

WINTER INJURY OF LODGEPOLE PINE FOLIAGE

By L. B. MACHATTIE

Forest Research Branch, Department of Forestry, Canada

IN the Rocky Mountain forest reserves of western Alberta horizontal streaks are visible on a few mountain slopes almost every spring as a result of injury to lodgepole pine (*Pinus contorta*) foliage the previous winter. This injury is called 'red belt'. It affects spruce (*Picea glauca*) and Douglas fir (*Pseudotsuga menziesii*) as well as lodgepole pine, but it is not so obvious on the first two species because their needles fall off soon after being injured.

Red belt may appear as a narrow horizontal stripe, or as a broad band on a mountainside, or it may (less commonly) affect extensive valley-bottom forests. This paper discusses a case of valley-bottom injury which occurred the winter of 1955-56 at a broadening of the Kananaskis river valley (50°53'N, 115°9'W). The reddish discoloration of the affected foliage was so pronounced it was quite noticeable from a distance of five miles.

In the literature, red belt has been associated with Chinook winds, the injury usually being attributed to desiccation (Henson 1952, Boyce 1948).

Any proportion of a tree's foliage up to 100 per cent may be killed. However, even when all the current foliage is killed the buds sometimes survive, in which case tufts of fresh green needles appear at the ends of the branches in early summer. A comparison of radial growth after red belting with that before indicates that growth is reduced in proportion to the fraction of foliage killed.

PHOTOGRAPHIC DATA

The accompanying colour pictures, taken in June 1956, illustrate two points:

1. Snow-covered foliage is not affected (Fig. 1) (see p. 304). The protective role of snow cover applies down to fractions of a needle. When the snow has apparently been lying on top of a branch the upper needles remain green even though those growing on the underside of the branch have been reddened. Or, if the snow has not completely covered the upper needles, their tips may be red while the rest remains green.
2. The windward side of trees is injured more severely than the lee side. Exposed trees or parts of trees are often injured while those sheltered in a stand are not. The windward aspect of a knoll or a hollow shows much more injury than the lee aspect (Fig. 2) (see p. 304).

Though red belt appears more frequently on slopes exposed toward the south it also occurs on northern exposures.

TIME OF OCCURRENCE

In the Kananaskis case illustrated, the extensive reddening of valley bottom forest was first noticed by the district forest ranger during a routine inspection in February 1956. The height of the boundary between green lower foliage and red upper foliage in Fig. 1 indicates that snow had accumulated to a depth of 1 to 2 feet on the ground before the weather factors causing red belt occurred.

Snowfall data from the nearest climatological station (the headquarters site of the Kananaskis Forest Experiment Station, 12 miles north-north-east down the Kananaskis river valley from the red belt site), show that no significant falls occurred before 20 December. The total snowfall previous to that date was 6.5 inches, from four falls of 1 to 2 inches each. Each fall was separated by a week or more from the others. For the period 20–23 December Kananaskis reported snowfall totalling 11 inches; another 5 inches fell on 27–28 December. Similar snowfall data from two neighbouring climatological stations in this section of the Rocky Mountains indicate that the late December snowstorms were general, and that they were the earliest that could have given 12 inches or more of snow on the ground in the red belt area.

Thus the time of occurrence of the weather factors which caused this instance of red belt is restricted to the period between mid-December and February.

CAUSE OF INJURY

One usually thinks of low temperature or a sudden temperature drop as the most likely thermal cause of injury to plants. However, plant injury may also occur during or subsequent to thawing, especially if the thawing is rapid (Levitt 1956, p. 116). Repeated freezing and thawing may increase an injury from which a plant cell could have recovered after a single freezing, and may therefore lead to death.

Henson (1952) states that neither warm nor cold air alone is likely to produce red belt; alteration between the two is required. He records a suggestion of C. G. Riley's that the damage pattern indicates killing of needles during a rise in temperature when snow is on the ground and trees. The Kananaskis data for 1955 appear to support Riley's suggestion.

A sharp temperature drop had been experienced in mid-November without apparent injury. The sequence of daily maximum and minimum temperatures is given in Table 1.

The most significant occurrence between mid-December 1955 and February 1956 appears to have been the sharp temperature fluctuations in the period 21–27 December. Successive daily maximum and minimum temperatures are shown in Table 2. Lacking thermograph records, one cannot tell what fluctuations occurred within the diurnal cycle.

The surface wind data for 25 December shown in Table 3 suggest that a Chinook type of cross-mountain wind was blowing, but only reaching the surface part of the time. This would give alternations between residual cold



Fig. 1. Looking west-north-west toward Mt. Kidd, 2 miles distant, showing 15-20 year old lodgepole pine whose lower branches have been protected by snow



Fig. 2. Looking north-west showing variation of injury with topography; the north-east aspect escaped injury



Rare Halo in 'Arctic Smoke' on Lake Geneva (see page 319)

Photograph by O. M. Ashford

TABLE 1. Kananaskis daily extreme temperatures, 9-13 November 1955

Date	..	9	10	11	12	13
Max. °F	..	50	44	38	-9	-15
Min. °F	..	40	28	-13	-28	-32

TABLE 2. Kananaskis daily extreme temperatures, 20-28 December 1955

Date	..	20	21	22	23	24*	25	26	27	28
Max. °F	..	-7	35	37	36	—	34	37	35	20
Min. °F	..	-17	-10	17	-18	—	-24	29	-5	-13

* Data for the 24th are missing.

TABLE 3. Hourly winds, Kananaskis, 25 December 1955

Hour ending	..	1	2	3	4	5	6	7	8	9	10	11	12
Prevailing direction	..	NW	SW	NW	S	SW	SE	SW	NW	SW	SW	SE	SW
Total mileage	..	1	1	2	1	7	4	9	7	8	8	3	8
Hour ending	..	13	14	15	16	17	18	19	20	21	22	23	24
Prevailing direction	..	SW	SW	SW	NW	SW	SW	SW	SW	SW	SW	SW	SW
Total mileage	..	25	25	24	17	15	16	12	9	12	14	13	14

Note: Chinook winds blow from the south-west at this Station.

air and mild Chinook air at the station and account for the 58°F diurnal range. Somewhat similar wind variations occurred on 21-22 December.

The red belt injury described above is thought to have resulted from sharp temperature rises during the period 21-27 December occasioned by arctic air in the valley bottom being abruptly displaced by strong Chinook winds bringing warm dry air down to the surface and impinging with particularly sudden and lethal effect on exposed needles, trees and slopes.

REFERENCES

- BOYCE, J. S. 1948 *Forest pathology*. xii+550. McGraw-Hill Book Co., New York
- HENSON, W. R. 1952 Chinook winds and red belt injury to lodgepole pine in the Rocky Mountain parks area of Canada. *For. Chron.*, **28**, p. 62-64
- LEVITT, J. 1956 *The hardiness of plants*. vii+278. Academic Press Inc., New York

REFLECTIONS IN FLOOD WATER

The photograph on page 209 of our July issue which shows cloud reflections in flood water at Lustleigh, Devon, was taken by Mr J. I. Meardon. We apologize for the omission of this acknowledgment.