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ENTOMOLOGY

A Hot-water Technique to Remove Insect Eggs From Foliage.—An improved technique was devised to remove eggs of western blackheaded budworm [*Aclevis gloverana* Walsingham] from western hemlock [*Tsuga heterophylla* (Raf.) Sarg.] foliage to facilitate counting. It was developed from a poaching method used on the spruce budworm [*Choristaneura fumiferana* (Clemens)] (Eidt and Cameron, Bi-Mon. Res. Notes 26: 46-47, 1970). Previously, blackheaded budworm eggs were removed from foliage by soaking in a 1.5% sodium hydroxide solution, followed by a spry wash and filtration (Condrashoff, Can. Ent. 99:300-303, 1967). A similar method was developed to separate budworm hibernacula (Miller et al., Can. For. Serv. Info. Rep. M-X-25, 1971). Although egg recovery was satisfactory, this method was slow, and foliage dry weights that formed the basis of our sample method were reduced.

Samples are trimmed to 18 inches in length, and the fresh weight is recorded. Each branch is immersed in a 3000 ml beaker of boiling water which removes all eggs within 30 seconds; longer immersion removes needles, necessitating screening. The branch is swirled in the water with tongs to ensure that all eggs are free to settle out. A large supply of boiling water can be obtained by piping steam into a 45 gal (205 l) drum containing 25-30 gal (114-136 l) of water. The water and eggs are slowly poured into an 18.5 cm Buchner funnel with attached vacuum; grade 202 coarse filter paper (Reeve Angel, 9 Bridewell Place, Clifton, New Jersey) is used to speed filtering. A circular plexiglass ring, placed around the edge of the labelled filter paper, prevents eggs from floating underneath. The container and ring are rinsed and examined after each filtering to ensure that no eggs stick to the apparatus. Eggs or the filter paper can be counted immediately, or the papers may be stored between polyethylene sheets in a refrigerator or deep freeze for counting later.

Bulky branches should be cut into small segments to ensure proper immersion; this increases the amount of debris in the water and slows counting. To alleviate this problem, pour the water and eggs onto two screens (mesh #20 and #50 U.S. Series Equivalent). The top screen removes needles, branchlets and coarse debris, which must be repeatedly mixed under a spray rinse. The bottom screen, which contains the eggs, is inverted over a large plastic funnel and the contents washed into a l-qt (1.1 ml) sealer and then into the Buchner funnel, as previously described. Adequate rinses must be used.

Two people can process 70 branch samples per day with the screens; whereas without them, up to 200 samples can be handled. This difference is compensated, to some extent, by the ease of counting eggs from the screened process.

Reliability of this procedure was tested by processing branches by the sodium hydroxide method after all eggs had presumably been removed by the hot-water technique. Only 11 eggs were recovered from 100 branches that had over 2000 eggs. Thus, this procedure was simpler, faster, and appeared to be almost as reliable as the sodium hydroxide method.

This method was also tested with eggs of the false hemlock looper [*Nepytia freemani* Munroe] deposited on Douglas-fir branches. Screens could not be used effectively, as the eggs often remained in clusters and were removed with the debris by the first screen. When the maximum likelihood method (Shepherd and Gray, Can. Ent. 104: 751-754, 1972) with three washes is used to estimate total population, 84% of 2970 eggs were recovered in the first wash and a total of 98% in three washes. Visual counts of eggs on foliage only yielded 82% of the total and required considerably more time. Removal of eggs remained relatively constant with each wash (74-84%): therefore, the method was considered satisfactory for this species, provided three washes and the maximum likelihood method were used to estimate density. This may be a fast and accurate technique for extracting eggs of other species, but it should be checked for each species of insects before the technique is accepted.—T. G. Gray, R. F. Shepherd and C. S. Wood, Pacific Forest Research Centre, Victoria, B.C.

Smaller European Elm Bark Beetle Found in Ottawa.—Reports by the Forest Insect and Disease Survey, Great Lakes Forest Research Centre, show that the smaller European elm bark beetle [*Scolytus multistriatus* (Marsh)], is distributed generally throughout southwestern Ontario below 44°30'N, in the Bruce Peninsula, roughly south of a line across Barrie at Lake Simcoe, Fenelon Falls, slightly north of Peterborough, Belleville and Kingston, and along a narrow belt following the St. Lawrence River approximately to Morrisburg in eastern Ontario.

Thomas (Bi-mon. Res. Notes 27(1):3, 1971) observed that the rate of dispersal of *S. multistriatus* northward has declined in recent years and in some areas appears virtually static. He suggests that low winter temperatures may be regulating the northward spread of the insect. Preliminary tests by Thomas indicate that the mean freezing point of *S. multistriatus* larvae appears to be approximately −30°C (−22°F) (Thomas, *ibid.*).

Scolytus multistriatus was found at one location on a single, standing, diseased elm in Ottawa along the Ottawa River at Remic Rapids on 22 June 1973. This is approximately 55 miles (88.50 km) north of its nearest known distribution in Ontario. Numerous brood and larval galleries typical of the smaller European elm bark beetle were found on the dead portion of the elm at a height of 10-20 ft (32.8-65.6 m). The lower trunk of the elm was still alive at the time of collection and no galleries were found in this region. Dead adults of *S. multistriatus* were found in a few of the galleries. Detailed examination of the collected elm material revealed that none of the larvae above snow level survived the low 1972-73 winter temperatures in this region as no spring development was evident. Table 1 shows temperature data from three locations in Ottawa obtained from the Department of the Environment, Atmospheric Environment Service.

TABLE 1
Temperature Data, Ottawa (October 1972-March 1973)

Weather Station	No. of days equal to or below −10°F (−23.0°C)	−15°F (−26.1°C)	−20°F (−28.9°C)	Lowest temperature (°F)	(°C)
National Research Council (Montreal Road)	11	8	2	−24	−31.1
Agriculture Canada (Central Experimental Farm)	12	5	2	−22	−30.0
International Airport	10	2	1	−20	−28.9

These data provide supporting evidence that low winter temperatures may be regulating the northward dispersal of *S. multistriatus*. A survey for further *S. multistriatus* will be maintained in this area in Ottawa.—E. S. Kondo and G. D. Huntley, Great Lakes Forest Research Centre, Sault Ste. Marie, Ont.

Dispersal of Second Instar Spruce Budworm.—Dispersal of the spruce budworm [*Choristoneura fumiferana* (Clem.)] occurs three times during its life cycle: in the fall, by first instar larvae; in the spring, by second instar larvae; and in late summer, by moths. These dispersals affect the distribution of the budworm and, in the case of first and second instar larvae, result in high mortality (Miller, Can. J. Zool. 36: 409-422, 1958), thus they play a major role in the population dynamics of the insect.

Only a few facts are known about the springtime dispersal of second instar larvae. Date of emergence from the hibernaculum is determined by the rate of accumulating degree-day heat units (Miller, Eidt, and McDougall, Bi-Mon. Res. Notes 27: 33-34, 1971). Emergents are photo-positive and crawl toward the branch terminals, where turbulent winds cause the dispersal by carrying away many larvae before they establish in protective or feeding sites (Wellington and Henson, Can. Entomol. 79: 168-170 & 195, 1947).

The present investigation monitored the dispersal of second instar larvae from a surrounding, infested forest to a group of nursery-grown trees used in budworm nutrition experiments. The objectives were to detail the beginning, intensity, and duration of dispersal in relation to weather and to assess early and late dispersing larvae for differences in survival, duration of larval development, and pupal weight.

Wooden frames, 3 x 2 x 2 feet (0.9 x 0.6 x 0.6 m) high and covered with sheer polyester fabric were constructed to catch wind-borne second instars. To prevent the wind from blowing the larvae off the trap surfaces, 2-in. (5 cm) baffle plates were placed on all edges.

Ten traps were spaced evenly in a north-south line across the west end of the boundary nursery at the Acadia Forest Experiment Station. The traps were raised 1 foot (30.5 cm) above the ground and oriented with their 2- x 2-foot (0.6 x 0.6 m) ends facing east and west. The ends of the trap line were about 50 feet (15.2 m) from the forest, while the middle was 150 feet (167 m) east of the forest. All traps were 4 to 6 feet (1.2 to 1.8 m) west of three closely spaced rows of 7-year-old balsam fir trees used in budworm nutrition experiments.

Although average spring emergence begins when 75 degree days have been accumulated above 42°F (Miller et al., *loc. cit.*), trap monitoring was begun on 8 May at 67 accumulated degree days to avoid missing any earlier emergence and dispersal. Hourly checking of all 10 traps was continued daily from 9 AM to 7 PM until dispersal stopped. On days of high influx, traps were checked every 15 min. to assure that no larvae escaped.

Degree days were computed (Miller et al., *loc. cit.*) using the air temperature data from a standard weather station 6 miles (9.7 km) from the experimental site. Daily rainfall and cloudiness were recorded at the site.

All larvae were removed carefully from trap surfaces and placed in groups of 10 on artificial diet (McCorran, Can. Entomol. 97: 58-62, 1965) in closed 1-oz. plastic containers. These larvae were reared under a constant high humidity and a 16-hour photoperiod at 70°F, then weighed and sexed as first-day pupae. Density per container was reduced to five during the late third instar and again to two by the fifth instar. Food was renewed at these times and at one other time.

Only 1.7% of all captured larvae had dispersed before 11 May when 75 degree-days had been accumulated (Table 1), which is in agreement with previous results (Miller et al., *loc. cit.*).

Although larvae were caught over a 15-day period, 77.4% were trapped between 14 and 18 May, when daily accumulated degree days were consistently high. About two-thirds of all larvae were trapped during the hottest part of the day (Fig. 1).

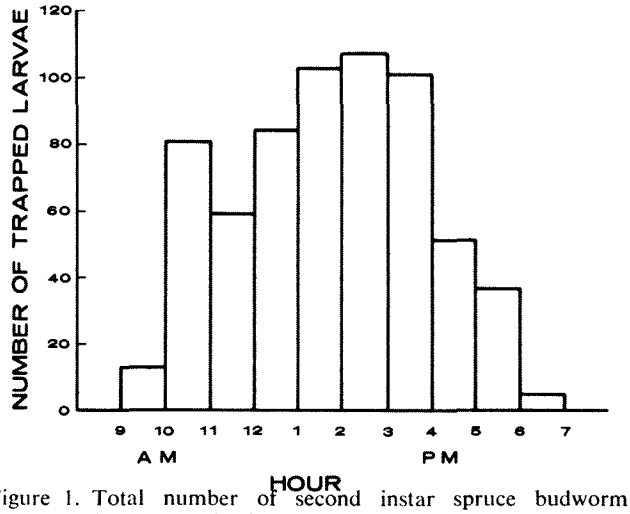

Figure 1. Total number of second instar spruce budworm larvae caught in 10 traps from 8 to 22 May in consecutive 1-hour periods during the day.

No association of daily numbers of dispersing larvae could be made with wind parameters. Winds varied from 6 to 23 mph (9.7 to 37.0 km/h) with higher gusts and came from all directions. However, very little wind may be required for dispersal since most larvae were trapped on 18 May, when wind speeds were only ca. 7 mph (11.2 km/h).

Rainfall markedly inhibited dispersal, even in the presence of favorable increases in degree-days, as indicated by the few larvae trapped on 15 and 16 May (Table 1).

TABLE 1
Daily weather and number of trapped second instar spruce budworm larvae during the 1972 dispersal period

Date (May)	Weather[a]	Number of budworm	Heat units[b]
8	C	7	67
9	C	4	71
10	O	0	71
11	C	7	75
12	O	6	79
13	C	49	86
14	C	131	101
15	M	10	114
16	O	4	127
17	C	113	146
18	C	232	168
19	M	32	176
20	C	24	187
21	M	11	211
22	C	3	224
23	C	0	242

[a] Daytime sky condition C = clear, O = Overcast, M = mixed. Showers occurred on 12 May. Heavier rainfall occurred on 15 and 16 May.

[b] Accumulated degree-days above 42°F.

Only 29% of the larvae survived to the pupal stage (Table 2), which is a relatively low figure for an indoor rearing (McMorran, *loc. cit.*). Nevertheless, several significant correlations involving dispersal date are apparent in the rearing data: the later the dispersal date, the poorer the survival (Table 2), the later the pupation date ($r=0.55$), and the lower the pupal weight ($r=0.46$ and 0.40, for females and males respectively). Pupal weight also was correlated with pupation date ($r=0.82$ and 0.70, for females and males respectively); this correlation was better than that between pupal weight and dispersal date, probably because the duration of pupation was twice that of dispersal.

TABLE 2
Survival to pupation of second instar spruce budworm larvae trapped in the field in consecutive 4-day dispersal periods and reared on artificial diet in the laboratory

	Date (May)				
	8-11	12-15	16-19	20-22	Total
No. dispersing	18	196	381	38	633
No. surviving as pupae	10	85	81	6	182
% survival	55.6	43.4	21.3	15.8	28.8

The data on initiation and intensity of larval entrapment are consistent with the concept that emergence from the hibernaculum is related to accumulated heat units above a certain threshold (Table 1; Fig. 1). Most dispersal may be over in 1 or 2 days (Morris and Mott, Mem. Entomol. Soc. Can. 31:180-189, 1963) or last more than 1 week (Table 1), depending on the rate of accumulating degree days and the frequency of heavy rainfall. Precipitation apparently either washes most of the larvae out of the air or, in combination with cloud cover, reverses their normal photopositive response.

Early and late dispersing second instar larvae differed appreciably, the latter having lower survival, lower pupal weight, and a later pupation date. Greater parasitism of late emergents by *Apanteles fumiferanae* Vier. and *Glypta fumiferanae* (Vier.) may explain these differences (Renault, Can. Forest. Serv., Inform. Rep. M-X-32, 1972). On the other hand, Lewis (Can. Entomol. 92:881-891, 1960) observed that non-parasitized larvae are preferentially dispersed, suggesting that other causes, e.g. infectious diseases, may also play a role. There may even be inherent differences in vigor between early and late dispersing larvae which are related back to early life history events such as egg-laying order.—G. G. Shaw and C. H. A. Little, Maritimes Forest Research Centre, Fredericton, N.B.

Erratum

The formula in Vol. 29, page 11, col. 1 should read:

$$\text{Infestation Index} = \frac{\text{sum of individual tree infestation ratings}}{\text{sum of maximum tree infestation ratings (4 x 3 x no. trees)}} \times 100$$

FIRE

Burning Properties of Some Canadian Forest Fuels.— Work in the United States and in Australia has shown that the burning rates of forest fuels are depedent, amongst other things, upon inorganic content. (Pompe and Vines, Australian Forestry 30:231, 1966; King and Vines, Report, CSIRO Division of Applied Chemistry (Australia, July 1969)). A few simple experiments have, therefore, been carried out using some typical Canadian fuels to see if their behavior is similar.

Burning rates of leaves and pine needles gathered from representative tree species in the eastern Provinces, were determined in a laboratory on a recording balance. Definite differences in burning properties were observed, and it appeared that these differences were related to the inorganic contents of the fuels.

The samples were enclosed in an open wire basket which conveniently held 20 g of leaves, or needles, at a time. They were burnt on the pan of a continuously recording balance, so that changes in weight on combustion were easily followed.

Care was taken to see that the volume occupied by the samples was the same in all cases. This meant that the packing and aeration of the fuels (i.e., their volume to weight ratio) were as similar as possible. However, because of the high density of individual pine needles, it was easy to pack 20 g of needles into the basket, whereas it was more difficult to compress an identical mass of leaves into the same space. For this reason, leaves were usually more "closely packed".

Fuels were dried overnight in an oven 100-105°C so that moisture contents were reduced to a very low level, and reproducible properties could be assured. The drying also served to remove most of the volatile oils or waxes, which are known to influence burning rates. All measurements were duplicated. Each series of tests was completed during a single afternoon to ensure standard conditions, i.e., the temperature of the day, and relative humidity were not variables. For the same reason, all subsequent checks, on other days, were carried out on all samples.

To obtain quick and uniform ignition, 0.25 ml of acetone was introduced into a small cone of filter paper placed on top of the sample at the center, and a burning match was quickly thrown into the cone. The resulting flame spread into the fuels, which ignited from the top and burnt downwards.

To have some basis of comparison, crumpled balls of dry (ashless) filter paper were also burnt in the basket. The natural fuels used were collected in autumn from the forest floor, those tested being: red pine, white pine, white birch, red oak and poplar (from two different sources). Badly fragmented samples of jack pine and white spruce were also available, but they could not strictly be compared with the other samples, since fragmentation made their packing very different. Nevertheless, a few representative measurements were carried out with these fuels.

Typical traces may be seen in Fig. 1, which shows results for poplar and red pine. There are considerable differences in maximum burning rate — that for red pine being 39 g/min., and that for poplar 17 g/min. Maximum burning rates for all species studied are given in Table 1 (see Column II), together with average burning rates up to the time when two thirds of each sample have been consumed (Column III). The approximate weight of the residue remaining when burning in the basket is finished, is also given (Column IV).

The major aim of these experiments was to obtain comparative values of maximum burning rates, when the fuels were fairly closely packed within the basket. But, because of

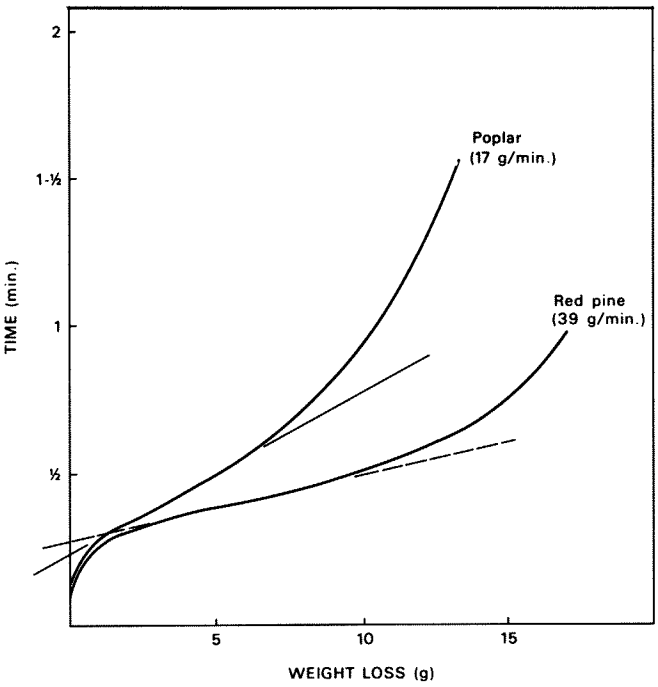

Figure 1. Traces showing burning rates of red pine and poplar.

the somewhat confined nature of burning, ashing of the samples was usually incomplete, and significant amounts of charred, carbonaceous material remained. Thus, to derive a more representative measure of residual material, small, well aerated samples were burnt over an open flame, and the remains collected and weighed to obtain "ash", or the percentage of inorganic residue which was not consumed (c.f., Table 1, Column I). An alternative method would have been to ash the fuels in a dish over a burner; however, as the equipment needed was not available, the above procedure was adopted. It may be seen that, as the ash content of the fuels rises, the flammability, or burning rate, falls. Thus, burning rates decrease in the order shown in Table 1 (from red pine to white birch), and correspondingly the ash content of the fuels increases (6½% for red pine to 15% for white birch). Even the fragmented samples show the same typical behavior for pack pine, despite its "close-packed" arrangement, burns quite well, whereas white spruce, with a much higher inorganic content, does not.

TABLE 1
Burning rates and ash contents of sample fuels

Fuel Sample	I Residual ash on "complete combustion" (%)	II Maximum burning rate (g/min)	III Average burning rate (g/min)	IV Residue in basket (g)
Filter paper	–	>35	20	nil
Red pine	6–1/2	35–40	~27	2
White pine	9	25	12	4
Poplar (from Chalk River)	10	19	11	<4
Poplar (from Thomas Lake)	12	17	10–1/2	4
Red oak	12	16–20*	10	>4
White birch	15	15–20*	10	4–1/2
Fragmented Samples				
Jack pine	11	15	9	4
White spruce	17	5	<4	<4

* Rate when burnt with very open arrangement.

The present work thus serves to confirm previous experiments in Australia, and the findings of Philpot in the United States. Furthermore, the technique is eminently suited to a study of changes in fuel burning rates as the moisture contents of fuels are varied. Indeed, the present equipment is obviously useful for a variety of studies on fuel flammability, and it is planned to carry out additional work along these lines with other Canadian forest fuels.—J. Armstrong and R. G. Vines, Forest Fire Research Institute, Ottawa, Ont.

PATHOLOGY

Forests Affected by Sulphur Dioxide in Northeastern New Brunswick.—Since mining for heavy metals started at an open-pit mine 20 miles southwest of Bathurst, N.B., large quantities of a sulphide material (pyrites, FeS_2) have accumulated. This material has no economic value and was discarded in slag piles. As a result of weathering and leaching, nearby waters have been polluted. In 1970, in an effort to reduce this pollution, the waste was trucked 5 miles and used to fill underground, mined-out sections of another mine.

By January 1971, the sulphide material was apparently being oxidized and the resulting sulphur dioxide (SO_2) venting to the surface. Depending on existing weather conditions and atmospheric stability, concentrations in excess of 1.0 ppm have been monitored more than 1.5 miles (2.4 km) from the source. Southwesterly winds prevail during the summer in this area.

Foliar discoloration became apparent in May 1971 and, by mid-July, all tree and ground-cover species in the vicinity of the mine displayed symptoms typical of SO_2 injury, i.e. an interveinal necrosis with a reddish brown or ivory discoloration of the leaves of broad-leaved plants and usually an orange-red tip necrosis of the leaves of evergreens.

Up to 3 miles (4.8 km) southeast from the source all fronds on bracken fern [*Pteridium aquilinum* (L.) Kuhn], a sensitive indicator of SO_2, were orange-red, and 6 miles (9.7 km) away up to half the fronds on about 5% of the plants had discolored margins. Within 3 miles (4.8 km) of the source, eastern white pine [*Pinus strobus* L.], the most susceptible tree in the area, retained only current-year foliage and browning was apparent on the distal half to three-quarters of each needle. The incidence and intensity of injury decreased with increasing distance from the source (Table 1) and trees 11 miles (17.6 km) from the mine showed no symptoms of SO_2 injury. Yellow tops and branches caused by cankering from white pine blister rust [*Cronartium ribicola* J. C. Fischer], however, were obvious and may be confusing in aerial surveys. Broadleaved trees, particularly white birch [*Betula papyrifera* Marsh.], were affected to varying degrees; nearest the mine, 30 to 70% of the foliage was brown, but premature defoliation was generally light and refoliation of some hardwoods was occurring. Because emissions of SO_2 continued, and because SO_2 was the cause of extensive tree mortality at Trail, B.C. and Sudbury, Ont., ground and aerial surveys were again conducted near the mine in September 1972. The area of apparent damage, involving almost 4,000 acres (1619 hectares) of immature forests did not differ greatly from that noted in 1971.

TABLE 1
Percentage of eastern white pine trees with crown discoloration attrbiuted to SO_2 injury[a]

Distance and direction from SO_2 source	September 1971 Green	Yellow	Red	September 1972 Green	Yellow	Newly dead
1 mile E	75	25	0	0	0	100
1 to 3 miles SE	71	0	29	55	20	25
3 miles NW	75	25	0	45	0	48
5.5 miles SE	100	0	0	61	17	22
7 miles NE	47	36	17	67[b]	25[b]	8[b]
8 miles NE	90	10	0	67	22	11
11 miles NE	100	0	0	100	0	0

[a] Dead or yellow tops due to cankering from white pine blister rust were classed as green for this survey.
[b] Recent cutting has reduced the apparent damage.

In damage class 1 (all species dead), ground surveys with a prism, confirmed that all eastern white cedar [*Thuja occidentalis* L.] and white birch had been killed, as had 94% of the balsam fir [*Abies balsamea* (L.) Mill.] and 74% of the black spruce [*Picea mariana* (Mill.) B.S.P.] and red maple [*Acer rubrum* L.]. The few conifers that were alive in this class possessed no older foliage and so little current-year foliage that from the air, they appeared to be dead. They probably will not recover. At 0.7 mile (1.1 km) southeast of the SO_2 source, no living ground cover existed and lichens had disappeared. As distance from the source increased, scattered patches of grasses, bunchberry, aralia, goldenrod, and bracken fern became evident, although 75 to 100% of the existing fern fronds had been affected. Some scattered maple and trembling aspen [*Populus tremuloides* Michx.] had a normal amount of foliage, but the leaves had light to moderate browning, symptomatic of SO_2 injury.

In damage class 2 (most trees affected), 48% of the balsam fir volume was dead, as was 6% of the black spruce and 39% of the beech [*Fagus grandifolia* Ehrh.]. Ground cover, including asters, grasses, aralia, and bunchberry showed only light browning; lichens were present on the maples; ferns were common but had light to moderate browning; and living balsam fir and spruce saplings had current plus 2 to 5 years of foliage.

In "control" plots, no foliar symptoms of SO_2 injury were evident. The 9% mortality of balsam fir observed was probably due to the spruce budworm which caused moderate to severe defoliation in north-central New Brunswick in 1970 and 1971.

Near the mine, most eastern white pine are scattered, 200- to 300-year-old veterans. From data in Table 1 and an estimated frequency of 0.5 pine per acre there would be 235 dead pine in damage class 3 (all white pine dead) and 180 in damage class 4 (white pine affected). Another 135 trees have thin, yellow crowns and further mortality is expected. Increment cores from a few veteran white pine indicated that as much as 80% of some trees could be free of decay. Since they are highly susceptible to injury from SO_2, the prompt removal of any economically valuable stems should be considered.

Further mortality can be expected with continued exposure. The few remaining spruce and balsam fir in damage class 1 will decline as will an increasing number of the more susceptible species farther from the source. Additional losses include the reduction of increment in the living but affected trees, and reduced stand values through changes in stand composition. This will continue to be a problem until the fire is extinguished and the release of SO_2 stopped, or until the SO_2 is diluted by dispersion to non-toxic levels during the growing season.—G. A. Van Sickle, Maritimes Forest Research Centre, Fredericton, N.B.

SOILS

Biometer Flask for Determining Microbiological Respiration in Forested Soils.—Field measurements of soil respiration, which include microorganism, animal and root activity, generally overestimate microbial activity in the soil. Three aeration systems, continuous, intermittent and static, have been used in the laboratory to determine soil respiration in the absence of root activity. For the latter two systems, a variety of biometer flasks have been developed (Bartha and Pramer, Soil Sci. 100: 68-70, 1965; Nommik, Soil Sci. 112: 131-136, 1971). These flasks are expensive to purchase or construct (approximately $10-15). All systems use ground or extensively disturbed samples, which lead to increased respiration rates (Webley, J. Agr. Sci. 37: 249-256, 1947) and inaccurate measurement of microbiological activity as it exists within the undisturbed field soil. The flask described herein is inexpensive (approximately $1.35) and allows the use of samples which have undergone a minimum of disturbance.

The biometer flask (Fig. 1a) is a one-quart, wide-mouth mason jar with a plexiglass lid. The lid seals the container and holds the vial with alkali. Alkali is introduced and removed through a plastic syringe and needle held in place by a #00 rubber stopper. A three-way plastic aquarium valve is included so tha the system may be flushed with CO_2-free air at selected intervals, generally every 14 days, for long-term incubations. The alkali must be removed during this procedure.
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Samples are collected in the field with a 5-cm core sampler (Burkard Mfg. Co. Ltd., Rickmansworth, England) and placed directly into the glass sample-holder and transported in a cooler to the laboratory. Sample and sample holder are placed in the mason jar; the closure with alkali vial is secured in place with a metal-O-ring and the alkali is introduced. The complete system is then incubated at the soil temperature present in the field at the time of sampling (Fig. 1b).

Sample moisure content is determined following the incubation period. In this way, sample disturbance and pretreatment is kept to a minimum.

Calculations of respiration rate are based upon the quantity of organic matter (weight loss on ashing oven-dry samples) present in each soil core. This reduces variation between samples taken from the same plot. Averaged values for each sample area are converted to grams CO_2 respired/meter^2/hr.

A 75-day incubation experiment was conducted to determine the minimum time required for maximum differences

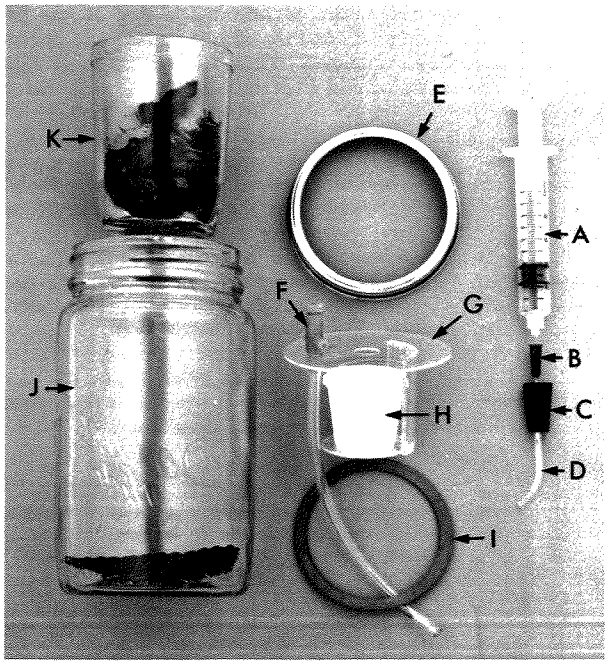

Figure 1. (a) Components of biometer flask. A. 10 cc plastic Luer lock syringe. B. 16G 1½ disposable hypodermic needle. C. #00 rubber stopper. D. 3.18 mm (1/8") O.D. tygon tubing. E. Metal-O-ring. F. Plastic aquarium valve. G. Lid constructed from 1.59 mm (1/16") clear plexiglass and quartered 3.18 mm (1/8"). H. Plastic vial. Lily #3/4 SP. I. Rubber-o-ring. J. 1 quart wide-mouth mason jar. K. Glass sample holder and sample.

between sample areas to become evident. Twenty-four cores were collected (March, 1972) from each of control and urea fertilized plots (448 kg N/ha applied March, 1971) under Douglas-fir and incubated at 13 C. After removing the alkali, the system was flushed with CO_2-free air every 14 days. Statistical analysis of data (Fig. 2) indicated that a significant difference ($P=0.05$) in respiration rates was detectable after 2 weeks, and this difference was maintained for the duration of the incubation. At 4 weeks, respiration rates were significantly different at the 1% level. This would suggest that measurement of respiration rate should be performed over a 4-week incubation period.

In a second experiment, respiration rates determined in the field and laboratory were compared by collecting cores (14) from each of three plots on the day the field rates were determined, using the method of Lieth and Quelette (Can. J. Bot. 40: 127-139, 1962). The cores were incubated at the same temperature (10 C) as the field soil at the time of sampling. Since the respiration rates determined in the laboratory exclude root respiration, the difference between laboratory and field values (Table 1) should represent root respiration. In this case, root respiration accounts for 60-75% of the total field respiration. Rieners (Ecology 49: 471-483, 1968) has suggested that root respiration may represent two-thirds of the field measured soil respiration in Minnesota forests. This comparison would suggest that the laboratory determined respiration values are in fact a reasonable measure of microbiotic activity as it existed in the field.

Maximum respiration rates of 0.25 gm and 0.10 gm CO_2/meter^2/hr were obtained for the March and mid-July samp-

Figure 1. (b) Assembled flasks within incubator.

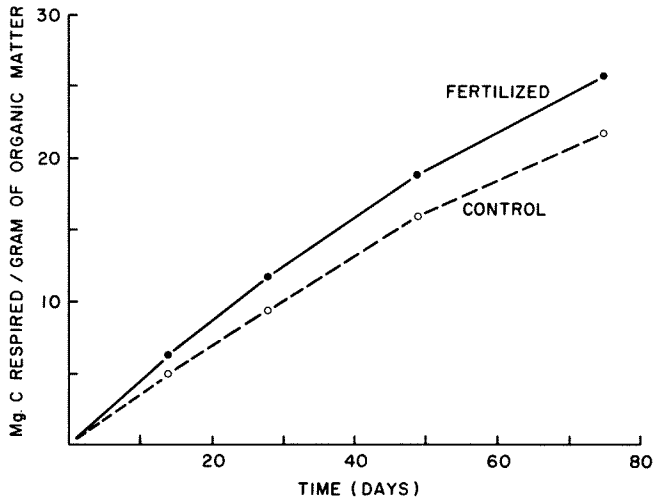

Figure 2. Statistical analysis of data.

TABLE 1
Field and laboratory determined soil respiration

Thinned Plots	Field Value* mg $CO_2/m^2/hr$	Laboratory Incubation** mg $CO_2/m^2/hr$	% of Field Value
No Fertilizer	260	65[a]	25
224 Kg N as urea	256	108[b]	42
448 Kg N as urea	216	90[ab]	41

* Unpublished results, V. G. Marshall. Collected 20 July 1972.
** Cores collected for inclubation 19 July 1972. Values followed by the same letter are not significantly different $P = 0.05$.

lings, respectively, of urea fertilized plots, using the described biometer flask. An average annual leaf fall of 1,780 kg C/ha could maintain a uniform respiration rate of 0.075 gm CO_2/meter^2/hr for the year, whereas a respiration rate of 0.3 gm CO_2/meter^2/hr could be maintained only for 91 24-hr days (Wiant, J. For. 65: 408-409, 1967).

The respiration rates calculated in our experiments fall between the values mentioned by Wiant and again suggest that a reasonable measure of field microbiotic activity has been obtained by using the minimally disturbed soil cores in the described biometer flask.—J. A. Dangerfield and P. E. Olsen, Pacific Forest Research Centre, Victoria, B.C.

(Continued from back cover)

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