

**FOREST SUCCESSION FOLLOWING THE MOUNTAIN PINE BEETLE OUTBREAK IN KOOTENAY
PARK WHICH OCCURRED DURING THE 1930's**

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ABSTRACT:

During the 1930's, a mountain pine beetle outbreak killed almost 80% of the lodgepole pine on 25,600 acres (10,364 ha) along the Kootenay River in Kootenay National Park. Three even aged stands of pine were infested. The two oldest (130 years and 110 years) sustained the greatest loss and the youngest (60 years) more northerly stand sustained patches of damage toward the end of the outbreak period. Immediately along the highway some trees were salvaged. Fifty years after the outbreak the stand has been surveyed just outside the area where salvage occurred. On the area covered by the outbreak, the new stand is developing towards a mesic montane spruce type. Most of the present trees were alive at the time of the outbreak. Since the outbreak, regeneration, which is largely spruce, has been sparse and uneven.

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IMPACT OF THE OUTBREAK AND RECOVERY OF THE STAND:

The impact of the mountain pine beetle on the volume of evenaged pine stands along the Kootenay River in the 1930's and the recovery over the past 50 years is summarized in Table 1. Prior to the outbreak, the stand volume was 350 cubic meters per hectare. The mountain pine beetle reduced this volume to about 50 cubic meters per hectare. The few residual pines and the understorey of spruce have grown to 200 cubic meters per hectare in the intervening 50 years. At the time of the outbreak it was predicted that the result of the outbreak would be a "spruce type" (2, 1942, FIDS Report). This prediction has largely been realized. The species composition of the present stand is in Table 3. The high percentage of spruce, almost 80% in the present stand, is a strong contrast to the evenaged stand, predominantly pine, which was destroyed by the mountain pine beetles.

THE STANDS PRIOR TO THE OUTBREAK:

Three evenaged lodgepole pine stands were infested during the outbreak. All originated following fires. Furthermore, to the north of this area, in 1926 and to the south, in 1917, fires had occurred which had given rise to regenerating pine stands which contained a small proportion of spruce. At the time of the outbreak, the oldest stand was 130-140 years old and extended from about four miles south of Nixon Creek to two miles north of McLeod Meadows. The second stand was between 110 and 120 years of age and extended from a point two miles north of McLeod Meadows to Dollyvarden Creek. Trees in the third stand were between 60 and 70 years of age. However, a few small groups of mature pines were scattered throughout this stand. This stand extended from Dollyvarden Creek to Kootenay Crossing. Thus from Nixon Creek to Kootenay Crossing there were three zones of evenaged and progressively younger pine stands caused by a succession of fires. A map showing the location of rivers and creeks in relation to the highway to Radium is in Fig. 1.

At valley bottom, where the highway runs close to the Kootenay River, the forest was almost entirely pine. Photographs of the area taken in 1935 show the occasional mature spruce and a small percentage of codominant spruce and spruce regeneration. Published reports on the history of the outbreak and the salvage activities also refer to the spruce understorey and regeneration which was present in the stand at that time (1, 2, 3). The proportion of spruce increased toward the sides of the valley. Up river, approximately in a northerly direction, the proportion of spruce also increased. From Wardle Creek to Vermillion Summit a large percentage of spruce was mixed with the pine.

At the start of the outbreak, pines in the 130 year old stand averaged 11" (28 cm.) in diameter. For the 110 year old stand the average diameter was 8" (20 cm.) and the average diameter of the 60 year old stand was 6.5" (16 cm.).

Stand densities were about 250 stems/acre for the 130 and 110 year old stands. The other stands supported about 400 stems per acre. The basal area, stand volume and average diameter of the two pine stands destroyed in the outbreak is given in Table 1.

TABLE 1

COMPARISON BETWEEN THE ORIGINAL PINE STANDS, THE POST OUTBREAK STAND AND THE PRESENT STAND

	Basal Area m ² per ha	Volume m ³ per ha	Average diameter cms.
Original Stand	28	350	25
Post Outbreak Stand	6	50	21
Present Stand	25	200	31

OUTBREAK HISTORY:

National Parks reported the outbreak to the federal forest entomologists late in 1934. At which time, "the outbreak had assumed huge proportions in the upper Kootenay Valley" (1935, FIDS Report). The area was surveyed in 1935 and seven one acre plots (fig. 1) established to measure the rate of spread and intensity of the infestation. The number of trees attacked on these plots each year from 1935-1944 was recorded. Detailed measurements of attack densities and emergence were made. Also recorded were diameters and crown characteristics, radial growth, bark characteristics and leader growth of regeneration on adjacent areas. The daily temperature and precipitation was obtained from Park's records.

The outbreak started about 1929 in the Kootenay River valley near Pitts Creek in the 130-140 year old stand. There is some anecdotal evidence that outbreaks had been active around Canal Flats and had spread northwest up the Kootenay River., (1935, FIDS Report). It was more active on the east side of the river before 1934 but began to develop on the west side in 1934. By 1937, over 80% of the timber had been killed in this stand south of McLeod Meadows. North of McLeod meadows, in the remainder of the 130 year old stand, 40-50% of the pines had been killed.

The rate of spread of the outbreak declined each year from 1935-1938. By 1938 less than 10% of the stems in the 110 year old stand had been killed. In 1939 and 1940 however, there was a sharp increase in the infestation. By 1941, the three plots in the 110 year old stand had sustained 46, 68 and 79% mortality and the outbreak was active toward the upper timberline on the slopes of the mountains from Meadow Creek northward. Between Dollyvarden Creek and Kootenay Crossing, scattered small groups of mature trees in the 60-70 year old stand had been killed and scattered groups of red trees were throughout the southern part of the Vermillion Valley and extended towards the Simpson River.

The outbreak was over by 1944. On the sample plots 69 trees were killed in 1943 and only two in 1944. In 1944, scattered small groups of red trees were recorded mainly to the north of the main outbreak area. Nothing was reported in 1945 on this outbreak.

The active centre of the outbreak had followed the same progression as the fires which gave rise to the different age classes moving from south to north along the Kootenay River. In total, the outbreak killed about 80% of the timber on 25,600 acres (10,360 ha). The total volume killed was about 111,000,000 cubic feet (3,200,000 cubic meters) which was 85% of the original volume.

During the 14 year period of the outbreak 120 of the 1204 trees killed on the study plots had fallen, about 10% of the trees killed.

Since 1945, there have been infestations near Settler's Pass and periodically scattered small groups of trees have been killed within the area covered by the outbreak in the 1930's. There is now a small outbreak which has been active since 1993 in the stand north of Dollyvarden Creek. This stand was 60-70 years old in 1935.

Fig. 1.

Map showing the boundaries of the outbreak in 1937 and the location of plots.

THE RESIDUAL STAND:

Stand density after the outbreak was less than 70 stems per acre for the 130 year old stand and the average diameter was about 10" (25 cm.), about 1" (2.5 cm.) less than the original stand. For the 110 year old stand, residual stand density was about 100 stems/acre with an average diameter of 7" (18 cm.). Again, about 1" (2.5 cm.) less than the original stand. The residual volume was 50 cubic meters per ha. (Table 1).

In the 60 year old stand, the majority of the killed trees were immediately north of Dollyvarden Creek, that is adjacent to the older stand. At this point, stand density was decreased to about 200 stems per acre and the average diameter declined about 1/2" (1.2 cm.) to about 6" (15 cm.). This younger stand sustained little damage overall. Most of the dead trees were in scattered small groups.

THE SALVAGE PROGRAM:

The Banff-Windermere highway had been built through Kootenay Park during the depression. The tourist traffic which this highway was generating had raised concerns about the fire hazard along the highway. There was also some concern that the large number of dead trees could lessen the steadily increasing flow of tourist traffic.

The salvage work began in January of 1942. Dead trees were cleared by hand logging from each side of the highway. Trees were pulled to two portable mills at McLeod Meadows by a small bulldozer. The small diameter logs were cut into pit props and larger diameter logs cut into 2x4's or 2x6's. (T. Lofting, personal communication).

The edge of the logged area is still evident from the stumps. A strip about 200 yards wide on each side of the highway was cleared.

THE STAND 50 YEARS AFTER THE OUTBREAK:

The area covered by the outbreak in the 1930's now supports an uneven spruce stand. Evidence of the outbreak still exists in the large amount of pine deadfall which is covered in beetle galleries, particularly Ips, although mountain pine beetle galleries can also be found. Few standing dead trees can be found and none can be reliably dated back to the time of the outbreak.

The present stand is progressing toward a mesic montane spruce association. Evidence of the original evenaged lodgepole pine stands remain in the few veteran pines still present, the very small proportion of Douglas Fir and the dominance of Calmagrostis and Pachystema throughout much of the area.

Englemann Spruce accounts for 78% of the standing trees and 88% of the regeneration. The remainder of the stand is mostly lodgepole pine. Small proportions of Douglas Fir, Alpine Fir, Paper Birch and Aspen are also present. Stocking is variable with a few small groups of spruce veterans and several large openings. Regeneration is uneven. Spruce accounts for 88% of the regeneration counted in the plots. One douglas fir and one Alpine Fir seedling were also counted. The pine regeneration is mostly restricted to a few large openings in the driest location. Table 2 lists the tree species and their frequency and the regeneration in the present stand.

TABLE 2**SPECIES COMPOSITION AND REGENERATION IN THE PRESENT STAND**

	Stand Composition	Regeneration
Spruce	78%	90%
Pine	17%	8%
Douglas Fir	2%	1%
Alpine Fir	0.5%	1%
Birch	1%	
Aspen	1%	

About half of the spruce in the present stand were in the dominant and codominant crown class at the time of the outbreak. Most of the remainder were advanced regeneration as the age structure shows (Table 3). The age structure of the pine indicates that almost all of the lodgepole pine were survivors from the largely evenaged stand which was destroyed in the outbreak (Table 3). There have been small periodic mountain pine beetle infestations since 1940 in this forest which has further reduced the numbers of pine over the past 50 years.

TABLE 3**AGE STRUCTURE OF THE PRESENT STAND**

Age	21-40	41-60	61-80	81-100	101-120	121-140	141-160	161-180	181-200
Spruce	2	7	8	12	6	4	5	3	0
Pine	0	2	1	0	1	3	1	3	2

Vegetation in the stand indicates that the association is developing to a mesic or subseric montane spruce association but the openness of the stand has encouraged the persistence of species that were prevalent under the pine stand. *Pachystima*, *Calamagrostis* and *Shepherdia* are common and provide the greatest proportion of the ground cover in three of the locations surveyed. Of the species which are common in spruce habitats, the moss layer is moderately well developed and forms the greatest proportion of the ground cover in areas where the spruce canopy is developing. Subalpine fir is a small component of the stand. A complete list of the species observed is appended.

Site index of the four locations surveyed varies from medium (20) on the driest site to good on the other three sites (22, 23, 23) for the Montane Spruce Association.

A well developed duff layer varied between 5 and 15 cms. depth. Soil is mostly clay with patches of silty material at many locations. The substrate is gravel.

The existing stand appears well suited to Parks uses. There are numerous signs that the area is used by ungulates and porcupines. The many openings provide attractive views of the surrounding mountains and the groupings of mature trees can be used to frame photographs. From the point of view of timber production, however, the stand has not yet recovered to a satisfactory level. It is understocked and is uneven in tree size, age and species.

LIST OF VEGETATION:

TREES

Pinus Contorta*
Picea Glauca
Pseudotsuga Menziesii
Betula Papyrifera
Populus Tremuloides
Abies Lasiocarpa

HERBS**

Achillea Millefolium
Cornus Canadensis
Fragaria Virginiana
Galium Boreale

SHRUBS**

Arctostaphylos Uva-Ursi
Juniperus Communis
Linnaea Borealis
Pachystima Mysinites
Potentilla
Rhododendron Albiflorum
Rosa Spp.
Shepherdia Canadensis
Spirea Betulifolia
Vaccinium Spp.

GRASSES

Calamagrostis Rubescens

MOSSES, FERNS, LICHENS, ETC.

Peltigera Spp.*
Sphagnum Spp.

* Species of trees and mosses are listed in order of their prevalence

** Pachystema and Shepherdia are the most consistent throughout the area . The other species are variable in occurrence and density.

METHODS:

Fifty years after an outbreak of mountain pine beetle, the present stand was surveyed to determine forest succession. Four locations (see Fig. 1) were surveyed between Nixon Creek and Dollyvarden Creek along the Kootenay River. Each location was surveyed by 10 full sweep prism plots at 100 m. intervals. At each location, the initial bearing, elevation, slope and aspect were recorded. Notes on the appearance of the stand, extent of dead fall, insect galleries on the fallen trees and any insect or disease problems were taken. Soil was examined by disturbing the surface material down to the mineral layer and by examining the soil surrounding overturned root systems.

On each of the 10 plots, species and diameter at 1.3 m. height (dbh) were recorded for all sample trees. Also recorded was any physical damage, evidence of disease and damage caused by insects.

For plots two, five and eight an increment core was taken from each tree on the plot. Height was recorded to a maximum of five trees per plot. For plots with more than 5 trees, trees were selected to include a range of diameters.

For plots three, six and nine a 3.1 m. radius plot was established and regeneration by species and height class (0.1, 0.5, 1.0, 1.5 and 2.0) were counted. Also recorded was the vegetative cover by species and by the approximate percentage of ground cover for each specie.

LITERATURE:

1. G. R. Hopping and W. G. Mathers, 1945, Observations on Outbreaks and Control of the Mountain Pine Beetle in Lodgepole Pine Stands of Western Canada, *Forestry Chronicle*, 21(2):1-11.
2. G. R. Hopping, 1951. Forest Entomology in Relation to Silviculture in Canada: Part V The Mountain Pine Beetle, *Forestry Chronicle*, 27:26-29.
3. G. R. Hopping, 1951. Timber Types in Relation to Insect Outbreaks in the Canadian Rocky Mountains, 81st Annual Report of the Ent. Soc. Ontario, 72-75.

SOURCE MATERIAL FOR THE KOOTENAY PARK OUTBREAK:

The Kootenay Park outbreak was monitored by George Hopping between 1935 and 1942. The outbreak was reported late in 1934, at which time it "had assumed huge proportions in the upper Kootenay Valley", and was inside the Park along the Settlers Pass Road. Progress of the outbreak was followed by annual counts of trees killed by mountain pine beetle on a series of one acre plots on the west side of the Kootenay River. The results together with maps, observations on the factors which influenced the spread of the outbreak and some photographs are in the Annual Reports of the Vernon Forest Insect Laboratory and are on file in the library of the Pacific Forestry Centre.

Summaries of the information contained in the pertinent Annual Reports of the Vernon Forest Insect Laboratory are listed below.

1935 The initial survey of the infestation is reported in 1935. The major block of dead trees was on the east side of Kootenay River near Pitts Creek. The report contains a series of photographs of the infested area and the adjacent mountain slopes which show many small patches of dead trees.

The photographs show stands which are mostly pine with the occasional mature spruce, patches of deciduous trees and some spruce in the understorey.

The location and description of the plots is included and notes on the infestation and the outlying patches of dead trees.

Discussion with the park warden is mentioned which indicates that the outbreak started in the Park in Settlers Pass near the Cross River about 1929. Some anecdotal information is included which indicates that the outbreak had spread into the Park from the Canal Flats area.

1936 This report lists the attack on the study plots and includes notes on the location of patches of infestation outside the main outbreak.

1937 Trees killed by beetles on each study plot from 1934 to 1937 are listed and notes on the spread of the infestation included. It was concluded that the infestation was almost at an end. Extensive notes on predators and parasites are included.

1938 A complete list of trees on the seven study plots, trees that had been attacked in each year and whether they died or survived is in this report. The seven sample plots, located near McLeod Meadow, Kootenay National Park, were checked each year since 1934, with observations made on parasites and predators. Green unattacked, green attacked; turning; and dead trees have been recorded each year as well as those which have fallen.

1939 Trees attacked in 1938 and 1939 are listed. Also included are notes on the spread of the outbreak and on the activity of parasites and predators.

1940 There is no information on the outbreak in this year's report.

1941 The 1941 report contains a detailed analysis of the outbreak history and observations on the extent of the patches of dead trees outside the main outbreak. Also included is an analysis of the volume killed and the control program.

1942 The 1942 report provides an analysis of the stand before the outbreak and a review of outbreak history. The major and minor bark beetles which were prevalent during the outbreak are discussed. Temperature and precipitation records are also listed. The relationship between several tree characters and attack by bark beetles is analyzed. Diameter growth of attacked and nonattacked trees was analyzed and also leader growth of nearby regeneration. Attack patterns and attack/emergence ratios for various species of bark beetles was calculated by diameter class.

George Hopping concluded "the probability is that in lodgepole pine stands approaching maturity or overmature, the removal and utilization of all trees above ten inches in diameter would reduce the bark beetle hazard materially. An even greater reduction in the hazard could probably be attained by utilization of all trees above eight inches in diameter. This would accomplish two desirable things; it would remove high hazard trees and at the same time produce ideal conditions for spruce reproduction. A much more desirable stand for park purposes and one much less susceptible to bark beetle attack would result."

1943 A summary of the outbreak history by plot is given. Also included is a record of the killed trees that have fallen on each plot.

1944 The status of each plot is summarized.