AN UNEXPLAINED DECLINE IN VIGOR OF LODGEPOLE PINE [1]

By A. K. PARKER [2]

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ABSTRACT

A condition of decline in vigor of pole-sized lodgepole pine (Pinus contorta *Dougl. var.* latifolia *Engelm.), characterized by a marked reduction in radial increment, bark lesions, and a general deterioration of the crown, is described. The relationship of the decline to pole blight of western white pine* (Pinus monticola *Dougl.) is discussed.*

INTRODUCTION

An unexplained condition of decline in vigor of pole-sized lodgepole pine was first noted in a lodgepole pine-spruce-balsam[3] stand in the Manning Park region of southern British Columbia in 1951 (2). The condition was subsequently noted several hundred miles away in a Douglas fir-white pine-lodgepole pine[4] stand near Creston at the southern end of Kootenay Lake, and in a white pine-lodgepole pine-Douglas fir stand near the headwaters of the Kettle River.

Preliminary studies indicated that affected lodgepole pine were characterized by a general deterioration of the crown, bark lesions, and reduced radial increment, and that a species of *Leptographium* Lag. & Melin occurred in association with bark lesions. since these symptoms were suggestive of pole blight (5), a decline in vigor of western white pine of considerable importance, further studies were undertaken to clarify the symptom picture and to determine the nature of the association of *Leptographium* sp. with bark lesions.

METHODS

A total of 48 trees was felled, sectioned, and examined in detail. Measurements were made of radial and crown growth, and culture samples were taken from lesions on trees affected by decline.

Isolations were made from the culture samples by removing small cubes of bark or wood aseptically and placing them on potato-dextrose agar in culture tubes.

Inoculations were made with 10-day-old, single-spore cultures growing on potato-dextrose agar. Inoculum was placed on the outer bark of trees or in wounds made by removing aseptically with a cork borer a piece of bark 5mm. in diameter.

Samples for histological examination were placed in formalin-alcohol-acetic acid fixative immediately after collection. Sections were made with a sliding

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[3] *Picea Engelmanni* (Parry) Englm. and *Abies lasiocarpa* (Hook.) Nutt.

[4] *Pseudotsuga menziesii* (Mirbel) Franco and *Pinus monticola* Dougl.

microtome and staining was carried out by the method of Cartwright and Findlay (1), modified by leaving the sections in safranin for 2 hours rather than 20 to 60 seconds.

Results

Symptoms

A marked reduction in radial growth appeared to be the first symptom to occur on trees affected by decline (Fig. 1). Although all trees showed some reduction of radial growth, trees with decline in vigor were characterized by a drastic reduction in increment with annual growth rings as small as 1 mm. Bark lesions (Fig. 2) appeared to be the second symptom in order of occurrence, although a sudden reduction in leader growth sometimes occurred simultaneously. All trees selected for analysis on the basis of crown symptoms possessed one or more bark lesions and displayed a marked reduction in radial growth.

Most lesions occurred in the first 16 ft. of the main stem, but some were found on the main lateral roots and in the mid and upper portions of the bole. Lesions were not found on branches. No correlation was found between the number of lesions and the severity of decline of individual trees. Resinosis generally occurred on the outer bark covering lesions (Fig. 3). The length of lesions varied from 0.5 to 40.0 ft. and the width from 0.5 to 4.0 in. The average lesion extended 6 ft. and was 3 in. in width.

The crown characteristics of 20 trees with symptoms of decline and 10 healthy trees in a stand near Creston are presented in Table 1. Leader growth

TABLE 1

Crown Characteristics of Lodgepole Pine Affected by Decline in Vigor, Near Creston, B.C.

Crown characteristics	Trees affected by decline (20 trees)		Healthy trees (10 trees)	
Yearly leader growth (in.)[1]	6	(2 - 11)	12	(10 - 15)
Needle-bearing stem (in.)[1]				
Leader	27	(5 - 54)	59	(48 - 84)
Upper crown	17	(6 - 32)	30	(28 - 33)
Needle length (in.)	2.7	(1.9 - 3.0)	2.8	(2.6 - 3.0)
Needle color (no. of trees)				
Normal green	18		10	
Yellow green	2		—	
Crown density (no. of trees)				
Normal	7		10	
Thin	13		—	
Length of live crown (ft.)	30	(12 - 45)	44	(30 - 52)

[1] Average annual growth with range for the 5 years prior to measurement.

was reduced considerably in most trees and was as little as 2 inches each year for several years in trees in a late stage of decline. The length of needle-bearing stem in the upper crown was reduced on nearly all affected trees and was least on trees in a late stage of decline. However, only 4 of the affected trees had needles shorter than those on healthy trees and only 2 of the affected trees showed pronounced discoloration of the foliage. Nevertheless, as decline progressed the size and density of the crowns of affected trees became less; on trees affected by decline the average length of live crowns was 32% less than on healthy trees. Thinning of the crowns resulted from needle fall and a tendency of upper branches to form right angles with main stems rather than acute angles. Crowns appeared to be dying from the bottom towards the top (Figs. 4, 5, 6).

Symptoms similar to those of the trees near Creston were associated with declining trees in Manning Park and in the stand near Kettle River, although quantitative measurements varied. Trees in the three areas varied from 40 to 170 years of age and were representative of all crown classes. On the basis of radial growth analyses it was found that the decline in vigor had been in progress in the Manning Park, Creston, and Kettle River areas since at least 1936, 1940, and 1942, respectively. A number of dead trees were associated with the declining trees in the three areas and there was no evidence that affected trees could recover once decline in vigor began. It was found that trees may be in a state of decline for at least 15 years prior to death.

Isolation of fungi from bark lesions

Samples for culturing were taken from 83 bark lesions which occurred on trees in the three sample areas (Table 2). A species of *Leptographium* was isol-

TABLE 2

THE INCIDENCE OF *Leptographium* ASSOCIATED WITH BARK LESIONS ON LODGEPOLE PINE

Location of stands	No. of lesions cultured	No. of lesions yielding *Leptographium* sp.	Percentage of lesions yielding *Leptographium* sp.
Manning Park	23	18	78
Kettle River	2	2	100
Creston	58	20	34
Total	83	40	48

ated from 40 of these lesions. No other fungus was isolated from more than 2 lesions. A blue-stained or pronounced resin-soaked appearance of the sapwood beneath bark lesions always occurred in samples from which *Leptographium* sp. was isolated.

The fungus isolated during this study does not appear to be *Europhium trinacriforme* Parker, the fungus with a *Leptographium* imperfect state found associated with lesions on white pine affected by pole blight (4). No perfect state has been found in the field for the *Leptographium* sp. associated with lesions on lodgepole pine, and numerous matings with the isolates obtained from lodgepole pine with *E. trinacriforme* failed to produced a perfect state in culture.

Perithecia of *E. trinacriforme* are readily produced in culture when compatible isolates are mated (3).

Inoculation of lodgepole pine with *Leptographium* sp.

Leptographium sp. was tested for pathogenicity by inoculating the main stems of 27 healthy pole-sized lodgepole pine. Inoculum was placed on each tree at 6 points on the outer bark which had not been wounded, in 4 to 6 wounds which extended to the outermost part of the inner bark, or in 4 to 6 wounds which extended to the sapwood. A control point was established on each tree for each type of inoculation. After three months, lesions had not been produced at any of the 24 inoculation points where the bark was left intact and at only 12 of the 20 inoculation points where the wound extended only to the outermost part of the inner bark. Lesions were produced at all 82 inoculation points where the wound extended to the sapwood. All lesions resulting from the inoculations were associated with a pronounced resin-soaking of the underlying sapwood. The resin-soaking became blue-stained in a few weeks when sections of the main stems of trees containing lesions were allowed to dry slowly. Lesions were similar in shape to the lesions which occurred in trees affected by decline in vigor and resin occurred on the outer bark overlying the lesions.

The main stems of 7 pole-sized lodgepole pine affected by decline in vigor were inoculated with *Leptographium* sp. Inoculum was placed on each tree at 5 points on the outer bark which had not been wounded, or in 4 to 5 wounds which extended to the sapwood. Care was taken to avoid the areas of existing lesions. After three months lesions had not been produced at any of the 15 inoculation points where the bark was left intact, but lesions were produced at all 18 inoculation points where the wound extended to the sapwood. Sixteen of the lesions were associated with a pronounced resin-soaking and 2 with blue-staining of the underlying sapwood. Artificially-produced lesions were similar in shape to naturally-occurring lesions, and resin occurred on the outer bark overlying the lesions.

Histological examination of lesions

Samples were taken for sectioning from 5 lesions produced as a result of inoculation with *Leptographium* sp. and from 12 lesions occurring on 5 trees affected by decline. Hyphae were numerous and drops of resin were readily seen in sections made from the 5 lesions produced as a result of inoculation with *Leptographium* sp. and from 4 naturally-occurring lesions associated with blue-stained and resin-soaked sapwood. Hyphae were most abundant in ray parenchyma, but they also occurred in the tracheids where they passed from cell to cell through the bordered pits. Sections of samples with resin-soaking contained hyaline hyphae, while sections with blue stain contained hyaline and dark colored hyphae. There was no evidence of fungi or bacteria in the slides made from samples of 8 lesions without associated blue stain or resin-soaking, nor was there any indication that they had been present.

Discussion and Conclusions

The crown symptons of decline were those that might be expected to occur as a result of any one of a number of factors affecting tree vigor. Lesions oc-

curred so infrequently on trees and affected so little of the circumference, that it is unlikely that they influenced crown symptom development. Since a sharp reduction in radial increment appeared to be the first symptom to occur, it is most likely that crown symptoms are a further reflection of the factor or factors responsible for the loss of radial growth.

The sapwood beneath all lesions from which *Leptographium* sp. had been isolated, and beneath all lesions produced as a result of inoculation of wounds with the fungus, was either resin-soaked or blue-stained. Other samples, however, showed no evidence of resin-soaking or blue-staining; the sapwood beneath 40% of the lesions sampled failed to show either symptom, and histological examination failed to show any evidence of hyphae. From the data obtained in this study, therefore, it would appear that, although *Leptographium* sp. may be associated with, or perhaps cause some of the lesions occurring on trees affected by the decline in vigor, many lesions are of unknown origin. Further investigation would probably reveal an association similar to that found between *Europhium trinacriforme* and lesions on white pine affected by pole blight; namely, invasion of lesions already formed from causes of unknown origin (4).

Decline of lodogepole pine and pole blight of western white pine are both characterized by a marked reduction in radial increment, bark lesions, and a general deterioration of the crown. With the exception of differences in crown symptom development, which may be attributable to differences in species characteristics, the two conditions appear similar. Despite this apparent similarity between the two disorders, however, there is no evidence of extensive damage in lodgepole pine similar to that reported in white pine. The full significance of the similarity between the two diseases will remain unknown until the causal agent or agents are determined.

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FIGURE 1: Cross section through a bark lesion showing reduced radial growth.
FIGURE 2: Part of a bark lesion on the main stem of a tree with bark removed.
FIGURE 3: Resin from an underlying bark lesion on the surface of the main stem of a tree affected by decline in vigor.
FIGURES 4 to 6: The crowns of three lodgepole pine affected by decline in vigor. In Figures 4 and 6 healthy crowns may be seen to the left of the trees affected by decline in vigor.

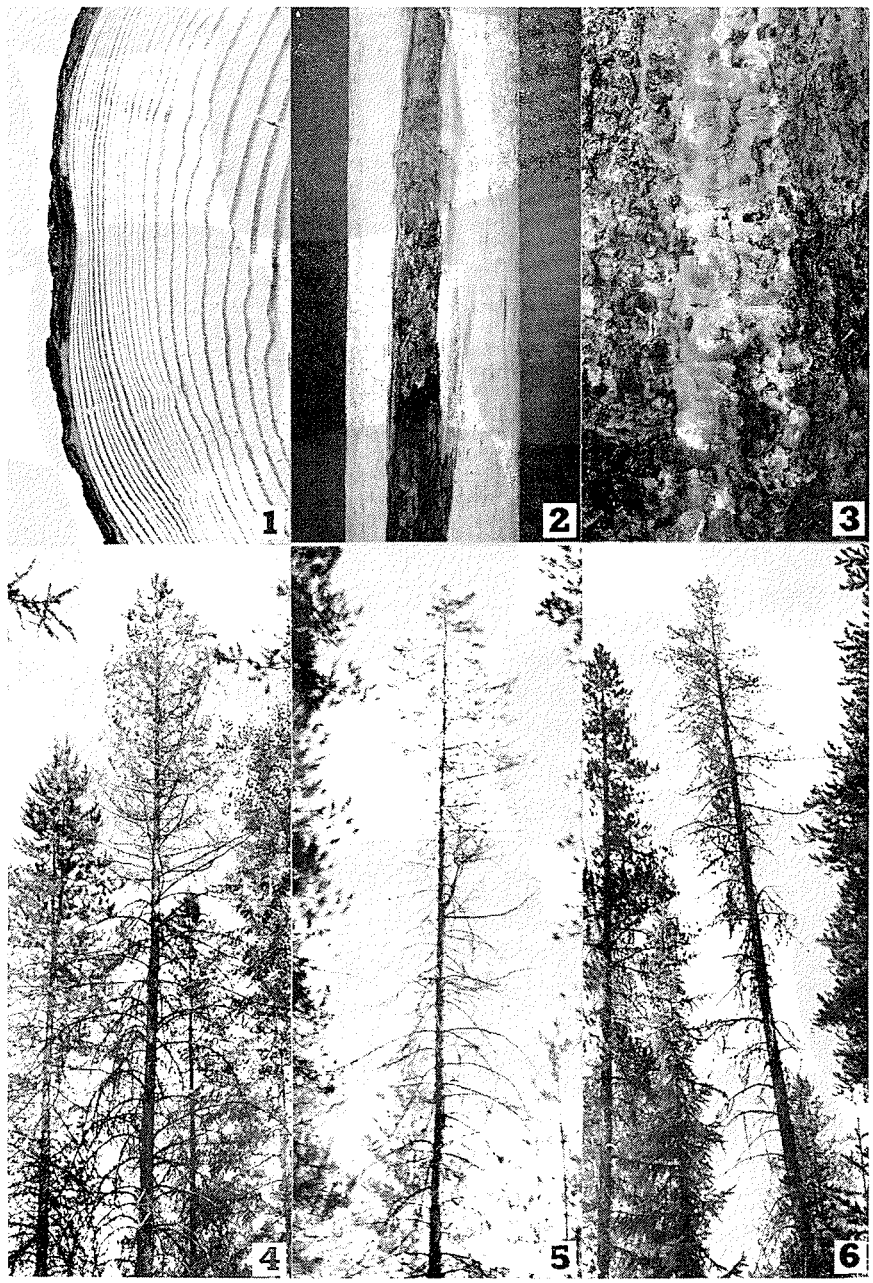

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FIGURE 1
White spruce stump, showing heavily buttressed variant of usual rooting habit.

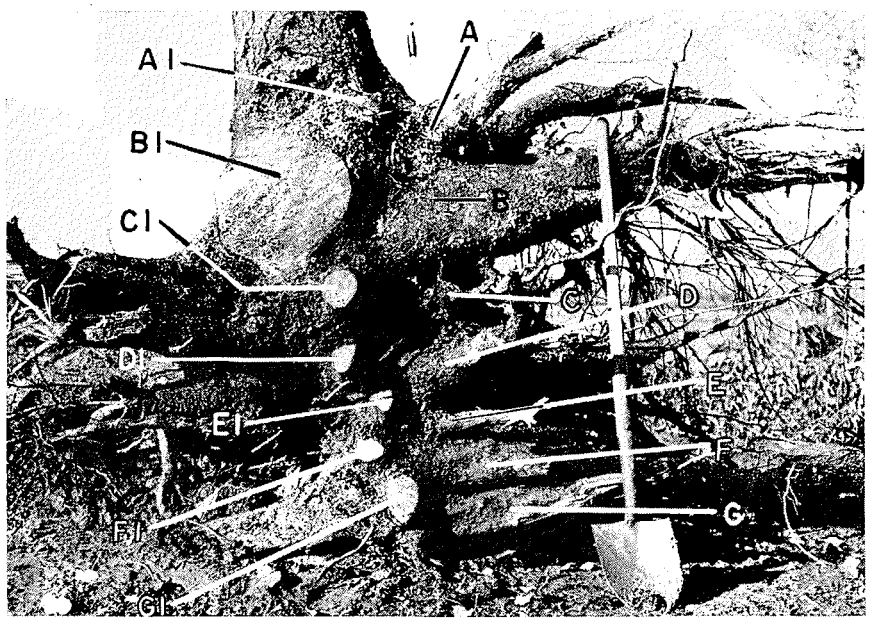

FIGURE 2
Multi-layered variant of white spruce rooting habit.