Soil Moisture Patterns

in a Northern Coniferous Forest

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Thomas F. McLintock served as leader of the Northeastern Forest Experiment Station's research center at Bangor, Maine, in 1946-56; and this report is a product of his research work in that region. At present he is Staff Specialist in the Research Branch of the U. S. Forest Service's national headquarters at Washington, D. C.

THE trend of soil moisture during the growing season, the alternate wetting from rainfall and drying during clear weather, determines the amount of moisture available for tree growth and also fixes, in part, the environment for root growth. In much of the northern coniferous region both moisture content and root environment are in turn affected by the hummock-and-hollow topography so characteristic of the softwood forest types.

These hollows and hummocks had their origin long ago, as large trees were uprooted in the normal evolution of the forest, tearing out good-sized holes and heaving up heaps of soil and roots. Gradual weathering over the years has reduced the holes to hollows and the heaps to hummocks.

This is a brief summary of major soil-moisture trends and a report on differences as apparently influenced by micro-topographic position.

A Study in Maine[1]

In 1955, daily soil-moisture measurements were made from May 12 to September 9 in a mixed pine-fir-spruce stand near Orono, Maine. The topography here was flat to gently sloping. Four replicate samples were composited from each of two depths (0-6 and 6-12 inches below the A_0 layer) on each of three sites.

To study how the typically uneven micro-topography affects soil moisture content, four separate samples were taken at each depth and site, once a week. These were designated as occurring on level ground, in a hollow, or on a hummock. Soils on all sites were shallow stony loams developed from rocky glacial tills, with an impervious layer at 15 to 30 inches.

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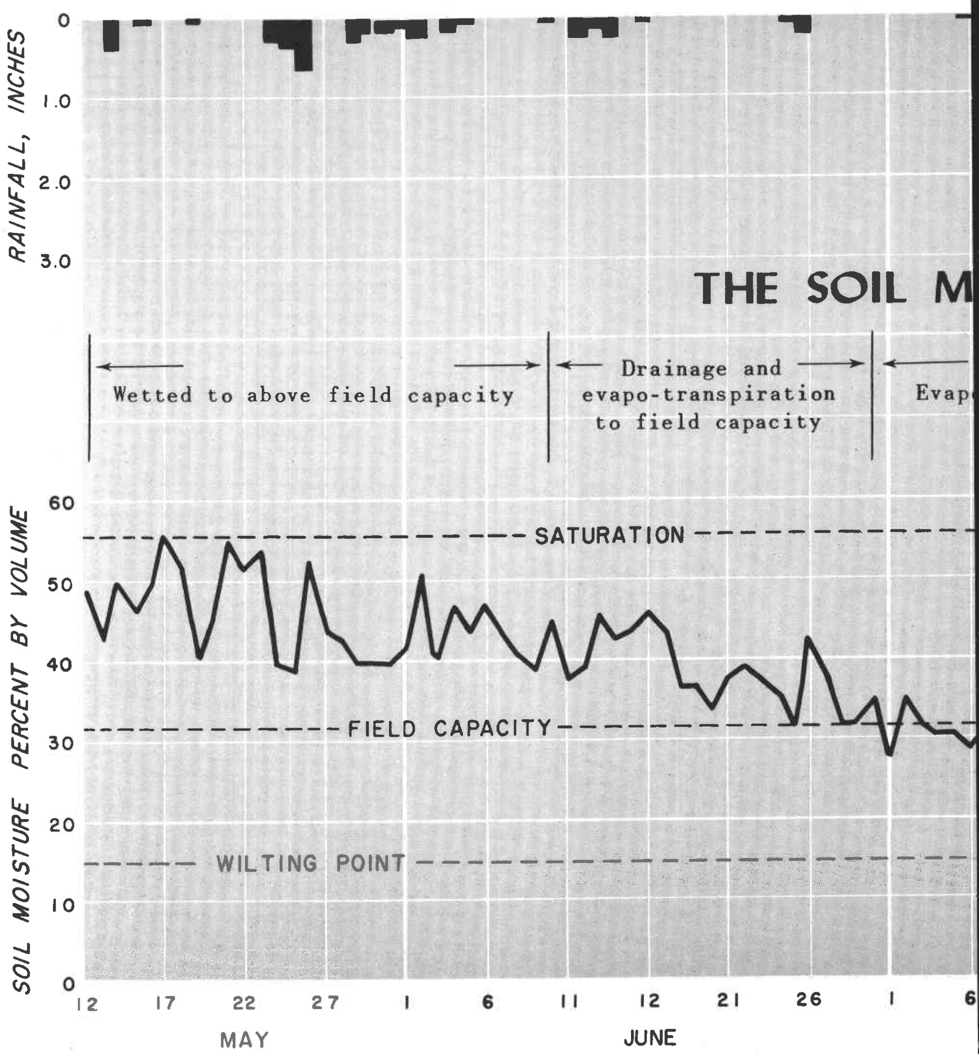
[1]This study was carried out by the Northeastern Forest Experiment Station in cooperation with the Vicksburg Research Center, which is maintained at Vicksburg, Miss., by the Southern Forest Experiment Station in cooperation with the Waterways Experiment Station of the U.S. Army Corps of Engineers.



At the start of the study, May 12, snow had but recently disappeared and isolated pockets of frozen soil could still be found in sheltered locations. Frequent light rains fell, averaging about 1/4 inch and totaling 3.18 inches for the first 30 days (May 12 to June 10). During this period a perched water table fluctuated between the surface and about a foot below the surface, with pools of water sometimes standing in hollows. Average moisture content for the 0- to 6-inch layer was about 47 percent by volume, and that for the 6- to 12-inch stratum about 45 percent. None of the

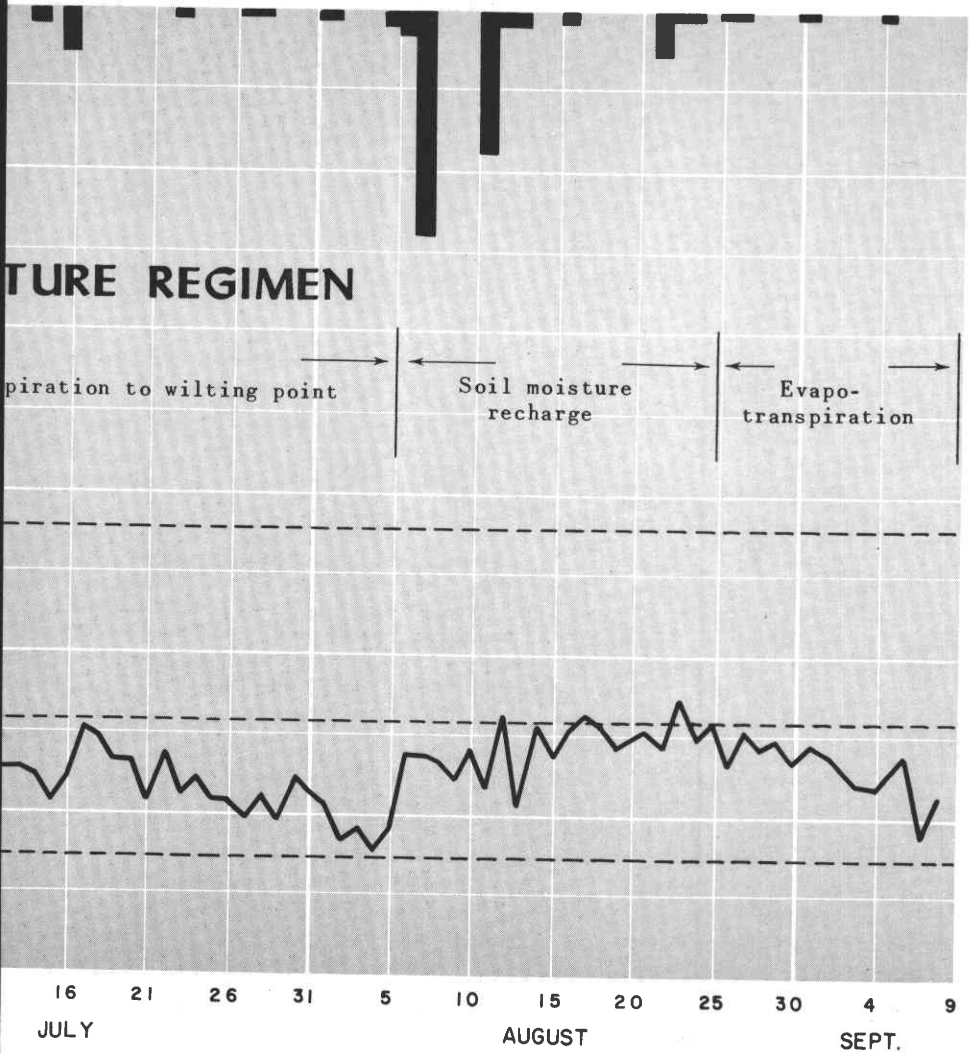


Figure 1.--The daily rainfall and soil-moisture record.

daily composited samples from the upper or lower layers dropped below 32 percent, the estimated field capacity. (No determinations of this were made, but moisture-equivalent values obtained from several hundred soil samples taken on similar sites throughout this part of the spruce-fir region indicate a fairly consistent average of about 32 percent by volume.) It is fairly certain that soils were consistently above field capacity through June 10 (fig. 1).

In the next 20 days, June 11 to 30, soil moisture content of the upper foot was reduced, by drainage and evapo-transpiration, from 46 percent to about field capacity. Moisture content for the last 4 days of this period averaged 34 percent. Rainfall was relatively light, totaling 0.90 inches.

By July 1 the perched water table had dropped well below direct contact with the roots. The steady decline of soil moisture from July 1 to August 5, an abnormally dry period, reduced moisture content to an average of 18 percent (on August 2-5), a value very close to wilting point (fig.1).

Heavy rainfalls of August 7 and 11, totaling 4.56 inches, recharged soil moisture content; and thereafter, with intermittent rains, soil moisture was maintained at an average of 29 percent, or close to field capacity, to August 25. During early September another general decline set in, with moisture percent dropping to 24 percent by the time the study ended (fig. 1).

Rainfall

The significance of these observations can be interpreted in respect to both actual and normal rainfall. Normally, rainfall is evenly distributed during the growing season, each summer month receiving about 3 inches of rainfall. For the summer of record, June and July were dry (1.68 and 0.89 inches of rainfall, respectively) whereas August had about twice normal rainfall (6.28 inches).

As a result of the persistent perched water table, even with the dry June, soil-moisture and aeration conditions did not appear to be favorable for tree growth until about July 1. Under the wetter regimen of a more normal summer, the unfavorable conditions might prevail for most of the growing season and could help explain the very slow growth that is typical of this region.

On the other hand, in a dryer-than-normal summer, such as the one experienced, as soon as the perched water table dropped below the root zone, the soil dried rapidly and its shallow depth restricted the amount of moisture available for growth.

A striking feature of this study was the frequent wide variation among samples taken at the same time on the same site, and the inconsistent reversals of trend from one day to the next. This was attributable partly to the difficulty of obtaining precise results with saturated soils. But another possible factor was micro-relief.

Micro-relief

As already mentioned, a hollow-and-hummock surface was characteristic of all three sites. The effect of this micro-relief on soil-moisture trends was examined in 14 series of weekly non-composited samples taken from June 7 to September 7.

Since there was no logical basis for individual comparisons, the 24 values on each date were grouped by soil stratum and by relief class: level, hollow, hummock. At the 0- to 6-inch position, hummock soils were drier than those in hollows in all but 1 of the 12 weeks. On two additional occasions when none of the samples occurred in hollows, hummocks were drier than level places. Averages for the entire period were 26.0 percent by volume for hummocks, 33.9 percent for hollows. Level positions were intermediate at 31.4 percent, as might be expected.

At the lower soil depth, differences were less consistent and less pronounced. Hummocks were drier on 9 of 12 days, and wetter on 3 others--though in the latter case differences averaged only 1 percent. Averages for the period were 28.5, 35.5, and 31.6 percent for hummock, hollow, and level, respectively. When values for the two depths were pooled, corresponding soil-moisture values were 27.2, 34.7, and 31.5 percent.

These data suggest that moisture content of soils in hummock positions dropped below saturation 1 to 2 weeks before this occurred in hollows and on the level. Differences between the two extremes, which averaged about 10 percent in June, narrowed to 3 percent when the soil dried out.

The above observations help explain between-sample variations. But more important, they suggest that soils in hummocks, contrasted to hollows, may represent more favorable growing conditions early in the season when the soil is wet, and may be but little more adverse when the soil is dry. Implications of these relationships with respect to successful establishment of reproduction merit study.

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