BC-X-62

SPRUCE BEETLE BROOD PRODUCTION IN LOGGING SLASH AND WIND-THROWN TREES IN BRITISH COLUMBIA

E.D.A. DYER and D.W. TAYLOR
CANADIAN FORESTRY SERVICE

SPRUCE BEETLE BROOD PRODUCTION IN LOGGING SLASH AND WIND-THROWN TREES IN BRITISH COLUMBIA

BY

E. D. A. DYER AND D. W. TAYLOR

PACIFIC FOREST RESEARCH CENTRE

CANADIAN FORESTRY SERVICE

VICTORIA, BRITISH COLUMBIA

INFORMATION REPORT BC-X-62

DEPARTMENT OF THE ENVIRONMENT

DECEMBER, 1971

Abstract

In British Columbia, the spruce beetle attacks and kills many mature spruce, during periodic outbreaks. The beetle usually breeds in logging slash and wind-thrown trees, but when populations increase to epidemic levels, standing living trees are frequently attacked and killed. A large increase in the beetle population depends on the availability of large amounts of suitable host material. In the Prince George region, fresh logging slash and recently wind-thrown trees in the forest boundaries of new clear-cut areas are usually abundant where spruce stands are being harvested. This material is attacked by the beetle, and broods develop in the selected shaded parts of slash and in all bark of wind-thrown trees in forest shade. In exposed slash or trees, solar heat or winter cold can be lethal to the broods under the bark. The broods usually require two seasons to mature but following a warm summer, more than half the larvae may complete development by the first autumn. Survival through the second year is poor in slash but generally good in shaded wind-thrown trees. Because such trees are the principal sources of beetle population increase, their removal, within a year, from logging boundaries and road edges is strongly recommended.

Spruce Beetle Brood Production in Logging Slash and Wind-thrown Trees in British Columbia

by

E. D. A. Dyer and D. W. Taylor[1/]

Introduction

In British Columbia, spruce beetles, Dendroctonus rufipennis (Kirby), have caused periodic loss in mature spruce forests (Engelmann spruce, Picea engelmannii Parry and white spruce, Picea glauca (Moench) Voss). From 1960 to 1963, they killed about 440-million cubic feet of spruce in the Prince George and Prince Rupert Forest districts, in the north-central part of the Province (Cottrell and Fiddick, 1968) and, from 1967 to 1969, caused extensive loss of spruce in the south-eastern and central regions. This loss is of particular significance because, in the Interior, about 40% of all accessible mature softwood timber over 7.1 inches dbh is spruce (B.C. Forest Service, 1969). This species also contributes about the same percentage of the annual cut.

During epidemics, the bark beetle attacks standing green timber, fresh wind-thrown trees, and slash (cull-logs, tops and stumps) from logging operations. In most years, it breeds only in cut or wind-thrown host material. Increased populations to epidemic numbers over widespread areas depend

---

1/ Respectively, Research Scientist and Forest Research Technician, Canada Department of the Environment, Victoria, British Columbia.

primarily on an increased supply of suitable widely distributed breeding material.

This study, begun in 1966 in the Naver Forest about 50 miles southeast of Prince George, in central British Columbia, was carried out to determine the potential of spruce logging slash and wind-throw for producing spruce bark beetles. The study was designed to yield data on slash bark areas, and on the size and distribution of the beetle populations breeding in various types of slash and adjacent wind-thrown trees in three winter-logged, clear-cut timber sales. The spruce beetle usually requires two years to complete development and most of the brood remains in the larval stage during the first summer and winter. Larvae that survive the winter remain in the host all the second summer, and overwinter as young adults. The broods that become young adults by the first autumn can fly and reproduce the next spring (Massey and Wygant, 1954; Knight, 1961). The potential of breeding sites to produce beetles is increased by warm summer temperatures which induce rapid brood development to maturity (Dyer, 1969).

Methods

Timber sales at Ross Lake (R), Genevieve Lake (G) and Henry Creek (H) were about 12 miles apart in three directions from an undisturbed forest (N) reserved for bark beetle studies. The approximate sizes of these areas were: R, 30 acres; G, 340 acres; H, 188 acres and N, 135 acres. In all timber sales, the trees had been clear-cut during the previous autumn and winter and the merchantable logs removed before beetles attacked the remaining stumps and slash, and the fresh wind-thrown trees in the adjacent forest edges. At each location, two additional trees were felled in the spring before beetle flight.

In the cutover areas, 60 plots, each 66 ft square, were delineated in continuous strips 660 or 1,320 ft long, in each of the locations. Within the plots, the bark area of all slash over 6 inches in diameter was measured. Deductions were made for bark lost or damaged during logging. Calculations of bark area were made from measurements of the top diameter and height of stumps, and the diameter at both ends and length of remaining logs. The stumps averaged 1.8 ft in height and 19.6 inches in diameter. The average diameter of logs was 8.5 inches. In the plots, the number of spruce beetle attacks and living progeny was determined after removing 6-x 12-inch bark samples from positions on the slash shown in Fig. 1. The bark samples, from adjacent pairs of plots, containing sufficient sampling material, were taken as follows:

Stumps - 2 samples at A
2 samples at B
1 sample at C

Logs - 4 samples at A
4 samples at B
2 samples at C

Approximately 450 samples were taken in each location. The estimates of attacks and living progeny per square foot in slash at locations R, G and H during the first summer are shown in Table I. The distribution of attacks is illustrated in Fig. 2. About 90% of the progeny were larvae in late August and hibernated in this stage.

Several forest edges of logged areas R, G and H contained numerous wind-thrown trees as a result of exposure following clear-cutting. The edges nearest the sample plots in the slash were examined in strips

132 ft wide and 660 to 1,320 ft long, covering 6 to 8 acres along the timber boundaries in each location. All of the wind-thrown trees were sampled on one side of the bole and the bark area was measured to a 6-inch top diameter.

Attack and Progeny in the First Season

The attack at the shaded stump bases and the undersides of logs in slash was denser than in adjacent wind-throw in each area (Tables I and II). The beetles usually selected slash breeding niches in shade and close to the ground (Table I), where heat, cold and desiccation were less extreme. Progeny numbers were directly related to the density of attacks in the different strata of the habitat. Broods appeared to develop successfully during the first summer while the slash was still fresh (Table 1).

In every location, the area of bark on logs in slash was much greater than that on stumps (Table III). Removal of all logs by close utilization would have reduced the slash bark area by more than two-thirds in most locations. However, this would not have reduced the beetle progeny by the same proportion (Table III) and, in fact, might have induced additional attacks on nearby wind-throw where more progeny could mature.

In larger areas of slash (G and H) where more adjacent wind-thrown trees occurred, the attacks per acre were more numerous in the wind-throw than in the slash. In R, a small slash area, with few wind-thrown trees, the reverse prevailed. Here the slash had larger numbers of attacks per acre (Tables III and IV). This points out the necessity of estimating both area of suitable breeding material and number of beetles per unit area before population estimates can be determined. The ratio of progeny to attack per acre was much higher in wind-thrown trees than in slash (Tables III and IV) and, as shown later, survival in the second year was also much greater in wind-thrown trees.

Progeny Survival in the Second Season

Although slash offered an excellent breeding site during the first season after logging, brood survival in the second season was usually low. Examinations of R and other slash areas in the years following 1966 showed that few beetles survived in slash the second year, possibly because of exposure to temperature extremes. At the same time, wind-thrown trees at the sheltered edges of slash and throughout the forest produced larger numbers of maturing beetles.

In area R, the optimum brood sites were sampled in 1967, during the second summer after logging. The number of progeny surviving in the slash and in adjacent wind-thrown and felled trees is shown in Table V. In slash, even the protected niches at the shaded stump bases and under logs contained less progeny than the number of parents (a pair per attack) that entered the previous year (Table I). This slash absorbed more beetles than it subsequently produced. At the same time, the trees lying within the forest edge contained an average of 31 beetles per square foot (Table V), about three times as many as the parents that had attacked them in the previous year (Table II). In wind-throw within the forest (N), the average number of young beetles per square foot was 41, over eight times the number of parents that entered these trees in 1966 (Table II). Parts of these wind-thrown trees were caged to capture the emerging beetles in 1968, and an average tree (18.8 in. dbh) was estimated to have produced about 5,600 mature beetles. Attacks on living trees in this forest were numerous in 1968.

Additional data were taken in different slash areas in the Naver

Forest in 1967, 1968 and 1969. Eighty-four samples from winter-logged slash, in 1968 and 1969, showed that the shaded stump bases contained means of 50 progeny per square foot the first summer; 11 the next spring, and only 2 by autumn of the second year. These stumps absorbed more parent beetles than were produced. Eighty samples taken in another area, winter-logged in 1969, showed that the shaded stump bases had 10 progeny per square foot in July and 6 in September of the first summer. Sixty-one per cent of the latter were mature, but since 10 parents per square foot had entered these stumps no increase could result.

In 1967, 40 stumps (3 ft high) in a winter-logged timber sale were sampled at the base, middle and top on the shaded sides. Distribution of attack and progeny are shown in Table VI. Adjacent wind-throw contained an average of 69 progeny per square foot at this time. The stump broods developed rapidly during the warm summer and about two-thirds of the larvae matured by autumn. The extra 1.2 ft height of these stumps, over the average of 1.8 ft in other areas, did not appreciably increase their potential as breeding sites because the beetles did not infest the upper parts of them significantly (Table VI). A slight increase of progeny over parents did develop during the unusually warm season, which was followed by the relatively moderate winter of 1967-68, when the minimum temperature was -27.2 C (-17 F).

Environmental Temperature Extremes

Excessive heat from direct sunshine on the bark may be one factor contributing to brood mortality in slash (Massey and Wygant, 1954; Reid, 1957). However, typical sub-cortical temperatures taken in spruce slash on a clear day in August 1966 (Fig. 3) showed that only the upper surfaces and sides exposed to direct sunshine reached excessive temperatures. Spruce billets containing young adults were exposed in sunlight from mid-August to mid-September. The air temperature maximum during the warmest day of that period was 27.2 C (81 F) for three hours. The sub-cortical maximum temperatures on that day were 43 C on the top and 22 C on the bottom of the billets. Ninety-two per cent of 201 beetles survived on the lower half but only 13% of 106 beetles were alive on the top. Since the beetles, when attacking, select shaded parts of slash, this would usually protect most of the brood from the lethal effect of solar heat. Desiccation of exposed slash may also be a cause of mortality, especially in the second summer, but no measurements of this were taken.

Extreme cold in 1968-69 caused extensive mortality of larvae and adults in bark above the snow. That winter, the minimum temperature within the Naver Forest was -37.8 C (-36 F) above the snow and -22.8 C (-9 F) near the ground below the snow. The minimum temperatures for the previous three winters were -27.2 C (-17 F), -29.4 C (-21 F) and -31.7 C (-25 F) above the snow, none of which caused significant mortality of beetle broods in felled trees. In unprotected, windswept slash, beetles would be exposed to minimum air temperatures. Massey and Wygant (1954) reported that most adults are killed by -26.1 C (-15 F) and most larvae by -28.9 C (-20 F). Snow cover for the beetle broods seems to be a critical factor in preventing mortality from low temperature. Adequate snow cover might be removed by wind in clear-cut areas.

Discussion and Recommendations

Logging slash is potentially a good breeding place for spruce beetles but, in most years, it absorbs more beetles than it produces. It provides a refuge where beetles can survive in years when wind-thrown trees are scarce and standing trees are not attacked. Slash maintains a small, well-distributed population capable of taking advantage of wind-thrown or susceptible living trees. During seasons when standing trees are being attacked, the fresh slash absorbs part of the population that would otherwise kill trees. Closer utilization of slash by removing logs over 6 inches in diameter would considerably reduce the bark area (Table III). However, it is unlikely that this would equally reduce the beetle population because the remaining stumps would still provide breeding space and more beetles might attack adjacent wind-thrown trees.

Wind-thrown trees in forest shade are the most productive breeding sites for spruce beetle (Watson, 1928; Massey and Wygant, 1954; Knight, 1961). Thomson (1951) states that spruce wind-throw in the forest is the most favorable breeding place because it often remains covered with snow. Snow cover on wind-throw prevents woodpecker predation, a very important factor in reducing bark beetle populations in standing trees (Massey and Wygant, 1954). In the forest, only infested wind-thrown trees suspended above the snow received much woodpecker feeding. In open slash, little woodpecker predation was found. Forest boundaries created by logging and road construction are exposed to wind and increase the probability of extensive wind-throw. From the point of view of reducing wind-throw, large clear-cut areas should be preferred over small ones because the length of timber edge becomes proportionately less as the area is enlarged. Although access roads developed far ahead of harvesting create miles of timber edges, they also provide an opportunity to effect a program of sanitation by making windfall salvable over a large forest area. In Colorado, recent studies showed that two-thirds of the wind-throw beside cutting boundaries occurred during the first two years after logging. Also, exposed ridges sustained the most wind damage (Alexander, 1967). Wind-thrown trees in forest shelter are protected from the extremes of solar heat, intense cold and desiccation. Snow usually covers wind-throw on the forest floor and gives protection from cold and woodpeckers. Spruce beetle survival is relatively high in wind-throw in the forest and this appears to be a major factor in production of large beetle populations.

Recommendations

1. Annual removal of wind-thrown trees from cutting boundaries for two years following logging and road construction is recommended in the management of spruce stands.
2. Cutting boundaries on ridge tops or where exposed to severe winds should be avoided.
3. From the point of view of beetle hazard, partial or strip cutting creates conditions which may favor beetle population build-up in shaded slash and wind-throw.

References

Alexander, R.R. 1967. Wind-fall after clearcutting on Fool Creek - Fraser Experimental Forest, Colorado. U.S. For. Service Res. Note RM-92: 1-11.

B.C. Forest Service. 1969. Forest inventory statistics of British Columbia, 1967. Inventory Div., B.C. For. Service, Dept. Lands, Forests and Water Resources, Victoria, B.C. Canada.

Cottrell, C.B. and R.L. Fiddick. 1968. Appraisal of timber killed by some important insects in British Columbia from 1961-1965 inclusive. Can. Dep. Forest., Forest Res. Lab., Victoria. Inf. Rep. BC-X-26. 49 p

Dyer, E.D.A. 1969. Influence of temperature inversion on development of spruce beetle, Dendroctonus obesus (Mannerheim), (Coleoptera: Scolytidae). J. Entomol. Soc. Brit. Columbia 66: 41-45.

Knight, F.B. 1961. Variations in the life history of the Engelmann spruce beetle. Ann. Ent. Soc. Amer. 54: 209-214.

Massey, C.L. and N.D. Wygant. 1954. Biology and control of the Engelmann spruce beetle in Colorado. U.S. Dept. Agric. Circ. 944: 35 p.

Reid, R.W. 1957. The bark beetle complex associated with lodgepole pine slash in Alberta. Part IV - Distribution, population densities, and effects of several environmental factors. Can. Ent. 89: 437-447.

Thomson, M.G. 1951. Engelmann spruce beetle. Can. Dept. Agric. Science Service Bi-monthly Prog. Rept. 7: (1) 4.

Watson, E.B. 1928. The bionomics of the spruce bark beetle Dendroctonus piceaperda Hopk. The result of observations carried out in the Algoma District of Ontario. Scientific Agr. 8: 613-635.

Acknowledgments

The cooperation of the British Columbia Forest Service in providing information on timber sales is gratefully acknowledged. The assistance with field work by D.M. Rolston, D.T. Elliott, D.M. Summers and J.E. Serveau is appreciated.

Table I

Estimated attack and progeny in slash during the first summer after logging in three locations

Location and acreage	Types of host material	Number of samples	Attack per sq ft mean	Attack per sq ft S.E.	Progeny per sq ft mean	Progeny per sq ft S.E.
	Stumps					
	base-shade	60	5.6	0.55	127.1	17.55
	top-shade	60	3.5	0.54	66.0	12.56
R	side in sun	30	1.4	0.54	27.7	12.57
30 acres	Logs					
	bottom on ground	118	4.5	0.36	104.9	6.95
	bottom off ground	122	1.0	0.19	26.4	5.43
	top in sun	60	0.2	0.15	3.8	3.77
	Stumps					
	base-shade	60	3.4	0.36	64.7	7.9
	top-shade	60	1.0	0.23	19.3	4.53
G	side-in sun	30	0.4	0.17	13.3	5.05
340 acres	Logs					
	bottom on ground	117	2.7	0.25	57.0	6.20
	bottom off ground	124	0.2	0.06	3.3	1.09
	top in sun	60	0.1	0.07	0.2	0.20
	Stumps					
	base-shade	60	2.3	0.30	63.4	4.47
	top-shade	60	0.9	0.18	14.0	4.32
H	side-in sun	30	0.2	0.09	0.7	0.42
188 acres	Logs					
	bottom on ground	124	2.2	0.19	62.6	6.09
	bottom off ground	116	0.3	0.10	6.4	2.13
	top in sun	60	0.0	0.00	0.0	0.00

Table II

Estimated attack and progeny the first summer in wind-thrown and felled trees in forest edges surrounding slash and within a forest remote from logging

Location and host material		Acres examined	Trees per acre	Number of samples	Attacks per sq ft mean	Attacks per sq ft S.E.	Progeny[1/] per sq ft mean	Progeny[1/] per sq ft S.E.
Forest edges adjacent to logging								
R	Wind-throw	8	0.4	36	4.2	0.35	158	12.8
	Felled[2/]		0.2	16	6.5	0.19	202	21.3
G	Wind-throw	6	9.7	36	1.3	0.28	63	15.1
	Felled[2/]		0.3	24	2.9	0.45	89	17.8
H	Wind-throw	8	15.8	36	0.8	0.23	41	15.7
	Felled[2/]		0.2	16	1.9	0.53	88	20.6
Undisturbed forest								
N	Wind-throw	135	0.5	239	2.5	0.15	119	6.9
	Felled[2/]		0.01	32	3.2	0.38	197	25.5

1/ 90% larvae.

2/ 2 felled trees in each location.

Table III

Bark area in slash and estimated attack and progeny the first summer after logging in three locations

Location and acreage	Types of host material	Bark sq ft per acre	Estimated attacks 1/ per acre	Estimated progeny 1/ per acre	Ratio of progeny to attacks
	Stumps				
	base-shade	116	650	14,744	
	top-shade	116	406	7,656	
	side in sun	232	325	6,426	
R	total stumps	464	1,381	28,826	
30 acres	Logs				
	bottom on ground	425	1,912	44,582	
	bottom off ground	363	363	9,583	
	top in sun	788	158	2,994	
	total logs	1,576	2,433	57,159	
	total slash	2,040	3,814	85,985	22.5
	Stumps				
	base-shade	128	435	8,281	
	top-shade	128	128	2,470	
	side in sun	256	102	3,405	
G	total stumps	512	665	14,156	
340 acres	Logs				
	bottom on ground	222	599	12,654	
	bottom off ground	373	75	1,231	
	top in sun	595	60	119	
	total logs	1,190	734	14,004	
	total slash	1,702	1,399	28,160	20.8
	Stumps				
	base-shade	229	527	14,519	
	top-shade	229	206	3,206	
	side in sun	458	92	321	
H	total stumps	916	825	18,046	
188 acres	Logs				
	bottom on ground	255	536	15,963	
	bottom off ground	566	170	3,622	
	top in sun	821	0	0	
	total logs	1,642	706	19,585	
	total slash	2,558	1,531	37,631	24.6

1/ based on means shown in Table I.

Table IV

Bark area and estimated progeny per acre during the first summer in wind-thrown trees in forest edges adjacent to three logged areas (R, G and H) and within a forest (N) undisturbed by current logging

Location	Estimated adjacent wind-throw acreage	Acres examined	Bark per acre sq ft	Estimated attacks[1/] per acre	Estimated progeny[1/] per acre	Ratio of progeny to attacks
R	12	8	161	676	25,438	37.6
G	28	6	1,849	2,404	116,487	48.5
H	20	8	4,197	3,358	172,077	51.2
N	135	135	120	300	14,280	47.6

1/ based on means shown in Table II.

Table V

Live progeny the second summer compared to the first summer in area R slash and in nearby sheltered wind-throw and felled trees edge

Host material	Progeny second summer			Progeny[1/] first summer
	Number samples	Mean per sq ft	S.E.	Mean per sq ft
Stumps				
base-shade	60	4.2	1.54	127
top-shade	60	2.3	0.64	66
Logs				
bottom on ground	60	2.9	0.86	105
Wind-throw and felled trees	40	30.6	4.52	158 202

1/ From Tables I and II. Means for wind-throw and felled trees shown separately.

Table VI

Distribution of attacks and progeny in high stumps the first summer after logging

Position on shaded side of stumps	Height in feet	Number of samples	Attacks per sq ft		Progeny per sq ft	
			mean	S.E.	mean	S.E.
Base	0-1	40	4.0	0.60	18.8	5.90
Middle	1-2	20	1.7	0.58	2.5	1.20
Top	2-3	40	0.4	0.17	0.8	0.65

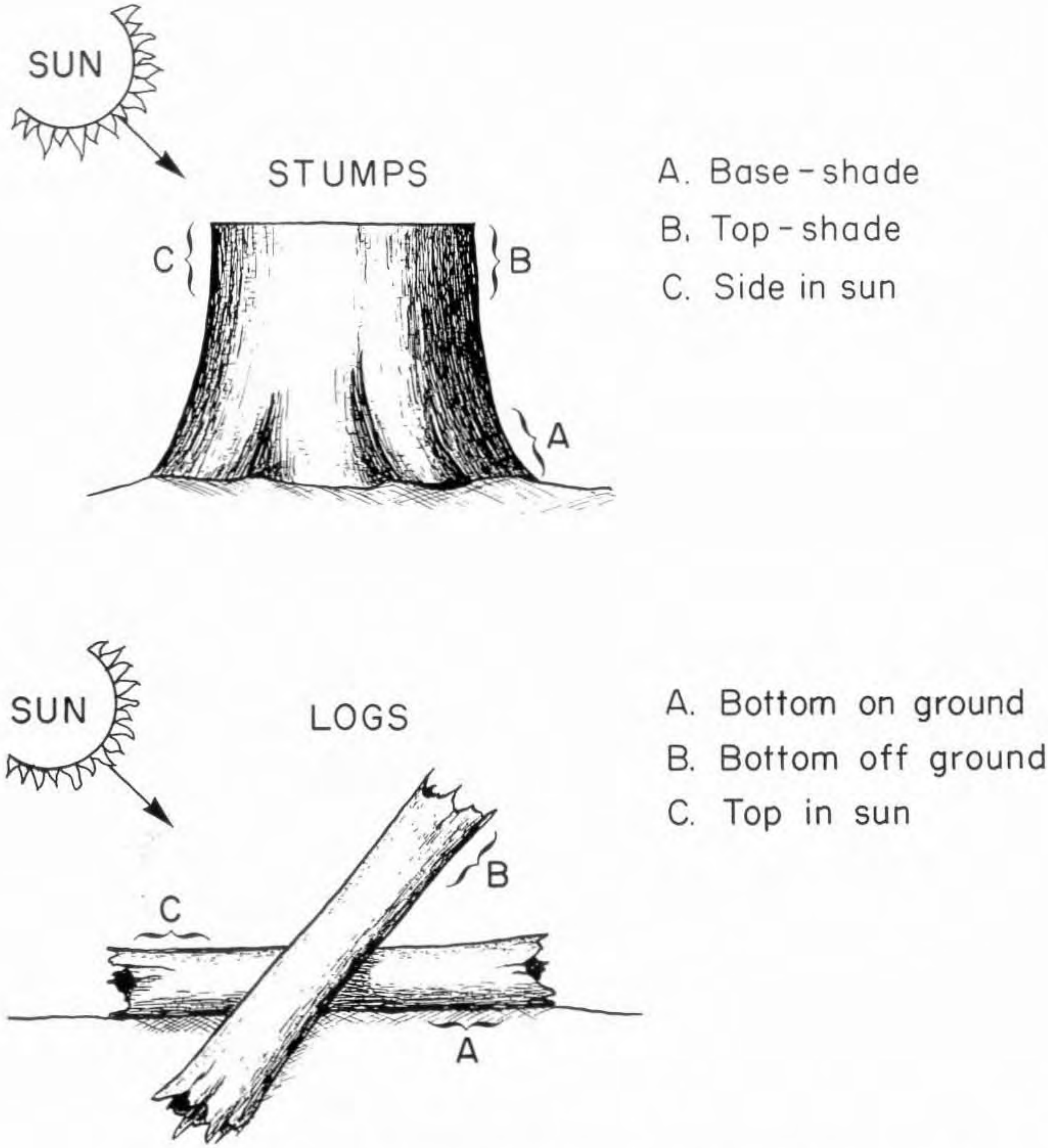

Fig. 1. Diagram of the positions of bark samples taken from spruce slash to estimate the beetle populations.

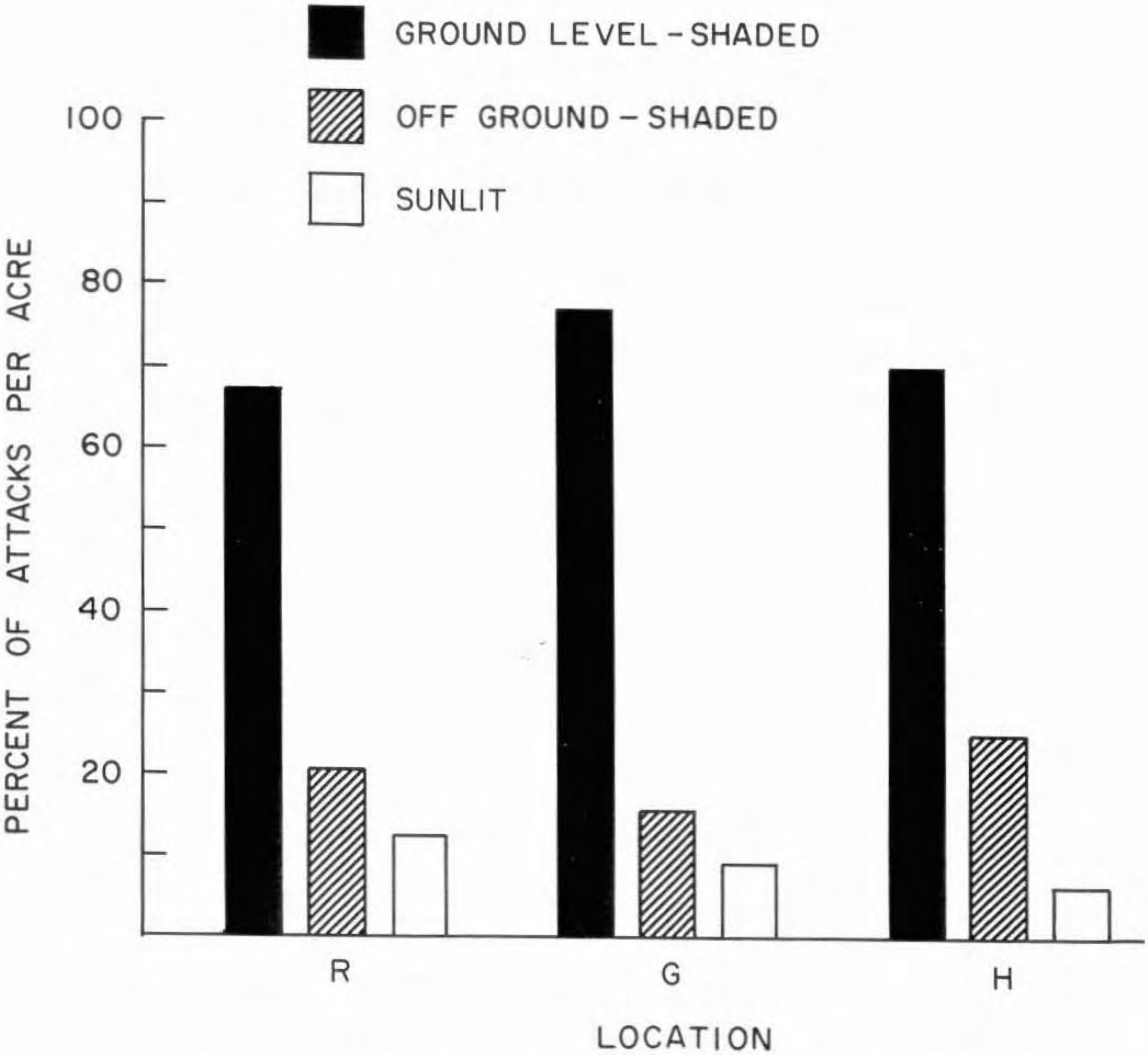

Fig. 2. Distribution of beetle attacks in spruce slash at three locations.

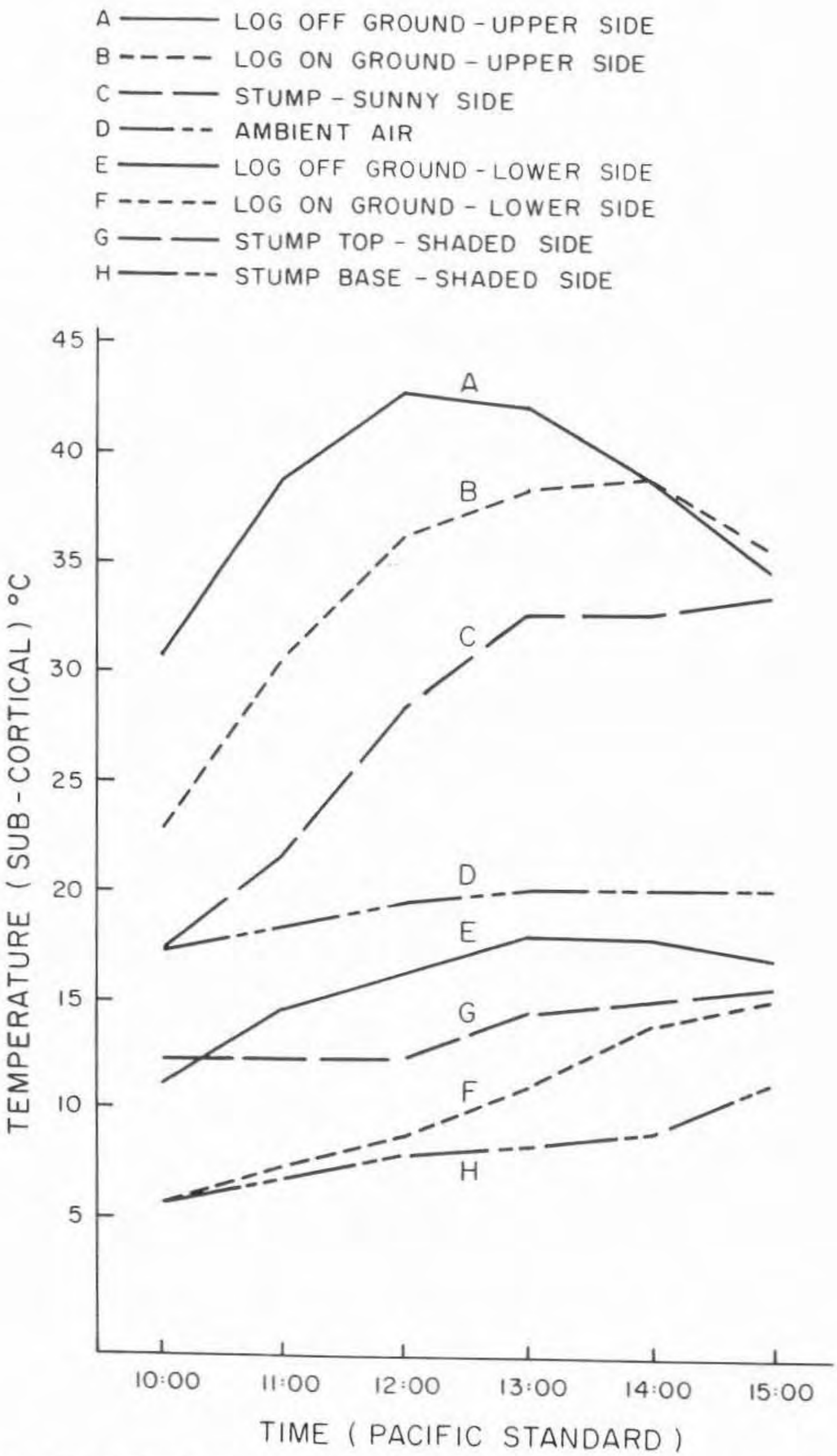

Fig. 3. Temperature of the air and beneath the bark of spruce slash during a clear August day.