DETECTION SURVEYS FOR BALSAM WOOLLY APHID, ADELGES PICEAE (RATZ.), IN BRITISH COLUMBIA

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INTRODUCTION

The balsam woolly aphid, *Adelges piceae* (Ratzeburg) (Homoptera: Adelgidae), is an important introduced pest on North American *Abies* species (Harris 1967). Its principal hosts are balsam fir (*Abies balsamea* (Linnaeus) Miller) in the Maritime Provinces and northeastern states, Fraser fir (*Abies fraseri* (Pursh Poiret) in North Carolina and Tennessee, and amabilis fir (*Abies amabilis* (Douglas) Forbes), grand fir (*Abies grandis* (Douglas) Lindley) and alpine fir (*Abies lasiocarpa* (Hooker) Nuttall) from southwestern British Columbia to northern California. In British Columbia amabilis and grand firs are the principal species attacked, the former most seriously; alpine fir, the least resistant to damage, occurs only in a few areas within the infestation boundaries. The aphid was first discovered in British Columbia in 1958 and is now present in the southwest corner of the Province. There are indications, however, that the infestation could spread throughout much of the commercial *Abies* forests in the southern third of the Province (Atkins 1967).

The balsam woolly aphid disperses in the egg and wingless first-instar crawler stage. It must be carried by some agency such as wind or animals to its hosts, where it may become established in the crowns or on the boles of trees. Since the aphid is so small, detection is easiest on trees where large populations have built up on the lower bole (stem attack) (Figure 1), giving a whitish appearance to the bark; smaller populations require careful examination of the branches and stems. The aphid is more difficult to find on the branches, even though its feeding there sometimes causes noticeable swelling or "gouting" at the nodes (Figure 2). Infested trees may die quickly, turning red, or more slowly, with crowns gradually thinning and fading (Figures 3 and 4).

Detection and appraisal of balsam woolly aphid infested *Abies* by the Forest Insect and Disease Survey, Department of Forestry and Rural Development, has been carried on in British Columbia for the past ten years. A reassessment in 1965 of the implications of this problem pointed out a need for an increase in the scope and intensity of the work. As a result, the British Columbia Forest Service Protection Division in 1965 assumed primary responsibility for the detection aspects under the federal department's guidance. In this survey large areas were to be covered to delineate the extent of the infestation as a basis for assessing the magnitude of the damage, the feasibility of eradicating spot infestations, for developing restrictions on log movement, and establishing quarantines on nursery stock.

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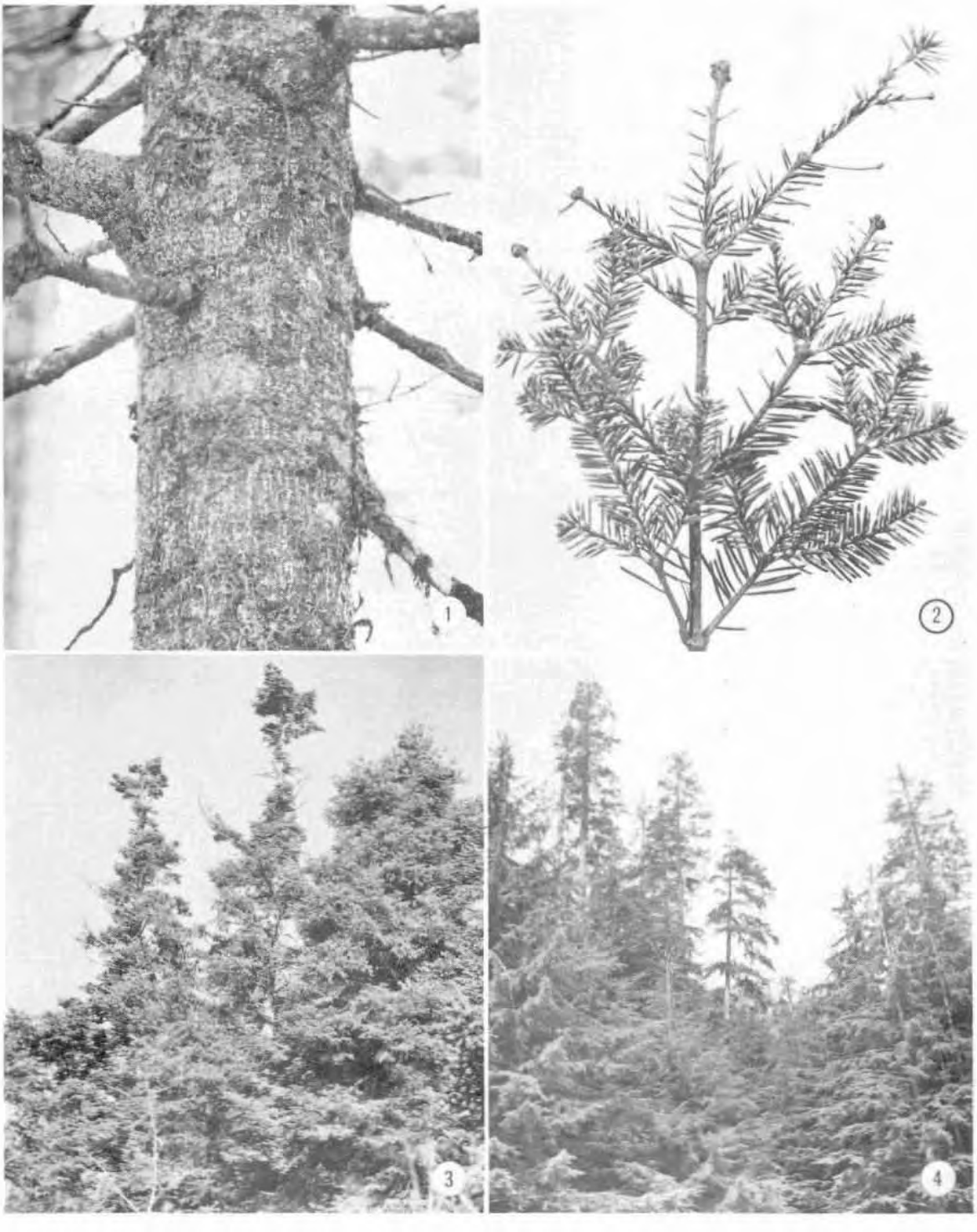


Figures 1-4. Symptoms of balsam woolly aphid attack. Fig. 1. Medium stem attack on grand fir. Each of the thousands of tiny white spots is a woolly aphid. Fig. 2. Amabilis fir branch showing swelling or gouting at the branchlet tips and joints. Fig. 3. Grand fir showing deformed crowns which may be caused by attack. Fig. 4. Amabilis fir showing thin crowns which may result from attack.

It was intended to detect the presence of the insect even at low population levels before the advent of symptoms. Since previous surveys in British Columbia and other regions had been confined to observations of damage, it was necessary to develop more precise diagnostic procedures. This report describes the development of the balsam woolly aphid detection survey in British Columbia.

SURVEY METHODS

Aerial Observations

Detection of the balsam woolly aphid in British Columbia required observations of large forest areas, much of it inaccessible by road. Concern was primarily for detection and not for assessing population numbers. Aerial examination of dying trees and crown damage, followed by ground observations, was believed to be the best way of achieving maximum coverage with limited resources.

Fixed-wing aircraft and small helicopters were used to delineate and assess broadly the extent of the infestations. However, although mortality could be recorded and suspicious areas noted for ground checking, tree damage was not sufficient for positive diagnosis of the aphid from the air.

Aerial spotting of dying trees was effective in amabilis fir stands, particularly in over-mature types, because mortality was often high. Aerial observations were of lesser help in detecting infested grand fir because this species generally showed less damage. Alpine fir, however, turned red quickly after attack and damage could easily be detected from the air. Because this species occurs along much of the currently known fringe of the infestation, aerial observations should become a valuable aid in early detection of the aphid.

Ground Observations

Positive detection of infested areas in spring, summer and fall was achieved principally by searching the lower six feet of stems at convenient locations along road-sides. Rarely was the aphid present in sufficient numbers on the bole to be easily seen. Generally, only small spots of wool on the bark were found, covering aphids which had developed from crawlers drifted down from the crown. Samples of all aphids detected had to be collected and identified in the laboratory to distinguish Adelges piceae from a common morphologically similar, native, non-destructive adelgis, Pineus abietinus Underwood and Balch.

Because the surveys were designed to assess only the geographic distribution of the aphid, positive results from lower bole inspections obviated the need for further search. Where no aphids were found, bole inspections were sometimes supplemented by examinations of tree crowns, particularly in winter when aphids bore little "wool" and were almost

invisible on the bark. Effective branch samples could be more easily obtained and handled by inexperienced collectors than samples of infested bark. Branches were also useful in searching the fringe of known infestations because aphids occurred fairly regularly throughout tree crowns when they were sporadic, rare or absent on boles.

Development of Branch Examination Techniques

Branch samples showed considerable variation in aphid populations within and between trees. In detection surveys at low populations this variation could be important because missing a few aphids on such samples could mean failure to detect the pest entirely at a locality. Knowledge of aphid distribution within the crown was desirable so that the parts most likely to have aphid could be sampled while expending a minimum of effort. Knowledge of the variation might also be useful for future more elaborate studies of aphid populations and their predators.

Early in the study of branch populations, detailed examination of complete branches was found to be very time-consuming. In order to reduce the volume of material handled only 18-inch tips were used. This was believed to be acceptable for detection purposes because the aphid was observed to congregate at the outer nodes of branches. This observation was supported by studies on the aphid in eastern Canada.

It was also found that the volume of branches searched could be reduced by omitting parts of them. Aphids on winter-collected branches, particularly amabilis fir, occurred more frequently at nodes and around male buds than between the nodes, indicating that internodal material might be removed before examination commenced.

Tree species	No. of branches sampled	No. of aphid found	% at nodes and male buds	% on upper side of branches
grand fir	56	2,758	64.0	30.0
amabilis fir	250	849	91.3	84.3

Also, on grand fir, greater numbers of aphid occurred on the lower side of branches than on the upper, suggesting that only the lower side need be searched. This did not apply for amabilis fir, possibly because its needle growth form is more dense on the upper side, providing more appropriate light conditions for aphids at these sites.

To test for crown level variation in aphid numbers, two branches were selected from each of the upper, middle and lower thirds of the crowns of infested grand and amabilis firs. Aphids were found at all crown

levels; the greatest percentage of trees missed, using only branch samples from one of three crown levels, was 38% of those examined (Table 1). Upper and middle crown samples of amabilis fir appeared to reveal aphids more reliably than lower crown level samples, but detection on grand fir was about equally successful at any crown level.

Table 1

Percent infested trees detected using two 18-inch tip branches from different crown levels

Tree Species	No. trees sampled	% infested trees detected		
		Upper level sample only	Middle level sample only	Lower level sample only
grand fir	60	75.0	65.0	76.7
	20	70.0	--[1]	65.0
amabilis fir	29	93.1	93.1	62.0

[1] Not sampled.

The tedious examination of large numbers of branches led to inaccuracies in detection, so mechanization of aphid detection was attempted. Early experiments were ineffective. These involved the soaking of branches in a caustic solution (Condrashoff 1967) or in ethyl alcohol, saturating branches with alcohol fumes or drying them before shaking and filtering.

Aphids were effectively recovered by shaking the branches in hot water. Foliage to be examined was clipped to include only branch nodes, placed in a vessel with boiling water and allowed to cool for about 20 minutes. The vessel was then agitated on a paint shaker for 5 minutes, the water screened through size 20 and 50 mesh sieves to remove as much detritus as possible, and filtered on a Buchner Funnel. The filter papers were examined for aphid under a dissecting microscope.

The major difficulty with the method was the time spent in examining filter papers which filled quickly with bark detritus. Washing entire 18-inch tip samples took slightly longer than direct observations. However, after discarding the internodal parts of the branches, examination times were markedly shorter as shown in the following tabulation.

No. of branch tips	Type of branch	Ave. obs. time/branch (min.) Direct	Wash
90	whole[1]	43.8	48.7
440	without internodes[2]	20.7	4.8

[1] grand fir.

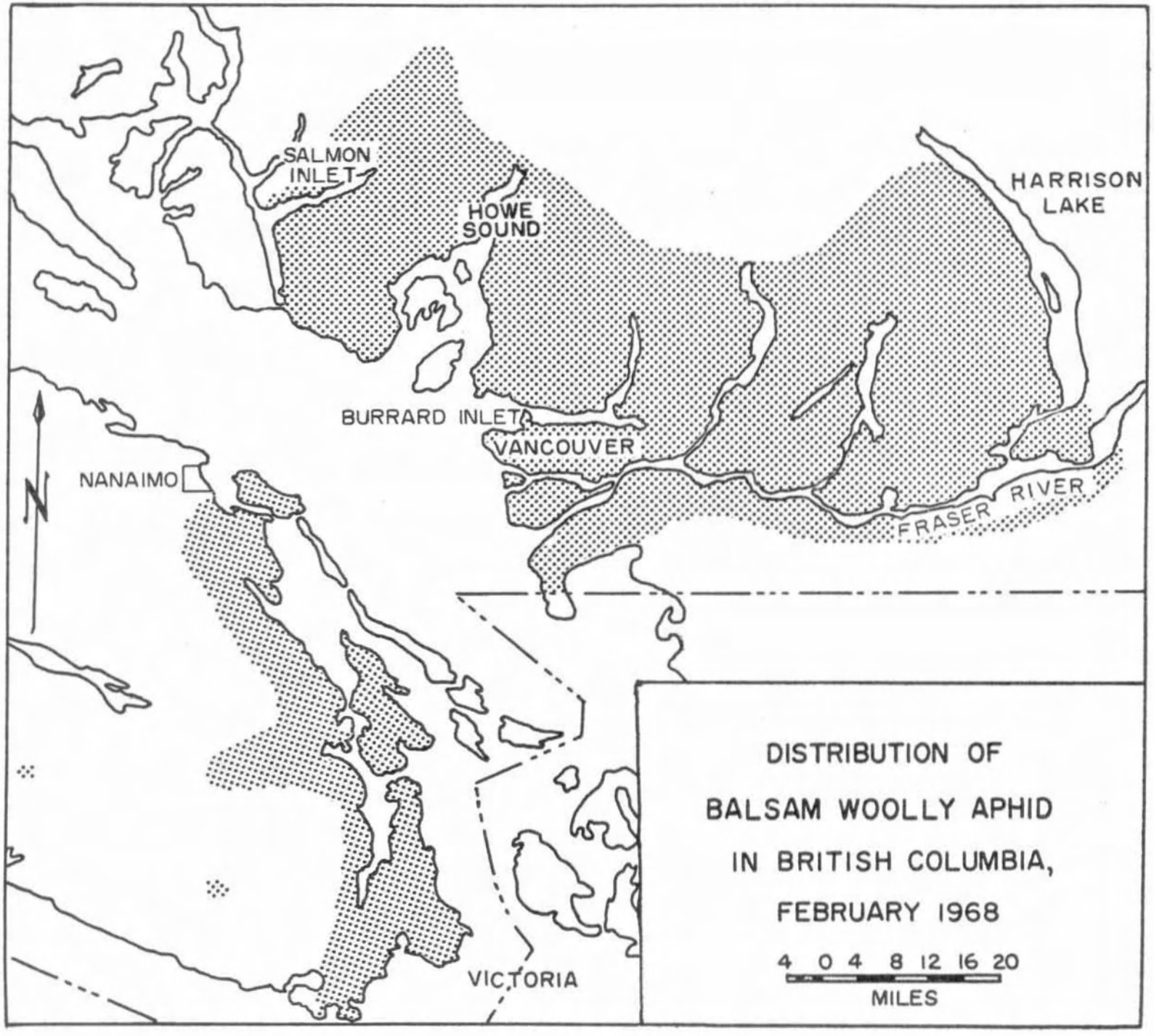
[2] amabilis fir; this species, however, was more difficult to examine and wash.

The percentage of aphids found by washing six 18-inch branch tips from each of 18 grand fir ranged from 12 to 600% of the numbers found by direct observations and averaged 123% (aphid numbers on the branches sampled directly ranged from 0 to 162 and averaged 25). Furthermore, in all instances where aphids were known by direct observations to be present, at least one aphid, identifying the collection as a positive one, was found by the washing technique. Also, washing resulted in at least 65% recovery of the aphid known present in 82% of the cases.

Besides high reliability of detection, the wash method made the searching of filter papers with negative results a relatively routine job that could be done repetitively with some confidence, whereas examination of branches in such instances was more difficult. Nevertheless, periodic checks with foliage containing known numbers of aphids were necessary to maintain crew efficiency.

SURVEY RESULTS

Surveys in British Columbia were most intensive in the southwest but did include observations in other areas of southern B. C. Aerial and ground examinations during 1965-1967 were made chiefly by a special British Columbia Forest Service Protection Division Crew, but Forest Insect and Disease Survey Rangers and company foresters also contrituted. About 2,000 collections were made in 1965, 4,000 in 1966 and 1,500 in 1967. The native adelgid, Pineus abietinus, was common on the three native host species of Abies in all areas. Interior surveys in 1967 revealed five balsam woolly aphid infested trees at two residences in the southern Okanagan Valley and the aphids were destroyed. The known distribution of the balsam woolly aphid as of February 1968 is defined as being on Vancouver Island south of Nanaimo and on the mainland in the Salmon Inlet, Howe Sound, Burrard Inlet and Lower Fraser River Valley drainages east to Harrison Lake (see map).


SALMON INLET
HOWE SOUND
HARRISON LAKE
BURRARD INLET
VANCOUVER
NANAIMO
N
FRASER RIVER
VICTORIA
DISTRIBUTION OF
BALSAM WOOLLY APHID
IN BRITISH COLUMBIA,
FEBRUARY 1968
4 0 4 8 12 16 20
MILES

FUTURE SURVEYS

At present, control of the balsam woolly aphid is feasible only on highly valued ornamental trees. Where the aphid occurs in forest situations, losses can be reduced by adjusting logging plans to effect early removal of Abies, and early detection of the balsam woolly aphid is therefore of importance to most forest land managers.

Unfortunately, decline of Abies can be the result of a variety of factors not related to the balsam woolly aphid, including diseases and defoliating or bark boring insects. The areas which could become infested with aphid are extensive and in many cases inaccessible. To assist the Forest Insect and Disease Survey in detecting the pest outside of its presently known boundaries, foresters in British Columbia have been asked to observe damaged Abies; they are requested to look particularly for thinning, browning or reddening of the foliage, swollen nodes near branch tips, and tiny, white "wool" spots on the bark (Figures 1-4). When such symptoms are detected, samples should be submitted to the nearest Forest Insect and Disease Survey field officer or the Department of Forestry and Rural Development Laboratory at Victoria or Vernon. The samples should be several branch tips and pieces of bark on which wool spots are noticed.

ACKNOWLEDGMENTS

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