gerator until used; thereafter, weevils emerging from currently infested leaders were used. Until that date all weevils were sexed (Harman and Kulman, Ann. Ent. Soc. Amer. 59: 315-317, 1966). Twenty-four hours after spraying and at 2-week intervals thereafter, four adult weevils (2 males and 2 females) were introduced into a screen-sleeve cage (1 mm mesh) placed over each leader. On August 18, a comparison of mortality between males and females, and old (field-collected) and young (newly emerged) adults showed no significant differences, and subsequently the weevils were not sexed.

Within 24 hours after the first introduction, about 90% mortality had occurred in all groups except propoxur (50%) and the control (0% to the end of the tests). Mortality for the seven introductions assessed 48 hours after each introduction is shown in Fig. 1. The insecticides, in descending effectiveness, were: Gardona®, Methyl Trithion®, fenitrothion, benzene hexachloride, propoxur and phosphamidon.

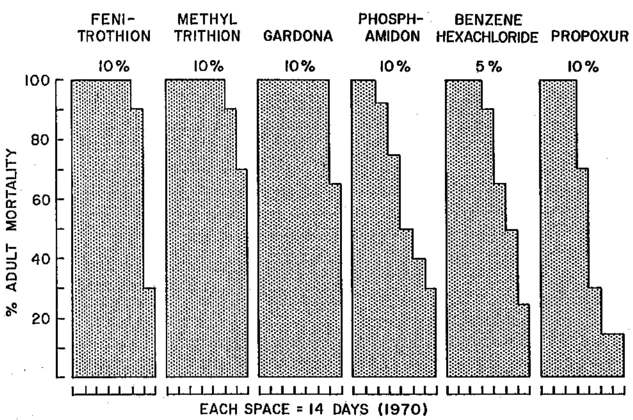

Figure 1. Residual toxicity of various insecticides over 14 weeks, showing percent mortality of weevils within 48 hr of introduction on to pre-sprayed trees.

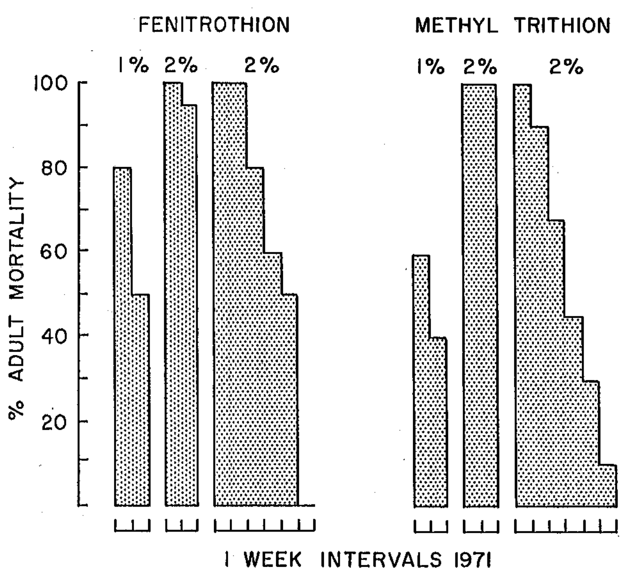

Figure 2. Percent mortality of weevils 48 hr after introduction at different periods of time following insecticide application.

Further tests, conducted in 1971, used the more effective insecticides, Methyl Trithion® and fenitrothion, at more ecologically acceptable levels (1 and 2% a.i.). Gardona® was eliminated because it was thought to be toxic to fish (Tech. Bull. Gardona Insecticide, Shell Chemical Co., New York), but this decision needs to be reconsidered because another report (Thompson, Agricultural Chemicals Book I Insecticides 1972 revision) indicates that the insecticide is relatively non-hazardous to fish. The same methods and materials as in 1970 were used, except that introduction of weevils was weekly instead of biweekly. The interval was changed from 1970 because lower concentrations of insecticides were used, and reduced residual toxicity was anticipated. Tests started on June 28, with new groups of trees, indicated that only 2% concentrations were effective (Fig. 2); mortality on unsprayed trees was nil. On July 12 additional groups of trees were sprayed with 2% concentrations. The early mortality was similar to that of the prior test and the residual toxicity gradually decreased after the first week (Fig. 2). Reduction in toxicity of fenitrothion was more gradual than Methyl Trithion® in the early period after application, but the latter retained some toxicity to the end of the 6-week test period.

These results show that of the insecticides tested, fenitrothion and Methyl Trithion® at 2% minimum concentrations were the most promising for control of the Sitka spruce weevil. They appear suitable for further testing in ground application and aerial spray under field conditions.—S. Ilnytzky, Pacific Forest Research Centre, Victoria, B.C.

Establishment and Survival of Balsam Woolly Aphid on Second Growth Amabilis Fir at Intermediate Elevations.—Regeneration of many cutovers at intermediate elevations to amabilis fir [*Abies amabilis* (Dougl.) Forbes] is desirable in British Columbia in view of the frequent failure of other species, e.g. Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco] at these elevations. However, planting of *Abies* ceased in 1966, when the province imposed quarantine regulations on the commercial growing and transport of *Abies*. These regulations resulted from the threat of the balsam woolly aphid [*Adelges piceae* (Ratz.)], an insect pest of *Abies* for which there is no practical control. Although the aphid is now concentrated in high-value, old-growth stands, the possibility of dispersal into regenerated stands is increasing as the supply of old-growth trees dwindles. Whether it will establish and survive on young second-growth amabilis fir at elevations above 2000 ft (610 m) is uncertain.

Three study areas, located at various elevations within the aphid infestation zone, were selected in the Haslam Creek watershed west of Ladysmith, B.C. The forest cover was predominantly second-growth amabilis fir, 15-30 yr old. Table 1 shows the size of sample, elevation and stand characterestics in the three areas. In an initial crown sampling and stem inspection of all trees in July 1969, no aphids were found. In August, pieces of aphid-infested bark, each bearing approximately 50 eggs, were collected from low elevation grand fir [*A. grandis* (Dougl.) Lindl.] near Ladysmith and used to infest the study trees. On each tree, two pieces were taped to the stem, one at breast height and one 12 ft (3.7 m) above the ground, and two pieces were tied to twig ends in the mid-

TABLE 1

Characteristics of second-growth amabilis fir stands selected for study

No. of trees	Elevation ft	(m)	Stocking (stems/acre)	Dbh inch	(cm)	Height ft	(m)	Aspect
18	2300	(701)	200	8-10	(20-25)	30-40	(9.1-12.2)	NW
36	2850[a]	(869)	450	4-8	(10-20)	25-35	(7-6-10.7)	W
18	3500	(1067)	900	4-8	(10-20)	20-30	(6.1- 9.1)	E

[a] Range of elevation 2700-3000 ft (825-918m).

crown, thereby exposing four sites per tree to the aphid. Infestations on the stem were located so they were not exposed to direct sunlight. Plastic flagging tape was tied around the stem about 6 inches (15 cm) above each piece of bark. Since these trees were uniformly smooth-barked, the tape served to simulate lichen or moss under which future generations of aphids could gain protection. When the bark pieces were removed in September, aphids had settled on all trees and at all 288 sites.

Each infestation was observed annually but the plastic tapes were not removed for aphid counting until 1972. For twig infestations, the entire internode was checked; on the stem, the bark within 4 inches (10 cm) of the infestation center was checked. Aphids were counted at the end of a generation when the population was mostly wool-bearing adults, and each infestation was classified as either 0, 1 (light; 1-10 aphids), 2 (moderate; 11-50) or 3 (heavy; > 50). Each tree was rated, using these infestation categories, e.g. a tree with two light and two moderate infestations was rated 6. From these tree ratings, an Infestation Index was calculated for each elevation to provide a cumulative measure of initial establishment, survival and population change.

$$\text{Infestation Index} = \frac{\text{sum of maximum tree infestation ratings } (=4\times3\times\text{no. trees})}{\text{sum of individual tree infestation ratings}} \times 100$$

In 1970, at the end of the summer generation, infestations at 2300 ft and 2850 ft were 65-69% of maximum but only 53% at 3500 ft (Table 2), indicating that establishment in 1969 and/or 1970 population growth was less at the higher elevation. The count in mid-July 1971, at the end of the overwintering generation, indicated that winter mortality increased with elevation. The Infestation Index decreased, 68% at 2300 ft, 74% at 2850 ft, and 78% at 3500 ft. By August 1972, at the end of the summer generation, all exposed infestations on the twigs and stems had died out. The aphids, however, did survive in protected areas. When the plastic tapes were removed from the stems, aphids were found on most trees (Table 2). Furthermore, examination of twig nodes adjacent to the infestation sites revealed that progeny of the initial twig infestation had settled under old bud scales and survived. Thus aphids survived in protected sites on the majority of trees for at least 3 years, with infestation ratings 20-32% of maximum. Although the populations were relatively low on all trees in 1972, they may have been increasing when counted. Continued observation was impossible, since the aphids had to be eradicated in 1972 to prevent possible spread into the surrounding stand.

Aphids infesting exposed sites on twigs or bark apparently have little chance for success. No tree exhibited an increase in infestation rating from year to year, regardless of elevation. The initial stem populations, which in 1970 were confined to an area about 2 inches (5 cm) square, did not disperse except to protected sites under the tape. Likewise, the only dispersal of twig populations was to the protection of bud scales.

The balsam woolly aphid will apparently establish and survive in twig nodes of second-growth fir at intermediate elevations. However, the lower Infestation Index and incidence of crown attack at 3500 ft indicates that populations may be less viable at that elevation. This has important implications, since a crown infestation normally produces offspring which infest the stem and tree mortality in British Columbia is associated mainly with stem attack. Furthermore, aphids infesting the stem have difficulty surviving unless protected sites, e.g. lichen, moss, bark fissures, etc., are a common feature of the stand. At 3500 ft, low winter temperatures are undoubtedly a major factor limiting aphid survival,

TABLE 2

Survival of balsam woolly aphid and infestation trends on second-growth amabilis fir at intermediate elevations

		2300 ft (701 m)	2850 ft (869 m)	3500 ft (1067 m)
Exposed sites				
1969				
Trees infested:	crown	18	36	18
	stem	18	36	18
1970				
Trees infested:	crown	18	35	18
	stem	18	36	18
Infestation Index		65	69	53
1971				
Trees infested:	crown	8	15	3
	stem	17	30	13
Infestation Index		21	18	12
1972				
Trees infested:	crown	0	0	0
	stem	0	0	0
Infestation Index		0	0	0
Protected Sites				
1972				
Trees infested:				
crown (bud scales)		13	22	5
stem (under tape)		14	30	14
Infestation index		31	32	20

but the summer drought which frequently occurs at higher elevations may be equally important. Results of a recent study at this laboratory (unpublished) indicate that, on trees receiving a reduced water supply, balsam woolly aphid survival is decreased and development is delayed.

Before any recommendations can be made regarding amabilis fir regeneration, the development of aphids at intermediate elevations and their impact on second-growth stands must be assessed over a longer time period.—J. R. Carrow, Pacific Forest Research Centre, Victoria, B.C.

Effect of Cold Treatment on Post-diapause Spruce Budworms.—In rearing post-diapause larvae and pupae of spruce budworm [*Choristoneura fumiferana* (Clem.)] at diurnal fluctuating temperatures of amplitude 16.7°C with means of 10.0°, 12.8°, 15.5°, and 18.3°C, we have found that survival was drastically reduced in the lower temperature regimes (unpubl.). Survival was particularly poor at a mean of 10°C (range 1.7° to 18.3°C) among larvae and female pupae. The surviving adults had deformed wings and failed to produce progeny. The experiment had not given a good measure of pupal survival because the pupae had been selected and preconditioned by the low larval rearing temperature. The cool temperature regime did not simulate the sort of day that people generally regard as cool, which would be humid, cloudy, and have a narrow temperature range. The temperature range of 16.7°C is typical of the clear, dry, sunny days found in continental air masses over central and northern New Brunswick during June and July. Such weather is regarded as favorable for spruce budworm survival (Greenbank, Mem. Entomol. Soc. Can. 31: 19-23, 1963). Our observations led us to ask if survival is more effectively reduced when any particular post-diapause stage is exposed to the cool temperature regime with broad amplitude, and if survival is affected by the duration of the treatment.

Spruce budworm larvae were collected from an epidemic field population near Juniper, N.B. by dislodging larvae from excised branches of balsam fir [*Abies balsamea* (L.) Mill.] onto a white sheet. The larvae were in the third to fifth instars, but most were in the fourth. They were immediately transferred to 1 oz. plastic cups with corrugated sides, waxed cardboard covers, and a supply of artificial insect diet (McMorran, Can. Entomol. 97: 58-62, 1965) in the bottom. Five larvae were placed in each cup. Extremely large or small larvae were rejected and larval size bias was avoided