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BI-MONTHLY RESEARCH NOTES

A selection of notes on current research conducted by the Canadian Forestry Service, Department of Fisheries and Forestry

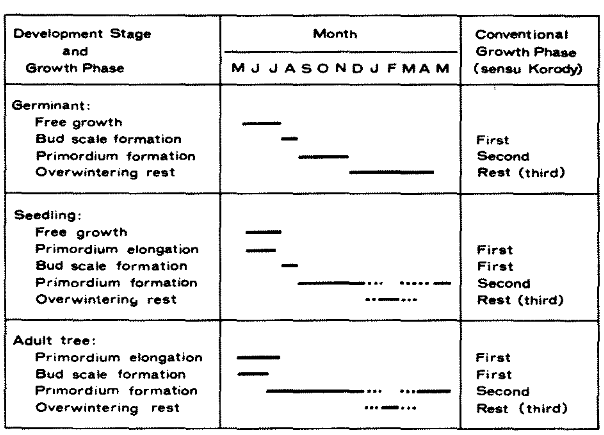
BOTANY

Changes Due to Age in Apical Development in Spruce and Fir.—The literature on morphogenisis of the shoot apex in spruces and firs beyond the seedling stage has been reviewed by Clowes (Apical meristem, Blackwell Sci. Publ., Oxford, 1961). Korody (Beitr. Biol. Pflanz. 25: 23-59, 1937) separated three main phases of growth in the meristematic tissues (Fig. 1): (1) elongation of the shoot primordium after bud-break and simultaneous development of bud scales for the next overwintering bud; (2) formation of primordium for the next year's leader; and (3) a rest period with no significant primordial development, ending with bud-break the next spring.

As delayed bud formation after spring bud-break is commonly observed on juvenile conifers under favorable growth conditions, the pattern for trees is not applicable to seedlings. No comment was found in the literature to explain the difference in developmental pattern in seedlings.

Leaders of spruce and fir seedlings of different stages of life grown under natural or controlled conditions, were collected during the four seasons for 7 years. For comparison, branch or leader tips of mature trees were also sampled. Specimens of *Picea glauca* (Moench) Voss., *P. rubens* Sarg., *P. mariana* (Mill.) BSP., *P. abies* (L.) Karst., and *Abies balsamea* (L.) Mill. growing in the Maritimes Region were obtained.

Gross anatomical and microscopic examinations of the seedling samples grown under natural conditions revealed five growth phases (Fig. 1): **Primordial shoot elongation** (of preformed stem and needles) beginning at the time of bud-burst; **Free growth** of additional non-preformed stem with new needles on it (Fig. 2); **Bud scale formation** for the terminal bud, as during the first phase on old trees; **Primordial shoot formation** starting immediately after formation of bud scales and proceeding intermittently throughout the **Overwintering phase.** The free growth phase is the only evident growth on germinants (first-years seedling), it is typical on young seedlings, and absent on old trees. Development of primordial shoots was obviously slowed during the winter; except for the most severe few weeks of mid-winter, however, dormancy was not evident.



Note: Broken line marks intermittent action.

FIGURE 1. Yearly cycle of growth phases of the shoot apex on germinants, seedlings, and adult trees of spruce and fir in the Maritimes.

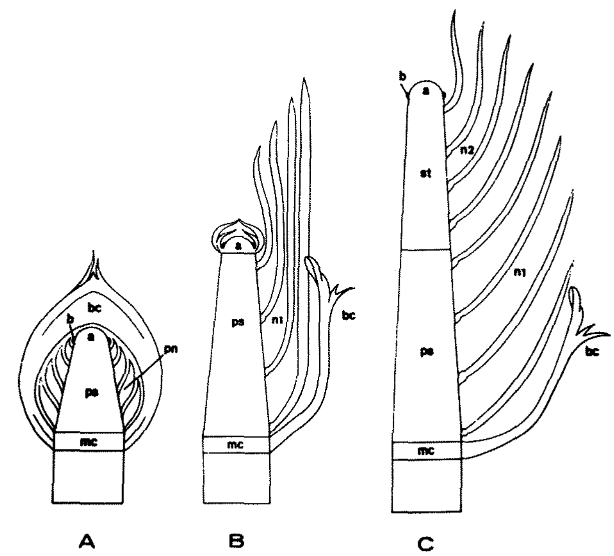


FIGURE 2. Comparison of shoot development from the spring primordium (A), in mature trees (B, after Korody) and young seedlings (C). Legend: bc—bud scale coat, b—buttress, a—apex, pn—primordial needle which extends to form n_1 —primary needle, ps—primordial stem, mc—medullary cavity, st—stem portion formed by free growth, n_2—needles formed *de novo*.

Although the pattern of development of a germinant is sharply distinguished from the pattern of succeeding years, no such definite distinction can be made between a seedling and a tree beyond seedling age. There is a gradual transition during which the free growth phase diminishes in about 5 to 10 years after germination. During these years, while bud formation depends primarily on availability of growth factors (Jablanczy, unpubl. results), the silviculturalist has a challenge to take advantage of the non-proformed free-growth potential.—A Jablanczy, Forest Research Laboratory, Fredericton, N.B.

ENTOMOLOGY

Attack by the Spruce Beetle, Induced by Frontalin or Billets with Burrowing females.—Previously we reported (Chapman and Dyer, Bi-Mon. Res. Notes 25:31, 1969) strong cross attraction between the Douglas-fir beetle, [*Dendroctonus pseudotsugae* Hopk.] and the spruce beetle, [*D. rufipennis* (Kirby)]. Pitman and Vité (Ann. Ent. Soc. Amer. 63:661-664, 1970) found that frontalin, the principal pheromine of the southern pine beetle, *D. frontalis* Zimm. (Kinzer *et al.*, Nature 221: 477-478, 1969) was also produced by the female Douglas-fir beetle. In combination with camphene it was attractive to this insect, and it induced attacks in the field. We now report that frontalin induced spruce beetle attacks on *Picea engelmannii* Parry and *P. glauca* (Moench) Voss during tests conducted in British Columbia, near Elko (East-Kootenay mountains) and Naver (Prince George district) in 1970. We also found that frontalin combined with alpha-pinene or spruce billets attracted spruce beetles, although not as effectively as billets with females.

Trees were baited by placing small plastic caps of frontalin (>99.2% purity) at or near breast height. Axe-cuts were made near the caps to supply the host-tree volatiles. Frontalin was tested for attractiveness, using a sleeve olfactometer (Gara, Vité and Cramer, Contrib. Boyce Thompson Inst. 23: 55-66, 1965) and polyethylene covered cages on which barrier traps were mounted, as in our earlier cross-attraction tests. For comparisons of beetle response, spruce billets with attacking females were used as sources of attraction. Many trees were baited by hanging such billets against them 3 to 5 feet above ground.

At Elko, olfactometer tests during early beetle flights showed that frontalin, released from vials in combination with alpha-pinene, beta-pinene or 3 carene, attracted spruce beetles. For example, on June 5 and 6 during 4.6 hours of testing, 61, 40 and 37 beetles per hour were attracted to these combinations, respectively, as compared with 22 per hour responding to an uninfested billet. However, during later flights, June 18 to 21, more beetles responded to a billet with 15 attacking females than to the frontalin and alpha-pinene combination (71 and 18, respectively, during 3.7 hours of testing). The cage-trap units showed that although beetles were attracted to frontalin with alpha-pinene, females in billets were more attractive (Table 1).

TABLE 1
Flight-trap catches at cages in three[1] replications of five different sources of attraction

Attractants	Dates June 1970	*Dendroctonus rufipennis* No. of males	No. of females	Per cent males	Per cent total catch for period
Spruce billet	6-9	169	133	56	66
+ 40 females	20-23	1143	352	76	77
Spruce billet	6-9	25	28	47	12
+ frontalin	20-23	55	90	38	8
Alpha-pinene	6-9	23	38	38	13
+ frontalin	20-23	45	96	32	7
Frontalin	6-9	13	8	62	5
only	20-23	31	24	56	3
Spruce billet	6-9	12	8	60	4
only	20-23	45	54	46	5

[1] Only two functioning June 6-9.

When attacks were noticed on standing trees near sites of frontalin release, four uninfested trees were each baited with two caps of frontalin and axe-cuts. These trees were attacked the same day. The brood survived and eventually killed the trees. Four days later the caps were transferred to four other trees, over 600 feet away. These trees were also attacked, during at later and less intense flight; however, their beetle broods failed and the trees survived that season. After beetle flight had ceased, all trees within 50 feet and several within 300 feet from each frontalin source were exeamined. The results were as follows:

	within 30 ft	30—50 ft	50—300 ft
No. trees examined	48	36	47
No. trees attacked	28	1	0

Baited and surrounding trees ranged from 6.0 to 33.0 inches, with an average of 13.6 inches dbh.

The sex ratio of beetle samples at Elko is of interest. The percentage of males was 41.4 in 955 beetles hibernating the previous autumn, 34.3 in 233 beetles taken by sticky wire traps on frontalin-baited trees, and 31.8 in 585 beetles caught by barrier traps on a felled tree, but males predominated in flight trap samples at billets with females and at frontalin only (see Table 1). The sex ratio differences apparently reflect differences in male and female activity or response to different kinds of attraction.

At Naver, olfactometer tests were negative with frontalin combined with various monoterpenes found in spruce, during small early-season beetle flights. However, billet-cage tests, replicated in three locations, indicated that frontalin with alpha-pinene was somewhat attractive. For example, numbers taken June 14 to 21 were: 80—frontalin with alpha-pinene; 417—billet with 40 females; 101—frontalin with billet, and 17—frontalin alone.

A series of trees in 18 locations were baited with billets to which 10 or 15 female beetles were added. The beetles were placed in small holes punched in the bark, and covered with screen wire. Of the 58 baited trees (9 to 23 inches, avg 16.6 inches dbh), 31 were attacked. Most of the billets on these trees had four or more successful attacks by the added females. Most unattacked trees had fewer than four successful attacks by screened females on the bait billet. No trees next to the billet-baited ones were attacked.

On July 17, 10 trees (12—30 inches avg 18.0 inches dbh) in three areas five or more miles apart, were each baited with five caps of frontalin and axe-cuts. Although only a small flying population, mainly reemerged parent adults, was to be expected late in the season, all 10 trees were attacked as well as several others adjacent to the baited trees.

Densities of induced attacks were low at Naver and no attacked trees were killed. Most attacks failed, apparently due to resin flow. Some long egg galleries were noted, but most had no larvae. Attacks were concentrated more at the base of trees baited with billets than when frontalin was used (Table 2). Here, as at Elkio, all attacks seen on standing trees in the test areas were associated with billet- or frontalin-baiting.

TABLE 2
Vertical attack distribution on baited trees—Naver

Height above ground—ft	Billet-female bait[1] No. attacks	Per cent	Frontalin bait[2] No. attacks	Per cent
0 - 1	202	57	56	25
1 - 2	68	19	22	10
2 - 3	38	11	30	13
3 - 4	32	9	33	15
4 - 5	15	4	24	11
5 - 6	1	0.5	21	9
over 6	0	0	37	17
Total	356		223	

[1] 31 trees attacked.
[2] 10 trees attacked.

We conclude that frontalin triggers the process of mass attack by the spruce beetle and that, as with several other *Dendroctonus* species (e.g., McCambridge, Ann. Ent. Soc. Amer. 60: 920-928, 1967), baiting with billets and female beetles acts in a similar way. The low attractiveness of frontalin with alpha-pinene indicates that there are other chemical cues, as yet unknown, involved in secondary attraction of the spruce beetle. However, the consistency with which trees baited with frontalin were attacked, in stands where no attacks on unbaited standing trees were found, suggests that frontalin is a component of spruce beetle secondary attraction. Investigations into the potential uses of frontalin for study, survey and control of the spruce beetle are planned.

The tests were carried out, as part of a cooperative study of secondary attraction in the spruce beetle, with J. P. Vité and G. B. Pitman, Boyce Thomson Institute for Plant Research, Inc. We thank that organization and the Southern Forest Research Institute, Houston, Texas, for supplying the frontalin and D. W. Taylor and T. G. Gray for assistance. E. D. A. Dyer and J. A. Chapman, Forest Research Laboratory, Victoria, B.C.

Field Test of Ethanol as a Scolytid Attractant.—Ethanol, produced in softwood logs, serves as a primary attractant for *Gnathotrichus sulcatus* Lec. (Cade, Hrutfiord and Gara, J. Econ. Entomol. 63: 1014-1015, 1970) and in laboratory tests, for *Trypodendron lineatum* (Olivier) (Moeck, Can. Entomol. 102: 985-995, 1970). A field test with ethanol (Moeck, *loc. cit.*) in 1969 was unsatisfactory due to a small beetle population in the test area, which necessitated repetition in a more highly populated area.

On 29 Apr. 1970, 40 pan-type glass-barrier traps (Dyer and Chapman, Can. Entomol. 97: 42-57, 1965) (Fig. la) were placed on the ground in groups of four at three locations in stands of 60–70-year-old Douglas-fir near Mesachie Lake and Caycuse, B.C. In each group, traps were situated at the corners of a 6-foot square, with the glass panes of adjacent traps oriented at right angles to each other, to reduce directional effects. The test solution (750 ml of 10% ethanol) was placed in each of two adjacent traps of each group, and 750 ml of water (control) was placed in each of the other two traps. The solutions were replaced three times until the conclusion of the test on 19 May.

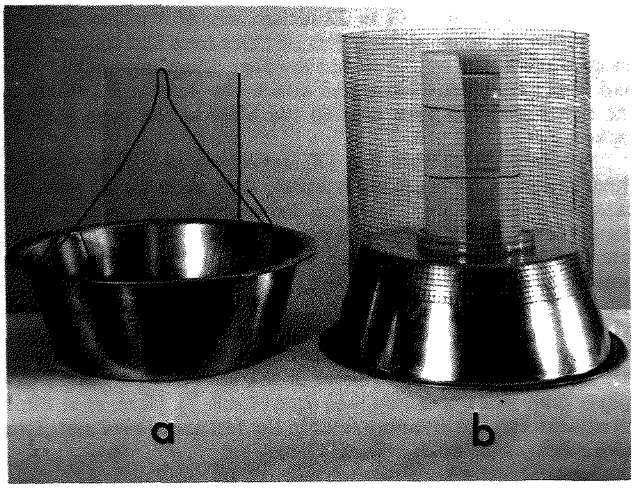


FIGURE 1. Flight traps: a) glass barrier type; b) sticky screen type.

A new flight trap was also used. It consisted of an inverted 64 oz large-mouth jar supported by a ¼-inch mesh wire collar ⅜ inches above the bottom of a petri dish (Fig. 1b). Two paper towels (high wet strength, fast flow rate) wrapped around the jar served as a wick. The jar was surrounded by a ¼-inch mesh wire cylinder dipped in melted 'Stikem Special' (Michel and Pelton Co., Oakland, Calif.). These nondirectional traps operated unattended for a week or more, depending on rate of evaporation as affected by weather. Trapped insects were washed off the wire screen with benzene. Six pairs of these traps were placed at the same locations as the barrier traps between May 12 and 22, one pair-member containing 10% ethanol, the other water. They appeared to be much more effective than the pan-type traps.

The numbers of insects caught in the traps are listed in Table 1. *Trypodendron*, *G. sulcatus*, *Anisandrus* and *Xyleborus* were clearly attracted by ethanol, as was *Rhizophagus dimidiatus*. Analysis of the data for *Trypodendron* (Table 2), with the Wilkoxon matched-pairs signed-ranks test (Siegel, Nonparametric Statistics, McGraw-Hill Co., 1956), indicated significant differences between control and test trap catches for males and females at P=0.025 and 0.005 levels, respectively. Fewer *Trypodendron* were caught than expected, judging by the large number of beetles flying in the area. Several explanations are possible: a) ethanol *per se* may be a weak attractant; b) the ethanol concentration used may not have been the optimum for this insect; c) other chemical or visual factors may play a role in primary attraction; d) only a fraction of the population may be responsive to ethanol, the remainder using the secondary attractant as the main cue, or e) the behavior of the local population may have been dominated by stronger natural attractant sources in the vicinity.

TABLE 1
Field test of ethanol as an attractant

Insect		No. of insects: water (26 traps)	No. of insects: 10% ethanol (26 traps)
Trypodendron lineatum (Olivier)	♂	6	22
	♀	17	55
Gnathotrichus sulcatus Lec.	♂	7	282
	♀	9	58
Anisandrus pyri Peck.	♀	142	3457
Xyleborus saxeseni Ratz.		6	102
Other Scolytidae		50	70
Rhizophagus dimidiatus Mann.		12	126
Cerambycidae		0	12
Other Coleoptera		1202	2251

TABLE 2
Numbers of *T. lineatum* caught in control and test traps

Group No.	Trap Type	No. of beetles: water ♂	water ♀	10% ethanol ♂	10% ethanol ♀
1	Glass barrier	0	1	0	1
2	"	0	0	1	1
3	"	0	0	0	4
4	"	0	0	1	2
5	"	0	0	3	13
6	"	1	7	4	13
7	"	1	2	1	4
8	"	1	1	0	1
9	"	1	0	0	1
10	"	0	0	2	1
11	Sticky screen	0	0	1	0
12	"	0	0	1	1
13	"	1	0	1	1
14	"	0	0	1	1
15	"	0	0	0	0
16	"	1	6	6	11
Totals		6	17	22	55

The large number of *Anisandrus* females captured (males are flightless) was unexpected. This ambrosia beetle attacks a variety of hardwoods, and at times is a pest in fruit orchards (Mathers, Can. Entomol. 72: 189-190, 1940; Jack, B.C. Dept. Agr. Rep., 1965). Trapping with ethanol may be useful in the study or control of this insect.

The attraction of *Rhizophagus* by ethanol is interesting. Although the biology of the western North American species is virtually unknown, Escherich (Die Forstinsekten Mitteleuropas Vol. II, 1923) states that adults and larvae of various *Rhizophagus* species prey on the brood of bark and ambrosia beetles. If *R. dimidiatus* is predaceous on Scolytidae, attraction by ethanol (i.e., log odor) would help in locating prey. Henry Moeck, Forest Research Laboratory, Victoria, B.C.

Mortality of Monochamus Larvae in Slash Fires.—The use of prescribed fire as a management tool is increasing and it is of value to know the effect of these fires on wood borer populations in slash. In 1969, experimental fires in slash of lodgepole pine [*Pinus contorta* Dougl. var. *latifolia* Engelm.] at the Kananaskis Experimental Forest, Alberta, (Quintilio, Intern. Rep. A-30. May 1970) provided an opportunity to study the effect of fire on the survival of larvae of the genus *Monochamus*. The experimental plots varied in total fuel loading from 30 to 50 tons per acre, slash was 4 inches and over in diameter, and plots were burned under various hazard ratings. Adjacent 1-acre plots had been cut in the spring of 1968 and were burned in the summer of 1969.

Monochamus adults laid eggs into the logs in 1968, and by 1969 all larvae had tunnelled into the wood. After each plot had been burned, the author chose logs for sampling by walking in straight lines through the plot and sampling the first 10 infested logs. Logs within 10 ft of plot boundaries were not sampled to avoid any edge effects. A sample consisted of one larval entrance hole or more on each log. These were cut open and the larvae were recorded as alive or dead. Larvae previously killed by diseases, as evidenced by their dark brown coloration and shrivelled body, were not included. These were separated from fire-killed larvae which were yellow-brown and brittle.

All *Monochamus* larvae were killed by extreme- and high-rated slash fires; moderate-rated slash fires killed most of the larvae, and low-rated slash fires killed only a few larvae (Table 1).

TABLE 1
Mortality of *Monochamus* larvae in slash fires

Hazard rating of slash fire	Avg fire intensity (BTU/sec per 2 feet)	Slash consumption (>4 inches) (%)	No. of logs sampled	No. of larvae: Live	Dead	Total	Larval mortality (%)
Low	358	10	20	25	5	30	16.7
Moderate	1,708	31	20	3	20	23	86.9
High	5,791	42	30	0	39	39	100.0
Extreme	12,544	60	30	0	38	38	100.0
Total	—	—	100	28	102	130	—

The data from logs in the plots with low and moderate hazard ratings were grouped according to several heights of logs above ground and analysed for borer mortality. No clear relation was indicated except for reduced mortality of borers in logs at ground level.—B.M. Dahl, Forest Research Laboratory, Edmonton, Alta.

Comparative Susceptibility of Eastern and Western Hemlock Loopers and Green-striped Forest Looper to Zectran, Fenitrothion and Phosphamidon.—Populations of the eastern hemlock looper [*Lambdina fiscellaria fiscellaria* (Guen.)], western hemlock looper [*Lambdina fiscellaria lugubrosa* (Hulst)], and green-striped forest looper [*Melanolophia imitata Wlk.*] have recently increased to outbreak levels in eastern and western Canada. The eastern hemlock looper (EHL) has severely defoliated trees over 562,000 acres from 1966 to 1969 in Newfoundland (Warren and Singh, Annu. Rep. For. Ins. Dis. Surv., p. 11-13, 1969). Green-striped forest looper (GSL) and western hemlock looper (WHL) also reached infestation levels during 1969 in British Columbia (Molnar, *et al.*, Annu. Rep. For. Ins. Dis. Surv., p. 101, 1969).

In an attempt to replace DDT recommendations against the loopers, nine compounds have been tested in the laboratory since 1968. The relative susceptibility of the three loopers to contact toxicity of Zectran®, fenitrothion and phosphamidon is discussed in this report.

Insect collections were made by the regional staff of the Forest Insect and Disease Survey. The looper larvae were reared to 3rd and 4th instar in Ottawa either from eggs collected in the field or obtained from adults emerged from field collected pupae, or from younger field collected stock. EHL collections were made from Newfoundland and WHL and GSL from British Columbia. The experiments were conducted under laboratory conditions similar to those described by Nigam, 1968 and 1969 (Bi-mon. Res. Notes 24:4-5 and 25:11-12). Thirty larvae per dosage were sprayed in three replications of 10 larvae each, under a modified Potter's tower, except in the case of 5% fenitrothion, when 15 (3rd instar) GSL larvae per dosage were sprayed. The insecticides were applied at six volumetric rates for the several concentrations tested. Concentrations which gave progressive mortality response at different rates of applications are discussed in this paper. Post treatment observations were made at 24, 48 and 72 hours. The corrected 72 hours percentage mortality values and the minumum effective doses ($\mu g/cm^2$) for maximum observed mortalities are presented in Table 1.

The results indicate that 3rd-instar EHL and WHL larvae and 4th-instar GSL larvae are susceptible to Zectran, although GSL larvae are approximately three times more tolerant than the 3rd-instar larvae of the other two loopers. Third-instar EHL and WHL larvae are equally susceptible to fenitrothion while 3rd-instar GSL larvae are approximately 8 to 10 times more tolerant to fenitrothion. Fenitrothion is not effective against 4th-instar GSL larvae. Third-instar WHL larvae appear to be twice as susceptible to phosphamidon as 3rd-instar EHL larvae.

Fenitrothion and phosphamidon have been used successfully to control EHL in Newfoundland on approximately 2.5 million acres. Aerial applications of fenitrothion with 2 oz active ingredient/acre twice at 7 day intervals against 1st- and 2nd-instar larvae were carried out and 3rd-instar larvae were treated with 3 oz/acre at four day intervals. Phosphamidon was used at the same rates adjacent to most of the salmon streams (Warren and Singh, Annu. Rep. For. Ins. Dis. Surv., p. 11-12, 1968, and *ibid.*, p. 11-13, 1969). These compounds have also controlled effectively spruce budworm, jack-pine budworm and sawflies (Nigam, Inform. Rep. CCX-1, 45 p., 1969; Bi-mon. Res. Notes 26:2-3, 1970; J. Econ. Ent. 63:620-4, 1970).

Field trials against GSL and WHL could not be carried out in British Columbia as the infestations had subsided (Fiddick, For. Ins. Dis. Condition B.C., p. 2-3, July, Victoria [memo], 1970). As WHL is susceptible to phosphamidon and fenitrothion, these compounds should be tested against it by aerial application at the earliest opportunity. It is clear that fenitrothion would not be effective against GSL at dosages (30-50 oz/acre) that can be tolerated by fish and wildlife. However, Zectran under laboratory conditions seems to be quite effective against GSL larvae, so it may be useful for their control.

Zectran would be effective against all the loopers tested, and fenitrothion against all but GSL. Zectran is also a promising compound against other forest insect pests (Nigam, Proc. Ent. Soc. Ont. 100:233-234, 1969). It gave good results against spruce budworm under field conditions and should be tested in the field against loopers and other pests.—P.C. Nigam, Chemical Control Research Institute, Ottawa, Ont.

FOREST PRODUCTS

Specific Volume *vs.* Canadian Standard Freeness in Determining Kraft Pulp Quality.—Current North American practice in determining physical properties of pulp handsheets involves plotting Canadian Standard Freeness (CSF—a measure of wire-drainage time), burst factor, tear factor and breaking length as a function of beating time. This procedure results in a set of curves for sheet physical properties, which tend often to assume plateau-like configuration in the critical range between 500 and 300 CSF, even though these curves are generally steep at higher freeness values. Two disadvantages can result: (a) accuracy may be limited in defining pulp quality parameters within the range 500 to 300 CSF; (b) scattering of experimental points about the "best fit curve" in this region could contribute to a lack of precision in test data reported.

The suitability of CSF as a yardstick against which to measure pulp physical properties has been questioned, particularly by Clark [Svensk. Papperstidn. 73(3): 54-62, 1970] who proposes that pulp physical properties be expressed in terms of the bulk or specific volume (c^3/g) of pulp handsheets. We have investigated this proposal, and found that when bulk is measured according to Clark's method [Tappi 53(7): 1340; 53(12): 2325, 1970] linear plots are obtained of bulk *vs.* burst factor, tear factor and breaking

TABLE 1

Toxicity of three insecticides to eastern hemlock looper (EHL), western hemlock looper (WHL), and green-striped forest looper (GSL).

Insect & Instar		Concentration %	Control Mortality %	Corrected % Mortality[1] (72 hours after treatment) — Rate of Application (gpa*) 0.1	0.2	0.4	0.6	0.8	1.0	Minimum effective dose for maximum mortality observed $\mu g/cm^2$**
				Zectran (4-dimethylamino-3,5-xylyl methylcarbamate)						
EHL	3rd	0.20	0	7	10	27	70	90	*87*†	0.224
WHL	late 3rd	0.25	0	3	34	77	93	*100*†	100	0.224
GSL	4th	1.00	0	7	70	59	*100*†	100	100	0.673
				Fenitrothion (0,0-dimethyl 0-(4-nitro-m-tolyl) phosphorothioate)						
EHL	3rd	0.50	3	0	0	28	62	90	*100*†	0.560
WHL	late 3rd	1.00	3	14	41	87	*100*†	100	100	0.672
GSL	3rd	5.00	0	20	13	80	100	87	*93*†	5.605
GSL	4th	8.00	13	5	0	0	0	13	*9*†	8.968
				Phosphamidon (2-chlor-N,N-diethyl-3-hydroxycrotonamide, dimethyl phosphate)						
WHL	late 3rd	1.00	3	0	0	33	85	90	*95*†	1.121
EHL	3rd	1.00	0	0	0	7	38	48	*53*†	1.121

* gpa = gallons per acre.
** 1.121 $\mu g/cm^2$ = 1% @ 1 gpa or 1.6 oz./acre active.
† Maximum mortality at minimum effective dose.
[1] Abbott's formula.

length. Linear plots are easier to interpret than a corresponding set of beating curves and the new procedure has the following other advantages:

(a) Physical properties of pulp handsheets can be measured more accurately in the 500 to 300 CSF range.

(b) Determination of bulk is more precise than determination of CSF [see, for example, P.P.R.I.C.—Standard Reference Unbleached Eastern Softwood Kraft Pulp No. 10-65] by a factor of about 5.

(c) Regression lines can be determined of bulk *vs.* physical properties and logarithm of beating time for plups from different processes, different wood species, etc. These regression lines may lead to a reduction in the quantity of test data collected to define properly pulp physical properties and may also simplify quality control within a mill.

A larger investigation of this new procedure is being pursued on kraft pulps prepared from tree components of white spruce [*Picea glauca* (Moench) Voss]. Future publication of these results will include a discussion of what reference values of bulk should be considered in reporting test data. One suggestion is that regression line formulae, *per se*, may replace beater curves, and be used in quality control.—M. Samek and J. V. Hatton, Forest Products Laboratory, Vancouver, B.C.

The Effect of Enzyme Inhibitors on Extractives Formation of Western Red Cedar.—The ability to effect changes in extractives formation or composition would be important to the utilization of western red cedar [*Thuja plicata* Donn]. For example, a tree with no extractives would be more valuable for pulping or a tree with high extractives content would be more valuable for siding. Since extractives formation is under genetic control, any method affecting formation must interfere with genetic material (e.g. DNA) or enzymes. One such study was recently made on *Rhus* sp. and enzyme inhibitors by Hillis and Inoue (Phytochem. 5:483-490, 1966). In this work, several other compounds, growth hormones and β-thujaplicin were tested as well as seven enzyme inhibitors on western red cedar sapwood, *in vitro*, rather than *in vivo* as by Hillis and Inoue.

Freshly cut western red cedar sapwood (about 5g) was treated *in vitro* with solutions of the chemicals listed in Table 1, for 3 months in the dark at about 16 C. The solutions were then extracted with ethyl acetate and examined via paper and thin-layer chromatography for any differences between them and the control. The amounts of thujaplicatins and thujaplicatin methyl ethers (T.M.E.) present in the solution were determined paper chromatographically by the method of Swan, Jiang and Gardner (Phytochem. 8:345-351, 1969). The free and bound β-sitosterol were determined as the trimethylsilyl ether in the gas chromatograph. The column used was 5 ft x 1/8 inch stainless steel packed with 25% SE-30 on Gas Chrom Q (100-120 mesh) operating at 280 C and with nitrogen carrier gas passing at 15 ml per min. The recorder was equipped with a disc integrator, standard solutions were run consecutive to the determinations, and during each run the gas chromatograph was temperature programmed up to the isothermal temperature. During the run an internal standard (octadecane) was added to each solution in order to check on the injection efficiency. Bound β-sitosterol was similarly determined: an aliquot of the sample, octadecane, and sodium ethoxide in ethanol (1 ml of 1%) was heated under nitrogen to about 70 C for 1 hour. The solvent was evaporated, the solution taken up in dioxane-carbon tetrachloride (1:4) filtered, reacted with trimethylsilylating reagent, and made up to volume. Analyses were run on standards concurrently. Table 1 presents the data.

TABLE I
Experiments with western red cedar sapwood *in vitro*

No.	Reagent	Percent extractive yield[a]	pH[c]	Yields of extractives—ppm: Thujaplicatins	T.M.E.	Free β-sitosterol	Combined β-sitosterol
1	$NaAsO_2$	0.4	9	25	59	100	530
2	NaN_3	0.4	7	19	78	50	560
3	$NaOOCCH_2I$	—b	2	—b	—b	5	6
4	2,4-dinitrophenol	—b	5	—b	—b	80	750
5	NaF	0.5	6	93	100	100	640
6	KCN	0.5	11	107	61	90	640
7	NH_2OH	0.6	1	91	290	90	660
8	Kinetin	0.3	6	25	29	120	570
9	Gibberellic acid	—b	5	—b	—b	110	450
10	Naphthalene acetic acid	—b	4	—b	—b	70	520
11	β-thujaplicin	—b	4	64	—b	120	80
Control	none	0.3	4	25	30	30	30

a. Combined yields from extraction of the wood in a soxhlet and the liquor in a separatory funnel—ethyl acetate solubles.
b. Yield cannot be calculated because the inhibitor was soluble in ethyl acetate and interferred with paper chromatographic analytical method.
c. Of the solution before extraction. Adjusted to 3.0 with 6N HCl before extraction.

The table shows that the yield of heartwood lignans (thujaplicatins and T.M.E.) was affected most by $NaAsO_2$, NaN_3 and kinetin. Hydroxylamine gave at least one unique product and an extractives distribution pattern close to heartwood, other inhibitors giving unknown products were $NaAsO_2$, NaN_3, NaF and KCN. Also the solutions contained more β-sitosterol, both free and bound as a putative fatty acid ester, than the control extract.

Although these compounds have not been previously noted in western red cedar, data on the control (Table 1) shows the presence of small amounts of these ubiquitous extractives. The enhanced yields of these compounds meant that the biochemical synthesis of them was either insensitive to the enzyme inhibitors and more precursors were channelled to their syntheses or sensitive to the inhibitors but positively rather than negatively.—Eric P. Swan, Forest Products Laboratory, Vancouver, B.C.

PATHOLOGY

Residual Effects of Sunscald and Frost Injury or Young Douglas-Fir.—Frost and sunscald injury in 15- to 17-year-old Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco] plantations on Vancouver Island (Foster and Johnson, Dep. Forest. Can. Pub. 1011, 1963, pp. 14-16) resulted from low temperature before hardening-off during the winter of 1955-56, and high temperature and low precipitation during the 1958 growing season. Foster and Johnson reported a high level of fungal invasion through exposed sapwood in the first 3 years after frost injury. *Haematostereum* (*Stereum*) *sanguinolentum* (Fr.) Pouzar, *Merulius* sp. and *Peniophora* sp. were isolated from about 30% of examined frost lesions, and Fungi Imperfecti from about 70%. Numerous fungi of undetermined pathogenicity were isolated from sunscald injuries. This paper reports the results of examinations of the older Douglas-fir plantation 11 years after the frost and 8 years after the sunscald injury.

Ten trees with 28 frost lesions and 10 with 31 sunscald injuries were selected from ones examined every 3 years, beginning in 1958. The sample trees were chosen from those having maximum injuries during the first examination. Each tree was cut into 1-foot lengths and the sections split to expose decay and stain; lesions were split through the face. By using the methods of Foster and Johnson (*loc. cit.*), isolations were taken from both sapwood and heartwood of those sections encompassing injuries and from all others showing evidence of decay or abnormal staining. Effect of the injuries on tree growth and form was recorded.

Three years after the original injury, the frost lesions had exposed sapwood, and sunscald injuries had dessication and lesion or canker formation. In severe injuries, bark sloughing and exposure of the sapwood usually occurred within 2 years. Multiple injuries were present on many stems and often combined to produce extensive necrotic areas. Girdling of the stem by one or more lesions frequently resulted in death of the leader above the injury; however, a permanent or continuing defect in tree form did not occur in the sample trees.

Fifty percent of the frost lesions had callused over within 6 years of the injury and 70% by 11 years. Girdling by either a single large lesion or multiple lesions occurred in 50% of the frost-injured sample, killing 2- to 4-year-old leaders. In all cases, a branch assumed dominance and little evidence of damage could be found after 11 years.

Thirty percent of the sunscald injuries had the sapwood exposed, and all callused over in 3 years, except one, which took 8 years.

Height growth of the frost- and sunscald-injured trees was reduced for 1-2 years following the injury (Fig. 1).

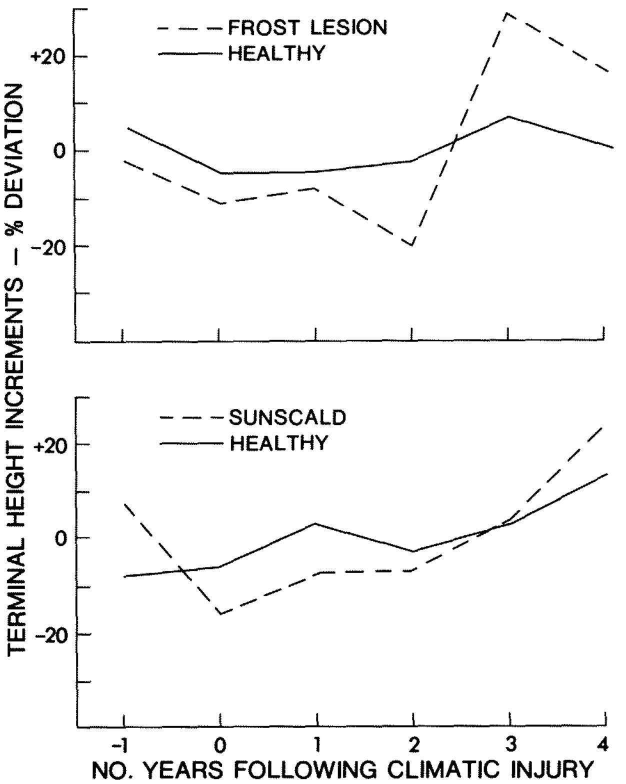


FIGURE 1. Percent deviation of terminal height increments for healthy trees, frost- and sunscald-injured trees.

Five hundred isolations were taken from the frost lesion samples and 452 from sunscald ones. Infection by wood destroying fungi was insignificant; 2% of the isolates were wood decay fungi; over 28% were non-Basidiomycetes, and over 69% failed to show any organism. No explanation is evident for the lower percentage of fungi isolated, compared with that of Foster and Johnson. *Sistotrema* (*Trechispora*) *brinkmannii* (Bres.) Erikss. was isolated from only one tree, a frost-lesion killed top, in which it was restricted to the sapwood. *Lenzites saepiaria* (Wulf. ex Fr.) Fr. was found in one sunscald lesion only; decay was confined to the scar face. *Haematostereum* (*Stereum*) *sanguinolentum* (Fr.) Pouzar was isolated from two trees; one infection originated from a 2-year-old lesion, the other from a branch stub.

This study revealed that even with severe sunscald and frost injury, Douglas-fir of these age classes recover rapidly with little lasting defect. A.L.S. Johnson, Forest Research Laboratory, Victoria, B.C.

Forceps: a Time-Saver in Agar Slant Work.—Polyfoam tube plugs, as apposed to cotton plugs, speed up the plugging process of agar slants. However, rather than follow the directions of the manufacturer (Gaymar Industries Inc., Buffalo 10, N.Y.), the use of straight 6-inch forceps with blunt serrated ends to insert the plugs will increase the plugging speed 2-3 times.

Simply pick up the plug so that most of it is held between the arms of the forceps (Fig. 1); squeeze and insert to the desired depth in the tube and, while holding the plug in position with the forefinger, withdraw the forceps. This technique can be used to replace sterile plugs by employing flame-sterilized forceps.

FIGURE 1. Forcep-plugging of racked agar slants with polyfoam plugs.

The method also eliminates individual handling of tubes when plugging racks of agar slants. A.L.S. Johnson, Forest Research Laboratory, Victoria, B.C.

Discoloration and Decay Following Inoculations of Yellow Birch and Sugar Maple with *Pholiota aurivella*.—In central and eastern Canada, yellow birch [*Betula alleghaniensis* Britt.] and sugar maple [*Acer saccharum* Marsh.] are often affected by the decay fungus *Pholiota aurivella* (Batsch ex Fr.) Kummer (Basham and Morawski, Can. Dep. Forest. Pub. 1072, 1964; Lavallée, Phytoprotection 50:16-22, 1969; Stillwell, Forest. Chron. 31:74-83, 1955). In the present study, trees were inoculated at Dudswell, and at Duchesnay, Quebec. At Dudswell, trees of both species were about 50 years old and 4-10 inches dbh, while at Duchesnay trees averaged 30 years of age and were 3-5 inches dbh. The inoculum was a yellow birch dowel colonized by *P. aurivella.* Controls were tested with sterile dowels.

In both hosts at Dudswell and in yellow birch at Duchesnay, the bark was surface-sterilized with ethyl alcohol (95%) before boring a 0.8 x 10 cm hole, with a sterilized bit, 2 or 4 feet above ground level at right angles to the axis of the trunk. On sugar maple at Duchesnay, a piece of bark was removed and the wood surface-sterilized before the boring was made. After inoculation, wounds were covered with a commercial dressing ("Braco").

Over a period of 2 years, trees were felled and sectioned and the sections split longitudinally. Isolations were made from discolored or decayed zones and from the surrounding unchanged wood. Chips of wood, varying in number between 15 and 116, were taken around each inoculation and placed on a 2% malt extract agar medium; a total of 4,661 chips were thus tested. Results are given in Tables 1 and 2.

Pholiota aurivella was recovered from all inoculations. The fungus was found at greater distances longitudinally from the source of inoculum in tissues close to the center of the trunk (Fig. 1A). Therefore, conditions in the central part of a living tree are more favourable for the fungus than in the outer region of the trunk. In inoculations through the bark, the surrounding dis-

TABLE 1
Vertical extent of *P. aurivella* and surrounding discoloration in inoculated living yellow birch[1]

Localities and dates	Average vertical extent (inches)		
		Discoloration	
	Decay	Inoculated	Controls
Duchesnay			
Inoculated: Oct. 27, 1967			
Dissected: Oct. 30, 1968	8.1 (22)	13.0 (22)	13.0 (6)
Dudswell			
Inoculated: Aug. 15, 1967			
Dissected: Aug. 7, 1968	12.5 (8)	20.7 (8)	10.1 (4)

[1] The number of observations is shown in brackets.

TABLE 2
Vertical extent of *P. aurivella* and surrounding discoloration in inoculated living sugar maple[1]

Localities and dates	Average vertical extent (inches)		
		Discoloration	
	Decay	Inoculated	Controls
Duchesnay			
Inoculated: June 27, 1968			
Dissected: July 2, 1969	4.0 (30)	10.9 (30)	9.2 (6)
Dissected: July 6, 1970	7.9 (10)	11.5 (10)	10.3 (2)
Dudswell			
Inoculated: May 30, 1967			
Dissected: June 3, 1968	6.5 (8)	11.8 (8)	6.9 (6)

[1] The number of observations is shown in brackets.

coloration produced in both yellow birch and sugar maple started under the bark and enlarged toward the pith; in inoculations after the bark had been removed, discoloration in the cambium region was at least the size of the wood exposed (Fig. 1B).

Discoloration in inoculated trees was more extensive than in controls (Tables 1 and 2). For the same period of time, discoloration and decay by *P. aurivella* developed more rapidly in yellow birch than in sugar maple, and the decay process was more rapid in larger trees (Dudswell) than in smaller ones (Duchesnay). The results suggest that the date of inoculation was an important factor in decay progress.

Isolations obtained from the discoloration surrounding decay, yielded fewer bacteria and imperfect fungi in sugar maple than in yellow birch. It is assumed that some of these microorganisms probably came from the bark, since only 12% of the isolations yielded microorganisms other than *P. aurivella* when the bark had been removed before inoculation compared with 30% when the bark was not removed. Thus surface sterilization of the bark was not sufficient to eliminate microorganisms before inoculation, and removal of bark was of some value in avoiding contamination by bark microorganisms.

From these data, *P. aurivella* appears to be an aggressive decay fungus, in sugar maple and yellow birch.—André Lavallée and Marcel Lortie, Forest Research Laboratory, Quebec 10, Quebec.

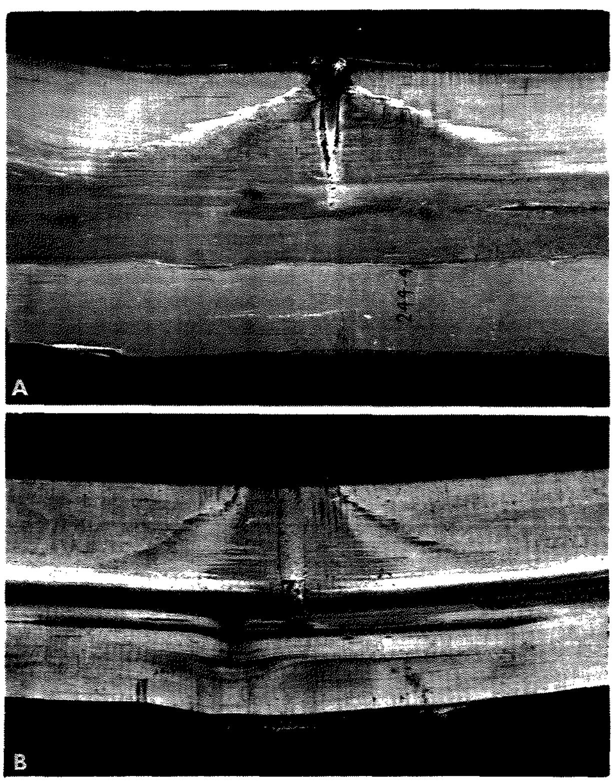


FIGURE 1. Pattern of discoloration and decay in sugar maple trees inoculated with *Pholiota aurivella:* A) standard inoculations; B) two square inch of bark removed before inoculation. The wooden dowel was lost during dissection.

SILVICULTURE

Black Polyethylene Mulch, Best for Germination and Growth of Seeded Black Walnut.— Direct seeding of black walnut [*Juglans nigra* L.] is generally preferred to planting because it is easier and cheaper, and it prevents root damage which is unavoidable when planting nursery-grown stock. Unfortunately, seeding in open-field plantations has generally been unsuccessful because of slow, uneven germination and the young germinants' inability to compete with faster growing weeds.

To determine the effects of various weed control treatments upon the germination, early survival, and growth of seeded black walnut over a 5-year period, three walnut seeds were seeded in each of 25 seed spots in a randomized block arrangement with three replications of each of four treatments. The experimental site was a former agricultural field with a deep, uniform alluvial silty clay. Weed growth was very intense. The planting site was plowed and tilled the autumn before spring seeding.

Weed control treatments consisted of: a) mulching with a 3-foot-wide cover of black polyethylene film, .0015 inch thick; b) mulching with a layer of hardwood sawdust 3 inches thick and 3 feet wide; c) manual weeding in June and July of the first year; d) a single application of 1.5 pounds of active dalapon per acre, sprayed in 3-foot-wide bands in June of the first year.

Emergence of germinants was earliest and germination, highest in the polyethylene plots (Fig. 1). The early emergence was especially important for first year seedling survival, because the seedlings that emerged early completed their growth before the usual summer drought and hardened off earlier in autumn, thereby escaping frost damage.

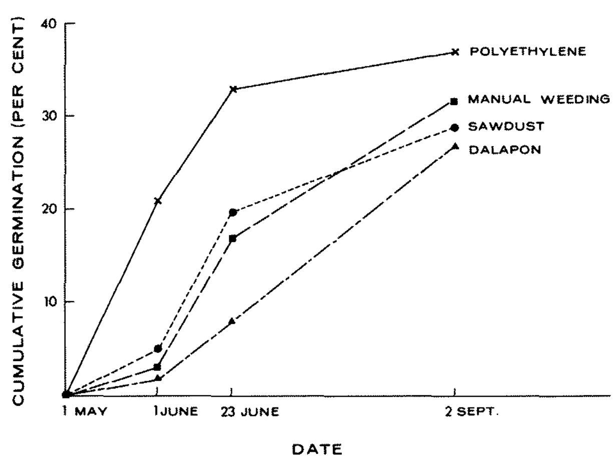


FIGURE 1. The effect of mulching and weed control treatments on germination of black walnut seeds.

Seedling survival and growth were best in the polyethylene-covered plots (Table 1). While weed control was fair to good in all plots during the first year, only polyethylene mulch afforded effective control during the second year, with some control being apparent until the fifth growing season.

Mulching with hardwood sawdust did not appreciably reduce weed growth, moreover extensive seedling girdling occurred as a result of a large mouse population that developed in this material.

TABLE 1
Five-year survival and height growth of seeded black walnut by treatments

Treatment	Survival (percent)	Height growth (inches)
Polyethylene mulch	100a	63b
Sawdust mulch	83a	30c
Manual weeding for 1 year	94a	44c
1.5 lb/acre of dalapon	77a	37c

Common letters denote treatments which showed no significant differences (5%) in survival or growth.

Manual weeding controlled weed growth very effectively during the first year but heavy new growth developed as soon as the hoeing was discontinued.

The single application of 1.5 pounds of active dalapon per acre controlled weed growth only partially during the first year and provided no relief in the second or subsequent years.

Although the application of polyethylene mulch currently is probably too expensive for large-scale plantation establishment (approximately $125/acre for 907 trees spaced 8 x 6 feet), this method may be of use in areas where seeding is preferred to planting or where mechanical weed control is not possible. —F. W. von Althen, Forest Research Laboratory, Sault Ste. Marie, Ont.

Cost Comparison of Four Methods of Eliminating Wolf Trees from Pine Plantations.—The preparation of planting sites in Manitoba currently includes the destruction of all standing trees of no commercial value. Wolf trees, however, occur on several thousands of acres of older plantations. In addition to natural competition, these wolf trees (usually *Pinus banksiana* Lamb.) provide optimum feeding sites for the jack-pine budworm [*Choristoneura pinus pinus Free.*]. For example, in 1966 a young red pine [*P. resinosa* Ait.] seed production area was infested by budworm dropping from large wolf trees. About 20% of the 3-4 ft, red pines were killed over an 8-acre area. In July 1969 a study of the costs and effectiveness of three methods for destroying wolf trees was initiated.

The study area was located in 4-year-old red and jack-pine plantations in southeastern Manitoba (49° 35′ N, 95° 52′ W) (Table 1). Six 1-acre plots were established: on two, wolf trees were treated with a silvicide; on one they were girdled with a chainsaw; on one they were girdled with an axe; on the remaining two plots wolf trees were felled, bucked and piled between the rows. Time and costs for each treatment were recorded and the effectiveness of the silvicide was assessed visually 68 days after treatment.

TABLE 1
Treatments and time for treatments in 1-acre plots located in red and jack-pine plantations in southeastern Manitoba July 8 and 9, 1969

Treatment	Wolf Trees Per Acre	DBH (in)[1]	Time (man-min)	
		Mean (Range)	Total Treatment	Per Tree
I Silvicide injection				
Rep. A	54	4.1 (2-9)	35	0.6
Rep. B	24	4.6 (1-15)	20	0.8
II Trunk girdling				
chainsaw	79	2.4 (1-7)	60	0.8
axe	39	4.6 (1-11)	100	2.6
III Fell, buck, pile				
Rep. A	36	3.7 (2-9)	210	5.8
Rep. B	60	4.6 (2-8)	500	8.3

[1]Includes several small trees 1-2 inches dbh which were treated as prescribed, but not necessarily as to be expected in normal plantation site preparation.

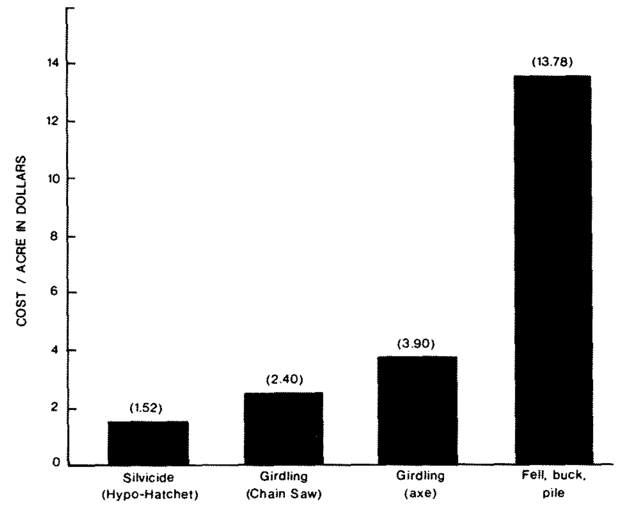


FIGURE 1. Comparative costs of treatments to wolf trees. Assuming 50 stems 4 inches avg dbh/acre; labor at $1.85/hr, not including cost and depreciation of equipment; variable costs: silvicide—$0.60, gas and oil for chain saw—$0.55 for girdling and $1.30 for fell, buck and pile between rows. Treatment costs calculated as follows:

Silvicide—labor @ $0.92 (0.5 hr) plus silvicide @ $0.60	=$ 1.52
Girdling (chain saw)—labor @ $1.85 (1 hr) plus gas and oil @ $0.55	=$ 2.40
Girdling (axe)—labor (only cost) 2 hr	=$ 3.90
Fell, buck, pile—labor @ $12.48 (6.8 hr) plus gas and oil @ $1.30	=$13.78

The silvicide, Silvisar 510® (cacodylic acid) was applied with a Hypo-Hatchet® following the method developed by the Ansul Company, Marinette, Wisconsin. Each cut of the hatchet (approximately 1.5 inches long) injected about 1 ml of silvicide into the tree. The dosage was based on one cut for each 2 inches dbh for trees under 8 inches dbh or two cuts for each 2 inches dbh for larger trees. All trees in the girdling plots were treated below the lowest living branch whorl. A light-weight chainsaw was used for the girdling, felling and buking procedures.

Time expenditures are summarized for the different treatments and are found in Table 1. Expected costs for a plantation having 50 wolf trees averaging 4 inches dbh/acre are derived from our calculations based on the variable stem density and dbh classes encountered in the experimental area (Fig. 1). Of the 78 trees treated with the silvicide, only 10 retained some living foliage. Our results indicate that the removal of wolf trees by the silvicide-injection method or by an inexpensive girdling technique should be considered with respect to the potential loss. R. F. DeBoo, Chemical Control Research Inst., Ottawa, A. G. Teskey, Forest Research Lab., Edmonton, Alta., and A. G. Copeman, Forest Fire Research Inst., Ottawa, Ont.

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