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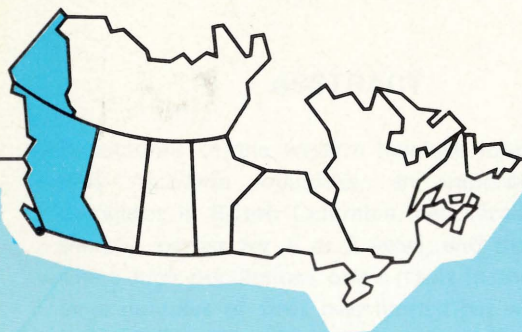
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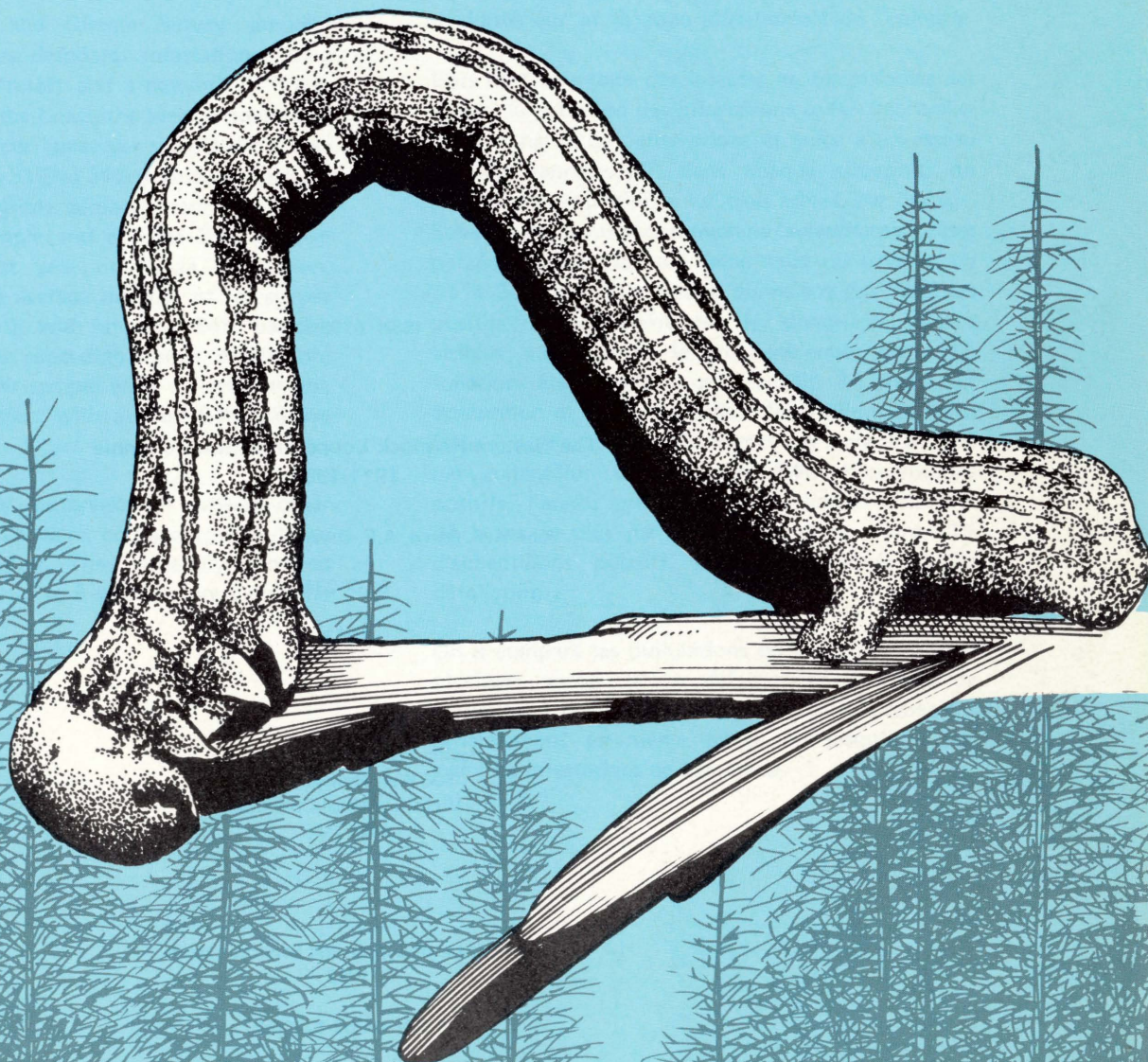
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ABSTRACT

Populations of the western hemlock looper, *Lambdina fiscellaria lugubrosa*, an important forest defoliator in British Columbia, periodically increase sharply, persist for 1 or 2 years, and then decline. These high populations often result in the death of large numbers of trees over limited but well-defined areas. Outbreaks have occurred in nine such areas, primarily in the Coastal and Interior Western Hemlock Biogeoclimatic zones, as well as in the Interior Douglas-fir and Sub-boreal Spruce zones.

The Forest Insect and Disease Survey annually detects and appraises defoliator infestations, using observers in small aircraft and a network of 3-tree beating samples. On the Coast, the average number of western hemlock looper larvae per sample was as low as two or three, with 31% to 34% positive samples, in the year preceding visible damage; there were about three larvae per sample and at least 39% positive samples, in the first year of visible defoliation. In the Interior, the average number of larvae per sample was 8 to 10, with at least 64% positive samples, in the year preceding visible defoliation; 25 or more larvae per sample were collected in the first year of defoliation, with at least 81% positive samples.

High populations or outbreaks of several other defoliating pest larvae were compared with those of the hemlock looper. They generally occurred at the same time or up to 6 years before *Lambdina* outbreaks.

RESUME

Les populations de l'arpenteuse de la pruche de l'Ouest (*Lambdina fiscellaria lugubrosa*), important défoliateur des forêts de la Colombie-Britannique, obéissent au cycle suivant: après une prolifération rapide, elles pullulent pendant 1 ou 2 ans puis déclinent. Lors des pullulations, elles tuent de nombreux arbres dans des secteurs peu étendus mais bien délimités. Neuf de ces régions ont ainsi été infestées, surtout dans les zones biogéoclimatiques de la pruche occidentale, de la région côtière et de l'intérieur ainsi que dans la zone du Douglas taxifolié de l'intérieur et la zone infra-boréale de l'épinette.

Lors de l'inventaire des insectes et des maladies des arbres, la détection des infestations se fait habituellement à partir de petits avions et grâce à un réseau d'échantillonnage où, dans chaque situation, on prélève des échantillons sur trois arbres, par battage. Sur la Côte, le nombre moyen de larves d'arpenteuses par échantillon était d'à peine deux ou trois, et de 31 à 34% des échantillons donnaient des résultats positifs, l'année avant que les dommages fussent visibles; au cours de la première année où la défoliation était visible, on trouvait 3 larves par échantillon et au moins 39% d'échantillons positifs. Dans l'intérieur, les chiffres moyens étaient 8 à 10 par échantillon et au moins 64% d'échantillons positifs, l'année précédant la défoliation visible et 25 larves et plus par échantillon et au moins 81% d'échantillons positifs, la première année de la défoliation.

On a comparé les pullulations ou les infestations de plusieurs autres larves défoliatrices à celles de l'arpenteuse de la pruche de l'Ouest. Elles survenaient généralement en même temps ou jusqu'à 6 ans avant les infestations de *Lambdina*.

INTRODUCTION

The western hemlock looper, *Lambdina fiscellaria lugubrosa* (Hulst) (Lepidoptera: Geometridae), occurs throughout most of British Columbia south of 56°N latitude (Erickson 1978). The larvae feed on the foliage of most conifers and some broadleaved species, but prefer western hemlock (*Tsuga heterophylla* (Raf.) Sarg.). This looper periodically increases in numbers and causes tree mortality over limited, well-defined areas.

Defoliator numbers, and the damage they cause, are monitored annually throughout B.C. by staff of the Forest Insect and Disease Survey (FIDS), Canadian Forestry Service, assisted by the Ministry of Forests and various logging companies. Population records taken prior to 1949 were largely estimates based on observations made without a particular sampling plan. In 1949, population numbers also began to be measured by FIDS staff at a network of permanent sampling stations (Harris 1976). Counts from selected sampling stations were combined and averaged, then plotted to show the rise and fall of populations over time. Observations of tree defoliation and mortality have continued to the present, with increased precision, as more and more use was made of aircraft for detecting and appraising damage (Harris and Dawson 1979).

Outbreaks of western hemlock looper have been recorded in B.C. since 1911. They occurred at intervals of 4 to 17 years (average about 9 years), primarily in the Coastal and Interior Western Hemlock Biogeoclimatic zones (Krajina 1965), but some outbreaks also extended into the Interior Douglas-fir Zone along the upper Columbia River, and in the Sub-boreal Spruce Zone around Prince George.

Several authors have described looper outbreaks and tried to explain their causes. Thomson (1952) examined weather records during four outbreak periods in an attempt to forecast outbreaks and suggested that an unusually dry September may precede peak moth flight by 3 years. Bitz and Ross (1958) and Silver (1962) analyzed larval population data, noting relationships with other pest species as possible indicators of impending looper outbreaks, but their results were largely inconclusive.

This report describes the history of western hemlock looper outbreaks in B.C. as recorded by FIDS, summarizing tree damage since 1911 and larval populations since 1949. In the latter case, the average numbers of larvae in samples were calculated from six geographic areas where infestations had occurred in the past. These figures were then plotted so that population changes could be readily seen.

METHODS

Information on the western hemlock looper in British Columbia was obtained from various published records dating back to 1911. Quantitative larval data for 1949-1980 were retrieved from the FIDS computer data file (Harris 1976) and examined.

The most important literature source was the FIDS annual regional report which summarizes forest pest conditions in B.C.¹, and an unpublished report series, "History of Population Fluctuations and Infestations of Important Forest Insects"². From 1923 to 1967, the "Canadian Insect Pest Review" was also consulted (Scientific Information Section, Research Branch, Canada Agriculture). Some of the principal papers were by de Gryse and Schedl (1934), who mentioned outbreaks up to 1930, and by Prebble and Graham (1945), Richmond (1947), and Wyatt (1954) who outlined outbreaks up to 1945.

Quantitative western hemlock looper larval figures were determined annually from records collected by FIDS at permanent sampling stations (Fig. 1), using the 3-tree beating method (Harris 1976). In this method, a 2.75-metre pole was used to beat larvae from 3 trees at each station onto a 2.10 x 2.75-metre sheet spread beneath each tree. The average numbers of larvae per sample and the percent of samples containing larvae (percent positive samples) for

1949-1980 were calculated to the nearest integer for sampling stations within six geographic study areas (Fig. 1, A-F), three on the Coast and three in the Interior. These areas were major drainages in which infestations (visible damage) or high populations (no visible damage) had occurred between 1949-1980 in at least some portion of the study areas (i.e., within a study area, visible damage may not have occurred everywhere the host stand type was present, and some sampling stations may have never had high looper populations; also, looper populations were not necessarily sampled where damage occurred). Data for the common hosts western hemlock and western red cedar (*Thuja plicata* Donn) were combined for each area. The population figures were graphed by year for each area to show population trends.

In some areas, a comparison was also made of average numbers of larvae of the looper and other defoliator species; for the Coast these were the western black-headed budworm, *Acleris gloverana* (Wlsh.), the green-striped forest looper, *Melanolophia imitata* (Wlk.), and a sawfly *Neodiprion* sp., and for the Interior the western blackheaded budworm, the green-striped forest looper, the filament-bearer, *Mematocampa filamentaria* (Guen.), and the saddle-back looper, *Ectropis crepuscularia* (Schiff.).

¹ By Forest Region since 1920, in "Annual District Report, Forest Insect and Disease Survey" and "Annual Forest Insect and Disease Conditions", Canadian Forestry Service, Victoria; and for the Province since 1937, in "Annual Report of the Forest Insect and Disease Survey", Canadian Forestry Service, Ottawa. These reports were compiled from insect collections taken each summer on the ground and from annual aerial defoliation surveys (Harris and Dawson 1979).

² Unpublished file reports: Allen and Koot (1974), Allen and Wood (1975), Cottrell and Monts (1970), Morris and Monk (1974a), and Wood and Doidge (1972), Pacific Forest Research Centre, Victoria, B.C.

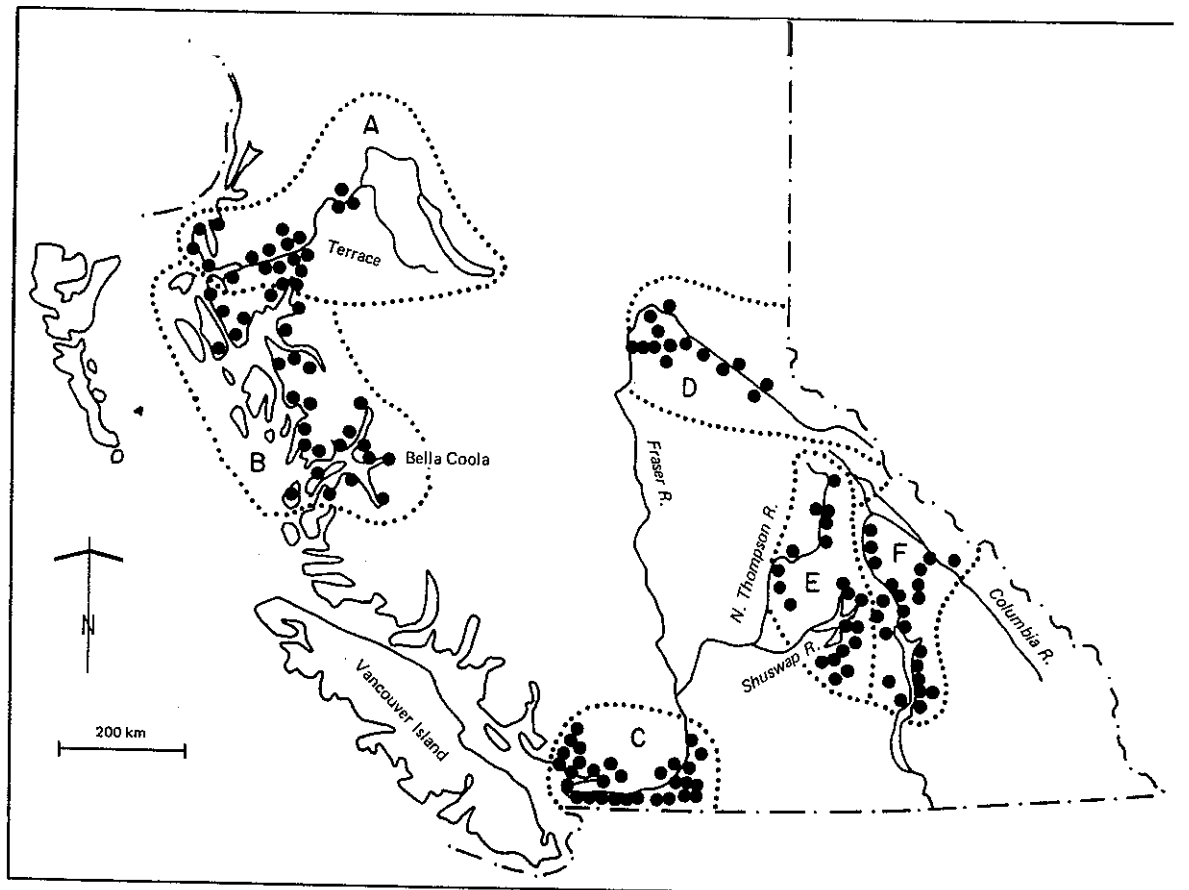


Fig. 1: Western hemlock looper Forest Insect and Disease Survey permanent sampling stations (●) from 1949-1980; samples were combined into major study areas A-F to determine average numbers of larvae per sample and percent positive samples in each area.

RESULTS

Western hemlock looper larval populations increased to outbreak proportions eight times at one or more of nine locations in B.C. (Fig. 2) between 1911 and 1980. Outbreaks lasted for 1 to 5 years before subsiding, with intensity varying from no apparent damage to visible defoliation and tree mortality (Fig. 3). The infestations are described in greater detail in the following descriptions based on damage data only from 1911 to 1948, and on both damage

and larval numbers (the latter calculated for the six major geographic study areas) from 1949 to 1980. For the first two locations (northern and southern Vancouver Island), outbreaks occurred before larval population data collection started. The remaining seven locations fell into the six study areas in which at least some outbreaks occurred since 1949, when larval sampling was initiated.

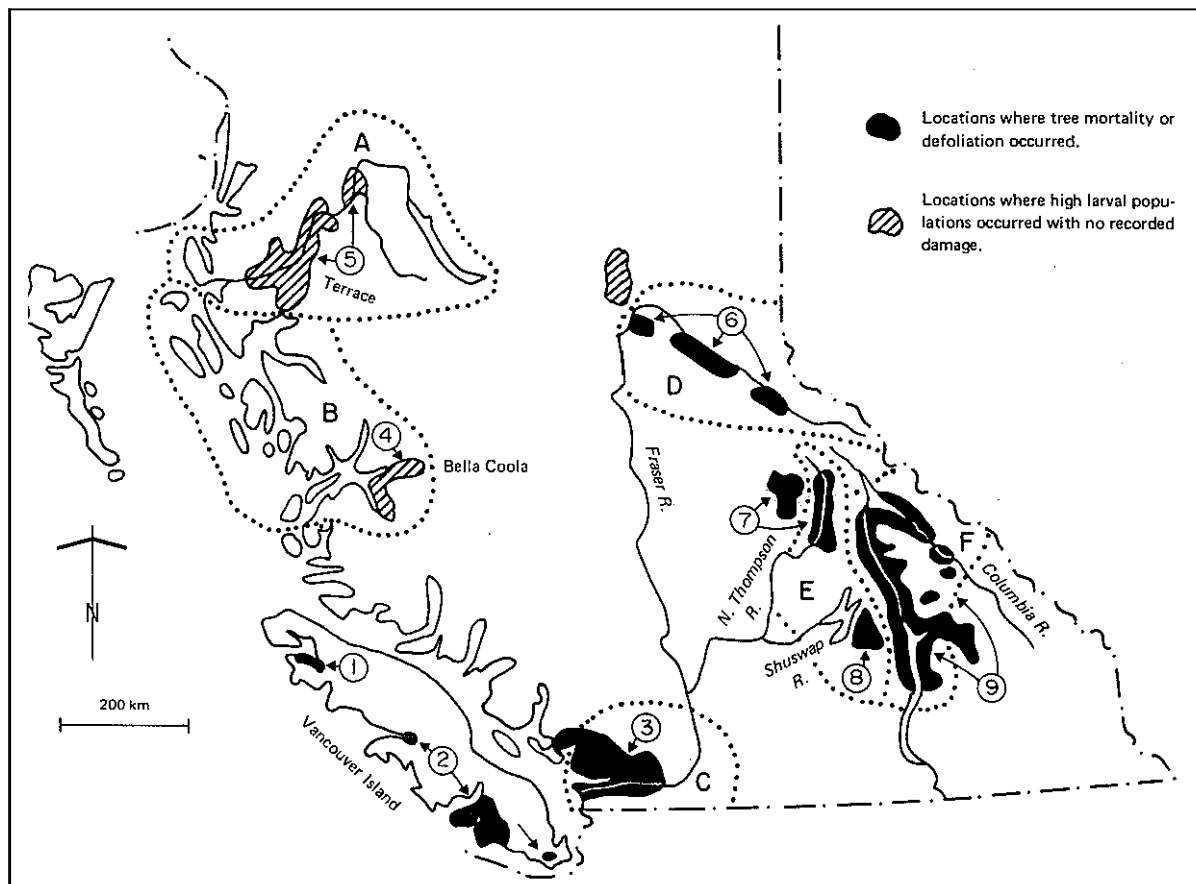


Fig. 2: Distinct western hemlock looper outbreak locations (1-9) in British Columbia, 1911-1980, see also Fig. 3. A-F identify areas from which permanent sampling station records were extracted and averaged from 1949-1980.

Coastal British Columbia

Outbreaks of the western hemlock looper in Coastal British Columbia occurred primarily in mature and overmature western hemlock-western red cedar stands in the Coastal Western Hemlock Biogeoclimatic Zone. Five outbreaks were recorded in the south at intervals of 12 to 17 years (Fig. 4). High populations with no noticeable defoliation occurred only once on the north Coast. Outbreak periods of the western hemlock looper on the Coast were as follows.

1911-1914

The first record of western hemlock looper in the province was at Stanley Park, Vancouver, where severe defoliation and mortality of western hemlock occurred from 1911 to 1913 (Fig. 4a). Although a large moth flight occurred in the autumn of 1913, heavy parasitism by an undetermined tachinid fly considerably reduced the population in 1914 (de Gryse and Schedl 1934). In addition, in 1913-1914, the looper defoliated and killed a large area of western hemlock on Vancouver Island, but no other details were recorded (Wyatt 1954).

1925-1930

Severe defoliation and mortality of western hemlock was reported in a 9-km strip along the west side of Neroutsos Inlet, northern Vancouver Island, in 1925-1926 (Fig. 4a). Subsequent tree mortality continued until 1930. Severe defoliation with extensive top-kill and tree mortality occurred from 1928-1930 in the lower Fraser River Valley, west of Hope, and in the Howe Sound area. In 1927, a large moth flight was noticed at Indian River northwest of Vancouver. In 1928, severe defoliation and up to 80% tree mortality of western hemlock, western red cedar, Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and grand fir (*Abies grandis* (Dougl.) Lindl.) occurred on over 800 ha in this area. Defoliation also occurred to the east at Alouette and Coquitlam lakes. Infestations increased in 1929 at these areas, with 450 ha at Alouette Lake and 260 ha at Coquitlam Lake. New areas appeared from Port Mellon to Woodfibre on Howe Sound, at Seymour

River (1 300 ha), Capilano River, Lynn Creek and Stanley Park north of Vancouver, and at Chehalis River, and Popkum (10 ha). In 1929, 18 ha at Wigwam Inn near Indian River were dusted with calcium arsenate (1 part to 6 parts hydrated lime, at about 20 lb./acre) and in 1930, 325 ha in Stanley Park and a 3-km strip along Seymour River were treated with the same insecticide (Hopping 1934). It was estimated that 75% to 85% of the larvae were killed. Infestations declined in 1930, apparently due to heavy larval parasitism in most areas (primarily by the tachinid, *Winthemia cilitibia* Rond. (Hopping 1934)). although some defoliation continued in Stanley Park. Besides Indian River, tree mortality occurred in 1930 at Coquitlam Lake and Popkum and extensive topkill at Seymour River.

1944-1947

Extensive infestations occurred again on Vancouver Island and in the lower Fraser River Valley-Howe Sound area during this period (Fig. 4b). On Vancouver Island, large moth flights were observed at Cowichan Lake in 1943, and at Gordon River, Quatsino and Thurston Bay in 1944. Severe defoliation and top-kill of western hemlock and amabilis fir (*Abies amabilis* (Dougl.) Forbes) occurred in 1944 at Gordon River, with some lesser damage at Lens Creek near Cowichan Lake. In 1945-1946, the outbreak expanded considerably, with severe defoliation and tree mortality centered at Caycuse River, Nitinat Valley, Klanawa River and Coleman Creek; severe defoliation also occurred at Sarita River, Pachena River, Poett Nook, Frederick Lake and Old Wolf Creek near Sooke. A small localized infestation caused defoliation at the mouth of Burman River near Gold River. Several of the areas were treated with DDT in 1946 to reduce damage and this, combined with an unidentified viral disease, caused the outbreak to subside (Leech 1946), although in 1947 some looper activity persisted at Poett Nook, Gordon River and upper Nitinat River.

In 1945, a large moth flight occurred at Port Mellon, northwest of Vancouver, and in 1946 there was up to 100% defoliation of trees. Populations developed

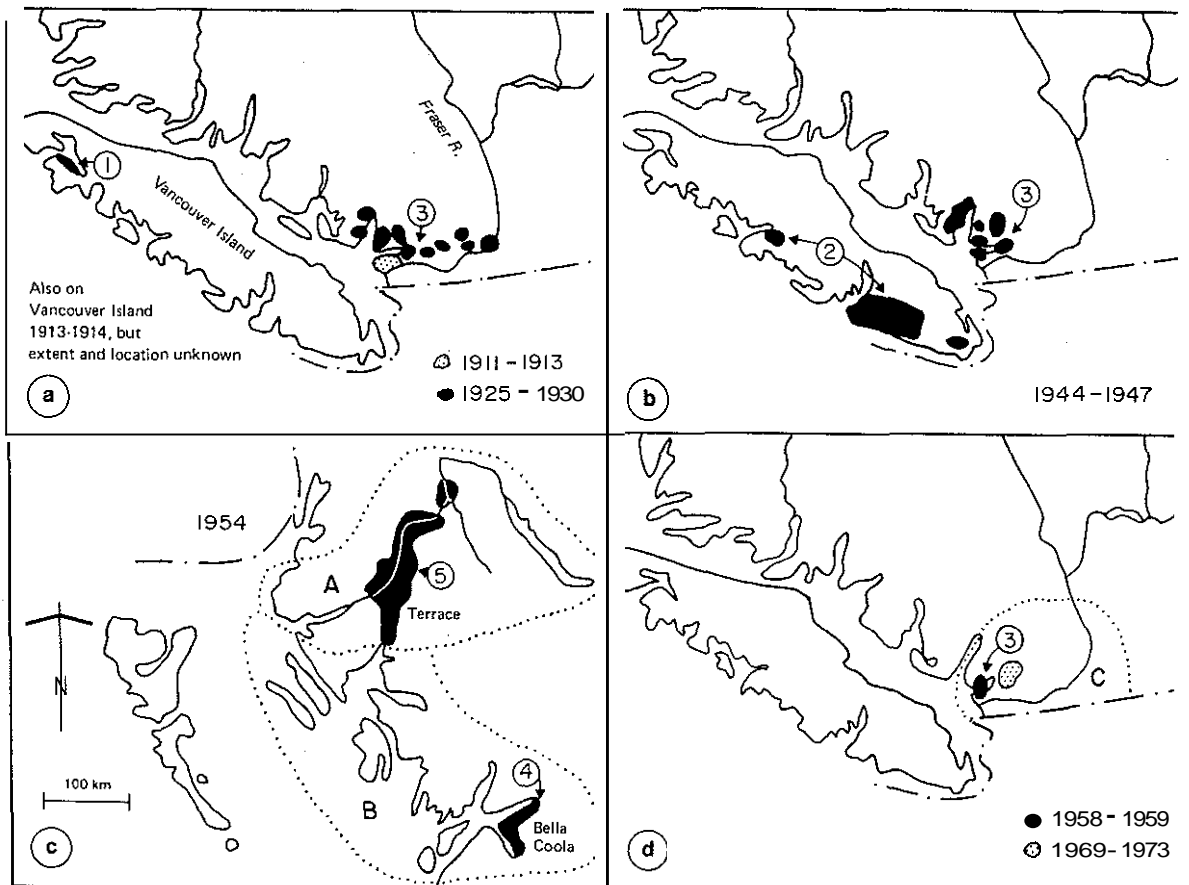


Fig. 4: Outbreaks of western hemlock looper, Coastal British Columbia, 1911-1980. Numbers refer to those in Fig. 3. A-C are study areas where larval populations were compared from 1944-1980.

in 1946 at Indian River, Stanley Park and near Woodfibre, but little damage was recorded. In 1946, severe defoliation occurred at Clowhom Lakes, on the Salmon Inlet near Sechelt. In 1945-1946, extensive damage occurred in the Seymour and Capilano River drainages and at Widgeon Creek, with considerable tree mortality. Though populations remained in some areas, heavy parasitism is thought to be responsible for the collapse of looper populations in most areas in 1947 (Cottrell and Monts 1970).

1954

Population levels increased noticeably in the Terrace area (study area A, Fig. 4c, Fig. 5) to 3 larvae per sample and in the Bella Coola area (study area B, Fig. 4c, Fig. 5) to 6 larvae per sample in 1954, with a corresponding rise in percent positive samples

to 35% and 74%. No visible damage occurred and numbers decreased in 1955.

1958-1959

In the lower Fraser River Valley (study area C, Fig. 4d, Fig. 5), there were 2 larvae per sample in 1957, but in 1958 this had increased to 6. Percent positive samples rose from 10% in 1956 to 34% in 1957, peaking at 65% in 1958, the year defoliation first became evident at Stanley Park.

Light to severe defoliation occurred on understory and light defoliation on overmature western hemlock in Stanley Park (Fig. 4d, part of study area C). Some of the area was sprayed with 10% DDT and fuel oil in 1958, but populations persisted in 1959, so the area was treated again, with up to 97% larval

mortality recorded (Ruppel 1959). No defoliation was recorded in 1960.

1969-1973

In the lower Fraser River Valley (study area C, Fig. 4d, Fig. 5), populations in 1968 and 1969 were low, averaging 3 larvae per sample, while percent positive samples rose from 31% to 39%. In 1970, larval populations fell to below one larva per sample and percent positive collections decreased to 19%. Numbers of larvae rose to 19 per collection in 1971 and 12 in 1973, and percent positive samples returned to 30% in 1972.

Light defoliation occurred at Coquitlam Lake (Fig. 4d, part of study area C) in 1969, increasing to severe in 1970 on 80 ha. In 1971 and 1972, the infestation expanded to 260 ha and extensive mortality of western hemlock occurred in most of the infested stands. Some defoliation continued in 1973, though populations subsided in parts of the outbreak, and the loopers all but disappeared in 1974.

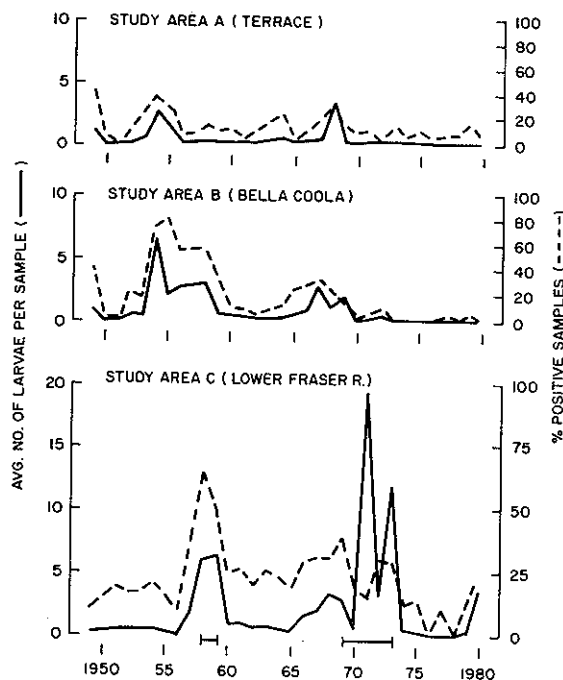


Fig. 5: Average annual western hemlock looper larval populations for selected study areas, Coastal British Columbia, 1949-1980, on tree hosts western hemlock and western red cedar. — years with defoliation (area C only).

Other Insect Species

A comparison of populations of three other common defoliating insect species in study area C showed a 1958-1959 western hemlock looper infestation (Fig. 6) at Stanley Park was preceded by high numbers of western blackheaded budworm there in 1957, and accompanied by defoliation of western hemlock by the green-striped forest looper. Increases in numbers of *Neodiprion* sp. also occurred in Stanley Park, during the outbreak period, with defoliation also occurring elsewhere in study area C.

The 1968-1973 hemlock looper outbreak at Coquitlam Lake was preceded by population increases of these pests throughout much of study area C. Green-striped forest looper populations peaked in 1966 but there was no visible damage. *Neodiprion* sp. numbers peaked in 1968 with scattered defoliation, and blackheaded budworm populations rose in 1966, and peaked in 1968 and 1970, causing widespread defoliation.

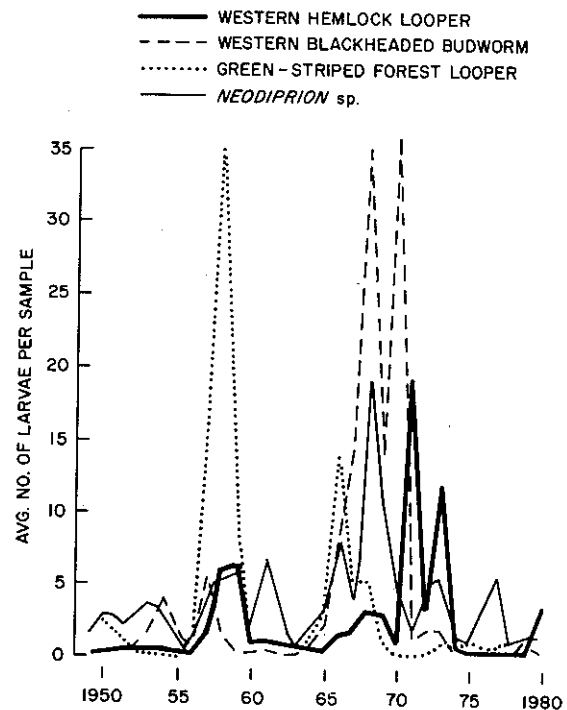


Fig. 6: Comparison of samples of several insect species for study area C (lower Fraser River Valley), Coastal British Columbia, 1949-1980, from western hemlock and western red cedar.

Interior British Columbia

Five outbreaks of the western hemlock looper were recorded in the Interior at intervals of 8 to 9 years (Fig. 7). Most outbreaks occurred in mature and over-mature western hemlock-western red cedar stands, but in 1973 damage also occurred in mixed immature stands, including Douglas-fir, at Shelter Bay and Nakusp. Outbreak areas closely followed the Interior Western Hemlock Biogeoclimatic Zone, but also extended into the Interior Douglas-fir Zone along the Columbia River north of Donald. Localized outbreaks also occurred in the Sub-boreal Spruce Zone around Prince George, where white spruce (*Picea glauca* (Moench) Voss) and alpine fir (*Abies lasiocarpa* (Hook.) Nun.) were defoliated. The individual outbreaks recorded in the Interior are discussed below.

1937-1938

In 1937, major infestations were recorded in western hemlock-western red cedar stands at Trout Lake over 10 000 ha and over 22 000 ha along the Columbia River north of Donald (Fig. 7a). Smaller infestations occurred on 800 ha at Lardeau Creek and Wilson Lake. At Trout Lake, the main infestation extended 35 km from Armstrong Lake down the southwest side of Trout Lake. Considerable mortality of hemlock-cedar occurred, with severe feeding on western white pine (*Pinus monticola* Dougl.), Douglas-fir and Engelmann spruce (*Picea engelmannii* Parry). Small, isolated infestations also occurred at Mt. Revelstoke Park, and at Arrowhead, Galena Bay, Comaplix and Beaton on the Upper Arrow Lake, and in the Lardeau region at Howser, Duncan River, Cooper Creek and Lardeau River. Up to 50% tree mortality occurred at some locations. Along the Columbia River, severe defoliation occurred at Blackwater Lake and Bush River, resulting in considerable mortality of Douglas-fir and Engelmann spruce. Heavy larval parasitism from a tachinid, *Winthemia cilitibia* Rond., possibly resulted in a collapse of the infestation in 1938 (Anon 1938).

1945-1947

In 1944, a large moth flight occurred along the Columbia River between Revelstoke and Downie

Creek, and in 1945, severe defoliation occurred in localized areas (Fig. 7a). Further large moth flights were recorded here and in the North Thompson River and Adamr River valleys in 1945. In 1946, the infestation along the Columbia River covered about 39 000 ha, with severe defoliation in many areas. A large moth flight occurred from Kinbasket Lake to Blackwater Lake and at Lardeau Creek and severe defoliation was noted along the North Thompson River and in Wells Gray Park (Fig. 7a). In 1947, the infestation along the Columbia River subsided, but considerable top-kill and up to 70% tree mortality occurred. Severe defoliation occurred at Lardeau Creek on 1 500 ha of overmature hemlock-cedar. There were no records for the North Thompson River and Wells Gray Park in 1947, but surveys in 1948 showed a total collapse of the infestations in these areas as well as at Lardeau Creek. Up to 100% mortality of western hemlock was reported for some locations in Wells Gray Park.

1954-1955

In the upper Fraser River area (study area D, Fig. 7b, Fig. 8) the average number of larvae per sample rose from near 0 in 1951 to 9 in 1953, and then to 42 in 1954, when defoliation first became visible within the study area. At the same time, percent positive collections rose from 17% to 81%. Larval numbers peaked at 48 in 1955, then fell sharply in 1956, while percent positive samples rose to 95% in 1955, peaked at 100% in 1956, before dropping sharply in 1957.

Defoliation of overmature western hemlock, white spruce and alpine fir occurred at Eaglet Mountain near Giscome in 1954 (Fig. 7b). Patches of light to moderate defoliation of hemlock-cedar stands occurred from Lunate Creek to Slim Creek along the upper Fraser River. At Penny, light defoliation occurred in overmature western red cedar. In 1955, severe defoliation occurred near McBride. Populations declined in 1956, but some tree mortality occurred at McBride.

In study areas E and F, the percent positive samples increased dramatically from 1952-1955 (Fig. 8)

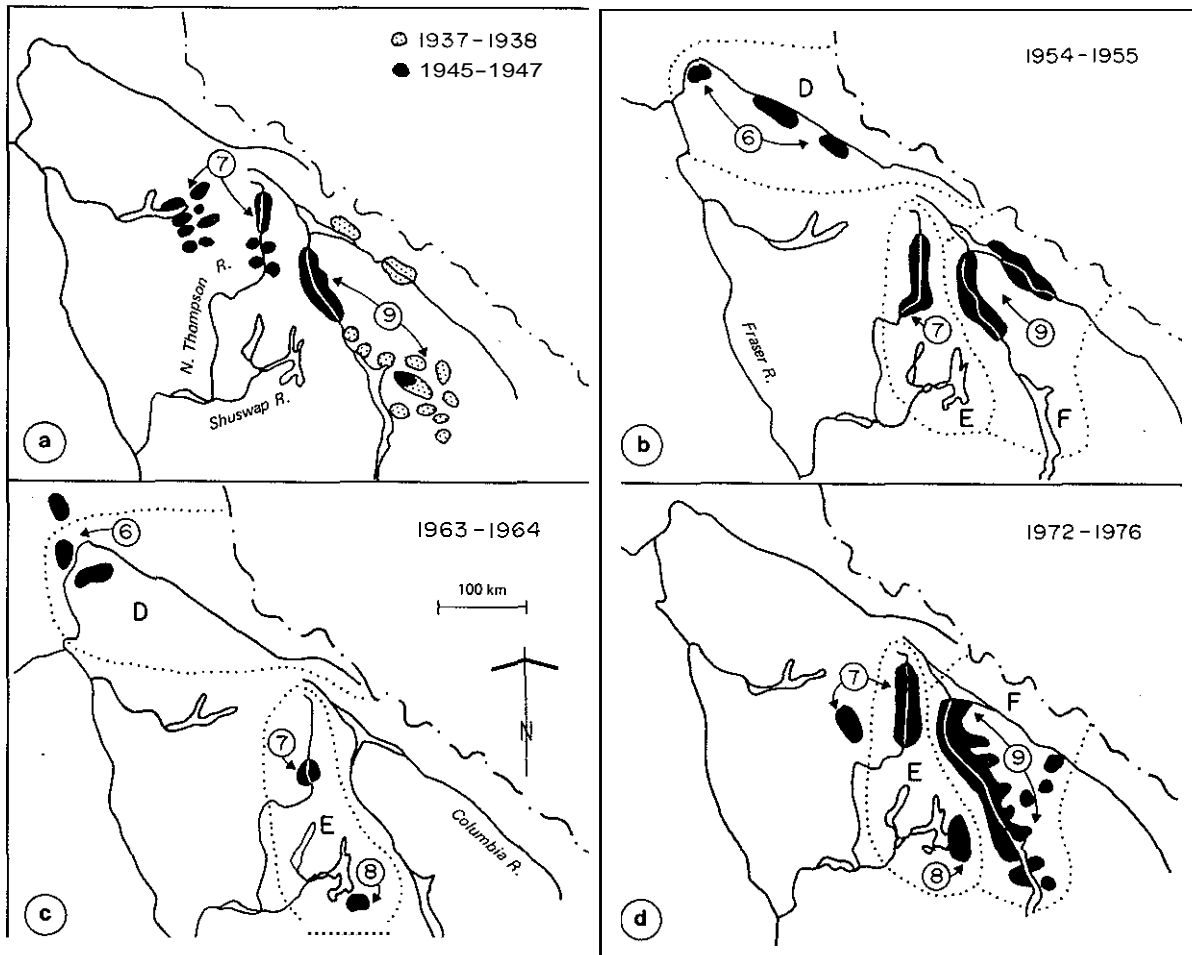


Fig. 7: Outbreaks of western hemlock looper, Interior British Columbia, 1937-1980. Numbers refer to those in Fig. 3. D-F are study areas where larval populations were compared from 1949-1980.

but no visible damage occurred. The larval count for the North Thompson River in 1953 (study area E, Fig. 7b) peaked at 5 and for the Columbia River (study area F, Fig. 7b) it reached 8 in 1955.

1963-1964

Higher than normal populations (4 larvae per sample in 1964) developed in the Upper Fraser River area (study area D, Fig. 7c, Fig. 8) primarily near Prince George in the Bear Lake, Summit Lake and Wansa Lake areas, mainly on white spruce and alpine fir, and from Giscome to Hansard on white spruce, but no defoliation was observed. Percent positive collections rose from 0% in 1961 to nearly 100% in 1962, and then declined during the next several years. In 1964, however, 70% of the samples still contained hemlock looper larvae. Cool temperatures delayed

moth flight in 1964, and although adults were numerous, the cool weather probably interfered with mating because the numbers of larvae were considerably reduced in 1956.

In the Shuswap River and North Thompson River drainages (study area E, Fig. 7c, Fig. 8), larval populations rose from 2 larvae per sample in 1961 to 11 in 1962, and to 37 in 1963, when defoliation was first noticed within the study area, then peaked at 59 in 1964, before plummeting to 1 larvae in 1965. Percent positive samples rose from 29% in 1960, to 67% in 1961 and 1962, to 85% in 1963, and peaked at 90% in 1964. Light to severe defoliation occurred at Hidden Lake on 46 ha of hemlock-cedar forest in 1963 and light defoliation occurred at Lempriere in 1964 (Fig. 7c). The populations began to collapse in 1964, apparently due to cold weather and an

unknown viral disease affecting larvae (Andrews 1964, Grant 1964). In 1965, populations dropped to very low levels.

1972-1976

In the North Thompson-Shuswap River drainages (study area E, Fig. 7d, Fig. 8), larval numbers rose from 0 in 1970 to 6 in 1972 and peaked at 25 in 1973, when defoliation was first evident. Percent positive collections rose from 23% in 1970 to 47% in 1971 to 68% in 1972, and peaked at 94% in 1973. Light to severe defoliation of isolated western hemlock or western hemlock-western red cedar stands occurred along the North Thompson and Shuswap River drainages in 1973-1974 (Fig. 7d), but populations collapsed in 1975.

In the upper Columbia River area (study area F, Fig. 7d, Fig. 8), larval numbers rose from 1 in 1970, to 10 in 1971, to 38 in 1972, when defoliation was

first evident within the study area, and peaked at 100 in 1973. Percent positive samples rose from 41% in 1970, to 76% in 1971, to 98% in 1972, and peaked at 100% in 1973. Populations fell to low levels in 1975.

In 1972, in study area F, the increased larval population from Arrow Park to Boat Encampment caused light defoliation at some localities. A large moth flight was observed in the fall. In 1973, defoliation occurred on over 28000 ha of mature and over-mature hemlock-cedar forests from Nakusp on the upper Arrow Lake to Boat Encampment on the Columbia River, and at Albert Canyon, Flat Creek and Quartz Creek on the Rogers Pass (Fig. 7d). Populations collapsed in 1974 apparently due to cool wet weather during early larval development and by severe egg parasitism (up to 80%) by *Trichogramma* sp. and *Telenomus* sp. (Morris and Monts 1974b).

In 1976, 10500 ha of defoliation occurred in Wells Gray Park, where tree mortality occurred over

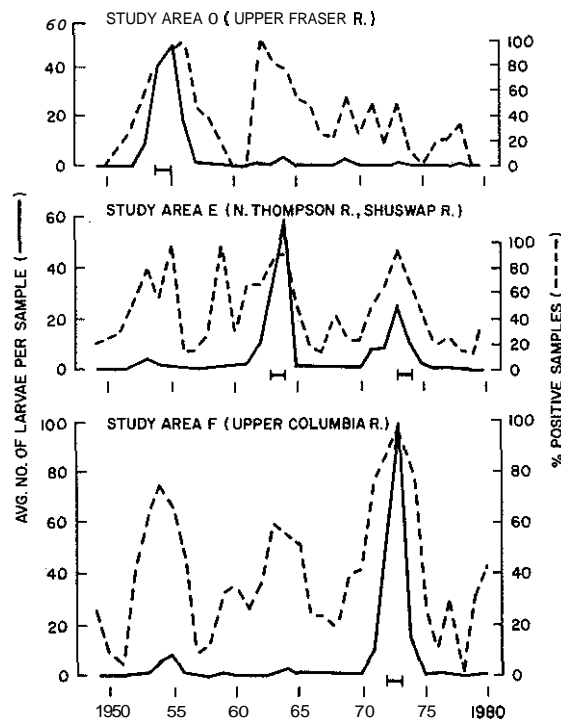


Fig. 8: Average annual western hemlock looper larval populations for selected study areas, Interior British Columbia, 1949-1980, on tree hosts western hemlock and western red cedar. ■—■ years with defoliation.

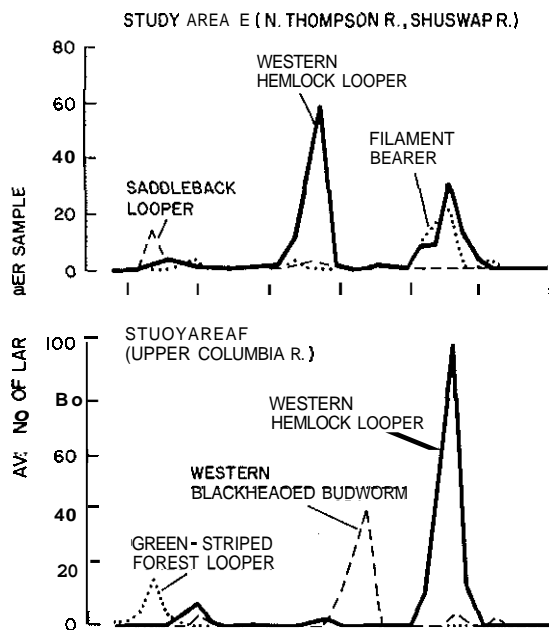


Fig. 9: Comparison of samples of several insect species, Interior British Columbia, 1949-1980, from western hemlock and western red cedar.

1200 ha. The area apparently had been infested for 2 to 3 years previously, but no surveys were undertaken during that period. That infestation collapsed in 1977.

Other Insect Species

In the Shuswap River drainage (study area E, Fig. 9), large numbers of filament-bearer larvae were collected in hemlock-cedar stands in association with western hemlock looper in 1973. High populations of filament-bearer also caused severe defoliation of understory outside stands infested with hemlock looper. High populations of saddleback looper

occurred along the North Thompson River, in study area E, in 1952, one year before a slight rise in hemlock looper populations. Along the upper Columbia River, study area F, high populations of green-striped forest looper showed a peak in 1952, 3 years before a peak in looper populations. In the same area, an outbreak of blackheaded budworm peaked in 1967, when hemlock looper populations were low. Defoliation occurred in many of the same hemlock-cedar stands later infested by the hemlock looper, as well as stands outside the looper-infested area. During the 1972-1974 western hemlock looper outbreak, blackheaded budworm populations were at a low level, showing only a slight rise in numbers in 1973.

DISCUSSION

Western hemlock looper population or damage records in B.C. since 1911 have shown that this insect periodically and suddenly increases in numbers to outbreak levels, causes considerable tree mortality for one to several years, and suddenly declines. Much of the Interior Western Hemlock Biogeoclimatic Zone is susceptible (Fig. 10) and infestations have been mostly confined to it. On the Coast, areas with high populations fall almost entirely within the Coastal Western Hemlock Zone, but damage has occurred only on Vancouver Island and in the lower Fraser River Valley-Howe Sound area in the southern portion of the zone. While high looper populations occurred north of this area, notably at Bella Coola and Terrace, the infestations collapsed without causing noticeable damage.

High priority sampling areas would be locations where infestations have occurred in the past, with consistently high larval populations and visible damage (Fig. 10). A rise in the number of larvae per sample and in the frequency at which larvae occur in samples taken from these areas should alert the observer, causing a closer monitoring of these stands, and possibly an assessment of current economic values and preparation for control action.

Since 3-tree beating samples began in 1949, there have been three western hemlock looper outbreaks on the Coast and three, in slightly different years, in the Interior. Thus, there were three outbreak periods examined in each of our six study areas and, in these 18 instances, defoliation was significant

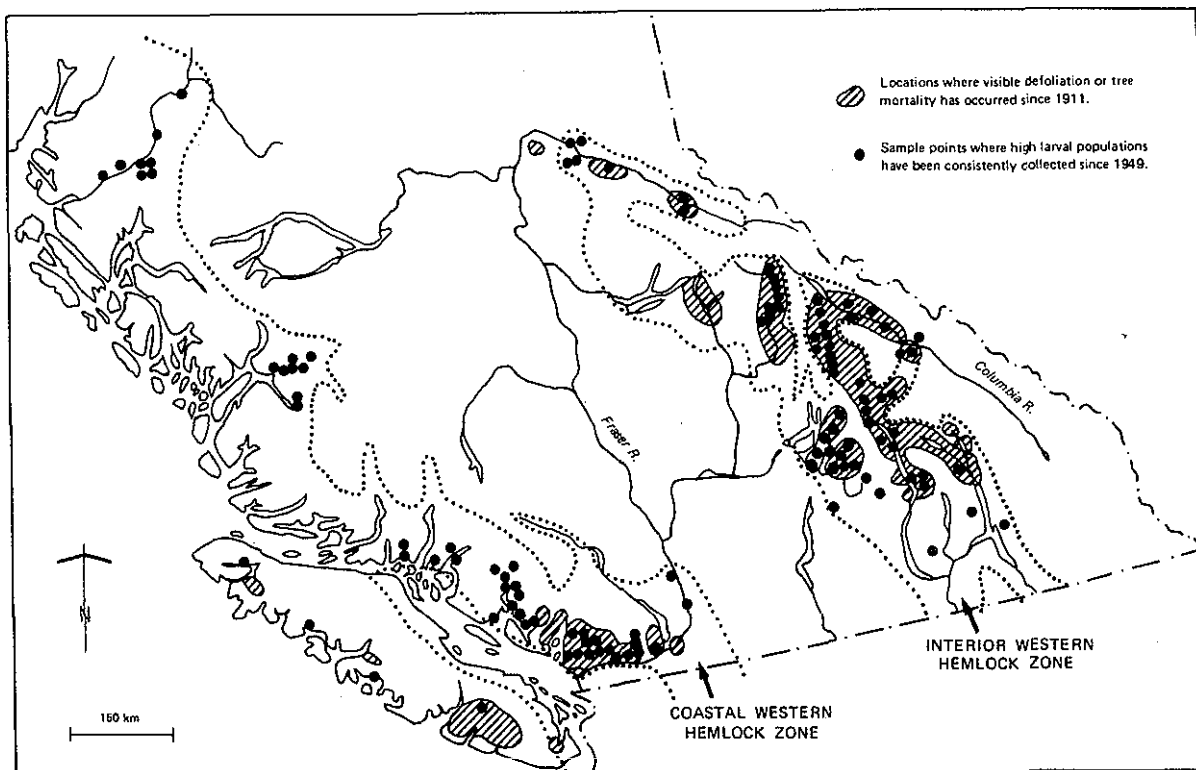


Fig. 10: Locations most likely to have western hemlock looper outbreaks in British Columbia.

enough in six to be noted in survey records. In five of these, the period of defoliation lasted two years, but in the other (lower Fraser Valley, study area C), defoliation occurred over five years (1969 to 1973). In five of the remaining 12 instances, the numbers of larvae rose noticeably and the percent positive samples increased markedly, but no defoliation was noted in the survey records for those years. In the other seven remaining instances, looper activity was at a very low level.

In four of the six instances where defoliation was noted, the average numbers of larvae per sample found in the year prior to visible defoliation were rising and there was an average of at least eight larvae per sample and at least 64% positive samples. In the following years, when defoliation occurred, there were at least 25 larvae per sample and at least 81% positive samples.

Two out of the six instances in which defoliation occurred showed a different pattern. In one, there were only two larvae per sample the previous year and 34% positive samples. Defoliation occurred at six larvae and 65% positive samples the following year. In the other case, which was the one where defoliation lasted five years, there were three larvae per sample prior to the year when defoliation was

first noted and a peak of 19 larvae per sample during the third year of defoliation. In the fourth year, however, larval numbers decreased to 3 (possibly this was only the result of a very small number of samples that year) but rose again in the fifth year to 12 larvae per sample. Percent positive samples, however, reached only 31% prior to defoliation and was never higher than 39% during the 5-year period of defoliation.

It appears that the average number of larvae per sample is the most critical factor to watch, with defoliation likely in the year following that in which 8 larvae per sample are found. Percent positive samples on the other hand, may be as high as 100% without defoliation occurring but as long as they remain under 30%, significant defoliation is unlikely in that year or the following one.

Further work with these data, interpreting the effects of various weather factors on the host trees and pest insects, is needed. This, combined with past and current records of defoliation giving information on the quantity of foliage available to the larvae at critical times, and of foliage quality, might help explain some of the observed population fluctuations and permit better predictions of population changes and expected tree damage.

REFERENCES

- Allen, S.J. and H.P. Koot. 1974. History of population fluctuations and infestations of important forest insects on Vancouver Island. Pacific Forest Research Centre, Victoria, File Rept., 31 pp.
- Allen, S.J. and C.S. Wood. 1975. History of population fluctuations and infestations of important forest insects in the Prince George Forest District. Pacific Forest Research Centre, Victoria, File Rept., 39 pp.
- Andrews, R.J. 1964. Forest insect and disease survey, Central Kamloops District, 1964, pp. 128-145. In Annual District Reports, Forest Insect and Disease Survey, British Columbia 1964, Forest Research Laboratory, Victoria.
- Anon. 1938. Annual report of the Vernon forest insect laboratory for the year 1938. Forest Insect Laboratory, Vernon, 228 pp.
- Bitz, W.E. and D.A. Ross. 1958. Population trends of some common loopers (Geometridae) on Douglas-fir, 1949-1956, in the Okanagan-Shuswap area. Bi-monthly Progr. Rept. 14:2-3.
- Cottrell, C.B. and J.S. Monts. 1970. History of population fluctuations and infestations of important forest insects in the Mainland Section, Vancouver Forest District. Pacific Forest Research Centre, Victoria, Internal Rept. BC-9.44 pp. (revised 19761).
- de Gryse, J.J. and K. Schedl. 1934. An account of the eastern hemlock looper, *Ellopija fiscellaria* Gn. on hemlock, with notes on allied species. Sci. Agric. 14:523-539.
- Erickson, R.D. 1978. Western hemlock looper. Pacific Forest Research Centre, Victoria, Forest Pest Leaflet 21, 3 pp.
- Grant, J. 1964. Forest insect and disease survey, East Kamloops District, 1964, pp. 109-127. In Annual District Reports, Forest Insect and Disease Survey, British Columbia 1964, Forest Biology Laboratory, Victoria.
- Harris, J.W.E. 1976. Storage and retrieval of quantitative British Columbia-Yukon Forest Insect and Disease Survey records. Pacific Forest Research Centre, Victoria, Rept. BC-X-120.30 pp.
- Harris, J.W.E. and A.F. Dawson. 1979. Evaluation of aerial forest past damage survey techniques in British Columbia. Pacific Forest Research Centre, Victoria, BC, Rept. BC-X-198, 22 pp.
- Hopping, G.R. 1934. An account of the western hemlock looper, *Ellopija somnaria* Hulst, on conifers in British Columbia. Sci. Agric. 15:12-29.
- Leech, H.B. 1946. Summary report of the forest insect survey, British Columbia and Rocky Mountain National Parks. Dominion Entomological Laboratory, Vernon, 105 pp.
- Krajina, V.J. 1965. Biogeoclimatic zones and classification of British Columbia. Ecology of Western North America 1:1-17.
- Morris, E.V. and J.S. Monts. 1974a. History of population fluctuations and infestations of important forest insects in the Nelson Forest District and adjoining National Parks. Pacific Forest Research Centre, Victoria, File Rept., 68 pp.
- Morris, E.V., and J.S. Monts. 1974b. Annual district report, forest insect and disease survey, British Columbia, 1974. Part V, Nelson Forest District. Pacific Forest Research Centre, Victoria, 25 pp.
- Prebble, J.L. and K. Graham. 1945. The current outbreak of defoliating insects in coast hemlock forests of British Columbia. Part 1. Description of outbreak and damage. BC. Lumberman, Feb. 1945, 6 pp.
- Richmond, H.A. 1947. Current trend of the western hemlock looper (*Lambdina f. lugubrosa*) in the coastal forests of British Columbia (Lepidoptera: Geometridae). Proc. Ent. Soc. BC. 43:33-35.
- Ruppel, D.H. 1959. Forest biology survey, Vancouver Forest District, Mainland Section, 1959, pp. 29-48. In Annual Report of Forest Biology Rangers, British Columbia, 1959, Forest Biology Laboratory, Victoria.
- Silver, G.T. 1962. A review of some forest insect survey records associated with defoliator infestations in coastal British Columbia. Forest Entomol. and Pathol. Lab., Victoria, 23 pp.
- Thomson, M.G. 1952. Western hemlock looper. Bi-monthly Progr. Rept. 8:3.
- Wood, R.O. and D.F. Doidge. 1972. History of population fluctuations and infestations of important forest insects in the Kamloops Forest District. Pacific Forest Research Centre, Victoria, Internal Rept. BC-32.65 pp. (revised 19761).
- Wyatt, G.R. 1954. Hemlock looper, history of outbreaks on the Pacific Coast 1946. Forest Biol. Lab., Victoria, Interim Tech. Rept., 7 pp.