gested that researchers, who wish to evaluate yearly growth response to fertilization, should concentrate on obtaining reliable and detailed information on a suitable representative sample from each treatment, and analyse differences between treatments on one or more traits per tree rather than analysing data from all measured trees.

This note describes a simple and quick method of assessing growth response of natural stands to fertilization by a statistical treatment of data from representative trees. This approach does not prevent recording yearly measurements of all trees. Yearly recording is advisable since it gives tree mortality for every diameter class and, in case of serious windfall, insect infestation, or other disaster, the fertilization trial is not a total loss. However, after using the "quick" method for a number of years, it is my opinion that the effort spent on analysing data, yearly, from all trees does not merit the results obtained. As an alternative, the "single tree method" where trees are paired is proposed. The efficiency of this method is dependent on two strict rules: 1) representative trees that are paired must be as similar as possible; 2) pairs of trees, one from the treatment and one from the control plot, must be randomly selected from among the sample pairs.

Within a randomly-selected sample plot a certain number of trees representative of various diameter classes of the stand are randomly-chosen. Trees are identified according to diameter, height, position in the stand, crown class, distance from neighboring trees, apparent pathological conditions, etc. Taking these factors into account, trees from treated and from the control plots are matched by diameter at breast height. Then, a choice at random can be made between the main diameter classes to evaluate yearly reaction to fertilization for various tree sizes. Growth increment can be assessed either by the "t" test method or by analysis of variance or covariance. In the present case comparison between two sample plots was made by the "t" test method.

Since the efficiency of the described method is dependent upon the degree of similarity of matched trees, the value of pairing should be determined by the two-tailed "t" test.

Before fertilization, the difference between the average diameter of the two groups of trees was not significant and th pairing of trees by diameter was well done (Table 1).

To evaluate the effect of fertilization on diameter growth of paired trees it must be assumed that fertilization cannot inhibit growth of the treated trees. The hypothesis must be raised that diameter growth increment of fertilized trees after x years is greater than that of non-fertilized trees. This assumption should be tested by the "t" test (Table 2).

Differences in diameter growth, expressed in percentage, are more precise than straight differences. On the other hand, it lessens the chances of obtaining a significant difference. Indeed, using the straight differences between growth, the "t" test value would have been 3.8598 rather than 3.4422 (Table 2).

At the end of a fertilization experiment, when all trees will be cut for determination, conventional techniques, such as variance or a covariance analyses, will be required to evaluate growth, i.e. the effect of fertilization. However, during fertilization trials of natural forest stands, company foresters will want to know annually, with a high degree of accuracy, the growth response to treatments. The "single tree method" where trees are paired is simple, quick and sufficiently accurate because absolute values are compared whereas, with classical methods average or adjusted values are compared.

The "single tree method" where paired trees are matched in terms of dbh, height, position in the stand, crown class, distance from neighboring trees, apparent pathological conditions, etc., does not replace conventional methods, but it gives a quick and simple method of annually evaluating the effects of fertilizers on a natural stand.

TABLE 1

Two-tailed "t" value for test of difference in diameter before treatment

Trees fertilized		Control trees				
Tree no.	Diameter (1967)	Tree no.	Diameter (1967)	Difference (d)	$d-\bar{d}$	$(d-\bar{d})^2$
979	.91	4421	.92	—.01	.0485	.002352
2986	4.14	4465	4.07	.07	.1285	.016512
948	2.53	4475	2.50	.03	.0885	.007832
928	7.44	4457	7.70	—.26	—.2015	.040602
910	1.29	9381	1.30	—.01	.0485	.002352
—	—	—	—	—	—	—
—	—	—	—	—	—	—
Total difference (d)				—1.17		
Mean difference ($\bar{d}$) = 1.17 — 20				— .0585		
Summation $(d-\bar{d})^2$						1.6797

Number of pairs = 20

$$s^2_{\bar{d}} = \frac{1}{N-1}\sum(d-\bar{d})^2 = \frac{1.6797}{19} = .0884 \qquad t = \frac{4.4721 \times .0585}{.2973} = 0.879 \text{ N.S.}$$

With 19 D.F. for P = .05, t = 2.09

TABLE 2

One-tailed "t" test of signifieance in diameter growth after treatment expressed as percentage of original diameter

Tree no.	Dia. 1972 / Dia. 1967	Tree no.	Dia. 1972 / Dia. 1967	Difference (d)	$d-\bar{d}$	$(d-\bar{d})$
979	1.15 / 0.91	4421	0.94 / 0.92	.2420	.1912	.036557
2986	4.48 / 4.14	4465	4.16 / 4.07	.0600	.0092	.000085
948	2.80 / 2.53	4475	2.79 / 2.50	—.0093	—.0601	.003612
928	7.90 / 7.44	4457	8.00 / 7.70	.0229	—.0279	.000778
910	1.35 / 1.29	9381	1.35 / 1.30	.0080	—.0428	.001832
—	—	—	—	—	—	—
—	—	—	—	—	—	—
Total $\bar{d}$	1.0161 ÷ 20 =			1.0161 / .0508		.082859

N = 20 $\quad \bar{d} = .0508 \quad s^2_{\bar{d}} = \dfrac{N(d-\bar{d})^2}{\sum_1^{N-1}} = \dfrac{0.082859}{19} = 0.0044$

$$t = \frac{4.4721 \times 0.0508}{0.0663} = 3.422 \text{ H.Sig.}$$

With 19 D.F. for P = .005, t = 2.86

With 19 D.F. for P = .0005 t = 3.88

A useful complement to this method is the competition index described by Areny (Can. For. Serv. BC-X-78, 1973.)

The author wishes to thank Dr. A. W. Douglas of the Computing & Applied Statistics Directorate, Ottawa for his comments on statistical procedures.—J. D. Gagnon, Laurentian Forest Research Centre, Quebec, Que.

PATHOLOGY

Fungitoxic Effects of Fatty Acid Salts.—An investigation of the effects of fatty acids and soaps on *Adelges piceae* (Ratz.) showed that the insecticidal activity of saturated fatty acids increased with increasing carbon number and reached a peak around capric acid (C_{10}) (Puritch and Talmon de l'Armee, Bi-mon. Res. Notes, 30:35-36, 1974). A second peak of insecticidal activity occurred around the unsaturated 18-carbon fatty acids, oleic and linoleic. Activity was similar for the fatty acid salts. Reports have indicated that fatty acids around capric are also toxic to fungi. Rothman, Smiljanic and Weitkamp (Sci. 104:201-203, 1946) found that a combina-

tion of fatty acids in the range of C_7 to C_{11} inhibited growth of *Microsporon audouini* Gruby, the ring-worm fungus, at concentrations of 0.0002 to 0.0005%. Wyss, Ludwig and Joiner (Ann. Biochem. 7:415-425, 1945) showed that the optimum saturated fatty acid chain length for fungistatic action varied according to the organisms tested and solubility, and was C_{11} for *Aspergillus niger* van Tiegh, C_{13} for *Trichophyton interdigitale* Priestley and C_{14} for *T. purpurem* Pres. Kitajima and Kawamura (Bull. Imp. Forestry Exp. Stn., Japan 31:108-113, 1931) bioassayed the effects of fatty acids on the wood-rot fungi *Poria vaporaria* Pers. and *Paxillus panuoides* Fr. and found that activity increased with chain length and reached a maximum around C_{12} (lauric acid). We tested the response of some common forest fungi to certain fatty acid compounds in the form of water-soluable potassium salts (soaps).

The agar-plate bioassay method described by Etheridge and Craig (Can. J. Microbiology, 19:1455-1458, 1973) was adapted for these tests. Appropriate concentrations of the soap solutions were incorporated into 2% malt agar, autoclaved at 120 C for 20 min and then poured into petri dishes. The pH of controls was adjusted to that of the autoclaved soap-agar solutions by adding of 1 *N* KOH before sterilization. Infrared spectrophotography showed that sterilization did not affect the chemical structure of the soaps. The fungitoxicity of the soaps was evaluated by the growth response of up to 10 lsolates of each organisms on a single layer of the agar-soap mixture. Fungicidal activity was determined by transferring the inoculum plugs at the end of the test to fresh untreated malt agar.

By the agar-plate bioassay method, a 0.15% solution of K caprate was tested against seven isolates each of *Fomes annosus* (Fr.) Karst. and *Armillaria mellea* (Vahl ex Fr.) Kummer and four isolates of *Poria weirii* Murr. The treatments were replicated twice with two controls for each fungus. After 10 days, all isolates on the K caprate-agar were killed; controls showed abundant growth. Fine, feather-like crystals in the agar indicated that capric acid had precipitated.

The fungitoxic effects of K caprate and K oleate soaps were tested against *F. annosus* on 1.5 cm discs of freshly cut western hemlock. The discs were sterilized on both sides for 0.5 hr with ultraviolet light, placed in sterile petri dishes and sprayed to run-off with K caprate or K oleate at each of the following concentrations: 0.005, 0.05, 1.0 and 1.5%. There were three replicates per treatment; the six controls were sprayed with sterile distilled water. Two hours after spraying, inoculum plugs from the margin of 10 isolates of *F. annosus*, prepared according to the agar-plate bioassay method, were placed mat-side-down on the discs. The discs were incubated at room temperature and 100% relative humidity for 7 days. The fungitoxic effect was evaluated according to the scale: 0 = no mycelial growth on inoculum plug; 1 = growth on the plug of a few scattered mycelial bristles; 2 = growth uniform around plug but not on entire surface; 3 = growth on entire plug surface but not on adjoining wood disc; 4 = growth on adjoining disc less than 1 mm from plug (colony diam. < 6 mm); 5 = growth on adjoining disc more than 1 mm from plug.

Results (Table 1) show higher concentrations of K caprate inhibit growth, although the degree of inhibition varies with concentration and isolate. K oleate showed no toxic effect on *F. annosus*. A field trial is currently underway to test the effectiveness of K caprate as a stump treatment against *F. annosus*.

We also tested K caprate for fungitoxic effect against *Ceratocystis picea* (Munch) Bakshi (7 isolates), *C.* sp. (2 isolates) and *Europhium clavigerum* R. and D. (1 isolate), using the agar-plate method. Three concentrations (0.01, 0.1, 1.0%) were tested and each treatment was replicated three times. Fungitoxic effect was scored as descript, except that values greater than 3 indicate growth on agar rather than wood. After 18 days, all 10 isolates of the test fungi were killed by the 1.0% concentration, but only 7 by the 0.1 % and none by the 0.01% (Table 2). However sensitivity of the isolates to the different concentrations of K caprate was variable and had the bioassays been based on only one of the test isolates, e.g. one of the insensitive strains, or terminated after the shorter test period, fungitoxicity at the two lower concentrations would have been greatly overestimated. The toxic effect of K caprate on *Ceratocystis* spp. suggests that this compound should be tested against *C. ulmi*, the Dutch elm disease. Recently, Doskotch *et al.* (Phytopathology 65:634-635,1975) reported that capric acid will prevent spore germination of *C. ulmi, C. minor* (Hedge) Hunt, *C. fagacearum* (Bretz.) Hunt, *Nectria cinnabarina* Tode ex Fr. and *Fusarium solani* (Mart.) Appel and Wr. They also reported that it is a natural antifungal agent in *Ulmus americana* L. seed. However, the soaps, unlike fatty acids, are water soluble and preliminary results have shown that K caprate will move in the xylem stream of certain softwoods and hardwoods. Experiments are now underway to ascertain their mobility in white elm.

TABLE 1

Effect of various concentrations of K caprate on growth of *Fomes annosus* after 7 days on cut hemlock discs. Results shown are the average of 3 replications for each treatment and 6 for the controls

% K caprate	*Fomes annosus* isolates tested										
	1	2	3	4	5	6	7	8	9	10	Avg
0.005	5+	5+	5+	5+	5+	5+	5+	5+	5+	5+	5+
0.050	5+	5+	5+	5+	5+	5+	5+	5+	5+	5+	5+
0.500	4	3	4	3	2	1	3	2	2	5	2.9
1.000	0	0	0	2	0	0	0	0	0	0	0.2
1.500	0	0	0	0	0	0	0	0	0	0	0
Control	5+	5+	5+	5+	5+	5+	5+	5+	5+	5+	5+

TABLE 2

Effect of various concentration of K caprate on growth of *Ceratocystis picea* (isolates 1-7), *Europhium clavigerum* (isolate 8) and *Ceratocystis* sp. (isolates 9-10) after 18 days. Results are averages of 3 replicates. Values greater than 5 indicate colony diameter (mm)

% K caprate	*Ceratocystis picea*				*Europhium clavigerum*				*Ceratocystis* sp.		
	1	2	3	4	5	6	7	8	9	10	Avg
0.01	8.3	20	20	18	20+	20+	8	20+	20+	4	15.8
0.10	0	0	0	0	20+	20+	0	0	15.3	0	5.8
1.00	0	0	0	0	0	0	0	0	0	0	0
Control	20+	20+	20+	20+	20+	20+	20+	20+	20+	20+	20+

Our findings indicate that certain soap solutions warrant further testing as treatments against pathogenic fungi such as *Fomes annosus* and *Certatocystis ulmi*. Because soaps are water soluble, very low in phytotoxicity, cheap, fairly abundant and relatively harmless to humans, they should be reconsidered as fungal control agents.—George S. Puritch and D. E. Etheridge, Pacific Forest Research Centre, Victoria, B.C.

SILVICULTURE

Preliminary Observations on Mortality of Red Pine on a Calcareous Soil in Southern Ontario.—In two of the oldest plantations of red pine [*Pinus resinosa* Ait.] in Grey County, mortality has recently become apparent. The plantations are situated at approximately 44°15′N, 80°50′W and are known as the King and Grey Main plantations. The trees are between 30 and 35 years old and their diameters at breast height are mainly between 15 and 20 cm (5.85–7.8 in.). The Grey Main