bi-monthly research notes

A selection of notes on current research conducted by the Canadian Forestry Service and published under the authority of the Minister of the Department of the Environment. A French edition is published under the title of Revue bimestrielle de recherches. It is the editorial policy of the Canadian Forestry Service Bi-monthly Research Notes that the names of members of review boards considering manuscripts submitted for publication shall not be disclosed. Manuscripts submitted for review will be accepted for consideration only on this basis.

PATHOLOGY

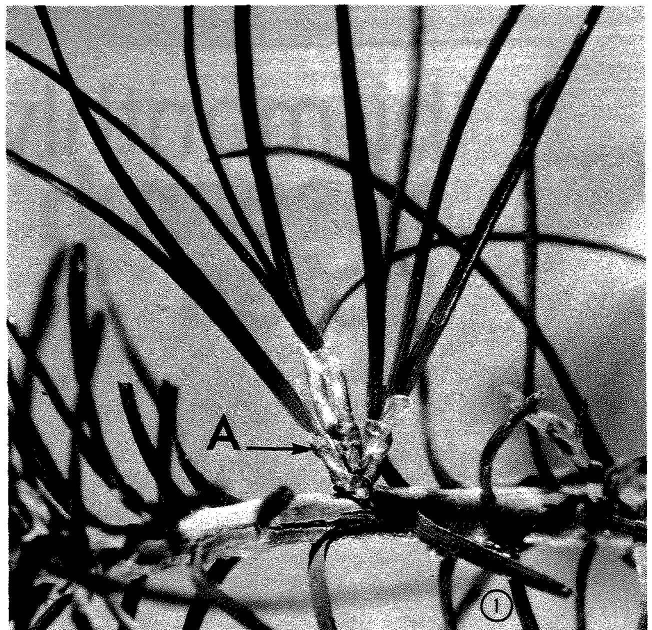
Lodgepole Pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) Shoot Abnormalities from Frost Injury.—Frost damage to phloem and buds can affect growth characteristics of new bud primordia (Zalasky, Bi-mon. Res. Notes 34:26-27, 1978) and subsequent development of shoots in lodgepole pine. The damage normally occurs when ground-level diurnal temperatures fluctuate drastically during prolonged dormancy, during May-June flushing, or during the ensuing development of new terminal buds. Undesirable phenophase shifts and adverse somatogenic changes follow. This paper describes new-dwarf-shoot abnormalities that arise from somatogenic damage to the phloem and buds of lodgepole pine seedlings.

Two groups of lodgepole pine seedlings were studied: one group was container-grown and field-outplanted in 1976; the other was container-grown and either field-outplanted or overwintered outside in 1977. The 1976 seedlings were reared in the greenhouse at 20° C and 20-h photoperiod for 16 wk and were then outplanted in Mayon lodgepole pine clear-cuts near Grande Prairie, Alta. The 1977 seedlings were reared under the same greenhouse conditions for 10 wk and in a growth chamber at 20° C and a 15-h photoperiod for 4 wk before being hardened for 2 wk at 6° C and 1 wk at 1.6° C without change in photoperiod. Some were then outplanted at the time on clear-cuts at Grande Prairie. Others were overwintered outside the greenhouse for various storage periods from September to April. After being moved to standard conditions in the greenhouse, the seedlings were transplanted and tested for frost damage and shoot rejuvenation. No comparisons were made between treatments, because the shoot abnormalities were similar for both groups.

Observations on microscopic deviations of new shoots in field-planted and overwintered seedlings were made over two or three growing seasons and one growing season, respectively. Similar observations were made on natural seedlings regenerated on the same clear-cuts in which the experimental seedlings were planted. Microscopic examination of the internal anatomical features was performed on macerated wood of new shoots obtained after growth had ceased (Zalasky, Bi-mon. Res. Notes 34:13-15, 1978).

Two types of abnormal short shoots were observed in the outplanted and overwintered containerized stock: clustered short shoots (Fig. 1) and sprouting short shoots (Figs. 2 and 3).

The clustered short shoots, with two to five fascicles (Fig. 1), developed on the stems of seedlings with frost-damaged phloem. Frost damage to the phloem during September-May triggered development of clustered short shoots from basal cluster primordia in the phloem. Each short shoot contained two needles (A in Fig. 1). Cluster primordia occurred after the spring flush either in axils of primary needles, where short shoots normally develop, or as outgrowths of needle internodes (A in Fig. 1). Each seedling had one to several outgrowths of clustered short shoots. In general, the seedlings were in good condition, and their terminal buds flushed to form normal leaders. Clustered short shoots usually increased the foliage density but did not form buds, unlike sprouting short shoots.



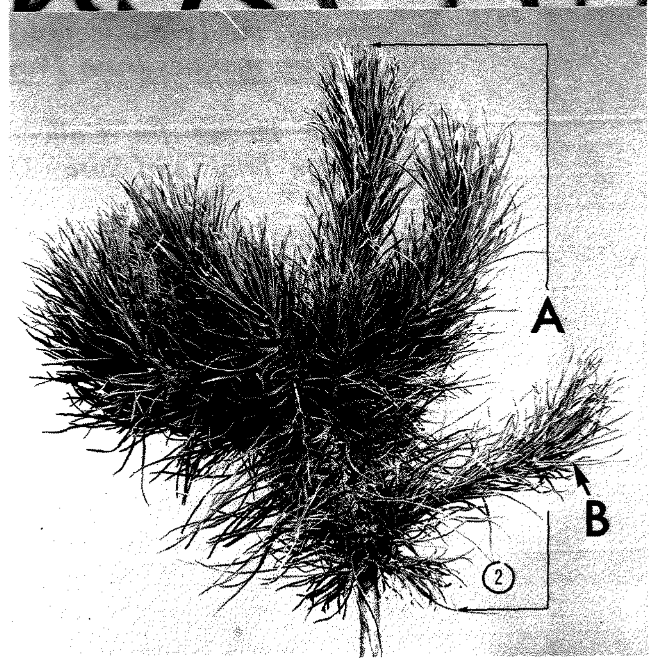


Figure 1. A seedling shows a cluster of five intercalary short shoots (A) developed from clustered primordia in the frost-injured phloem of a lodgepole pine overwintered in a container.

Figure 2. An outplanted lodgepole pine tree shows a bushy-growth habit (A) after all sprouting short shoots have either partly or fully developed into interfoliaceous shoots. A normal branch (B) developed before the seedling was frost injured.

The sprouting short shoots developed terminally from latent buds in the center of needle fascicles and resulted in interfoliaceous shoots (Figs. 2 and 3), which have been described by Morohin (For. Abstr. 17:194, 1956) as long shoots on short shoots. Such abnormal short shoots are recognized by their broad, flat, tapered needles in fascicles of two or three (A in Fig. 3) and by buds in various stages of dormancy. Smaller-than-normal interfoliaceous buds flushed either in the year of their production or in the following year. The abnormal shoots that developed from them resulted in two variations in crown form: the bushy (round) type and the flat-top type.

The bushy (round) crown form occurred in seedlings with a terminal bud killed entirely or partially during the winter months. The killing resulted in the production of a small number (mostly 1 to 12) of sprouting short shoots with interfoliaceous buds. These seedlings showed the most erratic shoot development, because frost damage to root and shoot tips resulted in delays in root and shoot regeneration. Such seedlings foliated sparely by producing new secondary needles developed in the axils of dead primary needles. Frost-damaged seedlings with only one or two living primordia and no living foliage from the previous year were weakest in development and survival. Very few interfoliaceous buds flushed in 1977: the majority overwintered anf flushed in 1978. Interfoliaceous buds on upper short shoots developed earlier than those on lower short shoots and produced candles (competing shoots) with primary and secondary needles or with secondary needles only. The affected seedling lost its natural symmetry and became bushy and multiwhorled from an overabundance of short horizontal lateral shoots, 65 of them counted on one stem measuring 8.5 cm (A in Fig. 2). Shoots were spindly, and only a few developed mature wood in basal parts (B in Fig. 3). Immature shoots were killed by frost in September.

In the second variation, a limby, flat-topped seedling with basket-whorled branches was produced. Occasionally healthy, undamaged seedlings flushed normally in the spring and produced vigorous first-cycle leading shoots. Low June temperatures often triggered primordia of new leading shoots to flush and produce up to 25 sprouting short shoots with active interfoliaceous primordia and broad, thick secondary needles. These active interfoliaceous primordia developed into buds that flushed immediately or throughout the season until September. Buds enlarged about to the size of a normal bud flushed and produced mostly two-cycle shoots during July-August; a few buds showed even a third partial flush in September-October. Some buds remained dormant (A in Fig. 3)and flushed throughout the next season. Normally buds flush only during May and June in the second season of development. Two changes occurred during abnormal flushing: an additional internode appeared between the unflushed bud and the short shoot, and the interfascicular internodes that followed flushing were abnormally elongated, measuring up to 2 cm.

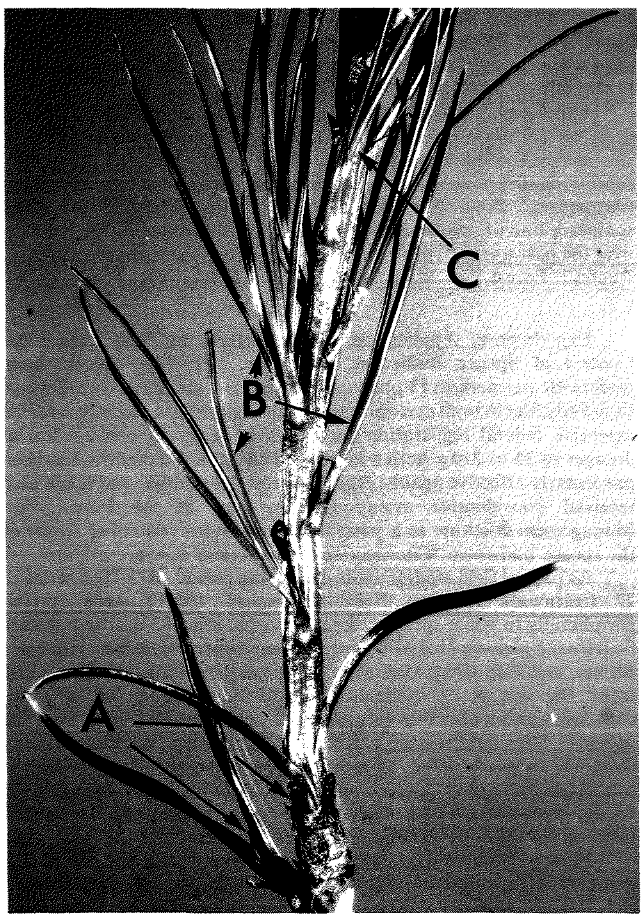


Figure 3. Two sprouting short shoots: (A) one has a bud and one has develope into a two-cycle interfoliaceous shoot; (B) the first-cycle portion shows two- and three-needle short shoots: (C) the second-cycle shoot starts with needles only half as long as those in B, the first-cycle portion.

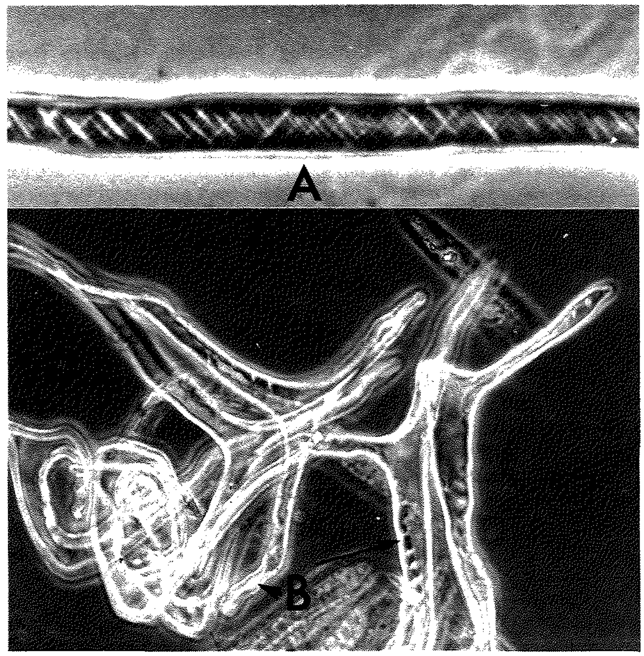


Figure 4. Summerwood tracheids from one of the interfoliaceous short shoots with (A) spiral thickenings in the tracheid and (B) branched, curvate tracheids.

Interfoliaceous shoots had an immature green periderm, well-spaced scales, and short shoots with two- and three-needle fascicles in their basal parts (first flush) as in B of Fig. 3. The late second flush formed short, tufted shoots with needles half as long as those in the first flush (B and C in Fig. 3). The longest shoots terminating with a bud in August were spindly to vigorous, often needleless in the lower half, and measured 20 cm. Affected seedlings with basket-whorled branches were limby and flat-topped, but height growth was not retarded as it was in the bushy variation.

The tracheids of spindly interfoliaceous shoots were immature; summerwood tracheids were long, slender, and straight, with or without spiral thickenings (A in Fig. 4). A few tracheids from brashy (short-grained) wood were curvate and branched (B in Fig. 4). Tracheid anomalies of frost-affected seedlings are similar to those in frost-affected juvenile trees and in mature timber (Zalasky, Can. J. Bot. 53:1888-1898, 1975) where trees have been affected by frost throughout the life of the stand.

Frost-damaged trees have an abnormal phenology of shoot development (Zalasky, Can. J. Bot. 34(4):26-27, 1978), slower height increment and crown closure, and increased risk of mortality from subsequent frost injury to late-maturing shoots (Ruden, For. Abstr. 23:227, 1962). The total fiber and timber yield are reduced because of a brashy wood and a greater number of large limbs. Because of growth retardation, which persists for 5 to 6 yr, bushy trees are subject to culls (Kienholtz, J. For. 31:392-399, 1933). Interfoliaceous shoots from flat-topped trees should not be used for scions, because tissues of this wood tend to grow into cone-shaped nodules and do not serve effectively as vascular tissues in graft unions (Zalasky, Can. J. Plant Sci. 56:501-504, 1976).—H. Zalasky, Northern Forest Research Centre, Edmonton, Alta.

ISSN 0317-6908

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Vol. 36, No. 5, SEPTEMBER-OCTOBER 1980

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