Report on Forest Pest Conditions

Queen Charlotte Islands, British Columbia, 2000

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South Moresby Forest Replacement Account (SMRFA)

Eggs of the western blackheaded budworm on western hemlock foliage. These eggs are used to forecast defoliation.

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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 2000 as well as predicted defoliation in selected areas in 2001. Also included are the third 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, 2000. Visible defoliation, caused mainly by the western 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. In addition to the blackheaded budworm and hemlock sawfly, pests of particular interest during the surveys included; the Cooley spruce gall adelgid, *Adelges cooleyi*, the spruce weevil, *Pissodes strobi*, and the green spruce aphid, *Elatobium abietinum*.

Cooley spruce gall adelgid was found for the 11th consecutive year on Douglas-fir, *Pseudotsugae menziesii*, near Queen Charlotte City. Douglas-fir was first introduced to the Islands about 30 years ago when trees were brought in from southern B.C. and planted near Queen Charlotte City. There have been subsequent plantings near Sandspit and Port Clements. Sitka spruce, *Picea sitchensis*, is one of the alternate hosts for the Cooley spruce gall adelgid and it is on the spruce host that the adelgid forms typical galls on the new growing tips of spruce branches. These galls kill the branch tips and can stunt and deform trees. The adelgid was first confirmed on the exotic Douglas-fir plantings near Queen Charlotte City in 1990, and near Sandspit in 1991. Galls were found for the first time on adjacent spruce near Sandspit from 1991 to 1993. The Douglas-fir were removed form the area in 1992-93 and surveys in subsequent years found no evidence of galls on adjacent spruce. To date, there has been no record of these galls on spruce elsewhere on the Islands where Douglas-fir has been planted. The disappearance of galls from spruce in the Sandspit area following the removal of the alternate host, Douglas-fir, confirms the potential effectiveness of this type of corrective treatment. The potential spread of Cooley spruce gall adelgid to Sitka spruce on the Queen Charlotte Islands will continue as long as Douglas-fir remains on the Islands.

Surveys on both Graham and Moresby Islands failed to find evidence of the spruce weevil, *Pissodes strobi,* on Sitka spruce. This insect has caused significant damage to spruce regeneration in the Kitimat Valley and Prince George areas, and could cause similar damage in the Islands if it were accidentally introduced.

Light defoliation by the green spruce aphid, *E. abietinum*, was again evident on larger Sitka spruce along the coast and major waterways of eastern Graham Island and the north-east corner of Moresby Island.

INSECT DEFOLIATORS

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 on the Queen Charlotte Islands. The blackheaded budworm feeds preferentially on current-year foliage, but when numerous , will feed on older foliage (Koot, 1991). The sawfly is primarily a feeder on older foliage. In combination, these insects can totally defoliate trees in one year. Historically, outbreaks have been observed mostly in mature forests. Recent outbreaks, particularly this current infestation, have caused dramatic defoliation in juvenile stands of western hemlock.

Ground surveys

Ground surveys for the larval and pupal stages of blackheaded budworm and hemlock sawfly were carried out in early August. Insect populations were sampled using the standard three-tree beating method. Key information on insect development was used to determine the optimal time for aerial surveys. Tree beatings also helped to confirm the identity and relative abundance of the two insect species causing the defoliation mapped during aerial surveys.

Ground surveys during the first week of August indicated that blackheaded budworm populations were just beginning to pupate and sawfly populations were in their final instar. Thus nearly all of the defoliation had occurred by the time aerial surveys were conducted. The ratio of budworms to sawflies varied, but in nearly all locations the density of blackheaded budworm larvae greatly exceeded (4x to 10x) that of the sawfly. This has been consistent throughout the current outbreak and is one of the aspects that differentiates it from the last outbreak, in which, as the infestation neared its conclusion, sawfly populations greatly outnumbered those of the budworm. We conclude that, in the year 2000, the blackheaded budworm was largely responsible for the defoliation mapped during the aerial surveys.

Aerial Surveys

Total area of defoliation mapped during aerial surveys in 2000 was 31 400 ha: 9475 ha of severe, 7120 ha of moderate, and 14 800 ha of light defoliation. This is a 40% decrease in the total area defoliated from the 55 050 ha of defoliation recorded in 1999 (Turnquist et al. 1999). However, this is the largest area of severe defoliation recorded since the current outbreak began in 1996 (Table 1). Most of this severe defoliation occurred in young regenerating hemlock stands. This was the fifth consecutive year of recorded defoliation on the Queen Charlotte Islands, and the first year of decline (Table 1). All previously recorded outbreaks of the blackheaded budworm on the Queen Charlotte Islands have collapsed following two to four years of defoliation.

Table 1. Year, area of defoliation by intensity, and total area defoliated by the blackheaded budworm and hemlock sawflies, Queen Charlotte Islands, 1996-2000.

	1996[1]	1997[2]	1998[3]	1999[3]	2000
Light	8100	15 000	30 760	37 630	14 800
Moderate	1180	14 800	4280	11 220	7120
Severe	180	7200	2260	6200	9480
Total	9460	37 000	37 300	55 050	31 400

[1] Vallentgoed, 1996; [2] Koot, 1997; [3] Turnquist et al. 1998, 1999.

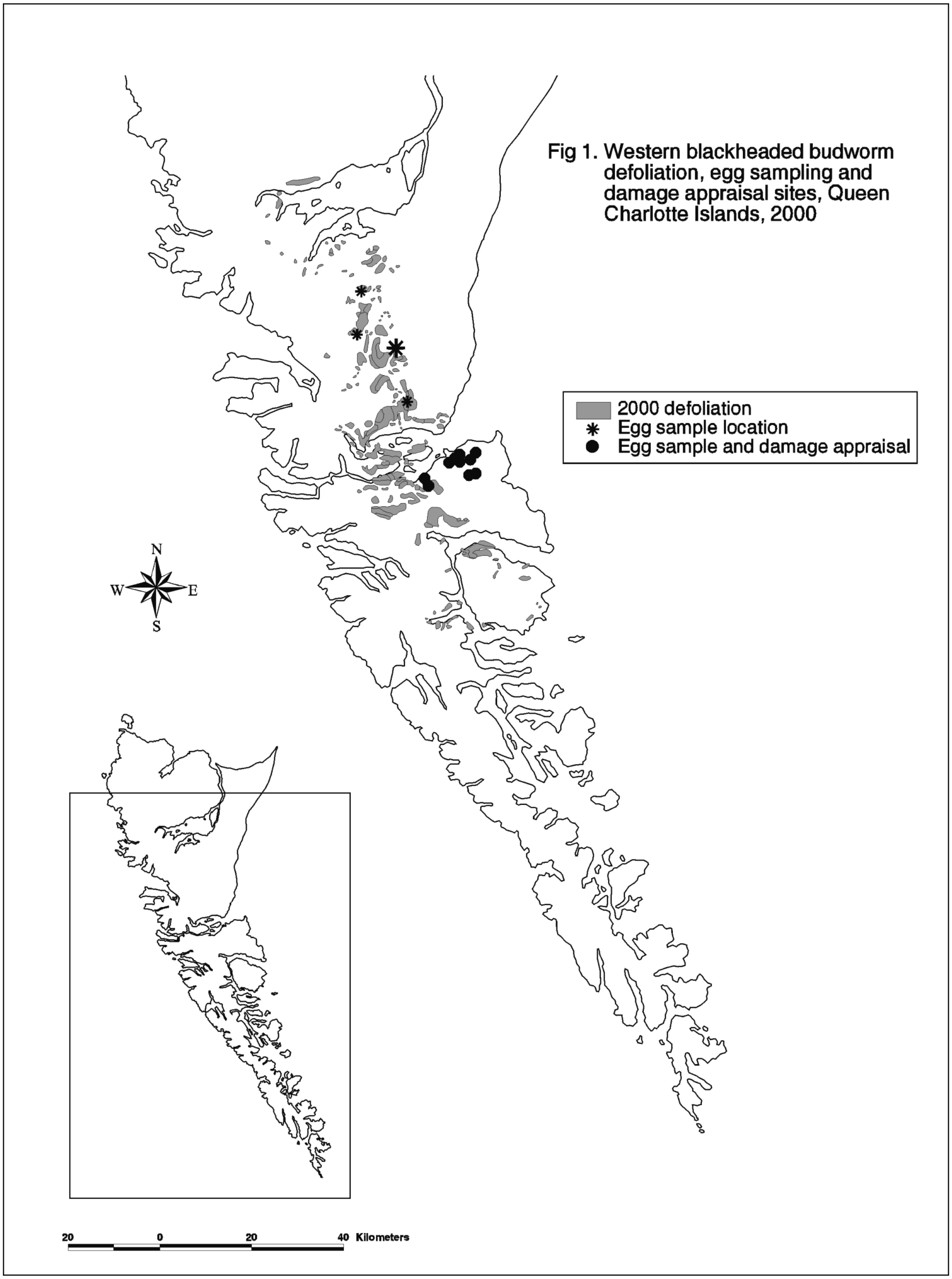


Fig 1. Western blackheaded budworm defoliation, egg sampling and damage appraisal sites, Queen Charlotte Islands, 2000
2000 defoliation
Egg sample location
Egg sample and damage appraisal
N
W
E
S
20
0
20
40 Kilometers

As in the two previous outbreaks, in the 1970 s and 1980 s, defoliation in the current outbreak was first seen on southern Moresby archipelago, and in subsequent years, progressed northward. From 1997 to 2000, defoliation was recorded on both Islands, with the total area on Graham Island increasing each year. In 2000, most defoliation was recorded on Graham Island and the very northern portions of the Moresby Archipelago (Fig. 1). No defoliation was recorded in Gwaii Haanas National Park Reserve/Haida Heritage Site in 2000.

The most extensive severe defoliation occurred in regenerating western hemlock in the central portion of Graham Island between Queen Charlotte City and Juskatla. Mainly severe or moderate defoliation also was recorded from Queen Charlotte City west to Long Inlet, on both sides of Skidegate Channel, on the Kagan Peninsula on Graham Island, and in the Deena River area on northern Moresby Island. Much of this defoliation also occurred in regenerating western hemlock. Only a few, small patches of light and moderate defoliation were recorded in the Sewell Inlet and Louise Island areas in the Moresby Archipelago. No defoliation was recorded north-west of Masset Inlet, or in the Rennel Sound area on Graham Island. No defoliation was recorded in the Alliford Bay area on Moresby Island, where moderate to severe defoliation occurred in regenerating hemlock in 1998 and 1999.

Defoliation and recovery 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 2000, as in 1999, defoliation estimates by crown thirds, and length of top stripping were recorded. The heights of a subsample of 10 trees per site were re-measured. Branch samples to estimate egg densities were also collected as in 1998 and1999. Finally, defoliation and egg populations were again estimated at four locations on Graham Island where populations and damage have been observed since 1998.

Blackheaded budworm populations collapsed in 2000 at the ten damage appraisal sites on Moresby Island. The cumulative mean percent defoliation was reduced from the maximum observed in 1999 for all sites at each crown level (Table 2, Fig. 2). This indicates a net recovery of foliage during the 2000 season. Nonetheless, stripped tops (100% defoliated) were observed again in 8 of the 10 sites in 2000 (Table 3) so recovery was not uniform throughout the crown. The mean proportion (ratio of 100% defoliated top to tree height) of the crowns totally denuded declined from 1999 (Fig. 3) but the failure of these stripped tops to recover at least 1 full-year s growth following a decline in the budworm population is indicative of the vulnerability of these trees to severe and repeated defoliation. The apparent trend of greater overall damage to trees in spaced stands that has been noted in earlier reports (Turnquist *et al.* 1998, 1999) persisted in 2000 (Tables 2, 3; Figs. 2, 3).

Cumulative mean percentage of defoliation increased at each of the sites at Phantom, King, Skowkona, and Survey creeks on Graham Island, indicating continued high budworm populations in these areas in 2000. Where observations were made by crown thirds, defoliation was most severe in the upper crown (Table 2).

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, 1998-2000.

Stand			Cumulative mean % defoliation[1]											
			Whole tree			Upper Crown			Middle crown			Lower crown		
Location	Opening No.	Treatment	1998	1999	2000	1998	1999	2000	1998	1999	2000	1998	1999	2000
Alliford Bay	J1185	Spaced	75	87	72	98	92	83	84	94	76	44	74	57
	J1105	Spaced	62	71	56	85	81	73	71	78	59	31	54	35
	J1065	Spaced	58	94	91	82	96	93	70	98	93	23	89	89
	57-B	Spaced	26	29	26	41	50	46	26	29	24	9	9	7
	J1108	Spaced	13	47	30	18	70	48	15	52	33	5	20	10
	J1137/1054	None	59	73	61	82	88	79	66	88	71	27	44	34
	J1041	None	17	60	54	20	89	80	15	70	61	10	22	21
	J1107	None	7	19	8	12	32	16	7	19	6	1	8	1
	J1109	None	37	47	37	59	72	57	43	55	41	10	13	14
	57-A	None	23	29	18	38	43	28	23	34	20	7	10	4
Phantom Cr.	-	Spaced	0	28	54	0	45	80	0	38	59	0	9	21
King Cr.	-	Spaced	0	17	83	0	26	97	0	19	90	0	7	63
Skowkona Cr.	-	Spaced	0	60	65	-	-	-	-	-	-	-	-	-
Survey Cr	-	None	0	20	35	-	-	-	-	-	-	-	-	-

[1] Alliford Bay site based on 50 trees/site, Phantom Cr. based on 59 trees, all others based on 10 trees/site.

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, 1998-2000.

Stand		Avg. 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	2000	1998	1999	2000	1998	1999	2000
J1185	Spaced	11.4	90	70	72	4.5	4.5	2.5	0.4	0.4	0.2
J1105	Spaced	6.8	44	56	46	1.5	1.6	0.8	0.2	0.2	0.1
J1065	Spaced	7.2	30	88	82	1.0	5.6	4.3	0.1	0.8	0.6
57-B	Spaced	7.5	4	10	10	0.1	0.2	0.2	0.01	0.03	0.02
J1108	Spaced	7.9	0	14	6	0	0.5	0.1	0	0.1	0.01
J1137/1054	None	8.7	40	66	50	1.8	3.2	1.4	0.2	0.4	0.1
J1041	None	6.0	0	80	40	0	2.6	0.7	0	0.4	0.1
J1107	None	6.8	0	0	0	0	0	0	0	0	0
J1109	None	6.7	0	8	6	0	0.3	0.1	0	0.02	0.01
57-A	None	6.5	0	0	0	0	0	0	0	0	0

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

Fig. 2. Cumulative mean % whole-tree defoliation, 1998, 19 caused by blackheaded budworm, at ten damage appraisal si Island, Queen Charlotte Islands

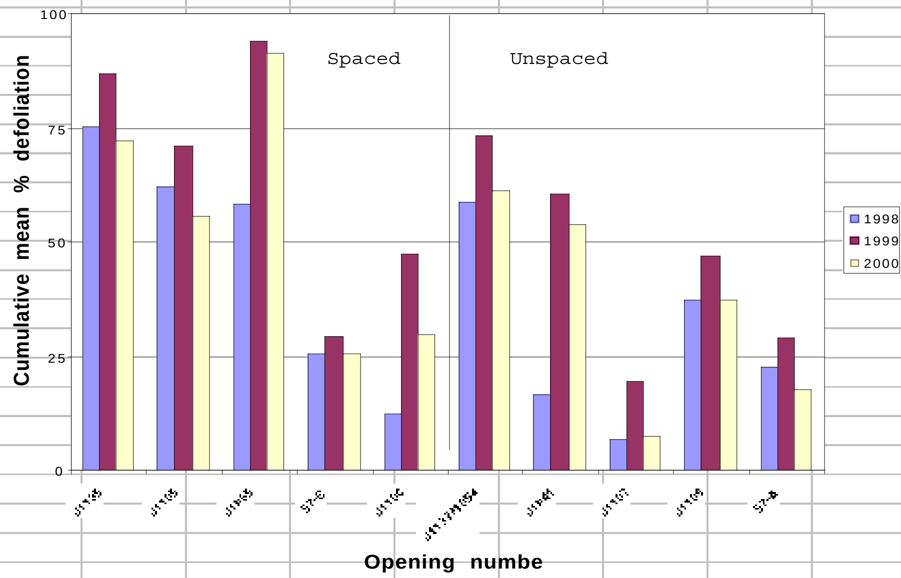
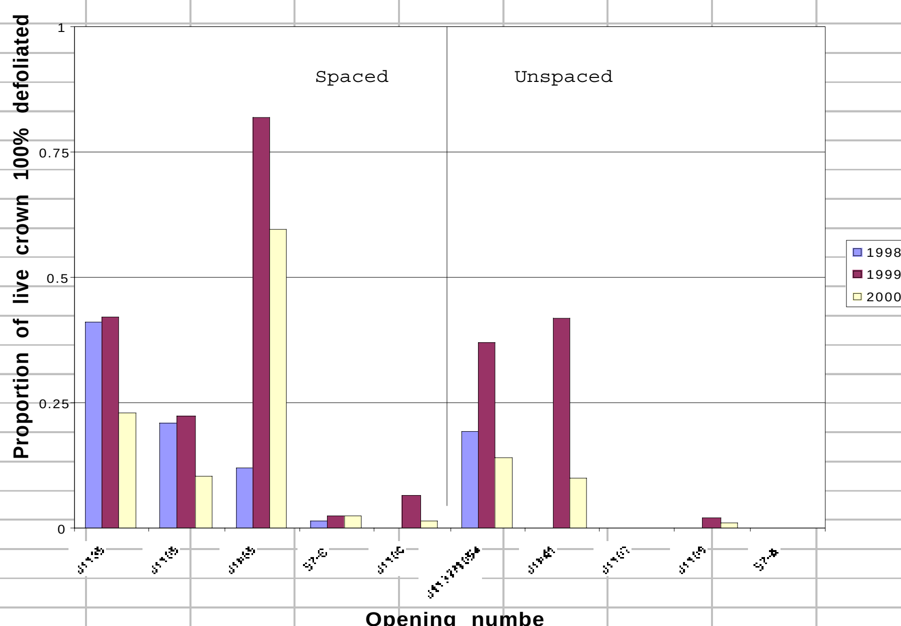


Fig. 3. Proportion of live crown 100% defoliated by blackhead 1998, 1999, and 2000, at ten damage appraisal plots, Moresby Charlotte Islands.



IMPACT

Mortality and top kill

This is the first year that evidence of tree mortality has been observed at any of the ten study sites in the Alliford Bay area. At one site, opening J1065 near Macmillan Creek, 26 % of the sample trees were recorded as 100 % stripped of foliage in 2000. If there is no recovery in 2001, these trees may be considered dead. An additional 40 % percent of the trees had 40-90 % of their total crown area stripped of foliage, with the remaining foliage largely confined to the lower few branch whorls. The ability of these trees to survive this level of cumulative defoliation is in doubt. This site, which was spaced, had the highest overall mean percent whole tree defoliation, the highest overall percent of trees with top stripping, the greatest mean stripped top length, and the greatest mean proportion of live crown 100 % defoliated in the past two years (Tables 2, 3; Figures 2, 3). Similarly, top stripping at 8 of the 10 sites (Table 3) likely represents at least top kill in these stands.

Height growth

Heights were re-measured at one of each of the five plots (plot 3) at each of the ten study sites in 2000, for a 20 % re-measurement. Average height growth in these plots ranged from 0.1m to 1.3 m. The average proportional height growth, expressed as a percentage of the original tree height, ranged from 1.5 to 22.6 %. Relative height growth appears to be inversely related to levels of previous defoliation, with the lowest observed rates of growth in height in the most severely damaged sites. All tree heights and DBH s will be re-measured at the end of this project and the relationship between height and DBH, relative to defoliation, will be examined.

Damage to associated conifers

In 2000, as in 1999, 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 in 1999. In 2000, many of the leaders on the Sitka spruce appeared to be dead. 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 this damage will be an important aspect in subsequent assessments following this outbreak.

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 1 in Table 4) was originally calibrated for mature trees. One of the objectives of the current study is to examine the veracity of these predicted damage classes in juvenile stands. Accordingly, 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 (Turnquist et al. 1999). Eggs were collected again in 1999 and the sites were then examined in 2000, and defoliation levels were compared to predictions from 1999 egg samples. With two consecutive years of data, it now appears that predicted defoliation based on criteria originally developed for mature stands may overestimate defoliation in juvenile stands.

In 1999, egg samples at the ten Alliford Bay sites indicated generally light to moderate defoliation in 2000 (Turnquist et al. 1999). Aerial surveys in 2000, however, recorded no defoliation in the Alliford Bay area. Predictions of defoliation made from egg samples collected from four sites on Graham Island in 1999 also overestimated actual defoliation in 2000 at three of the four sites (Table 4). It must be noted, however, that when defoliator populations are in decline, egg numbers typically overestimate predicted damage. Planned analysis of all available data from the current and previous outbreaks will permit more rigorous conclusions and should lead to more accurate predictions of defoliation in juvenile stands.

Table 4. Location, average number of eggs/45 cm branch in1999, predicted 2000 defoliation class and observed 2000 defoliation class and percent defoliation caused by the blackheaded budworm, Graham Island, Queen Charlotte Islands, 2000.

Location	1999 Avg. No. eggs/45 cm branch	Predicted 2000 defoliation class[1]	Observed in 2000 defoliation class[2]	Observed in 2000 percentage defoliation[3]
Phantom Cr.	146	S	M	26
King Cr.	269	S	S	67
Skowkona Cr.	243	S	L	5
Survey Cr.	75	S	L	15

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

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

[3] Percent defoliation in 2000 is the difference between cumulative defoliation observed in 1999 and in 2000 (Table 2).

In 2000, egg samples were again taken at the ten Alliford Bay sites as well as four locations on Graham Island, to estimate potential defoliation for 2001. These samples were collected in late October to ensure that all moth flight and egg laying activities had ceased prior to branch collection. The results of egg sampling are presented in Table 5. Given these results and the suspicion that predicted damage categories may be too high, it appears that, in the surveyed sites at least, the current outbreak of defoliating insects may be coming to an end. This conclusion must be qualified by noting that all sites sampled in 2000 had previous histories of defoliation. Since damaging levels of blackheaded budworm usually persist in any one location for only one, or at most, two years, we expect that egg samples from these previously-damaged sites indicate declining populations and little damage in 2001. At present we have no information from susceptible but as yet undamaged stands on the Queen Charlotte Islands and so we can not accurately predict the probability of defoliation in new areas in 2001.

Table 5. Stand location, opening number, average number of eggs/45 cm branch in 2000, and predicted 2001 defoliation by the blackhead budworm, Queen Charlotte Islands, 2000.

Stand		Average No. eggs/45 cm branch, 2000	Predicted 2001 defoliation
Location	Opening No.		
Alliford Bay	J1185	<1	N
	J1105	1	N
	J1065	<1	N
	Block 57-B	<1	N
	J1108	<1	N
	J1137/1054	<1	N
	J1041	<1	N
	J1107	<1	N
	J1109	<1	N
	Block 57-A	<1	N
King Cr.	-	24	L
Phantom Cr.	-	1	N
Skowkona Cr.	-	10	L
Survey Cr.	-	19	L

Plans for 2001

We propose to re-assess defoliation, recovery, top kill and tree mortality at all study sites in 2000. In addition to determining the relationship between severity of defoliation and mortality of regenerating western hemlock, annual remeasurements 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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