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Occurrence of Insect and Disease Pests on Young-Growth Sitka Spruce and Western Hemlock in Southeastern Alaska

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Abstract

Insects and diseases were surveyed in 16 even-aged, young-growth stands of Sitka spruce *(Picea sitchensis* (Bong.) Carr.) and western hemlock *(Tsuga heterophylla* (Raf.) Sarg.) in southeastern Alaska. Stand ages ranged from 17 to 27 years in nine thinned stands and from 12 to 22 years in seven unthinned stands. All stands appeared healthy. Although some organisms with damage potential were observed, no pests occurred at levels likely to cause damage. Insects recorded on spruce included a *Zeiraphera* sp. shoot moth (the first record of this insect in southeastern Alaska), a *Dioryctria* sp. moth, and a *Pineus* sp. aphid. Fungi that cause spruce diseases included *Lophodermium picea* (needle cast), *Chrysomyxa ledicola* (needle rust), and *Discocainia treleasei* and *Heliotium resinicola* in cankers. Insects on hemlock included *Pseudohylesinus tsugae* bark beetles, which occurred more frequently in thinned stands and on trees larger than 3 inches in diameter at breast height, and the adelgid, *Aldeges tsugae.* Diseases on hemlock included needle rust caused by *Pucciniastrum vaccinii* and dwarf mistletoe *(Arceuthobium tsugense).* Sawflies *(Neodiprion spp.)*, geometrid moths (including *Melanolophia imitata),* blackheaded budworm *(Acleris gloverana),* and the shoot blight fungus, *Sirococcus strobilinus,* appeared on both spruce and hemlock. *Armillaria* sp. occurred in 39 percent of 165 hemlock stumps and 36 percent of 165 spruce stumps following thinning and was more common in hemlock stumps from stands thinned 5-6 years earlier than in those thinned 3-4 years earlier. *Fomes annosus* was found in only 2 percent of the spruce stumps and in no hemlock stumps.

Keywords: Insect surveys, diseases (plant), young-growth stands, Sitka spruce, western hemlock, Alaska (southeast).

Introduction

The mainland and islands of southeastern Alaska extend south from Yakutat to the Canadian border at Portland Canal (fig. 1). The area is heavily forested and contains some of the State's most valuable timber producing lands. Prior to 1953, timber harvest was limited (Harris and Farr 1974), and even now most areas are occupied predominantly by old-growth western hemlock *(Tsuga heterophylla* (Raf.) Sarg.) and Sitka spruce *(Picea sitchensis* (Bong.) Carr.).

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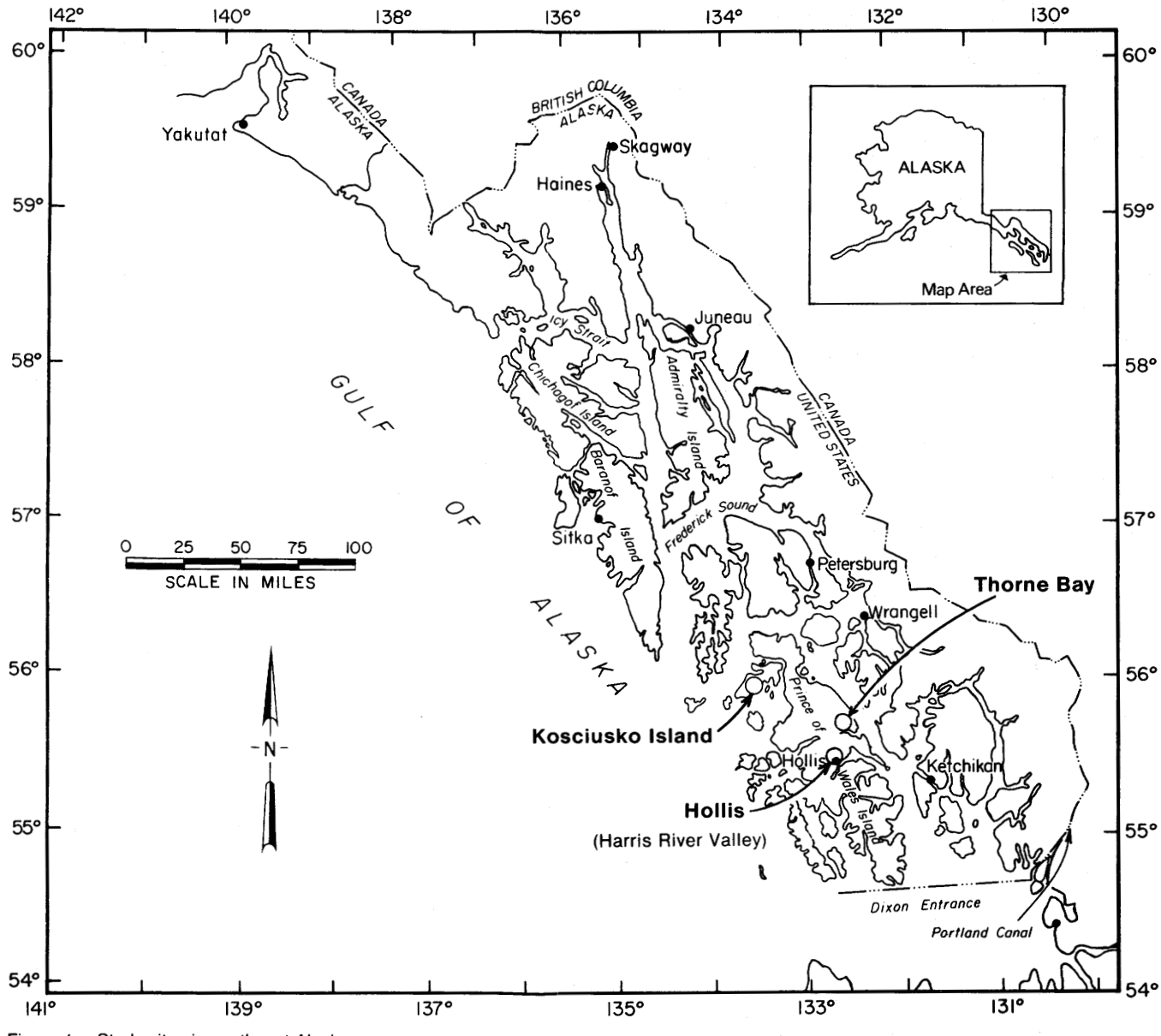

Figure 1.—Study sites in southeast Alaska.

These virgin forests have suffered periodic insect damage through epidemics of blackheaded budworm *(Acleris gloverana* (Wals.) (Lepidoptera: Tortricidae)) and hemlock sawfly *(Neodiprion tsugae* Midd. (Hymenoptera: Diprionidae)) (Hard 1974). The most serious pest-related loss has been wood decay caused primarily by *Fomes pinicola* (Schwartz ex Fr.) Cke. and *F. pini* (Thore) Lloyd in Sitka spruce, and *Armillaria mellea* (Vahl. ex Fr.) Cke., *F. pinicola,* and *F. annosus* (Fr.) Cke. in western hemlock (Farr and others 1976, Kimmy 1956, Laurent 1974). Dwarf mistletoe *(Arceuthobium tsugense* (Rosendall) G. N. Jones) is also common on western hemlock (Laurent 1974) and reduces growth and increases mortality of severely infected old-growth trees.

The relatively recent development of dense, naturally regenerated, even-aged stands over some 250,000 acres of land once occupied by uneven-aged, old-growth forest provides a setting for new pest problems. Stocking density, stem size, tree age, species composition, and stand microclimate differ from that in the old growth. Continued harvest of old growth is enlarging this young forest by 15,000 to 18,000 acres per year (Harris and Farr 1974). Management is intensifying on these lands as foresters initiate planting and thinning programs. This increased financial investment requires that forest managers have adequate knowledge of the occurrence and distribution of insects and diseases, and of the possibilities that damage may result from them.

Except for shoot blight caused by *Sirococcus strobilinus* Preuss, at Thomas Bay (Shaw and others 1981, Wicker and others 1978) foresters have reported no noticeable or serious pest problems in these young stands; however, there has been no ground monitoring of pest populations, nor has there been a thorough cataloging of the pest organisms present.

In this study we cataloged insects and diseases occurring in young stands, determined their relative abundance, and assessed their potential for causing damage.

Methods

Survey Procedures

Three locations with substantial areas occupied by young-growth forest (the Harris River valley and Thorne Bay on Prince of Wales Island, and Kosciusko Island, fig. 1) were sampled during summer 1982. Stands in each area were grouped by aspect, elevation, age, and year of thinning; 16 stands were selected for sampling.

In each stand three plots (5.5 feet wide) were sampled along a single, randomly located transect (fig. 2). The first plot was located a random 1 to 4 chains from the road, and the second and third plots were 2 or 3 chains beyond the origins of the preceding plot. Individual plots were oriented by randomly selecting an azimuth from 0 to 180 degrees when facing away from the road (fig. 2). Plot lengths were determined by extending each plot until six to eight crop trees, including at least two Sitka spruce and two western hemlock, were encountered (fig. 2). Crop trees were defined as those trees that should be left, on the basis of size and spacing, after thinning the stand to 300 stems per acre (12-foot by 12-foot spacing).

All trees over 4.5 feet tall were counted by species to determine stocking density, and crop trees were measured for diameter. Table 1 summarizes stand characteristics. Insects, stem wounds, cankers, distortions, offsets, and other damage were recorded. Leaders were rated as normal, distorted, short, dead, or missing. On hemlock, stem bases were examined for symmetry, indentations, or actual fluting in an attempt to identify incipient fluting (Harris and Farr 1974).

Pest organisms or damage were noted by height in the crown. One branch each from the lower, middle, and upper thirds of the crown was measured to determine the percentage of the branch containing foliage, percentage of green and discolored foliage present, and percentage of "needle cast" on spruce. Any pest organisms observed were also recorded. In addition, 0.5 inch of current, first-year, and second-year foliage at the distal end and midpoint of each branch was examined for organisms and damage. A more general sampling for insects was also conducted three times on each tree by inserting densely foliated branches into a large net and vigorously shaking the branches. Insects found in the net were recorded by species or were collected for later identification.

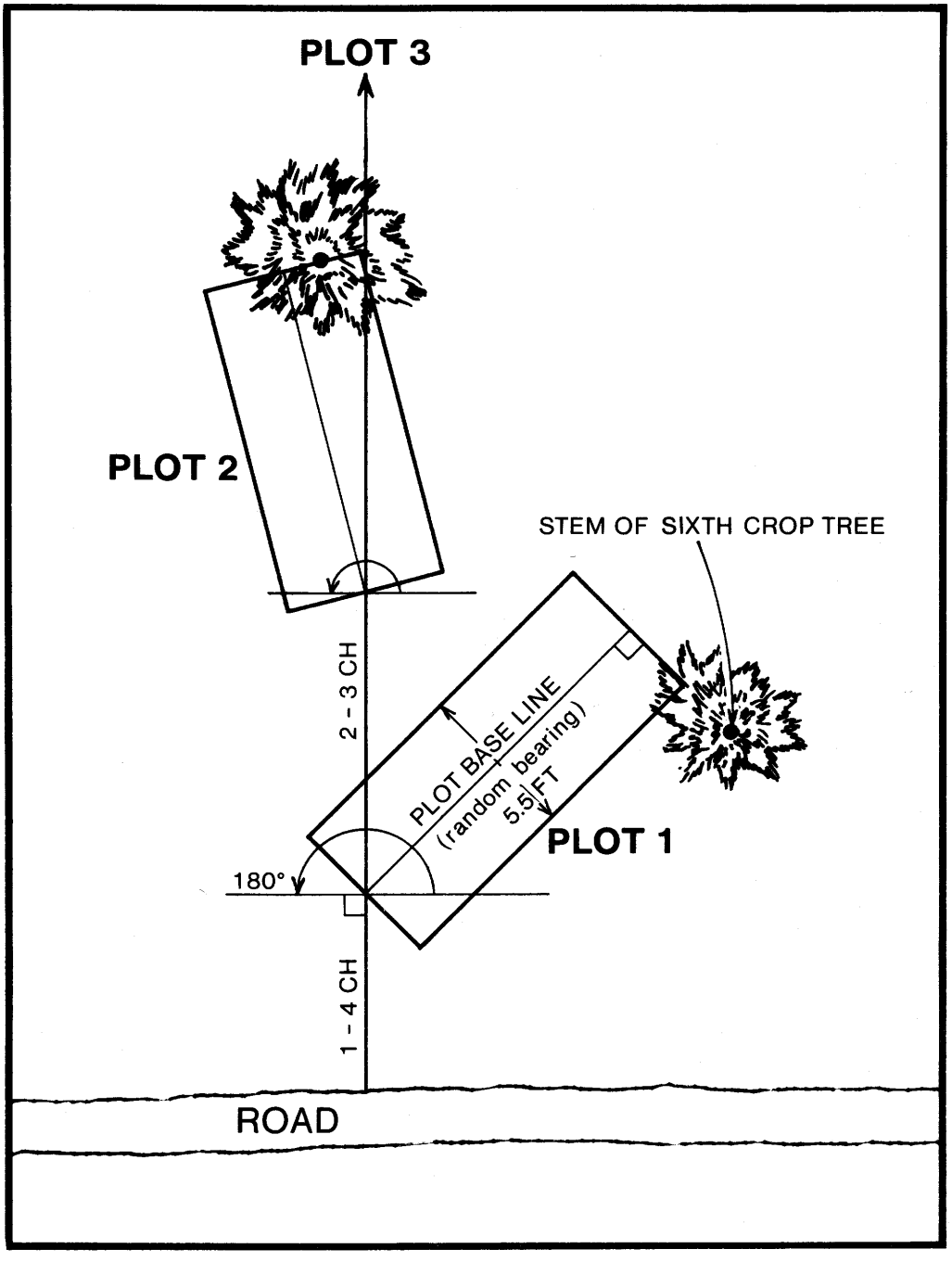

Figure 2.—Design for plot layout (not to scale).

Table 1—Stocking densities and distribution of crop trees in the 7 thinned and 9 unthinned stands sampled[1/]

Tree species	Stand type		Total crop trees
	Unthinned	Thinned	
Western hemlock:			
No. of crop trees sampled	75	84	159
Percent of all crop trees sampled	55	46	49
Stems per acre[2/]	2856±547	404±100	--
Percent of total stocking[2/]	76	53	--
Sitka spruce:			
No. of crop trees sampled	53	95	153
Percent of all crop trees sampled	43	52	49
Stems per acre	800±228	337±113	--
Percent of total stocking	21	44	--
Western redcedar:			
No. of crop trees sampled	3	2	5
Percent of all crop trees sampled	2	1	2
Stems per acre	95±43	26±22	
Percent of total stocking	3	3	--
Total:			
No. of crop trees sampled	136	181	317
Percent of all crop trees sampled	100	100	100
Stems per acre	3752±517	767±172	--
Percent of total stocking	100	100	--

[1/] Stand ages appear in tables 4 and 5.

[2/] Includes all trees over 4.5 feet tall.

Subsampling was done to quantify the occurrence of organisms or of damage that was abundant or of particular interest. For insects on shoots and buds of Sitka spruce, 10 current-year shoots were examined on each sample branch, 5 at the distal end and 5 at midbranch. Numbers of shoots with *Zeiraphera* sp., spider mites, and needle miner damage were counted. The same system was used to record damage from *S. strobilinus* or from other causes on western hemlock branches, except that shoots were used regardless of age. On all trees, the length of each sampled primary branch was measured and cankers counted.

To quantify the occurrence of *Pseudohylesinus tsugae* Swaine bark beetles on hemlock, feeding galleries were counted on 6-inch-long cylinders of stem bark centered at breast height. From this count and from each tree's diameter at breast height (d.b.h.), insect galleries per square foot of bark surface area were calculated. Three neighboring stands at Thorne Bay that had been thinned 1, 2, and 3 years previously were sampled in a separate survey to compare attack patterns in similarly situated stands. Eleven trees in each stand were selected on similar terrain and sampled for attacks by *P. tsugae* by counting old and new galleries on these cylinders of stem bark.

Another separate survey was conducted in stands thinned 3 (or more) years previously to determine levels of colonization by *F. annosus* and *Armillaria* sp. in stumps left after thinning. In each of 11 stands (6 in the Harris River valley, 2 at Thorne Bay, and 3 on Kosciusko Island), 15 western hemlock and 15 Sitka spruce stumps were inspected for *Armillaria* sp. The top 2-4 inches of each stump was cut off and a 0.5- to 1-0-inch-thick disc was removed. These discs were examined microscopically for *F. annosus* as described by Shaw (1981).

Data Analysis

The percentages of trees infected with various insect and disease pests were tallied on a stand basis, and differences in pest occurrence between thinned and unthinned stands were evaluated using the Student's "t" test. The same test was used to examine differences in attack intensity for *P. tsugae* in thinned and unthinned stands, the occurrence of *Zeiraphera* sp. on branches with less than or greater than 75 percent foliage retention or greenness, and the occurrence of *Armillaria* sp. in stumps of different ages left from thinning. The correlation coefficient between tree diameter and attack intensity of *P. tsugae* in thinned stands was also examined. A one-way analysis of variance was used to evaluate differences between stands in the symmetry of the base of hemlock crop trees. In all these analyses, differences were tested for significance at $P < 0.05$.

Results

Although various organisms were encountered (tables 2-8), their occurrence was low and all stands appeared healthy. No pests were found at levels likely to cause damage. As a further indication of health, the branches of both spruce and hemlock retained 85 percent of their foliage of which at least 95 percent was green.

The most notable of the organisms found were *Armillaria* sp. and *F. annosus* in stumps left from thinning; *Zeiraphera* in spruce buds; and *P. tsugae* in hemlock stems. Data obtained on these organisms are treated below; others are described in table 8 with their occurrences noted in tables 4-7.

***Armillaria* sp. and *F. annosus* in thinning stumps.**—*F. annosus* was found in only 2 percent of the spruce stumps examined and in none of the hemlock stumps (table 2). *Armillaria* sp. occurred in 39 percent and 36 percent of the hemlock and spruce stumps, respectively (table 2). Occurrence of *Armillaria* sp. was significantly higher in hemlock stumps from the seven stands thinned 5 to 6 years previously (11 $\pm$ 1 infected stumps per sample) than in those thinned 3 to 4 years previously (3 $\pm$ 1 infected stumps per sample). Levels of colonization by *Armillaria* in spruce stumps did not differ significantly by time since thinning. Spruce stumps from stands thinned 3 to 4 years earlier averaged 4 $\pm$ 1 infected stumps per sample, while stands thinned 5 to 6 years earlier averaged 7 $\pm$ 2 infected stumps per sample.

***Zeiraphera* sp. in spruce buds.**—After mid-June, larvae of *Zeiraphera* sp. *(Lepidoptera: Tortricidae)* were found on current-year spruce shoots at all three locations.[1] On affected buds the cap was webbed and remained in place longer than caps on neighboring, unaffected shoots. Beneath the bud cap, portions of the new needles were eaten and topped with a deposit of frass and webbing. Some feeding occurred further down the developing shoot later in summer, but most larvae evidently left the shoots before pupating. Six larvae from affected shoots were identified as *Zeiraphera* sp.—as was one adult reared from a larva and one reared from a pupa found in a shoot.[2]

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[1] Similar larvae were found in buds of 20-year-old Douglas-fir on Kosciusko Island.

[2] Another adult reared from a larva was identified as *Griselda radicana* Heinrich.

Table 2—Occurrence of *F. annosus* and *Armillaria* sp. in stumps left from thinning

Location	Years since thinning	Number of stands	Number of stumps		Infected by *F. annosus*		Infected by *Armillaria* sp.	
			Hemlock	Spruce	Hemlock	Spruce	Hemlock	Spruce
					Percent			
Hollis	5-6	1	15	15	0	0	67	13
Hollis	3-4	5	75	75	0	1	25	37
Kosciusko	5-6	3	45	45	0	7	75	55
Thorne Bay	3-4	2	30	30	0	2	3	20
Total or mean		11	165	165	0	2	39	36

Table 3—Occurrence of *Pseudohylesinus tsugae* feeding galleries by thinning year in 3 adjacent stands at Thorne Bay[1/]

Years since thinning	Tree d.b.h. (mean)	Galleries	
		New	Old
	Inches	- Number -	
One	3.7±0.3	64	1
Two	2.7±0.3	13	101
Three	3.4±0.3	6	77

1/Galleries counted on a cylinder of stem 0.5 feet long that was centered 4.5 feet above the ground. Eleven trees sampled per stand.

Table 4—Occurrence of pest organisms on hemlock crop trees in thinned stands[1/]

Location	Stand age	Number of trees	Rust	*Sirococcus strobilinus*	Cankers	Dead twigs	Erythraeids	Aphids and adelgids	Geometrids	Sawflies	*Pseudohylesinus tsugae* 2/
Kosciusko	--	8	0	25	25	63	0	0	0	0	--
	17	6	67	67	50	71	0	29	14	71	--
	27	12	58	75	100	100	0	0	0	17	--
Thorne Bay	20	9	78	11	0	33	44	22	0	0	11
	19	11	63	8	9	100	9	18	0	0	91
	20	12	67	17	8	58	0	25	8	0	67
Hollis	20	6	33	17	50	83	17	33	17	0	50
	22	11	37	18	18	36	27	45	18	36	91
	23	8	50	38	0	75	0	0	0	0	63
Mean	21	9	50±8	32±8	29±11	69±8	11±5	19±5	6±3	14±8	62±12

-- = data missing.

1/Data are percentage of trees affected in each stand.

2/Data are only for stands in which both old and new galleries were counted.

Table 5—Occurrence of pest organisms on hemlock crop trees in unthinned stands[1/]

Location	Stand age	Number of trees	Rust	*Sirococcus strobilinus*	Cankers	Dead twigs	Erythraeids	Aphids and adelgids	Geometrids	Sawflies	*Pseudohylesinus tsugae* 2/
Kosciusko	15	9	78	78	0	78	0	0	0	11	--
	18	6	17	33	33	100	0	0	0	17	--
Thorne Bay	15	12	42	8	0	50	0	0	8	0	--
	12	17	35	18	12	88	12	18	0	35	35
Hollis	22	8	75	25	0	63	38	25	0	38	0
	21	13	23	23	31	100	0	0	8	0	15
	22	10	30	10	0	50	0	10	0	30	--
Mean	18	11	43±5	28±9	11±6	76±8	7±5	8±4	2±1	76±8	17±10

-- = missing data.

1/Data are percent of trees affected in each stand.

2/Data are only for stands in which both old and new galleries were counted.

Table 6—Occurrence of pest organisms on spruce crop trees in thinned stands[1/]

Location	Number of trees	Rust	*Sirococcus strobilinus*	Needle cast	Cankers	Dead buds	Dead twigs
Kosciusko	13	0	0	92	62	0	28
	16	6	0	100	31	7	27
	8	0	[2/]0	88	38	25	38
Thorne Bay	10	40	0	90	0	20	10
	9	44	11	100	0	56	11
	8	25	13	88	0	63	0
Hollis	14	71	0	93	38	7	7
	8	50	0	75	25	75	13
	10	40	10	100	40	20	10
Mean	11	31±8	4±2	92±3	26±7	30±9	16±4

	Erythraeids	*Zeiraphera*	Needle miners	Mites on shoots	Aphids	Geometrids	Sawflies
Kosciusko	8	38	0	0	0	0	0
	0	88	0	0	7	7	7
	0	63	0	0	0	0	0
Thorne Bay	30	50	0	0	0	0	20
	11	44	0	0	0	11	0
	38	25	38	50	13	0	13
Hollis	29	36	14	36	0	0	14
	25	63	25	50	13	0	25
	0	40	30	0	0	0	10
Mean	16±5	50±6	12±5	15±8	4±2	2±1	10±3

[1/]Data are percent of trees affected in each stand. Stands are listed in the same sequence as in table 4; stand ages are given there.

[2/]Noted in this stand, but not on sampled trees.

Table 7—Occurrence of pest organisms on spruce crop trees in unthinned stands[1/]

Location	Number of trees	Rust	*Sirococcus strobilinus*	Needle cast	Cankers	Dead buds	Dead twigs
Kosciusko	9	0	22	100	0	0	11
	13	0	0	100	23	8	31
Thorne Bay	7	14	14	86	0	0	14
	5	20	0	100	0	20	40
Hollis	10	0	0	100	10	30	10
	6	17	0	100	[2/]0	33	17
	8	13	0	88	0	0	38
Mean	8	9±3	5±3	96±3	5±3	13±6	23±5

	Erythraeids	*Zeiraphera*	Needle miners	Mites on shoots	Aphids	Geometrids	Sawflies
Kosciusko	0	33	0	0	22	0	0
	0	69	8	0	0	0	8
Thorne Bay	0	43	0	0	0	0	29
	0	20	0	0	0	0	40
Hollis	50	50	50	10	0	0	40
	0	33	0	17	0	0	0
	0	13	0	0	0	0	[2/]0
Mean	7±7	37±7	10±8	4±3	3±3	0	17±7

[1/]Data are percent of trees affected in each stand. Stands are listed in the same sequence as in table 5; stand ages are given there.

[2/]Noted in this stand, but not on sampled trees.

Table 8—Observations on the less common insects and diseases found in young-growth stands[1/]

Host and pest	Remarks
Sitka spruce:	
Spider mites (Acari: Tetranychidae)	Mites inhabited bud surfaces and the bases of nearby needles. The limited webbing contained exuviae and other debris. Infested buds were not obvious to casual observation. Six percent of all sample branches were infested. The intensive subsample yielded 22 infested branches with 42 infested shoots--a mean of 1.9 shoots per 10-shoot sample on infested branches. Although species were not determined, a possible Oligonychus sp. was found in late August.
Needle miners	Microlepidoptera larvae mining needles at shoot tips, or the damage from these larvae, were observed in August and September. Twenty infested branches yielded 27 infested shoots. Five percent of all sample branches were infested.
Dioryctria (Lepidoptera: Pyralidae)	A single specimen of Dioryctria sp., possibly D. reniculelloides Mutuura & Munroe, was collected after it emerged from a bent spruce leader that had been incubated in a rearing cage for 28 days. The 0.75-inch-long larva had hollowed out the top 6 inches of the leader, causing it to shrivel. Although this was the only specimen collected, 10 percent of the spruce crop trees had abnormal leaders (6 slightly distorted, 9 very distorted, and 1 absent, out of 153). Leaders were often difficult to collect without felling the tree, so few of these leaders were examined; some of the distortions may have been caused by such insects.
Lepidoptera in cankers	Larvae were occasionally found in spruce cankers or wounds. Most larvae were damaged beyond recognition in cankers during location, but two were identified simply as Microlepidoptera; a third, reared to an adult, was identified as a Laspeyresia sp. (Lepidoptera: Olethreutidae). Some species in this genus mine in tree bark (Furniss and Carolin 1977).
Zeiraphera sp. in bark (Lepidoptera: Olethreutidae)	Blisters on spruce stems frequently appeared as if they had been bored by insects. Pupae were found in the bark of two crop trees and twice on nonsurvey trees. These four specimens, including one that was reared to an adult, were identified as Zeiraphera sp., probably Z. destitutana Walker.
Needle cast	Most spruce had some needle cast. No differences occurred between thinned and unthinned stands in the percentage of trees affected (see tables 6 and 7). Sampling by crown position showed that branches in the lower crown had 4.0 + 0.7 percent needle cast, those in the midcrown had 0.9 + 0.1 percent, and upper crown branches had 0.2 + 0.04 percent. At each crown level, needle cast was greater in unthinned than in thinned stands, but the difference was significant only for lower crown branches. Lophodermium picea Fuckel is common on spruce in southeastern Alaska (Laurent 1974) and was likely present on many cast needles.
Needle rust	Significantly more trees were infected by Chrysomyxa ledicola Lagerh. in thinned stands (31 percent) than in unthinned stands (9 percent) (see tables 6 and 7). Differences among areas were not analyzed because on Kosciusko Island stands may have been examined too early for detection of rust. Some heavily infected small trees were observed near muskegs--sites likely to contain Labrador tea (Ledum groenlandicum Oeder), which is an alternate host for this rust (Ziller 1974).
Necrotic flecking	This needle symptom (Bega 1978) occurred frequently, but did not appear to cause any damage.
Sitka spruce:	
Cankers	Cankers were found on live and dead branches and on stems. On live trees, cankers were pitchy and eruptant and often had a cleft in the center, parallel to the branch or stem axis. A significantly greater percentage of spruce trees in thinned stands had cankers than did those in unthinned stands (see tables 6 and 7). Thinned stands at Thorne Bay differed strikingly from those in the Harris River valley and on Kosciusko Island in that no cankers were found on spruce at Thorne Bay, but 43 percent and 30 percent, respectively, of the spruce crop trees in thinned stands along the Harris River valley and on Kosciusko Island had cankers. There were 17 stem cankers on the 9 affected crop trees. Branch cankers occurred on 7 percent of the 146 lower crown branches sampled, 10 percent of the 131 middle crown branches, and on none of the 91 upper crown branches. On average, there were 2.4 + 0.5 cankers per infected branch. Cankers were more common close to the stem, regardless of branch length. At least 2 fungi occurred on these cankers: Discocainia treleasei (Sacc.) J. Reid & Funk, a fungus known to cause serious damage on Sitka spruce in Canada (Funk 1981); and Heliotium resinicola Baranyay & Funk, a fungus that occurs on resin (Funk 1981) but apparently has not been tested for pathogenicity. Although not confirmed, black globular fruiting bodies present on small twig cankers from four spruce crop trees appear to be Botryosphaeria picea Funk.
Western hemlock:	
Microlepidoptera	These larvae were found webbed in a few needles on several trees at Thorne Bay and twice in the Harris River valley.
Acantholyda (Hymenoptera: Pamphiliidae)	Webspinning sawfly larvae were collected at least twice.
Cutworms (Lepidoptera: Noctuidae)	At least one larva of Panthea sp. was found.
Cankers	Cankers occurred on both live and dead branches. The most common were sunken and resinous and often encompassed the stub of a twig. Other cankers were resinous but not sunken and tended to occur on small-diameter branches. Only 1 crop tree had a stem canker. Fifteen percent of the 153 lower crown primary branches were cankered, 4 percent of the 150 middle crown branches, and none of the 107 upper crown branches. On average, there were 2.1 cankers per infected branch. Organisms causing these cankers have not been identified, but likely include: Discocainia treleasi, a fungus that occurred on spruce in this survey and also infects hemlock (Funk 1981); and Xenomeris abietis Barr (Funk 1981), a pathogen noted elsewhere on Prince of Wales Island.[2/]

See footnotes at end of table.

Table 8—Observations on the less common insects and diseases found in young-growth stands[1] (continued)

Host and pest	Remarks
Needle rust	Pucciniastrum vaccinii (Wint.) Joerst occurred at low intensity in 15 of 16 stands and infected nearly 50 percent of the trees (see tables 4 and 5).
Dwarf mistletoe	Although hemlock residuals infected with A. tsugense occurred in the surveyed stands, dwarf mistletoe infections were found only twice on branches of young trees, neither of which was on a survey plot.
Fluting	No actual fluting was found; however, the analysis of variance indicated that there was a difference among stands in the basal symmetry of hemlock crop trees. If or how this difference relates to the potential for fluting to develop is unknown.
Sitka spruce and western hemlock:	
Sawflies	Levels of sawfly infestation were similar on spruce and hemlock and in thinned and unthinned stands (see tables 4-7). Sawflies were not recorded by species; however, Neodiprion tsugae (Hymenoptera: Diprionidae) and other Neodiprion sp. occurred on hemlock. A Neodiprion sp. and a possible Pikonema sp. (Hymenoptera: Tenthredinidae) were found on spruce.
Geometrids (Lepidoptera: Geometridae)	The green striped forest looper (Melanolophia imitata Wlk.), which can kill tops and, rarely, whole trees (Holsten 1980), occurred in low numbers (see table 4-7). A Hydriomena sp. and an Anthelia sp. (Columbia brindle looper) were also observed.
Aphids and adelgids (Homoptera: Adelgidae	These insects were recorded together (see table 4-7). A Pineus sp. was found on spruce and the hemlock woolly aphid, Adelges tsugae, on hemlock. Other, unidentified species were also present.
Erythraeids (Acari)	Predatory mites were collected from spruce and hemlock in the beating samples. The percent of trees with mites did not differ significantly between thinned and unthinned stands.
Sthereus sp. (Coleoptera: Curculionidae)	This weevil was found on only 6 hemlock and 8 spruce crop trees, although it is considered common in British Columbia and Alaska.[3]
Blackheaded budworm	Acleris gloverana Wals. (Lepidoptera: Tortricidae) was found only twice on hemlock and once on spruce.
Needle miners	Mined needles were found on 8 hemlock and 2 spruce.
Sirococcus shoot blight	The percent of hemlock trees infected with S. strobilinus did not differ significantly between thinned and unthinned stands (see tables 4 and 5). Even though the fungus occurred in all stands and about 30 percent of the hemlock crop trees were infected, intensity was low. Less than 6 percent of the sampled branches were infected and mean intensity of infection in affected subsamples was 1.7 out of 10 shoots. The fungus also occurred on spruce, in both thinned and unthinned stands, but to a very limited degree (see tables 6 and 7), which confirmed an earlier report that the fungus occurs on spruce in southeastern Alaska, but to a much lesser degree than on hemlock (Wicker and others 1978).
Injuries and distortions	Of the 317 crop trees examined, 15 had stem wounds, and 27 had slight and 4 had serious stem distortions. Of the 155 hemlock leaders observed, there were 5 slightly distorted and 2 dead. On 153 spruce there were 6 slightly distorted leaders, 9 very distorted, and 1 absent.
Western redcedar:	
Leaf blight	Didymascella thujina (Durand) Marie caused considerable browning of foliage on all 5 western redcedar crop trees.

[1] Tables 4-7 summarize occurrence for most of these pests by stand.

[2] Unpublished data (Shaw) on file, Forestry Sciences Laboratory, P.O. Box 909, Juneau, Alaska 99801.

[3] Personal communication, D. Evans, Canadian Forestry Service, Victoria; British Columbia, Canada.

Larvae were found in all 16 stands with no significant differences in occurrence between thinned and unthinned stands; however, there was a greater variation in attack intensity in unthinned stands (tables 5 and 6). Fifteen percent of the 367 samples either had larvae or had damage typical of these larvae; there was an average of 1.7 infected shoots per affected sample of 10 shoots.

Initial observations suggested that larvae were more frequent on vigorous shoots. The percentage of foliage retention and "green color" ratings were examined for correlation with occurrence of larvae or damage. Significantly more branches with over 75 percent foliage retention had attacks than those with less than 75 percent retention, but differences based on "foliage greenness" ratings were not significant—perhaps because only 17 of the 342 branches had less than 75 percent of their foliage classed as green. Buds on branches at all crown levels were attacked with no apparent preference for any crown height.

These collections are the first record of this insect in southeastern Alaska, although *Zeiraphera* sp. have caused serious damage to terminals of Sitka spruce trees in the Queen Charlotte Islands (Silver 1962, Unger and Humphreys 1984). The insect also occurs on white spruce *(Picea glauca* (Moench) Voss) and eastern larch *(Larix laricina* (Du Roi) K. Koch) in south-central and interior Alaska (Holsten and others 1980).

***Pseudohylesinus tsugae* (Coleoptera: Scolytidae) on hemlock.**—Short, vertical galleries, 0.25-0.5 inch long, occurred frequently on stems of western hemlock in thinned stands. Beetles identified as *P. tsugae* were often found in these galleries. In vigorous, live trees a few feeding galleries contained two beetles, but no egg galleries were found. Early in summer, only galleries with a beetle, fresh frass, or fresh clear resin were recognized and counted. Presumably these galleries were made during the current year. Later in summer, galleries with solidified opaque resin, and sometimes a scar scoring the sapwood under the bark, were also recognized. Actual age of these galleries was unclear.

Data on *P. tsugae* in tables 4 and 5 include only those stands in which both old and new galleries were recognized. The percentage of trees attacked was significantly greater in thinned stands than in unthinned stands—consistent with observations in coastal Oregon where *P. tsugae* attacked slash and leave trees after precommercial thinning (McGhehey and Nagel 1969). Our subsampling found from 0 to 47 feeding galleries per square foot of bark surface on the 92 hemlocks on which both old and new galleries were looked for. The number of galleries per square foot of bark surface area was significantly higher on hemlock trees in thinned stands (13) than on those in unthinned stands (0.4).

Feeding galleries of *P. tsugae* were more common on large trees, perhaps because the beetle preferred to enter under a bark flap and small trees had smoother bark. Attack intensity in thinned stands on trees with a d.b.h. of 3 inches or less (5 $\pm$ 2 galleries per square foot) was significantly lower than on trees with d.b.h. greater than 3 inches (21 $\pm$ 3 galleries per square foot). Also, the 0.69 correlation coefficient between total galleries per square foot and tree d.b.h. for the 54 hemlocks in thinned stands was significant.

The ratio of new to old galleries on trees in the separate survey at Thorne Bay suggests that *P. tsugae* breed in thinning slash and feed on residuals the year following thinning with few new feeding attacks occurring in succeeding years (table 3). In the main survey plots, however, there was no significant difference in intensity of new galleries by years since thinning. In two of the three stands thinned the previous year there were no new galleries. Possibly, these stands were thinned too late in the year for adults to lay eggs in the slash and produce attacking broods the following year. If only stands from the main survey that were attacked by *P. tsugae* are examined, then the temporal pattern of attack appears similar to that found in the separate survey.

Discussion

Even though this survey found only minimal pest damage, continued ground monitoring of insect and disease levels in young stands is justified because several organisms capable of causing significant damage were detected. Insects of concern include the blackheaded budworm and hemlock sawfly. The budworm is one of the area's most destructive insects and is of particular concern in young-growth stands (Hard 1974). Low populations of these and other defoliators are typical between outbreaks and their current absence does not imply that young stands are resistant to attack.

Results of this survey showed relatively low levels of stump colonization by *F. annosus* and, thus, confirm previous results (Shaw 1981); however, the potential for damage from this root disease is still of concern because the fungus frequently builds up after thinning (Morrison and Johnson 1978). Since current management plans call for several thousand acres of young-growth forest to be thinned before commercial harvest, sampling for *F. annosus* should continue. The relatively common occupancy of thinning stumps by *Armillaria* sp. also confirms earlier results (Shaw 1981) and emphasizes the need for pathogenicity testing and species determination for Alaska isolates of *Armillaria*.

Results of this survey also confirm previous work suggesting that neither *Sirococcus* shoot blight nor hemlock dwarf mistletoe will cause significant damage in managed young stands (Shaw and others 1981, Shaw 1982). It also appears unlikely that *Zeiraphera* sp. in spruce buds, *P. tsugae* on hemlock stems, or cankers on either spruce or hemlock will cause significant damage. Periodic monitoring, however, would reveal any unexpected population increases by these organisms or by others not observed in this survey.

A pest notable for its absence is the Sitka spruce weevil *(Pissodes strobi* Peck). This weevil has not been recorded in Alaska or the Queen Charlotte Islands, but has caused extensive damage elsewhere in coastal British Columbia, Washington, and Oregon (Hard 1974).

With thinning currently the main form of management in young stands, differences in occurrence of pests and levels of infestation between thinned and unthinned stands are of particular interest. Spacing, species selection, stand age, time of year when thinned, size and shape of thinning units, and time when adjacent units are thinned are all subject to manipulation that could influence development of pest populations. If pest damage were severe on particular stems, then thinning could reduce populations by removing these trees (for example, damaged leaders—such as the one we found killed by a *Dioryctria* sp.). At the low population levels we observed, however, it is unlikely that pests were a factor in many, if any, crop tree selections.

In our survey, comparison of pest levels among the three sampling areas was difficult because differences in time of year when stands were sampled might have affected results. Future surveys should be performed over a shorter time span (consistent from year to year) to allow for comparisons of data among different areas and stand types.

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Metric Equivalents

1 inch = 2.54 centimeters
1 foot = 30.48 centimeters
1 chain (66 feet) = 20.12 meters
1 acre = 0.4047 hectare

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