

WATER TABLE, SOIL MOISTURE, AND OXYGEN DIFFUSION RELATIONSHIPS ON TWO DRAINED WETLAND FOREST SITES

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This note presents the results of a study designed to investigate the relationship of a fluctuating water table to the moisture and aeration status of a portion of the root zone on drained forest land. These relationships could be of value to the engineer, soil scientist, and agronomist interested in the creation of a satisfactory soil environment for crop production. Although the success of a drainage operation is often linked to lowering the groundwater table to a specified level, there is some question of this being the best criteria (8). Of more importance to plant roots may be the moisture and aeration status of the zone above the water table.

This study was conducted on two drained wetland forest sites. One site contained a heavy soil, Bayboro clay loam and the other a sandy soil, Plummer loamy sand. Every two weeks from March 1963 to February 1965 measurements were made of depth to the water table, soil moisture content, and oxygen diffusion rate on a $\frac{1}{2}$ -acre plot within each area. Soil moisture content was measured with a neutron probe 12 inches below ground surface and oxygen diffusion was measured at the same depth using the platinum microelectrode technique (4). The biweekly data for the three variables were utilized in a stepwise regression analysis to develop statistical models of several relationships. The models have not been tested to determine their accuracy of prediction.

DEPTH TO WATER TABLE

Soil Moisture Content Relationships

The relationship between depth to water table and soil moisture was different for the clayey (Bayboro) and sandy (Plummer) soils

(fig. 1). In both instances, however, soil moisture was negatively related to depth to water table and the independent variable was expressed in the same mathematical form. The statistical models depicted by the curves for the Bayboro and Plummer plots respectively are as follows:

$$Y_{sm} = 58.0509 + \frac{223.5075}{(X_1 + 1)^2} \quad (1)$$

$$- \frac{95.3870}{X + 1} - 2.0791X_1$$

$$Y_{sm} = -.7058 - \frac{191.1411}{(X_1 + 1)^2} \quad (2)$$

$$+ \frac{216.7699}{X + 1} - 1.6751X_1$$

Y_{sm} = Soil moisture content 6- to 18-inches below ground surface (per cent moisture by volume)

X_1 = Depth to water table from ground surface (ft.)

For equations (1) and (2), respectively, depth to water table accounted for 96 per cent and 83 per cent of the variation in soil moisture content, and the standard errors of estimate were 2.8519 and 3.7276.

The model developed for the Bayboro plot represents the shape of a typical soil moisture-suction curve (1, 5). The model for the Plummer plot appears to be incomplete because moisture content failed to level off as the water table dropped. This was probably caused by the short range of the independent variable. Plummer sand has a low water-holding capacity and may not have reached the end of its rate of maximum water loss under the moisture tensions developed.

The models established in this study fit the data well, as indicated by the high coefficients of determination. Dylla and Muckel (2) listed

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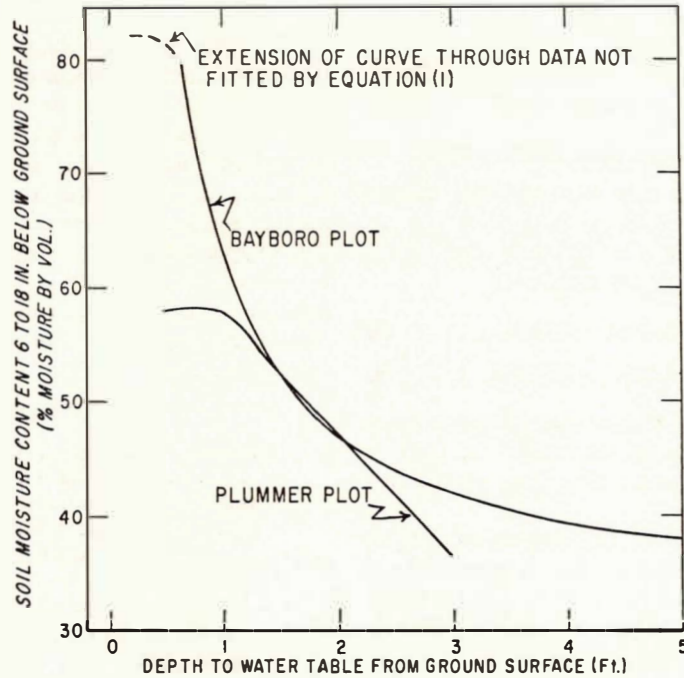


FIG. 1. Water Table—Soil moisture relationships for two soil types.

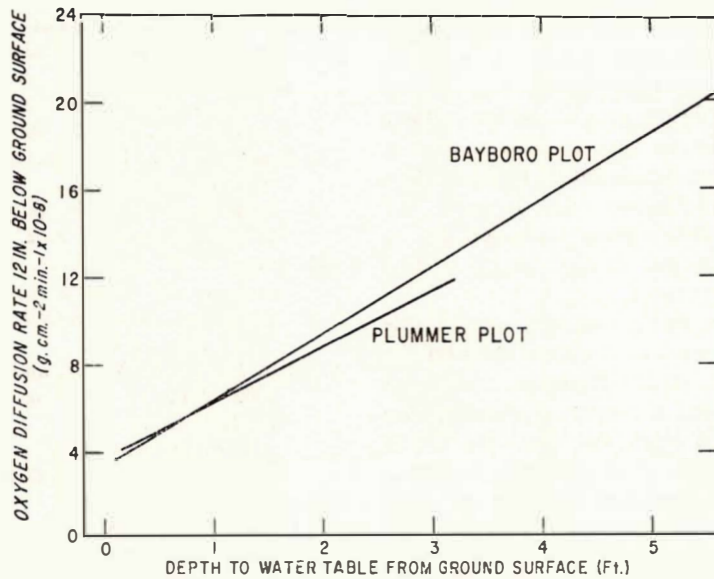


FIG. 2. Water Table—Oxygen diffusion relationships for two soil types.

changes in evapotranspiration rate, moisture extraction patterns of roots, and quantity and timeliness of precipitation as added factors that govern soil moisture content above a water table. The amounts of variation in soil mois-

ture attributed to these other variables in our study were only 4 per cent and 17 per cent for the Bayboro and Plummer soils, respectively. Under similar conditions, therefore, the probability is high that soil moisture can be

successfully related to the single variable: depth to water table.

DEPTH TO WATER TABLE

Oxygen Diffusion Rate Relationships

Oxygen diffusion rate was positively related to depth to water table on both plots (fig. 2). The equations for the Bayboro and Plummer soils respectively are as follows:

$$Y_{OD} = 3.3784 + 3.3846X_1 \quad (3)$$

$$Y_{OD} = 3.5061 + 2.6284X_1 \quad (4)$$

Y_{OD} = Oxygen diffusion rate 12 inches below ground surface ($\text{g. cm.}^{-2} \text{ min.}^{-1} \times 10^{-8}$)

X_1 = Depth to water table from ground surface (ft.)

For equations (3) and (4), respectively, depth to water table accounted for 86 per cent and 59 per cent of the variation in oxygen diffusion rate, and the standard errors of estimate were 2.0426 and 2.0815.

The form of the models developed in this study are supported by data presented by Williamson (10) and Waddington and Baker (9). They indicated a near linear relationship between oxygen diffusion rate at a point in the soil and water table levels that ranged from 0 to 3 feet below ground surface. Others (3, 6, 7) have shown that there is a definite curvilinear relationship between moisture tension and oxygen diffusion rate; however, for the portion of their curves corresponding to the tensions developed in this study, a near linear relationship existed.

As water table levels dropped, oxygen diffusion rates increased at a greater rate on the Bayboro soil than on the Plummer. Stolzy and Letey (6) observed a similar relationship between a Yolo silt loam and Hamford loamy sand up to a tension of 40 millibars. However, Kristensen (3), Lemon and Erickson (4), and Van Doren and Erickson (7) observed the opposite relationship, i.e., coarse textured soils have a higher oxygen diffusion rate than do finer textured soils at a given moisture tension, providing that a rupture of the moisture film around the electrode does not occur. Soil porosity may be the key to the apparent differences in results. At a particular moisture tension, Lemon and Erickson (4) observed a higher oxygen diffusion rate on the soil with

the highest porosity. Our Bayboro soil had much higher porosity than the Plummer and probably a much higher air exchange rate.

The amount of variation in oxygen diffusion rate attributed to a single variable was high, particularly on the Bayboro soil. This high variation coupled with the simple mathematical relationship between water table level and oxygen diffusion rate may open the door to estimating and easily computing a hard-to-measure variable (oxygen diffusion rate) from data of an easy-to-measure variable (depth to water table).

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