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Interception of Precipitation by a Hardwood Forest Floor in the Missouri Ozarks

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INTRODUCTION

The influence of forest litter[2], in maintaining the proper nutritive and hydrologic balance in the growth of forest trees, is well known. Various aspects of both functions have been under investigation for a number of years and the conclusions drawn from research have been widely distributed and read.

Forest litter plays a complex role; it supplies the major source of organic matter in forest soils, maintains a high water-infiltration rate, reduces surface runoff and erosion, and liberates considerable quantities of mineral elements through decomposition of the litter by biological and bacteriological action. Cope (1923) determined that removal of forest litter had a detrimental effect on the height growth of loblolly pine in Maryland. Auten (1933) showed that the water-infiltration rate in forest soil with a cover of litter was considerably greater than that through grass-covered soils. Forest litter is instrumental in the formation of soil aggregrates, resulting in greater aeration and increased biological activity.

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The amount of forest litter present at any given time is dependent on a number of factors. Among the most important factors are:

1. Length of time since past stand disturbance
2. Nature of past disturbance
3. Site quality

[1]The authors are former graduate student at the School of Forestry, University of Missouri, and Associate Professor of Forestry, respectively.

[2]Forest litter definition follows the U.S.D.A. Soil Survey definition: Aoo-loose leaves and organic debris, largely undecomposed; Ao-organic partially decomposed or matted; A1-a dark-colored horizon with a high content of organic matter mixed with mineral matter.

4. Stand age
5. Species composition and its stage in natural succession
6. Stand density
7. Time of year.

The total oven-dry weight of the forest floor varies tremendously from one area to another. In the Central States region, a total accumulation of eight tons per acre in hardwood stands has been given by Auten (1933). The accumulation of litter is primarily dependent upon the combined effects of moisture and temperature. In northern latitudes, litter accumulates at a faster rate than it decomposes. The proportion of total forest floor composed of freshly-fallen material is relatively constant within a given climatic zone. Lutz and Chandler (1946) quote a figure of 2700 pounds per acre as an average weight of freshly-fallen litter in the central zone of the United States. Ebermayer (1876, 1890) stated that the weight of dry organic matter returned to the soil annually by stands of different species growing in the same general environment appears to be about the same.

The study reported in this paper was conducted as a cooperative project with the University of Missouri School of Forestry and the Central States Forest Experiment Station of the U. S. Forest Service. It is concerned with the amount of water that is prevented from entering the soil by the forest litter and the canopy of tree crowns. The amount intercepted by the forest floor and retained by it has been estimated by a number of workers. Some of the major contributions to this phase of forest research have been those of Lunt (1937), Broadfoot (1953), Johnson (1940), and Blow (1955). These studies have been concerned mainly with the effect of the forest floor itself, whereas the research reported in this paper has been aimed at evaluating the total effect of canopy and litter as it occurs in natural forests. Considering the forest floor separately, water retention capacity is dependent on the quantity, quality, condition and arrangement of the litter.

The general objectives of the study were to determine the amount of precipitation intercepted by the canopy and the forest floor, from August 5 to November 5, 1959. Light showers are almost entirely intercepted by a dense canopy, resulting in a decrease in the amount of precipitation reaching the forest floor. In regions where summer drouths are characteristic, this represents a considerable decrease in available moisture. The intensity and total amount of precipitation are important in evaluating the combined effects of canopy and forest floor as moisture interceptors. In order to achieve the general objective stated above, the study was separated into three subdivisions as follows:

1. To determine the water-retention capacity of the total forest floor under a hardwood stand in the Missouri Ozarks
2. To determine the difference in interception by a hardwood forest floor in the open and under natural conditions
3. To determine the rate of evaporation of intercepted water from forest floor samples in the open and under natural forest conditions.

The Study Area

The study area was located at University Forest, Butler County, Missouri, on the top of a spur ridge on gently undulating terrain. The soil is classed as a Grenada-like silt loam formed from a rock-free loessial mantle which is approximately three feet thick in this particular locality. The loessial soil lies on a cherty residuum from the Roubidoux geologic formation as described by Fletcher and McDermott (1957). This soil type supports a forest growth consisting of black oak, post oak, and hickory species[3] growing in a uniform well-stocked stand approximately 40 years old. The dominant and co-dominant trees in the stand range in diameter from 8 to 10 inches at a point four and a half feet above ground[4] and have an average height of 60 feet. There has been no record of fire in the study area for the last 15 years. The crown canopy was considered to be dense; some openings occurred in the canopy but they were of limited size and number. There was no killing frost during the period of field investigation and the density of the crown foliage was assumed to be uniform since the oaks did not start shedding their leaves until November 10, 1959, which was after the end of the field measurements.

While most of the work was conducted within the forest area, some measurements were made on litter samples placed near a meteorological station operated by the University Forest staff in cooperation with the U. S. Weather Bureau. Forest canopy not only breaks the impact of falling raindrops but concentrates them into a drip-pattern of drops larger than the original. Canopy also lowers the evaporation rate from the forest floor due to temperature reduction and decrease in air movement. By comparing data from litter samples in the open and beneath the forest canopy, the effect of the canopy on drip pattern and reduction of evaporational losses could be calculated. The approach to the problem was similar to that employed by Black (1957).

Since interception data and the effect of the canopy on evaporation rate was desired for the dominant and co-dominant trees only, the undergrowth and saplings were removed from the study area. A comparison showing the differences is given in Figures 1 and 2.

The position of the dominant and co-dominant trees with their crown sizes and overlap was recorded and plotted. A map showing the study area, weather station and positioning of the litter samples is given in the Appendix.

METHODOLOGY

Weather Records

The instruments at the weather station included:

1. A standard eight-inch non-recording rain gauge
2. A recording rain gauge

[3]Scientific names of tree species given in this publication are listed in the Appendix.
[4]Abbreviated to dbh.

Fig. 1—Undisturbed area immediately adjacent to the study area.

Fig. 2—The study area after removal of underbrush and saplings.

3. An evaporation pan with instrumentation for measuring evaporation from a free water surface to the nearest one one-hundredth of an inch

4. A cup anemometer recording total miles of air movement

5. Maximum and minimum thermometers

6. A recording hygro-thermograph to measure relative humidity and air temperature.

Weather records were taken daily for the duration of the field work, from August 5 to November 5, 1959, inclusive.

Forest Litter Trays

Eighteen litter trays were constructed of 20-gauge sheet metal. Each comprised three compartments: (1) the central portion was four feet long and one foot wide (2) two side-troughs were four feet long and three inches wide. An outlet pipe was inserted at one end of each compartment to permit drainage of moisture. A five-gallon can was connected to the central compartment by rubber tubing; each of the side troughs was connected to another five-gallon can. To permit free drainage of water, the trays were tilted slightly toward the outlet tubes.

The purpose of the side-troughs was to obtain a measure of the precipitation actually falling on the litter sample which occupied the central compartment.

Air circulation beneath the trays was reduced by packing earth underneath and around the edges of the trays; this was done to limit evaporation from the litter sample to the effects of air currents across the top of the litter samples.

The details of the tray and its apparatus are shown in Figure 3.

Forest Litter Samples

Samples of forest litter were obtained from randomly-selected locations in the study area and were lifted from the forest floor with as little disturbance of their horizontal arrangement as possible. Although it was not intended to include any mineral soil in the litter samples, minor variations in the level of the soil surface made it practically impossible to achieve the original intent.

A four-foot by one-foot board was placed on the litter which was then cut with a knife to the board's dimensions. After clearing away the litter from the edges of the sample, a heavy galvanized sheet was carefully inserted under the sample. By inverting the sample on the board, excess mineral soil could be removed by hand. Before re-inverting it to its original position, a one-quarter inch mesh hardware cloth was placed on the exposed (under) surface; then the sample was brought to its natural position and placed in the central compartment of the tray. One-inch mesh hardware cloth was then placed on top of the litter sample to prevent litter from being blown away or additional material from falling on to the sample. The details of the procedure for lifting the samples are shown in Figures 4 and 5 while the tray and the litter sample are shown in Figure 6.

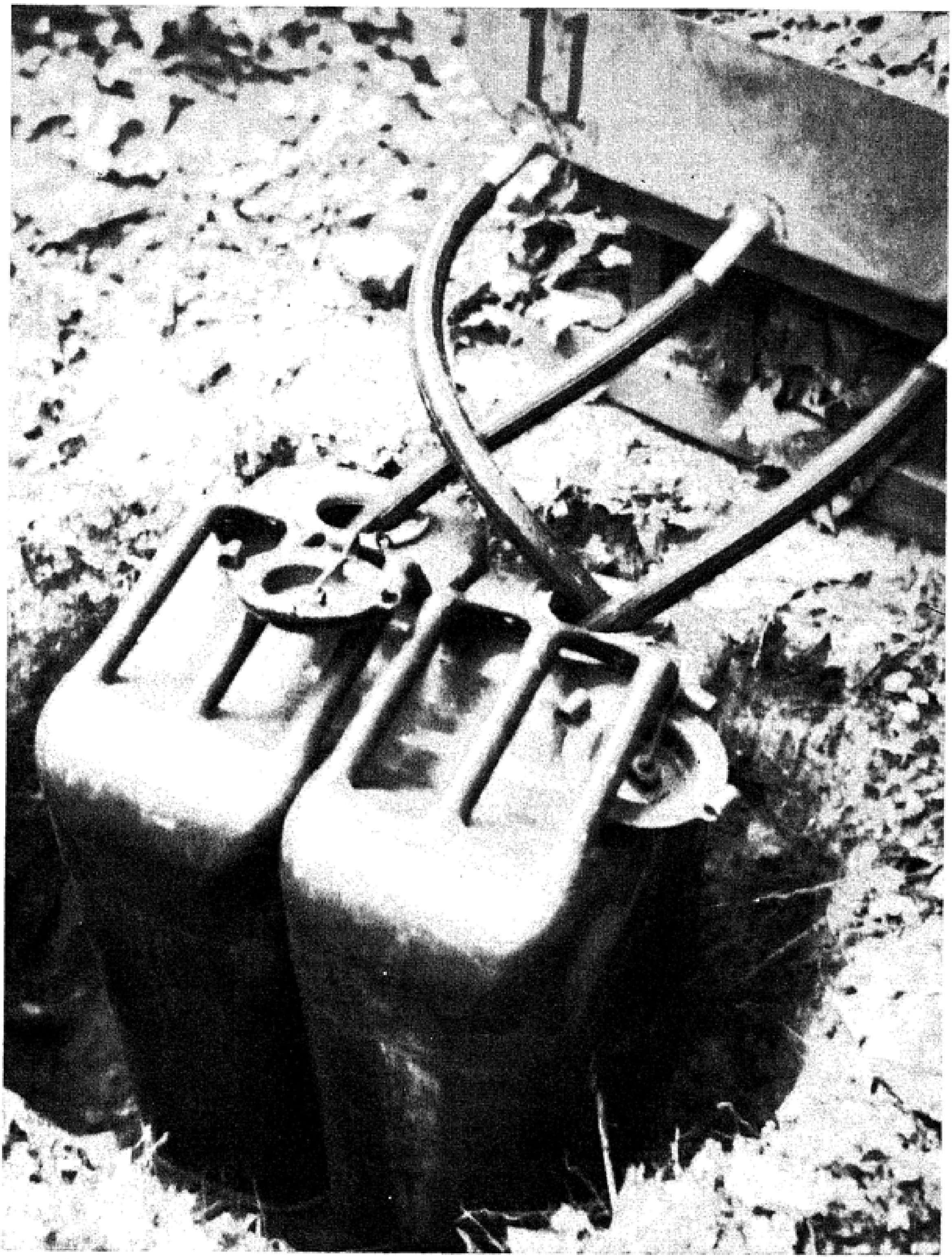

Fig. 3—Forest litter tray and its associated apparatus.

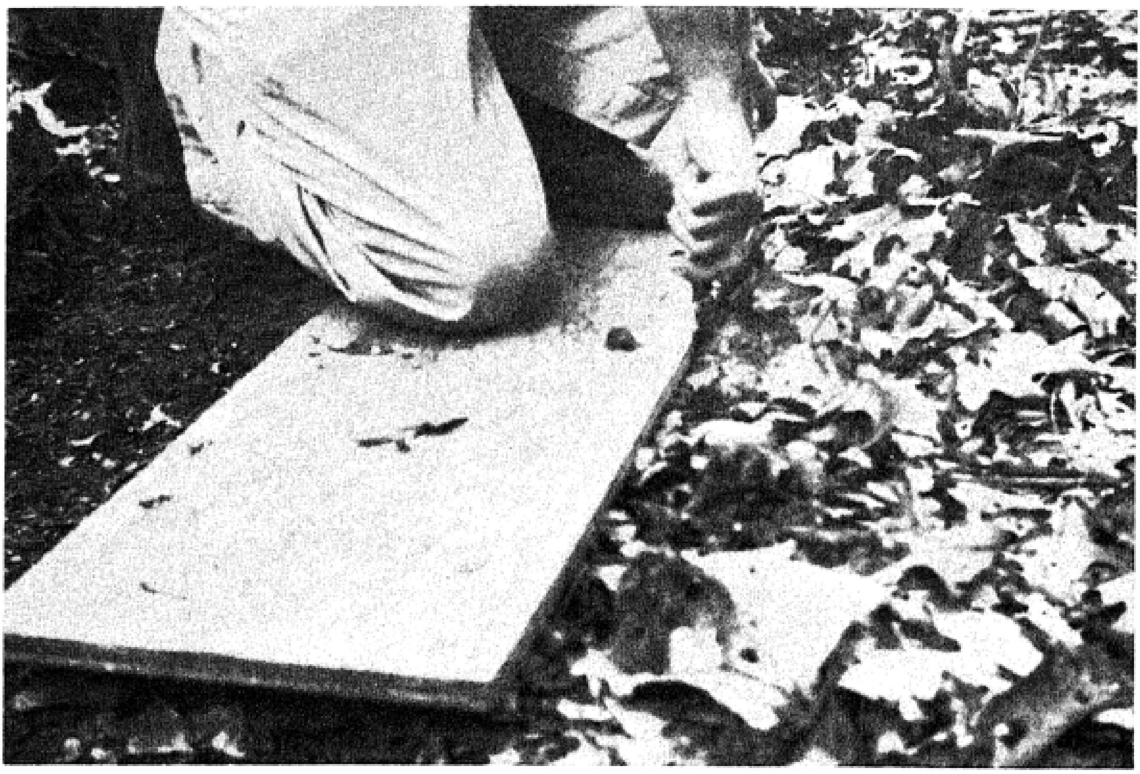

Fig. 4—Method of obtaining the forest litter samples.

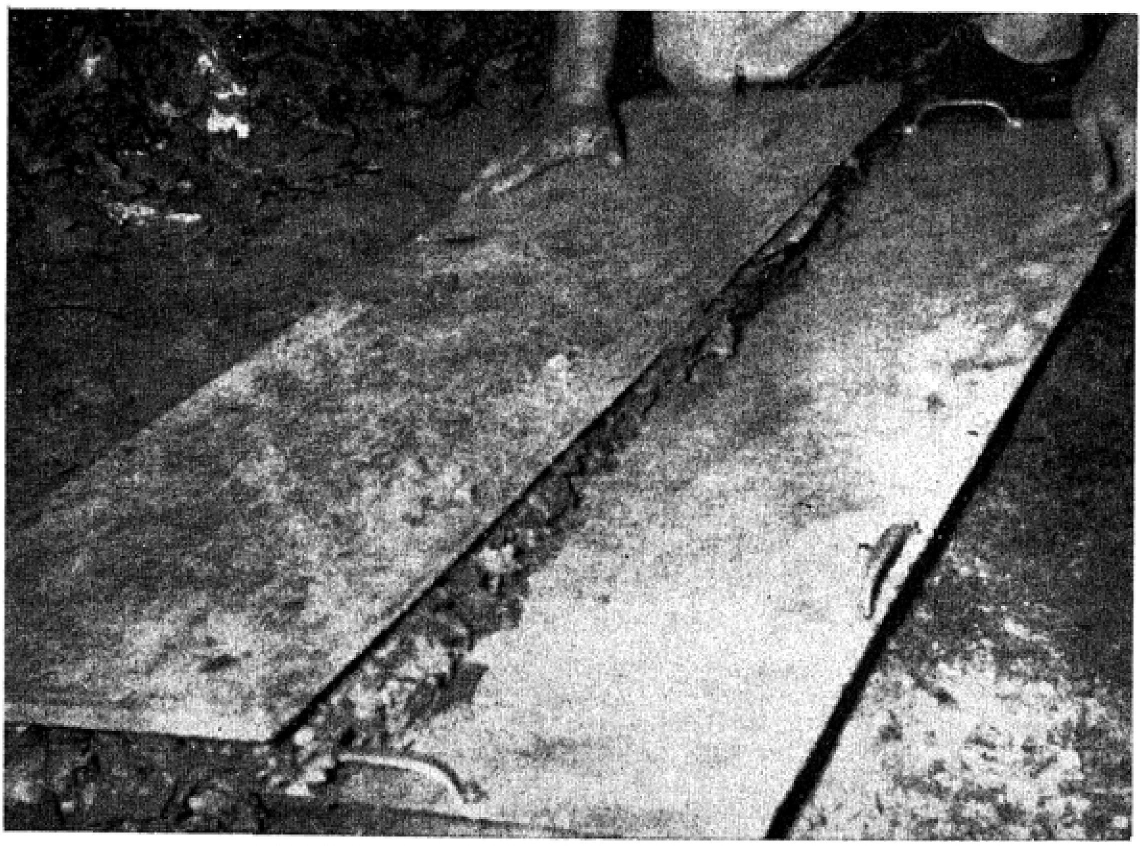

Fig. 5—Forest litter sample ready to be lifted from the ground.

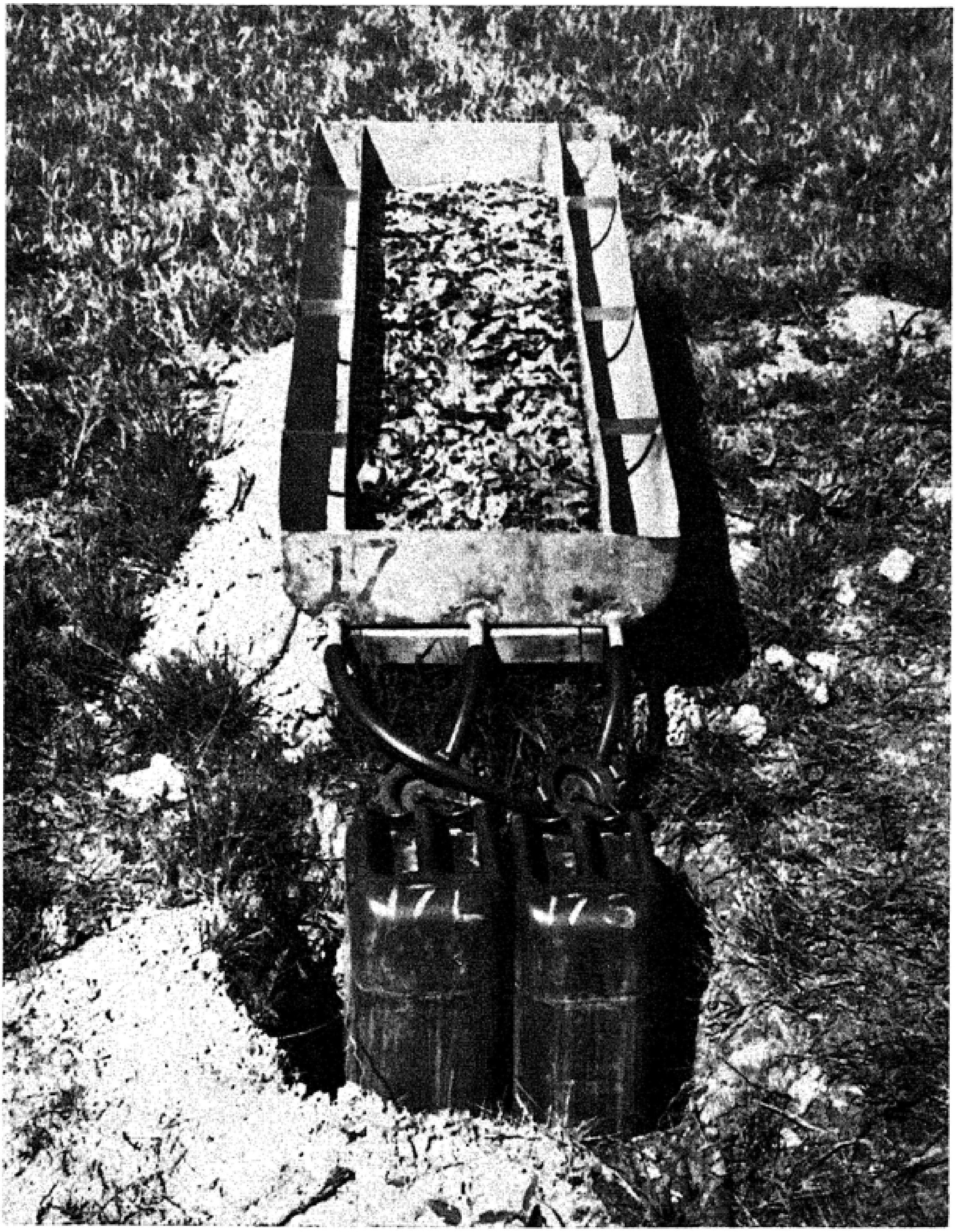

Fig. 6—Detail of tray in position with its apparatus and litter sample.

Positioning of the Trays

The eighteen trays were placed in groups of three throughout the study area in order to obtain measurements of interception and evaporation under various conditions of crown canopy. The locations selected were:

1. Close to the trunk of a dominant tree in the stand and placed radially from the trunk (Trays 1-2-3)
2. Beneath the edge of the crown of a dominant tree but not directly beneath nor near large openings between crowns (Trays 7-8-9)
3. Underneath large openings between the crowns of dominant trees (Trays 13-14-15)
4. In the weather station clearning, away from the effects of the forest stand (Trays 16-17-18).

Conditions 1 and 2 were repeated by Trays 4-5-6 and Trays 10-11-12, respectively. The tray locations were not changed during the 13-week study period. Figure 7 shows the positioning of the first group of trays (Condition 1).

Fig. 7—Trays 1-2-3 in position close to the trunk of a dominant tree. The weather station can be seen in the background.

EXPERIMENTAL PROCEDURES

Experimental Design

The three canopy positions—close to the trunk, beneath the crowns and under large openings—were regarded as separate treatments with one replication each in the original experimental design. In the course of analyzing the data, no significant differences between treatments were found to occur when canopy interception, initial evaporation, infiltration and litter retention were compared. Therefore, throughout this study, the measurements for trays located within the forested area were grouped together and compared with those measurements for the trays located in the open.

Daily Weight Changes of Litter Samples

In order to determine daily change in weight of the litter, the initial weight of each tray alone and that of the tray and the litter sample were necessary. These were weighed in the field by disconnecting the outlet hoses and recording the weight to the nearest one-hundredth of a pound. All subsequent weighings followed the same procedure. Figure 8 illustrates the method.

Since the litter samples were obtained from randomly selected locations, there was considerable variation in weight because of the differences in thickness and to the amount of mineral soil which adhered to the lower litter layer.

The trays were weighed each morning during the three-month period, except when a rain storm was in progress at the normal time of weighing. When this occurred, the trays were weighed on the first clear morning following the storm.

Fig. 8—Weighing the forest litter trays in the field.

Litter Components

The litter components were classified as follows:

Component A—freshly-fallen, undecomposed leaf litter (the L layer)

Component B—partially decomposed leaf litter; the form and structure of the leaves were still evident (the F layer)

Component C—twigs, acorns and parts of acorns, leaf petioles, bark and pieces of wood

Component D—fine roots, fibrous matter, completely decomposed leaf lit-litter and mineral soil (the H layer).

RESULTS AND DISCUSSION

Weather Records

In order to evaluate the daily changes in litter weight, it was necessary to record the amount of each rainstorm during the three-month period. There were 21 separate storms ranging from a trace of precipitation to one of 2.95 inches. A histogram showing the amount of each storm is given in Figure 9. It must be remembered that this record is of precipitation which fell at the weather station and is the basis of comparison upon which figures for canopy interception, evaporation and litter interception will later be based. A total of 10.84 inches of precipitation fell between August 5, and November 5, 1959; this is slightly above average for the location and period.

A summary of monthly averages of other weather data is given in Table 1.

The litter in each tray was oven-dried at the end of the field study and the weights recorded in Table 2. In order to preserve as natural a state as possible, the litter samples were placed in their respective positions with minimum disturbance. It is realized that some biological and pathological change could have taken place during the three-month period, resulting in a change in the weight of the litter, but it was the intent of the experiment to obtain moisture measurements on relatively undisturbed litter samples.

The weights have been given for Components A, B, and C in addition to the weight of all components combined. It is felt that the first three components are more closely related to the commonly-accepted concept of forest litter since Component D includes mineral soil as well as fine roots and fibrous matter. The weight of mineral soil far out-weighs the other portions of Component D, therefore its inclusion might lead to misinterpretation of the data.

Daily Variation in Litter Weight

An increase in litter weight due to absorbed moisture or a decrease due to evaporation depends on a number of factors, among them being:

1. Actual weight of the litter
2. Total amount and intensity of the precipitation
3. Relative humidity

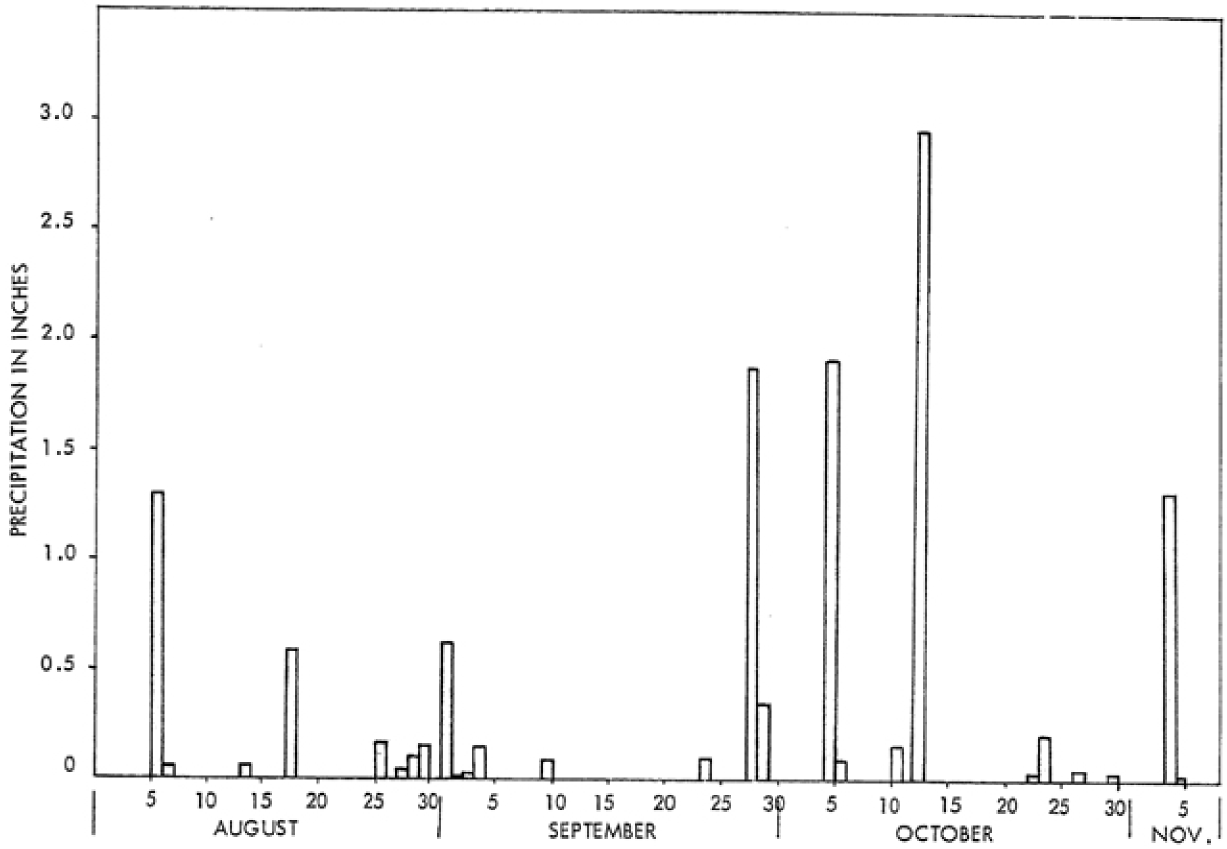

Fig. 9—Precipitation data at the University Forest between 5 August, and 5 November, 1959.

TABLE 1-MONTHLY TOTAL AND AVERAGES OF WEATHER DATA AT UNIVERSITY FOREST FROM AUGUST THROUGH NOVEMBER, 1959

Month	Wind movement Total	Wind movement Aver.	Evaporation Total	Evaporation Aver.	Aver. relative humidity	Average temperature
	miles		inches		percent	°F
August	305	9.8	5.10	0.16	87.0	79.4
Sept.	520	17.3	3.56	0.13	82.0	71.7
October	522	18.0	2.12	0.08	82.4	58.5

4. Wind movement
5. Position of the tray in relation to overhead canopy
6. Number of days since the last precipitation.

The daily weight changes were plotted for each tray; these weight changes are the basis for determining evaporation rate and depletion rates. A graphic illustration of the daily weights for Trays 1, 2, and 3, is given in Figure 10. Similar graphs for the remainder of the trays are shown in the Appendix. The dashed portion of the line indicates that precipitation was falling at the normal time of measurement.

TABLE 2-OVEN-DRY WEIGHT OF LITTER SAMPLES AND COMPONENTS

Sample No.	Litter Component A	B	C	D	Total A+B+C	A+B+C+D
		pounds per acre				
1	910	5140	2710	21150	8760	29910
2	1510	9820	1390	3980	12720	16700
3	910	4300	1390	10350	6600	16950
4	1390	6000	1870	21750	9260	31010
5	1270	6700	910	3260	8800	12060
6	1150	5860	1390	12630	8400	21030
7	1270	8620	2230	25950	12120	38070
8	910	6000	2590	30180	9500	39680
9	1270	6460	2230	21770	9960	31730
10	1520	6580	1390	13710	9490	23200
11	1030	6820	2350	19350	10200	29550
12	1630	5830	680	6500	8140	14640
13	1270	5380	2570	40500	9240	49740
14	1150	4300	790	28260	6240	34500
15	1270	4540	3550	39780	9360	49140
16	1270	6000	1630	29220	8900	38120
17	1630	5840	2350	11070	9820	20890
18	2230	8710	1750	6380	12690	19070

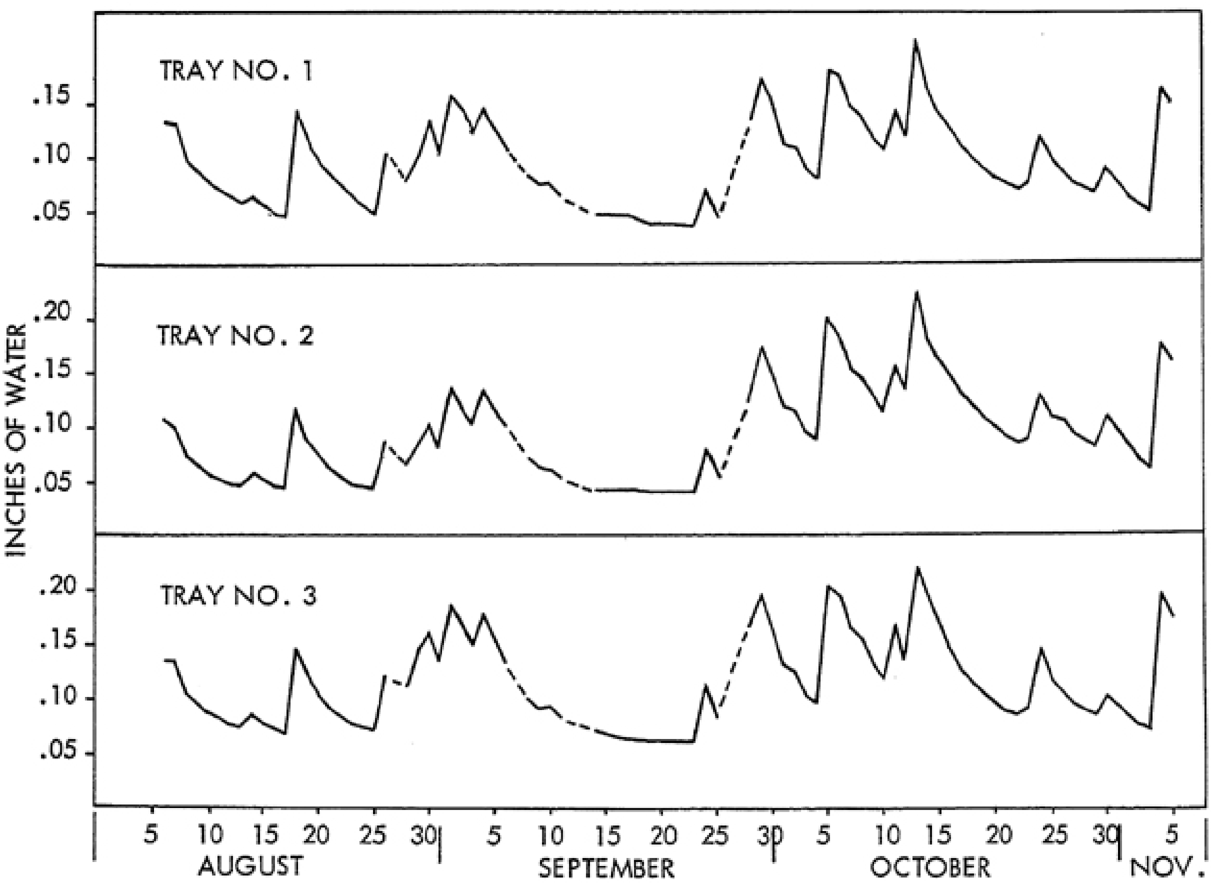

Fig. 10—Daily variation of weight of trays 1, 2, and 3 (under dense canopy, close to trunk of dominant tree).

Depletion Curves

Of greater interest than daily weight variation is a depletion curve showing the length of time during which a litter sample would achieve a constant weight, assuming no further precipitation. The process of constructing these curves is similar to that employed in watershed management problems and described by Kittredge (1948). A depletion curve was drawn for each litter sample; Figure 11 shows the depletion curve for Trays 1-2-3. The curves for the remainder of the trays are given in the Appendix.

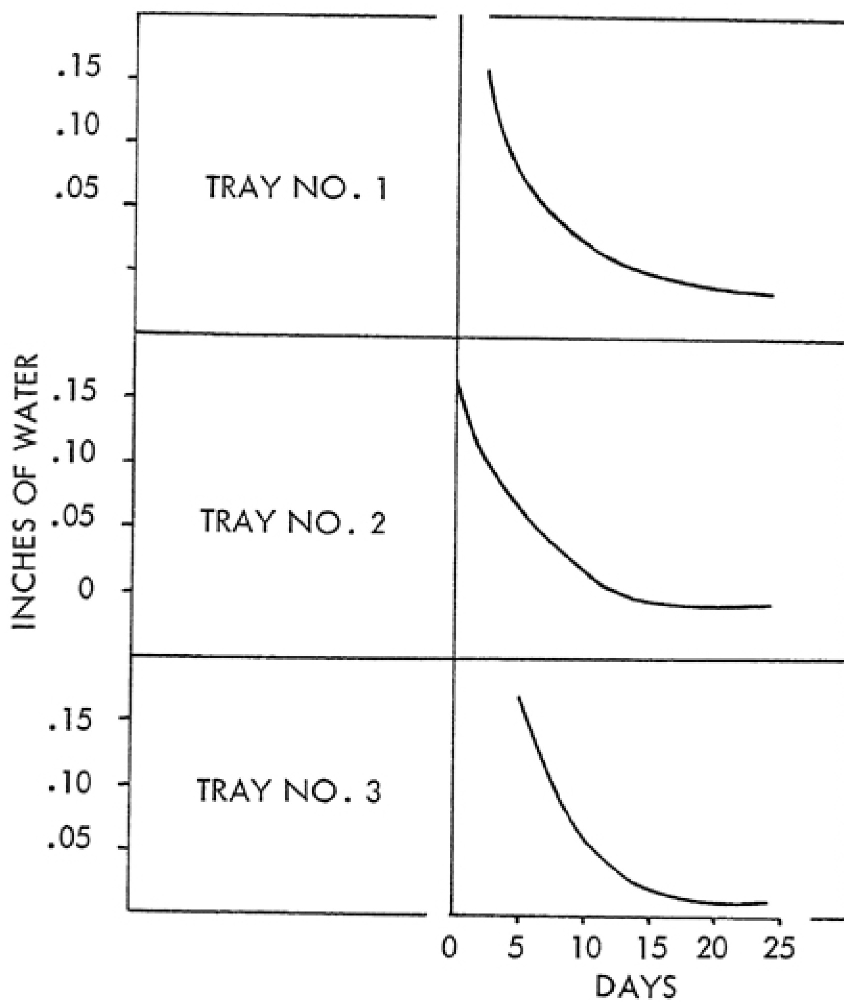

Fig. 11—Depletion curves for trays 1, 2, and 3 (under dense canopy, close to trunk of dominant tree).

Among the eighteen litter samples, there was some variation in the number of days required to attain a constant weight; in fact, a few samples (Trays 4, 7, and 13) never did achieve equilibrium. The time variation was caused primarily by differences in the initial total weight of the litter, but it was also caused by the combined effects of temperature and humidity. The heavy samples absorbed greater quantities of precipitation while the evaporation rate was not sufficiently fast to reach a steady weight before a subsequent rainfall increased the weight.

Other studies on evaporation rate substantiate the findings in this study. Metz (1958) reports that approximately 77 percent of the moisture in loblolly pine litter was lost within the first four days following heavy precipitation, with equilibrium being reached on the eleventh day. A hardwood forest floor in Mississippi was reported by Broadfoot (1953) to have lost 95 percent of its moisture within five days after light showers. Blow (1955) states:

> "The steepness of the curve for the first few days after a rain indicates the moisture lost by evaporation during that period. After about 20 days, further moisture loss from litter is relatively minor."

Interception of Precipitation by Forest Canopy

To illustrate the effect of the canopy as an interceptor of precipitation, the amount of moisture reaching the forest litter compared to the total precipitation is an indication of canopy interception. The net precipitation for each group of trays was calculated separately, but there was no significant difference between any of the groups. Therefore, net precipitation and interception as a percentage of total precipitation is shown in Table 3 for all trays under forest conditions.

TABLE 3-CANOPY INTERCEPTION FOR 21 STORMS FOR ALL TRAYS UNDER FOREST CONDITIONS

Storm	Total Precipitation	Net Precipitation	Canopy Interception	
	Inches	Inches	Inches	Percent
1	1.30	1.16	0.14	10.8
2	0.06	0.05	0.01	16.7
3	0.05	0.02	0.03	60.0
4	0.60	0.47	0.13	21.7
5	0.17	0.11	0.06	35.6
6	0.04	0.03	0.01	25.0
7	0.10	0.06	0.04	40.0
8	0.15	0.10	0.05	33.3
9 10	0.65	0.56	0.09	13.8
11	0.03	0.01	0.02	66.6
12	0.16	0.11	0.05	31.2
13	0.09	0.04	0.05	55.6
14	0.10	0.06	0.04	40.0
15 16	1.88	1.68	0.20	11.1
17	0.36	0.30	0.06	16.7
18 19	1.90	1.69	0.31	16.3
	0.10			
20	0.15	0.11	0.04	26.7
21	2.95	2.71	0.24	8.1
Totals	10.84	9.27	1.57	14.5

Thus, 14.5 percent of the total precipitation falling in the three-month period was intercepted by the forest canopy. Naturally, the interception of the heavier storms is less than for the lighter showers as the canopy, once it is wet, will not hold back any further precipitation.

During the summer months when temperatures are high and evapotranspiration losses are similarly high, the moisture requirements of the vegetative cover are great. During this period a number of the rainfalls occur as light showers of less than 0.20 inches. If these occur over a relatively long period, the loss of moisture by canopy interception can be excessive.

To illustrate this point, the data for light showers have been extracted from Table 3 and presented in Table 4. While these data are for the late summer and early fall, they show conclusively that canopy interception is high.

These findings are in general agreement with numerous studies made on the interception of precipitation by tree crowns. Beall (1934), working in white and red pine stands in Ontario, found that 27 percent of the total precipitation was intercepted under average crowns.

TABLE 4-CANOPY INTERCEPTION OF PRECIPITATION OCCURRING AS LIGHT SHOWERS OF 0.20" AND LESS

Storm	Total Precipitation	Net Precipitation	Canopy Interception	
	Inches	Inches	Inches	Percent
2	0.06	0.05	0.01	16.7
3	0.05	0.02	0.03	60.0
5	0.17	0.11	0.06	35.6
6	0.04	0.03	0.01	25.0
7	0.10	0.06	0.04	40.0
8	0.15	0.10	0.05	33.3
11	0.03	0.01	0.02	66.6
12	0.16	0.11	0.05	31.2
13	0.09	0.04	0.05	55.6
14	0.10	0.06	0.04	40.0
20	0.15	0.11	0.04	26.7
Totals	1.10	0.70	0.40	36.3

Initial Evaporation from Forest Floor Samples

A definition of initial evaporation is the calculated evaporation which takes place from the surface of the litter between the time precipitation commenced to the time the samples were weighed. During the field study, the samples were weighed at 8 a.m. each day providing precipitation was not in progress at that time. If conditions made it necessary to delay the readings, they were made as soon as possible after the precipitation had ceased. The average time lapse from precipitation to time of measurement was 9 hours. In previous studies by Curtis (1960) and Rowe (1955), litter interception was taken as the difference between total precipitation and the water that had percolated through the litter. This concept is valid only if the samples are located in the open and if moisture measurements are taken immediately after the rainfall has ceased. Even if these conditions are met, there is likely to be a small discrepancy between the weights.

Initial evaporation was calculated for all the trays located in the forest. The weight of water in the "litter" cans was subtracted from the weight of water in the "side trough" cans; this difference gives the calculated litter interception. However, if the *actual* litter interception was calculated from the difference in weight of the litter after the storm, it was found in nearly all instances, that the two figures did not coincide. The difference between the two indicated that evaporation was taking place *during* and *after* the rainfall. Evaporation will take place as long as the air above the litter sample is not saturated. After a very light shower, some of the trays showed a net loss in weight; the litter sample evaporated all the moisture it had received plus some additional moisture before the tray was weighed. The trays in the open lost substantial amounts of water during and immediately after precipitation, due to increased solar radiation and air movement.

In order to be able to calculate initial evaporation, it is necessary to know the exact amount of water in the cans. Storm 21 amounted to 2.95 inches and the litter cans received so much water that they overflowed. Initial evaporation, therefore, was calculated on the basis of 7.89 inches rather than 10.84 inches as quoted in an earlier section.

The initial evaporation for the trays under forested conditions amounted to 5.17 percent of the 7.89 inches of precipitation, while the trays in the open by the weather station accounted for 10.20 percent.

Evaporation from forest litter is dependent on relative humidity, temperature, air movement, thickness of the litter and its composition. The fact that litter is under forest canopy is not a factor in itself, but canopy is important as it affects these factors.

Forest Floor Interception of Precipitation

Of the total precipitation occurring in any one storm, part is intercepted by the canopy, part is evaporated from the surface of the litter, part is retained in the litter and the remainder infiltrates through the litter to:

1. Satisfy soil moisture deficits
2. Become available for plant growth
3. Support biological activity
4. Become a solution medium for the decomposition of rocks
5. Add to ground water supply.

The amount of moisture that litter will retain is dependent on the initial moisture content of the litter prior to rainfall. Litter that is very dry will retain a large percentage of the water, while that which is close to saturation point will retain very little additional moisture. The intensity and duration of the precipitation will also affect the percent retained by the litter. For very light showers, the litter will retain approximately 60 percent of total precipitation; for heavy storms, the litter retains less than 1 percent.

After taking into account the water loss caused by canopy interception and initial evaporation and measuring the amount which infiltrates through the litter, the remainder of the total precipitation is that retained by the litter. In the case of the trays within the forested area, the litter retention amounted to 0.676 inches of precipitation or 8.5 percent of the 7.89 inches which fell exclusive of the last storm. For the trays at the weather station, canopy interception is not a factor and the amount of moisture that infiltrates through the litter is considerably greater. The moisture retention is approximately of the same order as under forested conditions, being 0.645 inches or 8.2 percent of the 7.89 total precipitation.

Water Balance

The water balance, or distribution of precipitation, for the three-month study period can be calculated easily. In the study, total precipitation was divided into four measurable components:-canopy interception, initial evaporation, retention by the forest floor, and infiltration through the forest floor. Since there was no significant difference between groups of trays within the forested area, the figures given in Table 5 are average figures for all trays except those in the open.

TABLE 5-WATER BALANCE FOR ALL TRAYS IN FORESTED AREA FOR A TOTAL PRECIPITATION OF 7.89 INCHES AND FOR SHOWERS OF 0.20" AND UNDER

	Total Precipitation		Showers of 0.20" and less	
	inches*	percent	inches*	percent
Canopy Interception	1.3	16.9	0.4	36.3
Initial Evaporation	0.4	5.2	0.2	17.4
Forest Floor Retention	0.7	8.6	0.3	23.8
Infiltration	5.5	69.4	0.2	22.5
Totals	7.9	100.00	1.1	100.0

*The inches of precipitation have been rounded to the nearest 0.1 inch.

It is interesting to note the differences between the two precipitation totals and percent of moisture that is actually available to plant life and ground water. When heavy rainfalls are included, 69.4 percent of the total precipitation infiltrates through the litter, while only 22.5 percent becomes available as a result of light showers.

For the trays in the open, the water balance shows a proportionately greater amount of infiltration since there is no canopy interception and the values for initial evaporation and retention are fairly close to the values given for trays under forested conditions.

Table 7 summarizes the factors which lessen the amount of moisture reaching mineral soil and gives net precipitation for both open and forested conditions.

Net precipitation, or the amount of moisture entering mineral soil, can be expressed in terms of gross precipitation by plotting the former on the latter.

TABLE 6-WATER BALANCE FOR TRAYS IN THE OPEN FOR TOTAL PRECIPITATION OF 7.89 INCHES AND FOR SHOWERS OF 0.20" AND UNDER

	Total Precipitation		Showers of 0.20" and less	
	inches*	percent	inches*	percent
Initial Evaporation	0.8	10.2	0.2	20.8
Forest Floor Retention	0.6	8.2	0.3	26.8
Infiltration	6.5	81.6	0.6	52.4
Totals	7.9	100.0	1.1	100.0

*The inches of precipitation have been rounded to the nearest 0.1 inch.

TABLE 7-AMOUNT OF PRECIPITATION LOST TO MINERAL SOIL BY CANOPY INTERCEPTION, INITIAL EVAPORATION AND LITTER RETENTION BY STORMS AND FOR OPEN AND FORESTED CONDITIONS

Storm		Canopy Inter.		Initial Evap.		Litter Reten.		Net Precipitation	
		Open	Forest	Open	Forest	Open	Forest	Open	Forest
No.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1	1.30	-	0.13	0.09	0.03	0.03	0.05	1.18	1.10
2	0.06	-	0.02	0.05	0.03	0.00	0.00	0.01	0.01
3	0.05	-	0.03	0.02	0.00	0.03	0.02	0.00	0.00
4	0.60	-	0.13	0.01	0.00	0.10	0.09	0.50	0.39
5	0.17	-	0.06	0.01	0.01	0.07	0.05	0.09	0.05
6	0.04	-	0.02	0.04	0.03	0.00	0.01	0.00	0.01
7	0.10	-	0.04	0.03	0.02	0.02	0.03	0.05	0.02
8	0.15	-	0.05	0.04	0.03	0.01	0.02	0.10	0.05
9, 10	0.65	-	0.09	0.06	0.04	0.04	0.05	0.55	0.47
11	0.03	-	0.02	0.03	0.02	0.01	0.01	0.00	0.03
12	0.16	-	0.05	0.05	0.03	0.01	0.02	0.10	0.06
13	0.09	-	0.05	0.03	0.02	0.05	0.02	0.00	0.00
14	0.10	-	0.04	0.00	0.00	0.06	0.04	0.03	0.01
15, 16	1.88	-	0.21	0.16	0.09	0.09	0.10	1.63	1.48
17	0.36	-	0.06	0.04	0.02	0.02	0.04	0.30	0.24
18	1.90	-	0.27	0.12	0.02	0.11	0.10	1.67	1.50
19	0.10	-	0.03	0.03	0.02	-0.01	-0.01	0.08	0.06
20	0.15	-	0.04	0.01	0.02	0.05	0.04	0.09	0.05
21	2.95	-	0.24	*	*	0.08	0.08	*	*

*Indicates that data was not available.

The results appear to be linear, as shown in Figure 12, and were used to develop the following two linear equations:

1. For the trays located in the open by the weather station

   $Y = -0.0401 + 0.9007\ X$

2. For the trays located within the forested area

   $Y = -0.0313 + 0.7698\ X$

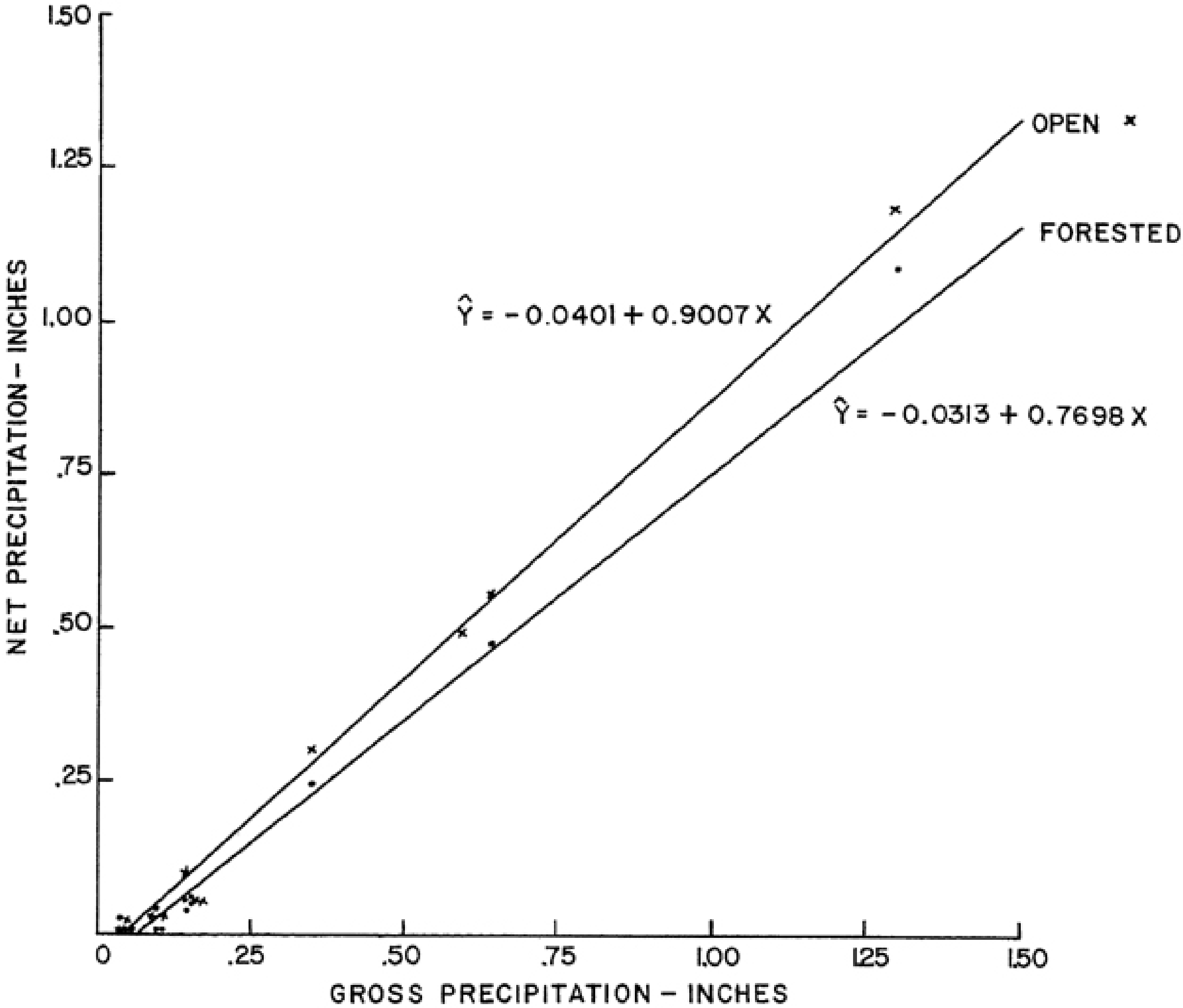

Fig. 12—Relationship between gross and net precipitation.

In each case, X is inches of gross precipitation and Y is inches of net precipitation. Thus, for the conditions under which this study was conducted, it is possible to estimate the inches of moisture that will enter mineral soil for any given precipitation.

Summary

Forest litter is a major source of organic matter and it influences the water-infiltration rate in forest soils; in addition, litter reduces runoff, checks soil erosion and limits evaporation of soil moisture. During a three-month period, from August to November, 1959, measurements were taken at the University Forest, Butler County, Missouri, to determine the effects of hardwood litter on the interception of precipitation.

Moisture losses to a soil in a forested area are dependent on the density of the overhead canopy, evaporation from the litter during and after precipitation, the water-holding capacity of the litter, the moisture content of the litter at the time of precipitation and the intensity and duration of the rainfall.

It was found that the canopy of a well-stocked oak stand intercepted an average of 16.8 percent of total precipitation when all storms were taken into account. The interception figure is raised to 36.3 percent when only the light showers of 0.20 inch and under are included. Approximately one-half the summer rainstorms in southeastern Missouri occur as showers and canopy interception becomes an important cause of moisture loss to the soil.

Evaporation from forest litter accounts for a further 5.2 percent under forested conditions. In comparison, litter placed in the open where temperature and wind effects are greater, loses 10.2 percent of total precipitation during late summer and early fall.

The third factor measured, litter retention, accounted for 8.6 percent of total precipitation under forested conditions and 8.2 percent in the open. Apparently, the presence or absence of overhead canopy has little effect on the amount of moisture retained by the litter. Even after light showers of 0.20 inch and less, litter retention in the open amounted to 20.8 percent and to 26.8 percent under forested conditions.

After the three factors have been taken into account, the remainder of total precipitation is that which is available to plants for growth, support of biological activity and to make up any moisture deficit in the soil; the excess becomes an addition to ground water storage. Under forested conditions, the amount of moisture that infiltrated through the litter was 69.4 percent of total precipitation and 81.6 percent for litter samples placed in the open. Taking light showers only into consideration, the amount which infiltrated through the litter into mineral soil was 22.5 percent and 52.4 percent respectively.

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APPENDIX

TABLE 8-COMMON AND SCIENTIFIC NAMES OF TREE SPECIES FOUND ON THE STUDY AREA

Common name	Scientific name
Post oak	*Quercus stellata* Wang.
Black oak	*Quercus velutina* Lamarck.
Scarlet oak	*Quercus coccinea* Muench.
Hickory	*Carya* species
American elm	*Ulmus americana* L.
Black gum	*Nyssa sylvatica* Marsh.
Red bud	*Cercis canadensis* L.
Persimmon	*Diospyros virginiana* L.
White oak	*Quercus alba* L.
Black walnut	*Juglans nigra* L.

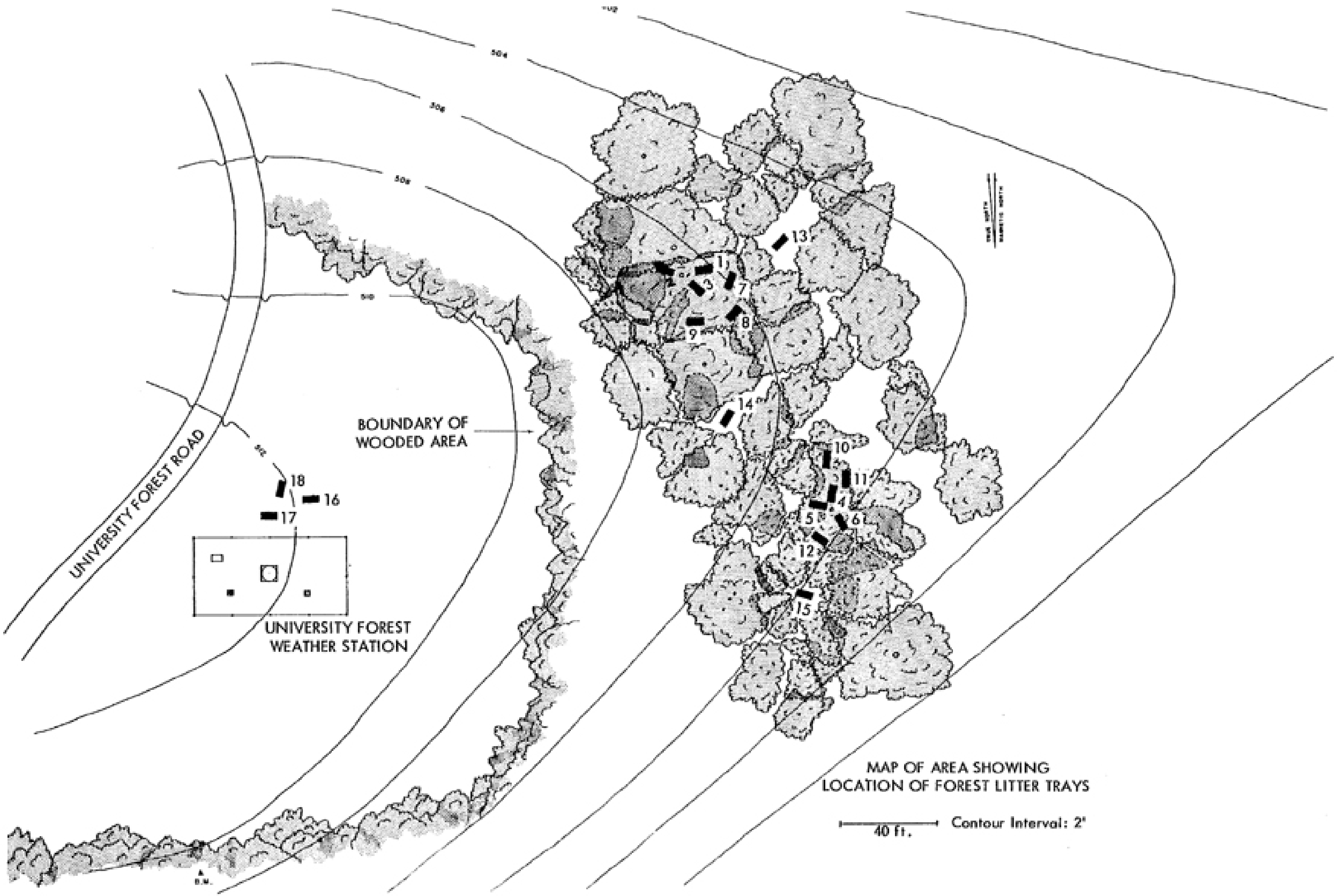

Fig. 13—Map of study area showing location of litter samples and weather station.

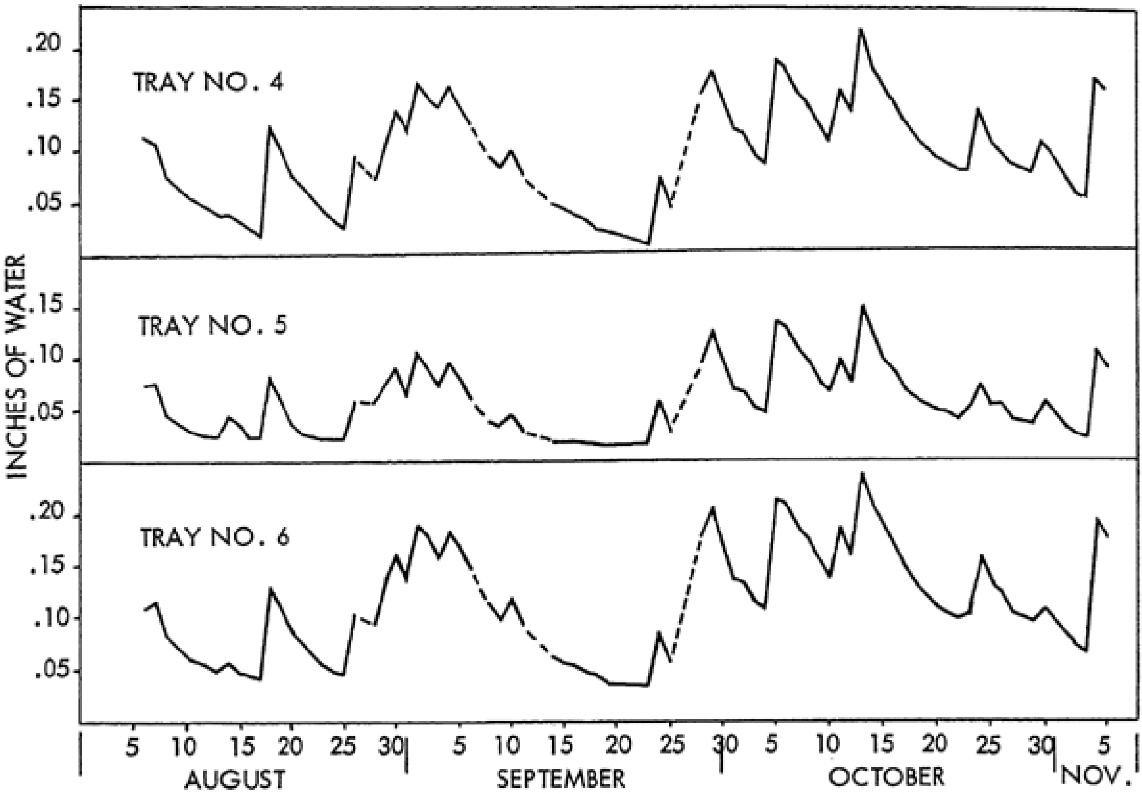

Fig. 14—Daily variation of weight of trays 4, 5, and 6 (under dense canopy, close to trunk of dominant tree).

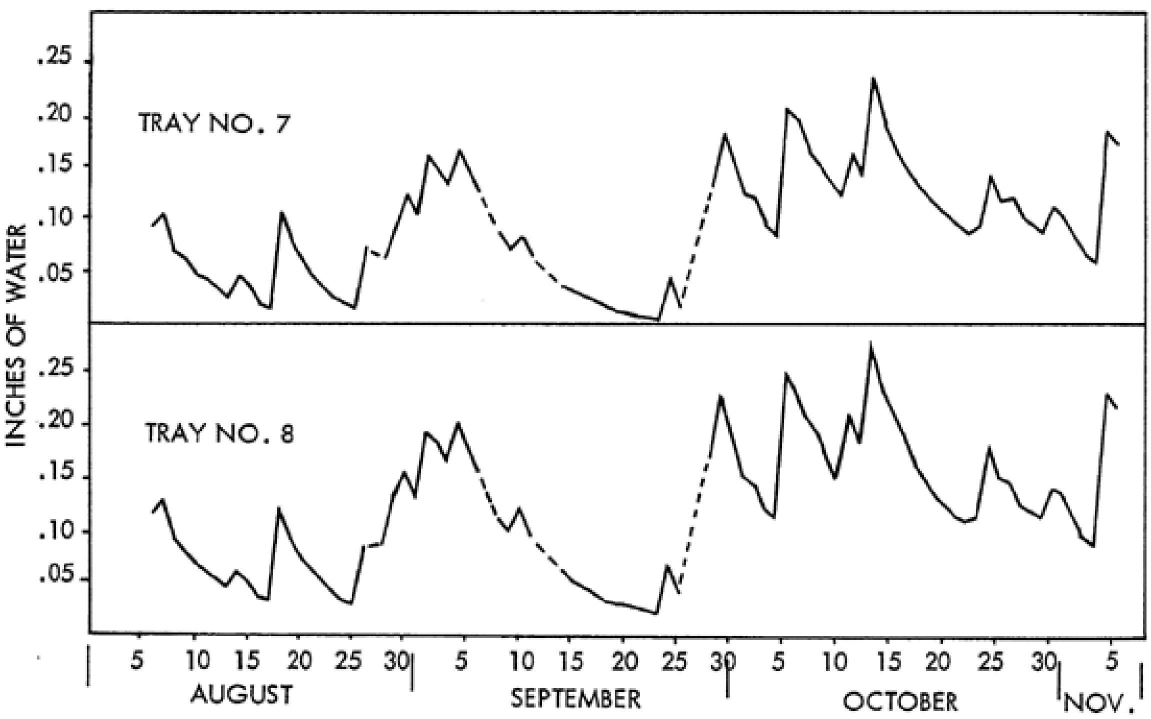

Fig. 15—Daily variation of weight of trays 7 and 8 (beneath edge of dominant tree).

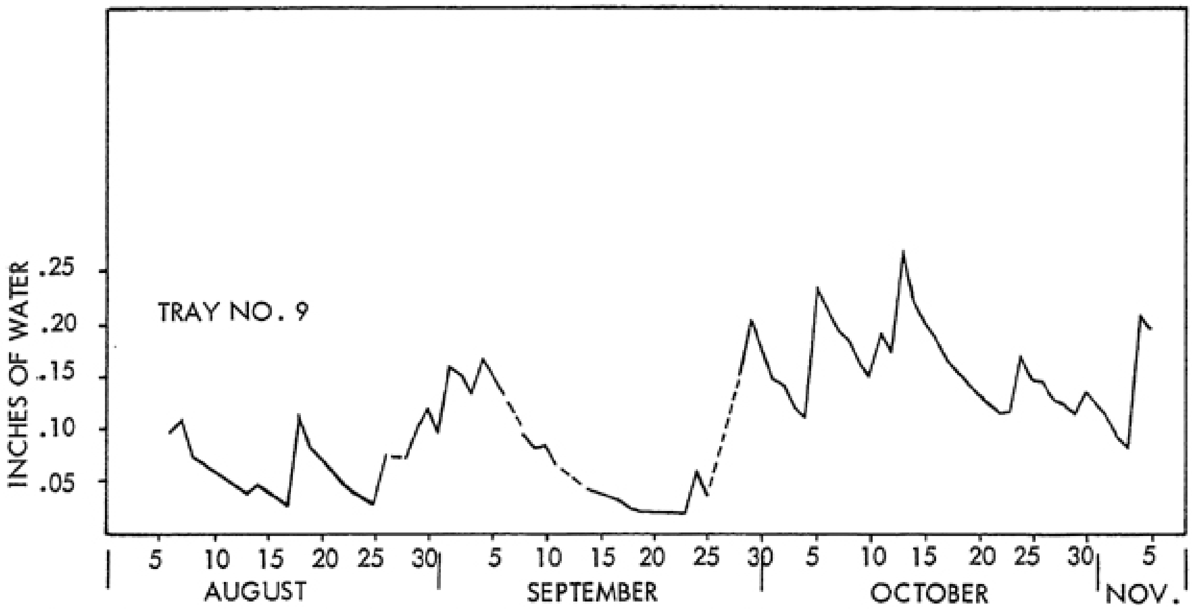

Fig. 16—Daily variation of weight of tray 9 (beneath edge of dominant tree).

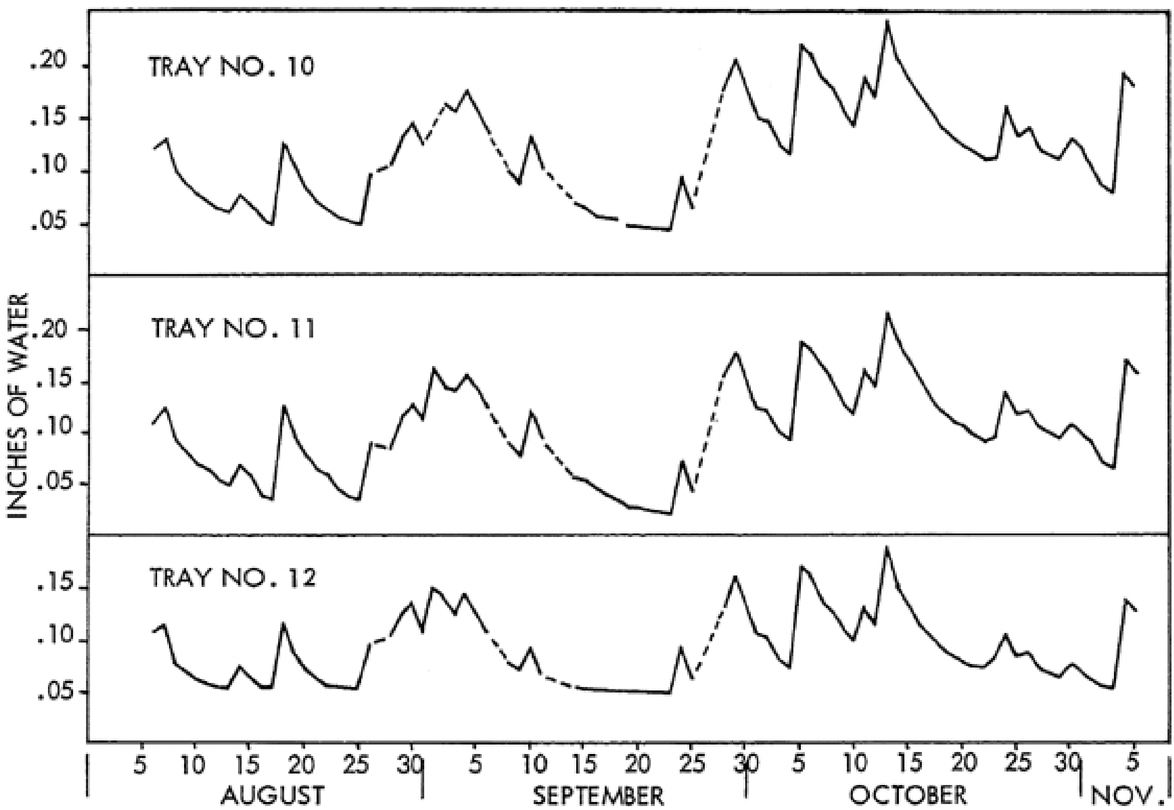

Fig. 17—Daily variation of weight of trays 10, 11, and 12 (beneath edge of dominant tree).

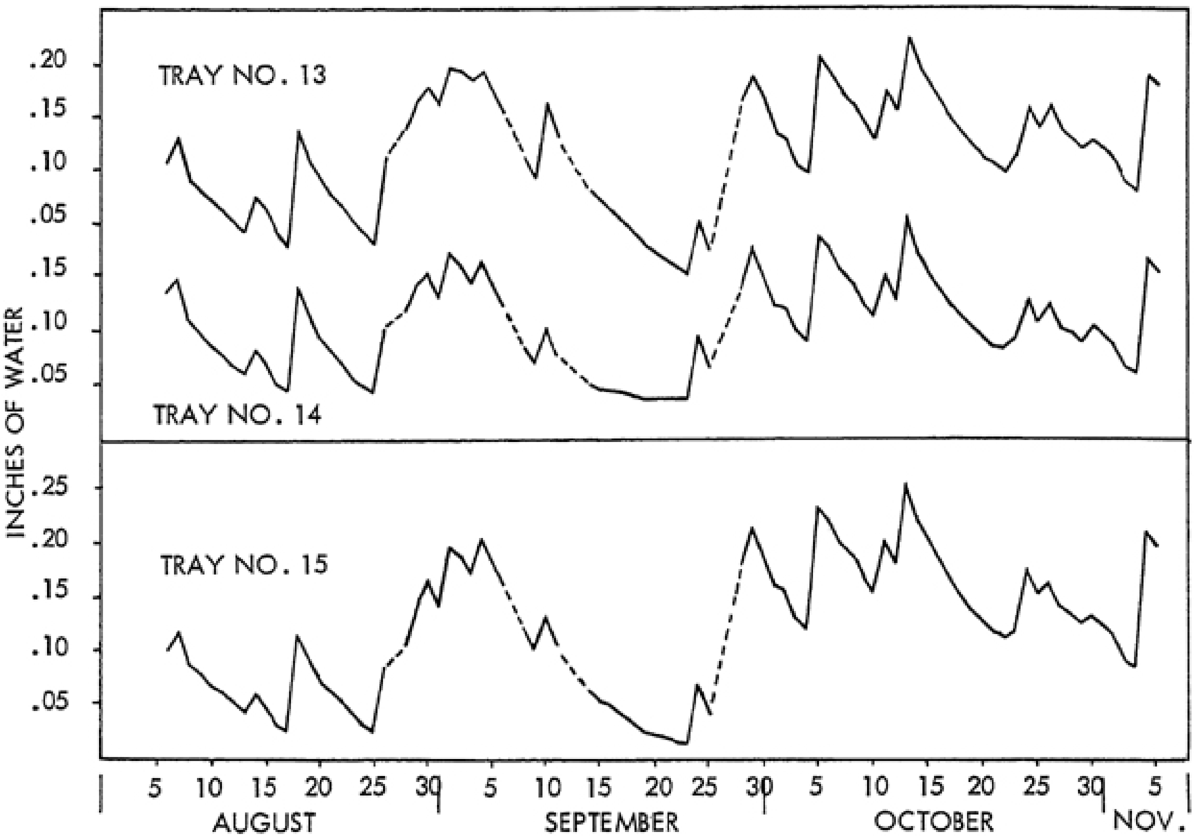

Fig. 18—Daily variation of weight of trays 13, 14, and 15 (under large opening between crowns).

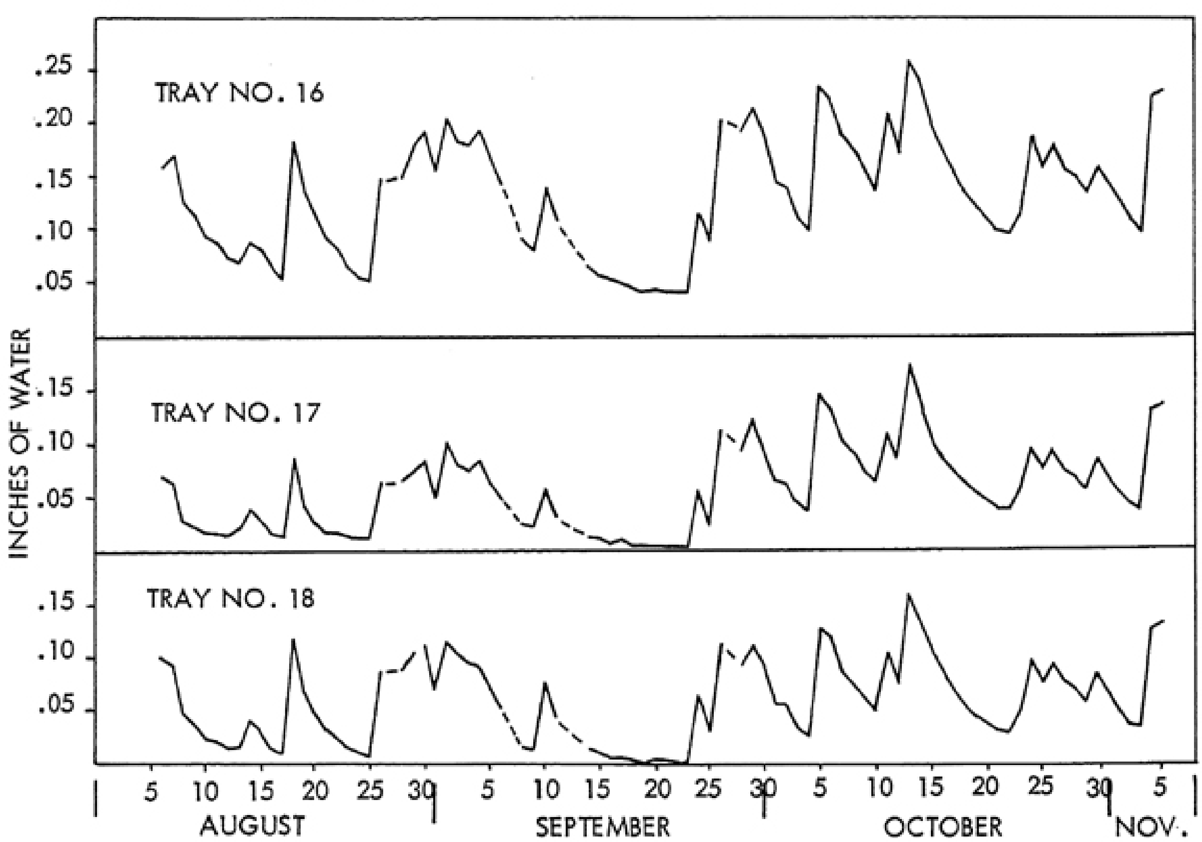

Fig. 19—Daily variation of weight of trays 16, 17, and 18 (in the open by weather station).

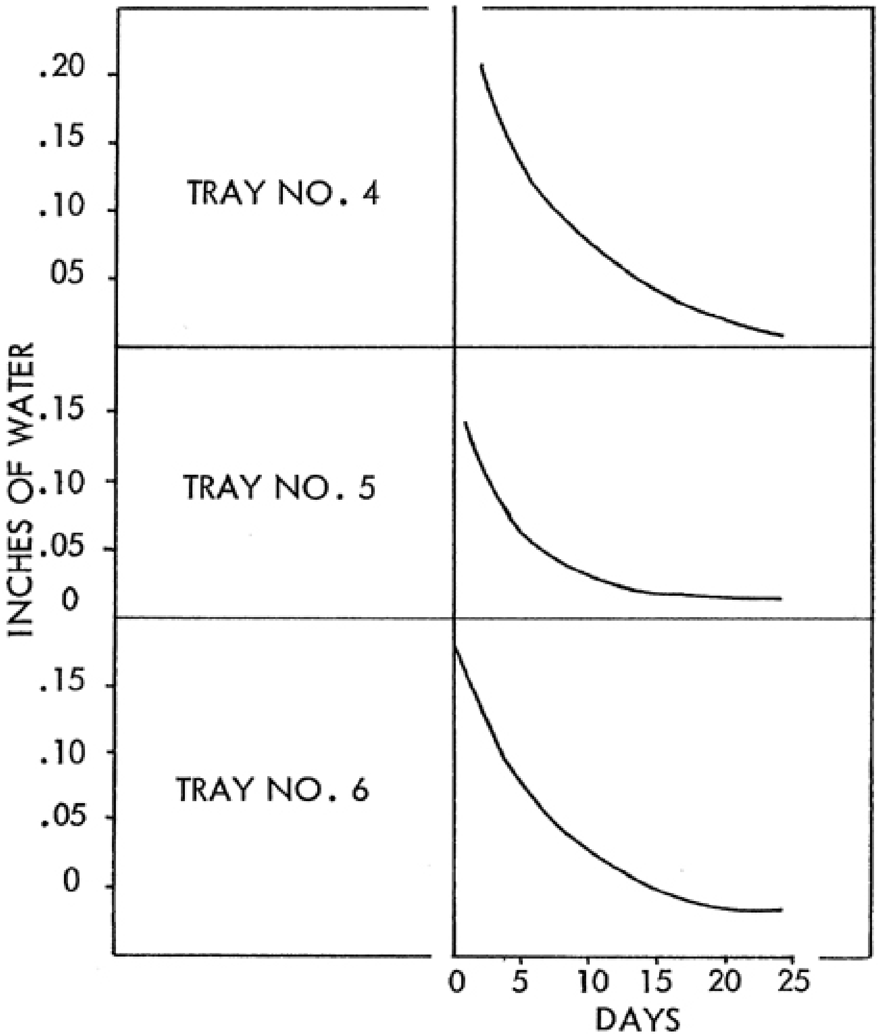

Fig. 20—Depletion curves for trays 4, 5, and 6 (under dense canopy, close to trunk of dominant tree).

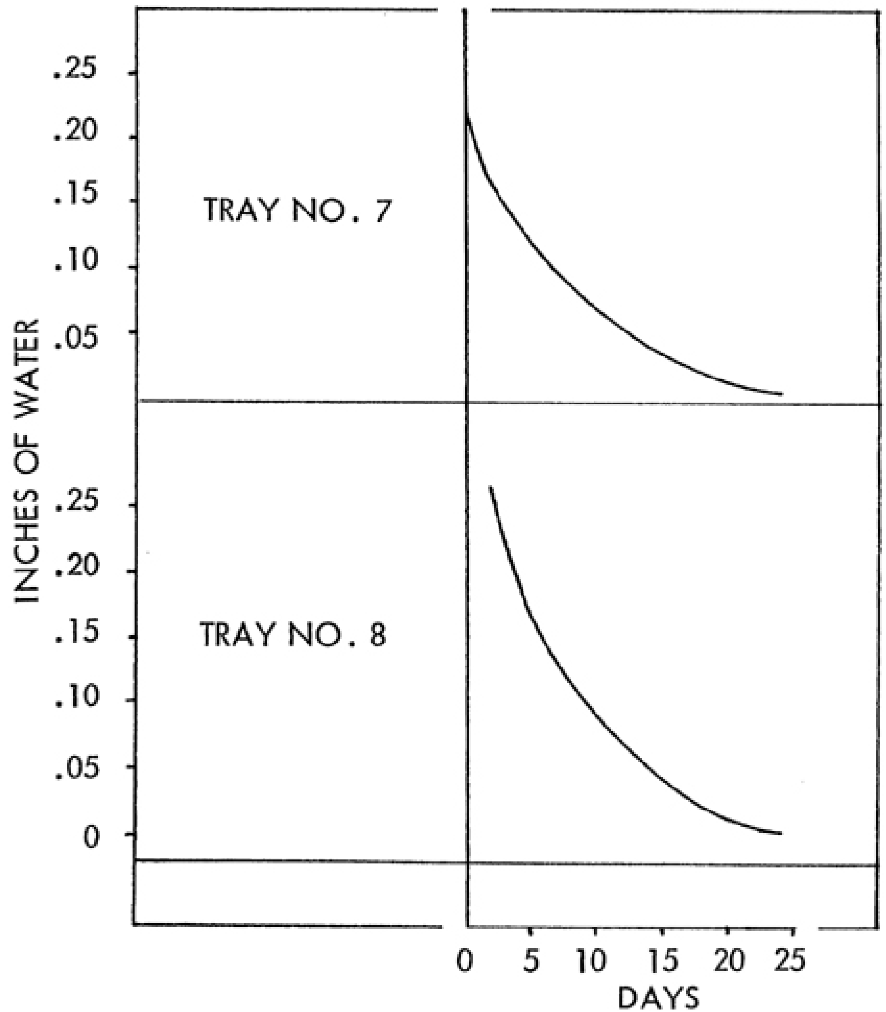

Fig. 21—Depletion curves for trays 7 and 8 (beneath edge of dominant tree).

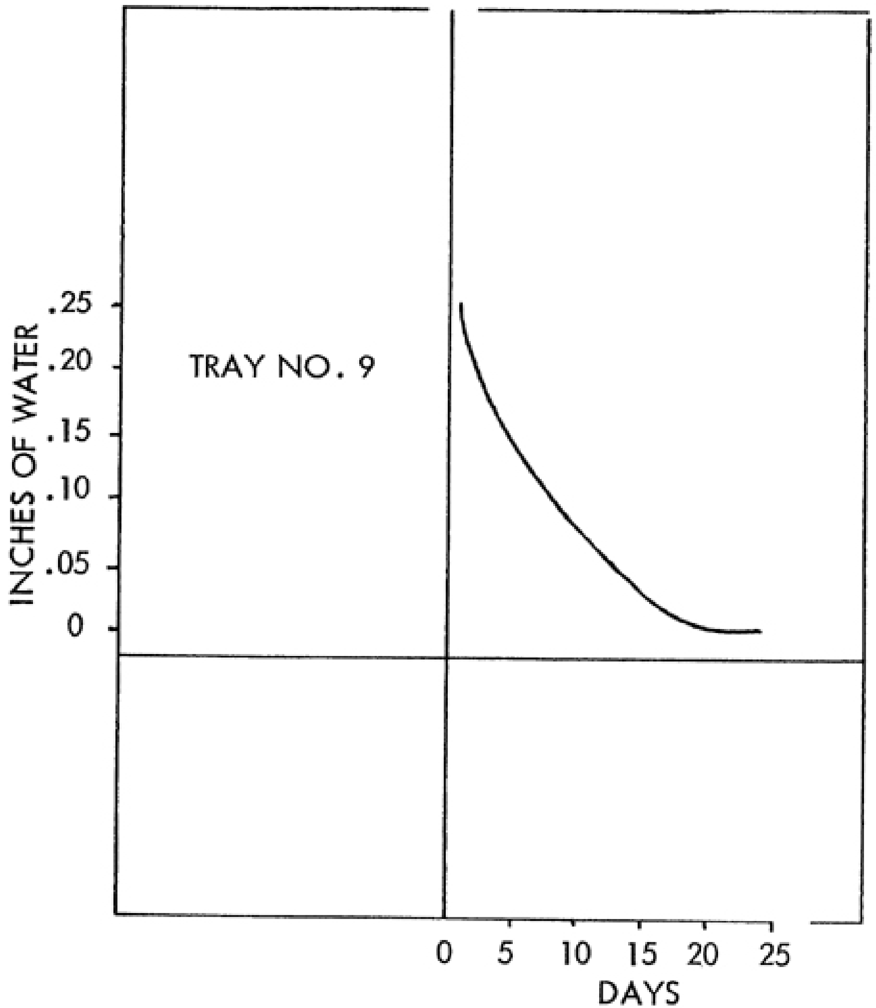

Fig. 22—Depletion curve for tray 9 (beneath edge of dominant tree).

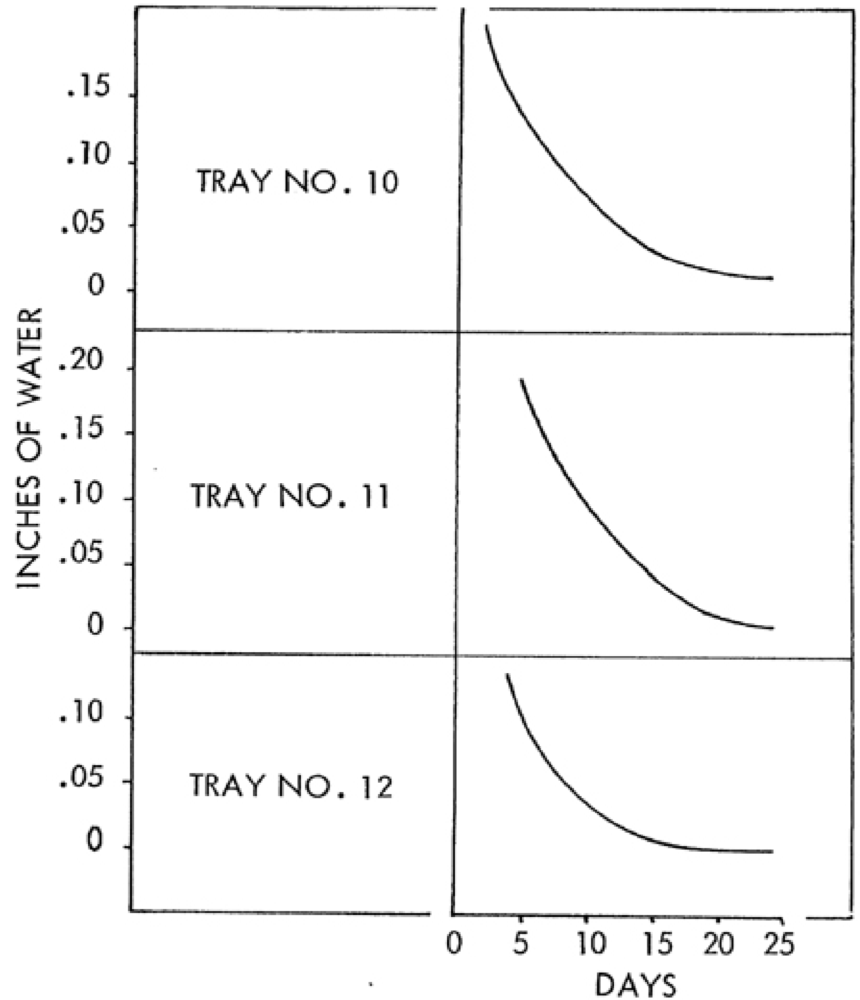

Fig. 23—Depletion curves for trays 10, 11, and 12 (beneath edge of dominant tree).

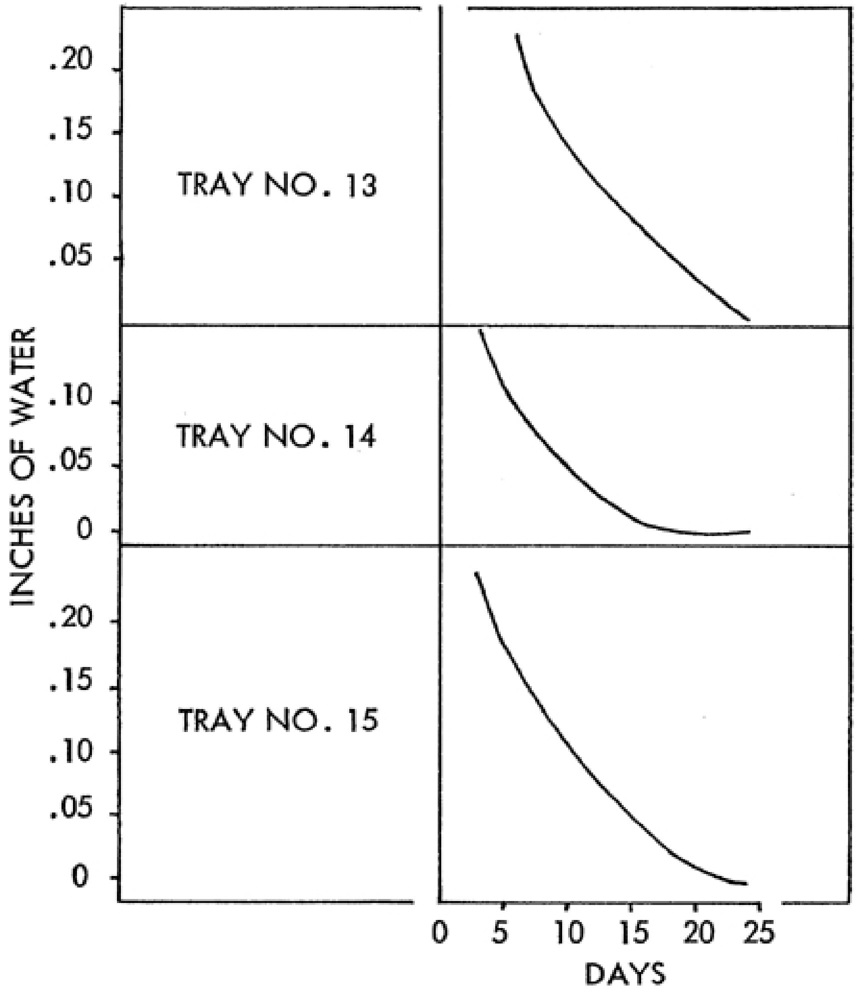

Fig. 24—Depletion curves for trays 13, 14, and 15 (under large opening between crowns).

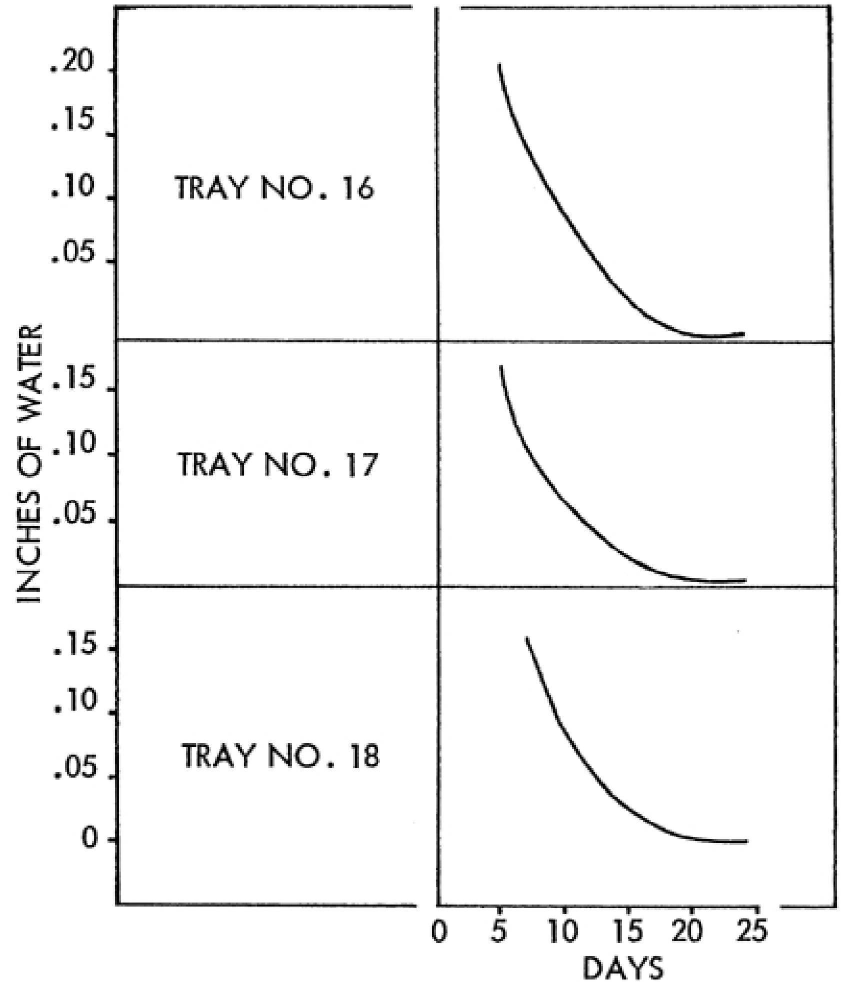

Fig. 25—Depletion curves for trays 16, 17, and 18 (in the open by weather station).