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INTERCEPTION OF RAINFALL BY A HARDWOOD CANOPY

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by

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THE PRIMARY OBJECTIVE of the study was to obtain interception values including throughfall and stemflow for an old-field, cove hardwood forest type. A secondary objective was to utilize the data and conclusions to aid in the determination of an optimum method for sampling interception, and to proceed with obtaining interception values for the major forest types at the Coweeta Hydrologic Laboratory in western North Carolina.

Interception may be considered as a loss of rainfall from the standpoint of soil moisture. This loss is estimated by subtracting the amount of precipitation falling directly through the crowns, plus stemflow, from gross precipitation. The quantity of precipitation dripping from and falling through, the crowns is termed throughfall. For purposes of this study, a storm was considered to be a measurable quantity of rainfall separated from consecutive rains by a length of time sufficient to permit complete drying of the foliage.

Interception studies have been made under plantation, and natural-grown coniferous stands, and under plantation-grown hardwood stands. A search of the literature reveals that there have been very few published studies of interception in natural-grown hardwood stands. Wood (9) and

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Beall ([1]) carried out exploratory studies in hardwood stands and both of these deal with some interesting problems. First, Wood reported that 18 gages were necessary for measuring throughfall «to obtain significant results.» The results of the present study indicate that a ratio of nine gages measuring throughfall to one measuring gross precipitation is more than adequate in order to keep the associated errors of each parameter roughly equal.

Second is the problem of how the gages should be located in the field. Horton ([2]) had described the variation in interception in relation to distance from the tree stem. Utilizing Horton's findings in a coniferous, or even a hardwood plantation would undoubtedly strengthen the data. In a natural stand of hardwoods, however, the random location of the trees and the extensive overlapping of the crowns makes Horton's findings inapplicable, as in the present study, which used random gage location.

Another problem is whether interception loss is greater in winter than in summer. Beall reports virtually no difference whereas Wicht ([7]) reports a 3 per cent loss during the dormant season and a 14 per cent loss during the growing season in a hardwood plantation. Kittredge ([3]) points out that the various influencing factors may compensate for each other's effect and resulting net precipitation (throughfall plus stemflow) may be the same for both winter and summer. Other factors, such as storm size, duration, and intensity, as well as vegetal factors do influence net precipitation, and these variations, which are generally related to season of the year, may further the compensating effects. In the present study, where gross precipitation is well distributed throughout the year, throughfall per unit gross precipitation and stemlow are found to be greater in the winter.

The forest type studied occurs on land which was cleared and farmed in the early part of this century. It is presently a pole stand, some forty years old, of yellow poplar (**Liriodendron tulipifera**) and hickory (**Carya,** spp.) with a liberal scattering of about twenty other hardwood species (Fig. 1). There is no understory of laurel and rhododendron as is typical of the hardwood forest of the Southern Appalachian mountains. The study area is at an elevation of 3000 feet and receives an average of 77 inches of precipitation per year. During the course of the study, one of the 67 storms was ice and one snow. Orographic and convectional type storms, which yield high intensities but small amounts of precipitation, predominate in the summer months, while the winter storms, which are generally frontal or cyclonic, yield more precipitation per storm, but at lower intensities. The growing season at the above elevation averages 140 days in length.

Gross precipitation was measured by four standard rain gages. Three were located under vertical openings in the crown and one under a 45-degree opening. There were no consistant differences between these gages, indicating that in this case, type of opening did not seriously influence the catch. The four gages were averaged to obtain gross precipitation, but were used separately, each in conjunction with a throughfall plot, for purposes of analysis. A recording rain gage was used to study time-lag relationships and to determine duration and intensity of the storms. It was located under the 45-degree opening.

Figure 1. — The cove hardwood forest type found on the study area. Note the general lack of heavy understory vegetation.

Şekil 1. — Çalışma sahasında bulunan taban yapraklı orman tipi. Umumiyetle kesif ikinci tabaka vejetasyonunun eksikliğine dikkat et

Throughfall was measured on four one-quarter acre plots, one near each gross precipitation gage. There were nine gages on each plot, and these were moved at random every three months. The move-dates coincided generally with foliage development changes, and thus differences in throughfall were confounded to a certain degree with place-effects. The plots were located on the slopes of a small bowl-shaped drainage area and were situated so as to help eliminate any effects of aspect. Locations of the plots were selected, and orientation was in cardinal compass directions.

Standard rain gages measuring throughfall were wired to short stakes and were seated directly on the ground. Gages were re-located at random if obstacles prevented placement. One of the nine gages on plot I was a recording gage and was not moved for the entire year of study.

Two formal analyses were worked on the throughfall data. The first was an analysis of variance (5) between plots and between seasons. Since gross precipitation was different for each season, the difference between throughfall and gross precipitation for each plot and adjacent gage for each season was tested. These figures were expressed as a per cent of the seasonal gross precipitation. The distribution of the degrees of freedom was three each for between-plot- and between-season-variance, and nine for within-plot-variance or error. A standard F-test yielded a greater value of F for between-season-variance than for between-plots, but neither were significant. A test for least significant differences showed that there was no significant difference between any two plots or any two seasons. An additional analysis of variance, using an arcsin angular transformation of the data (5), did show a significant difference between seasons at the 5 per cent level, but not between plots. Thus, seasonal variations are not too important, but they probably should be taken into account in future work at the Laboratory. It should be noted that a large amount of variation was attributed to error: part of this is due to the fact that the areal variation of precipitation is increased by the non-uniform crown canopy, and part due to the technique of measurement.

The second major analysis concerned the calculation of regression equations. With the exception of the summer season, the regression equations of throughfall (T) on gross precipitation (P) follow the expected pattern (Table 1).[3]). The correlation coefficients are high undoubtedly due to the fact that the only data used for the computations were taken from storms that were isolated by measurement. The regression equations agree closely slowely with those calculated by Trimble and Weitzman (6), Loughead and MacKicken (unpublished), and Pereira (4), the two former investigators worked in similar forest types in the Appalachian mountains, while Pereira reported on interception in a plantation of bamboo in Kenya, Africa. Figure 2 shows the relationship of the average regression of this study to those mentioned above.

(3) A heavy wind storm at the beginning of the summer season removed about 15 to 20 per cent of the crown canopy.

Table: I

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Summary of regression equations, standard errors of regression, and correlation coefficients for throughfall on gross precipitation, by seasons

Mevsimlere göre ara yağış ve brüt yağışın regrasyon denklemlerinin hülâsası, regrasyon, standart hataları ve korrelasyon konfesyonları

Mevsim Season	Kullanılabilen yağmurlar adedi Number of usable storms	Regrasyon denklemleri P ve T inç olarak Regression equations (P and T in inches)	Regrasyon Standart hâtası Standard error of regression	Korrelasyon koefesyon Correlation coefficient
Fall	12	T=— .0331 + .9118 P	0.044	0.996
Winter	12	T=+ .0061 + .9021 Pa	,054	.999
Spring	12	T=— .0169 + 8333 P	.043	.998
Summer	12	T=— .0554 + .9338 P	.051	.998

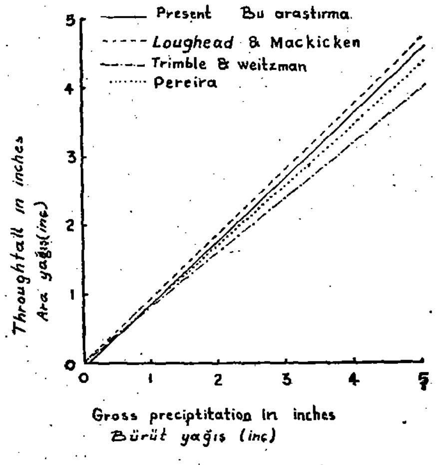
a) **The positive value of «a» in this equation is within the limits of error.**

a) Bu denklemde olan «a» nın pozitif kıymeti hata hududu içindedir.

FIGURE (2) ŞEKİL

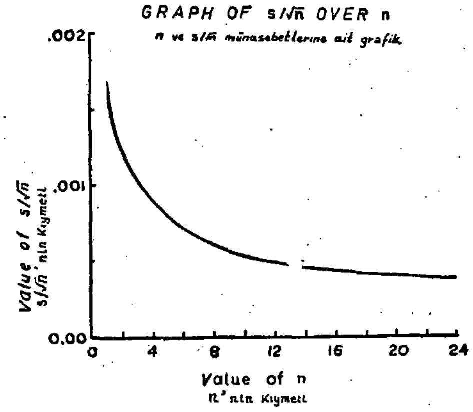
REGRESSION EQUATIONS OF THREE SEPARATE STUDIES COMPARED WITH THE PRESENT INVESTIGATION.

AYRI AYRI ÜÇ ÇALIŞMANIN REGRESYON DENKLERİNİN BU ARAŞTIRMA İLE MUKAYESESİ.



Total gross precipitation for the year was 81.79 = 0,17 inches and throughfall for the year was 73,24 = 0,15 inches (89,55 per cent of the gross precipitation). The attached error statements are the standard error of the mean of the observations and they indicate that throughfall was measured slightly more accurately than gross precipitation (the errors are 0,21 per cent of the total gross precipitation and 0,20 per cent of the total throughfall). Thus, nine gages are sufficient in conjunction with one gross precipitation gage to maintain approximately equal error in both parameters. Using a high value of variance of throughfall, a test was applied to determine if fewer gages would be satisfactory. The test was to plot the value of the standard error of the throughfall value divided by the square root of the number of samples $\frac{s}{\sqrt{n}}$ over the number of samples (n), and determine the breaking point in the resulting J-curve. The curve (Fig. 3) illustrates that 6 gages would maintain approximately the same degree of error as 9 gages, and the future studies could be simplified by using fewer gages.

FIGURE (3) Şekil
GRAPH OF s/√n OVER n
n ve s/√n münasebetlerine ait grafik



Stemflow measurement was accomplished during the winter season. The amount was small and highly variable, but is estimated to be about 8 per cent of the difference between precipitation and throughfall, on an annual basis. Tests for relationships with tree characteristics were inconclusive.

Summary

The techniques used in measuring the difference between gross precipitaion and throughfall shcw that variation between plots was less than the variation between seasons. Neither between-plot nor betweenseason differences were statistically significant at the 5 per cent level. in an analysis of variance on the originaldata. On transformed data there was a significant difference at the 5 per cent level between seasons. Within-plot-variance was high, indicating the improvement in teshniques is necessary to more fully assess the differences between seasons.

From 0,01 inches in winter to 0,06 inches in summer of gross precipitation are necessary before throughfall starts in the forest type studied. Throughfall for the year, which was about 73 inches, was measured slightly more accurately than gross precipitation, which was about 82 inches. The regression equations of throughfall on gross precipitation are in close agreement with other workers in both similar and dissimilar forest types.

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