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Measurement of Throughfall at Two Levels in a Young Aspen Stand

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MEASUREMENT OF THROUGHFALL AT TWO LEVELS

IN A YOUNG ASPEN STAND

by

John R. Clements[1]

INTRODUCTION

The purpose of this report is to compare measurements of the quantity of throughfall at two different heights above ground level in a seven-year-old sucker stand of largetooth aspen (Populus grandidentata Michx.). This comparison defines the influence rain splash from the forest floor has on the quantity of throughfall catch of trough rain gauges placed on the forest floor.

Rain splash into throughfall gauges may result in overestimates of throughfall in the forest. The overestimates would affect any computations of water budgets of the forest and of nutrient budgets involving rainfall input to the forest.

Throughfall is defined in this paper as free-falling rain beneath the crown canopy and comprises drops that fall between crowns or between branches, and the splash and drip from leaves and branches in the crowns. A storm is defined as any rainy period separated from any other rainy period by at least six hours, and storm size is the amount of rain that falls during a storm.

THE STAND

This work was done at Petawawa Forest Experiment Station, Chalk River, Ontario (46°N lat., 77.5°W long.). Soils, topography, climate and stand are described in detail by Clements (1971).[2]

In 1970, the suckers were seven years old. Average height was 8.5 m, sucker density was about 25,400 stems per ha, and diameter range at breast height was 0.5 cm to 6.5 cm. Leaf area index in 1969 was about 2.5 (Pollard 1970).

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[2] Summer rainfall in a young sucker aspen stand. In preparation.

The suckers originated after an intense fire in May 1964 (Van Wagner 1965). The fire consumed the L and F layers in the organic soil profile and may have consumed part of the H layer. In 1970, the litter layer was 1 to 2 cm thick and comprised debris of only largetooth aspen. There was virtually no understory.

METHODS

Throughfall

Throughfall measurements were made with trough-type rain gauges. The orifices were ~~64.5~~ 645 cm^2 in area and 63.5 cm long.

Gauges were mounted on wood frames so that the orifices were at either 25 cm or 75 cm above the ground surface. Ten gauges were randomly placed at fixed locations under the aspen canopy at each level. Also the long axis of the gauges was randomly oriented. In the remainder of the report the gauges are referred to as either low gauges or high gauges.

Measurements were made after each storm and began 30 May, 1970 and ended 29 June, 1970. Admittedly this is a short period of time for making the comparison intended in this report. The reason for terminating the field measurements is pointed out in the section on Results.

Gross Rain

Gross rain was measured in three Dorchester stainless-steel rain gauges (64.5 cm^2 orifice). These were placed in a clearing about 45 m from the throughfall gauges, and the orifice of the gauges was at 75 cm above the ground surface.

Gross rain was measured after each storm.

Analysis of Data

Mean throughfall and other descriptive statistics were computed after each storm. The descriptive statistics were: variance; coefficient of variation (standard deviation expressed as a percentage of the mean); and standard error of the mean (standard deviation divided by the square root of the number of measurements).

The numerical difference between mean throughfall of the low gauges and mean throughfall of the high gauges was tested for statistical significance (two-tailed t-tests) after each storm.

Differences between low and high gauges in the amount of variation in throughfall samples were also tested (F-tests) after each storm for statistical significance.

Gross rain per storm was computed as the mean of the three gross-rain gauges. Usually the three gauges had the same amount of rain per storm. When there was variation it was minor and neglected.

Mathematical relationships between mean throughfall per storm and gross rain per storm were computed for both low gauges and high gauges. The mathematical relationships were computed by least-square analysis from the formula:

$$T = a + bP \qquad \text{mm per storm} \quad (1)$$

where T = mean throughfall per storm in mm

P = gross rain per storm in mm

a and b are equation coefficients

The two sets of a and b coefficients computed from equation (1) were compared by analysis of covariance. Following this comparison, the two sets of throughfall data were combined. Then one mathematical relationship expressing throughfall per storm as a function of gross rain per storm was computed after equation (1).

RESULTS

Throughfall and gross rain were measured after eight storms ranging in size from 2.9 mm to 22.2 mm. Standard errors of the throughfall means ranged from 2.7% to 4.5% of the means for low gauges, and from 2.3% to 5.7% of the means for high gauges. Mean throughfall values and standard error of the means are listed in Table 1 in relation to storm size.

Small pieces of organic debris were occasionally seen in low gauges after rainfall, but none were seen in high gauges. The presence of the debris indicated that splash was entering low gauges from the forest floor. Similar debris was adhering to the side of the wood frames supporting the high gauges to a height of about 40 cm.

Even though there was evidence of splash into the low gauges, field measurements were discontinued after the eighth storm at the end of June. There were three reasons for discontinuing the measurements. First, for each storm the numerical difference in mean throughfalls for the low and high gauges was either zero or else small and not statistically significant ($P = 0.05$). Secondly, variances of low and high throughfall samples were not significantly different ($P = 0.05$) for any of the storms except two. For one of the exceptions, variance was greater for high gauges than for low gauges, and for the other exception variance was greater for low gauges than for high gauges. Thirdly a wide range in storm sizes had been sampled without finding significant differences between low and high gauges in mean throughfall values.

The relationships between throughfall per storm and gross rain per storm for low and high gauges were

$$\text{Low} \quad T = -0.38 + 0.99\,P \qquad \text{mm per storm} \qquad (2)$$

$$\text{High} \quad T = -0.42 + 0.99\,P \qquad \text{mm per storm} \qquad (3)$$

where the symbols are the same as before. In respect of low gauges, $r^2 = 0.99$, $n = 8$, and the standard error of estimated throughfall for the mean storm size was 0.19 mm. In respect of high gauges, $r^2 = 0.99$, $n = 8$, and the standard error of estimated throughfall for the mean storm size was 0.12 mm.

As expected on the basis of the results of the t-tests, the coefficients of equation (2) and (3) were not significantly different ($P = 0.05$).

When the relationship between throughfall per storm and gross rain per storm was computed again, based on samples of low and high gauges together, the relationship was

$$T = -0.40 + 0.99\,P \qquad \text{mm per storm} \qquad (4)$$

The value of $r^2 = 0.996$, $n = 16$, and the standard error of estimated throughfall for the mean storm size was 0.10.

DISCUSSION

It is clear from the analyses that the difference in amount of throughfall measured at 25 cm and 75 cm above the ground surface was more apparent than real, and that any splash from the ground surface into the low gauges was not a large enough quantity to influence the results.

The value of the slope coefficient in equation (4) was high compared to a theoretical maximum slope of unity. This theoretical slope would be reached only if there were no evaporation of rain water from plant surfaces wetted to full storage capacity during storms. The high value, therefore, indicates a low rate of evaporation from the sucker aspen trees during storms.

Trampling of the floor in this young sucker stand was not a serious problem. Trampling is a potential problem where there is intensive use of the site. For example, White and Carlisle (1968) observed in a mixed deciduous woodland used for several experiments that splash height increased with use, and they progressively raised rain gauges to keep them above splash height.

It is important to point out that although error for rain quantity is small and negligible in this young aspen stand, rain water collected in low gauges with splashed-in debris should not be used for chemical analysis. Otherwise, estimates of nutrient input to the forest and rate of nutrient cycling in the forest would be seriously affected. Carlisle, Brown and White (1966) noted the importance of avoiding soil contamination in studies of rain chemistry in forests.

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TABLE 1

Mean throughfall for high and low gauges for each storm.

Storm number	Storm size mm	High gauge mm	Low gauge mm
1	22.2	21.6 (± 1.1) 1/	21.6 (± 0.7)
2	2.9	2.5 (± 0.1)	2.4 (± 0.1)
3	11.3	10.5 (± 0.03)	10.1 (± 0.3)
4	20.8	19.8 (± 1.1)	19.6 (± 0.4)
5	18.7	18.6 (± 0.6)	18.7 (± 0.4)
6	6.6	6.4 (± 0.2)	6.0 (± 0.2)
7	10.7	9.9 (± 0.2)	10.5 (± 0.4)
8	10.3	9.7 (± 0.5)	10.4 (± 0.5)

1/ Values in parentheses are standard error of mean.