attempts to use a TBM aircraft were unsuccessful due to an insufficient supply of Dylox.

My final conclusions are: 1) Calibration procedures progressed well and ended successfully; 2) It is advantageous to check and inspect spray aircraft at the contractor's "home base".

Respectfully Submitted,

Ernest M. Richardson
Pesticide Residue Analyst
Public Health Laboratory

1979 AIRCRAFT CALIBRATION SUMMARY

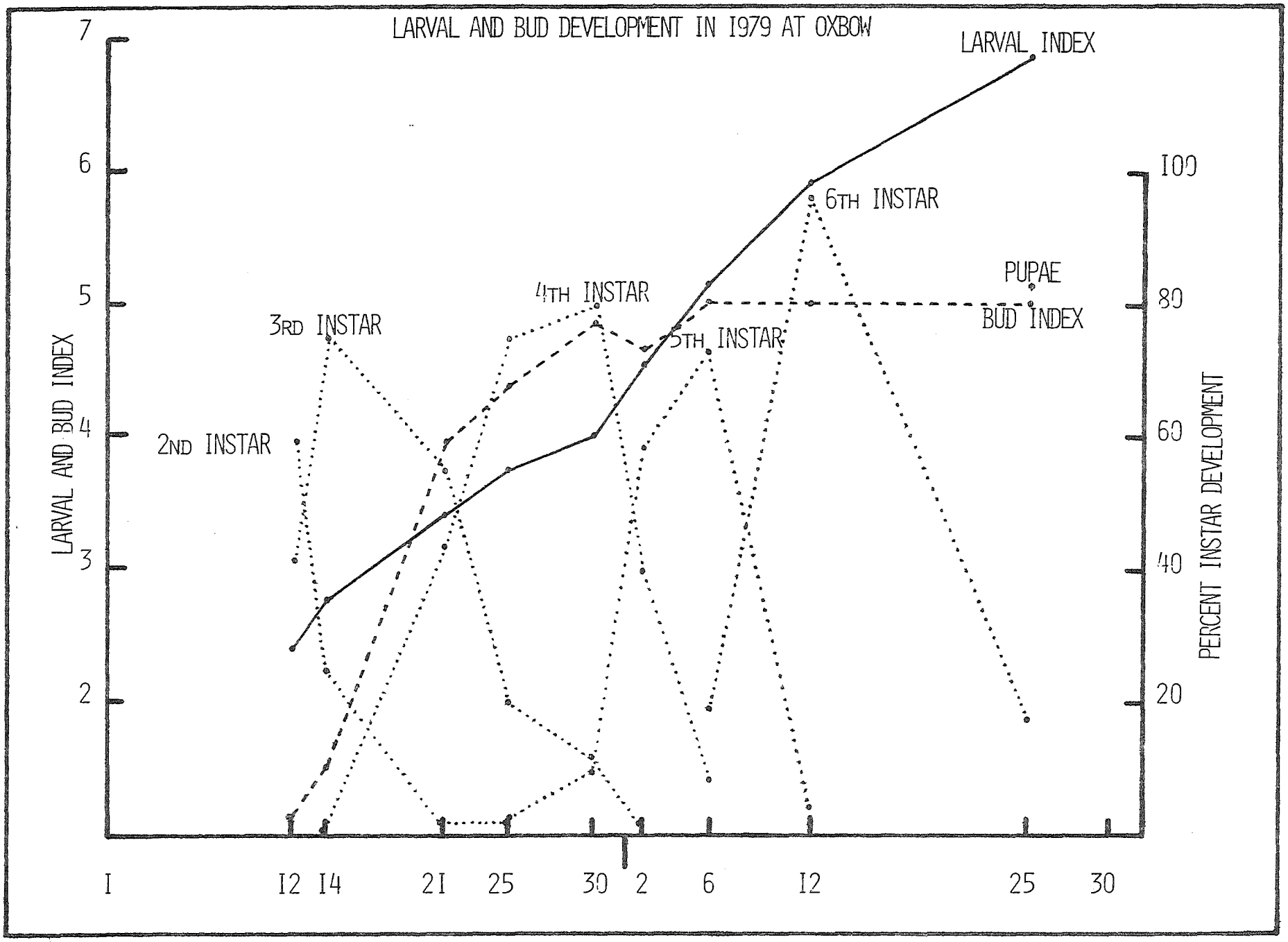
E. M. Richardson

	Calibration Test	Nozzles No./Size	Nozzle Direction	Gauge Press Pump/Cockpit	Theoretical Boom Time	Avg. Actual Boom Time
L-749	Sevin 20 oz. 1:1	64 / 8015		40	180.8 / 2-0	181.3 / 2-01
	Sevin 30 oz. 4:1	95 / 8015		40	284 / 2-0	284 / 2-0
B-17	Sevin 20 oz. 1:1	37 / 8015		42 / 40	448 / 4-28	448 / 7-15
	Sevin 30 oz. 4:1	56 / 8015		42 / 40	366 / 4-27	366 / 4-21
C-54	Sevin 20 oz. 1:1		Up Above	42 / 40	124 / 2-0	125.5 / 2-01
	Sevin 30 oz. 4:1		"	42 / 40	194.8 / 2-0	195 / 2-0
	Sevin 40 oz. 4:1		"		260 / 2-0	
PV2	Sevin 20 oz. 1:1	38 / 8008	Down Below	40	60.2 / 2-0	60.4 / 2-0
	Sevin 30 oz. 4:1	59 / 8008	"	40	95 / 2-0	94.9 / 2-02
	Sevin 40 oz. 4:1	79 / 8008	"	40	126.25 / 2-0	126.2 / 2-0
	Dylox 24 oz.	55 / 8008	"	40	87.8 / 2-0	87.8 / 2-0
TBM	Sevin 30 oz. 4:1	37 / 8008	Down (Edge)	40 / 40	58.6 / 2-0	79.6 / 2-39
	Sevin 40 oz. 4:1	50 / 8008	"	40 / 40	79.4 / 2-0	79.4 / 2-0
	Dylox 24 oz.	34 / 8008	"	40 / 40	55.2 / 2-0	155.2 / 2-02
	Orthene 64 oz.	83 / 8008	"	40 / 40	133.3 / 2-0	133.1 / 1-59
	Sevin	24 / 8008	"			39 / 2-0
Thrush	Sevin 30 oz. 4:1	26 / 8006	Down (Below)	40	29.8 / 2-0	30.2 / 2-01
	Dylox 24 oz.	23 / 8006	"	40	27.6 / 2-0	30.0 / 2-08
	Bt 64 oz.	56 / 8006	"	40	66.6 / 2-0	66.8 / 1-59
	Bt 80 oz.	69 / 8006	"	40	83.3 / 2-0	83.3 / 1-56
	Orthene 64 oz.	56 / 8006	"	40	66.6 / 2-0	66.8 / 1-59

APPENDIX D

SPRUCE BUDWORM PROJECT 1979

DEVELOPMENT CHARTS


LARVAL AND BUD DEVELOPMENT IN 1979 AT OXBOW
LARVAL INDEX
6TH INSTAR
PUPAE
BUD INDEX
4TH INSTAR
3RD INSTAR
5TH INSTAR
2ND INSTAR
LARVAL AND BUD INDEX
PERCENT INSTAR DEVELOPMENT
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6
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4
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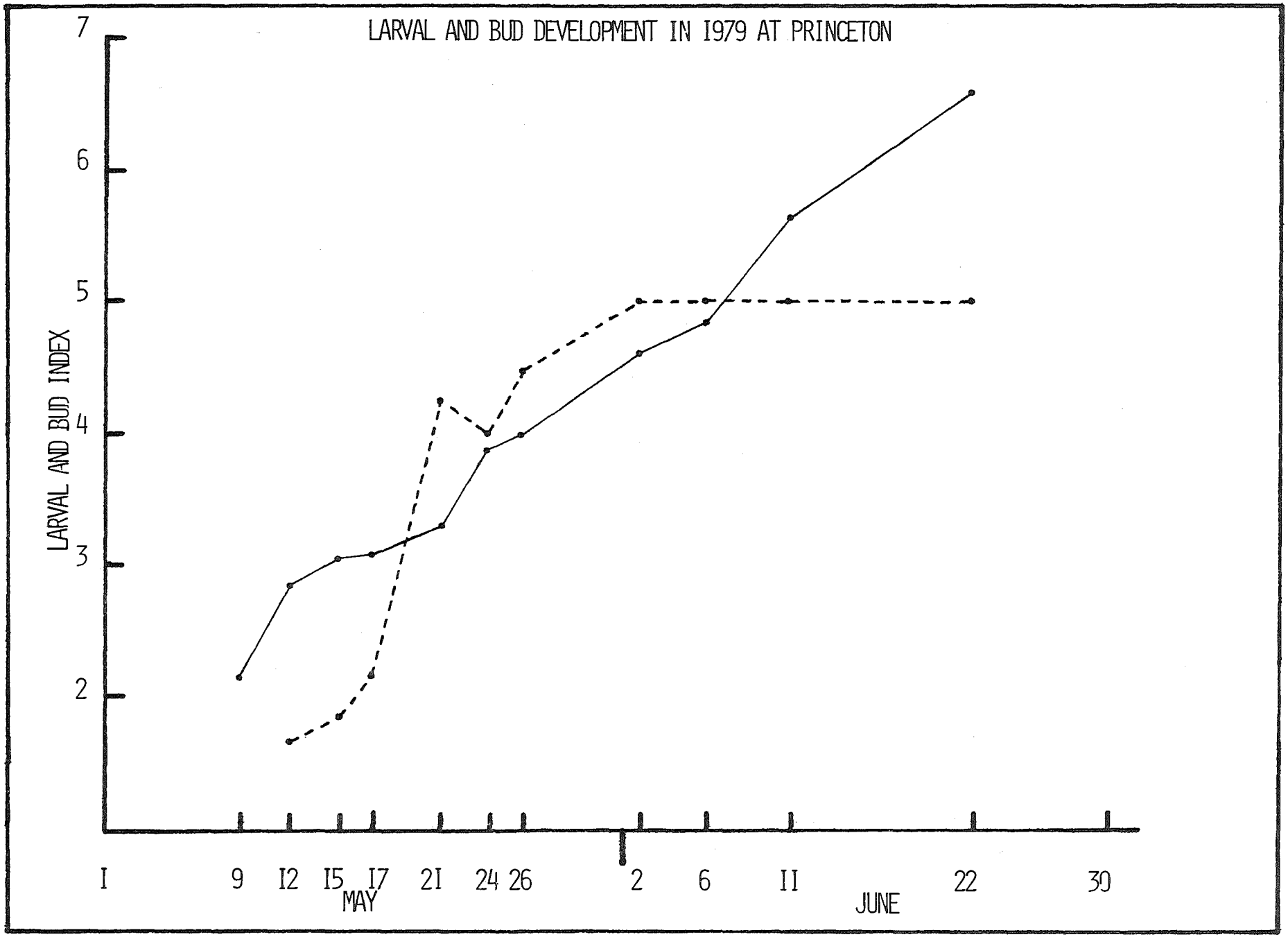
LARVAL AND BUD DEVELOPMENT IN 1979 AT PRINCETON
LARVAL AND BUD INDEX
7
6
5
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9
I2
I5
I7
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26
MAY
2
6
II
JUNE
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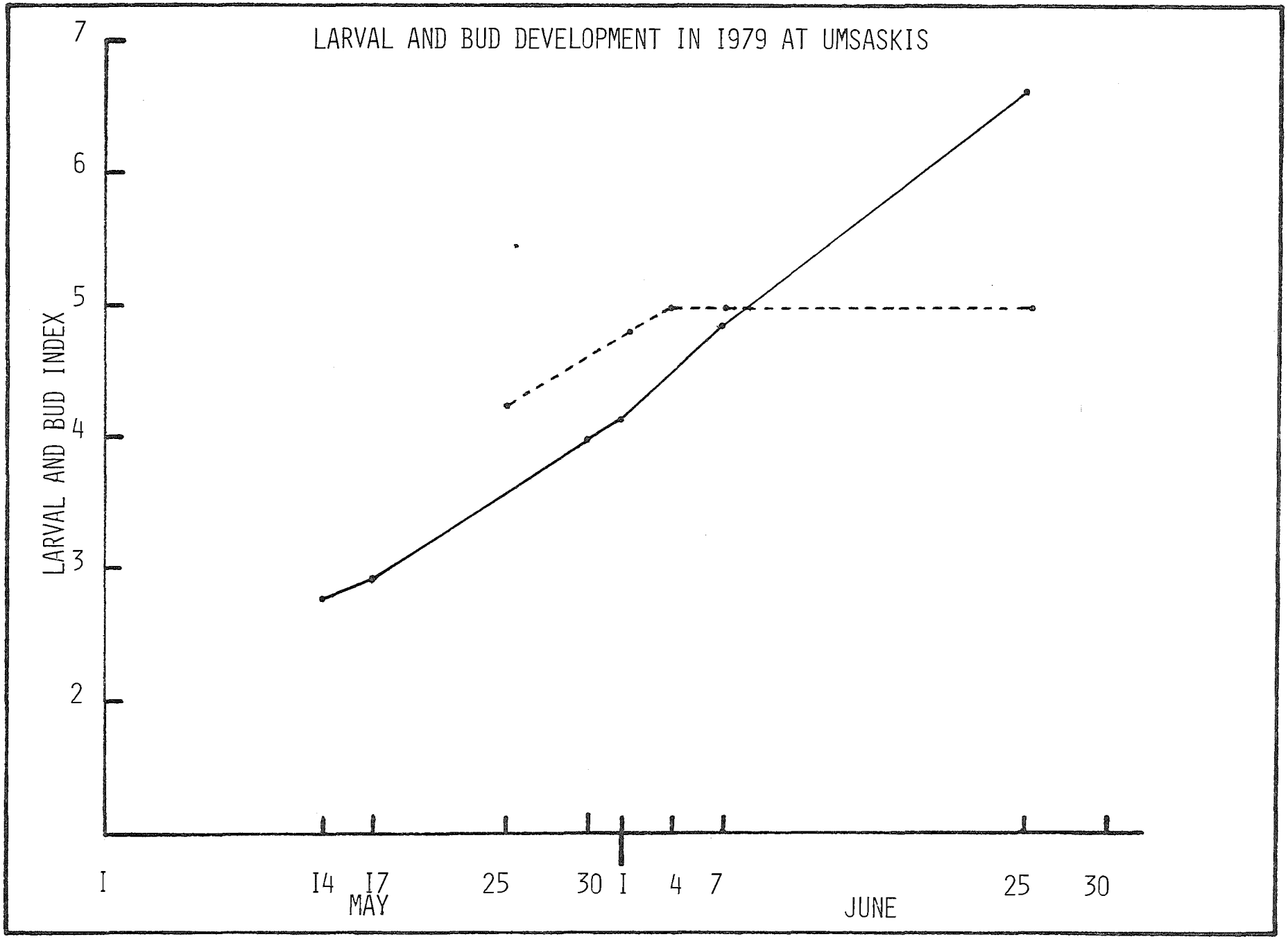
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LARVAL AND BUD INDEX
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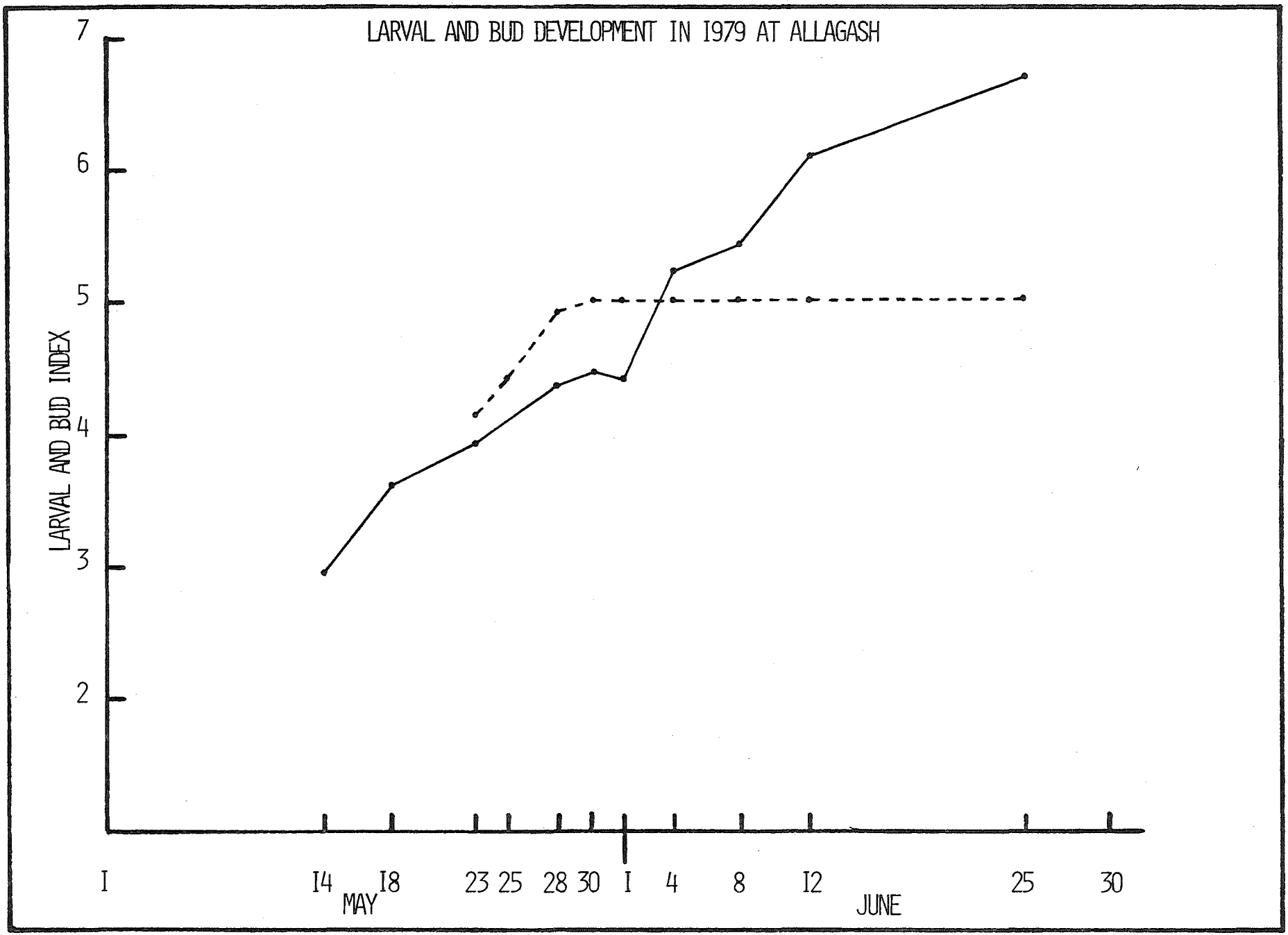
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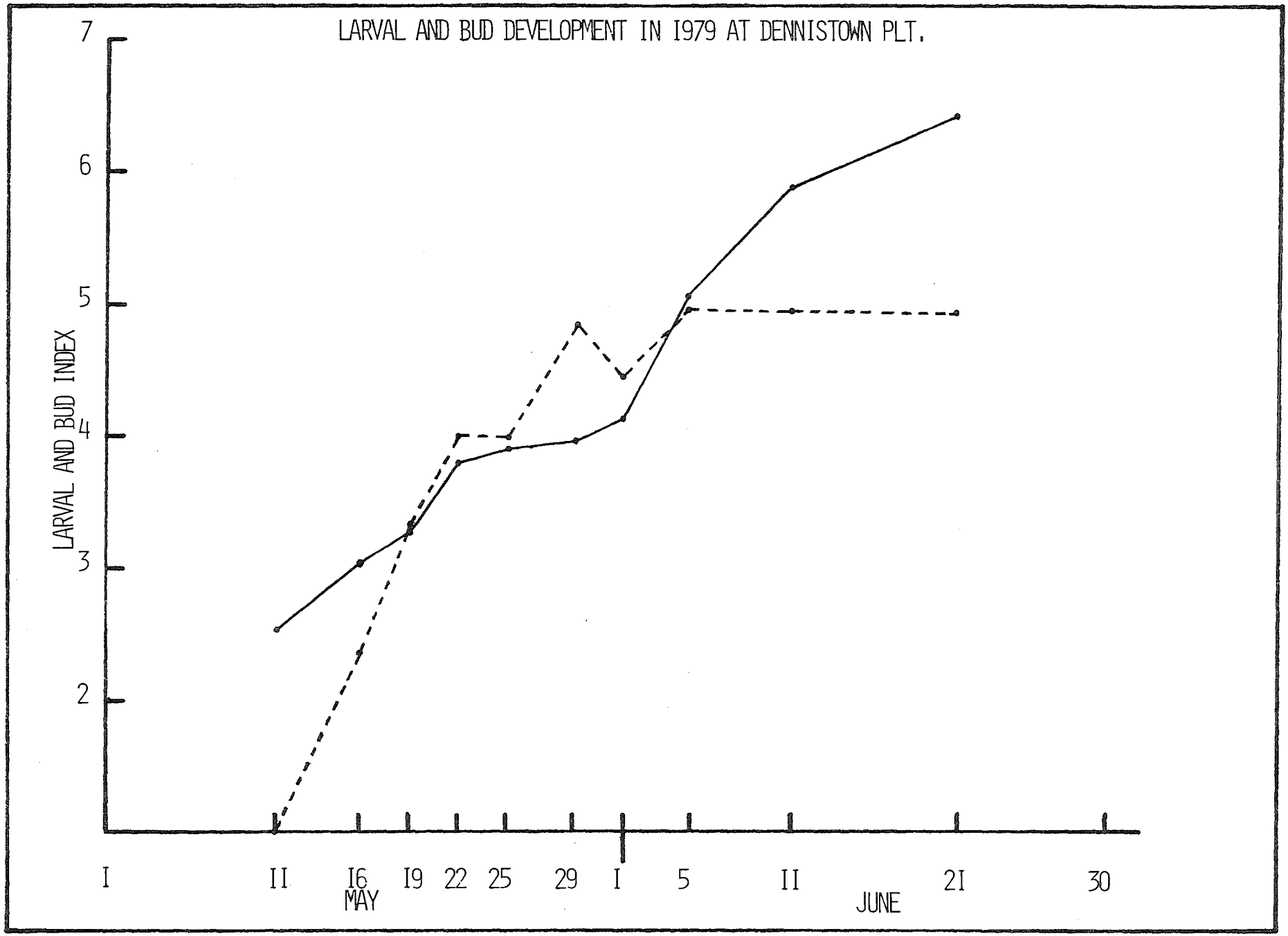
MAY
JUNE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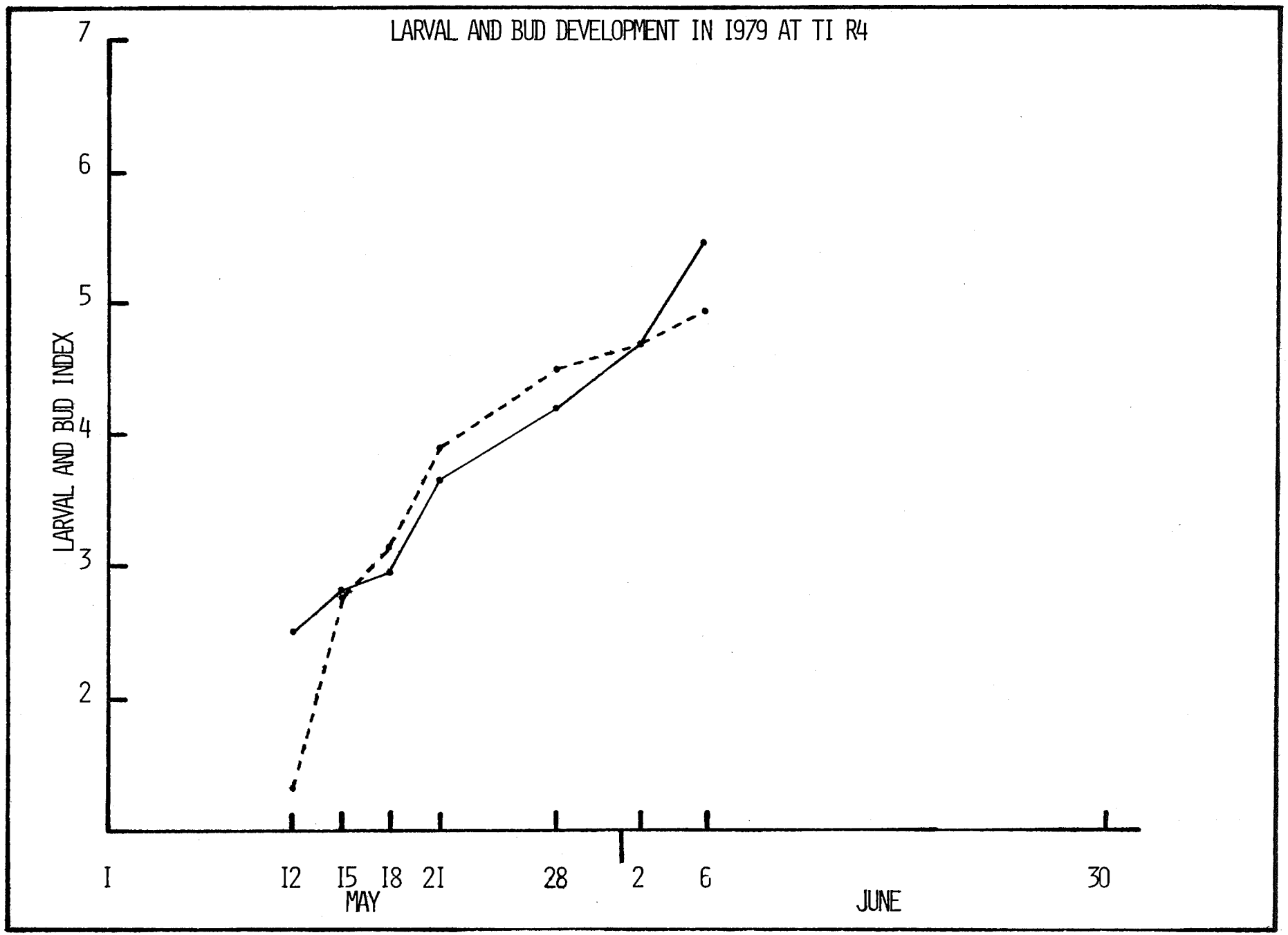
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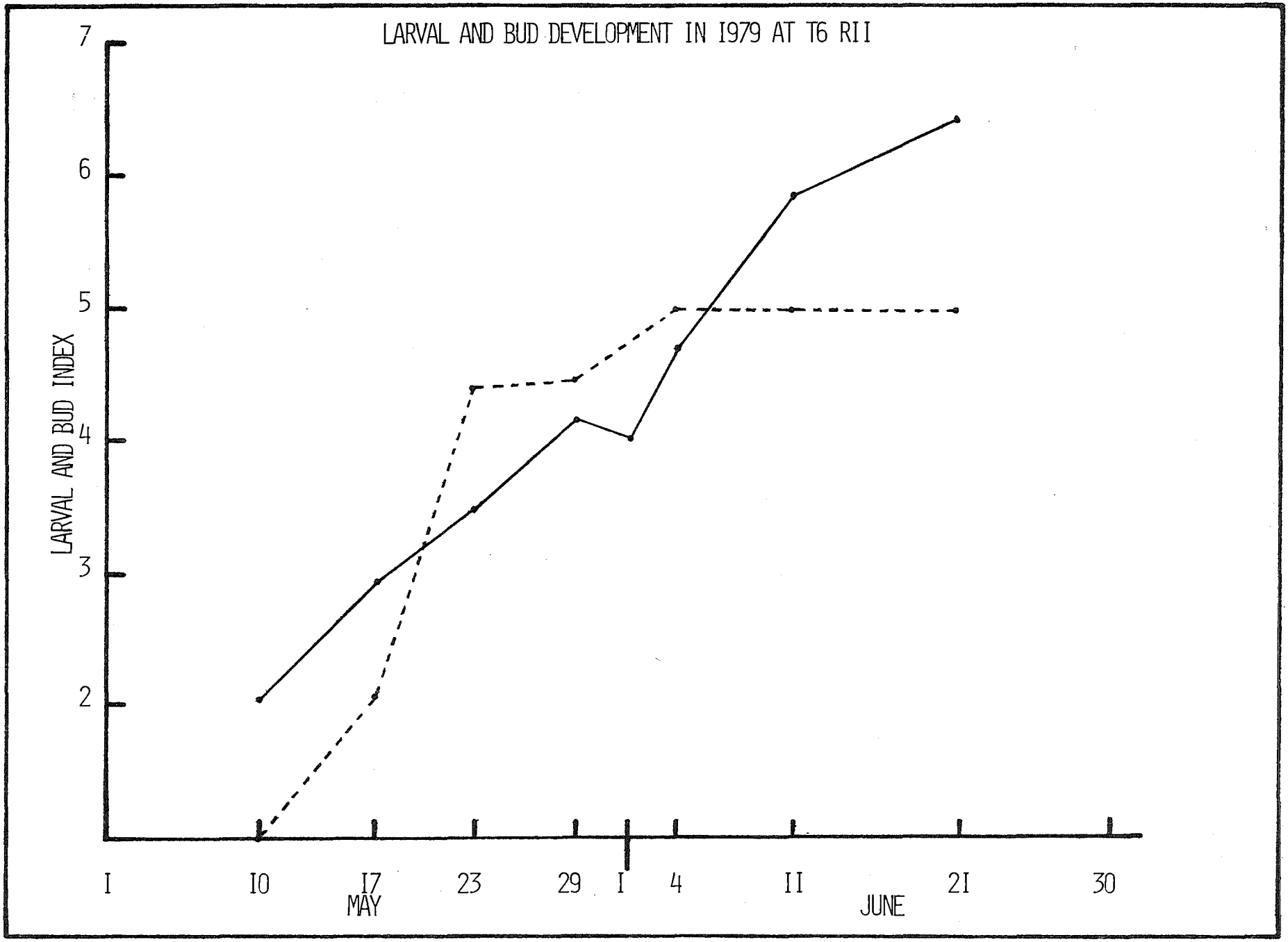
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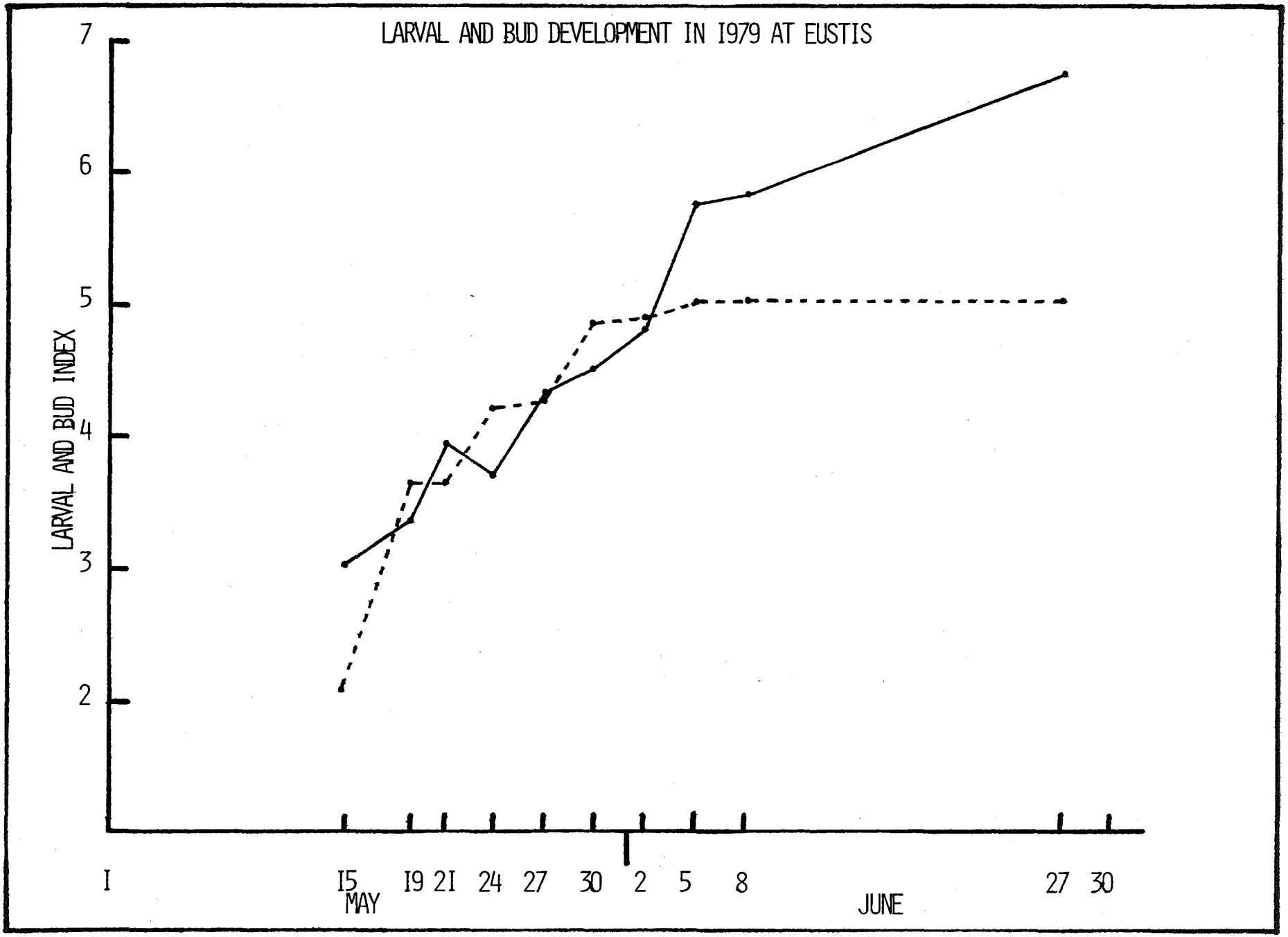
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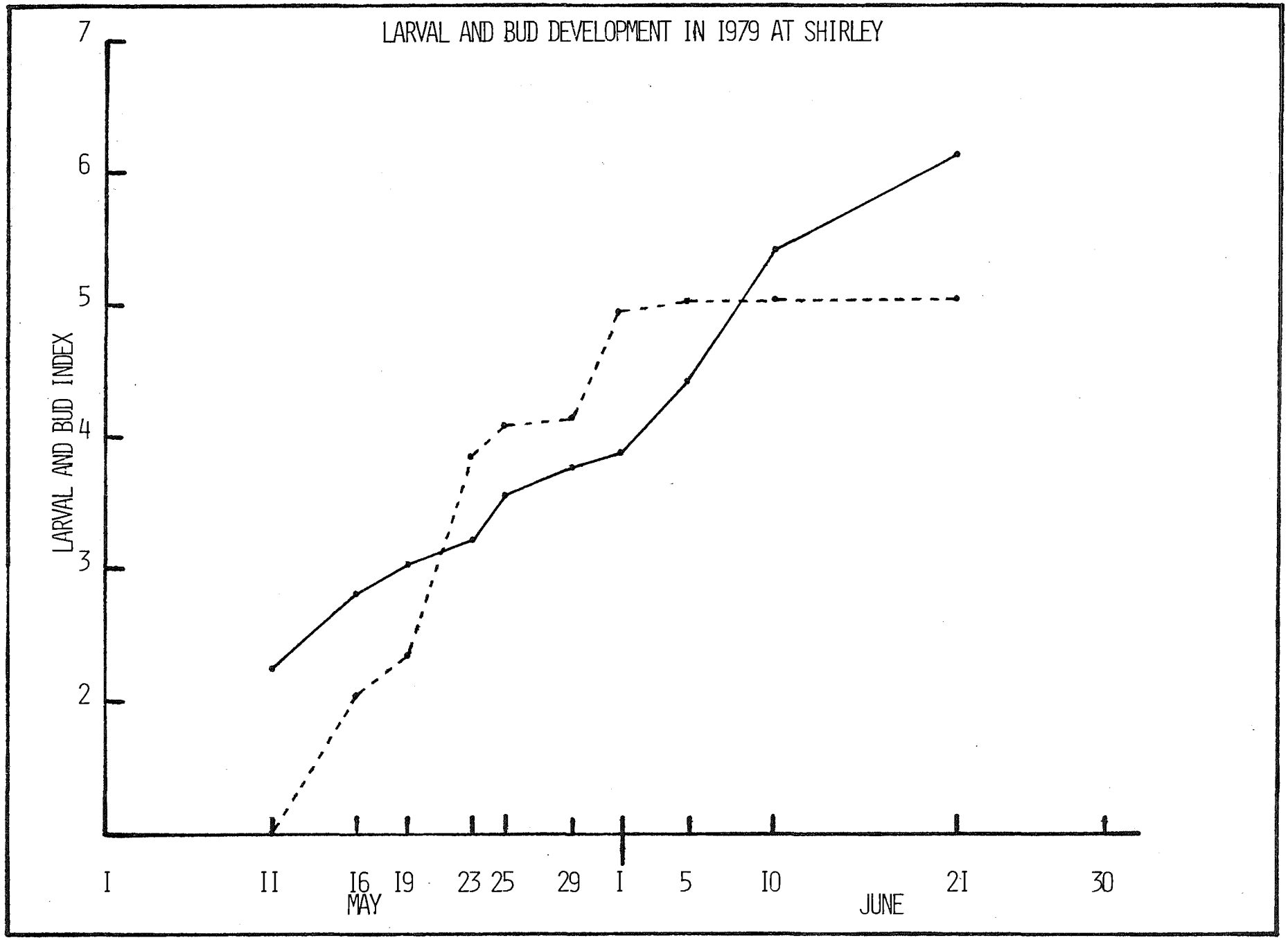
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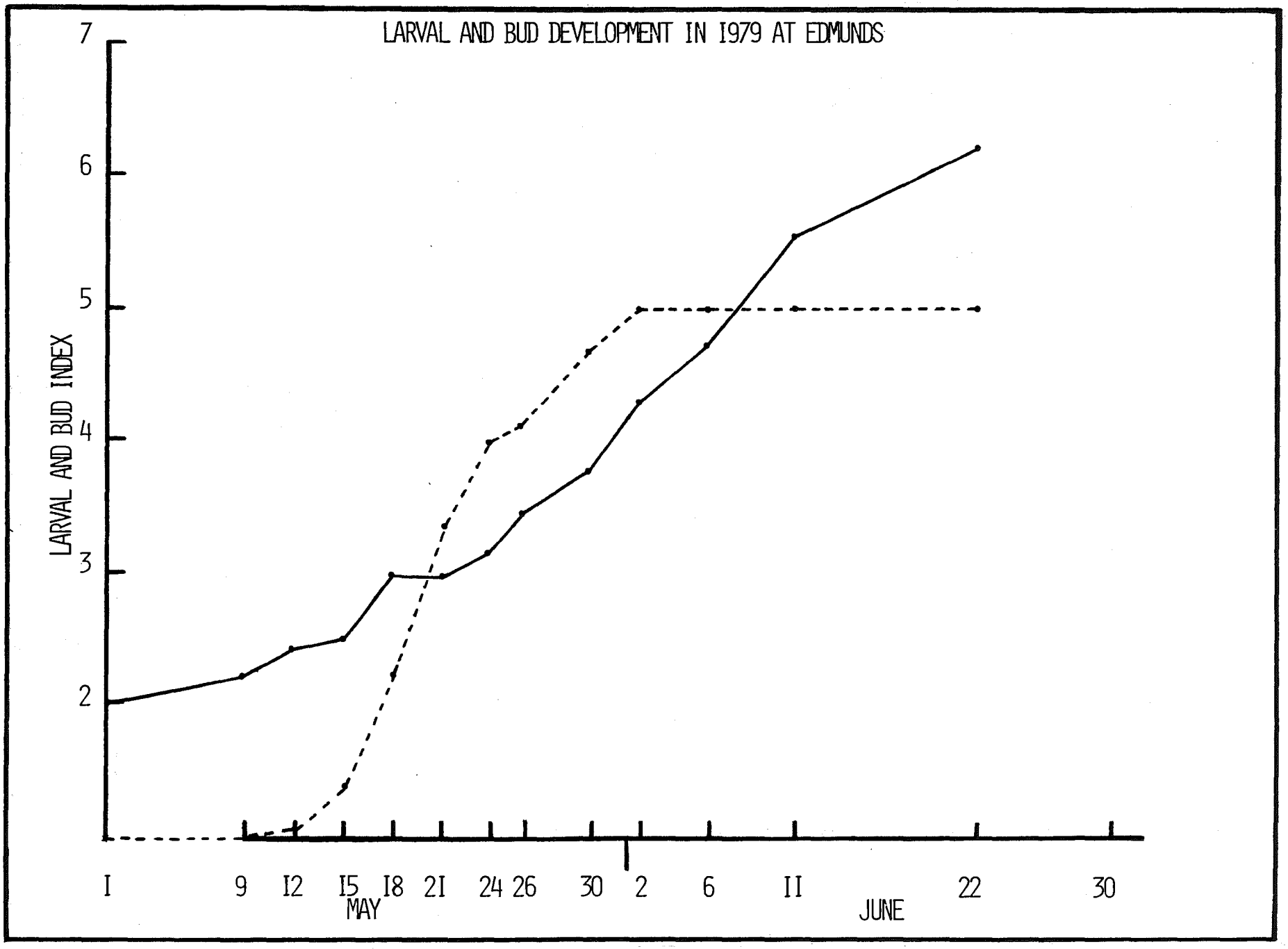
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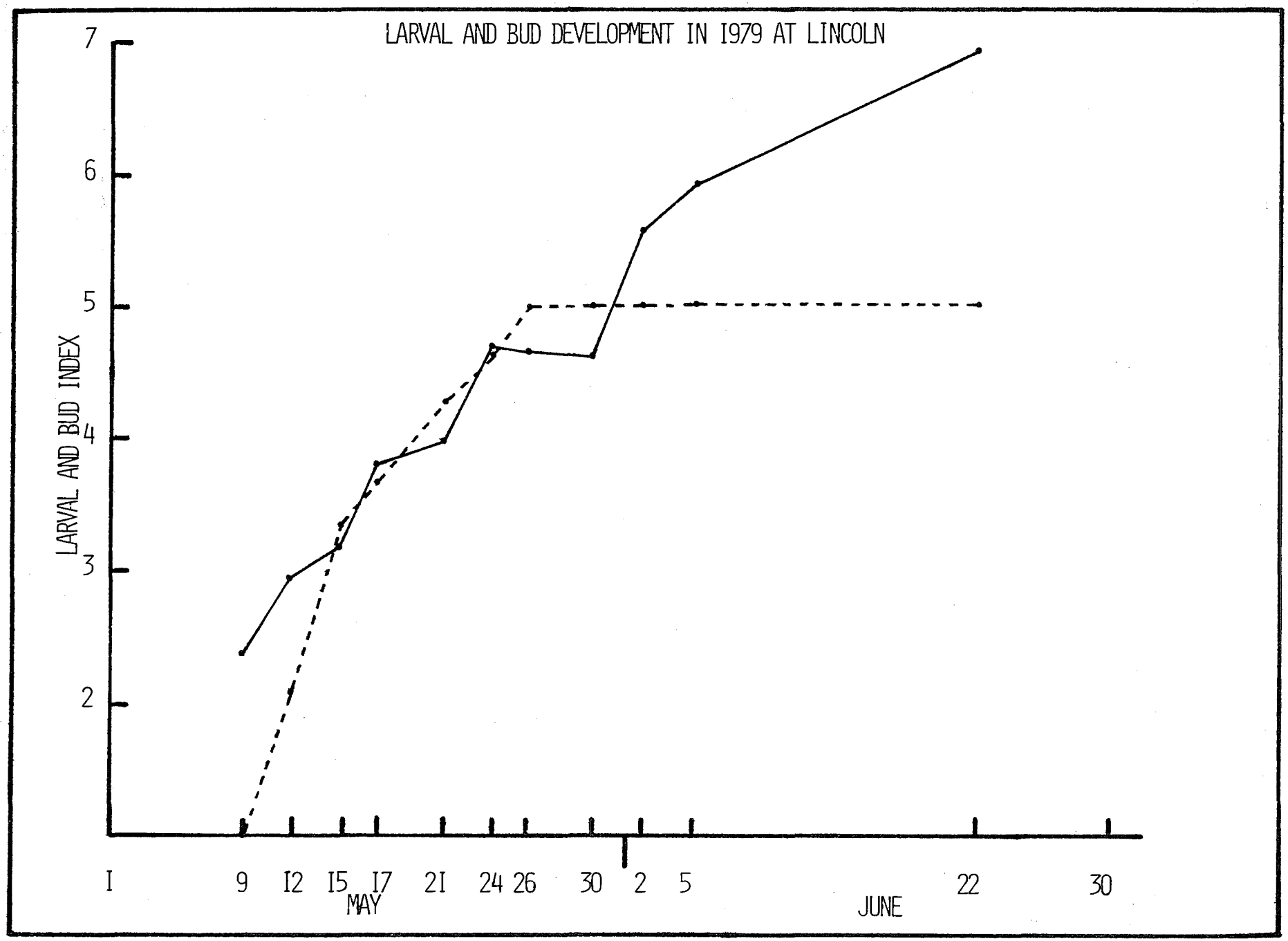
JUNE


LARVAL AND BUD DEVELOPMENT IN 1979 AT LINCOLN
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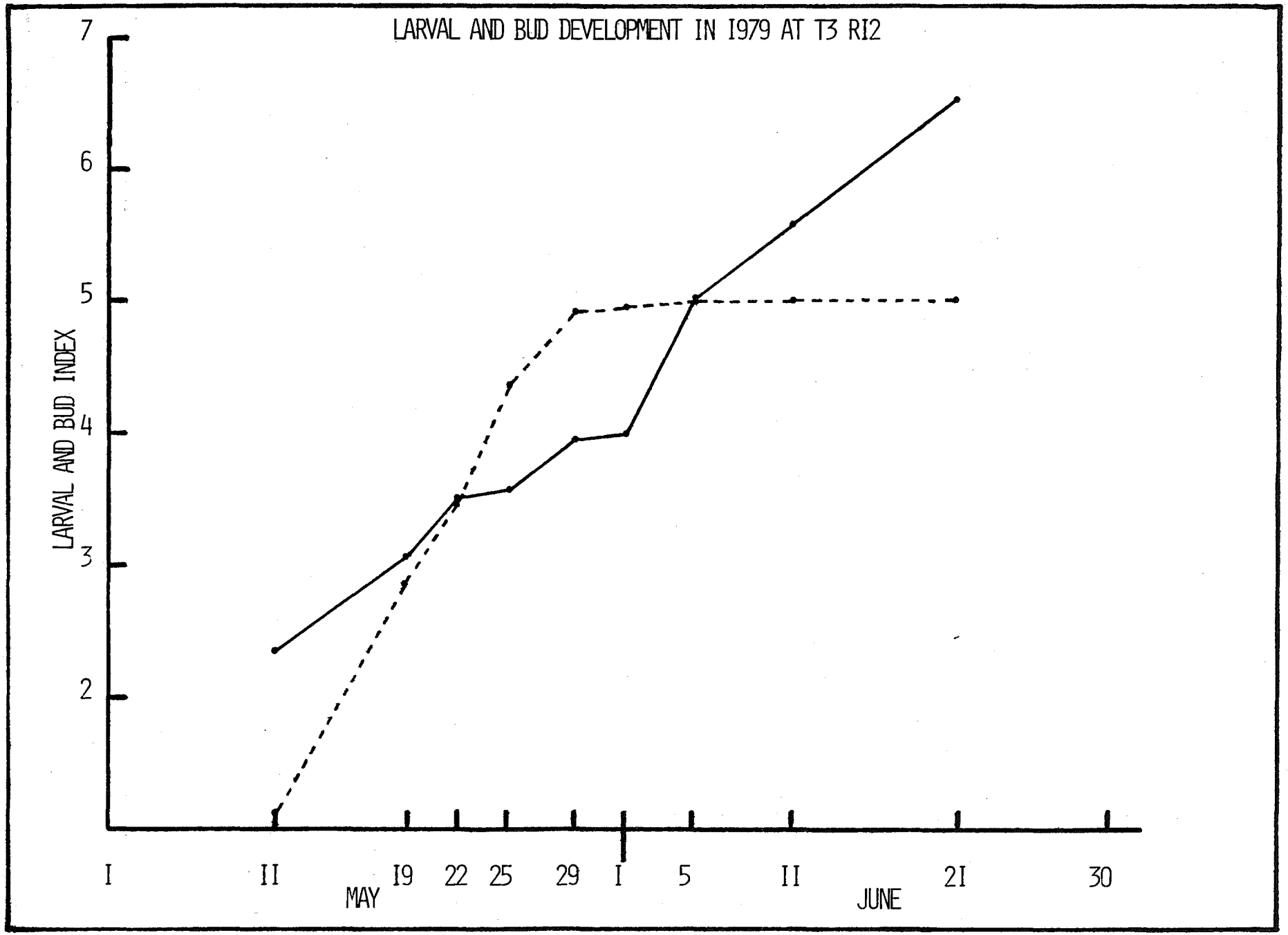
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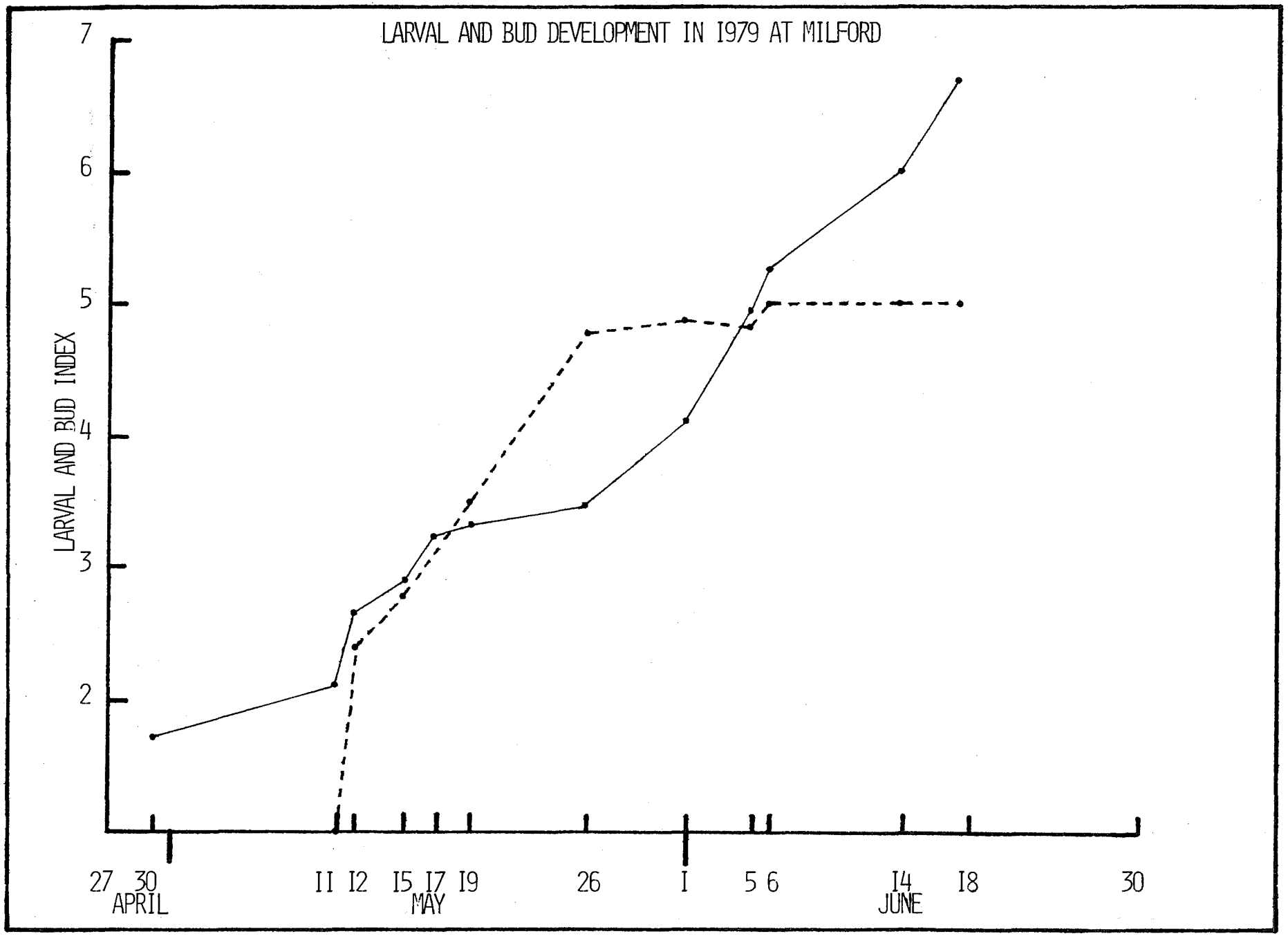
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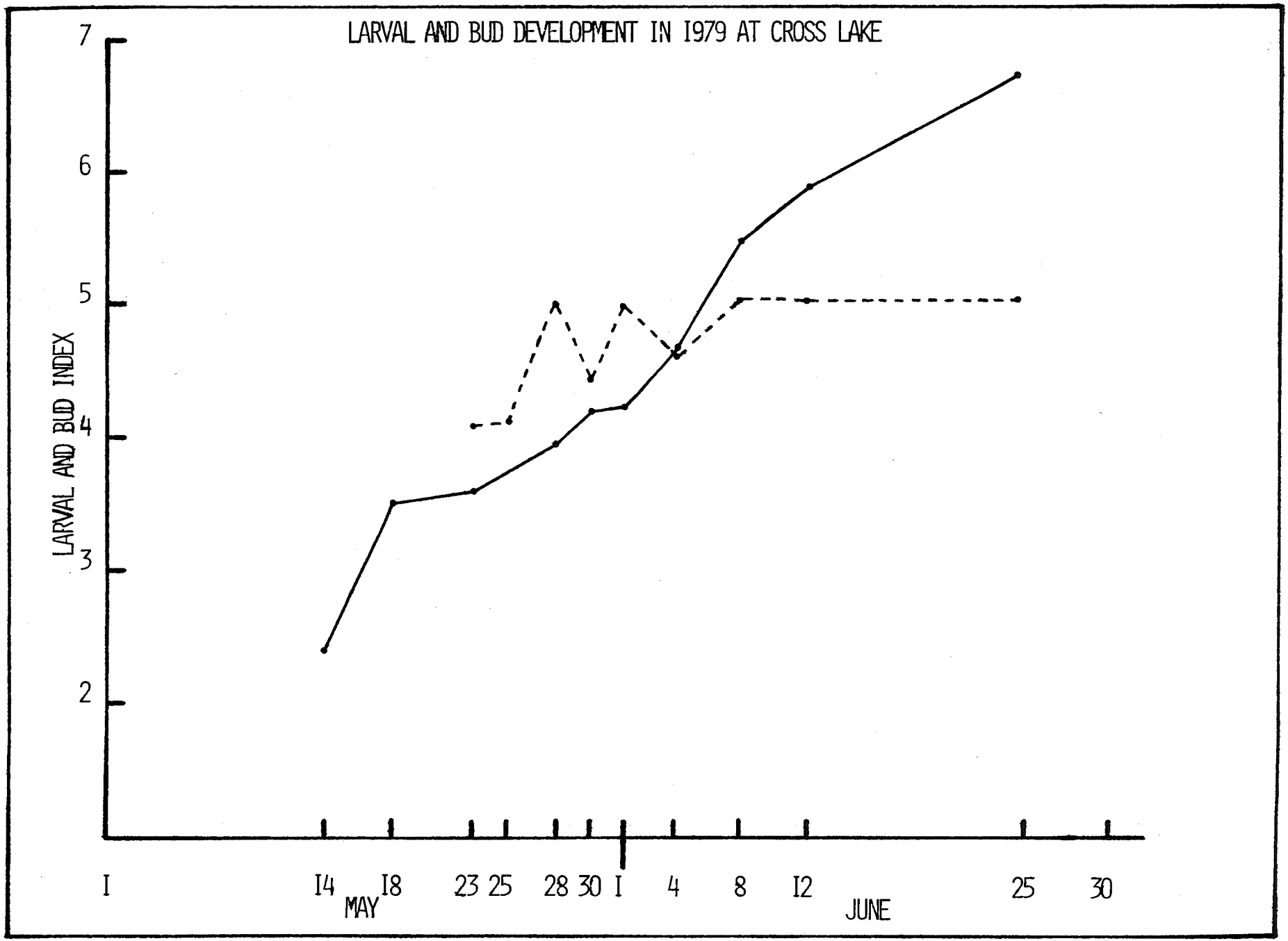
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I4
I8
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28
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I
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MAY
JUNE

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