

of: trees killed by budworm, trees dead from other causes, trees with dead tops resulting from budworm damage, and the total number of trees.

Tree mortality from budworm feeding had occurred in an area of 21.4 square miles. The boundaries of this area were considered to be those of the stands in which mortality occurred on one or more plots. Tree mortality on the individual plots within this area averaged 6.3 per cent ranging from 2.0 to 15.6 per cent.

Trees with dead tops as a result of budworm feeding were present in the 21.4 square miles where mortality occurred and in an additional 14 square miles where no mortality was recorded. The percentage of dead tops on individual plots averaged 22.9 per cent, ranging from 1.3 to 83.3 per cent of the trees. The plot with the highest percentage of budworm-killed tops was however, outside the area of tree mortality.

Sequential sampling of egg masses indicated that this infestation will continue at a high level in 1963; the area of moderate to severe defoliation could expand from 50 square miles in 1962 to approximately 65 square miles in 1963.—C. E. Brown.

Recent Population Trends of the Lodgepole Needle Miner.—High populations of the lodgepole needle miner, *Recurvaria starki* Free., were present in the Rocky Mountain National Parks in the 1940's but were reduced by cold winter temperatures in the 1950's. High winter mortalities were particularly evident in valley bottoms where temperatures were most severe. Trends continued downward until 1960, when a sharp reversal was detected (Table I). By the end of the first generation (1960-1962) following the increase, noticeable yellowing of trees had occurred in a few areas.

TABLE I
Population per 100 tips at Mount Eisenhower

Generation	Valley Bottom			Valley Bottom + 500'		
	1st Instar	Pupae	% Wint. Mort.	1st Instar	Pupae	% Wint. Mort.
1948-50	3015	2	84.6	3090	414	78.3
50-52	25	NS*		2500	1600	32.6
52-54	505	5	99.9	2709	1250	45.2
54-56	98	0	100.0	1114	105	69.3
56-58	0	NS		308	139	16.2
58-60	NS	NS		229	112	34.5
60-62	386	35	81.3	1359	649	6.7
62-64	1840			2764		

*NS—not sampled.

At the time of the decline it was thought that winter temperature was the most important factor controlling population levels (R. W. Stark. Can. J. Zool. 37: 753-761, 1959). Later, however, a series of successive mild winters did not result in population increases as expected. In 1960 there was a marked increase in oviposition rates; during the oviposition period the weather was exceptionally warm and winds were light. This led to speculation that weather during the oviposition period also regulates the population, i.e., increases in population occur when winter mortality is low and weather during moth flight permits a high oviposition rate; populations remain static or decrease when winter mortality is high or when weather during the oviposition period is cool, rainy, and windy. Observations have showed that the moth is sensitive to wind. Gentle breezes which just sway branch tips are enough to reduce adult activity significantly. The adults are crepuscular, with activity being concentrated in a few hours close to sundown when temperatures are usually dropping rapidly. Unless the weather is unusually warm, temperatures can drop below the threshold of activity and reduce the time available for oviposition.

Another interesting characteristic of these populations is their distribution over the valley slopes. Discoloration by the needle miner first became evident in a band of 250-700 ft. above the valley bottom, both in the outbreak of the 1940's and in the recent population rise. Regular sampling has indicated that high populations are found most consistently at these elevations. Previously it was thought that such a distribution was due to valley inversions in the winter, where temperatures were coldest at the bottom of the valley and increased up the slope to the inversion level and decreased again. Winter mortality was presumed to follow the same pattern, thus leaving the heaviest population near the inversion levels. Recently, however, winter temperatures were measured up a mountain slope and it was found that temperatures continued to become less severe above the band

of high population. This would indicate that the temperature pattern was not only a result of cold air drainage in the valleys but also the result of strong inversions which are characteristic of cold arctic air masses in winter. These air-mass inversions are much deeper than the valley inversions. A brief survey of representative tephigrams for Edmonton, Alberta, showed that they are commonly more than 1,000 ft. deep. If these temperatures measured up the slope are generally characteristic of these valleys then winter mortality would be expected to be greatest at valley bottom and decrease up the slope without showing any reversal. As measurements of winter mortality do follow this trend, some other explanation is needed to explain the decrease in populations at the higher elevations. The theory of weather during the period of moth flight could offer a logical explanation.

At higher elevations summer evening temperatures are probably lower than at valley bottom. This would reduce adult activity and decrease the rate of oviposition. Temperature observations made during the moth flight in 1962 illustrate this point. Degree hours above 50°F. for the period 6 to 10 P.M. on comparable days were extracted from thermographs exposed at the upper crown level of trees. At 900 ft. above the valley bottom the average degree hours per evening was 26.1, while at 400 ft. the average was 31.3. Exact comparable data for the valley bottom are not available, but degree hours determined from a thermograph positioned at 4 ft. above the ground in a large stand opening averaged 49.3 per evening. These temperatures indicate that there could be 37 per cent more adult activity at valley bottom than at the 400-ft. level and 47 per cent more than at the 900-ft. level. Further supporting evidence for this appears in the population data showing the ratio of increase (No. of first instar larvae / No. of pupae previous generation) between generations (Table II).

TABLE II
Distribution of population densities, winter mortality, and ratio of increase at oviposition up a mountain slope

Elevation above Valley Bottom (ft.)	Min. Temp. 1961-62 (°F.)	Winter Mort. 1961-62 (%)	Population/100 tips		Ratio of Increase (Fall 1962) (Spring 1962)
			Spring 1962 (Pupae)	Fall 1962 (1st Instar)	
VB	-50	88.6	1.3	184	142.0
170	-38	12.5	7	249	36.0
220	-34	0	23	115	5.0
275	-32	5.8	945	1,567	1.5
335	-36	0.9	526	1,161	2.2
600	-32	1.0	2,416	2,560	1.2
800	-28	2.3	205	229	1.1
900	-18	2.3	180	175	1.0

At valley bottom the rate of population increase was extremely high, but at the upper elevations the rate of increase was negligible. While it is possible there is some movement of moths towards the valley bottoms, no consistent movement in this direction could be detected visually. If, however, moths tend to move slowly from high elevations into valley bottoms over a period of two or three weeks an advantage in the natural control of the needle miner would be gained, for it is in valley bottoms that the greatest winter mortality occurs.

Present knowledge indicates that at elevations of 250 to 700 ft. above valley bottoms only a modest rate of population increase has occurred but, because winter mortality has been usually low at these elevations, there is a persistent high population. Above 700 ft. the rate of increase has been low, and moth emigration has probably been high, so that large populations are unlikely to build up quickly provided winter mortality remains low. However, a series of consecutive warm winters is rare enough that populations seldom reach outbreak proportions in valley bottoms. Further observations are needed to verify or modify these impressions.—R. F. Shepherd.

BRITISH COLUMBIA

Distribution of Trypodendron Attacks Around the Circumference of Logs.—During studies in 1961 of the effect of exposure of hibernation sites on the time of the ambrosia beetle, *Trypodendron lineatum* (Oliv.), spring flights (Dyer, E.D.A. Can. Ent. 94: 910-915, 1962), 4-foot logs were placed on the ground near the locations of hibernating beetles. These were primarily to indicate the time of attack in relation to flight from hibernation sites in shaded and exposed locations; they also provided information on the attack distribution

around the circumference of logs shaded by a dense forest compared with that on logs exposed to direct sunshine. Fifteen logs, from nine trees cut in November and December, 1960, were placed at each site with their long axes lying north-east-southwest. Each tree was represented at both sites. At the sunlit site, the upper and southeast sides of the logs were thus exposed to direct sunshine. Most of the attacks occurred during sunny days of March, April, and May.

In August, each log was peeled and the number of entrance holes tallied by quadrants which spanned the upper, lower, and two side surfaces. The attack on fifteen logs at each site is shown in the following table.

TABLE I
Distribution of *Trypodendron* attacks around the circumference of logs exposed to attack in direct sunshine and in shade

Quadrant	Exposed site			Shaded site		
	No. of holes	Holes per sq. foot	% of total	No. of holes	Holes per sq. foot	% of total
Lower	1925	69.8	47.3	5916	210.5	22.3
Northwest	1305	47.3	32.0	6877	244.7	25.9
Southeast	776	28.1	19.1	7075	251.8	26.7
Upper	66	2.4	1.6	6662	237.1	25.1
Total	4072	36.9	100.0	26530	236.0	100.0

The logs exposed to direct sunshine were scarcely attacked at all on the upper quadrant and had light attack on the southeast quadrant. Nearly 80 per cent of the attack occurred on the shaded lower and northwest quadrants. The attack on the shaded logs, although much denser, was uniformly distributed on all quadrants. These distributions might differ under other circumstances of partial shade or during unusual spring seasons when it is warm and cloudy at the same time.

The main reason that attack is sparse on the sunlit tops and sides of logs appears to be high bark temperature. That bark temperature can be lethally high has been confirmed by direct observations. Beetles have been seen to land on a sunlit log, search briefly, attempt to fly, and failing, move about excitedly before dying on the bark. However, in such a situation most beetles either succeed in taking flight again or crawl quickly to shaded portions of logs where they subsequently start to burrow. On clear days, the bark surface is often very hot even when air temperature is comparatively low. The sum effect of lethal temperature and avoidance by the beetles of hot surfaces, is the concentration of holes on the lower and shaded parts of logs exposed to direct sun.—E. D. A. Dyer.

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