element levels in peat media and shows the need for further research in the nutrition of container planted seedlings. Hocking (Bi-Mon. Res. Notes 28:26, 1972) has shown similar toxic effects on lodgepole pine in trays coated with metallic copper, but unexpected in this instance was the release of toxic levels of copper from a wood preservative that is reputedly fixed to the wood and is allegedly not damaging to plants. — R. E. Wall, Maritimes Forest Research Centre, Fredericton, N.B.

Zinc Chloride Effectively Controls *Fomes annosus* Stump Infection. — *Fomes annosus* (Fr.) Karst, is present in many second-growth stands in coastal Oregon, Washington and British Columbia, having originated in stumps of the previous stand. In Washington, Driver and Wood (Plant Dis. Rep. 52:370-372, 1968) found that 0 to 57% of trees in unthinned hemlock stands were infected. Infection centers, comprising 15 to 20 trees in a hemlock stand and 3 to 5 in a Douglas-fir stand, were found on the west side of Vancouver Island by Wallis and Reynolds (For. Chron. 46:221-224, 1970). The incidence of *F. annosus* in stands increases as a result of spore infection at the surface of stumps left during spacing or thinning operations (Driver and Wood, *op. cit.*). Although numbers varied with the season, viable *F. annosus* spores were present in the air (Wallis and Reynolds, *op. cit.*) and stumps were susceptible to infection (Morrison and Johnson, For. Chron. 46:200-202, 1970) throughout the year. Decay, attributable to spore infection at the cut surface, was found in an average of 19% (range 0–40%) of western hemlock stumps and 17% (range 3–37%) of Douglas-fir stumps in thinned stands (Wallis and Reynolds, *op. cit.*). To prevent the buildup of *F. annosus* to levels that would adversely affect stand management, it is essential that stumps be protected.

Weir (Plant Dis. Rep. 53:910-11, 1969) tested a number of chemicals as protectants for stump surfaces of hemlock and Douglas-fir; borax, as a dry powder, 10% suspension in water or 20% in glycol, gave the best results. However, the effectiveness of borax varied from trial to trial in Weir's study, and with time of year in those of Edmonds *et al.* (Plant Dis. Rep. 53:216-219, 1969) and Russell *et al.* (State of Washington, Dep. Nat. Resour. Rep. 33, 1973). This note reports the results of tests, conducted quarterly for 1 year, comparing the effectiveness of borax with that of zinc chloride, calcium nitrate and ammonium sulphamate. Chemicals were selected on the basis of preliminary results (Weir, unpublished results for zinc chloride and calcium nitrate) or proven effectiveness on stumps of other tree species (Rishbeth, Ann. Appl. Biol. 47:529-541, 1959, for ammonium sulphamate).

Near Jordan River on southwest Vancouver Island, trees 4 to 8 inches dbh (10-20 cm) were cut in a 40-year-old naturally regenerated western hemlock stand and a 28-year-old Douglas-fir plantation. Shortly after felling, stumps were re-cut and treated immediately. Fifteen western hemlock and 15 Douglas-fir stumps were treated with aqueous solutions or suspensions of 10% zinc chloride, 10% borax, 20% ammonium sulphamate and 50% calcium nitrate; distilled water was applied to control stumps. Five stumps in each treatment were inoculated with *F. annosus* basidiospores in water. Six months after treatment, a 10-cm-thick disk was cut from each stump, wrapped in moist newspaper, incubated at 20 C for 5 to 7 days, then examined for the imperfect stage of the fungus. For each disk, the area colonized by *F. annosus* and the area susceptible to spore infection were calculated (in hemlock, the entire surface and in Douglas-fir, the sapwood). Testing was begun in July 1972 and repeated the following November, February and May; sulphamate was omitted from the July trial, zinc chloride from the one in November, and calcium nitrate was discontinued after November.

For all treatments, area of stump surface colonized was a better indicator of treatment effectiveness than percentage of stumps infected (Fig. 1 and 2). Zinc chloride was most effective in preventing infection; none was detected in hemlock, and 7% of Douglas-fir stumps had small areas of infection. Furthermore, inoculation of

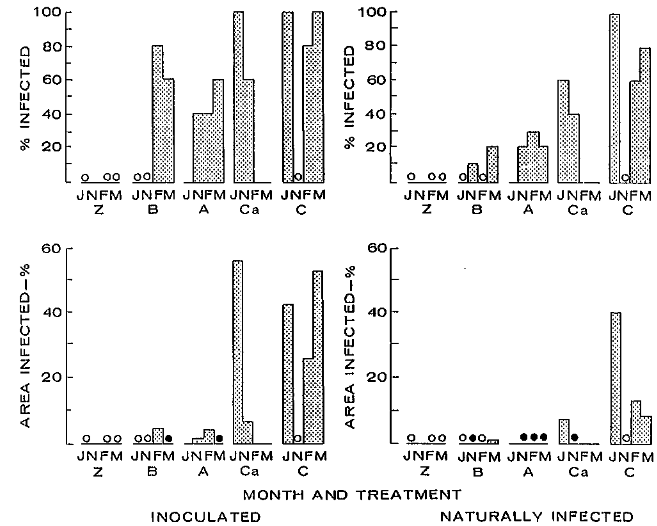

Figure 1. Percentage of stumps and surface area infected by *F. annosus* for inoculated and naturally infected western hemlock stumps. Months: July, November, February and May. Treatments: Z, 10% zinc chloride; B, 10% borax; A, 20% ammonium sulphamate; Ca, 50% calcium nitrate and C, control. (○ = zero, ● = trace).

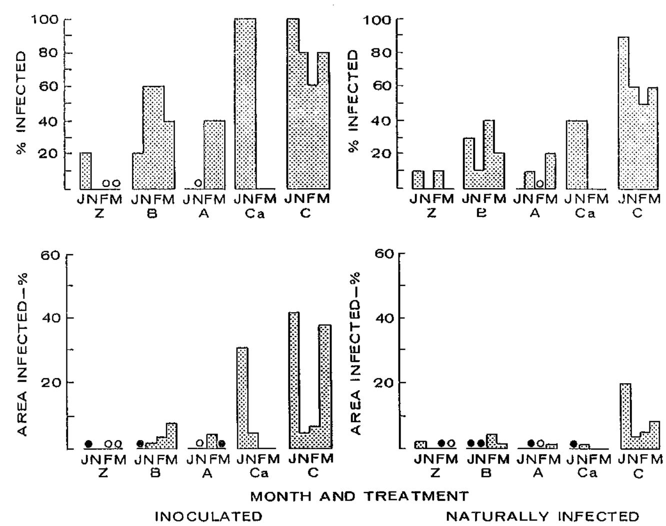

Figure 2. Percentage of stumps and surface area infected by *F. annosus* for inoculated and naturally infected Douglas-fir stumps. Months: July, November, February and May. Treatments: Z, 10% zinc chloride; B, 10% borax; A, 20% ammonium sulphamate; Ca, 50% calcium nitrate and C, control. (○ = zero, ● = trace).

stumps with basidiospores increased the overall frequency and amount of infection in all treatments except zinc chloride. Ammonium sulphamate was as effective as borax in preventing infection in hemlock, and more so in Douglas-fir. Calcium nitrate was ineffective.

As the studies of Edmonds *et al.* (*op. cit.*) and Russell *et al.* (*op. cit.*) showed, a treatment is more likely to fail during periods of heavy precipitation, particularly from November to March, than at other times. In fact, in the November and February trials, 20 and 25% of stumps treated with ammonium sulphamate and borax, respectively, were infected. Failure of borax was attributed by Edmonds *et al.* (*op. cit.*) to rain-washing of chemical from stump surfaces and hence to inadequate penetration. Ammonium sulphamate kills stump tissues rapidly, permitting invasion by saprophytic fungi; suppression of *F. annosus* is due to competition from these fungi (Rishbeth, *op. cit.*) and absence or reduced numbers of competitors in the air spora during winter months may reduce the effectiveness of sulphamate. Zinc chloride produces a toxic barrier at the stump surface that appears to be more durable and/or effective than that formed by borax.

The cooperation of Rayonier, Canada is gratefully acknowledged. — D. J. Morrison and A. L. S. Johnson, Pacific Forest Research Centre, Victoria, B.C.

SILVICULTURE

Growth Reduction Due to Cone Crops on Precocious White Spruce Provenances: — Early, heavy and frequent cone crops in seed orchards of silvicultural species are useful, if the progeny are productive in forest plantations. Genetic control of precocity (early maturity) and fecundity (fruitfulness) has already been demonstrated in white spruce [*Picea glauca* (Moench) Voss] (Teich and Pollard, Bi-Mon. Res. Notes 29:13-14, 1973) and in many other conifers (Puritch, Inf. Rep. BC-X-65, 1972). The abundant cone crops, however, act as sinks for carbohydrate and nitrogen reserves at the expense of vegetative structures (Puritch *loc. cit.*); that is, they cause a reduction in vegetative growth. To be useful, the progeny must either not inherit excessive fecundity, or must be able to grow rapidly even with heavy cone production.

This article describes the apparent loss in potential growth due to cone crops of two precocious, rapid-growing, white spruce provenances.

Two precocious white spruce provenances were found among 62 provenances from eastern and central Canada (Teich and Pollard *loc. cit.*) planted in over a dozen experimental plantations from Newfoundland to the Thunder Bay, Ont. (Teich, Inf. Rep. PS-X-40, 1973). One provenance from Winchester, Ont. (near Ottawa) #2442 in Table 1, had begun to flower in its 11th year from seed, and flowered each year after that. The other provenance, from Grand Mere, Quebec begun flowering in its 12th year from seed in normal quantities. Precocity of these provenances was evident in several plantations in addition to the few reported.

TABLE 1
Height growth of precocious provenances to 10 years of age, before flowering, and growth from 10 to 15 years of age, with cone production (p = .0625)

Provenance	Age Years	Experiment Location: Chalk River cm	Chalk River % of experimental mean	Owen Sound cm	Owen Sound % of experimental mean
2442 Winchester, Ont.	to 10	78	109	64	126
	10 to 15	151	90	92	108
2447 Grand Mere, Que.	to 10	87	121	47	93
	10 to 15	185	111	71	83

The experimental designs were previously described in detail (Teich *loc. cit.*). Briefly, in the Chalk River experiment there were 54 provenances, 100 trees per provenance planted in 10 randomized blocs with 10 trees in linear plots, and 1.8 X 1.8 m spacing. In the Owen Sound experiment there were 25 provenances, 150 trees per provenance in 6 randomized blocks, with 25 trees in square plots with 1.8 X 1.8 m spacing.

Height was measured following 10 growing seasons from seed, before there had been any flowering, and following 15 growing seasons from seed when many trees had flowered one or more years.

Some of the trees of Winchester provenance produced cones each year from 11 to 15 years of age. Before flowering the height growth, relative to the average of 54 and 25 provenances respectively, was 109% at Chalk River and 126% at Owen Sound (Table 1). During the 5 years in which there was some cone production, growth was reduced to 90% at Chalk River and 108% at Owen Sound. The Grand Mere provenance had lighter cone crops than the Winchester provenance and also apparently lost less potential growth during cone production, dropping from 121% to 111% at Chalk River and from 93% to 83% at Owen Sound.

The apparent reduction in potential height growth of the cone-producing provenances averaged 14% (calculated from height at 10 years of age relative to all provenances compared to growth from 10 to 15 years of age). This was significant, p = .0625 (calculated from the binomial distribution). During this 5 year period non-precocious provenances demonstrated only small changes in relative growth, with the average change being a 5% increase or decrease.

The precocious trees apparently have the inherent ability to grow rapidly in the absence of cone production, and to produce large quantities of seed. If a means can be found for them to transmit their rapid growth to their progeny, but not their seed-yielding capacity, they would be valuable in seed orchards. Pollen parents, which suppress cone production such as in Scots pine [*Pinus sylvestris*] (Teich and Holst, Can. J. Bot. 47:1081-1084), may be the means. Several rapid-growing, non-precocious provenances (Cobourg, Beachburg, and Petawawa, Ont.) are being studied for this property. If these provenances yield suitable pollen parents, seed orchards can be established in which precocious clones are surrounded with the selected pollen parents. Hybrid seed can then be collected mainly from the precocious trees, and likely in small quantities from the non-precocious trees.

In the early years of such an orchard there will be a scarcity of pollen from the non-precocious parents. It is therefore advantageous to have the orchard situated close to mature white spruce with high breeding value, such as in the Beachburg area in the Ottawa Valley. The feasibility of this producing useable seed is contingent upon existing experiments to demonstrate that precocity is largely suppressed in hybrids, or that hybrids are sufficiently vigorous to withstand the drain from cone production.

As the select pollen parents in the seed orchard mature they will increasingly function as the pollinators and the influence of external trees will become negligible. At this point, the breeding value of the seed from the orchard will likely reach its full potential. — A. H. Teich, Petawawa Forest Experiment Station, Chalk River, Ont.

Testing Resistance to Spring Frosts by White Spruce Provenances. — This note describes a method for ranking white spruce [*Picea glauca* (Moench) Voss.] provenances and individual trees according to their tolerance of spring frosts. The suitability of a provenance to any particular climate tends to be based more on the extremes that occur rather than on the norm. At any given location, a field trial of provenances may not provide a critical test until extreme conditions arise during the trial. In the technique described below, provenances are tested and ranked according to artificially-induced extreme conditions and can therefore be tested in any year. However, the technique does not replace the field trial because the value of long-term field trials lies in the multitude of factors, both expected and unexpected, that test provenances. In the study reported here, an index of frost resistance of six white spruce provenances was assessed from the ability of detached twigs to survive low temperatures in a commercial freezer.

Samples were collected from the same trees between 24 Apr and 4 Jun. Origins of seedlots are listed in Table 1. Trees were 12 years old and 1.5 m to 4.0 m tall when sampled. Twigs were clipped from the fourth whorl of branches from 15 trees per provenance. Samples were sealed individually in polyethylene bags and placed in a freezer; temperature was lowered at intervals of 5°C until temperatures found to be damaging in the previous run were