PHYSIOLOGY

Use of the Rhizometer to Estimate Foliar Surface Area.—Leaf functions such as transpiration, photosynthesis, and gaseous exchange are often monitored during scientific investigations of hydrologic cycles, plant growth, or the environmental impact of pollutants. These functions can be closely correlated with foliar surface area. The surface area of leaves or needles can be measured or estimated by several methods (Baker, Can. Dep. For. Rural Dev., For. Branch Publ. 1219, 1968; Strong and Zavitkovski, USDA Forest Serv. Res. Pap. NC-153, 1978), including the use of planimeters, grids, photosensitive papers, and even direct measurement of various foliar dimensions. All of these methods, however, are extremely time-consuming and rather laborious.

A more rapid photometric "rhizometer" method, originally developed to measure the surface area of seedling roots (Morrison and Armson, For. Chron. 44[5]:21-23, 1968), appeared to have a potential for leaf-area measurement. This method employs the principle of a photocell and intercepted light, assumes roots to be cylindrical, and uses a correlation formula related to the diameter of the cylinder. Because needles are neither cylindrical nor smooth, but convoluted, half-moon shaped, or rhomboid, the rhizometer method had to be used indirectly to obtain accurate measurements. Foliar-surface areas estimated by the rhizometer were correlated with those measured by the accurate glass-bead technique, and standard curves were established to be used with the rhizometer for lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.), Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco), white spruce (*Picea glauca* [Moench] Voss), Colorado spruce (*Picea pungens* Engelm.), and Siberian elm (*Ulmus pumila* L.).

The rhizometer was modified to use a phototransistor and a digital panel meter instead of a photoelectric cell and a galvanometer. The amount of light directed toward the phototransistor was regulated in two ways: (1) by varying light intensity and (2) by varying the size of openings (masks). In measuring small needles the latter way was used to increase the resolution of the rhizometer (e.g. the percentage of light intercepted by 1 cm^2 of leaf in a 100 cm^2 opening is only 1%; however, 1 cm^2 of leaf in a 10 cm^2 opening intercepts 10% of the light). Calibrations were made frequently, and care was taken to stop or to compensate for fluctuations in readings when there were voltage surges in the laboratory.

Surface area can also be measured by using fine glass beads to coat the leaf or the needle and then relating bead weight to some standard surface area (Thompson and Leyton, Nature 229(5284):572, 1971). This method, which is accurate but can take as long as 15 min per needle, uses beads of 0.11 mm diameter and thinned rubber cement (1 part cement to 7 parts thinner by weight). In our study, the leaves and needles were coated with an adhesive, weighed, coated with beads, and reweighed. The weight of the beads was then compared with standards to obtain the total surface area. Three rods of different diameters (0.32258, 0.24384, and 0.11938 cm) were used as standards; they were individually coated to give a total surface area of 1 cm^2. The average bead weight was 23 mg/cm^2.

Each needle or leaf was first measured by the rhizometer, then by the glass-bead technique. Needle and leaf measurements were conducted in daily "runs" by species groups. The number of runs per species and the number of needles or leaves measured per run varied from four runs of 30 to 60 needles per run for white spruce to one run of 30 leaves for Siberian elm.

Data from each run and the combined data for each species were analyzed by least-squares regression techniques. The surface area measured by the bead technique as the dependent variable (Y) and the rhizometer estimate of surface area as the independent variable (X) were used. The following regression model, a power or geometric curve, proved to be most appropriate for the five species studied:

$$\ln Y = \ln a + b(\ln X)$$

Covariance analyses were used to compare the individual curves for each species run with the common curve for each species. The covariance analyses indicated no overall significant differences between the run and common curves for each species. None of the comparisons showed significant differences in the slope (b) coefficients, and only for white spruce was a significant difference noted between the intercept coefficient (a) of a run equation and the common equation. Therefore, the common equations listed in Table 1 are considered to be representative of each species.

TABLE 1
Regression statistics for estimating leaf or needle surface area (cm^2) from rhizometer estimates (cm^2) for five tree species

Species	Regression coefficients a	b	No. obs.	$s_{y.x}$ (ln units)	R^2
White spruce	3.546	0.830	180	0.118	0.788
Colorado spruce	4.860	0.978	70	0.082	0.885
Lodgepole pine	1.949	0.826	130	0.107	0.857
Douglas-fir	2.540	0.812	140	0.115	0.780
Siberian elm	2.659	0.995	30	0.036	0.995

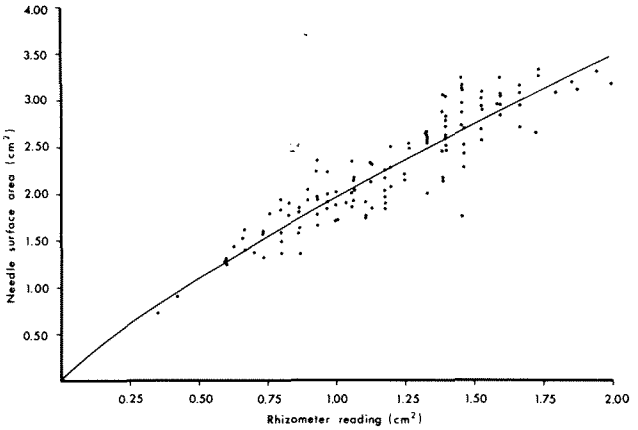

Figure 1. Standard curve for estimating the surface area of lodgepole pine needles with the rhizometer.

These results show the strong correlation between the two methods of surface-area measurement. The rhizometer method described will provide reliable estimates of needle or leaf surface area in a matter of seconds. Once standard curves, similar to the curve for lodgepole pine shown in Fig. 1, have been established between the rhizometer estimates and the highly accurate bead-technique estimates, only periodic spot-checks of the rhizometer itself need be conducted to ensure proper calibration.—L.W. Carlson, Forest Management and Conservation Branch, Ottawa, Ont., and W.D. Johnstone, Northern Forest Research Centre, Edmonton, Alta.

ENTOMOLOGY

A Release-recapture Experiment with Normal and Irradiated Spruce Budworm Males.—The depression of insect population fertility by the release of genetically altered males is attractive because it is species-specific and environmentally safe. Experience gained since the successful control of the screw worm (Bushland, Int. At. Energy Publ. STI/PUB/265:3-14, 1971) indicates that three main methodological challenges are associated with the approach. First is the development of a genetic control system appropriate to the target species. Second is the requirement that released insects remain fully competitive. Third is the necessity for an effective method of detecting released males and monitoring their dispersion. Underlying all these aspects is the concern that the laboratory-reared vector insects may differ from feral males in some subtle but significant genetic manner, thereby decreasing the effectiveness of the release.

A part of the 1978 research in this laboratory has been directed towards the development of a simple and effective method of detecting dispersal of released males into the target population, by the use of pheromone trapping. The results obtained also suggest differences in response of laboratory stocks to pheromone traps in the field.

Males released were from four sources. Field males ($+^f$) were

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Postglacial Fossil Tamarack (Larix laricina) *Wood from the Mackenzie Delta, N.W.T.*

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