in a valley near Fallen Timber Creek, Alberta. Fire had destroyed the previous stand except for scattered groups of trees, some of which had large cankers and apparently had supplied the inoculum to infect the new stand. A survey of the entire valley indicated that the incidence was usually highest close to the inoculum source and spread outwards in more than one direction, merging in places with infections which had apparently come from a different source. Discontinuities occurred concomitantly with changes in slope and aspect. The patterns were interpreted as having resulted from the dissemination of inoculum by winds from different directions. In one part of the valley the incidence gradient was steep for a distance of 400 feet from the apparent inoculum source. In another area little change occurred for a distance of 1,000 feet. Although the infections in this valley only have been shown to originate from inoculum on fire-residual trees, it seems likely that others, particularly in young stands, developed similarly, as lodgepole pine stands normally regenerate after fire.

Attempts were made to find infected trees farthest from their probable inoculum source and still with a fairly high incidence of cankers. On one plot, 11 of 22 trees had been infected at a distance of 1,200 feet from the nearest group of older trees, while on another plot 61 of 109 trees had been infected at 1,000 feet from their probable inoculum source. A sample of 96 cankers in these and neighbouring plots showed that 78 per cent had originated two or three years previously when very few, if any, apothecia would be present on the young trees. The youngest cankers with apothecia found in this stand were four years old. These cankers had only just commenced production of apothecia. It was concluded that the phase of intensification from adjacent inoculum could not have occurred to an appreciable extent. The results appear to indicate that inoculum may be carried by wind for considerable distances, and may partially explain the wide distribution of the pathogen.

There are indications from other locations, however, that a high incidence may also develop from a few cankers following initial infection by long distance spread of inoculum. In such instances the rate of inoculum production by a few initial infections would govern to a large extent the rate of intensification of the disease, and studies show that this rate of inoculum production varies considerably. Two phases are involved in the formation of inoculum: the period between infection and the initial appearance of apothecia, and the subsequent rate of apothecial production.

Inoculum formation was studied in three stands, where the age of 230 cankers was determined and counts made of the number of apothecia which expanded fully after wetting. Cankers lacking apothecia at the time of the examination were considered to have never formed them, as no apothecial remnants have been observed on living trees without enlarged ones being present. The remains of apothecia are usually retained for several years. These studies showed that on trees with a DBH of 3.5 inches or less, apothecia occurred on one two-year-old canker, several three-year-old cankers, and many four-year-old ones. Virtually no cankers over 10 years old lacked apothecia in this class of tree. On trees with a DBH of 5.1 inches and larger the youngest canker with apothecia was eight years old, and a few cankers up to 28 years old were without apothecia. The rate of apothecial formation was also higher for the small trees than for the larger ones. Proximity of several cankers appeared to have stimulated the early formation of apothecia and a higher rate of formation than normal for either solitary cankers or those over two feet apart. For example, on trees with a DBH of 5.1 inches and larger, the youngest solitary canker with apothecia was 13 years old. Stimulation was most apparent on the lowest canker of each group where up to 400 apothecia were noted. Few single or widely separated cankers formed more than 60 apothecia, and all cankers with over 100 apothecia occurred within a group.

The relative influence of host size and host vigour on the rate of inoculum formation is not yet known, as the small trees involved in this study were largely suppressed ones. However the results suggest that infections on small trees in densely stocked stands will produce large amounts of inoculum within a few years. This could permit a rapid intensification of the disease, and may partially explain why most high incidence levels have been found in overstocked stands. —J. C. Hopkins.

BRITISH COLUMBIA

The Balsam Woolly Aphid in British Columbia, 1960. —The balsam woolly aphid, *Adelges piceae* (Ratz.), was first discovered in the lower mainland of British Columbia in 1958. Since 1959, efforts have been directed mainly to a survey to follow the annual trend of the infestation with its resulting tree mortality. A program to introduce and establish predators which give promise of effecting some control was started in 1960, and continued in 1961. (The balsam woolly aphid project is under the direction of Mr. J. W. E. Harris who is currently taking graduate work at Wisconsin University).

The infestation was appraised in 1959 (Harris, J. W. E., Bi-Mo. Prog. Rept. 16(2), 1960). This report summarizes the results of the 1960 and 1961 work.

The known range of the balsam woolly aphid has increased each year since 1958. It now extends from Sechelt in the north around Howe Sound and includes the upper Capilano, upper Seymour, and Indian rivers, and the height of land east of Indian Arm as far as Coquitlam Lake. The aphid is suspected of being present from Alouette Lake and Pitt Lake, northward up the Pitt River Valley to Garibaldi Park and west to Jervis Inlet south of Vancouver Bay. The area known to be infested is approximately 600 square miles, and the suspect area is about 1,250 square miles. The balsam woolly aphid was found in Thetis Lake Park and in Beacon Hill Park, Victoria, in 1959, but has not been detected outside the Greater Victoria area.

Amabilis fir, *Abies amabilis* (Dougl.) Forb., is the major host, but several grand fir, *A. grandis* (Dougl.) Lind. have been attacked. Amabilis fir is the predominant fir tree in the infestation area.

Twelve trend plots were established in 1961 (Table I). The damage indicated by these plots is not indicative of tree mortality as areas of heavy tree mortality were purposely avoided since it was desirable to have a large number of living trees in the study plots. The amabilis fir stems in the stands varied from 27 to 80 per cent. Gout attack was very prevalent; heavy stem attack occurred only at Indian River. Heavy stem attack is present in some localities in Mt. Seymour Provincial Park as well as at Grouse Mountain. Nevertheless, considering the entire area, stem attack is relatively scarce.

The percentage of amabilis fir trees attacked by the balsam woolly aphid varied from 2.4 to 39.6 per cent. Many of the trees were of a size regarded as too small for attack. The amabilis fir in all plots were grouped and tallied by diameter classes (Table II). No attacks occurred on the 420 trees below eight inches d.b.h., but 120 or 29.6 per cent of the 405 trees over eight inches were attacked. Stem attacks occurred on trees between eight and 26 inches d.b.h.; gout attacks were recorded on all diameters from 8 inches up to 52 inches.

During the aerial survey in 1961 the dead and red-topped trees were tallied by drainages. Over 8,300 such trees were recorded. Areas in which tree mortality has reached heavy proportions are Cypress Creek (2,375 trees), and in the Seymour River Valley (2,470 trees). Estimates, based on aerial surveys, indicate a minimum of 1,500,000 cu. ft. of amabilis fir timber has been killed to date, throughout the known infested area.

Several other insects are associated with the balsam woolly aphid infestation. Another aphid, *Pineus* sp., is present in some areas, but very little is known about it. A bark beetle, *Scolytus ventralis* Lec., is believed responsible for some balsam mortality. A *Pseudohylesinus* sp. bark beetle is also associated with the balsam woolly aphid, but observations to date indicate that this beetle attacks only trees which are being killed by the aphid and does not contribute to tree mortality by itself.

The following species of introduced predators were released in 1960 at Seymour Mountain, Grouse Mountain, or Thetis Park, Vancouver Island; *Laricobius erichsonii* Rosenh., *Aphidecta obliterata* L., *Scymnus pumilio* (Wse.), and *Pullus impexus* (Muls.). Only the first two species were released again in 1961, both in the Seymour Mountain release area used in 1960.

There is very little information available on survival or establishment of the released predators. Three adult *Pullus impexus* were found on June 15, 1961, and as this species was released only in 1960, this shows that at least some survived the winter of 1960-61. *Laricobius* adults were observed in 1961 nearly three months after they were released so it is hoped that this species might establish itself. No *Aphidecta* or *Scymnus* have been recovered.

The fate of a large volume of amabilis fir depends on the trend of the balsam woolly aphid infestation in the next few years. It is hoped that the combination of aerial surveys, trend plots, and random ground checks will be sufficient to eventually delimit the area of infestation and record the course of the outbreak. The infestation in British Columbia is restricted mainly to the "gout" form of attack. There are several possible reasons for this. The stem attacks are usually found in fairly open stands, and much of the infested area is in fairly closed stands with a heavy canopy. Furthermore, stem attacks are seldom found on large trees with heavy thick bark, and are usually found on trees less than 20 inches d.b.h. The gout form is found on all sizes, and as much of the amabilis fir in the Howe Sound area is mature and overmature, this form of attack is prevalent.

The stem form of attack is more serious, and is capable of killing trees more quickly than the "gout" form. Nevertheless tree mortality has been heavy, and can be expected

to continue. The current program of predator releases, even if successful, will provide no immediate control. The survey program will therefore continue. One objective will be to detect areas where tree mortality is heavy and where it might be advisable to recommend salvage logging.—G. T. Silver, D. H. Ruppel and S. J. Allen.

TABLE I

Stand density and number of amabilis fir attacked by balsam woolly aphid, 1961.

Location of plot and area (in acres)		Total no. stems	No. amabilis fir	No. amabilis fir attacked		No. amabilis fir killed
				Gout	Stem	
Cypress Cr.	(0.4)	—	61	18	0	0
Cypress Cr.	(0.6)	171	80	15	0	7
Grouse Mtn.	(1.2)	–	48	19	0	1
Rainy R.	(1.2)	–	60	14	0	7
Indian R.	(0.3)	64	51	0	13	1
Raffuse Cr.	(0.6)	123	80	2	0	0
Brittania Cr.	(0.3)	109	55	5	0	0
Seymour R.	(0.3)	194	110	5	0	1
Seymour R.	(0.4)	201	88	3	1	0
Woodfibre Cr.	(0.4)	141	82	6	0	0
Dakota Cr.	(0.6)	134	84	2	0	1
McNair Cr.	(1.2)	96	26	16	0	5

TABLE II

Type and distribution of balsam woolly aphid attack by diameter classes, 1961

Diameter class	No. of amabilis fir	No. amabilis fir trees attacked	
		Stem	Gout
— 3.9	220	0	0
4.0— 7.9	200	0	0
8.0—11.9	113	1	6
12.0—15.9	93	5	15
16.0—19.9	67	4	13
20.0—23.9	54	3	23
24.0—27.9	41	1	25
28.0—31.9	19	0	10
32.0—35.9	7	0	5
36.0—39.9	2	0	2
40.0—43.9	5	0	2
44.0—47.9	3	0	3
48.0—51.9	1	0	1
Total	825	14	105

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