Summer Evapotranspiration Trends as Related to Time Following Logging of High Elevation Forest Stands in Sierra Nevada

By

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

The quantity of summer soil moisture loss from logged forest openings was related to the length of time since the creation of the opening in a study made in the subalpine forest zone of the Sierra Nevada west-side near the Central Sierra Snow Laboratory, California, within the elevational range of 6,000 to 7,000 feet. Soil moisture depletion was measured in logged forest openings which were created in 1959, 1955, 1950, and 1948, and in the forest surrounding these openings. At the period of maximum soil moisture depletion, openings 1 year old were found to have 6.9 inches more soil moisture per 4-foot soil than did the surrounding forest which is an expression of the quantity of moisture saved as a result of the logging operation. In openings 5 years old the savings has decreased to 2.9 inches, after 10 years to 1.2 inches and after 12 years to 0.7 inches. A projection of the regression in-dicates that the moisture savings at maximum depletion will reach zero 16 years after cutting. Soil moisture depletion is traced through two summer depletion seasons and into the fall moisture recharge periods. The effect of soil field capacity soil depth, ground cover, and summer precipitation upon soil moisture depletion trends also is discussed.

ACKNOWLEDGEMENT

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“The annual supply of rainfall . . . was received by the country, in all its abundance, into her bosom where she stored it in her impervious potter's earth and so was able to discharge the drainage of the heights into the hollows in the form of springs and rivers with an abundant volume and a wide territorial distribution.”

PLATO, "Critias"

INTRODUCTION

The demand for fresh water in the United States will reach 600 billion gallons per day by 1980, according to the U.S. Public Health Service (1958). This amount equals the present fresh water supply. When the demand exceeds the supply, as it has in many parts of California, efforts must be made to satisfy that requirement, if the economic growth of an area is to continue. Therefore it would be desirable if, in our timber management practices, we could increase the quantity and the quality of the water flowing from mountain watersheds as we commercially harvest the forest, and assure delivery of this water to the consumer at the desired time. We need to understand the basic principles of water disposition within a watershed before we can effectively manage timber stands to augment or be compatible with the existing water values of the area. Such information is the overall goal of the Cooperative Snow Management Research Program [1/] being conducted by the Pacific Southwest Forest and Range Experiment Station, U. S. Forest Service, in cooperation with the State of California Department of Water Resources. This study is a portion of that program. [2/]

Throughout history man has considered a forest and forest conservation as synonymous with sufficient quantity and good quality supplies. As populations increased and requirements for water became more critical, man, in seeking methods to augment existing water supplies looked to the forested areas for an answer.

[1/] Anderson, H. W. Proposed program for cooperative snow management research. 1956. (Unpublished report on file at Pacific SW. Forest and Range Expt. Sta., U. S. Forest Serv., Berkeley, Calif.)

[2/] Ziemer, R. R. Summer water loss as related to time following logging and associated vegetation recovery. 1960. (Unpublished report on file at Pacific SW. Forest and Range Expt. Sta., U. S. Forest Serv., Berkeley, Calif.)

Not until the establishment of the Wagon Wheel Gap study in 1909 (Bates and Henry 1928) did the problem of the effect of forests upon streamflow come under scientific study In the United States. Watersheds were calibrated for 8 years after which one watershed was completely denuded by logging and burning. In the 8 years after treatment, the denuded watershed developed a moderately dense stunted stand of aspen, whereas the untreated control remained relatively unchanged. As a result of this treatment, an average annual increase of 0.96 inch of streamflow was calculated which was attributed to a decrease in interception and snow evaporation losses.

This study by Bates and Henry aroused interest in watershed research which resulted in the development of several similar study sites made possible by relief programs begun during the economic depression of the 1930's. The establishment of the Coweeta Hydrologic Laboratory was the result of one of these programs. In 1939-1940, an area with heavy overstory and understory vegetation was clearcut (Kovner 1956). In the first growing season heavy sprout and brush promptly covered the area. An increase of 14.45 inches in streamflow was reported for the first year following treatment. By the thirteenth year this increase in streamflow had decreased to 4.99 Inches. Extrapolation of the regression suggests that increased streamflow is a decreasing linear function of the logarithm of the time in years since treatment which becomes negligible after 35 years and zero after 50 years.

The Wagon Wheel Gap and Coweeta studies are the classic works on the effect of vegetation removal upon streamflow. Several equally important studies by Savina (1956), who worked in Russia on forest thinnings of various intensities; Johnson and Kovner (1956), who did research at Coweeta in which only the laurel and rhododendron understory was

removed; Kihlberg (1958), who worked on clearcut watersheds in Sweden; and Johnson and Meginnis (1960), who reported on streamflow from watersheds in Ohio after pine plantations were established, indicate an initial increase in streamflow immediately after vegetation removal with streamflow subsequently decreasing as the vegetation becomes established.

If we are to manage our forests to increase water values, we must understand the duration of diminishing water yields with time after treatment so that we can effectively and rationally remove vegetation or harvest timber at a period which will maximize the water value to be derived.

The objective of this study was to relate soil moisture depletion resulting from evapotranspiration occurring during the summer drying period to time after logging. Soil moisture depletion was measured in forest openings created by logging in 1959, 1955, 1950, and 1948, and in the forest surrounding these openings. Soil moisture was determined at monthly intervals through the 1960 and 1961 summer drying and fall recharge seasons. Depletion trends were related to the length of time after the creation of the opening and the effect of soil field capacity, soil depth, ground cover, and summer precipitation upon these trends.

DESCRIPTION OF THE STUDY

Location

The study area (fig. 1) is located in the subalpine forest zone of the western slope of the Sierra Nevada within the 6,000- to 7,000-foot elevational range in areas consisting of the better commercially forested portions of the zone. The dominant vegetation consists of forest stands of California red fir (*Abies magnifica*) and lesser amounts of lodgepole pine (*Pinus contorta*), White fir (*Abies concolor*) and Jeffrey pine (*Pinus jeffreyi*).

U. S. Forest Service records [3/] indicate that the high elevation forests were cut extensively during the period from 1880 to 1910. The wood was used primarily for mining purposes and for construction and fuel by the Southern Pacific Railroad. It was not of particularly high quality, but was available. Only in isolated instances since 1910 have these forests been considered economically important and the resultant timber sales have been limited in extent. Recently the forests of the subalpine zone have begun to be included in future timber management plans.

Soils

The general soil pattern of the area is characterized by variability in both type and depth as a result of glaciation. The forest sites studied were restricted to the Lytton soil series (Nelson 1957). Lytton soils are well-drained, moderately coarse textured cobbly sandy loam, forested soils developed in place from andesitic agglomerate rock. The effect of glacial action and the amount of glacial debris generally in negligible except in

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[3/] Records on file at Big Bend Ranger Station, Big Bend, California, and Supervisor's Office, Tahoe National Forest, Nevada City, California.

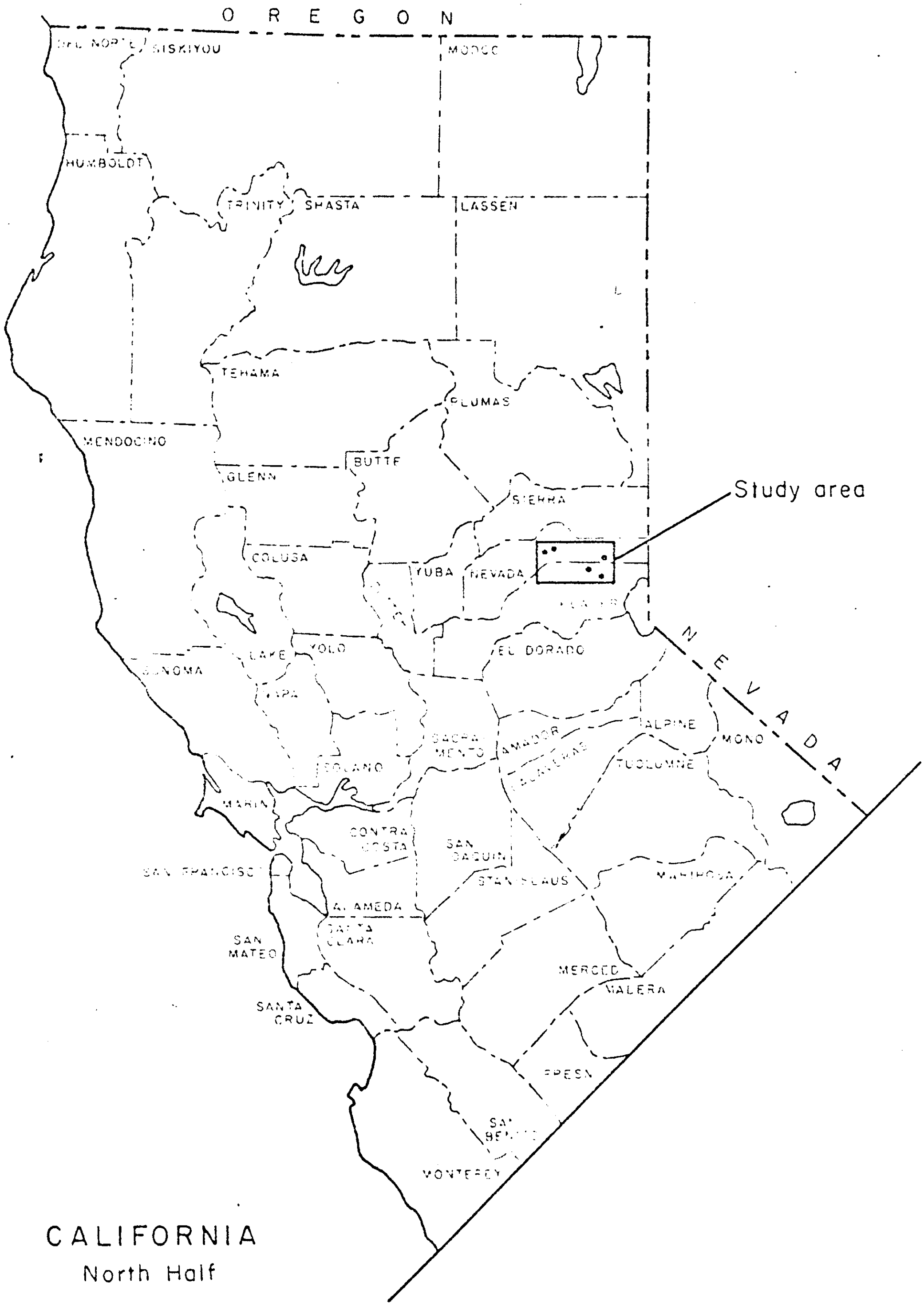
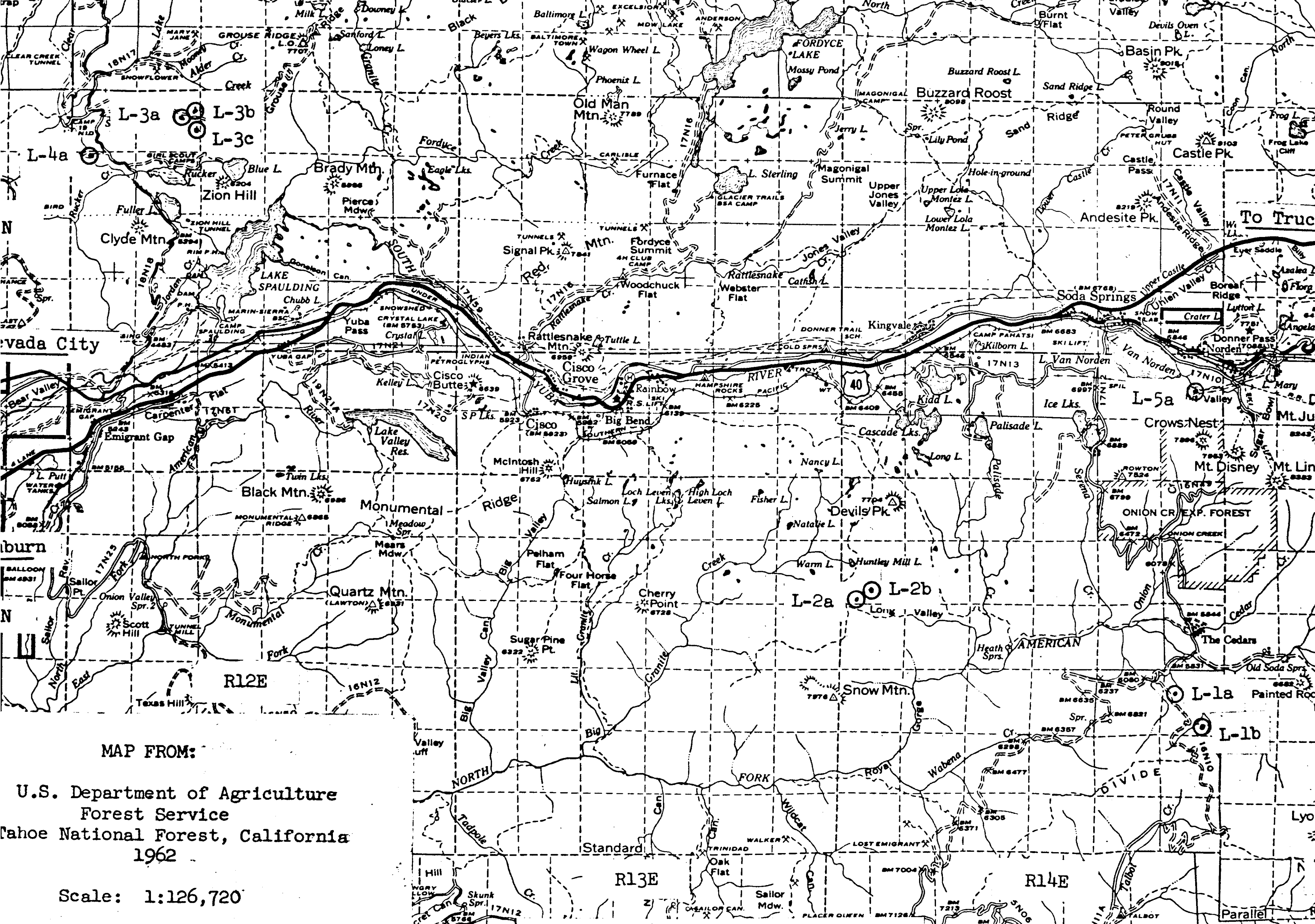


Figure 1. -- Location of study area.



MAP FROM:

U.S. Department of Agriculture
Forest Service
Tahoe National Forest, California
1962

Scale: 1:126,720

localized areas where the soil is c1assified by parent material phases. The parent material phases comprise areas of Litton soils with numerous morainal granitic erratics, basaltic rocks and rhyolitic rocks making up a significant part of the parent rock. For purposes of this study the sites have been grouped by field capacity characteristics for comparability analysis.

Precipitation

The long term average annual precipitation for the area is 51 inches. Of this amount 42 inches of water is present in the maximum snowpack which occurs on or about April 1 (California Department of Water Resources 1962; U.S. Army 1956). The summer soil moisture depletion period extends 4 to 5 months, from June into October, with a total average precipitation of about 3 inches. The summer precipitation generally occurs as light showers, but with an occasional high intensity convection storm of short duration. Consequently, this climate is ideal for a study of summer water loss by measuring soil moisture depletion.

SOIL MOISTURE SAMPLING SITES

Selection Criteria

The location and characteristics of the individual sites may be found in figure 1 and table 1. The criteria for selection of a soil moisture sampling site require the site to be an opening created in an originally forested stand which was comparable to the surrounding forest before logging. The sites were located on well drained soils with no water table in evidence. Generally, a stand of trees with little or no evidence of logging and with a definite boundary surrounds the opening.

Sampling Design

A transect was placed from the forest into the opening and then into the forest on the other side of the opening. In the case where no definite forest boundary exists on the opposite side of the opening, the transect extends from the forest into the approximate center of the

Table 1 -- Characteristics of soil moisture sampling sites

Plot No	Year logged	Elevation (feet)	Slope (percent)	Ave. soil depth (inches)	Aspect	Opening size [1/]
L-1a	1959	6170	5	35	N	1/2H-1H
L-1b	1959	6350	5	31	N	1H-1-1/2H
L-2a	1955	7200	5	54	N	1H+
L-2b	1955	7120	10	45	N	1H+
L-3a	1950	6200	5	37	N	1H+
L-3b	1950	6230	2	37	NW	1H+
L-3c	1950	6160	2	32	SW	1H+
L-4a	1948	5430	5	32	N	1/2H-1H
L-5a	(1923) (1949) (1955)	6860	10	42	N	2H

[1/] Opening size is a ratio of the diameter of the opening to the height of the surrounding trees (e.g. 1/2H opening is one-half tree height).

opening. Spacing of sampling points along the transect is in terms of proportions of the average height of the dominant and codominant trees surrounding the plot, based on the assumption that the effect of trees upon soil moisture loss is some function of the height of trees. The height of trees and the angle of incidence of solar radiation determines the distance shade extends into an opening and hence is related to the evaporation rate at various distances into the opening.

Moulopoulos (1956) correlated seedling regeneration in openings of various sizes and shapes with the heights of trees and the incidence of solar radiation. He arrived at a general formula for determining regeneration opportunity for any opening and derived an "ideal" opening size and shape by computing the amount of area within hypothetical openings being shaded at selected times during a day, for selected dates during the summer, at latitudes ranging from 35^o to 41^o N, for all exposures, and for slopes ranging from level to 100 percent. Moulopoulos measured the distribution of regeneration within natural openings and found that seedlings were concentrated in the southern or shaded portions of the opening. This measurement was highly correlated with the pattern of available soil moisture.

Anderson (1956) found that the height of trees determined the "effective opening size" in snow accumulation and melt relationships. He also found that the quantity of shade within an opening was a function of slope, aspect, tree, height, and the incidence of solar radiation. The combination of these factors determined the snow ablation rate.

Soil moisture sampling points proceed from the edge of the opening, as represented by a vertical projection of the canopy, at distances increasing logarithmically away from the forest and into the opening. That is, points located at 0-H (the edge of the canopy), 1/8 H, 1/4 H, 1/2 H, 1 H,

etc., into the opening where H equals the average height of the dominant and codominant trees. Two points were located within the forest at distances of 1/4 H and 1/2 H. Therefore, an opening one tree height in diameter was sampled at 11 points, beginning within one portion of the forest at 1/2 H and 1/4 H in the forest; 0-H at the south canopy border; 1/8 H, 1/4 H, 1/2 H, 1/4 H, and 1/8 H in the opening; 0-H at the north canopy border; and 1/4 H and 1/2 H in the forest. (fig. 2). The sampling point 0-H was located at random along the south forest border with the transect oriented perpendicular, north-south, to the border. A transect based upon a logarithmic progression was used on the hypothesis that the gradient of the soil moisture loss curve is greatest near the canopy edge and will diminish with distance away from and into the forest. (fig. 2).

Several authors support this hypothesis. Wyssotzky (1932) reported on a study conducted in 1899, which used graphs of soil moisture conditions extending from a stand of mature hardwoods into an adjacent cutover area. In September 1899 the soil moisture content under the forest was 10 to 15 percent less than that in the cutover, after correcting for precipitation, with the moisture content gradient being greatest near the tree canopy boundary.

Aaltonen (1926) found that in an opening about 20 years old, the seedlings in the center of the opening were the tallest and became relatively shorter as the edge of the mother stand was approached. This he attributed to the lower competition for water in the opening.

Toomey and Kienholz (1931) observed that during the driest periods from two to nine times as much moisture was available to plants in trenched plots as in untrenched plots. This difference appeared to be wholly due to the elimination of root competition.

Lunt (1934) found in practically all cases that the lowest soil moisture content was found immediately beneath the tree crown, close to the base of the trees. Moisture content increased ns distance from the trees increased.

Kalashnikov (1955) working in an area having little snow observed that forest strips caused considerable increase in soil moisture content on fallow ground, in the order of 16 - 17 mm. in the top 2 meters of soil, which he attributed to a decrease in evaporation.

Coutts (1958) indicated soil moisture content under the canopy is lower than that in the ride.

Giulimondi (1960) designed a study on the effects of Eucalyptus shelterbelts, upon soil moisture in adjacent cultivated soils in which he measured soil moisture at distances of 3, 5, 9, 17, and 25 meters from the shelterbelt. The moisture lost from the soil at the 3-meter sampling point was nearly twice that of the 5-meter sample, 3 times that of the 9-meter sample, and 13 times that of the 17-meter and the 25-meter samples.

Douglass (1960) worked in a thinned loblolly pine plantation with the remaining trees spaced 20 feet apart. He found that the moisture content increased with distance from the tree and became greatest midway between the trees. The differences in moisture content between trees and under trees averaged 3 inches the first year and 2 inches in the second year. He attributed this decrease to possible root extension into the cleared area.

SOIL MOISTURE MEASUREMENT

Neutron Soil Moisture Determination

Soil moisture determination was made with the use of a Nuclear-Chicago P19 neutron soil moisture probe and a model 2800 portable

scaler. Neutron scattering is becoming a widely acceptable method of determining the soil moisture regime. The theory and methodology of neutron scattering under a wide diversity of soil, vegetation, and moisture conditions have been described by many workers.[4/]

The P-19 probe contains a 4- to 5- millicurie, radium-beryllium source which emits approximately 6 x 10^4 fast neutrons per second with gamma rays (Nuclear-Chicago Corp., n.d.). When a fast neutron contacts hydrogen atoms it becomes a slow neutron. The number of returning slow neutrons is detected by a sensing tube within the probe. The chemical content of inorganic soils is such that the primary hydrogen present is in the soil moisture. The number of slow neutrons detected per unit time can be related to the quantity or moisture in the soil in percent by volume, because the rate of emitting fast neutrons is known. A single calibration of the probe would apply to a wide range of inorganic soils. Soils with high organic content would require a calibration related to the content of organic matter. The sphere of influence of the probe, or the effective volume of soil in which the moisture measurement is made, is a variable which is inversely related to the moisture content of the soil and can be computed by the formula:

$$\text{Diameter (inches)} = 12 \sqrt[3]{\frac{100 \text{ percent}}{\text{percent } H_2O \text{ (by volume) in soil}}}$$

(Nuclear-Chicago Corp., n.d.).

Under the soil moisture conditions of this study, which range from 50 percent by volume to 10 percent by volume, the diameter of the sphere of influence of the probe would range from 15 to 26 inches,

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4/ Burrows and Kirkham 1958; Davidson et al. 1958; Gardner and Kirkham 1952; Goldberg, et al. 1955; Letey et al. 1961; Merriam 1959; Mortier and de Boodt 1956; Preobrazhenskaya 1959; Van Bavel 1958; Van Bavel et al. 1956.

respectively. Carlton (1957) indicates that moisture contents from a single sample may be determined with an average accuracy of ± 1 pound per cubic foot of soil or about ± 1.6 Pv (percent volume). For repeated measurements, the relative accuracy increases to ± 0.4 to ±0.8 Pv, or 0.05 to 0.10 inches of water per cubic foot of soil in a 2-minute counting period (Merriam 1960).

To measure soil moisture we lowered the P-19 probe into an aluminum access tube which had previously been placed in holes augured at the desired sampling locations. The augured access holes were of about 1-inch larger diameter than the aluminum access tube. The access tube was then installed and the soil was back-filled around the tube in the sequence it was removed and tamped to the approximate density of the surrounding soil. The volume of the soil disturbed in relation to the sphere of influence of the probe is quite small, hence the effect of this disturbance upon the measured soil moisture would be negligible. Hanks and Bowers (1960) found that the access tube had a slight effect upon soil temperature adjacent to the tube, but no measurable influence on soil moisture content. The access holes were augured to bedrock or as deep as was possible after several attempts in the stony soils encountered. In some cases it was probably not possible to penetrate the rocky soil to actual bedrock.

Soil moisture measurements were made at depths of 6, 18 and 30 inches and at successive 1-foot intervals to bedrock. Following periods of summer and fall precipitation measurements at the 3- and 9-inch levels were also taken. Since the radius of the sphere of influence of the probe ranges from 7 to 13 inches, depending upon moisture content of the soil, a correction to the observed soil moisture reading at the more shallow depths becomes necessary because of neutrons being lost to

the atmosphere when the calculated moisture content is less than the actual moisture content. The magnitude of this correction has been a matter of conjecture for several years. However, a correction based upon relationships established by Anderson [5/] appears to be a more realistic correction for the conditions of this study (fig. 3). The correction is actually less important than one might anticipate in the range of soil moisture of 20 to 50 Pv if the difference between samples from one measuring period to another at the same site is used. For example, if the soil moisture, corrected for shallow depth, varies from 44 Pv at one measurement to 34.5 Pv a month later, for a loss of 9.5 Pv, the uncorrected moisture content for the same measurement would be 40 Pv at the first measurement and 30 Pv at the second for a loss of 10.0 Pv. The error in the example would be 0.5 Pv or 0.06 inches of water in the top foot of soil. If plots of equal moisture content were to be compared there would be no error in the comparison with or without correction. There would, however, be an error in the actual amount of water contained in the soil without a correction, but in many instances we are interested in simply comparing two plots or two measurements rather them having a requirement to determine the precise account of water in the profile.

Calculation of Soil Moisture

Soil moisture measurements for 1961 began early in June when the soil was at field capacity. Measurements were taken at about monthly intervals until late September when fall rains became frequent and soil moisture recharge was initiated. Soil moisture measurement for 1960

[5/] Anderson, H. W. Soil moisture probe. 1961. (unpublished report on file at Pacific SW. Forest and Range Expt. Sta., U. S. Forest Serv., Berkeley, Calif.)

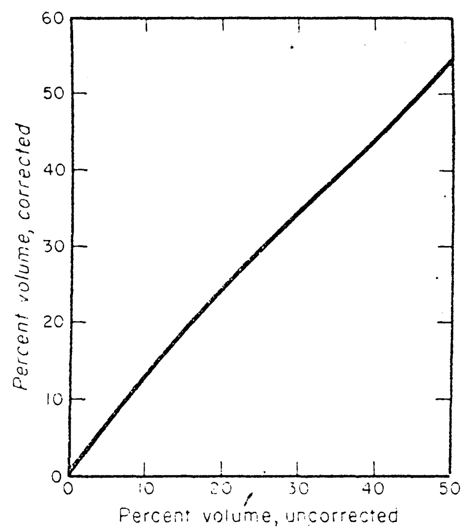

Figure 3. -- Correction of observed soil moisture in percent by volume for neutron loss to the atmosphere at the 6-inch soil depth.

began in July, was taken at monthly intervals and terminated in October. The field capacity measurement for 1961 was used as field capacity for both seasons. Depletion of moisture below field capacity for 1960 began in late May after a rain and snow storm of approximately 2 inches of precipitation which was the culmination of the spring storms for the year. A comparable storm from May 30 to June 1 terminated the spring storms in 1961.

The amount of soil moisture present at each sampling point at the measuring period was determined by taking the mean of the percent volume moisture content at the 6-, 18-, 30-, and 42- inch levels, which corresponds to a central measurement of the 1-, 2-, 3-, and 4-foot depths, and multiplying the mean by 46 inches, to obtain the number of inches of water in a 4-foot soil. In cases when the soil at a point was not 4 feet deep the moisture content at the deepest point attained was lineally projected to give an estimate of the lower depths. Since we are interested in the relationship of the change in moisture content of the soil over the summer period, rather than the absolute moisture value at any one time, this action is justifiable. Without the projection to lower depths the point would be biased by the upper levels which dry at a more rapid rate due to evaporation. Light summer precipitation also is usually wholly confined to the upper soil layers. Knoerr [6/] found that the wetting from summer precipitation on natural sites in the Sierra Nevada was confined to the surface foot of soil and no increase in soil moisture occurred below 2 feet. Summer precipitation was also found to have little influence upon the general rate of soil

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[6/] Knoerr, K. R. Exponential depletion of soil moisture by evapotranspiration at forest sites in the Sierra Nevada, as related to available soil moisture and vapor pressure deficit. 1960. (Unpublished dissertation on file Yale Univ. Libr., New Haven, Conn.)

moisture depletion in that the water is rapidly used by an increase in evapotranspiration with the result of a rapid return to the soil moisture conditions before precipitation.

Correction for Summer Precipitation

In some cases plots were measured shortly after the area received precipitation. The data indicated quite a variable pattern in the effect of this precipitation upon the soil moisture regime of the plot. Further analysis indicated in some cases all precipitation had been intercepted by the tree crowns or had been otherwise evaporated prior to measurement. In other cases where no interception resulted owing to the open position of the point, the soil moisture in the surface foot had increased to an amount comparable to the recorded precipitation. In some cases where precipitation reached the ground, under a canopy cover, the shade from the trees decreased the rate of surface evaporation and allowed measurable amounts of moisture to enter the soil. In several cases the moisture content at a point had increased an amount which was greater than the amount of precipitation received, which indicates probable surface runoff from some areas and ponding in slight depressions near the sampling point. Douglass [7/] observed that on plots near Union, South Carolina, much of the high intensity rainfall is lost as runoff which begins when as little as 0.3-inch of rain has fallen. Of the total rainfall between May and September 1959, 53 percent ± 2 percent of the water ran off a nearly level plot. These various processes cause the variable wetting pattern observed on plots in the Sierra.

[7/] Personal correspondence with J. E. Douglass, October 14, 1960.

The increase in measured soil moisture since the previous moisture measurement is perhaps the best indication of the amount of water received at a point and remaining in the soil as a result of intervening precipitation, runoff, and interception. Soil moisture data obtained following summer precipitation which indicated a rise in moisture content in the upper layers alone, while the lower depths decreased or remained constant, was adjusted by the amount of increase to obtain the amount of water received at that point since the last measurement. The amount was then subtracted from the measured soil moisture at the point to obtain a corrected moisture content had precipitation not occurred. This was necessary so that comparison could be made with plots which were measured before the precipitation.

Weighting of Area Sampled

To obtain a quantitative value for moisture content in the opening to compare with the moisture content in the forest, it became necessary to weight the data so the samples which represented a greater area would have the greatest weight, and the value obtained would be representative of the conditions of the opening rather than of a logarithmically spaced transect. The sample was weighted according to the distance between sampling points. Moisture values between two points along the transect were averaged to obtain the mean moisture content of the intervening distance between samples. These values were then weighted as follows: 0-H to 1/8 H and 1/3 H to 1/4 H equal a distance of 1/8 H between samples and received a weight of 1; 1/4 H to 1/2 H equals a distance of 1/4 H and received a weight of 2; 1/2 H to 1 H equals a distance of 1/2 H and was weighted by 4.

Correction to Comparable Periods of Measurement

The soil moisture data for this study was collected over a relatively large time range. The data was adjusted to comparable measuring periods for purposes of plot comparison. Time alone has been proven to be a poor determinant of evapotranspiration through a moisture depletion season or in the comparison of different seasons. The climatic events providing the opportunity for evapotranspiration are the more highly correlated factors of moisture loss. Consequently a simple index for the moisture loss opportunity was desirable. Several basic methods and many specific applications of these methods have been proposed in the past for estimating potential evapotranspiration.

Vapor flow methods are generally estimates of the turbulent transfer of moisture in the air near the ground. Energy balance methods evaluate the energy requirements for the evaporation process related to the energy received from net radiation and advection. Temperature index methods are probably related to the energy balance methods, in which temperature becomes an index to net radiation and this in turn becomes related to evapotranspiration. Evaporation pan index methods relate the evaporation from standardized pans to evapotranspiration from vegetation.

Knoerr [8/] reviewed the methods of estimating potential evapotranspiration as applicable to the Sierra Nevada. He found an index of vapor pressure deficit, which is a portion of the vapor flow method, to be closely correlated to the soil moisture loss rates experienced during his 2-year study at the Central Sierra Snow Laboratory. Vapor pressure deficit has been used as an index to moisture loss by a number of

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[8/] Knoerr, op. cit.

investigators in studies of evapotranspiration from seedlings of western conifers (Bates 1923), from seedlings of oak and pine in the Piedmont region (Kozlowski 1949), from scrub oak forests in Pennsylvania (Bethlahmy 1953), from clear-cut forested watersheds in Sweden (Kihlberg 1958), from forests in Russia (Pogrebnaik et al. 1957), from grass and lupine (Porkka 1956 and Haude 1952), and evaporation from bare soil (Penman and Schofield 1941 and Lowry 1956). Knoerr chose an index based on those used by Halstead (1951) and Haude (1952).

Other investigators (Tucker 1956; Prescott 1938, 1949) used essentially the same approach to evapotranspiration approximation.

Knoerr's application of the vapor pressure deficit index for evapotranspiration was based on the vapor pressure deficit at 2 p.m. adjusted for relative day length. Temperature and relative humidity data was obtained from Blue Canyon Airways Station which is a first-order U. S. Weather Bureau station located at 5,280 feet on an exposed ridge. Observation at this station would be representative of the air masses at ground level passing over the Sierra. The 2 p.m. vapor pressure deficit is generally the maximum deficit for the day. Temperature and relative humidity observations at this time are more stable than at other times during the day. Hence variability due to time of the observation would be at a minimum during this period. The day length correction was included on the assumption that the period of active transpiration is correlated with the length of day, in that this is the period in which solar energy is available for evapotranspiration. Day length corrections have been used by Halstead (1951), Haude (1952), Thornthwaite (1946), Crowe (1957), and others. Knoerr's formula for potential evapotranspiration then becomes:

$$E \sim Dr \times VPD_{2\text{ p.m.}}$$

In which E is the evapotranspiration index for the day, Dr is the ratio of day length of the particular day to the length of day on June 21, the longest day of the year. $VPD_{2\ p.m.}$ is the vapor pressure deficit based on the 2 p.m. observation.

The index of vapor pressure deficit times day length was computed for all days of the 1960 and 1961 summer soil moisture depletion seasons. A summation of the index was then made for the two depletion seasons (fig. 4) bringing the formulation of the index for accumulation of evapotranspiration potential to:

$$E_t \sim \Sigma Dr \times VPD_{2\ p.m.}$$

in which E_t is accumulated evapotranspiration over time t in days initiated when the soil is at field capacity and terminated at the conclusion of the summer depletion season.

Comparability of 1960 and 1961 Depletion Seasons

The climatic conditions of the two seasons were similar insofar as the moisture contained in the air masses passing over the Sierra is concerned. The 1960 season had the greater accumulated potential for evapotranspiration owing to slightly drier air mass conditions toward the end of the season, and a longer depletion season, extending until October 1 before the first precipitation of any significance. The 1961 depletion season ended on September 15.

For purposes of comparing the two depletion seasons measured and for comparing plots measured in the same season, but on different dates, the soil moisture data were indexed and adjusted to periods of comparable evapotranspiration potential in which E_t was equal to 0 (field capacity taken to June 1 in 1960 and 1961), 20 (approximately one-half of the soil moisture depleted; July 1 in 1960 and 1961), 67 (end of the 1961 depletion season, September 14 in 1961 and September 6 in 1960), and 80 (end of the 1960 depletion season on September 30, 1960). The adjustment

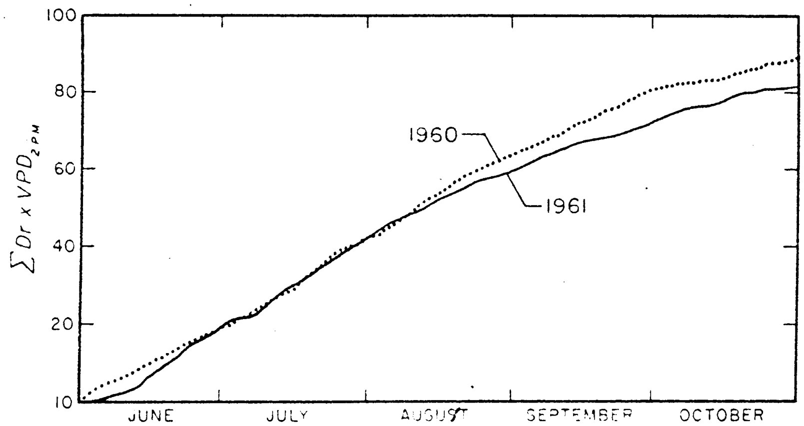


Figure 4. -- Accumulation of relative day length times 2pm vapor pressure deficit index (Σ Dr x VPD 2pm) from June 1st for 1960 and 1961.

of soil moisture data to desired periods of comparable evapotranspiration potential follows the general formula:

$$SM_a = SM_1 \pm \frac{\log SM_1 - \log SM_2}{E_{t2} - E_{t1}} (E_{t1} - E_{ta})$$

in which SM_a is the adjusted soil moisture for correction to the desired E_t value a, SM_1 and SM_2 are the measured soil moisture values at times 1 and 2 respectively, E_{t1} and E_{t2} are the corresponding E_t index values for times 1 and 2 respectively.

RESULTS AND DISCUSSION

The primary purpose of this study was to relate the quantity of summer soil moisture loss from logged forest openings to the length of time since the creation of the opening. To understand this general relationship it was necessary to determine the pattern of soil moisture depletion occurring both within each plot at various locations in the logged opening and in the adjacent unlogged forest. The depletion pattern was determined for each plot at monthly intervals throughout the summer moisture depletion season and into the fall moisture recharge period. It then became necessary to determine the effect of site variables, which we were unable to hold constant, upon the pattern of soil moisture depletion. Finally it was possible to subtract the quantity of moisture used by the forest from that which was lost from openings of various ages to determine the effect of opening age upon soil moisture loss throughout a summer period. By use of regression analysis it was then possible to determine the age at which the moisture loss in the logged area and the loss in the unlogged forest would approach equality.

SEASONAL TREND OF SOIL MOISTURE DEPLETION

Figure 5 is a graphic representation of the moisture conditions present in a recently created opening and within the surrounding residual forest at monthly intervals throughout a summer soil moisture depletion season. Figure 5 traces the change in moisture conditions as the summer depletion season progresses to termination and enters the fall soil moisture recharge season (see also fig. 6 and Appendix, table 3.). The general pattern of the disposition of soil moisture within the other plots studied during the depletion season was consistent with the example presented and only a graphic representation of the maximum depletion,

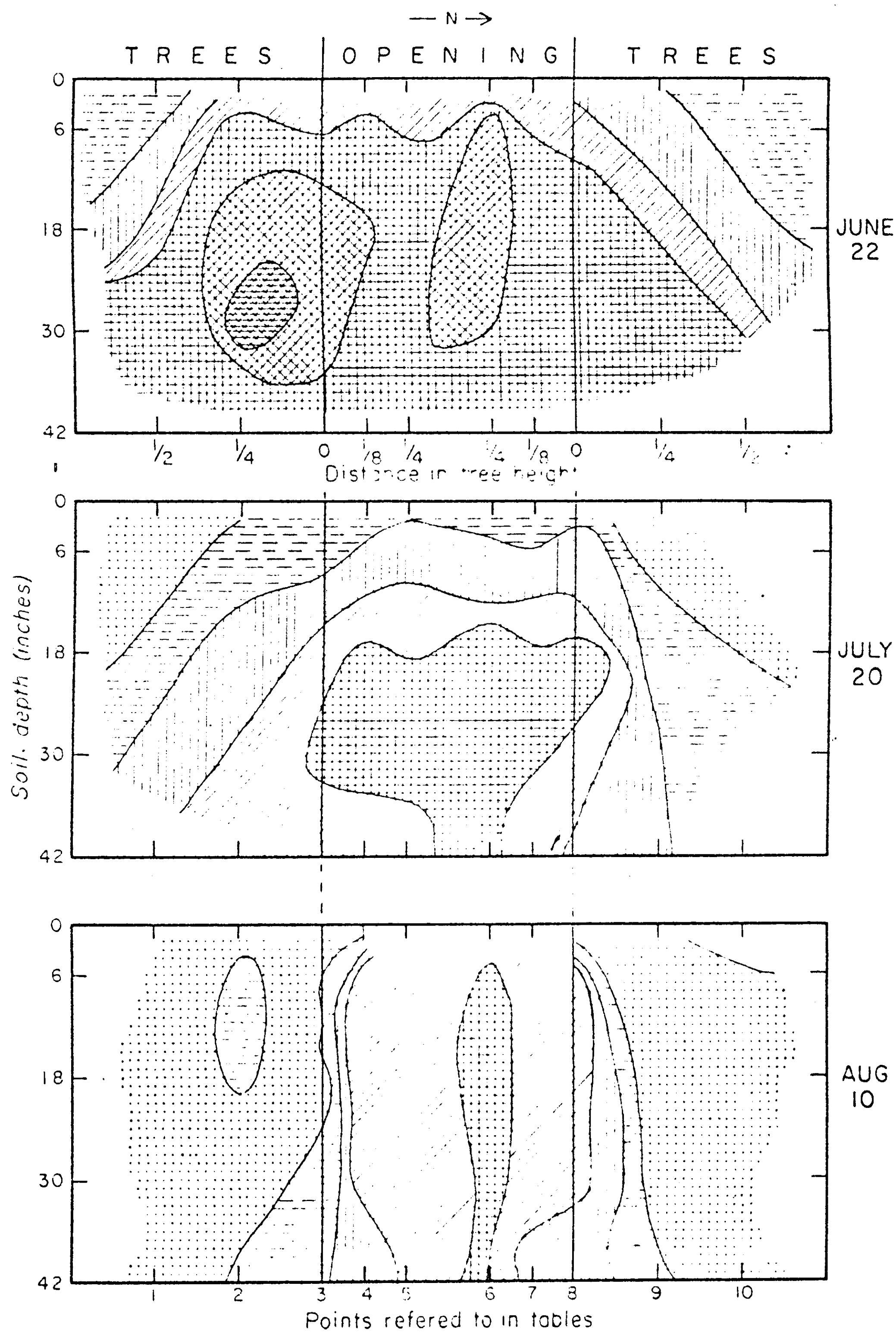
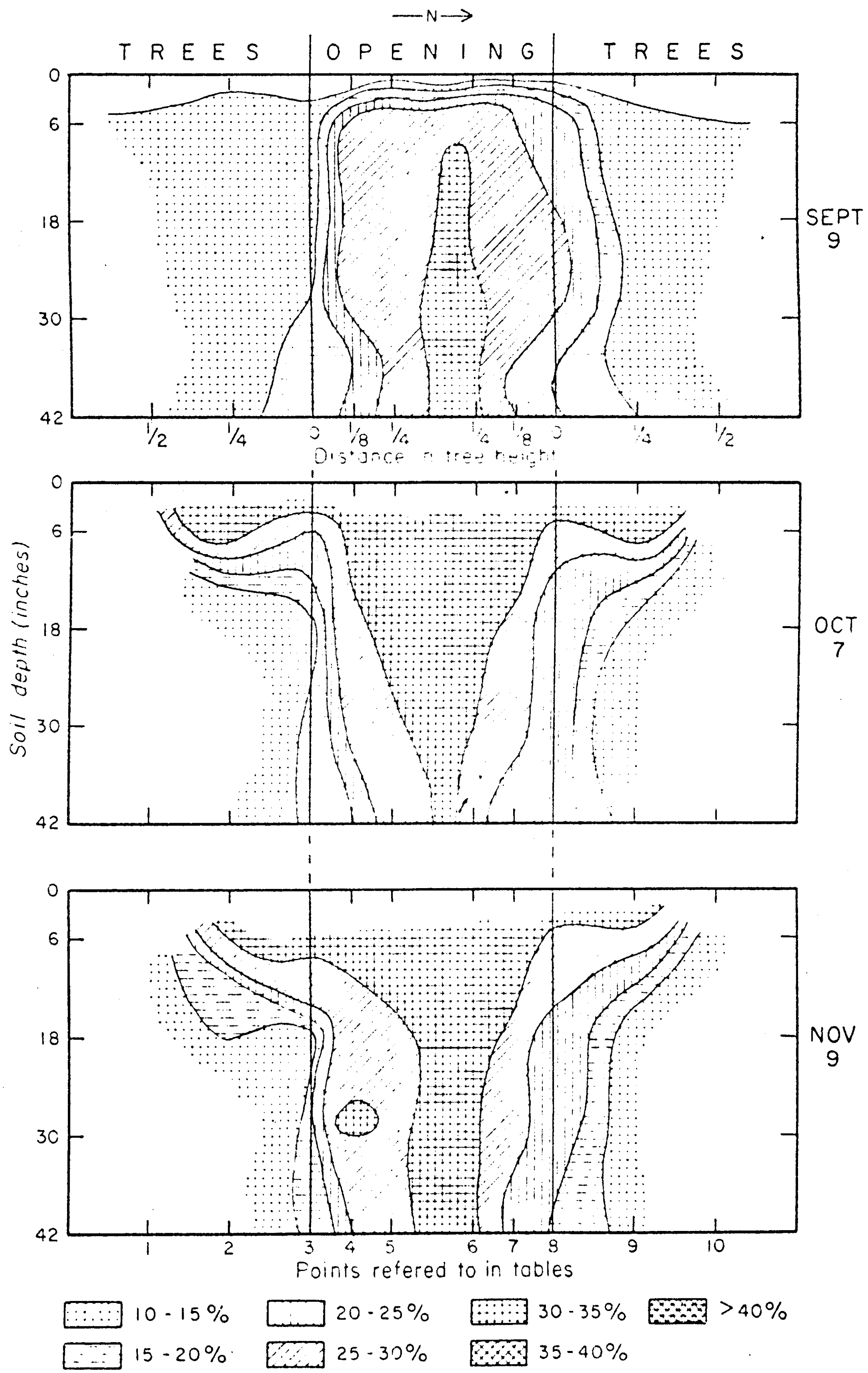


Figure 5. -- Soil moisture in percent by volume at 0- to 42-inch soil depth in plot L-1a, logged in 1959, for various dates through the summer moisture depletion season and into the fall moisture recharge season, 1960 to 1961.


N
TREES
OPENING
TREES
0
6
18
30
42
SEPT 9
OCT 7
NOV 9
Soil depth (inches)
Distance in tree height
1/2
1/4
0
1/8
1/4
1/4
1/8
0
1/4
1/2
1
2
3
4
5
6
7
8
9
10
Points refered to in tables
10 - 15 %
15 - 20 %
20 - 25 %
25 - 30 %
30 - 35 %
35 - 40 %
>40 %

occurring on/or about September 9, will be presented for these plots. However, a tabulation of the basic data for the entire series of measurements may be found in table 3 in the Appendix. Early in the summer season, June 22, 1961, moisture had been actively depleted in the forest to the canopy border with isolated areas being present in the open and forest in which the soil moisture was above field capacity when measured. This is particularly evident near the south edge of the opening. Within this portion of the plot, snow would have accumulated to greater than average depth during the winter period. The subsequent melt of snow from this area during the spring ablation period would be delayed due to the increased snow depth and to the shading effect from the forested area (Anderson 1956). Hence, the soil water within this portion of the plot would reach field capacity at a later date than the remainder of the plot because of the melting snow adding water to the soil for a longer period of time (fig. 10). Toward the center of the opening the soil remained at field capacity with evidence of moisture depletion occurring only within the surface 6 inches of soil.

One month later, July 20, most of the available moisture within the surface foot of soil has been lost to evapotranspiration from the forest beyond a distance of 1/2 H from the edge of the opening, with progressively more moisture being present as the center of the opening is approached. Differences in soil moisture due to the delayed snow melt at the south edge of the opening have disappeared by this date. About half the available moisture has been depleted from the soil within the forest at this date, with 10 to 20 percent of the available moisture being lost from the opening.

Twenty-one days later, on August 10, only 10 percent of the available moisture remains within the forest. The gradient of soil moisture

Figure 6. – Plot L-1a, logged 1959.

Figure 7. – Plot L-1b, logged 1959.

Figure 8. – Plot L-3a, logged 1950.

Figure 9. – Plot L-4a, logged 1948.

Figure 10. –- Plot L-5a, logged 1923, 1949, and 1955. Note the snowmelt pattern in southern edge of opening. Photo taken June 7, 1961.

near the south edge of the opening has become greatest at a point located a distance of slightly less than 1/8 H or about 10 feet beyond the canopy border into the opening. The gradient of soil moisture at the north edge of the opening appears to have shifted slightly, being greatest at a distance of 1/8 H into the forest. A more refined sampling design would be necessary in order to determine the explanation of this phenomenon with any degree of confidence.

By September 9, one month later, the maximum total seasonal soil moisture depletion has occurred. Nearly all the available moisture has been depleted from the forest with a rather definite and abrupt increase in soil moisture content being evident as one moves toward the center of the opening. Soil moisture loss within the opening primarily occurs within the top 6 inches of soil. The central portion of the opening is only slightly below field capacity. The shift to the northern or downslope portion of the plot remains apparent with the vertical gradient of soil moisture appearing less steep than in the southern portion of the plot.

Soil moisture measurement taken after late September and early October precipitation indicates that soil moisture recharge has occurred in all but the lower depths of the opening, but remains confined to the surface foot of soil within the forest. This difference in the effect of the extent of moisture recharge is, of course, explained by the quantity of water required to recharge the dry forest soil being much greater than the quantity of water required to recharge the more moist soil in the opening which was near field capacity at the time of initiation of recharge. By November little additional precipitation had fallen since the previous measurement, with the result of an insignificant change in the soil moisture pattern. However, a slight movement of moisture to lower depths in the forest becomes apparent.

Effect of Field Capacity

The water holding capacity or field capacity of a soil determines to a large extent the quantity of moisture which is available for use by a plant. As the quantity of available moisture is increased or decreased we would expect a corresponding change in the pattern of moisture depletion by a given type of vegetation. The quantity of water below field capacity used by the forested areas sampled over time, as a function of the cumulative vapor pressure deficit times day-length index, E_t and adjusted to a comparable period of initiation of moisture depletion below field capacity for three ranges of field capacity in Lytton soil is shown in figure 11. Several general relationships become apparent. First, the total quantity of water used by the vegetation in soils of lower field capacities is less than that used by the same vegetation in soils of higher field capacities. This is to be expected since physically less water is available for use. Second, the rate of water use decreases at an earlier date in the low field capacity plots and at a later date in the high field capacity plots. This is reasonable, since the rate of water loss is a function of availability (Thornthwaite 1954; Halstead 1954; Zinke 1959). The sooner the water becomes unavailable the sooner the rate of water loss will diminish. The initial rate of water loss was comparable for all plots, but decreased as the availability of water became limiting. Moisture became unavailable in the low field capacity range, 13.6 to 14.5 inches per 4-foot soil, after 50 units of E_t had been attained on approximately August 11, 1961 with a total of 6.4 inches of water being used during the depletion season (fig. 11). In the middle range of field capacity, 15.6 to 16.5 inches, moisture became unavailable when 59 units of E_t was attained on August 30, 1961 with a total of 9.4 inches of water being used during the depletion

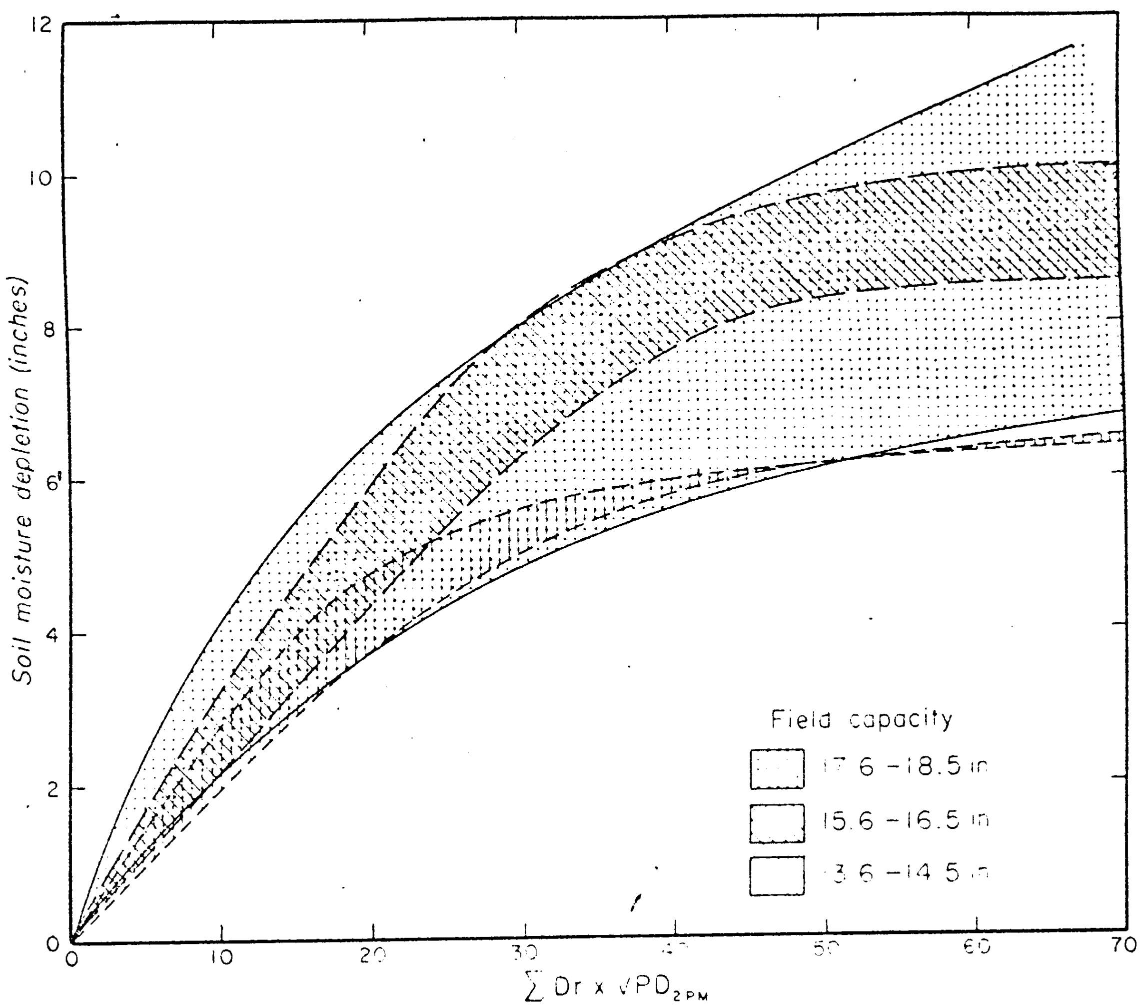


Figure 11. -- Soil moisture depletion related to day length times vapor pressure deficit from forested portion of plots of various field capacities in inches per 4-foot soil depth, June to September, 1960 and 1961.

season. The moisture use pattern in the high field capacity range of 17.6 to 18.5 inches is of a more complex nature covering a greater range of moisture depletion. However, it is apparent that water was still available for use at the end of the summer depletion season and moisture continued to be lost at a rate of 0.4 inch of water per week with an average of 9.6 inches of water being used by the end of the 1961 depletion season on September 12. Knoerr [9/] found that total depletion in his red fir sites ranged from 6.6 to 10.0 inches of moisture per 4-foot soil. The range of depletion encountered during this study for a comparable measuring period was 6.4 to 12.0 inches per 4-foot soil.

A greater quantity of water is being lost from a forest growing on soils of high water holding capacity than on soils of low water holding capacity. If the object of future treatment plans was to augment water supplies in several areas, one of which had a soil of a high water holding capacity and the others had soils of low water holding capacity -- all other factors being equal -- the proposal would be to treat the area with the higher water holding capacity or the higher potential for water loss in the untreated condition. Treatment of this area would have a potentially greater effect upon the quantity of water being used by the forest. In the range of water holding capacity encountered in this study, a difference of 3.0 inches of water per 4-foot soil exists between the use of moisture by vegetation on a soil of low field capacity as compared to use on a soil of high field capacity.

Effect on Soil Depth

The total depth of soil did not have a significant effect, upon the depletion rate of soil moisture for the plots studied. As previously

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[9/] Knoerr, ibid.

stated, we were unable to ascertain the true depth of soil at any given location -- only the depth to which the soil could be removed with a hand auger. Owing to the rocky nature of soil encountered, many of the sampling points probably do not represent the depth of the soil to bedrock, but only the depth of soil to a concentration of morainal material which we were unable to penetrate.

The soil moisture depletion rates at individual depths from the soil surface to a depth of 4 feet produce significant effects which can readily be observed in figures 5 and 13. Soil moisture was depleted from the surface downward and was recharged with precipitation from the surface downward. Several points in which deeper sampling depths were attained indicated a continuation of this relationship.

Effect of Ground Cover

It was difficult to separate the various ground cover conditions into various components and to determine the influence of these components upon soil moisture depletion. This is due primarily to the nature of plots with which we are dealing and to the original condition of the stand before and after logging. The original selection of plots was designed to eliminate as many stand variables, except age of the opening, as possible. Consequently, the conditions of the remaining stand were fairly uniform in aspect, slope, vegetation, soil, etc. The selection criteria would, in essence, be effective in eliminating a great amount of variability of understory, litter depth and composition, and general surface cover conditions within the forest. Originally the openings were of a very uniform cover condition, in that they were essentially composed of scarified bare soil without any vegetation cover. Within a year or two, small tree and brush seedlings germinated, but the soil was still essentially bare. Within 5 years after logging there was at least a

partial cover of trees, brush, and grass over the opening. This cover became more complete with time, with the trees and brush predominating. Inspection of all plots concerned indicated this to be the general pattern of events leading to the re-establishment of a forest stand within the logged openings selected.

Seasonal Soil Moisture Depletion in Logged Openings

We have observed that the pattern of moisture conditions within a recently logged forest opening changes as the depletion season progresses. We now are interested in the effect of the age of the opening upon the pattern of soil moisture depletion.

The soil moisture depletion in logged openings of various ages within the soil field capacity range or 15.9 to 17.8 inches of moisture per 4-foot soil, adjusted to a comparable period of the initiation of moisture depletion below field capacity for the 1961 depletion season is illustrated in figure 12. It becomes apparent from the figure that the loss of moisture from logged openings increases as the age of the opening increases. The availability of moisture for loss appears to be a limiting factor primarily in the more recently logged openings with the limiting nature or moisture availability becoming less as the age of the opening increases and reproduction becomes established. The reason for this relationship may be found in the method by which moisture is lost from these openings. In the more recently created openings, moisture loss is due primarily to surface evaporation from bare soil since very few seedlings have become established by this time and the use of moisture by those few seedlings do not as yet contribute to the moisture loss pattern. Moisture loss by evaporation begins at the soil surface and proceeds to subsequently lower depths with time, with the dry surface acting as an insulator against further loss. In the older openings

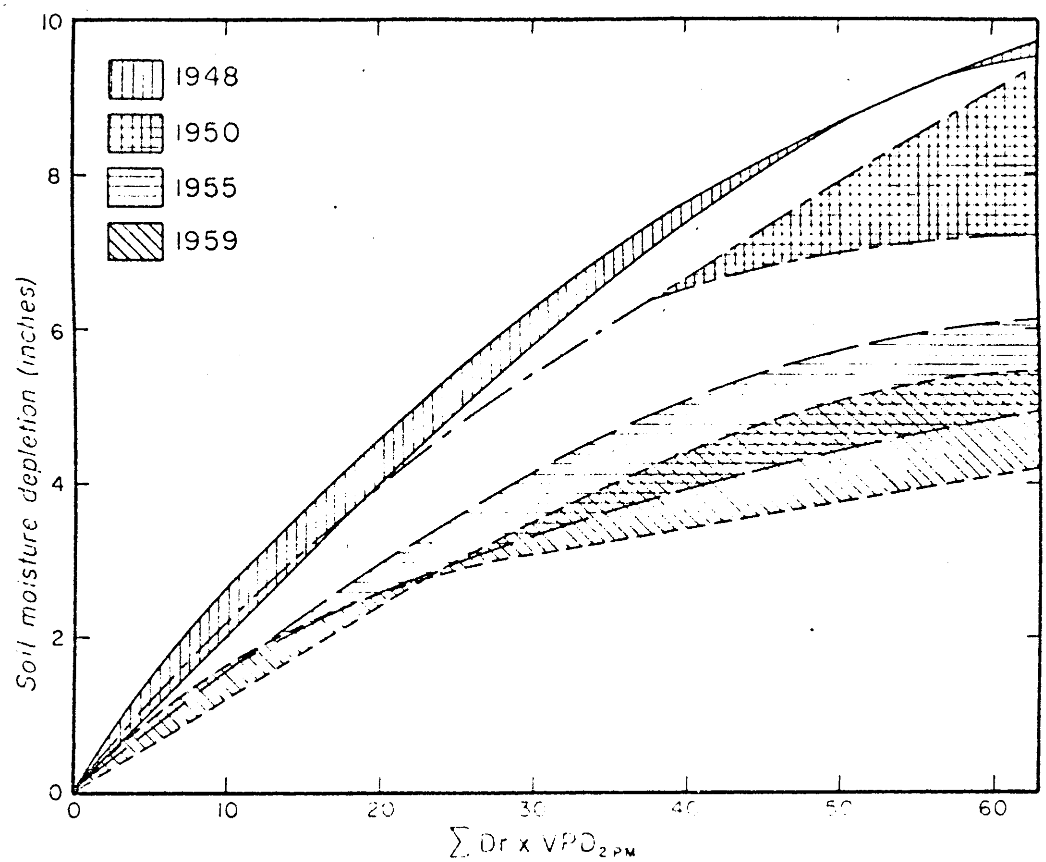

Figure 12. -- Soil moisture depletion in logged openings of various ages within a field capacity range of 15.9 to 17.8 inches per 4-foot soil.

moisture is lost through both surface evaporation and transpiration of the reproduction within the opening. The availability of moisture in the older openings is limited only by the distribution of the roots of the reproduction throughout the soil profile and does not limit moisture loss until all the available moisture is tapped, as is found in the mature forest, even through the total quantity of moisture which is lost is greater than that of the bare, more recent openings.

The results of Knoerr [10/] which reported moisture depletion in natural forest openings for the initial 20 units of VPD and also for total June to September depletion agree closely with the quantity of loss observed for the openings of this study which were created in 1950. Knoerr found 4.3 inches of soil moisture had been lost in the initial 20 units of VPD, which in the 1950 logged areas of this study had lost 4.0 inches and in the 1948 logged areas had lost 4.5 inches. Total June to September depletion was 8.4 inches per 4-foot soil. For a comparable period the 1955 logged openings had lost an average of 8.1 inches of moisture and the 1948 logged openings had lost 9.4 inches for each 4-foot soil.

MAXIMUM SOIL MOISTURE DEPLETION

Effect of Time Since Logging

The soil moisture pattern at the period of maximum depletion would be the best single indication of changes in soil moisture resulting from the age of the opening because a measurement at this period would represent the summation of the seasonal depletion within the plot. Any differences in soil moisture depletion between plots would be

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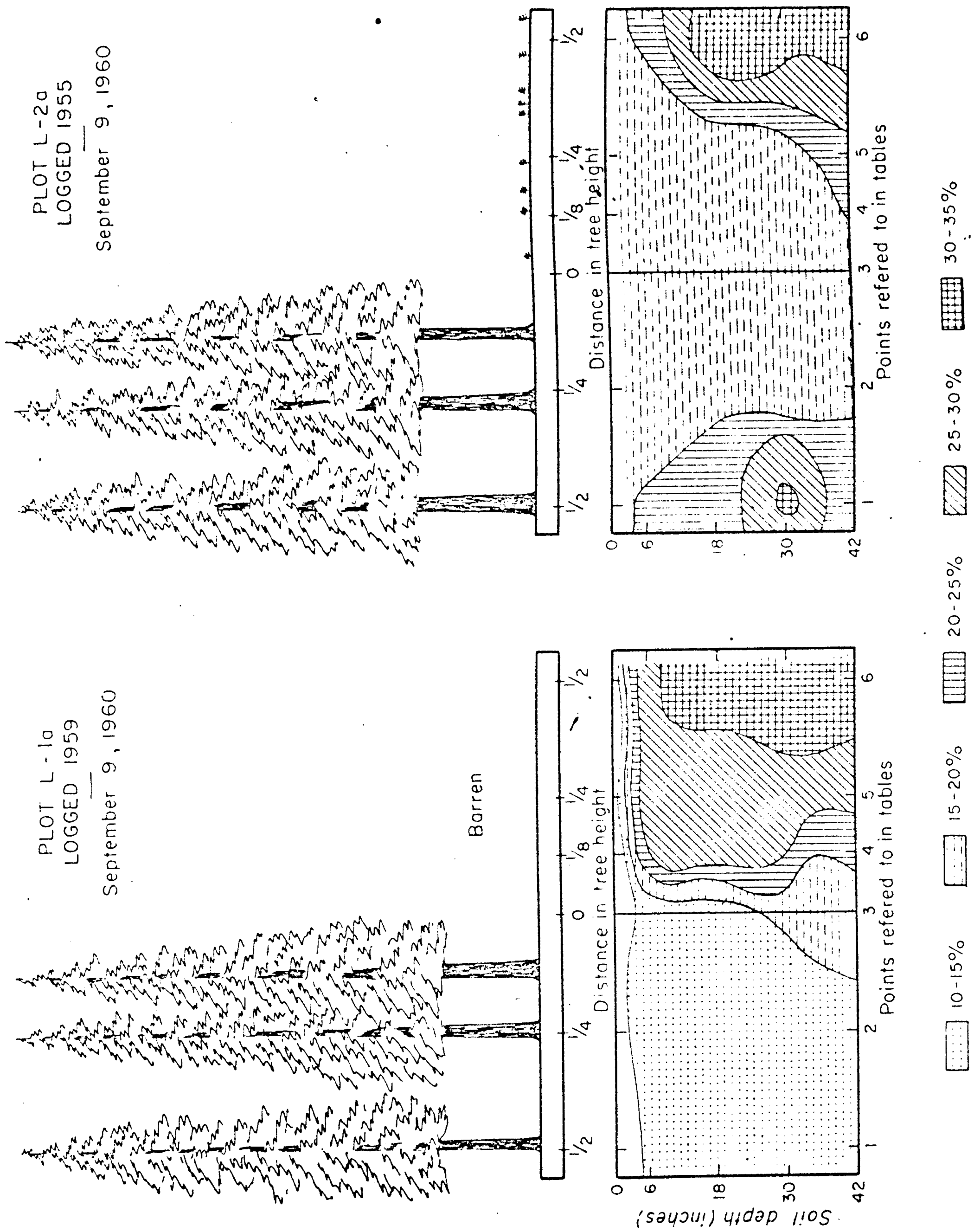
[10/] Knoerr, *ibid.*

compounded by this time and subtle differences could be readily ascertained.

We have described the soil moisture pattern in openings 1 year old in a previous section. Within openings 5 years old (fig. 13) the soil moisture content remains greatest toward the center of the opening, with an abrupt change in moisture conditions occurring at 1/3 H, or about 30 feet from the canopy border. This represents about a 20 foot shift in the moisture depletion into the opening in the 5 years since the opening was created. Moisture loss near the center of the opening extends downward an additional 6 inches beyond that in the year old logged opening. Vegetation in the 5 year old opening consists of small and scattered *Abies magnifica* and *Pinus contorta* seedlings and a smaller number of *Ceanothus* seedlings. The effect of this reproduction upon soil moisture depletion is slight. The primary change in moisture depletion within opening in the first 5 years since logging is probably caused by extension of roots or the residual forest into the opening. The determination of soil moisture at point 1 of this plot, located at 1/2 H in the forest, was influenced by the presence of a large dead root at the 30-inch depth. The entire profile at this point contained a large percentage of organic material which not only contained a large quantity of moisture but also influenced the number of modified neutrons returning to the soil moisture probe. The neutrons are modified by any hydrogen atoms present in the medium being measured. The value of moisture obtained is a value which would require a special calibration curve based upon the organic content of the soil. Consequently the point was not included in the analysis of data. By the next five years the influence of the reproduction within the opening had become apparent (fig. 8). Soil moisture still increases toward the center of the opening but the gradient is much



PLOT L-2a
LOGGED 1955
September 9, 1960
PLOT L-1a
LOGGED 1959
September 9, 1960
Barren
Distance in tree height
1/2
1/4
0
1/8
1/4
1/2
Soil depth (inches)
0
6
18
30
42
Points refered to in tables
1
2
3
4
5
6
10-15%
15-20%
20-25%
25-30%
30-35%

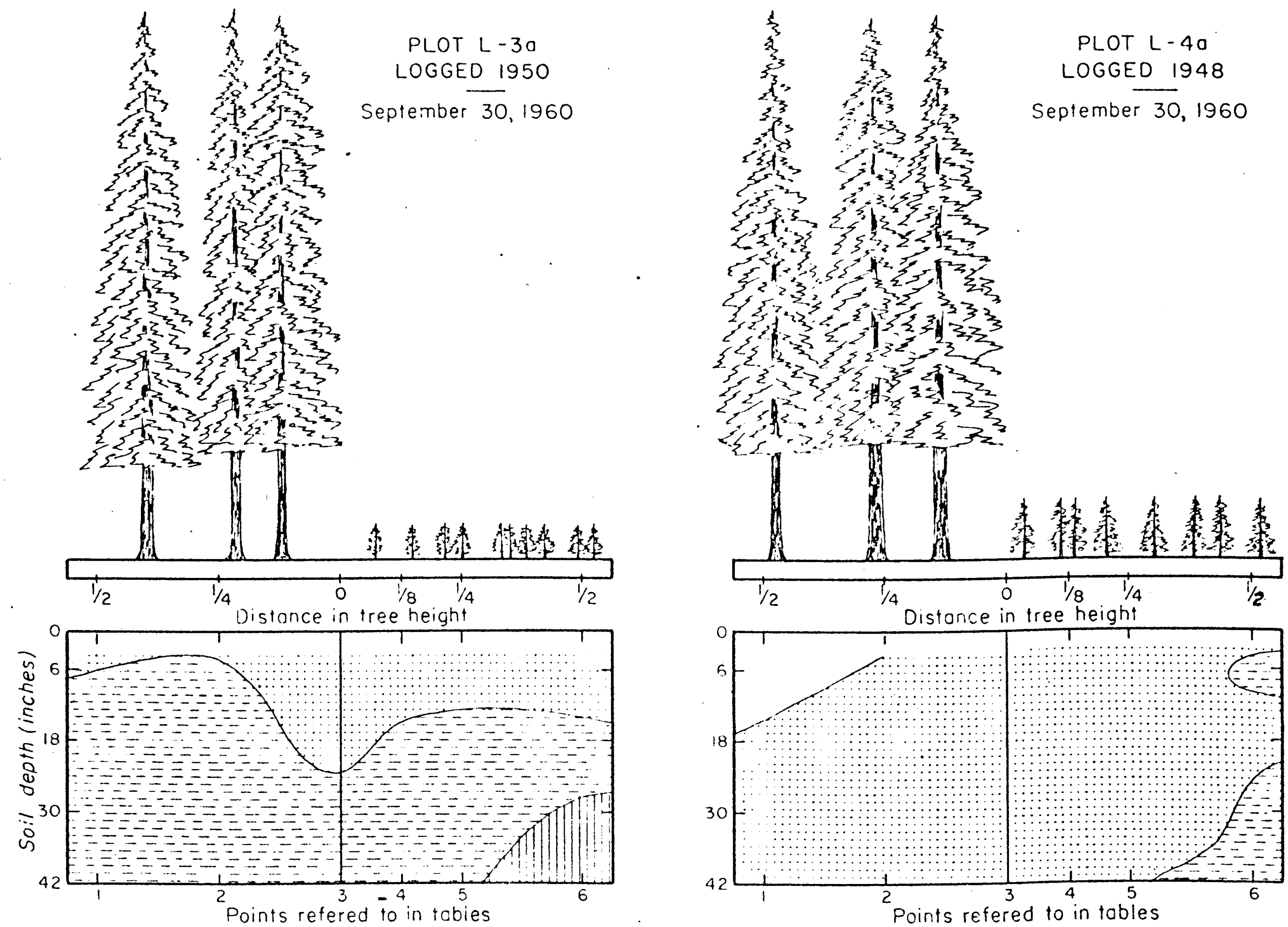


Figure 13. -- Soil moisture in percent by volume at 0- to 42-inch soil depth at maximum moisture depletion for logged openings of various ages.

less striking in this 10 year old opening. Reproduction within the opening averages 6 feet in height and is composed of *Abies magnifica* and an occasional *Pinus contorta* with a scattered understory of *Ceanothus cordulatus*, *Ceanothus cuneatus*, *Arctostaphylos nevadensis*, and *Ribes roezlii*. Moisture loss within the opening extends throughout the entire 4-foot profile. Except in the center of the opening below 2 feet, all available moisture has been lost from the plot. The effect of roots from the residual forest appears to extend a distance of 1/3 H into the opening, as was observed in the five year old opening.

In a 12 year old opening (fig. 9) all available moisture within the plot has been, depleted except at the lowest depths near the center of the plot. The roots of the reproduction have almost completely occupied the site. The total moisture loss pattern of the opening has essentially returned to the uncut condition with very little moisture being saved as a result of the logging by the end of the summer depletion season.

Effect of Canopy Cover

The effect of forest canopy density in the 10 percent of the hemisphere above the soil moisture point was found to have no definite correlation with maximum soil moisture depletion.

SOIL MOISTURE SAVINGS

Seasonal Trends

Soil moisture savings resulting from the creation of forest openings vary with the seasons of the year as well as with the age of the opening (table 2). Figure 14 depicts differences in the quantity of soil moisture between forest and opening as the depletion season progresses. On the recently logged plots, where reproduction is lacking, differences between the forest and the opening increase at a

rapid rate until the end of the depletion season is approached. At that time moisture availability becomes limiting in the forest and the rate of increase in savings begins to lessen. Moisture loss within the opening in the recently logged plots is restricted to surface evaporation and to use by the surrounding forest.

Differences in moisture loss within openings 5 years of age and the surrounding forest follow the same general pattern as that of more recently logged opening; that is, a consistent increase in the difference occurs throughout the depletion season. The rate of increase of this difference is less than in more recent openings due to increased use of moisture within the opening by young seedlings and by the adjacent residual forest.

The savings pattern becomes variable in the 10 years after logging and is dependent upon the quantity of regeneration. However, a lag in water use by the regeneration in the opening becomes apparent. Moisture is generally depleted from the forest at a rapid rate owing to the complete nature of root distribution within the forest and moisture becomes unavailable before the end of the depletion season. Apparently, the root distribution or the reproduction within the opening is more variable and patchy in nature with some areas and depths lacking complete occupation. As a result, the depletion of moisture from the opening is at a slower rate but continues for a longer period because water is still available for loss. The seasonal pattern of moisture depletion would then become one in which differences between forest and opening are small early in the depletion season, becoming greater by mid-season and then again becoming smaller as the season progresses toward culmination when moisture use in the forest has diminished due to availability and moisture use by reproduction in the opening continues at the same relatively slow

Table 2. -- Plot soil moisture (inches per 4-foot soil), adjusted for 1 H opening size, by year of logging, plot number, and time - 1960-1961

	L-1a	L-1b(R)	L-1b(T)	L-2a	L-2b	L-3a	L-3b	L-3c	L-4a	L-5a
Year logged	1959			1955		1950			1948	1949
1/	(16.5)	(16.5)	(13.7)	(17.8)	(17.8)	(15.9)	(13.7)	(16.7)	(15.9)	(17.8)
1961										
2/ $E_t = 0$										
Forest	20.0	18.1	14.5	18.0	snow covered	14.9	13.1	16.7	12.7	19.9
Open	17.9	16.7	13.1	19.8	18.0	15.0	14.6	16.7	15.2	20.8
Savings	-2.1	-1.4	-1.2	1.8	--	0.1	1.5	0.0	2.5	0.9
2/ $E_t = 20$										
Forest	14.4	11.8	11.3	13.6	15.8	10.7	8.8	10.7	10.7	13.8
Open	15.5	14.4	10.6	16.6	15.8	11.3	10.3	12.8	11.2	14.4
Savings	1.1	2.6	-0.7	3.0	0.0	0.6	1.5	2.1	0.5	0.6
2/ $E_t = 67$										
Forest	7.3	6.8	7.9	9.0	12.0	7.3	7.2	5.9	6.0	6.2
Open	12.8	12.3	8.4	12.0	12.9	8.5	7.2	6.9	6.0	7.5
Savings	5.5	5.5	0.5	3.0	0.9	1.2	0.0	1.0	0.0	1.3
1960										
2/ $E_t = 67$										
Forest	6.4	6.6	7.8	8.2	9.6	7.7	7.1	6.8	6.5	6.1
Open	12.7	13.4	9.4	12.3	12.1	9.0	7.2	8.2	6.5	7.4
Savings	6.3	6.8	1.6	4.1	2.5	1.3	0.1	1.4	0.0	1.3
2/ $E_t = 81$										
Forest	6.4	6.2	7.8	8.2	9.6	7.5	7.0	6.5	6.2	6.0
Open	12.7	13.2	9.4	12.2	12.0	8.8	7.1	7.6	6.4	7.1
Savings	6.3	7.0	1.6	4.0	2.4	1.3	0.1	1.1	0.2	1.1

1/ Numbers in parentheses indicate plot field capacity.

2/ E_t is a cumulative index of evapotranspiration computed as a function of vapor pressure deficit times a day length ratio.

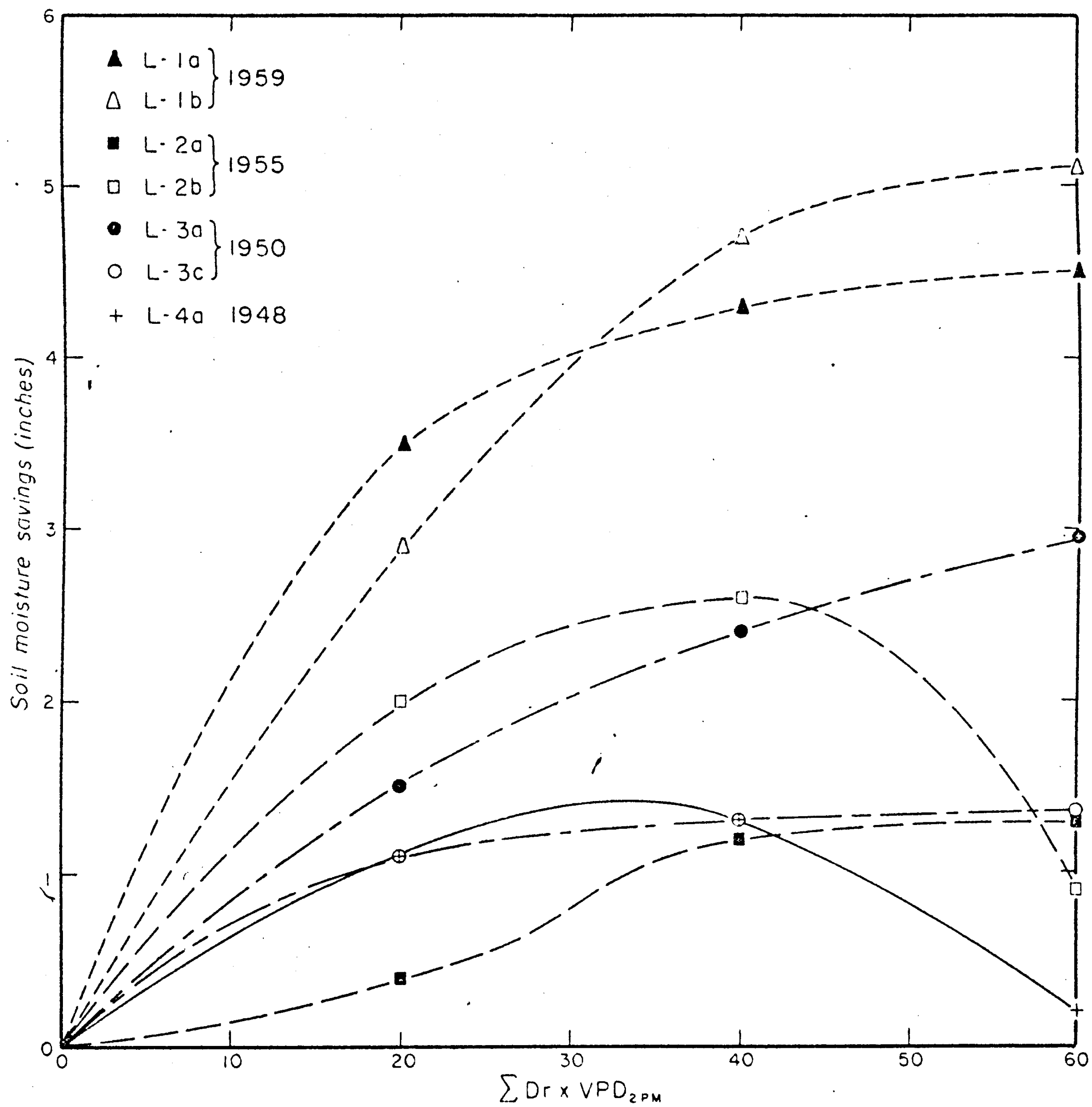


Figure 14. -- Seasonal pattern of soil moisture savings (moisture loss from open minus moisture loss from forest), by individual plots, logged in 1959, 1955, 1950, and 1948.

rate. The result of total moisture use in the forest and opening would become nearly equal by the conclusion of the depletion season.

At Maximum Depletion

The uncut forest surrounding the logged opening was assumed to be a representation of the soil moisture depletion pattern within the opening before the logging operation. This assumption requires the soil properties within the forest to be the same as those within the opening and is probably a reasonable assumption for the openings selected for this study. The difference between the quantity of moisture used by the forest and the quantity of moisture lost in the opening would be the amount of moisture which would be saved as a result of the logging operation. When the quantity of moisture used by the forest equals the quantity of moisture lost within the opening the amount of moisture saved by the cutting would, of course, be eliminated and the area must be cleared again if the function of the cutting was to increase water yield from the area.

The depletion of soil moisture was computed for all plots for the 1960 and 1961 depletion seasons and is tabulated for values of the evapotranspiration index, E_t of 0, 20, 67, and 81 (table 2). The negative values of saving at $E_t = 0$ indicate more moisture being present in forest at the period taken as field capacity than in the opening. This difference is due primarily to variations in snow melt rate in the exposed open and within the shaded forest. Several plots were above field capacity when the $E_t = 0$ measurement was made. The value of $E_t = 0$ was useful to determine the point at which depletion of soil moisture below field capacity began.

To determine the effect of the logging upon soil moisture loss, the water savings at maximum depletion was plotted over the logarithm of the age of the opening in years (fig. 15). The period of maximum depletion

was used because by this time of the season the rate of water loss has decreased and the measured soil moisture is more stable at this time. Hence, variability due to time of the observation would be at a minimum during this period. It was observed previously that the two plots with low field capacity reacted in a manner which was different from the rest of the plots. Therefore these two plots were analyzed separately. A regression was fit to the values of water saved in the various plots with field capacities between 15.6 and 18.0 inches of moisture per 4-foot soil as defined by the line:

$$Y = 6.891 - 5.728 \log t,$$

in which Y is the water savings at maximum depletion in inches of moisture per 4-foot soil, and log t is equal to the logarithm of age of the opening in years. The fit of this line to the data was found to have an explained variance (r^2) of 0.928, or 93 percent of the variation in the water savings at maximum depletion is explained by the logarithm of the age of the opening. The standard deviation was ±0.6404, that is, 2/3 of the observations could be found within the range of ±0.64 inches moisture content of this line. Soil moisture savings resulting from logging became zero 16 years after cutting.

In plots with field capacities between 13.6 and 14.5 inches of moisture the regression

$$Y = 1.304 - 1.295 \log t,$$

fits the scatter of points with an explained variance of 0.8367 and a standard deviation of ±0.364. Moisture savings become zero 11 years after cutting.

The time between the 1960 and 1961 measurement seasons resulted in a change in the quantity of savings for each particular age opening -- an amount equal to a change of one year, indicated by the regression equation.

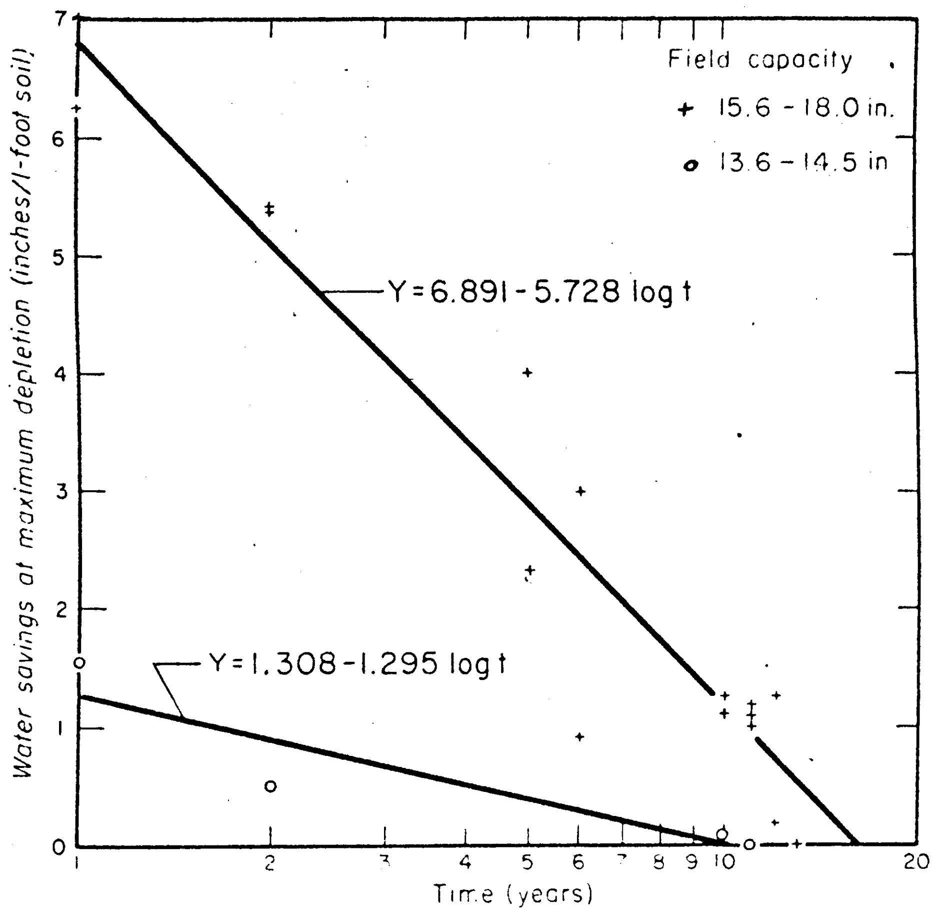


Figure 15. -- Effect of age of logged openings upon water savings at maximum soil moisture depletion for two field capacity ranges.

SUMMARY AND CONCLUSIONS

This study of soil moisture depletion was carried on in an elevational range or 6,000 to 7,000 feet in the subalpine forest zone on the west side of the Sierra Nevada, near the Central Sierra Snow Laboratory. Soil moisture depletion was measured in logged forest openings which were created in 1959, 1955, 1950, and 1948 as well as in the forest surrounding these openings.

The quantity of summer soil moisture loss from logged forest openings was related to the length of time since the creation of the opening. At the period of maximum soil moisture depletion, openings 1 year old were found to have 6.9 inches more soil moisture per 4-foot soil than did the surrounding forest. This is an expression of the quantity of soil moisture saved as a result of the logging operation. In openings 5 years old the savings had decreased to 2.9 inches; after 10 years to 1.2 inches; and after 12 years to 0.7 inches. A projection of the regression indicates that at the period of maximum seasonal depletion the soil moisture savings will reach zero 16 years after cutting. This implies that timber cutting operations designed to reduce summer water loss become ineffective in 10 to 15 years.

For purposes of the study soil moisture depletion was measured at monthly intervals through the 1960 and 1961 summer depletion seasons and fall recharge periods. The rate of moisture loss was found to follow an exponential depletion pattern -- being greatest early in the season when moisture was readily available and decreasing as the summer progressed and moisture availability lessened.

Data indicated that the field capacity of the soil had an effect upon the rate of moisture loss. Moisture in soil with low field capacity

became limiting to plant use early in the season and the rate of water loss decreased. Active moisture loss in soils of higher field capacity continued for a longer period of time resulting in a greater quantity of moisture being lost during the summer depletion period.

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APPENDIX

Table 3. -- Soil moisture data by plot number, sampling point, and soil depth

(Data in parentheses are estimates [1])

PLOT L-1a; opening created 1959; 8/10/60
Av. soil moisture in forest, 7.5 inches; in opening, 13.0 inches [2]

Sampling point [3]	Soil moisture (Percent volume) at depth in inches of -- 6	18	30	42	Soil moisture (inches) Total[4]	Precip.[5]
1	13.0	14.5	14.5	(14.5)	6.8	-
2	16.5	15.5	12.5	(12.5)	6.8	-
3	15.0	13.0	17.0	19.0	7.7	-
4	26.5	27.5	29.5	(29.5)	13.6	-
5	26.5	27.0	28.0	25.5	12.9	-
6	30.5	31.0	31.0	(31.0)	14.8	-
7	24.5	27.5	29.0	24.5	12.7	-
8	28.0	27.5	27.0	(27.0)	13.2	-
9	12.0	14.0	14.5	(14.5)	6.6	-
10	10.0	11.5	11.5	(11.5)	5.3	-

PLOT L-1a; 9/9/60
Av. soil moisture in forest, 6.9; in opening, 12.6 inches[2]

1	12.0	13.5	13.5	(13.5)	6.3	-
2	15.5	13.0	11.5	(11.5)	(6.2)	-
3	13.0	12.5	15.5	16.0	6.8	-
4	26.5	26.5	25.5	(25.5)	12.5	-
5	28.0	27.0	27.5	26.0	13.0	.2
6	29.5	30.0	30.0	(30.0)	14.7	-
7	25.0	26.5	28.5	27.0	12.9	.4
8	24.0	25.5	25.0	(25.0)	11.9	-
9	12.5	13.0	14.0	(14.0)	6.4	-
10	10.0	11.0	11.0	(11.0)	5.2	-

PLOT L-1a; 10/7/60
Av. soil moisture in forest, 6.8 inches; in opening, 12.5 inches[2]

1	13.0	14.0	14.0	(14.0)	6.0	.3
2	32.5	13.5	12.0	(12.0)	8.4	2.2
3	25.0	13.5	15.5	15.5	8.4	1.6
4	33.5	29.5	29.5	(29.5)	14.6	2.1
5	34.0	30.5	29.5	29.0	14.8	2.0
6	32.5	30.5	30.5	(30.0)	14.8	.1
7	32.5	26.5	28.0	24.5	13.4	1.0
8	28.0	23.5	24.0	(24.0)	11.9	.5
9	31.0	13.5	13.5	(13.5)	8.9	2.7
10	12.0	11.5	11.5	(11.0)	5.6	.4

Footnotes located at end at table

Table 3. -- (Continued)

PLOT L-la; 11/9/60

Sampling point [3/]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture(inches) Total [4/]	Precip. [5/]
1	13.5	13.5	13.5	(13.5)	6.5	-
2	32.5	15.0	11.5	(11.5)	8.5	0.1
3	30.5	13.5	15.5	15.5	9.0	0.5
4	31.5	29.0	30.0	(30.0)	13.8	-
5	34.0	29.0	29.5	27.0	14.4	-
6	34.0	31.0	31.0	(31.0)	15.2	0.4
7	34.0	27.0	28.5	24.5	13.7	0.3
8	28.5	22.0	22.0	(22.0)	11.3	0.5
9	29.5	13.5	14.0	(14.0)	8.5	-
10	13.0	11.0	11.0	(11.0)	5.5	-

PLOT L-la; 5/25/61

Sampling point	6	18	30	42	Total	Precip.
[6/] 1	26.0	39.5	42.0			
[6/] 2	46.5	48.0	54.5			
[6/] 3	43.0	52.0	53.0	46.0		
[6/] 4	52.0	47.5	50.0			
[6/] 5	46.0	48.0	47.5	45.0		
[6/] 6	48.5	52.0				
[6/] 7	35.5	51.5	45.5			
[6/] 8	33.5	48.0	45.0			
[6/] 9	34.0	42.0	47.0			
10	22.5	24.0				

PLOT L-la; 6/22/61
Av. soil moisture in forest, 15.1 inches; in opening, 16.1 inches [2/]

Sampling point	6	18	30	42	Total	Precip.
1	19.0	29.0	30.5	(30.5)	13.1	-
2	34.0	36.5	42.5	(42.5)	18.7	-
3	29.5	38.5	39.5	31.5	16.7	-
4	34.0	35.0	34.0	(34.0)	16.4	-
5	28.5	34.5	34.5	31.5	15.5	-
6	39.0	35.0	35.0	(35.0)	17.3	-
7	27.5	35.0	33.0	32.0	15.3	-
8	28.0	34.0	32.5	(32.5)	15.3	-
9	23.5	29.5	32.5	(32.5)	14.2	-
10	19.0	21.0	21.0	(21.0)	9.8	-

Table 3. -- (Continued)

PLOT L-1a; 7/20/61
Av. soil moisture in forest, 10.0 inches; in opening, 13.8 inches [2/]

Sampling point [3/]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture (inches) Total [4/]	Precip. [5/]
1	12.0	18.5	19.5	(19.5)	8.3	-
2	19.5	22.0	25.5	(25.5)	11.1	-
3	17.0	28.0	30.5	27.0	12.3	-
4	21.5	31.0	31.5	(31.5)	13.9	-
5	24.5	29.5	31.0	28.5	13.6	-
6	23.5	34.0	34.0	(34.0)	15.1	-
7	20.0	30.0	30.0	26.0	12.7	-
8	24.0	31.0	28.5	(28.5)	13.5	-
9	13.5	18.0	20.0	(20.0)	8.6	-
10	11.0	15.0	15.5	(15.5)	6.8	-

PLOT L-la; 8/21/61
Av. soil moisture in forest, 7.8 inches; in opening, 12.9 inches [2/]

1	10.0	15.0	15.0	(15.0)	6.6	-
2	16.5	14.5	14.5	(14.5)	7.2	-
3	12.0	20.0	25.0	23.5	9.6	-
4	24.5	28.5	30.5	(30.5)	13.7	.3
5	26.5	29.5	29.5	28.0	13.6	.2
6	28.0	32.5	32.5	(32.5)	14.5	-
7	21.0	28.0	29.0	24.0	12.1	-
8	20.5	26.0	26.0	(26.0)	11.7	-
9	13.0	14.5	15.5	(15.5)	7.0	-
10	10.5	13.0	13.5	(13.5)	6.0	-

PLOT L-la; 10/2/61
Av. soil moisture in forest, 7.1 inches; in opening, 12.3 inches [2/]

1	10.0	13.5	14.0	(14.0)	6.2	-
2	15.5	18.0	15.0	(15.0)	7.6	.5
3	15.0	17.0	21.5	21.5	9.0	.4
4	21.5	27.5	29.0	(29.0)	12.9	-
5	21.5	27.0	29.5	27.5	12.7	-
6	23.5	30.0	30.0	(30.0)	13.6	-
7	21.0	28.0	28.5	24.0	12.1	-
8	11.0	22.0	24.0	(24.0)	9.7	-
9	27.5	30.0	13.5	(13.5)	6.6	.2
10	11.5	11.5	11.5	(11.5)	5.5	.1

Table 3. -- (Continued)

PLOT L-1b(R); opening created 1959; 8/9/60
Av. soil moisture in forest, 7.2 inches; in opening, 12.3 inches [2/]

Sampling point [3/]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture(inches) Total [4/]	Precip. [5/]
1	15.5	15.5	15.5	(15.5)	7.4	-
2	12.0	12.5	13.0	15.0	6.3	-
3	13.0	19.0	23.0	(23.0)	9.4	-
4	31.0	21.0	26.5	(26.5)	12.6	-
5	30.0	27.5	31.0	(31.0)	14.4	-
6	30.5	29.5	(29.5)	(29.5)	14.3	-
7	32.0	(32.0)	(32.0)	(32.0)	15.4	-
8	16.0	17.0	17.0	(17.0)	8.0	-
9	16.0	20.5	19.0	(19.0)	8.9	-
10	12.5	15.0	18.5	(18.5)	7.7	-
11	12.0	14.0	(14.0)	(14.0)	6.5	-
12	17.5	15.5	17.0	(17.0)	7.9	-

PLOT L-lb(R); 9/8/60
Av. soil moisture in forest, 6.7 inches; in opening, 11.9 inches [2/]

1	14.0	14.5	14.0	(14.0)	6.8	-
2	11.0	11.0	11.5	13.5	5.7	-
3	11.0	14.0	17.0	(17.0)	8.1	-
4	30.5	20.0	26.0	(26.0)	12.3	-
5	28.5	26.0	30.5	(30.5)	13.9	-
6	30.5	28.5	(28.5)	(28.5)	13.9	-
7	33.0	(32.0)	(32.0)	(32.0)	15.5	.1
8	17.5	16.5	16.0	(16.0)	7.9	.2
9	16.0	19.0	16.5	(16.5)	8.2	-
10	12.5	14.5	17.0	(17.0)	7.3	-
11	12.0	13.5	(14.0)	(14.0)	6.4	-
12	16.0	13.5	16.0	(16.0)	7.4	-

PLOT L-1b(R); 10/7/60
Av. soil moisture in forest, 6.5 inches; in opening, 11.7 inches [2/]

1	25.5	15.0	14.5	(14.0)	8.3	1.5
2	22.0	12.0	12.0	13.0	7.1	1.5
3	18.0	19.0	16.0	(16.0)	10.0	3.2
4	41.0	24.0	30.0	(30.0)	15.0	2.7
5	32.0	27.5	30.0	(30.0)	14.4	0.6
6	51.0	40.5	(28.5)	(28.5)	18.3	4.4
7	53.5	(45.5)	(32.0)	(32.0)	19.6	4.2
8	26.5	16.0	15.0	(15.0)	8.7	1.3
9	16.0	17.5	15.5	(15.5)	7.7	-
10	28.5	17.5	16.0	(16.0)	9.4	2.3
11	16.5	14 0	(14.0)	(14.0)	7.4	1.0
12	30.5_	19.5	16.0	(16.0)	9.8	2.4

Table 3. -- (Continued)

PLOT L-lb(R); 11/9/60

Sampling point [3]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture(inches) Total [4]	Precip. [5]
1	25.5	15.0	14.0	(14.0)	8.2	-
2	24.5	12.5	11.5	13.0	7.4	.3
3	22.0	21.0	15.5	(15.5)	8.2	.7
4	42.0	23.5	27.0	(27.0)	14.3	
5	33.5	27.5	31.0	(31.0)	14.8	.4
6	46.0	31.0	(31.0)	(31.0)	16.7	-
7	Standing water in tube.					
8	27.5	15.5	14.5	(14.5)	8.5	.1
9	16 5	17.0	15.0	(15.0)	7.6	-
10	28.5	17.5	16.0	(16.0)	9.4	-
11	16.5	14.0	(14.0)	(14.0)	7.0	-
12	30.5	19.5	16.0	(16.0)	9.8	-

PLOT L-lb(R); 5/25/61

[6] 1						
[6] 2						
[6] 3	25.5					
[6] 4						
[6] 5						
[6] 6	49.5	39.5				
[6] 7						
8	28.0	24.0	25.0			
9	17.5	26.5	27.0			
10	23.5	24.5	30.0			
11	25.5	34.5				
12	29.5	26.5	29.5			

PLOT L-lb(R); 6/22/61

Av. soil moisture in forest, 12.9 inches; in opening, 14.0 inches [2]

1	24.0	24.5	25.0	(25.0)	17.3	-
2	17.0	27.0	31.0	32.0	12.9	-
3	13.0	19.5	35.5	(35.5)	12.4	-
4	27.5	22.5	29.5	(33.0)	13.5	-
5	25.0	28.0	34.0	(34.0)	14.5	-
6	36.0	34.0	(34.0)	(34.0)	16.5	-
7	36.0	(34.0)	(34.0)	(34.0)	16.5	-
8	22.0	22.5	21.5	(21.5)	10.5	-
9	21.0	24.5	23.0	(23.0)	11.0	-
10	20.5	21.5	26.0	(26.0)	11.3	-
11	25.5	26.5	(26.5)	(26.5)	12.6	-
12	22.5	20.0	25.5	(25.5)	12.0	-

Table 3. -- (Continued)

PLOT L-lb(R); 7/20/61
Av. soil moisture in forest, 8.2 inches; in opening, 11.5 inches [2/]

Sampling point [3/]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture(inches) Total [4/]	Precip. [5/]
1	21.0	23.0	20.5	(20.5)	10.2	-
2	10.5	15.5	18.0	20.0	7.7	-
3	8.0	18.5	27.5	(27.5)	9.8	-
4	24.0	21.5	28.5	(30.0)	12.5	-
5	22.5	27.0	34.0	(34.0)	14.1	-
6	25.0	31.0	(31.0)	(31.0)	14.2	-
7	18.5	(24.0)	(24.0)	(24.0)	10.9	-
8	17.0	19.5	18.5	(18.5)	8.8	-
9	14.0	20.0	19.5	(19.5)	8.8	-
10	13.5	18.0	21.5	(21.5)	8.9	-
11	9.0	15.5	(15.5)	(15.5)	6.7	-
12	11.0	14.5	18 5	(18.5)	7.5	-

PLOT L-lb(R); 8/21/61
Av. soil moisture in forest, 6.8 inches; in opening, 10.6 inches [2/]

1	17.0	22.0	18.5	(18.5)	9.1	-
2	9.5	12.0	14.0	14.5	6.0	-
3	6.5	13.0	18.5	(18.5)	6.8	-
4	24.5	21.0	27.0	(28.5)	12.1	-
5	25.0	25.5	32.0	(32.0)	13.7	.3
6	29.0	30.5	(30.5)	(30.5)	14.5	.5
7	31.5	(22.0)	(22.0)	(22.0)	11.7	1.5
8	11.5	16.5	16.0	(16.0)	7.2	-
9	14.0	16.5	17.0	(17.0)	7.7	-
10	11.5	16.0	19.0	(19.0)	7.8	-
ll	9.0	13.5	(13.5)	(13.5)	5.9	-
12	11.0	13.5	16.5	(16.5)	6.9	-

PLOT L-lb(R); l0/2/61
Av. soil moisture in forest, 6.6 inches; in opening, 10.4 inches [2/]

1	21.5	24.0	18.5	(18.5)	9.9	.8
2	11.5	11.0	13.0	13.0	5.8	.2
3	8.0	13.5	17.0	(17.0)	6.7	.3
4	28.5	21.5	28.0	(30.0)	12.5	.4
5	28.5	25.5	32.0	(32.0)	14.2	.8
6	31.0	31.0	(31.0)	(31.0)	14.9	.9
7	36.0	(24.0)	(24.0)	(24.0)	11.0	.8
8	13.0	14.5	14.5	(14.5)	6.8	.2
9	11.0	15.5	15.0	(15.0)	6.8	-
10	16.0	16.0	17.0	(17.0)	7.9	.5
11	9.0	13.5	(13.5)	(13.5)	5.9	-
12	12.0	12.5	15.5	(15.5)	6.7	.2

Table 3 -- (Continued)

PLOT L-1b(T); opening created 1959; 8/9/60
Av. soil moisture in forest, 7.3 inches; in opening, 9.3 inches [2/]

Sampling point [3/]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture (inches) Total [4/]	Precip. [5/]
1	13.0	14.0	16.0	(16.0)	7.1	-
2	19.0	20.0	22.0	(22.0)	10.0	-
3	14.0	16.5	(16.5)	(16.5)	7.6	-
4	24.0	19.5	19.0	(19.0)	9.9	-
5	24.0	23.0	22.0	(22.0)	10.9	-
6	22.5	19.0	21.5	(21.5)	10.7	-
7	16.0	17.0	17.0	(17.0)	8.0	-
8	15.5	15.5	16.5	(16.5)	7.7	-
9	12.5	13.5	13.5	13.5	6.3	-
10	10.0	12.5	13.0	13.0	5.8	-
11	9.5	11.5	12.5	13.0	5.6	-

PLOT L-1b(T); 9/8/60
Av. soil moisture in forest, 6.8 inches; in opening, 8.8 inches [2/]

1	12.0	13.0	15.0	(15.0)	6.6	-
2	17.0	18.0	19.0	(19.0)	8.7	-
3	15.0	16.0	(16.0)	(16.0)	7.6	.2
4	22.5	18.5	17.0	(17.0)	9.0	-
5	24.0	22.5	21.5	(21.5)	10.7	-
6	22.0	19.0	21.5	(21.5)	10.1	-
7	17.5	16.5	16.0	(16.0)	7.9	.2
8	14.0	14.5	15.5	(15.5)	7.1	-
9	12.5	13.5	14.0	13.0	6.3	-
10	11.0	12.0	13.0	13.0	5.9	.1
11	10.0	11.5	12.5	12.5	5.6	.1

PLOT L-1b(T); 10/7/60
Av. soil moisture in forest, 6.7 inches; in opening, 8.8 inches [2/]

1	16.0	13.5	16.0	(16.0)	7.4	.8
2	31.0	18.5	19.0	(19.0)	10.5	1.8
3	31.5	28.0	(20.0)	(16.0)	11.8	4.4
4	22.5	18.0	17.0	(17.0)	8.9	-
5	29.0	25.0	24.0	(22.5)	12.0	1.3
6	34.0	23.0	24.5	(23.0)	12.5	2.4
7	26.5	16.0	15.0	(15.0)	8.7	1.2
8	26.0	15.5	15.5	(15.5)	8.8	1.6
9	22.5	22.5	13.5	14.5	8.7	2.4
10	20.5	27.5	24.0	15.5	10.5	4.7
11	22.0	13.0	12.5	12.5	7.2	1.7

Table 3 -- (Continued)

PLOT L-1b(T); 11/9/60

Sampling point [3]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture (inches) Total [4]	Precip. [5]
1	19.0	14.0	15.5	(15.0)	7.6	.2
2	30.0	22.0	19.5	(19.5)	10.9	.4
3	34.0	28.5	(20.0)	(20.0)	12.3	.5
4	23.0	17.0	16.5	(16.5)	8.8	.1
5	31.0	24.5	23.5	(23.0)	12.2	.2
6	32.0	22.0	24.5	(23.0)	12.2	-
7	27.5	15.5	14.5	(14.5)	8.6	.1
8	24.5	19.5	19.5	(18.0)	9.8	1.3
9	25.0	22.0	14.0	13.5	8.9	.4
10	23.0	26.5	23.0	15.0	10.5	.3
11	23.0	13.5	12.5	12.5	7.4	.2

PLOT L-1b(T); 5/25/61

[6]

Sampling point	6	18	30	42	Total	Precip.
[6] 1	26.0	29.0	38.5			
[6] 2	41.0		45.5			
[6] 3	36.5	33.5				
4	32.5	25.0	28.5			
5	32.5	27.5				
6	29.5	24.0	28.5			
7	28.0	24.0	25.0			
8	24.5	29.5	31.0			
9	22.0	27.0	29.0	28.0		
[6] 10	31.5	32.0	30.0			
[6] 11	28.0	23.5	35.0	36.5		

PLOT L-1b(T); 6/22/61

Av. soil moisture in forest, 11.4 inches; in opening, 11.5 inches [2]

Sampling point	6	18	30	42	Total	Precip.
1	19.0	24.0	27.5	(27.5)	11.8	-
2	16.5	29.5	31.0	(31.0)	13.0	-
3	24.5	24.0	(24.0)	(24.0)	11.6	-
4	26.0	22.5	24.5	(24.5)	12.9	-
5	24.0	24.0	24.0	(24.0)	11.5	-
6	25.0	22.0	24.0	(24.0)	11.4	-
7	22.0	22.5	21.5	(21.5)	10.5	-
8	20.5	25.5	26.5	(26.5)	11.9	-
9	20.0	21.5	24.0	21.5	10.4	-
10	27.5	20.5	21.0	22.0	10.9	-
11	17.5	18.0	21.5	22.0	9.5	-

Table 3 -- (Continued)

PLOT L-1b(T); 7/2o/61 2/
Av. soil moisture in forest, 8.4 inches; in opening, 9.4 inches [2/]

Sampling point [3/]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture (inches) Total [4/]	Precip. [5/]
1	12.0	15.5	18.5	(18.5)	7.7	-
2	17.0	23.5	25.0	(25.0)	10.9	-
3	11.5	20.0	(20.0)	(20.0)	8.6	-
4	15.0	20.5	21.0	(21.0)	9.3	-
5	14.5	23.5	23.5	(23.5)	10.2	-
6	16.5	19.5	22.5	(22.5)	9.7	-
7	17.0	19.5	18.5	(18.5)	8.8	-
8	15.5	19.5	19.5	(19.5)	8.9	-
9	12.0	17.0	16.0	20.0	7.8	-
10	11.5	17.0	16.5	16.5	7.4	-
11	8.5	14.o	16.5	15.5	6.5	-

PLOT L-1b(T); 8/21/62
Av. soil moisture in forest, 7.4 inches; in opening, 8.3 inches [2/]

1	13.5	14.0	16.0	(16.0)	7.2	.3
2	12.5	18.0	21.0	(21.0)	8.7	-
3	12.0	17.5	(17.5)	(17.5)	7.7	-
4	18.0	17.5	17.5	(17.5)	8.4	.3
5	21.0	23.5	23.5	(23.5)	11.0	.8
6	20.0	19.0	19.0	(19.0)	9.2	.4
7	11.5	16.5	16.0	(16.0)	7.2	-
8	13.5	15.5	15.5	(15.5)	7.2	-
9	12.0	14.0	15.5	17.5	7.1	-
10	13.5	15.5	14.5	14.5	7.0	.3
11	8.5	17.0	20.0	13.5	7.1	-

PLOT L-1b(T); l0/2/61
Av. soil moisture in forest, 7.2 inches; in opening, 8.2 inches [2/]

1	10.5	12.5	16.5	(16.5)	6.7	.1
2	16.0	18.0	20.5	(20.5)	9.0	.4
3	17.5	20.5	(20.5)	(20.5)	9.4	1.7
4	15.5	15.5	16.0	(16.0)	7.6	.1
5	11.5	24.0	23.5	(23.5)	10.0	-
6	22.5	20.5	20.5	(20.5)	10.1	1.3
7	13.0	14.5	14.5	(14.5)	6.8	.2
8	14.0	15.0	15.0	(15.0)	7.1	.1
9	9.0	16.0	12.0	15.0	6.1	.1
10	13.0	19.0	17.0	(17.0)	7.9	1.2
11	12.0	12.5	13.5	12.5	6.0	.4

Table 3 -- (Continued)

Sampling point [3]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture (inches) Total [4]	Precip. [5]
PLOT L-2a; opening created 1955; 9/9/60						
Av. soil moisture in forest, 8.2 inches; in opening, 12.3 inches [2]						
[7] 1	21.0	23.5	30.5	22.0	11.6	-
2	19.0	18.0	18.0	18.5	8.8	-
3	17.5	16.0	16.0	13.5	7.6	-
4	18.0	17.5	18.5	23.5	9.3	-
5	16.0	18.0	18.5	(18.5)	8.5	-
6	21.0	34.5	32.0	(32.0)	14.4	-
7	22.5	28.5	34.0	36.0	14.5	-
PLOT L-2a; 10/12/60						
Av. soil moisture in forest, 8.2 inches; in opening 12.2 inches [2]						
[7] l	30.5	24.5	32.5	24.0	13.4	1.8
2	38.5	35.0	30.0	19.5	14.8	6.0
3	35.5	30.0	21.5	14.0	12.2	4.6
4	39.0	26.0	19.0	22.0	12.7	3.6
5	34.0	29.0	21.0	(21.0)	12.6	4.1
6	28.0	35.0	33.0	(32.5)	15.4	1.0
7	30.0	30.0	34.0	36.0	15.6	1.1
PLOT L-2a; 6/l9/61						
Av. soil moisture in forest, 15.7 inches; in opening, 18.2 inches [2]						
[7] 1	38.0	45.5	45.5	42.0	20.5	-
2	28.5	36.0	36.0	40.5	16.9	-
3	37.0	31.5	26.5	26.0	14.5	-
4	36.5	36.0	38.0	36.0	17.6	-
5	33.0	35.0	34.0	(34.0)	16.3	-
6	35.5	44.5	40.0	(40.0)	19.2	-
7	34.0	4o.5	44.0	43.0	19.4	-
PLOT L-2a; 7/13/61						
Av. soil moisture in forest, 12.2 inches; in opening, 15.5 inches [2]						
[7] 1	30.0	34.0	40.0	36.0	16.8	-
2	20.0	26.5	27.5	28.5	12.3	-
3	28.5	27.5	25.0	21.0	12.2	-
4	28.0	30.0	36.0	32.5	15.2	-
5	27.5	30.0	30.5	(30.5)	14.2	-
6	21.0	36.5	39.0	(39.0)	16.2	-
7	24.5	33.5	39.0	39.0	16.3	-

Table 3 -- (Continued)

PLOT L-2a; 8/l0/61
Av. soil moisture in forest, 9.7 inches; in opening, 13.0 inches [2/]

Sampling point [3/]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture (inches) Total [4/]	Precip. [5/]
[7/] 1	22.5	28.0	35.5	28.0	13.7	-
2	18.5	21.0	21.5	21.0	9.8	-
3	23.0	20.5	18.0	18.5	9.6	-
4	19.5	24.0	29.0	30.0	12.3	-
5	19.5	23.5	24.0	(24.0)	11.0	-
6	17.0	33.0	35.0	(35.0)	14.4	-
7	16.5	28.5	37.0	37.0	13.7	-

PLOT L-2a; 10/2/61
Av. soil moisture in forest, 8.8 inches; in opening, 11.7 inches [2/]

[7/] 1	23.0	25.0	32.0	23.0	12.4	-
2	18.0	21.0	19.5	18.5	9.2	-
3	23.0	17.5	15.5	14.5	8.3	-
4	17.5	18.5	20.5	21.5	9.4	-
5	21.0	20.0	18.0	(18.0)	9.2	.1
6	18.0	26.0	33.0	(33.0)	13.2	.1
7	17.5	27.5	34.0	35.0	13.7	.1

PLOT L-2b; opening created 1955; 9/12/60
Av. soil moisture in forest, 9.6 inches; in opening, 12.1 inches [2/]

1	24.0	20.5	28.5	(28.5)	12.2	.6
2	17.0	15.5	20.5	(20.5)	8.8	.2
3	25.0	20.5	20.5	(20.5)	l0.4	.6
4	19.0	23.5	20.5	20.5	10.0	-
5	29.5	29.5	21.5	24.0	12.5	-
6	20.5	24.0	26.0	37.5	13.0	-
7	16.5	23.5	27.5	32.0	12.0	-

PLOT L-2b; l0/12/60
Av. soil moisture in forest, 9.6 inches; in opening, 12.0 inches [2/]

1	31.5	20.5	29.0	(29.0)	13.2	1.6
2	28.5	16.5	20.5	(20.5)	10.3	1.7
3	22.5	20.5	22.0	(21.0)	10.3	.5
4	26.0	32.0	21.5	20.5	12.0	2.0
5	30.0	33.0	23.0	24.0	13.2	.7
6	29.5	25.5	26.5	39.0	14.4	1.4
7	26.0	25.0	27.O	32.5	13.2	1.3

Table 3 -- (Continued)

PLOT L-2b; 6/19/61

Av. soil moisture in forest, --; in opening, 16.9 inches [2/]

Sampling point [3/]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture (inches) Total [4/]	Precip. [5/]
[6/] 1						
[6/] 2	48.0					
3	30.0	34.0	40.0	(40.0)	17.3	-
4	31.0	41.0	44.5	44.5	19.3	-
5	33.0	34.5	24.0	35.5	15.2	-
6	32.0	34.0	34.0	45.5	17.4	-
7	26.5	31.5	33.5	44.5	16.3	-

PLOT L-2b; 7/13/61

Av. soil moisture in forest, 15.6 inches; in opening, 15.0 inches [2/]

1	30.5	29.0	37.5	(37.5)	16.1	-
2	26.5	29.5	37.0	(37.0)	15.6	-
3	28.0	29.5	35.0	(35.0)	15.3	-
4	29.5	40.5	40.5	40.5	18.2	-
5	29.0	34.0	23.5	29.5	13.9	-
6	24.5	30.5	31.0	43.5	15.6	-
7	14.0	28.0	31.0	37.5	13.3	-

PLOT L-2b; 8/l0/61

Av. soil moisture in forest, 13.8 inches; in opening, 13.7 inches [2/]

1	23.5	21.5	33.5	(33.5)	13.4	-
2	21.5	25.5	33.5	(33.5)	13.7	-
3	25.5	29.0	33.0	(33.0)	14.5	-
4	27.5	37.0	40.5	38.0	17.2	-
5	26.5	30.0	21.5	31.5	13.5	-
6	18.0	26.5	30.0	42.5	14.0	-
7	11.0	21.5	28.0	34.5	11.4	-

PMT L-2b; 10/2/61

Av. soil moisture in forest, 11.4 inches; in opening, 12.6 inches [2/]

1	17.0	18.5	27.5	(27.5)	10.9	-
2	19.5	18.5	24.0	(24.0)	10.3	-
3	25.0	28.0	32.0	(32.0)	14.1	-
4	28.5	35.5	36.5	37.5	16.6	.1
5	27.5	29.5	22.5	24.5	12.5	.1
6	17.5	21.0	26.5	39.0	12.5	-
7	12.0	20.0	25.0	30.0	10.4	.1

Table 3 -- (Continued)

PLOT L-3a; opening created 1950; 8/30/60
Av. soil moisture in forest, 7.8 inches; in opening, 9.1 inches [2/]

Sampling point [3/]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture (inches) Total [4/]	Precip. [5/]
1	15.0	15.0	17.0	(17.0)	7.4	-
2	16.0	17.0	18.0	16.0	8.1	-
3	13.0	14.0	17.0	(17.0)	7.3	-
4	13.0	16.0	19.5	(19.5)	8.2	-
5	13.5	16.0	19.5	19.5	8.2	-
6	13.5	15.5	23.5	28.0	9.6	-
7	16.0	17.5	25.0	(25.0)	10.0	-

PLOT L-3a; 9/30/60
Av. soil moisture in forest, 7.5 inches; in opening, 8.8 inches [2/]

1	15.0	15.0	16.5	(16.5)	7.6	-
2	16.0	16.5	17.0	15.0	7.7	-
3	13.0	14.5	16.5	(16.5)	7.7	.1
4	13.0	15.5	17.5	(17.5)	7.5	-
5	13.5	15.5	18.0	18.0	7.8	-
6	13.5	16.0	24.0	25.0	9.4	.1
7	17.0	17.0	22.0	(22.0)	9.4	-

PLOT L-3a; 11/8/60
Av. soil moisture in forest, 7.5 inches; in opening, 8.8 inches [2/]

1	26.5	15.0	16.0	(l6.0)	8.8	1.4
2	30.0	21.0	16.5	15.0	9.9	2.2
3	24.0	14.5	16.0	(16.0)	8.5	1.4
4	24.0	17.0	17.5	(17.5)	8.0	1.3
5	26.5	16.0	18.0	18.0	9.4	1.6
6	29.0	20.5	24.0	25.0	11.9	2.6
7	34.5	20.5	22.0	(22.0)	11.9	2.5

PLOT L-3a; 6/5/61
Av. soil moisture in forest, 14.7 inches; in opening, 14.8 inches [2/]

1	27.5	33.0	32.0	(32.0)	14.9	-
2	29.5	33.0	31.0	30.5	14.9	-
3	22.5	28.0	33.5	(33.5)	14.1	-
4	24.0	30.5	33.0	(33.0)	14.5	-
5	25.5	31.0	33.0	32.5	14.6	-
6	26.5	28.5	33.0	33.0	14.5	-
7	31.5	32.5	32.0	(32.0)	15.4	-

Table 3 -- (Continued)

PLOT L-3a; 7/5/61
Av. soil moisture in forest, 10.4 inches; in opening, 11.0 inches [2]

Sampling point [3]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture (inches) Total [4]	Precip. [5]
1	15.5	21.0	22.5	(22.5)	10.7	-
2	18.5	22.5	25.0	24.0	10.8	-
3	11.5	19.5	23.0	(23.0)	9.3	-
4	17.0	24.0	25.5	(25.5)	11.1	-
5	16.0	23.5	26.5	27.5	11.2	-
6	16.0	12.5	29.5	30.0	10.6	-
7	21.0	24.0	26.5	(26.5)	11.8	-

PLOT L-3a; 7/27/61
Av. soil moisture in forest, 7.9 inches; in opening, 9.2 inches [2]

1	11.5	16.5	18.0	(18.0)	7.7	-
2	13.0	17.5	20.0	18.5	8.3	-
3	9.5	15.5	18.5	(18.5)	7.4	-
4	12.5	19.5	21.5	(21.5)	9.0	-
5	14.5	18.0	21.5	23.0	9.3	-
6	11.0	17.0	25.5	25.5	9.5	-
7	14.0	19.5	22.0	(22.0)	9.3	-

PLOT L-3a; 9/5/61
Av. soil moisture in forest, 7.4 inches; in opening, 8.6 inches [2]

1	12.5	15.0	16.5	(16.5)	7.2	.1
2	18.5	19.5	17.0	15.5	8.4	.8
3	10.5	15.5	17.0	(17.0)	7.2	.1
4	12.0	18.5	19.0	(19.0)	8.2	-
5	13.5	16.5	18.0	19.0	8.1	-
6	15.0	16.0	23.5	23.5	9.4	.5
7	18.0	18.0	20.0	(20.0)	9.1	.5

PLOT L-3b; opening created 1950; 8/31/60
Av. soil moisture in forest, 7.1 inches; in opening, 7.2 inches [2]

1	12.0	15.0	16.5	(16.5)	7.2	-
2	11.0	14.0	17.5	(17.5)	7.2	-
3	11.0	14.5	16.0	(16.0)	6.9	-
[8] 4						
5	13.5	17.5	23.0	(23.0)	9.2	-
6	13.0	14.5	12.5	14.0	6.5	-
7	10.5	13.5	15.5	(15.5)	6.6	-

Table 3 -- (Continued)

PLOT L-3b; 9/30/60
Av. soil moisture in forest, 7.0 inches; in opening, 7.1 inches [2/]

Sampling point [3/]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture (inches) Total [4/]	Precip. [5/]
1	12.5	14.5	16.0	(16.0)	7.1	.1
2	11.0	14.5	17.5	(17.5)	7.3	.1
3	10.5	14.0	16.0	(16.0)	6.8	-
[8/] 4						
5	13.0	18.0	22.0	(22.0)	9.0	.1
6	13.5	14.0	13.0	14.0	6.5	.1
7	11.0	13.5	15.0	(15.0)	6.5	-

PLOT L-3b; 11/8/60
Av. soil moisture in forest, 7.0 inches; in opening, 7.1 inches [2/]

1	26.0	22.5	16.5	(16.5)	9.8	2.8
2	25.0	20.0	17.5	(17.5)	9.6	2.4
3	25.0	14.5	16.0	(16.0)	8.6	1.8
[8/] 4						
5	37.0	21.5	22.5	(22.5)	12.5	3.6
6	31.0	13.5	12.5	14.0	8.5	2.1
7	24.5	14.0	15.0	(15.0)	8.2	1.7

PLOT L-3b; 6/5/61
Av. soil moisture in forest, 12.9 inches; in opening, 14.4 inches [2/]

1	29.0	27.0	26.0	(26.0)	13.0	-
2	22.5	27.5	27.5	(27.5)	12.6	-
3	25.0	26.5	29.0	(29.0)	13.2	-
[8/] 4						
5	30.0	29.0	27.0	(27.0)	13.6	-
6	32.5	40.5	33.5	25.0	15.8	-
7	25.5	30.5	29.5	(29.5)	13.8	-

PLOT L-3b; 7/5/61
Av. soil moisture in forest, 8.5 inches; in opening, 10.0 inches [2/]

1	15.0	17.5	19.5	(19.5)	8.6	-
2	12.0	18.5	20.5	(20.5)	8.6	-
3	11.5	16.5	19.5	(19.5)	8.0	-
[8/] 4						
5	19.5	25.5	24.5	(24.5)	11.3	-
6	18.0	22.0	20.0	20.0	9.6	-
7	17.0	22.5	23.5	(23.5)	10.4	-

Table 3 -- (Continued)

PLOT L-3b; 7/27/61
Av. soil moisture in forest, 7.7 inches; in opening, 8.2 inches [2/]

Sampling point [3/]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture (inches) Total [4/]	Precip. [5/]
1	11.5	16.5	17.5	(17.5)	7.5	-
2	11.0	16.0	19.5	(19.5)	7.9	-
3	13.5	16.0	17.5	(17.5)	7.7	.2
[8/] 4						
5	13.0	21.5	23.5	(23.5)	9.8	-
6	13.0	16.5	14.5	16.0	7.2	-
7	12.5	18.5	20.5	(20.5)	8.6	-

PLOT L-3b; 9/5/61
Av. soil moisture in forest, 7.3 inches; in opening, 7.4 inches [2/]

1	14.5	20.0	16.5	(16.5)	8.1	.8
2	11.0	15.5	18.0	(18.0)	7.5	-
3	9.5	14.5	16.5	(16.5)	6.8	-
[8/] 4						
5	17.0	20.0	22.0	(22.0)	9.7	.5
6	16.5	13.5	14.5	15.0	7.1	.4
7	13.5	15.0	17.0	(17.0)	7.5	.1

PLOT L-3c; opening created 1950; 8/31/60
Av. soil moisture in forest, 6.9 inches; in opening, 8.4 inches [2/]

1	12.0	13.0	14.0	17.0	6.7	-
2	15.5	14.0	14.0	(14.0)	6.9	-
3	13.0	13.5	16.0	(16.0)	7.0	-
4	12.0	15.5	19.5	(19.5)	8.0	-
5	13.5	16.5	20.5	(20.5)	8.5	-
6	16.0	17.5	24.0	(24.0)	9.8	-
7	13.0	13.0	15.5	(15.5)	6.8	-

PLOT L-3c; 9/30/60
Av. soil moisture in forest, 6.5 inches; in opening, 7.6 inches [2/]

1	12.0	12.0	12.5	15.5	6.2	-
2	15.0	13.0	13.0	(13.0)	6.5	-
3	12.5	13.0	15.0	(15.0)	6.7	-
4	11.0	14.0	17.5	(17.5)	7.2	-
5	13.0	15.0	17.5	(17.5)	7.6	-
6	16.0	15.5	21.0	(21.0)	8.8	-
7	13.0	12.5	13.5	(13.5)	6.3	-

Table 3 -- (Continued)

PLOT L-3c; 11/8/60
Av. soil moisture in forest, 6.4 inches; in opening, 7.6 inches [2]

Sampling point [3]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture(inches) Total [4]	Precip. [5]
1	22.5	13.0	12.5	15.5	7.6	1.4
2	25.0	12.5	13.0	(13.0)	7.8	1.4
3	27.5	20.0	14.0	(14.0)	9.2	2.8
4	27.0	13.5	17.0	(17.0)	8.9	1.9
5	28.0	14.5	17.0	(17 0)	9.2	1.8
6	31.5	21.5	21.5	(21.5)	11.5	2.7
7	32.5	14.0	13.5	(13.5)	8.8	2.5

PLOT L-3c; 6/5/61
Av. soil moisture in forest, 16.4 inches; in opening, 16.5 inches [2]

1	27.0	34.0	37.0	39.5	16.5	-
2	31.0	36.5	33.5	(33.5)	16.1	-
3	28.5	36.5	37.0	(37.0)	16.7	-
4	30.5	37.0	40.0	(40.0)	18.1	-
5	29.5	35.5	39.5	(39.5)	17.3	-
6	33.0	33.5	35.0	(35.0)	16.4	-
7	32.0	28.5	34.0	(34.0)	15.4	-

PLOT L-3c; 7/6/61
Av. soil moisture in forest, 10.4 inches; in opening, 12.6 inches [2]

1	13.5	23.5	26.5	28.0	11.0	-
2	15.0	21.0	23.0	(23.0)	9.8	-
3	15.0	23.5	27.0	(27.0)	11.1	-
4	19.5	27.0	28.5	(28.5)	12.5	-
5	17.0	28.5	30.0	(30.0)	12.7	-
6	17.0	25.5	29.0	(29.0)	12.1	-
7	20.5	22.5	25.0	(25.0)	11.1	-

PLOT L-3c; 7/27/61
Av. soil moisture in forest, 7.6 inches; in opening, 10.1 inches [2]

1	12.5	13.5	18.0	18.0	7.4	-
2	12.5	13.5	24.5	(24.5)	7.4	-
3	12.0	16.0	19.5	(19.5)	8.0	-
4	15.0	19.0	23.5	(23.5)	9.7	-
5	14.0	21.0	25.5	(25.5)	10.3	-
6	16.5	25.5	29.0	(29.0)	l0.8	-
7	14.5	20.0	24.5	(24.5)	10.0	-

Table 3 -- (Continued)

PLOT L-3c; 9/5/61
Av. soil moisture in forest, 6.2 inches; in opening, 7.4 inches [2/]

Sampling point [3/]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture (inches) Total [4/]	Precip. [5/]
1	10.0	12.0	13.0	15.5	6.0	-
2	12.5	13.5	14.0	(14.0)	6.5	-
3	9.0	12.5	14.0	(14.0)	6.0	-
4	11.5	14.5	17.0	(17.0)	7.2	-
5	12.0	15.0	18.0	(18.0)	7.6	-
6	15.0	16.5	18.5	(18.5)	8.2	-
7	13.5	14.0	13.5	(13.5)	6.5	-

PLOT L-4a; opening created 1948; 8/31/60
Av. soil moisture in forest, 6.6 inches; in opening, 6.5 inches [2/]

Sampling point	6	18	30	42	Total	Precip.
1	9.5	12.5	13.5	(13.5)	5.9	-
2	12.5	14.0	14.5	(14.5)	6.7	-
3	14.0	14.5	14.5	(14.5)	6.9	-
4	12.5	12.5	14.0	(14.0)	6.4	-
5	10.5	13.0	13.5	13.5	6.1	-
6	15.0	14.5	15.5	(15.5)	7.2	-

PLOT L-4a; 9/30/60
Av. soil moisture in forest, 6.2 inches; in opening, 6.4 inches [2/]

Sampling point	6	18	30	42	Total	Precip.
1	9.0	12.0	13.0	(13.0)	5.6	-
2	12.0	13.5	14.5	(14.5)	6.5	-
3	13.0	13.5	13.5	(13.5)	6.4	-
4	12.5	12.5	13.0	(13.0)	6.1	-
5	10.5	13.5	13.0	13.0	6.0	.1
6	15.0	14.0	15.5	(15.5)	7.2	-

PLOT L-4a; 11/8/60
Av. soil moisture in forest, 6.2 inches; in opening, 6.4 inches [2/]

Sampling point	6	18	30	42	Total	Precip.
1	14.0	16.0	12.5	(12.5)	6.6	1.1
2	19.5	13.5	14.0	(14.0)	7.3	.9
3	28.0	14.5	13.5	(13.5)	8.3	1.9
4	27.0	12.5	13.5	(13.5)	8.0	1.9
5	23.0	13.5	13.0	13.0	7.5	1.6
6	31.5	14.0	15.5	(15.5)	9.2	2.0

Table 3 -- (Continued)

PLOT L-4a; 6/5/61

Av. soil moisture in forest, 12.6 inches; in opening, 15.2 inches [2]

Sampling point [3]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture (inches) Total [4]	Precip. [5]
1	20.0	29.5	32.5	(32.5)	11.3	-
2	18.5	28.5	28.0	(28.0)	12.4	-
3	29.0	31.0	30.0	(30.0)	14.4	-
4	28.5	29.0	33.0	(33.0)	14.8	-
5	28.0	35.0	33.5	38.0	16.1	-
6	38.0	28.5	27.5	(27.5)	14.6	-

PLOT L-4a; 7/6/61

Av. soil moisture in forest, 10.5 inches; in opening, -- [2]

1	22.0	23.5	27.0	(27.0)	11.9	-
2	19.0	22.0	22.0	(22.0)	11.2	-
3	8.5	19.5	18.5	(18.5)	7.8	-
4	14.0	23.0	23.0	(23.0)	10.0	-
[9] 5	17.5	25.0	25.5	30.0	11.8	-
6						

PLOT L-4a; 7/27/61

Av. soil moisture in forest, 7.3 inches; in opening, 8.3 inches [2]

1	10.5	17.0	16.0	(16.0)	7.2	-
2	12.5	15.5	16.5	(16.5)	7.3	-
3	15.0	16.0	15.5	(15.5)	7.4	-
4	12.0	17.0	18.5	(18.5)	7.9	-
5	12.5	18.5	20.0	19.5	8.4	-
6	16.0	20.5	20.5	(20.5)	9.3	-

PLOT L-4a; 9/5/61

Av. soil moisture in forest, 6.2 inches; in opening, 6.3 inches [2]

1	8.5	13.5	13.5	(13.5)	5.9	-
2	11.0	13.0	14.5	(14.5)	6.3	-
3	10.5	13.5	14.0	(14.0)	6.2	-
4	9.0	13.0	14.0	(14.0)	6.0	-
5	11.0	13.5	12.5	14.0	6.1	-
6	12.5	14.5	16.0	(16.0)	7.1	-

Table 3 -- (Continued)

PLOT L-5a; opening created 1949; 8/10/60
Av. soil moisture in forest, 7.6 inches; in opening, 9.3 inches [2/]

Sampling point [3/]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture (inches) Total [4/]	Precip. [5/]
1	12.0	12.5	13.5	16.0	6.5	-
2	19.5	15.0	15.0	24.0	8.8	-
[10/] 3	16.0	20.0	28.0	30.0	11.3	-
[11/] 4	12.5	23.5	32.0	29.5	11.7	-
5	12.5	17.0	19.5	28.5	9.3	-
6	11.0	16.5	25.0	(25.0)	9.4	-
7	12.0	18.5	20.0	23.0	8.9	-

PLOT L-5a; 8/30/60
Av. soil moisture in forest, 6.3 inches; in opening, 7.6 inches [2/]

1	10.0	10.5	11.5	14.5	5.6	-
2	16.0	12.0	11.0	19.5	7.0	-
[10/] 3	13.0	17.5	25.0	27.0	9.9	-
[11/] 4	11.0	21.5	30.0	29.0	11.0	-
5	10.5	13.0	16.5	27.5	8.1	-
6	10.0	13.0	22.5	(22.5)	8.2	-
7	10.5	10.5	14.5	19.0	6.5	-

PLOT L-5a; 9/12/60
Av. soil moisture in forest, 6.0 inches; in opening, 7.4 inches [2/]

1	9.0	10.5	11.5	14.5	5.5	-
2	14.0	11.5	11.0	18.5	6.6	-
[10/] 3	13.0	16.0	24.5	26.5	9.6	-
[11/] 4	12.0	21.5	28.0	30.0	11.0	.1
5	11.0	12.5	16.5	27.5	8.1	.1
6	11.0	13.0	23.0	(22.5)	8.3	.1
7	11.0	13.0	14.0	17.0	6.6	.4

PLOT L-5a; 10/17/60
Av. soil moisture in forest, 6.0 inches; in opening, 7.1 inches [2/]

1	10.5	10.5	11.5	14.5	5.7	.2
2	18.0	12.0	11.0	16.5	6.9	.5
[10/] 3	22.0	15.5	24.5	25.5	10.5	1.1
[11/] 4	19.0	22.5	28.5	29.0	11.9	1.2
5	19.5	13.0	16.0	26.0	8.9	1.1
6	24.0	13.5	21.5	(21.5)	9.6	1.7
7	22.0	13.0	13.0	14.5	7.5	1.7

Table 3 -- (Continued)

PLOT L-5a; 6/7/61

Av. soil moisture in forest, 19.4 inches; in opening, 20.4 inches [2]

Sampling point [3]	Soil moisture (percent volume) at depth in inches of 6	18	30	42	Soil moisture (inches) Total [4]	Precip. [5]
1	24.5	35.0	50.5	52.5	19.4	-
[11] 2	36.5	45.0	56.0	43.0	21.6	-
[10] 3	52.5	49.0	47.0	47.0	23.5	-
[11] 4	34.5	54.0	59.5	56.5	24.5	-
5	32.5	47.5	60.0	40.0	20.4	-
6	36.5	43.5	46.5	(46.5)	20.8	-
7	41.0	38.0	41.5	44.5	19.8	-

PLOT L-5a; 7/7/61

Av. soil moisture in forest, 13.2 inches; in opening, 13.6 inches [2]

Sampling point [3]	6	18	30	42	Total [4]	Precip. [5]
1	17.0	26.0	32.0	34.0	13.2	-
[11] 2	30.5	34.0	36.5	34.5	16.3	-
[10] 3	31.0	36.0	37.0	39.0	17.2	-
[11] 4	24.0	38.5	44.0	44.0	18.0	-
5	21.5	34.0	29.0	32.0	14.0	-
6	23.5	26.0	32.0	(32.0)	13.5	-
7	23.5	29.0	28.5	35.0	13.9	-

PLOT L-5a; 8/2/61

Av. soil moisture in forest, 9.1 inches; in opening, 9.5 inches [2]

Sampling point [3]	6	18	30	42	Total [4]	Precip. [5]
1	11.5	15.5	24.0	20.0	8.5	-
2	21.5	20.5	20.5	18.0	9.7	-
[10] 3	14.5	23.0	30.5	31.5	12.0	-
[11] 4	10.5	29.0	34.5	35.5	13.1	-
5	10.0	18.5	23.0	29.0	9.6	-
6	10.0	20.0	26.0	(26.0)	9.8	-
7	10.5	19.0	22.0	24.0	9.1	-

PLOT L-5a; 9/19/61

Av. soil moisture in forest, 6.1 inches; in opening, 7.6 inches [2]

Sampling point [3]	6	18	30	42	Total [4]	Precip. [5]
1	10.0	11.0	11.0	12.0	5.3	-
2	17.5	16.0	11.0	13.0	6.9	-
[10] 3	23.0	15.0	24.5	26.0	10.6	1.0
[11] 4	12.5	19.5	30.0	29.5	11.0	-
5	17.5	12.5	14.5	27.0	8.5	.9
6	20.5	16.0	23.0	(23.0)	8.7	.1
7	23.0	13.0	13.0	14.5	7.6	1.5

Table 3. -- Footnotes

[1] Data estimated owing to shallow depth of sampling point and is a projection of the soil moisture measurement at the greatest depth attained at that point.

[2] Average soil moisture in the forested portions of the plot and in the opening, computed on the basis of a 4-foot soil depth, adjusted for precipitation, and weighted for equal distance sampling.

[3] Points 1 and 2 are located within the forest; all subsequent points are located within the opening, except that if a plot contains more than eight sampling points, the first two points (points 1 and 2) and the last two points listed are located within the forest and the intermediate points are located within the opening.

[4] Total of soil water present in the 4-foot soil at the point sampled and on the date measured. Computed from the mean of four 1foot increments times 48 inches.

[5] Soil moisture increase since the previous measurement owing to precipitation, surface runoff and ponding.

[6] Measurement made while the soil was above field capacity owing to snow being present on the plot.

[7] Point eliminated from analysis owing to effect of adjacent tree stump and large roots upon the neutron count.

[8] Point eliminated owing to position in road.

[9] Point not measured at this date.

[10] Point eliminated from analysis owing to surface and subsurface drainage.

[11] Point eliminated from analysis due to the effect of point (see footnote [10]).