Ottawa. — W.T. Johnson, J.C. Cunningham, W.J. Kaupp, and J.C. Edwards, Forest Pest Management Institute, Sault Ste. Marie and Ottawa, Ont.

BOTANY

Variation in Fascicles, Primordia, and Phyllotaxy of Lodgepole Pine, *Pinus contorta* Dougl. var. *latifolia* Seedlings after Frost Damage. — Pine is often frost-damaged with resulting stem canker, bud injury, or needle browning (Zalasky, Can. For. Serv. Inf. Rep. NOR-X-190, 1977). The tissues most affected by frost are the bark and cambium of the stem (Zalasky, Can. J. Bot. 53:1888-1898, 1975) and the needles and primordia. This paper describes variable changes in growth characteristics of primordia, fascicles, and phyllotaxy of frost-damaged field-grown and overwintered containerized lodgepole pine seedlings.

Containerized seedlings were reared in the greenhouse by using Spencer-Lemaire containers, peat, a recommended fertilizer regime (Environ. Can., North. Forest Res. Cent. For. Rep. 5(4):6, 1976) and a 20-h photoperiod. In experiment 1, 16-week-old containerized seedlings were outplanted on two sites in late May 1976, 80 km south of Grande Prairie, Alta., to determine the occurrence and effects of frost damage in field plantings. Daily weather records were kept from May to October. In experiment 2, 17-week-old seedlings in containers were put outside in the nursery at Edmonton, Alta., during December 1976 and maintained under a 15 cm cover of perlite and snow until 20 April 1977. They had been reared for 10 weeks in the greenhouse and 7 weeks in the growth chamber,

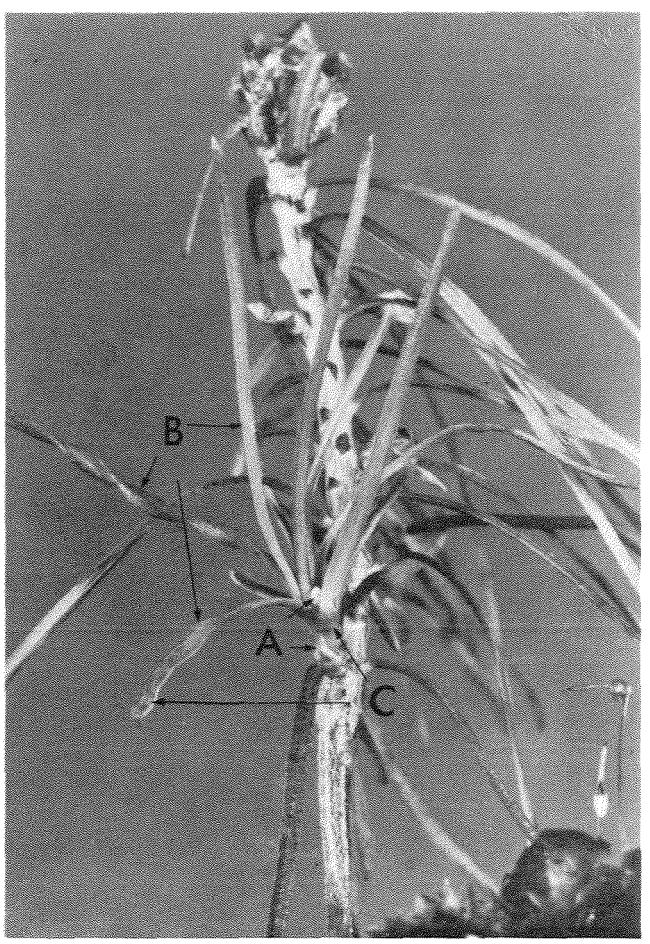


Figure 1. A short shoot with 12 secondary needles. A, vestigial needles; B, variable-length needles; C, flat, broad, needle base, or occasionally a whole needle. The leading shoot above and all the primary needles were frost-killed; primary needles droop.

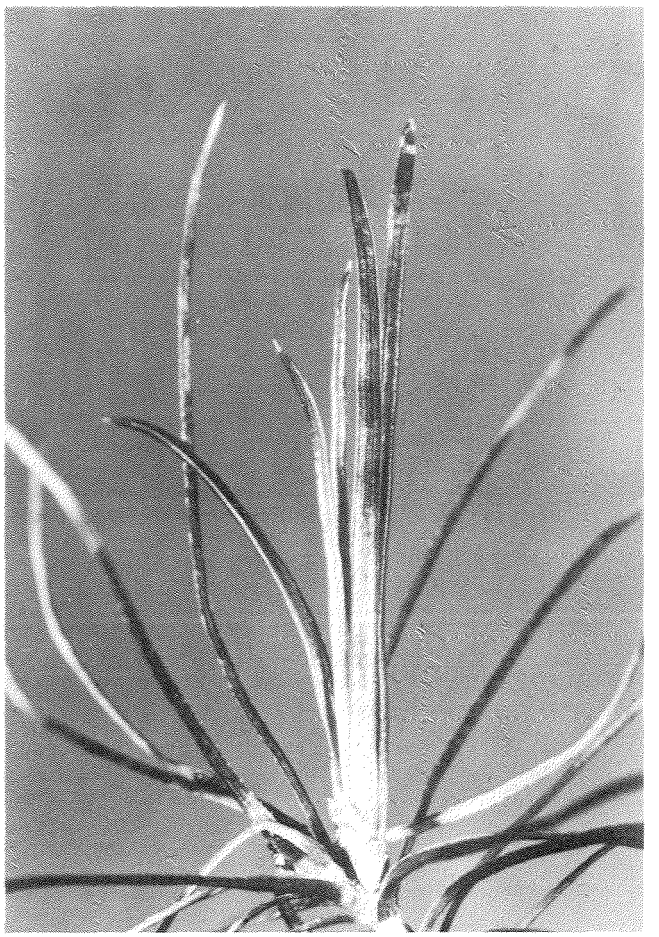


Figure 2. Short shoot showing five needles with broad flat bases. The leading long shoot bears healthy primary needles.

of which 4 weeks were at 20°C, 2 weeks were at 6°C, and 1 week was at 1.6°C. Surviving damaged seedlings from experiment 2 were then maintained in the greenhouse through the summer to determine their growth characteristics. Observations were made daily over a period of two growing seasons in experiment 1 and one growing season in experiment 2. Frost damage was recorded after an early or late frost in experiment 1, or after a spring thaw in experiments 1 and 2.

In a healthy seedling the primary needles are followed by secondary needle production on short shoots produced in the axils of primary needles. The primary needles are single and the secondary needles are in fascicles of two. Secondary needle production is maintained thereafter from apical and lateral buds or leading shoots. Seedlings of experiments 1 and 2 had primary needles and rudiments of short shoots and terminal buds at various stages of development when the experiment was started.

In most of the surviving seedlings from both experiments, frost damage resulted in dead, drooping, primary needles (Fig. 1); a few also had dead buds and small dead areas of bark. New needles of most surviving seedlings developed from existing lateral and terminal buds capable of producing candles of predetermined bicyclic growth (Bollmann and Sweet, N.Z.J. For. Sci. 6:376-392, 1976; Sweet and Bollmann, *ibid.*, 393-396, 1976). Some undamaged existing buds had a sterile needle zone at the base. The buds without a sterile needle zone were of two categories, those with uniformly developed needle primordia and those without. Those without uniform development usually produced the first needles in the lower midsection. Those with a sterile needle zone were subtended by a few tiers of advanced needle primordia followed by gradually smaller primordia toward the apex of the bud. In buds having two sterile zones, the advanced needle primordial zone was interrupted by a short sterile zone

followed by smaller needle primordia toward the apex. Newly proliferated adventitious buds were produced in seedlings only if existing buds were permanently damaged, failed to break, or broke belatedly.

Sterile zones in candles of damaged seedlings were entirely or intermittently leafless to the subapical area of the new shoot and measured up to 5 cm in length. Variable changes occurred in the number, shape, and size of secondary needles per fascicle as a result of sterility, fusion, or proliferation of tissues at the primordium. Occasionally a pair of secondary needles was fused, and frequently one was missing or vestigial (Fig. 1,A). Needles of abnormal fascicles were of diverse length (Fig. 1,B), ranging from a few millimeters to 14 cm. The variable-length needles tended to be tapered in the upper part, but thicker, flatter, and broader toward the base (Fig. 1,C). Short shoots that developed during May on the more vigorous plants often contained three, four, or five (Fig. 2) usually uniformly long needles per fascicle rather than the normal two measuring only 3-5 cm in length. Stunted seedlings developed new foliage belatedly only from adventitious proliferated buds, which produced stunted or very long needles. The stunted ones were usually primary and the long ones secondary needles. Distortion in shape and thickness was greatest in the primary needles. Stunted seedlings had very few short shoots, usually one, bearing up to 12 needles (Fig. 1).

Phyllotaxy of new shoots in frost-damaged pine seedlings varied in compactness and order of primary and secondary needles on first and second cycles of shoot growth. Variation was also accentuated by the presence or absence of June buds and scales at the end of the first cycle and the production of secondary needles in the absence of new primary needles. Thus, primaries were occasionally followed by a repeat flush of new primaries produced by a June bud. Secondaries, or primaries and secondaries, were often interrupted by a scale-scar region to be followed by compactly arranged secondaries, or primaries and secondaries. Or, lateral buds and a second-order scale-scar zone intervened between two compactly arranged tufts of secondaries. These examples of repeat flushes in frost-damaged pine were observed to arise from June buds in both experiment 1 and experiment 2. Repeat flushes are usually characterized by short shoots with two- and three-needle fascicles similar to those reported to occur in frost-damaged red pine (Kienholtz, J. For. 31:392-399, 1933); the needles of the earliest flushed short shoots are longest. — Harry Zalasky, Northern Forest Research Centre, Edmonton, Alta.

ERRATA

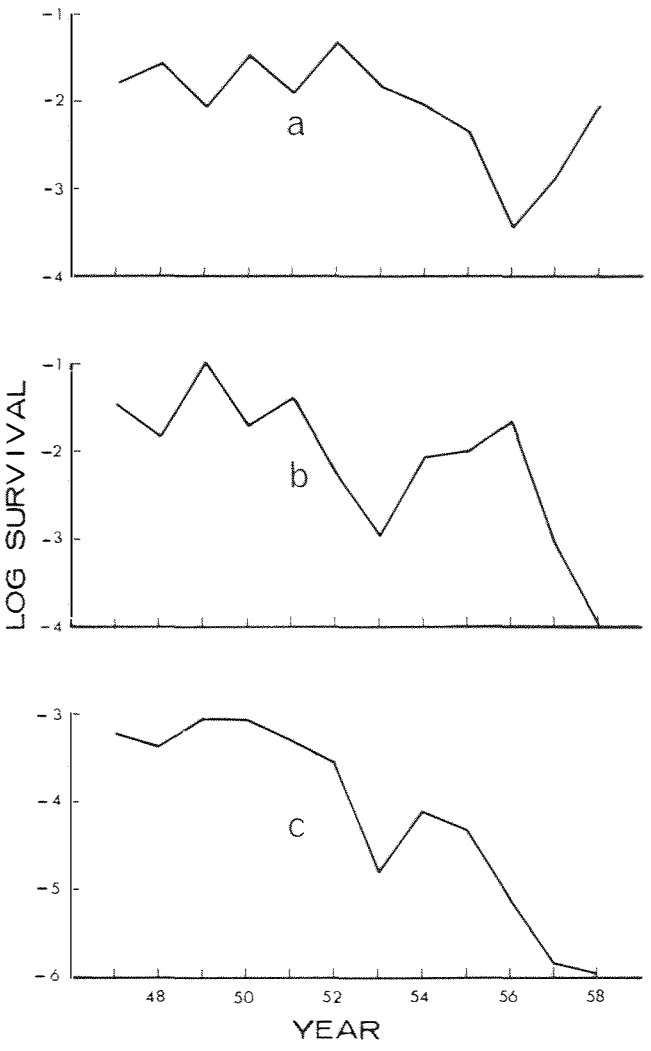
In the table on page 8 (vol. 34, no. 2) the symbols for male and female were incorrectly presented. The corrected table is as follows:

TABLE 1

Trap catches of *Dendroctonus rufipennis* (Kirby) at empty control cages and test cages containing spruce bolts, Naver Forest, 1975

Test area	Trapping days	Numbers of *D. rufipennis* caught					
		Control cages (empty)			Test cages (bolts)		
		♂	♀	♂ + ♀	♂	♀	♂ + ♀
A	35	0	0	0	4	5	9
		1	3	4	7	7	14
		0	0	0	5	5	10
		0	0	0	3	3	6
		0	0	0	7	7	14
B	31	0	0	0	2	6	8
		0	0	0	3	5	8
		0	1	1	1	3	4
Totals		1	4	5	32	41	73

On page 9, col. 1, line 9 (vol. 34, no. 2) *reviewed* should read *viewed*. In the figure on the same page all numbers on the vertical axis should be prefixed by a minus sign, as shown in the reproduction that follows.



ISSN 0317-6908

bi-monthly research notes

Vol. 34, No. 4, JULY-AUGUST 1978

Fisheries and Environment Canada
Forestry Service

Pêches et Environnement Canada
Service des forêts