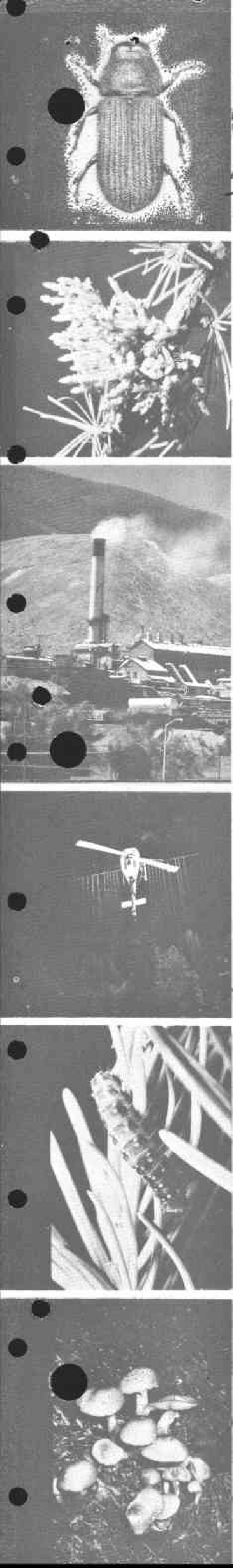

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OVERWINTERING SURVIVAL OF MOUNTAIN PINE BEETLE LARVAE AND RESULTANT EFFECTS ON BEETLE POPULATIONS IN THE NORTHERN REGION IN 1979

by

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ABSTRACT

During December 1978 and January 1979, temperatures reached all-time lows in some parts of Montana. Overwintering mountain pine beetle populations were sampled at 11 sites during February and March 1979. Effects of the extreme cold varied from site to site, with larval mortality ranging from 6 percent to 100 percent. As a result, beetle populations will likely be reduced substantially in some areas and affected little in others.

INTRODUCTION

Insects existing in temperate regions, and requiring a year to complete their life cycle, pass the winter in differing stages of development in a state of true hibernation. During this dormant period activity ceases, feeding stops, and physiological processes are greatly reduced. While in this state, a degree of cold-hardiness is obtained which enables overwintering insects to survive the low temperatures experienced in a normal winter (Salt 1961). Some insects even have a propensity to successfully pass through periods of severely cold temperatures. Bark beetles, on the other hand, passing the winter in the larval or adult stages, apparently are more readily affected by unusually low winter temperatures. Schmid and Frye (1977) stated that temperatures as low as -30° F. will kill all overwintering larvae of the spruce beetle. 1/ Adult spruce beetles are even less cold-hardy, succumbing at temperatures of -15° F. (Schmid and Beckwith 1975). Terrell (1954) cited evidence to show that spruce beetle mortality, both larvae and adults, was as high as 91 percent during the winter of 1953-54 when temperatures approached -70° F. in Montana. Keen (1966) stated winter air temperatures lower than -20° F. for a few days caused heavy brood mortality in western pine beetle 2/ populations. During the winter of 1924-25, cold temperatures to -27° F. killed 25 to 80 percent of western pine beetle broods throughout western North America (Andrewartha and Birch 1954). Quist (1951) indicated that temperatures of -40° F. during the week of January 29 to February 3, 1951, produced overall mortality of 89.5 percent in both larval and adult stages of overwintering Douglas-fir beetle. 3/ Numerous evidences cite apparent or substantiated mortality to mountain pine beetle 4/ populations resulting from severely cold winter temperatures. McCambridge, Amman, and Trostle (1978) cited -34° F. could greatly retard beetle infestations. Safranyik, Shrimpton, and Whitney (1974) maintained that survival of all stages of the mountain pine beetle is reduced by unseasonably cold temperatures. This relationship between declining temperatures and larval mortality is tempered by increasing cold-hardiness through the coldest winter months (figure 1).

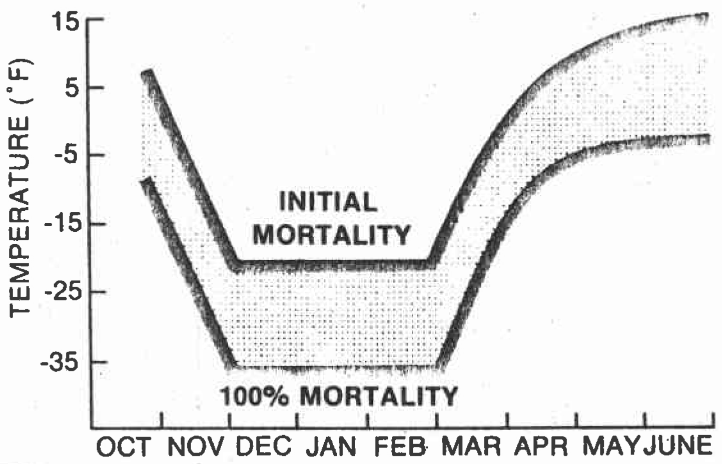

Figure 1.--Relationship of larval mortality and cold temperatures.

1/ Dendroctonus rufipennis (Kirby)
2/ Dendroctonus brevicomis (LeConte)
3/ Dendroctonus pseudotsugae (Hopkins)
4/ Dendroctonus ponderosae (Hopkins)

Cold-hardiness increases as the winter progresses. The larval stage is more resistant to cold than any other life stage of the beetle (Safranyik, et al. 1974; Reid 1963). Other ameliorating factors, with respect to the beetle, are bark thickness of its host and insulating properties of snow. Cole (1974) stated effects of cold are greatly reduced by increasing thickness of bark beneath which the larvae are passing the winter. Wygant (1940) has shown that average bark thickness results in subcortical temperatures as much as 12° warmer than corresponding air temperatures. The protective effects of snow are cited by numerous authors (Cole 1974; McCambridge, et al. 1978; Terrell 1954; and Reid 1963). Wilford (1954) maintained very little larval mortality would be experienced below snowline; and McCambridge 5/ stated that where snow depths were great enough, those larvae surviving below the snow could form the nucleus for a continued infestation, even if high mortality were experienced above snowline.

These evidences led us to assume that higher than normal larval mortality could be expected following the severely cold temperatures experienced in December 1978 and January 1979. During a mountain pine beetle outbreak in western Montana, Gibson (1934) indicated that the level of infestation decreased by 22.9 percent in 1933 following unseasonably cold temperatures (-40° F.) experienced in January 1933. To confirm these suppositions we sampled overwintering larval populations from 11 sites of active mountain pine beetle infestations in Montana. This report contains the results of those surveys.

METHODS

Sites from which to sample overwintering survival were selected from areas of current beetle activity as determined through bark beetle surveys conducted in 1978 (McGregor, et al. 1979). Five sites were chosen in northwestern Montana, while the remaining six were in the southwestern part of the State (figure 2). The sites were: (1) Pete Creek and (2) Waper Creek (Kootenai National Forest); (3) Red Meadow Creek (Flathead National Forest); (4) McGregor Lake and (5) North Fork Flathead River (private land); (6) Targhee Pass, (7) Rainbow Point, (8) Madison Arm, (9) Portal Creek, and (10) Spanish Creek (Gallatin National Forest); and (11) Big Sky (private land). Sites were selected to represent different locations within an infestation and the varying effects of elevational differences. Elevations for each site are listed in table 1.

5/ McCambridge, W. F. 1979. Personal communication.

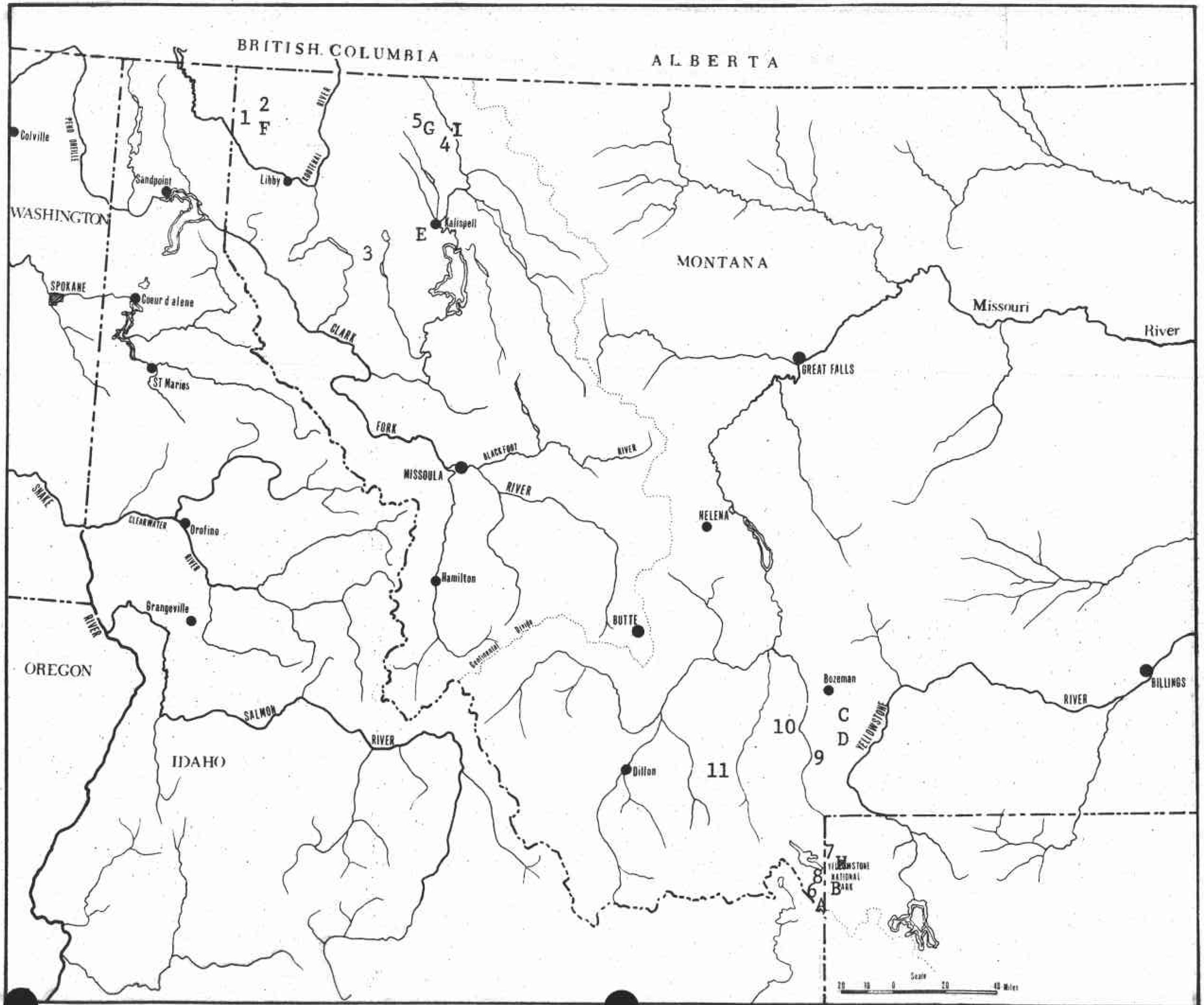

Figure 2.--Plot locations for sampling winter mortality (1, 2, etc.). Sites from which temperatures were recorded (A, B,=etc.).

Table 1.--Locations of sample plots and larval mortality data for each plot

Date	Tree No. and aspect		Pete Creek Snow depth 14" Elevation 2950'			Waper Creek Snow depth 13" Elevation 3100'			McGregor Lake Snow depth 20" Elevation 3500'			North Fork Flathead River Snow depth 18" Elevation 3450'			Red Meadow Creek Snow depth 18" Elevation 3840'	
		Dbh (in.)	A[1/]	D[1/]	Dbh (in.)	A	D	Dbh (in.)	A	D	Dbh (in.)	A	D	Dbh (in.)	A	D
Feb. 13-16	1N	11.7	4	14	7.8	1	12	9.0	14	5	12.7	1	24	7.3	18	59
	1S		6	15		4	3		48	18		1	21		3	5
	2N	10.8	0	40	10.8	0	0	12.3	53	0	10.0	0	65	7.0	0	16
	2S		0	0		1	9		37	10		0	46		0	27
	3N	14.6	0	16	10.4	13	32	8.5	25	0	11.7	44	34	6.0	10	38
	3S		1	2		12	15		12	8		0	12		3	37
	4N	10.5	0	3	12.7	13	8	8.5	16	4	9.3	10	63	10.2	0	42
	4S		3	12		17	10		45	1		12	56		0	17
	5N	14.9	11	20	12.9	5	2	12.1	118	5	8.5	6	10	6.4	0	80
	5S		10	13		4	5		76	1		1	1		0	41
	X		3	13		7	10		44	5		7	33		3	36
	Percent dead		79			60			10			82			91	

Date	Tree No. and aspect		Targhee Pass Snow depth 51" Elevation 7070'			Rainbow Point Snow depth 36" Elevation 6650'			Big Sky Snow depth 31" Elevation 8000'			Spanish Creek Snow depth 18" Elevation 6000'			Portal Creek Snow depth 17" Elevation 6840'	
		Dbh (in.)	A[1/]	D[1/]	Dbh (in.)	A	D	Dbh (in.)	A	D	Dbh (in.)	A	D	Dbh (in.)	A	D
Feb. 21-22	1N(A)[2/]	12.7	0	0	8.5	0	0	10.4	0	1	13.3	0	0	9.1	15	4
	1S(A)		2	5		0	0		15	71		0	0		10	13
	1N(B)[2/]		3	0		0	0		-	-		-	-		-	-
	1S(B)		13	4		0	0		-	-		-	-		-	-
	2N(A)	14.3	0	0	10.0	0	0	13.8	9	3	9.9	0	0	10.4	22	24
	2S(A)		0	0		0	0		2	0		0	0		1	3
	2N(B)		3	1		0	0		-	-		-	-		-	-
	2S(B)		0	0		0	0		-	-		-	-		-	-
	3N	13.9	1	2	10.3	0	0	12.5	0	0	9.0	23	2	9.2	49	47
	3S		0	0		0	0		0	0		18	2		17	61
	4N	14.4	12	1	11.3	14	3	8.1	0	0	10.4	0	0	8.0	17	10
	4S		0	0		0	0		0	0		0	0		0	2
	5N	15.5	0	4	11.5	0	0	8.2	0	0	10.3	0	0	6.7	13	16
	5S		0	0		0	0		0	0		37	0		0	11
	X		2	1		1	0.21		3	7		8	0.5		14	19
	Percent dead		35			17			75			6			57	

Date	Tree No. and aspect		Targhee Pass Snow depth 54" Elevation 7070'			Rainbow Point Snow depth 30" Elevation 6650'			Madison Arm Snow depth 42" Elevation 6600'			Big Sky Snow depth 36" Elevation 8000'			Portal Creek Snow depth 12" Elevation 6840'	
		Dbh (in.)	A[1/]	D[1/]	Dbh (in.)	A	D	Dbh (in.)	A	D	Dbh (in.)	A	D	Dbh (in.)	A	D
Mar. 28-29	1N(A)	10.5	25	8	10.2	0	0	9.7	0	0	12.2	1	4	3.8	35	25
	1S(A)		28	5		0	83		0	17		19	15		3	18
	1N(B)		-	-		-	-		-	-		2	7		-	-
	1S(B)		-	-		-	-		-	-		9	0		-	-
	2N(A)	9.5	43	14	7.8	0	28	8.2	0	8	9.0	0	15	8.7	50	25
	2S(A)		63	5		0	0		0	14		0	25		38	20
	2N(B)		10	1		-	-		-	-		-	-		-	-
	2S(B)		29	19		-	-		-	-		6	0		-	-
	3N(A)	9.2	28	2	6.2	0	0	9.8	0	11	9.9	1	8	7.8	22	57
	3S(A)		10	4		0	0		0	17		0	8		20	11
	3N(B)		-	-		-	-		0	0		-	-		-	-
	3S(B)		-	-		-	-		0	21		-	-		-	-
	4N(A)	7.2	21	20	10.1	0	39	11.7	6	18	9.7	2	6	8.2	41	16
	4S(A)		13	15		0	41		11	37		3	94		11	30
	4N(B)		7	4		0	48		2	16		-	-		-	-
	4S(B)		5	6		0	30		0	5		-	-		-	-
	5N(A)	10.2	0	0	8.0	0	27	12.2	0	24	8.3	8	23	8.1	33	40
	5S(A)		0	0		0	12		0	45		4	30		16	3
	5N(B)		-	-		0	19		-	-		-	-		-	-
	5S(B)		-	-		0	38		-	-		-	-		-	-
	X		20	7		0	26		1	17		4	17		27	25
	Percent dead		26			100			94			31			48	

1/ A = Alive, D = Dead
2/ (A) = Above Snow, (B) = Below Snow

The Kootenai and Flathead samples were collected between February 13 and 16. Those in the southern part of the State were taken February 21-22. Because of extremely low larval counts found in those samples, additional ones were collected on March 28-29. At each site five currently infested trees were selected. The five trees were chosen to represent a range of diameter classes and were taken from a small enough area to help eliminate individual tree variation. After selecting a tree, we measured its diameter, measured snow depth at the tree, marked north and south sides of the bole, then cut the tree at snowline. An 18-inch bolt was removed from the tree at either breast height or just above the snowline, whichever was higher. Where snow depths were greater than 2 feet, a below-snow sample bolt was also cut from one of the five trees. Each bolt was then marked with its location, tree number, diameter, north and south side, and taken to the laboratory.

After a period of 8 to 10 days at room temperature (suffient time for live larvae to become active and dead larvae to discolor), bark was removed from the north and south side of each bolt to determine larval survival. A piece of bark 6 by 12 inches was removed from each side of the bolt. From the area of stripped bark we recorded numbers of new attacks, accumulated lengths of all exposed egg galleries, and numbers of live and dead larvae. Where larval predators were found, numbers and conditions (alive or dead) were noted.

From these figures, average mortality percentage was calculated for each site. Using these mortality percentages, we projected an approximate effect on beetle populations for a specific area.

RESULTS

Results of the larval mortality counts are found in table 1. Percent dead varied from 6 percent from Spanish Creek samples, to 100 percent at Rainbow Point. Snow depths recorded at each site are also listed in table 1. Samples taken from below snow height show that where temperatures were not as severe; e.g., Targhee Pass, snow did protect some overwintering larvae. Where temperatures were the coldest, such as at Rainbow Point, the insulating effects of the snow were negated. Daily low temperatures were obtained from official recording stations as near to the sample sites as possible for the period December 25, 1978, to January 10, 1979. A check of available weather records indicates this was the coldest extended period of the winter. Temperatures are listed in table 2. Locations of the recording stations are shown in figure 2.

Table 2.--Recording locations and daily low temperatures for the period December 25, 1978, to January 10, 1979

	West Yellowstone		Gallatin Canyon				Polebridge	Yellowstone	Polebridge
Date	Black Bear (Elev. 7950')	Whiskey Creek (Elev. 6800')	Lick Creek (Elev. 6860')	Shower Falls (Elev. 8100')	Kalispell Airport (Elev. 2965')	Yaak Ranger District (Elev. 2725')	NPS (Elev. 3550')	NPS (Elev. 6670')	(Elev. 3550')
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
	Degrees F.								
(1978) Dec.									
25	2	-	10	5	-10	12	-	0	-16
26	5	-	-3	2	-12	10	-	-13	-16
27	8	-	24	11	8	4	-	-4	10
28	-24	-	1	-36	-8	2	-5	-7	-4
29	-39	-	-35	-37	-29	-22	-36	-51	-40
30	-32	-	-43	-26	-31	-25	-38	-50	-41
31	-36	-	-25	-25	-33	-24	-39	-63	-43
(1979) Jan.									
1	-40	-	-16	-18	-37	-16	-37	-47	-40
2	-19	-	6	2	-24	-16	-14	-34	-12
3	-4	-2	8	-1	-27	-14	-30	-9	-32
4	5	-	-8	-17	-24	-13	-33	-6	-36
5	-28	-	-28	-20	-30	-20	-34	-48	-38
6	-17	-	-17	-14	-28	-3	-29	-53	-31
7	-32	-23.1	-24	-21	-24	-19	-32	-56	-35
8	-16	-58.0	-9	-2	-27	-10	-33	-55	-33
9	7	-	11	13	-28	-14	-29	-25	-30
10	8	-	6	15	3	9	-8	0	-6

DISCUSSION

Amman 6/ stated that overwintering larval mortality in a typical winter approaches 50 percent. For a significant population reduction during the subsequent flight period of the beetle to be realized, larval mortality would have to be at least 80 percent. Using this criterion we assume that major population reductions will occur in the areas surrounding Rainbow Point and Madison Arm on the Gallatin NF, and in some areas of the North Fork of the Flathead River drainage, Flathead NF. Some reduction will be realized on the Yaak Ranger District, Kootenai NF, and around Big Sky in the Gallatin Canyon. From the admittedly small sample size used in our predictions, we would likewise forecast no notable population reductions in some of the other areas; e.g., around Targhee Pass, McGregor Lake, and in the Gallatin Canyon. The most overriding conclusion to be made is that beetle populations likely will be highly variable throughout infestations sampled in 1979. In some areas drastic reductions may be realized; but in others no effects of the past winter will be detected. Ultimately we will not know the full effect until after beetle flight later this summer. Only then will we be able to tell what the winter of 1978-79 has meant to the mountain pine beetle in Montana.

6/ Amman, G. D. 1979. Personal communication.

REFERENCES

Andrewartha, H. G. and L. C. Birch. 1954. The distribution and abundance of animals. University of Chicago Press, Chicago, IL, 782 pp.

Cole, W. E. 1974. Interpreting some mortality factor interactions within mountain pine beetle broods. Environ. Ent. 4: 97-102.

Gibson, A. L. 1934. Report covering the survey of the mountain pine beetle infestation on the Gallatin National Forest, 1933. USDA, Bureau of Entomology, Forest Ins. Invest., Coeur d'Alene, ID, 16 pp.

Keen, F. P. 1966. The western pine beetle. USDA-Forest Serv., Forest Pest Leaflet 1, 4 pp.

McCambridge, W. F., G. D. Amman, and G. C. Trostle. 1978. The mountain pine beetle. USDA-Forest Serv., Forest Pest Leaflet 2 (In press).

McGregor, M. D., K. E. Gibson, and D. D. Benentt. 1979. Bark beetle conditions report, Northern Region, 1978. USDA-Forest Serv., Northern Reg., Missoula, MT (In press).

Quist, J. A. 1951. Winter mortality of the Douglas-fir beetle. USDA-Forest Serv., Forest Insect Lab, Fort Collins, CO. Unpubl. data.

Reid, R. W. 1963. Biology of the mountain pine beetle, Dendroctonus monticolae Hopkins, in the East Kootenay region of British Columbia. III. Interaction between the beetle and its host, with emphasis on brood mortality and survival. Can. Ent. 65: 225-238.

Safranyik, L., D. M. Shrimpton, and H. S. Whitney. 1974. Management of lodgepole pine to reduce losses from the mountain pine beetle. Pacific Forest Res. Centre. Can. Forestry Serv. Victoria, B.C. Forestry Tech. Rep. 1, 24 pp.

Salt, R. W. 1961. Principles of insect cold-hardiness. Ann. Rev. of Entomol. 6: 55-74.

Schmid, J. M. and R. C. Beckwith. 1975. The spruce beetle. USDA-Forest Serv., Forest Pest Leaflet 127, 7 pp.

Schmid, J. M., and R. H. Frye. 1977. Spruce beetle in the Rockies. USDA-Forest Serv., Rocky Mtn. Forest and Range Expt. Sta., GTR-RM-49.

Terrell, T. T. 1954. Mortality of the Engelmann spruce beetle brood during the winter of 1953-1954. Int. Forest and Range Expt. Sta. USDA-Forest Serv. Res. Note 10, 9 pp.

Wilford, B. H. 1954. Climate and weather. USDA-Forest Serv., Rocky Mtn. Forest and Range Expt. Sta., Office report, 6 pp.

Wygant, N. D. 1940. Effects of low temperatures on the black hills beetle (Dendroctonus ponderosae Hopkins). Ph. D. Thesis, New York State College of Forestry, 57 pp.