Report on Forest Pest Conditions
Queen Charlotte Islands, British Columbia, 1999

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Second year of severe defoliation by the western blackheaded budworm in a regenerating western hemlock stand, Moresby Island, B.C.

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INTRODUCTION

A Memorandum of Understanding (MOU) between the British Columbia Ministry of Forests (MoF) and Natural Resources Canada-Canadian Forest Service (CFS) to report on forest health and pest conditions on the Queen Charlotte Islands was initiated in 1991. The required field studies have been funded by the South Moresby Forest Replacement Account (SMFRA). Since 1991, the Forest Health Unit of the CFS (formerly the Forest Insect and Disease Survey - FIDS), has carried out annual aerial and ground surveys of selected forest pests. In 1998, a special research project was initiated in response to expansion of an outbreak of the western blackheaded budworm, *Acleris gloverana*, and associated hemlock sawfly, *Neodiprion tsugae*.

This report includes the results of ground and aerial surveys carried out in 1999 as well as predicted defoliation in selected areas in 2000. Also included are the second year of measurements on study plots designed to estimate the impact of various levels of defoliation on regenerating stands of different stocking densities of western hemlock, *Tsuga heterophylla*.

GENERAL SURVEYS

Surveys focussed on known or potential pest problems. Aerial and ground surveys were carried out by R. Garbutt between August 1st and 9th, 1999 using both rotary and fixed-wing aircraft. Visible defoliation, mainly caused by the blackheaded budworm, was mapped from the air on 1:250,000 scale topographic maps. Ground surveys concentrated on areas on Graham and Moresby Island that were accessible by road. Pests looked for, or found, on these surveys included; the Cooley spruce gall adelgid, *Adelges cooleyi*, the spruce weevil, *Pissodes strobi*, the green spruce aphid, *Elatobium abietinum*, and spruce-Labrador tea rust, *Chrysomyxa ledicola*.

Cooley spruce gall adelgid was found for the 11th consecutive year on plantings of Douglas-fir, *Pseudotsugae menziesii*, near Queen Charlotte City, Juskatla and Sandspit. Neither Douglas-fir nor the Cooley spruce gall adelgid are native to the Queen Charlotte Islands. Sitka spruce, *Picea sitchensis*, is an alternate host for this adelgid, and there is justifiable concern that these exotic plantings of Douglas-fir with their attendant pests could result in infestation of local Sitka spruce.

Surveys on both Graham and Moresby Islands failed to find evidence of the spruce weevil, *P. strobi*, on Sitka spruce. There is concern that this weevil, which is not native to the Islands, could cause significant damage to spruce regeneration as it has in the Kitimat Valley and Prince George areas if it were accidentally introduced to the Queen Charlotte Islands.

Light defoliation by the green spruce aphid, *E. abietinum*, was evident on larger Sitka spruce along the coast and major waterways of eastern Graham Island and the north-east corner of Moresby Island. Light incidences of the spruce-Labrador tea rust, *C. ledicola*, affected the current needles of scattered small Sitka spruce in lowland wet areas between Port Clements and Masset.

BLACKHEADED BUDWORM

The western blackheaded budworm and hemlock sawfly are native insects that periodically cause extensive defoliation of western hemlock (Koot 1991). The current infestation is the third recorded outbreak of these defoliators in as many decades. The blackheaded budworm feeds preferentially on current-year foliage while the sawfly feeds primarily on older foliage. In combination, these insects can totally defoliate trees. Historically, outbreaks have been observed mostly in mature forests. Recent outbreaks, particularly this current infestation, however, have caused dramatic defoliation in young, regenerating stands of western hemlock.

Ground surveys

Ground surveys for the larval and pupal stages of blackheaded budworm and hemlock sawfly were carried out in August 1999. Accessible locations were sampled by beating foliage to collect insects and assess the life stages of the populations prior to aerial surveys. This helped to confirm the identity and relative abundance of the insect species causing the defoliation mapped during aerial surveys. The sampling also served to determine the extent of defoliator populations that were below levels that would be detectable from the air, and helped to assess predictions made from egg samples taken in 1998 (Turnquist et al. 1998).

The ground surveys indicated that blackheaded budworm populations were just beginning to pupate and sawfly populations were in their final instar during the first week of August. Thus nearly all of the defoliation had occurred by the time aerial surveys were carried out. The ratio of budworms to sawflies varied, but in all locations the density of blackheaded budworm greatly exceeded (4x to 10x) that of the sawflies. This has been consistent throughout the current outbreak. We conclude that the blackheaded budworm was largely responsible for the defoliation mapped by aerial surveys.

Aerial Surveys

Total area of defoliation mapped by aerial surveys in 1999 was 55 050 ha. This was nearly a 50% increase over the 37 300 ha of defoliation recorded in 1998 (Turnquist et al. 1998). In 1999, there were 37 630 ha of light, 11 220 ha of moderate, and 6200 ha of severe defoliation. This is the fourth consecutive year of recorded defoliation on the Queen Charlotte Islands, with the area of defoliation increasing each year (Table 1). All previously recorded outbreaks of the blackheaded budworm on the Queen Charlotte Islands have collapsed following two to four years of defoliation. Usually the area of defoliation declined in the last years of the outbreak. For example, in the last outbreak (1985-88), defoliation visible from the air was recorded for four consecutive years. The total area defoliated peaked in the second year, then declined for two years before collapsing (Forest Insect and Disease Survey, various, 1973-79; 1985-88)

Table 1. Year, area of defoliation by intensity, and total area defoliated by the blackheaded budworm and hemlock sawflies, Queen Charlotte Islands, 1996-1999.

	1996[1]	1997[2]	1998[3]	1999
Light	8100	15 000	30 760	37 630
Moderate	1180	14 800	4280	11 220
Severe	180	7200	2260	6200
Total	9460	37 000	37 300	55 050

[1]Vallentgoed 1996; [2]Koot 1997; [3]Turnquist et al. 1998

As in the two previous outbreaks, (in the 1970's and 1980's) defoliation in the current outbreak was first noted on the southern portions of the Moresby archipelago, and has progressed northward. When the current outbreak began in 1996, all of the defoliation was recorded on Moresby Island. In 1997 and 1998 defoliation was recorded on both Islands, with the total area on Graham Island increasing each year. In 1999, most defoliation was recorded on Graham Island and the northern portions of the Moresby Archipelago (Fig. 1). The most extensive severe defoliation occurred in regenerating western hemlock near Alliford Bay. This was the second

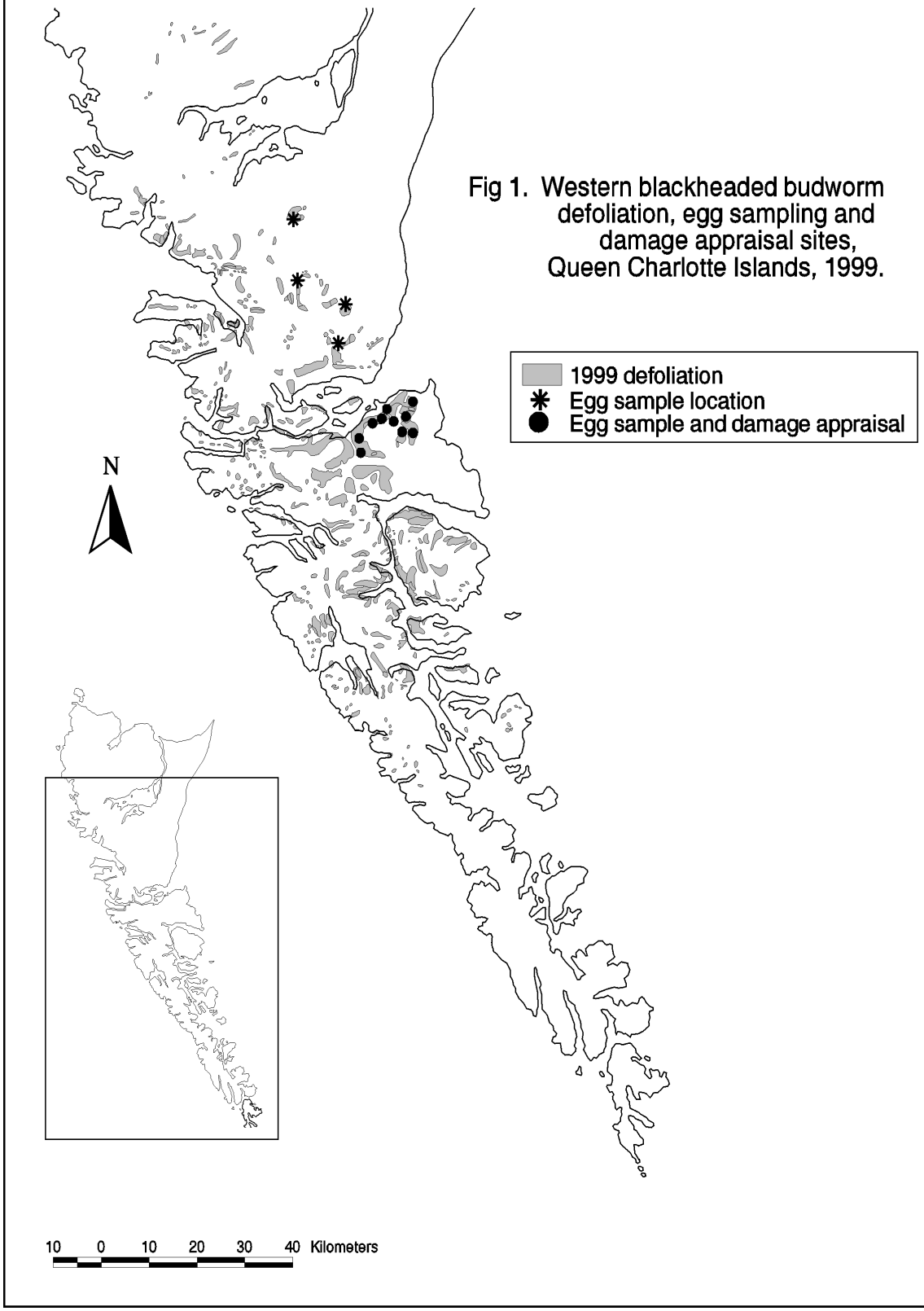


Fig 1. Western blackheaded budworm defoliation, egg sampling and damage appraisal sites, Queen Charlotte Islands, 1999.

consecutive year that severe defoliation was recorded in juvenile stands in the Alliford Bay area. In addition, patches of defoliation were far more numerous and severe in the south central and western areas of Graham Island, particularly in the Honna River and Rennel Sound areas, as well as in previously uninfested areas north of Masset Inlet in 1999.

Defoliation in regenerating western hemlock

In 1998 a project was initiated to examine the impact of defoliation on regenerating western hemlock. Ten sites consisting of five plots/site with 10 trees/plot for a total of 50 trees/site were established in 15-25 year old stands of regenerating hemlock near Alliford Bay on Moresby Island (Turnquist et al. 1998). In 1999, these plots were re-measured, with defoliation estimates by crown thirds, and length of top stripping again recorded. Egg samples were also collected in the same manner as in 1998. Defoliation and egg populations also were estimated at four additional locations on Graham Island in 1999.

Defoliation in 1999 resulted in an increase in the overall level of cumulative defoliation in the 10 Moresby Island study sites (Table 2 and Fig. 2). Much of the cumulative defoliation occurred in the mid and lower crown levels (Table 2). The overall pattern was that defoliation in the first year of an infestation is confined largely to the upper portions of the live crown, while in the second year, the entire tree may be defoliated.

Table 2. Stand location, opening number, and treatment, and cumulative mean % defoliation, by whole tree and crown thirds, caused by blackheaded budworm, Queen Charlotte Islands, 1999.

			Cumulative mean % defoliation[1]							
Stand			Whole tree		Upper crown		Middle crown		Lower crown	
Location	Opening No.	Treatment	1998	1999	1998	1999	1998	1999	1998	1999
Alliford Bay	J1185	Spaced	75	87	98	92	84	94	44	74
	J1105	Spaced	62	71	85	81	71	78	31	54
	J1065	Spaced	58	94	82	96	70	98	23	89
	57-B	Spaced	26	29	41	50	26	29	9	9
	J1108	Spaced	13	47	18	70	15	52	5	20
	J1137/1054		59	73	82	88	66	88	27	44
	J1041		17	60	20	89	15	70	10	22
	J1107		7	19	12	32	7	19	1	8
	J1109		37	47	59	72	43	55	10	13
	57-A		23	29	38	43	23	34	7	10
King Cr	-	Spaced	0	17	0	26	0	19	0	7
Phantom Cr	-	Spaced	0	28	0	45	0	38	0	9
Survey Cr	-		0	20	-	-	-	-	-	-
Skowkona Cr	-	Spaced	0	60	-	-	-	-	-	-

[1]Alliford Bay sites based on 50 trees/site, others based on 10 trees/site

There was an increase in the percent of trees with their tops stripped at seven of the ten Moresby Island sites. Both the mean length of top stripping and the proportion of the crown totally defoliated increased or remained unchanged at all sites in 1999 (Table 3, Fig. 3). What little recovery of tops that were defoliated completely in 1998, as observed in 1999, was more than offset by the increase in frequency of trees with totally defoliated tops.

In 1998, the most severe defoliation was associated with spaced stands. After two consecutive years of defoliation, the overall mean percent defoliation and mean proportion of stripped tops continues to be greater in spaced stands than in unspaced stands. The difference in intensity of defoliation between spaced and unspaced stands, however, decreased in 1999 as all study sites in the area suffered significant damage.

Table 3. Stand number, treatment, average (1998) tree height, percent of trees with stripped top, mean length of top stripping, and mean proportion of stripped top, caused by blackheaded budworm, at ten damage appraisal sites, Moresby Island, Queen Charlotte Islands, 1998 and 1999.

Stand		Ave. tree height (m)[1]	Percent of trees with stripped top		Mean length (m) of top-stripping		Mean proportion of 100% stripped top	
Opening No.	Treatment	(1998)	1998	1999	1998	1999	1998	1999
J1185	Spaced	11.4	90	70	4.5	4.5	0.4	0.4
J1105	Spaced	6.8	44	56	1.5	1.6	0.2	0.2
J1065	Spaced	7.2	30	88	1	5.6	0.1	0.8
57-B	Spaced	7.5	4	10	0.1	0.2	0.01	0.03
J1108	Spaced	7.9	0	14	0	0.5	0	0.1
J1137/1054		8.7	40	66	1.8	3.2	0.2	0.4
J1041		6	0	80	0	2.6	0	0.4
J1107		6.8	0	0	0	0	0	0
J1109		6.7	0	8	0	0.3	0	0.02
57-A		6.5	0	0	0	0	0	0

[1] All observations in table 3 are based on 50 trees/site.

Although no mortality or top-kill has been observed yet at the study sites as a result of defoliation from this current outbreak, all areas will bear close attention following the collapse of this infestation. Most studies of the impact of blackheaded budworm were concerned with mature trees. Because complete defoliation of larger trees is uncommon, mortality in mature stands has not been great although losses to increment growth are apparent (Turnquist et al. 1998). One previous study that compares with the current focus on juvenile stands was carried out on Kwaikans Island in Masset Inlet. In 1974, severe defoliation (95%) was recorded in a 20-year-old stand. A 100 tree plot was established to track mortality and this site was revisited for four consecutive years, 1976-1979. By 1976, 27% of the plot trees had died, and by 1977, mortality more than doubled to 62 %. At final measurement in 1979, 67% of the trees were dead and top-kill was recorded on 30% of the remaining trees. (Forest Insect and Disease Survey, various, 1973-1979, 1985-1988)

Several of the current study sites have suffered comparable levels of overall defoliation (Table 2 and Fig. 2) as well as having significant proportions of their live crowns 100% defoliated (Table 3, Fig. 3). If impact of the blackheaded budworm in the Alliford Bay stands follows the pattern that occurred earlier on Kwaikans Island, we expect significant losses of regenerating hemlock, possibly beginning as soon as 2000.

Fig. 2. Cumulative mean % whole-tree defoliation, 1998 and 1999, caused by blackheaded budworm, at ten damage appraisal sites, Moresby Island, Queen Charlotte Islands

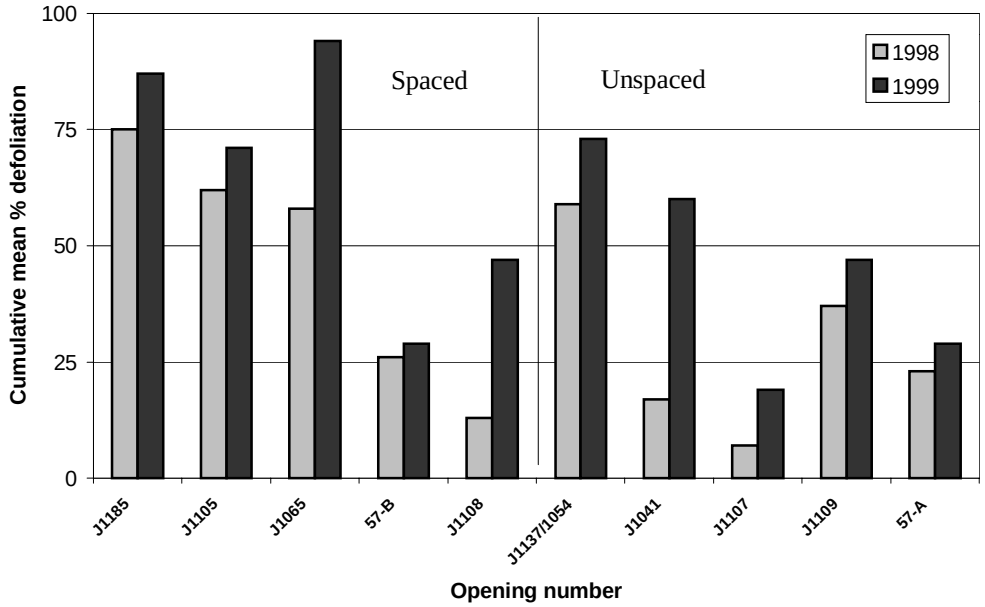
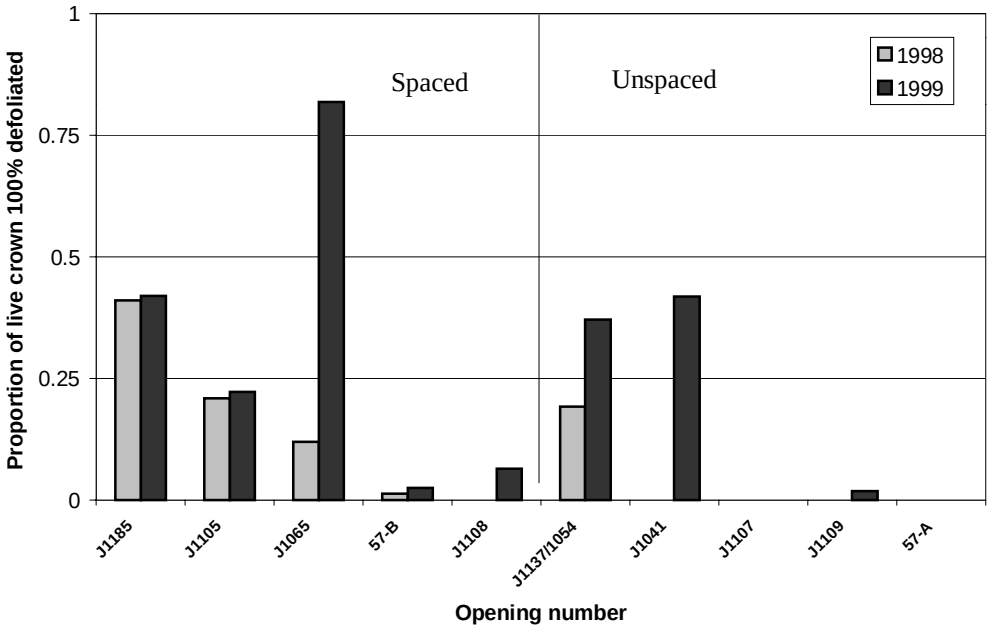


Fig. 3. Proportion of live crown 100% defoliated by blackheaded budworm, 1998 and 1999, at ten damage appraisal sites, Moresby Island, Queen Charlotte Islands



Egg sampling and defoliation predictions

The number of blackheaded budworm eggs per 45 cm branch tip estimated in the autumn has been used to forecast defoliation in the subsequent year (Forest Insect and Disease Survey, General Instructions Manual, 1984 Revision). The relationship between defoliation and egg densities (footnote in Table 4) was originally calibrated for mature trees. In order to check the accuracy of these categories in juvenile stands, all sites where egg samples were collected in 1998 were examined for defoliation in 1999 and defoliation levels were compared to predictions from 1998 egg samples (Table 4). The difference between predicted and actual defoliation recorded during ground surveys suggests that predictions developed for mature stands may slightly overestimate expected damage in juvenile stands. This may be due, in part, to the fact that damage in the juvenile stands was already substantial in 1998 and so cumulative defoliation measured in 1999 was even greater. The difference may also relate to age and spacing of juvenile stands.

Table 4. Site location, opening number, average number of eggs/45 cm branch in 1998, predicted 1999 defoliation class and observed 1999 defoliation class and percent defoliation caused by the blackheaded budworm, Queen Charlotte Islands, 1999.

Site		1998 Ave No. eggs/45 cm branch	Predicted 1999 defoliation class[1]	Observed in 1999	
				defoliation class[2]	percentage defoliation[3]
Location	Opening No.				
Alliford Bay	J1185	15	L	L	12
	J1105	87	S	L	9
	J1065	243	S	M	36
	57-B	44	M	L	4
	J1108	43	M	M	30
	J1137/1054	19	L	L	16
	J1041	29	M	M	43
	J1107	17	L	L	12
	J1109	51	M	L	10
	57-A	12	L	L	6
King Cr.	-	37	M	L	17
Phantom Cr.	-	65	M	L	28
Skowkona Cr.	-	82	S	M	60
Survey Cr.	-	62	M	L	20

[1] From CFS Data:
1-26 eggs = predicted light defoliation
27-59 eggs = predicted moderate defoliation
60+ eggs = predicted severe defoliation

[2] From CFS Data;
1-25% = light defoliation
26-65% = moderate defoliation
66%+ = severe defoliation

[3] Percentage defoliation in 1999 is difference between cumulative observed in 1999 and in 1998 (Table 2).

In 1999, egg samples were again taken at the 10 Alliford Bay sites as well as the four locations on Graham Island, to estimate potential defoliation for 2000. These samples were originally collected in early October but at that time numerous adult blackheaded budworm were still active in all sample areas. All sites were re-sampled in early November once all egg laying was completed. The results of egg sampling are presented in Table 5.

Table 5. Stand location, opening number, average number of eggs/45 cm branch in 1999, and predicted 2000 defoliation by the blackheaded budworm, Queen Charlotte Islands, 1999.

Stand		Average No. eggs/45 cm	Predicted 2000
Location	Opening No.	branch 1999	defoliation
Alliford Bay	J1185	7	L
	J1105	78	S
	J1065	39	M
	Block 57-B	22	L
	J1108	53	M
	J1137/1054	3	N
	J1041	51	M
	J1107	24	L
	J1109	35	M
	Block 57-A	4	L
King Cr.	-	269	S
Phantom Cr.	-	146	S
Skowkona Cr.	-	243	S
Survey Cr.	-	75	S

Considering the results of Table 4, estimates of egg density in 1999 (Table 5) indicate that defoliation will continue at all Alliford Bay sites, but will be in the light to moderate range. Sites on Graham Island, however, are expected to experience severe defoliation in 2000. This current outbreak offers an opportunity to revise thresholds for juvenile stands allowing for previous defoliation.

The estimates of egg densities recorded in 1998 and 1999 are the first available estimates for juvenile stands and are among the highest densities recorded on western hemlock on the Queen Charlotte Islands. In 1998, at opening number J1065 for example, an average of 243 eggs per 45-cm branch tip was recorded, with two branch tips having 560 and 746 eggs. In 1999, this site suffered the most damage and also had the greatest mean stripped top length. (Table 3, Figs. 2 and 3). This site also experienced the greatest increase, between 1998 and 1999 in all damage categories. Based on the 1998/1999 experience, very high numbers of eggs in young stands leads to severe damage, regardless of previous year's defoliation levels.

Damage to associated conifers

In 1999, significant damage caused by the blackheaded budworm was observed on Sitka spruce associated with severely defoliated western hemlock at the Alliford Bay study sites. In many cases, all the current growth on Sitka spruce was destroyed. This phenomenon was reported in 1986 in the Honna River drainage, with up to 2m of top-stripping of Sitka spruce recorded. Subsequent reports from this area do not mention either further damage or recovery. The ability of Sitka spruce to recover from these levels of damage will be an important aspect in subsequent assessments following this outbreak.

Plans for 2000

We propose to measure defoliation and tree mortality at each of the 14 study sites in 2000. To complete this study, we anticipate annual remeasurements of plot trees until the current infestation collapses, and mortality is complete. In addition to maintaining a unique longitudinal relationship between severity of defoliation and mortality of regenerating western hemlock, annual remeasurement allow us to address several specific points including:

- Behaviour of defoliator populations in advanced regeneration compared to known behaviour in mature stands
- Relative susceptibility and vulnerability of spaced and unspaced stands (hazard rating)
- Estimation of damage thresholds in juvenile stands
- Capability of egg surveys to forecast these damage levels
- Estimating collateral damage to associated conifers

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