

THE FOREST TENT CATERPILLAR IN ALBERTA

by

W.G.H. Ives

NORTHERN FOREST RESEARCH CENTRE

EDMONTON, ALBERTA

INTERNAL REPORT NOR-4

CANADIAN FORESTRY SERVICE

DEPARTMENT OF THE ENVIRONMENT

OCTOBER 1971

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ABSTRACT

The outbreak history of the forest tent caterpillar is reviewed. The most recent outbreak started in 1957 and lasted until 1970. This outbreak progressed in area and intensity until 1962, peaked in 1963, and collapsed over wide areas in 1964 and has been relatively unimportant since then. Radial growth studies indicated 80 to 90% loss in radial increment after three years severe defoliation but little tree mortality. The trees recovered within two years following severe defoliation. Evidence suggests that higher than average overwintering temperatures cause a decrease in populations the following summer. The day degrees above 40°F were higher for the winters (October 27 - April 26) preceding a decrease than they were for the winters preceding an increase. Egg parasitism was not a major mortality factor, although larval and pupal parasitism reached high levels in the older infestations. The role of disease was difficult to determine. Some second instar larvae were found to be infected with a nuclear polyhedrosis virus in 1964, and this may have caused widespread mortality. Disease was also believed responsible for population declines in 1966 in the Lake Wabamun area.

INTRODUCTION

The forest tent caterpillar, Malacosoma disstria Hbn., is a native insect that periodically reaches outbreak proportions. The insect has several hosts, but in the northern part of its range the preferred host is trembling aspen, Populus tremuloides Michx. Outbreaks on this host have been extensively reported in the literature (Churchill et al. 1964, Duncan and Hodson 1958, Hildahl and Reeks 1960, Sippell 1962) but no unified treatment of the outbreak history of the forest tent caterpillar in Alberta has been published.

This report collates available information on the outbreak history of this insect in Alberta, and presents summaries of some of the data collected since the start of the most recent outbreak in 1957.

OUTBREAKS PRIOR TO 1957

Early records of the forest tent caterpillar in Alberta are incomplete. Most observations were of a general nature prior to 1947, when systematic surveys were initiated by the Forest Insect and Disease Survey.

Baird (1917) stated that the insect was abundant all over Canada in 1887, and mentions a general outbreak in the Western Region from 1890 to 1894. This Region included British Columbia and the foothills of western Alberta. He also noted that the insect was recorded for the first time in Alberta in 1902 in the Red Deer-Lacombe area, and at Millarville, and mentioned the report of a mass emergence of adults near Edmonton about this time.

Baird (loc. cit.) noted a severe outbreak in the Western Region from 1908-1912. Although Hodson (1941) stated that the forest tent caterpillar was not generally abundant from 1914-1918, Tothill (1923) mentioned a continuing infestation near Sylvan Lake in 1917.

An outbreak apparently originating in the Moose Mountain area of Saskatchewan had extended west to Edmonton by 1924 (de Gryse 1925). Scattered outbreaks were reported in Alberta from 1924 to 1928 (Hodson 1941).

An extensive outbreak occurred in western Saskatchewan during 1929-1930, and it is likely that this continued into Alberta to some extent (Hildahl & Reeks 1960).

No record of this insect in Alberta could be found for the years 1931-1938, although outbreaks were recorded in Saskatchewan and British Columbia during this period.

In 1939, increases in populations of the forest tent caterpillar were noted from Edmonton northwest to Lesser Slave Lake, with heavy defoliation around Smith. In the following summer heavy defoliation occurred over most of this area, with a northwest extension through the Peace River region to Ft. St. John, B.C., and southeast of Edmonton to Viking. Low populations were observed in the Crowsnest Pass (Brown 1940, 1941). The outbreak northwest of Edmonton subsided considerably in 1941, leaving a small infestation west of Peace River along the Alberta-British Columbia border, but spread from Edmonton east almost to the Saskatchewan border, and southwest to the Drayton Valley-Rocky Mountain House area, where small patches of heavy damage occurred (Brown 1942).

Populations apparently continued to decline in 1942 (Brown 1943) in the areas to the north and west of Edmonton, but continued high east and south of this centre until 1943 (Leech 1944). Little activity was reported in 1944, with the exception of a small infestation in the Ft. Vermilion area (Richmond and McGuffin 1945), and this population dropped in 1945. The insect

was not abundant in Alberta from 1946 to 1949. A local infestation occurred around Nobleford in 1950 (Brown and Cumming 1951).

An upsurge of populations in 1951 marked the beginning of new outbreaks. Heavy infestations were found west of Rimbey and north of Rocky Mountain House, south of McKay, and northwest of Smith. An increase in populations was evident in the Whitecourt area (McGuffin and Reid 1952).

Populations continued to increase in 1952. The outbreak west of Rimbey expanded east and west, with about five townships of heavy defoliation, and extended through the Rocky Mountain House area almost to Nordegg. The McKay outbreak spread mainly to the north, with at least 40 square miles of heavy damage centred around the McKay-Chip Lake area, and moderate to light damage north to Whitecourt. The infestation at Smith also increased in size and severity. There was a report of a small infestation near Alexandra Falls in the N.W.T. (McGuffin 1953).

In 1953, the outbreaks increased in area, but decreased in severity. The Rimbey outbreak merged with the one around McKay, with the highest populations in the Chip Lake-Carrot Creek area, and around Crimson Lake. Populations declined in the Smith and Whitecourt areas. Low populations were found from Vimy south to Olds, and around Drumheller (Brown and Cumming 1954, McGuffin 1954). Populations in all areas collapsed in 1954, with only a few small patches of heavy defoliation southwest of Drayton Valley. (Brown, Cumming and McGuffin 1955).

Populations remained at endemic levels in 1955, with the exception of a moderate infestation covering about 40 acres near Keg River in northern Alberta and another at Mile 103 on the MacKenzie Highway. This infestation declined in 1956, and with the exception of the small infestation at Mile 103

MacKenzie Highway and a slight increase around Lethbridge, populations were low throughout Alberta. (Brown, Cumming and Robins 1956, 1957).

MOST RECENT OUTBREAK - 1957 TO 1970

Detection surveys specifically for forest tent caterpillar began in 1957 and were more detailed than those conducted previously. There has been no noticeable break in the continuity, in time, of recent forest tent caterpillar infestations in Alberta, so that this has been considered to be a single outbreak. The survey methods used are described briefly, followed by a history of the current outbreak.

Survey Methods

Detection surveys were conducted entirely on the ground during 1957, 1958 and 1970. From 1959 to 1969, the bulk of the surveying was done from the air, supplemented and checked from the ground where feasible.

Aerial surveys were flown on pre-arranged flight plans, and gave maximum coverage for available flight time. Complete visual coverage was not always possible, especially on dull days or when defoliation was predominantly in the lighter categories. However, during 1963, when the outbreak covered the greatest area, defoliation was predominantly severe and could be seen for up to 20 miles under ideal conditions and consistently for at least 12 miles, and coverage was fairly complete.

The aircraft used were Cessna 172's on wheels and Cessna 180's on wheels and floats, the former where few landings for ground observations were contemplated and the latter where ground observations and collections were to be made and where long flight lines were laid out over remote areas.

The observing crew consisted of two men. One observer occupied the

co-pilots seat, mapping the right hand side of the flight line and assisting the pilot in navigation. The second observer was seated behind the pilot in the left-hand seat and mapped the left side of the flight line.

Mapping was done on 4 or 8 mile-per-inch topographic maps depending on the preference of the observers and the detail expected. Flight speed and altitude depended on conditions of visibility, the distance between flight lines and the predominant category of defoliation. Most of the mapping was done at speeds of 100 to 125 M.P.H. at altitudes of between 1000 and 1500 feet, with occasional drops to lower elevations for closer observation.

In 1967, a comparison was made between aerial and ground surveys to check on the reliability of the former. Several areas in each of the light, moderate and severe defoliation categories were selected by experienced personnel during aerial surveys near the north shore of Lake Wabamun. Defoliation in the same areas was later categorized from the ground, using the following criteria:

Severe: Aspen trees completely stripped and conspicuous feeding damage on other species including under-brush.

Moderate: Occasional aspen completely stripped, most aspen with tops thin; little feeding on under-brush.

Light: No trees showing complete defoliation. Feeding damage confined to top of aspen crowns. Little or no feeding on other tree or brush species.

Nil: No leaves removed from crown of any tree species. Terminal branches with normal foliage.

Trees in each plot were selected at random using a "nearest-tree - bearing" method with 50' between trees. Only dominant, co-dominant, and

intermediate crown classes were included in the sample. One hundred trees in each category of light and moderate defoliation and ten trees in the category of severe defoliation were considered a reasonable sample.

Each sample tree was felled and all branches emanating from one-quarter of the circumference of the tree for the full length of the crown were cut off. Commencing at the outer tip of each branch and working inward to the base every third bundle of leaves was collected and put in a plastic bag. The sample therefore consisted of one-twelfth of the leaves of a tree. All the leaves from one tree were kept together. At the same time 27 samples of 100 whole, uneaten leaves were taken at random from some of the trees. These sub-samples were used to derive an average oven-dry weight for whole, uneaten leaves. The leaves were then stored in a deep-freeze until counts could be made at which time they were brought out, a few units at a time, thawed, counted, oven-dried and weighed. (The leaves remained fresh for 24 hours after thawing). The percentage of defoliation was estimated by subtracting the weight of 100 damaged leaves from that of 100 entire leaves collected from the same tree.

In all cases the aerial and ground qualitative visual estimates of defoliation were in agreement (Table I). Estimates of per cent defoliation, however, varied considerably between observers and deviated from the calculated defoliation by up to 30%. It is evident that estimating per cent defoliation from the ground cannot be done with high precision.

Plots in which defoliation is categorized as light from the ground or from the air had a minimum 20% defoliation as determined by weight of foliage eaten and a maximum of 57% (Table I). Individual trees within the light plots varied from 0% to 100% defoliation, which was identical to the range of

defoliation of individual trees in the moderate plots. The two categories differed in the percentage of trees that were severely defoliated. In the severe plots defoliation was almost 100%. One tree sampled was 53% defoliated, while all other trees had lost 100% of their foliage.

Difficulty was experienced throughout this survey in establishing meaningful categories for defoliation as observed from the air. Consequently, most of the ratings relied heavily on the experience and intuition of the observers. However, the foregoing discussion shows that experienced observers can reliably classify infestations from the air, and that the maps so prepared are a reasonably accurate depiction of actual conditions (Fig. I).

Outbreak History

1957 - Larvae were reported as numerous at 40 points in east central Alberta from Lac La Biche south-east to Czar and east to Elk Island. As the survey in this area was completed during early June, the amount of subsequent defoliation was not known. Elsewhere in central and northern Alberta a few larvae were found near the town of Slave Lake at Spirit River and south of Manning. The small outbreak at Mile 103 MacKenzie Highway disappeared completely. In southwestern Alberta larvae were numerous in many shelterbelts and on native trees.

1958 - A sharp increase in populations occurred in 1958, particularly in east-central and north-western Alberta. The outbreak around Elk Point increased in size and intensity with severe defoliation of aspen occurring over an area of about 4 square miles. In northwestern Alberta larvae were collected at a number of widespread locations; moderate to severe defoliation occurred in small patches of aspen south of Peace River and near Keg River. In southern Alberta, large numbers of larvae were found around Lethbridge, where some severe

defoliation was noted, in the Cypress Hills, in Waterton Lakes National Park and near Willow Creek.

1959 - The outbreak intensified in east-central Alberta and in the Peace River Block in 1959 and spread northward to Fort Vermilion. The infestation around Elk Point increased to over 600 square miles of light to severe defoliation, while severe defoliation of aspen aggregated about 3000 square miles in the Grande Prairie-Peace River area. Populations subsided considerably in southern Alberta.

1960 - Tent caterpillar defoliation in 1960 was characterized by increases in area and intensity in east-central Alberta, a decline in populations around Grande Prairie and a large increase in distribution and abundance along the Peace River from Cadotte River to Fort Vermilion. Numerous smaller patches of light to severe defoliation occurred between the two main centres of the outbreak. About 16,000 square miles of aspen forest were defoliated, about half being in the moderate and severe categories.

1961 - A further extension and intensification of the outbreak occurred in 1961. In east-central Alberta the size tripled to approximately 12,000 square miles, and about 8,000 square miles of aspen were moderately to severely defoliated in and adjacent to the Peace River valley between Dunvegan and Fort Vermilion. A further 6,000 square miles were similarly affected in scattered locations between these major infestations which were effectively linked along the south shore of Lesser Slave Lake.

1962 - The outbreak reached its peak in size and intensity in 1962 when aspen stands over an area of about 75,000 square miles suffered moderate to severe defoliation. The ratio of moderate and severe defoliation to light defoliation increased markedly over 1961. The outbreak spread across north-

central Alberta from the Saskatchewan border to within a few miles of British Columbia and extended north to beyond Fort Vermilion.

1963 - Although the outbreak covered much the same area as in 1962, there were considerable extensions on the southern, northeastern and western fringes in 1963. These increases were offset by population collapses at elevations above 2,000 feet, principally in the Buffalo Head Hills and north of Lac La Biche and Cold Lake.

1964 - Egg sampling carried out in the fall of 1963 indicated that the outbreak would continue in 1964 at much the same level as in 1963. However, after an apparently normal hatch, 7 to 10 days prior to aspen leafing, observers reported that larvae disappeared following moulting into the second instar. Ground and aerial surveys subsequently revealed that the outbreak collapsed to an area of about 15,000 square miles including a southern extension into previously uninfested territory. All that remained of the 1963 outbreak were extremely broken-up patches in east-central Alberta, around Peace River where the outbreak originated, and along the southern periphery.

1965 - A further decline in the outbreak occurred in 1965. Although sampling indicated sufficient egg bands present to maintain the outbreak at the 1964 level, severe larval mortality in early instars reduced the outbreak to about 30 square miles of moderate to severe defoliation around Lake Wabamun and scattered patches in the Vilna-Two Hills area.

1966 - Defoliation of aspen by the Forest Tent caterpillar was restricted to the same general areas as in 1965 although some intensification and southward extension was evident in the Wabamun Lake area. Populations declined around Vilna and Two Hills. Defoliation in moderate and severe categories totalled about 360 square miles.

1967 - The centre of the outbreak shifted southward about 50 miles in 1967. Moderate to severe defoliation of aspen encompassed about 380 square miles, mostly in the southern extension. Larval mortality in early instars reduced the populations around Lake Wabamun, and subsequent feeding caused relatively small patches of moderate to severe defoliation interspersed with larger areas of light defoliation.

1968 - Defoliation was more widespread and severe than in 1967. The outbreak occupied much the same area but with a northward extension to beyond Whitecourt. The defoliation pattern was much more patchy than in 1967. This was largely due to the scattered occurrence of aspen stands in a predominantly agricultural area. Colonies of larvae could be found without difficulty north-east and east of the outbreak area for about 75 miles.

1969 - The area encompassed by the outbreak increased in size by about 15 per cent in 1969 with an extension along the northeastern periphery. Defoliation was more severe in the southern portions than in 1968. Although little defoliation was noted south of Highway 11 between Red Deer and Rocky Mountain House, larvae were numerous at many points as far south as Calgary. Patchiness of defoliation was again evident.

1970 - Infestations were confined to much the same general area as in 1969, although their distribution was extremely patchy, particularly in the southern half of the outbreak area.

REDUCTION IN RADIAL INCREMENT OF POPLAR

FOLLOWING REPEATED SEVERE DEFOLIATION

Barter and Cameron (1955) reported that forest tent caterpillar defoliation caused 42, 52, and 77 per cent growth reduction for each of three

consecutive years of severe defoliation, 29 per cent tree mortality and severe crown injury to living trees. Duncan and Hodson (1958) confirmed that two to three years consecutive defoliation reduces radial growth but reported no significant tree mortality or twig dieback. The latter was confirmed by Hildahl and Reeks (1960). Churchill et al. (1964) concluded that tree mortality increased progressively with increasing consecutive years of severe defoliation.

Severe defoliation by the forest tent caterpillar for four to six consecutive years gave an opportunity to study the relationship between growth loss in aspen trees and repeated defoliation. Plots were chose near the towns of Elk Point, Cold Lake and Bonnyville. The defoliation in each of these plots had been recorded since 1955 by a ground observer, using the criteria described earlier in this report. In each plot 10 trees were selected by the closest-tree-bearing method with a 50 ft. interval. Discs were cut from each tree at breast height and the annual growths for the years 1948 to 1967 were measured. A single set of measurements was taken on each disc, as growth was fairly uniform. Increment borings from four spruce trees growing near the plots were used as checks on growing conditions.

The data indicate that 1957, the year preceding the first year of severe aspen defoliation at Elk Point, was a relatively poor year for spruce growth (Fig. 2). The years 1958 to 1967 were all better than 1957 for the growth of spruce. Therefore, if spruce growth is any indicator of growth conditions for aspen, it seems reasonably certain that most of the observed growth reduction in the three aspen plots during the forest tent caterpillar infestation was due to defoliation by this insect.

The amount of growth reduction increased during the first three or four years of severe defoliation, and then levelled off. In the Elk Point plot,

the trees produced less than 10% of the 1957 growth during each of the last three years of severe attack. Growth reduction was less extreme in the Cold Lake and Bonnyville plots, but the loss was still large, around 80%. The recovery period for trees with four to six years of moderate to severe defoliation appears to be about two years, similar to that reported for trees suffering two to three years of defoliation (Barter and Cameron 1955; Duncan and Hodson 1958; and Hildahl and Reeks 1960).

Probably the most significant result shown by these data is the fact that small (<5") aspen are able to withstand up to six consecutive years of moderate to severe defoliation without any detectable increase in tree mortality. Considerable branch mortality was observed in the Elk Point plot, but this could not be definitely attributed to forest tent caterpillar attack. The losses caused by forest tent caterpillar attack in young aspen therefore appear to be almost entirely in the form of lost increment. However, this conclusion must be accepted with reservation. Duncan and Hodson (1958) could find no evidence that forest tent caterpillar defoliation caused aspen mortality when the stands were examined at the end of the outbreak, yet the same stands showed a relationship between mortality and severity of attack when examined several years later (Churchill et al. 1964).

WEATHER AND FOREST TENT CATERPILLAR SURVIVAL

The forest tent caterpillar overwinters as a fully developed embryo within the egg. It passes through a period of obligatory diapause lasting about three months, and then is normally held in a dormant state by low winter temperatures (Hodson and Weinman 1945). These authors found that high temperatures after the diapause period apparently had an adverse effect on

subsequent survival. In another study, Hodson (1941) showed that high temperatures in March also caused mortality by activating some of the hibernating larvae.

Cool wet weather in the spring, after the larvae have hatched, has frequently been credited with causing the collapse of forest tent caterpillar outbreaks (Blackman 1918, Blais et al. 1955, Brown 1938, Hodson 1941, Sweetman, 1940). Hodson (1941) has shown that the newly hatched larvae are able to withstand low temperatures, but development is very slow at a constant temperature below 25°C. In fact, larvae did not develop beyond the fourth instar when the temperature was maintained at 15°C.

The preceding findings prompted a number of small-scale investigations to determine the role of weather in determining population trends during the current outbreak in Alberta. The results are outlined in the following paragraphs.

Warm overwintering temperatures

The few outbreaks of forest tent caterpillar that have occurred along the eastern slopes of the Rocky Mountains have been of very short duration. The aspen trees in these areas are of poor form, characterized by stunted height growth of 15 to 20 feet; small crowns; heavy branch mortality; and high incidence of diseases. The area is characterized by chinooks, warm dry winds that periodically blow eastward over the mountains throughout the year. In the winter, the mild (40°F-60°F) temperatures during chinooks could be expected to affect survival by causing precocious yolk-utilization of unhatched larvae, or by initiating physiological changes that reduce resistance to the freezing temperatures which follow the chinooks. However, earlier than

usual hatching as a result of increased day degrees due to chinook conditions in winter months has not been detected.

Longley (1967) showed the average number of days reaching 40°F during December, January and February for a number of locations in Alberta. Generally, there have been very few forest tent caterpillar infestations in areas having more than 15 days of chinooks. However, there were two exceptions during the current outbreak. In 1958, several small infestations occurred in this area, but they disappeared in 1959. In 1961, several small infestations were again noted in the area, but these largely disappeared in 1962.

The cumulative day degrees above 40°F for the period October 27 to April 26 were calculated for the year preceding an increase in forest tent caterpillar populations and for the year preceding a decrease for each of several stations in the chinook area of Alberta (Table II). For each station, the number of day degrees for the year preceding the increase was less than for the year preceding the decrease. This does not prove a cause and effect relationship, but certainly suggests that overwintering temperatures may affect forest tent caterpillar abundance in the chinook area.

Warm early spring temperatures

During late February and early March 1968, temperatures in west central Alberta rose above 45°F for 10 consecutive days. Eggs collected in the field following exposure to these unusually warm temperatures were stored at three different temperatures for varying periods of time (Table III).

No adverse effect of the unusual field temperature or subsequent storage is evident. Apparently the embryos remained dormant throughout the warm spell. No larval movement was detected when the freshly collected egg bands were examined under a microscope after being stored for 5 hours at 58°F.

These results appear to conflict with those in the preceding section. However, there were only 141 day-degrees above 40°F from October 27, 1967 to April 26, 1968 at Iacombe, across Gull Lake from Rimbey where the egg bands were collected. Apparently the unusually cool fall more than compensated for the warm spell in late February and early March.

Freezing temperatures after larvae have hatched

To study the possible effects of late spring frosts on hatching forest tent caterpillar larvae, a number of egg bands were collected in the field during September 1964 and overwintered at 38°F. In February 1965 the egg bands were incubated at 72°F until hatching started. Five egg bands were placed in a freezer for 7 days at 12-18°F, 10 were placed at 0-10°F for 5 days, and 10 were left at rearing room temperature (Table IV).

Temperatures of 0-10°F killed most of the larvae that had hatched when placed in the freezer. However, exposure of 7 days to temperatures ranging from 12-18°F caused very little mortality.

Spring snow storms

During the studies of the forest tent caterpillar in Alberta, unusual spring weather occurred on two occasions. In 1958, near Lac La Biche, a cold spell, accompanied by snow and sleet, occurred in early June after the larvae had hatched. In 1965, near Alder Flats, the larvae also had to endure a severe spring storm. Rain commenced on May 16, turned to sleet with winds up to 50 M.P.H., and then to snow. All colonies were covered with $\frac{1}{2}$ inch of ice plus 2 inches of snow. In neither of these cases was larval survival significantly reduced.

A possible explanation may lie in the fact that killing frosts did not occur on either occasion, so that food was available to the larvae once the weather warmed up. Furthermore, both of these cold spells were of relatively short duration.

No other evidence of catastrophic spring conditions was noted during the current outbreak in Alberta, although cool wet springs may have had adverse effects on survival, especially in 1965.

PARASITISM

Mass collections of forest tent caterpillar egg bands, larvae and pupae were made at a number of locations in Alberta during the current outbreak. The material was sent to the laboratory where it was examined and/or reared, in order to determine the rate of parasitism and the species of parasites present for each collection. The procedures were as follows:

Eggs - Ten egg bands were collected from each of a number of plots after hatching was completed. In the laboratory, the numbers of hatched eggs, parasites and dead eggs, were determined.

Larvae - Collections of late-instar larvae were reared to determine larval parasitism. Where feasible, the collections were made in the locations from which the egg bands had been collected.

Pupae - Collections to determine pupal parasitism were made just as adult emergence began. Larvae and empty cocoons were included in the sample, to avoid unnecessary bias, and samples were once again collected from the same areas as the egg bands whenever feasible.

Rates of parasitism - A summary of these parasite records is given in Table V for five different areas. There are gaps in the continuity of data from a number of the areas, especially in the data on egg parasites, and some rearing

difficulties were encountered. In spite of these shortcomings, however, the data do indicate a number of trends.

At no time were egg parasites a major mortality factor. The highest incidence reported was in the High Prairie area in 1964, when egg parasitism reached 16%. The percentage of eggs failing to hatch was generally low: the most noticeable exceptions were the Whitecourt and Elk Point areas in 1962, the Grande Prairie and Peace River areas in 1963 and all five areas in 1965. The widespread increase in egg mortality in 1965 suggests that adverse weather conditions may have played a role in reducing the percentage hatch in this instance.

Estimates of larval parasitism were variable, but there are indications that larval parasitism increased during the course of the outbreak.

Pupal rearing results indicate two significant features. There were low percentages of survival in all five areas in 1963, the year preceding the general population decline, and there was a definite increase in the rate of pupal parasitism towards the end of the outbreak. It must be concluded that pupal parasitism was a major mortality factor late in the outbreak, but it does not account for low survival of pupae in 1963.

Parasite Complex - The parasites reared from eggs, larvae and pupae of the forest tent caterpillar are listed in Table VI. Of the 26 species obtained from rearing, 13 were hymenopterous and 13 were dipterous parasites. Sarcophaga aldrichi Park was by far the most abundant dipterous parasite although it was collected in low numbers until 1964 when population levels increased to tremendous proportions. Pimpla pedales Cress. was the most common hymenopterous parasite collected during the early stages of the outbreak but collections became less frequent during the latter stages. None were collected in 1964 when the infestation of forest tent caterpillar collapsed throughout most of Alberta.

DISEASES

During the larval rearings, a large number of larvae died, apparently of disease (Table V). However, because of the practice of shipping and rearing diseased and healthy larvae together, it was impossible to assess the impact of disease on field populations from these data.

Field observations during the course of the outbreak were limited primarily to the early part of the season. Consequently, very little information was gathered on the general prevalence of disease. However, in 1964, a large number of second- and third-instar larvae that were apparently infected with disease were observed in the field. A sample of these diseased second-instar larvae, collected near Peace River, were submitted to the Insect Pathology Institute, Sault Ste. Marie, and were found to be infected with a nuclear polyhedrosis virus. These were the earliest instar forest tent caterpillar larvae known to have shown symptoms of virus infection (G.R.Stairs, personal communication June 15, 1964), although in 1955, at Summit Lake in the Nelson Forest District of B.C., a disease was reported to have wiped out the population in the early instars (Silver and Ross 1956). No estimates of the percentage infection in the different areas of Alberta are available, although heavy mortality (over 90%) during the early instar was widespread in 1964. The egg bands apparently hatched normally, but the larvae disappeared before causing any appreciable defoliation, and no trace of them could be found.

In 1966 a number of colonies were kept under observation in the Lake Wabamun area. Some of these colonies developed normally until reaching the fourth instar, and then started to die from disease. Most, however, showed disease symptoms during the second or third instar, and many died during the fourth instar. Disease was believed to be a major factor in the decline of

forest tent caterpillar populations in the Lake Wabamun area in 1966. Of the approximately 2000 larvae that hatched, nearly 1800 died of disease during the course of the observations, and over 75% of the remaining 200 larvae appeared diseased when the observations were discontinued.

ACKNOWLEDGEMENTS

The information on the forest tent caterpillar presented in this report was collected by the staff of the Forest Insect and Disease Survey, Calgary. Dr. A.R. Raske, Mr. C.E. Brown, and Mr. J.K. Robins all made significant contributions. Mesrs. J. Petty, D.S. Kusch, N.B. Patterson, F.J. Emond, E.J. Gautreau, G.J. Smith and J.P. Susut played significant roles in the collection of data. My role, as author, has been to try to bring all of this information together, but this would not have been possible without the efforts of all of the aforementioned people.

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TABLE I

Comparison of ground and aerial classification of aspen defoliation

Plot No.	Classification from ground			% defoliation estimated from ground			Classification from the air	Actual % defoliation from calculations
	Observer #1	Observer #2	Observer #3*	Observer #1	Observer #2	Observer #3*		
1	Severe	Severe	Severe	100	95	95	Severe	95.2
2	Light	Light	Light	25	30	40	Light	38.3
3	Moderate	Moderate	Moderate	75	55	75	Moderate	-
4	Moderate	Moderate	Moderate	75	65	60	Moderate	-
5	Light	Light	Light	10	35	20	Light	21.6
6	Light	Light	Light	25	25	30	Light	42.2
7	Moderate	Moderate	Moderate	80	75	70	Moderate	60.8
8	Moderate	Moderate	Moderate	70	60	80	Moderate	61.8
9	Moderate	Moderate	Moderate	70	60	80	Moderate	69.5
10	Severe	Severe	Severe	100	95	95	Severe	100.0
11	Moderate	Moderate	Moderate	65	45	55	Moderate	72.7
12	Light	Light	Light	30	25	25	Light	56.7
13	Light	Light	Light	20	30	15	Light	39.0

* Inexperienced observer.

TABLE II

Day degrees above 40°F during the period October 27 to April 26 for years preceding increases and decreases in forest tent caterpillar populations at several locations in the chinook area of Alberta.

Location	Before increase		Before decrease	
	Years	Day-degrees	Years	Day-degrees
Waterton Park	1957-58	192	1958-59	252
Pincher Creek	1957-58	163	1958-59	217
Lethbridge	1957-58	272	1958-59	329
Lethbridge	1960-61	301	1961-62	421
Rocky Mountain House	1957-58	131	1958-59	219
Rocky Mountain House	1960-61	134	1961-62	233
Medicine Hat	1960-61	321	1961-62	371

Table III

Effect of various storage temperatures and duration on hatch of
forest tent caterpillars egg bands exposed to abnormal
warm temperatures in February and March, 1968 near Rimbey, Alberta

	No. of egg bands	Temp. in storage (°F)	No. of days stored	Incubation period (days)	% Hatch estimated to nearest 10%	No. of days to first molt	No. days between hatch and appearance of virus in 50% of egg bands
Lot 1	20	35	1	6	80	6	20
2	20	0	7	6	80	5.5	22
3	20	10	10	6	80	8.5	26
4	20	25	16	6	80	8	29
5	20	35	28	6	80	6	--

Table IV

Effect of freezing during the hatching period of forest tent caterpillar larvae

Treatment		Number of eggbands	Number of larvae hatched before treatment per eggband	Mortality of hatched larvae after treatment per eggband	Hatch after treatment per eggband	Total larvae hatched per eggband
Temp. °F.	Duration days					
12-18	7	5	5.0	0.4	82.6	87.6
0-10	5	10	16.9	16.2	39.5	56.4
Control						
72	10	10	--	--	--	105

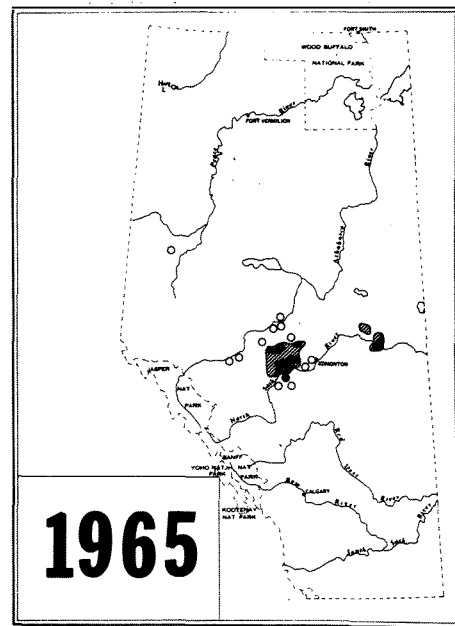
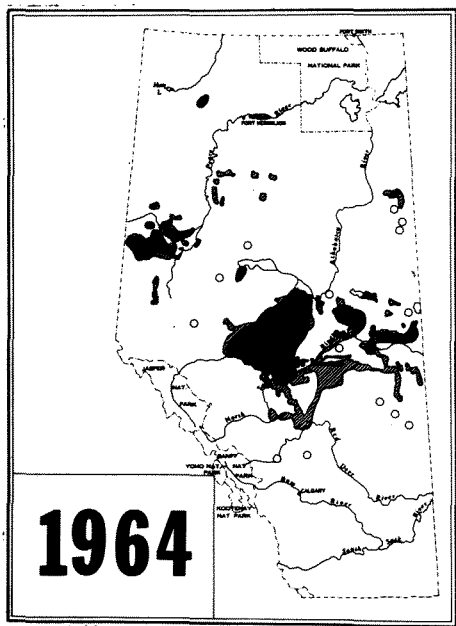
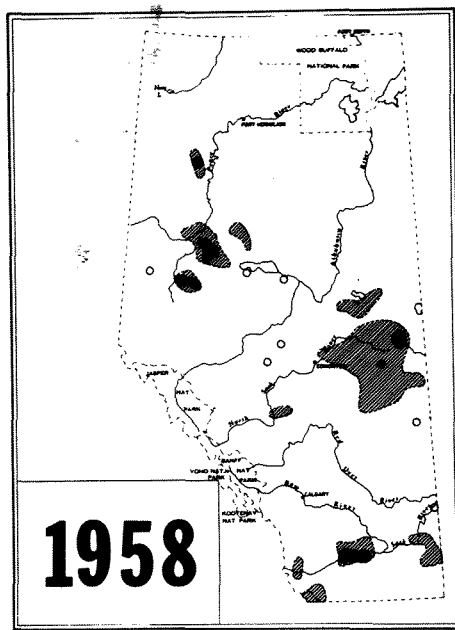
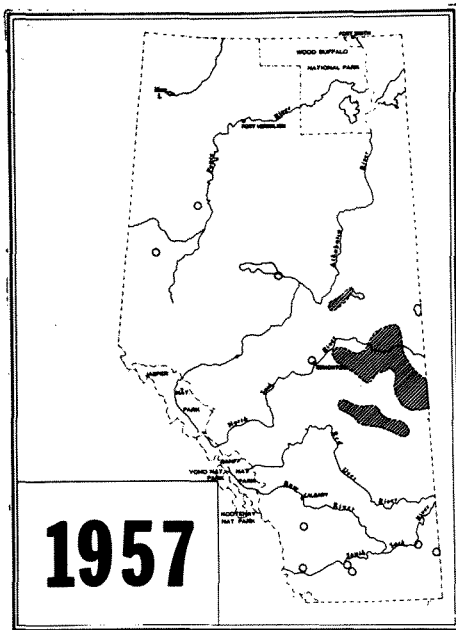
Table V concluded.

Year	Eggs/ band	Eggs				Larvae				Pupae			
		N	S	P	D	N	S	P	D	N	S	P	D
1963	95	85	34	--	66	199	33	7	60	398	10	53	37
1964	146	100	82	6	12	119	48	18	34	228	39	57	4
1965	135	40	60	4	36	--	--	--	--	--	--	--	--
<u>Whitecourt</u>													
1960	--	--	--	--	--	200	30	0	70	200	36	6	58
1961	--	--	--	--	--	191	0	0	100	400	46	9	45
1962	96	11	79	0	21	120	72	2	26	--	--	--	--
1963	--	--	--	--	--	399	18	11	71	127	0	46	54
1964	136	20	93	2	5	184	3	0	97	676	22	48	30
1965	139	20	66	1	32	150	25	0	75	386	33	19	48
<u>Elk Point</u>													
1958	--	--	--	--	--	200	48	2	50	151	38	30	32
1959	248	30	95	1	4	212	40	2	58	321	66	21	13
1960	108	45	95	1	4	974	17	1	82	162	90	10	0
1961	--	--	--	--	--	537	32	12	56	1122	48	32	20
1962	136	54	69	0	31	199	47	1	52	485	42	10	48
1963	--	--	--	--	--	650	22	19	59	1118	16	47	37
1964	236	37	86	--	14	734	53	30	17	184	44	52	4
1965	170	77	62	2	36	--	--	--	--	--	--	--	--

TABLE VI

List of parasites reared from *Malacosoma disstria* 1957-1966

<u>Hymenopterous Egg Parasites</u>	<u>Family</u>	<u>Remarks</u>
<u>Ooencyrtus clisiocampae</u> (Ashm.)	Encyrtidae	Common
<u>Tetrastichus silvaticus</u> Gah.	Eulophidae	Common
<u>Telenomus clisiocampa</u> Riley	Scelionidae	Common
<u>Hymenopterous Larval and Pupal Parasites</u>		
<u>Aphaereta</u> spp.	Braconidae	Rare
<u>Diaeretus</u> sp.	"	Rare
<u>Rogas</u> sp.	"	Common
<u>Iseropus stercorator orgyiae</u> (Ashm.)	Ichneumonidae	Rare
<u>Gambrus canadensis canadensis</u> (Prov.)	"	Rare
<u>Pimpla pedalis</u> Cress.	"	Very common
<u>Scambus tecumseh</u> Viereck	"	Rare
<u>Syrphoctonus</u> sp.	"	Rare
<u>Theronia</u> sp.	"	Common
<u>Theronia atalantae fulvescens</u> Cress.	"	Common
<u>Dipterous Larval and Pupal Parasites</u>		
<u>Pseudosarcophaga (affinis of authors)</u>	Sarcophagidae	Common
<u>Sarcophaga aldrichi</u> Park.	"	Very common
<u>Muscina stabulans</u> (Fall.)	Muscidae	Rare
<u>Megaselia</u> sp.	Phoridae	Rare
<u>Lespesia frenchii</u> (Will.)	Tachinidae	Common
<u>Lespesia melalophae</u> (Allen)	"	Common
<u>Bessa harveyi</u> (Tnsd.)	"	Rare
<u>Carcelia malacosomae</u> Sellers	"	Common
<u>Euexorista futilus</u> (O.S.)	"	Common
<u>Exorista mella</u> (Wlk.)	"	Rare
<u>Leschenaultia exul</u> (Tnsd.)	"	Common
<u>Euphorocera edwardsii</u> (Will.)	"	Common
<u>Patelloa pachypyga</u> (A. & W.)	"	Common



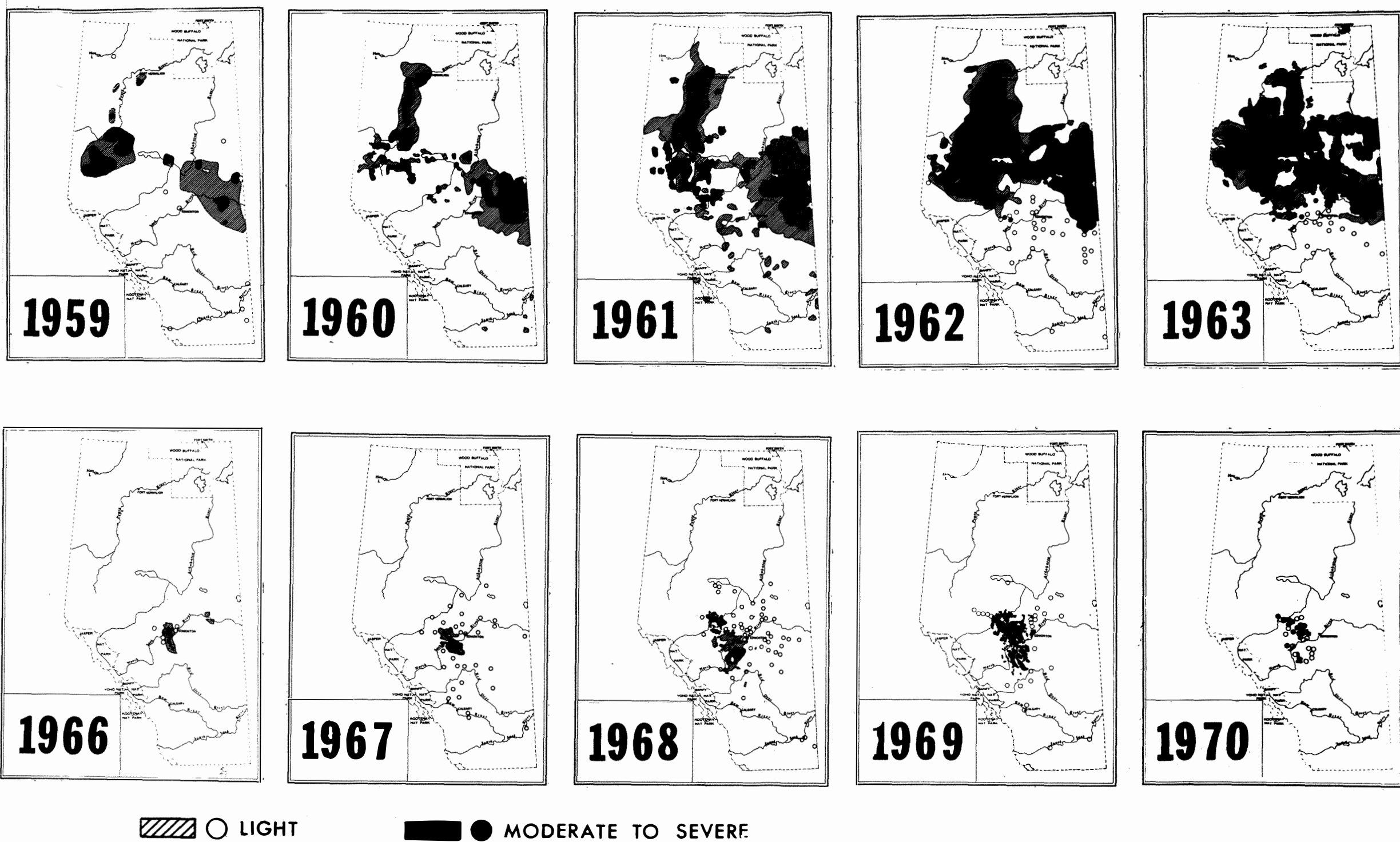


Fig. 1. Forest tent caterpillar infestations in Alberta from 1957 to 1970.

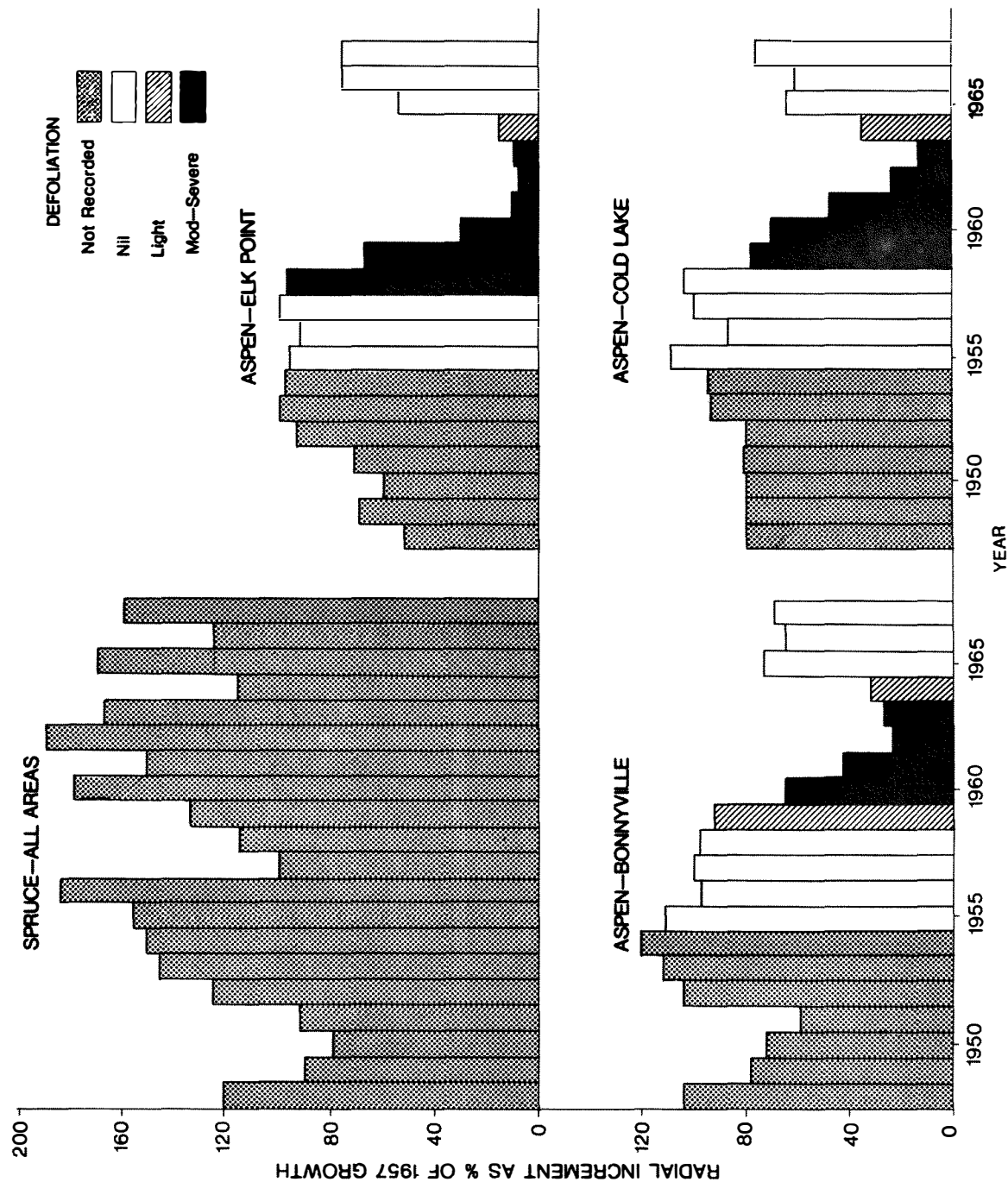


Fig. 2. Annual radial increments of spruce and aspen during the period 1948 to 1967 for three locations in Alberta.