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Ground-Water Levels and Soil Characteristics in a Forested Typic Glossaqualf

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SUMMARY

The presence of impermeable layers can affect the development of a soil and its water regime. In a forested Typic Glossaqualf in southwest Louisiana, moisture, density, and piezometer measurements revealed an impermeable layer of soil between about 1.8 and 2.8 m below the surface. A high proportion of very fine sand and development of platy structure appeared related to a low proportion of drainable pores in the layer. Glossic characteristics were well developed in the B horizon and were associated with an intermittent perched water table but disappeared as moisture content became more uniform at greater depths. An auger hole that extended through the impermeable layer indicated, during dry periods, the pressure variations of a deep water source rather than a continuous water tab/e.

Additional keywords: Water, regime, texture, density.

In an earlier study of the soil water regime under loblolly pine (*Pinus* taeda L.) on a wet site in southwest Louisiana, impermeable layers were not evident in the soil profile (Lorio and Hodges 1971). The presence of such layers in or immediately below the solum can affect the interpretation of the development of a soil and affect the soil's current water regime. The present study was conducted to clarify the nature of the water regime in relation to characteristics of a forested Typic Glossaqualf.

METHODS

The study was done in the West Bay Game Management Area in Allen Parish, Louisiana, in a natural stand of loblolly pine that was about 44 Years old. Elevation in 34.50 m above mean sea level. Climate is humid with an average annual rainfall of about 151 cm.

Soils in the study area were formed on the fluviatile Montgomery terrace, a stream deposit associated with a former Mississippi River course (Holland et al., 1952). The predominant soil is classified as Guyton silt loam, a member of the fine-silty, mixed, thermic family of Typic Glossaqualfs. Soils on the numerous mounds are somewhat more sandy and less clayey in the upper solum, and apparently have developed under less moist conditions than those on flats. The Messer series (Typic Glossudalf, coarse-silty, mixed, thermic) is representative of these soils. Although both soils are classified as Aifisols, chemical analyses indicated that soils in this area may be marginal to the Ultisols (Lorio and Hodges 1971).

An intermound site (Guyton series) was selected for this study. The profile description is for moist soil conditions.'

Horizon	Depth, cm	Description
Al	o-5	Dark grayish brown (1 OYR 4/2) silt loam; few fine faint grayish brown mottles; weak fine granular stucture; friable; many fine and medium roots; common fine and medium pores; common fine soft black specks; strongly acid (pH 5.5); clear wavy boundary.
A21g	5-30	Light brownish gray (10YR 6/2) silt loam: many (35%) medium distinct brownish yellow (10YR 6/6) mottles; weak fine subangular blocky

'Profile description by Mr. Arville Touchet, State Soil Scientist, Soil Conservation Service.

Horizon	Depth, cm	Description
		structure; friable; common fine, medium and coarse roots; common fine and medium pores; few medium krotovinas; many fine and few medium brawn concretions: very strongly acid (pH 4.9): gradual wavy boundary.
A22g	30-74	Light brownish gray (10YR 6/2) silt loam; common medium distinct yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure; friable; few fine roots; many fine and medium pores lined with clear silt; few medium brown concretions; tongues 5 to 15 cm wide extending through B21tg horizon; very strongly acid (pH 4.9); abrupt irregular boundary.
B21tg	74-117	Gray (10YR 6/1) silty clay loam; common medium distinct yellowish brown (10YR 5/6) mottles; compound moderate coarse prismatic and moderate medium subangular blocky structure; firm; few fine and medium roots between prisms; common fine pores inside of peds; few fine pores through face of peds; thick continuous clay films on surface of peds; few medium brown concretions; (30 to 40% of the mass is A22g tongues); very strongly acid (pH 4.9); gradual wavy boundary.
B22tg	117-158	Gray (10YR 6/1) silty clay loam; common coarse yellowish brown (10YR 5/8) and strong brown (7.5YR 5/8) mottles; compound moderate coarse prismatic and moderate medium subangular blocky structure; few fine and medium roots between prisms; common fine pores inside of peds; few fine pores through face of peds; thick continuous clay films on surface of peds; few medium silt loam pockets and thin patchy silt coats in vertical cracks; few medium brown concretions; strongly acid (pH 5.2); gradual wavy boundary.
B3g	158-183	Gray (10YR 6/1) silty clay loam; common medium distinct yellowish brown (10YR 5/4) mottles; compound moderate coarse platy and moderate medium subangular blocky structure; few fine and medium roots in cracks; few fine pores; thin patchy clay films on surface of peds; few medium brown concretions; strongly acid (pH 5.4).

Piezometer tubes (5.08 cm inside diameter thin-wailed electrical conduit) were installed on a 0.04 ha plot previously used for auger-hole and neutron-probe measurements. The tubes were 2 m apart and their lower ends were 0.75, 0.90, 1.20, 1.35, 1.65, 2.15, and 2.70 m below the surface of the soil. A cavity 10.2 cm long and 4.9 cm in diameter was augured below the bottom end of each tube. In anisotropic soils piezometers measure essentially horizontal hydraulic conductivity and can be used at almost any depth below a water table (Reeve and Kirkham 1951). Installation techniques and methods of measuring saturated hydraulic conductivity were those developed by Luthin and Kirkham (1949) and Reeve and Kirkham (1951) and described by Boersma (1965).

Depth to free water was measured weekly from January 1972 through December 1973 with the piezometers and with an auger hole. The auger hole extended to 4.4 m and was lined with perforated 5-cm diameter aluminum tubing. In both years, ground-water levels from January through June provided the best conditions for evaluating the nature of the water regime, and results presented are for those months.

Two access tubes (4.8 cm inside diameter) were installed to permit soil moisture readings to 4.2 m; three additional tubes allowed measurements to 1.4 m. A Kaiser probe (Model VMP 487)[2] adapted to a Troxler portable scaler-ratemeter (Model 1651) was used to measure moisture. Two 4.0 cm inside diameter tubes allowed access for density measurements that were made with a Troxler Model 505 density gauge and a Model 2008 scaler-ratemeter. Moisture measurements were made from January through June 1972 and at the time of density measurements in June 1974. Density measurements were adjusted to dry density by subtracting the water component of total density indicated by the moisture gauge.

Soil samples from access tubes were collected at 15-cm increments for particle-size distribution analysis by the hydrometer method (Day 1965). Rainfall on the site was measured with a recording gauge. Average semiannual precipitation (1931-1971) was calculated from data of the official weather station at Elizabeth, Louisiana, 4 miles from the study site.

[2] Mention of trade names is solely to identify material used and does not imply endorsement by the U.S. Department of Agriculture.

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RESULTS AND DISCUSSION

The average January through June rainfall for Elizabeth from 1931-1971 was 78.2 cm. The January through June rainfall in 1972, the first year of the study, was 65.7 cm; rainfall in the first 6 months of 1973 was 101.5 cm.

Saturated hydraulic conductivity varied from moderately slow to very slow, based on O'Neal's classification (1952). At 0.75 m, saturated hydraulic conductivity was 23×10^{-5} cm sec^{-1}; at .90 m, 2.6×10^{-6} cm sec^{-1}; at 1.20 m, 2.3×10^{-6} cm sec^{-1}; at 1.35 m, 5×10^{-6} cm sec^{-1}. Conductivities could not be measured at 1.65, 2.15, and 2.70 m because very little water entered the piezometer cavity at 1.65 m and none entered at the lower levels.

Water levels in the .75 m piezometer from January to June of both years closely paralleled those in the auger hole; levels in the deeper piezometers indicated the very low hydraulic conductivity of the soil at those depths (fig. 1). In 1973, after a year of equilibration, the water levels in the .90 m piezometer more closely approximated auger-hole fluctuations than in 1972.

By January 1974, no water had entered the two deepest piezometers. When the 2.15 m piezometer was lowered to 2.85 m and the cavity extended to 3.95 m and the cavity below the 2.70 m tube was extended to 4.15 m, water slowly entered both piezometers. By April it rose to 2.0 m and by June to 1.8 m, indicating that water was under pressure below an impermeable layer.

Changes in soil density with depth were nearly the inverse of changes in soil moisture (fig. 2). The density and moisture measurements indicated a nearly impermeable zone between 1.8 and 2.8 m that varied little in moisture content. Soil moisture above the impermeable layer varied greatly, with especially large fluctua-

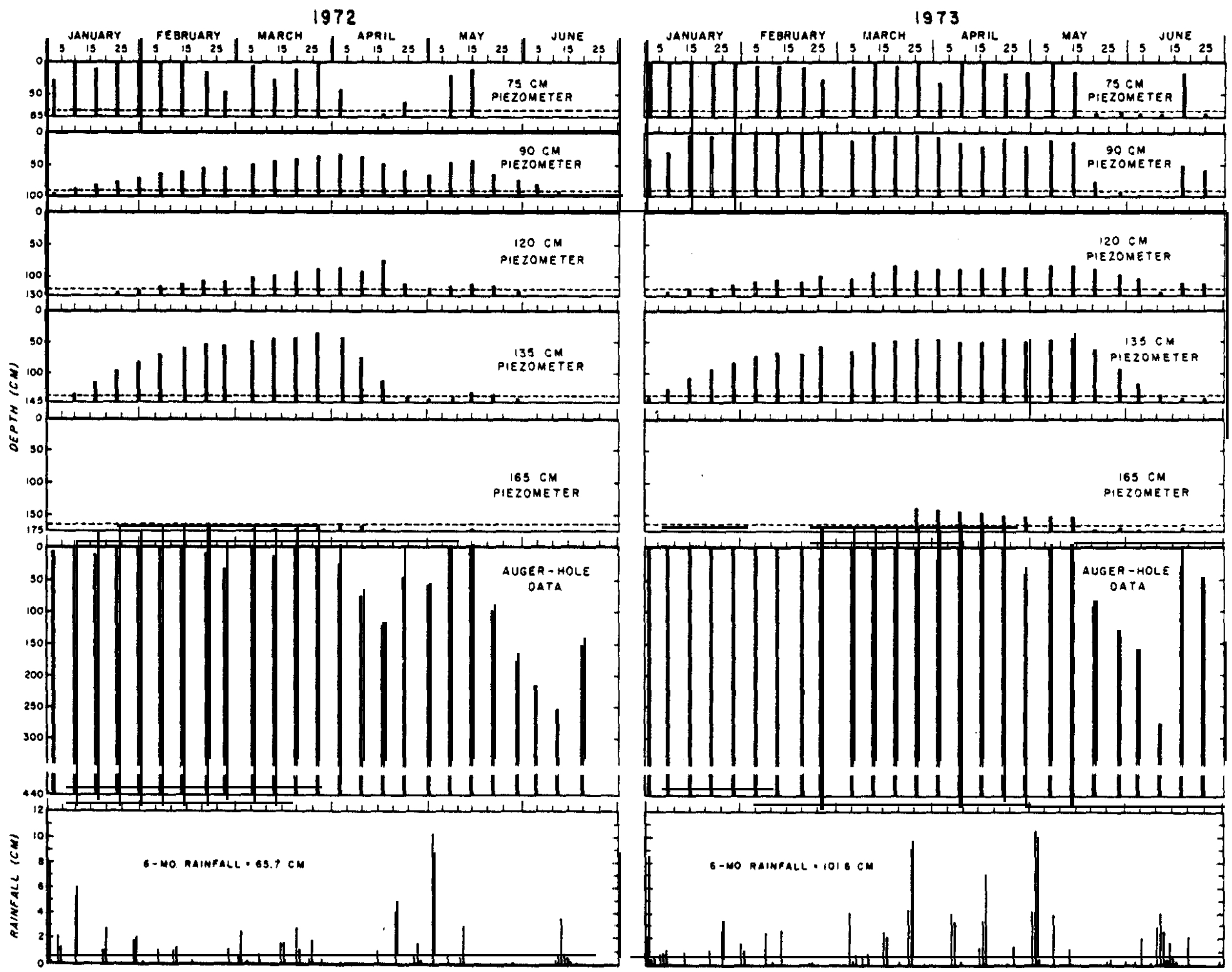

Figure 1.-Daily rainfall and depth to free water measured in auger hole and in piezometers (January through June 1972 and 7973).

tions in and above the B21 tg (74-l 17 cm). Such conditions are considered necessary for the development of tongues. As noted in the profile description, tongues of A22g disappeared in the B3tg horizon (158-l 83 cm) where moisture conditions are less variable. Below 3.0 m, the soil was apparently saturated or near saturation at all times.

Analyses of soil texture revealed the presence of the clay bulge characteristically associated with Btg horizons. No dramatic textural changes occurred in the apparently impermeable zone – clay was nearly constant (26-30 percent) and sand varied from about 25 percent near the top to about 40 percent near the bottom of the zone (fig. 3). Silt decreased from about 50 percent at the top to about 30 percent at the bottom. Very fine (50 to 100μ) and fine (100 to 250μ) particles comprised most of the sand fraction; very fine sand averaged 76 percent and ranged from 73 to 84 percent in the impermeable zone.

Because density was greatest at the top of the impermeable zone and tended to decrease with depth, it alone probably is riot responsible for the low hydraulic conductivity of the layer. The abundance of very fine sand, the platy structure in the B3tg horizon, and the high density may combine to produce a high proportion of undrainable pores.

The water regime described is at least partly the result of the impermeable zone that exists below the developed soil. Tonguing, evidence that the argillic horizon, has been partly destroyed (Soil Survey Staff 1975), is highly developed. This characteristic feature of Glossaqualfs may be viewed both as a factor affecting current water regime and direction of soil development, and as a product of soil degradation processes. In this case water depletion and accretion patterns and tree rooting are profoundly affected by the tongues that occupy 30 to 40 percent of the soil mass in the B21tg. However, assuming that water movement is an important factor in tongue development in these soils, the constant moisture below the B horizon probably is limiting deeper development of glossic characteristics.

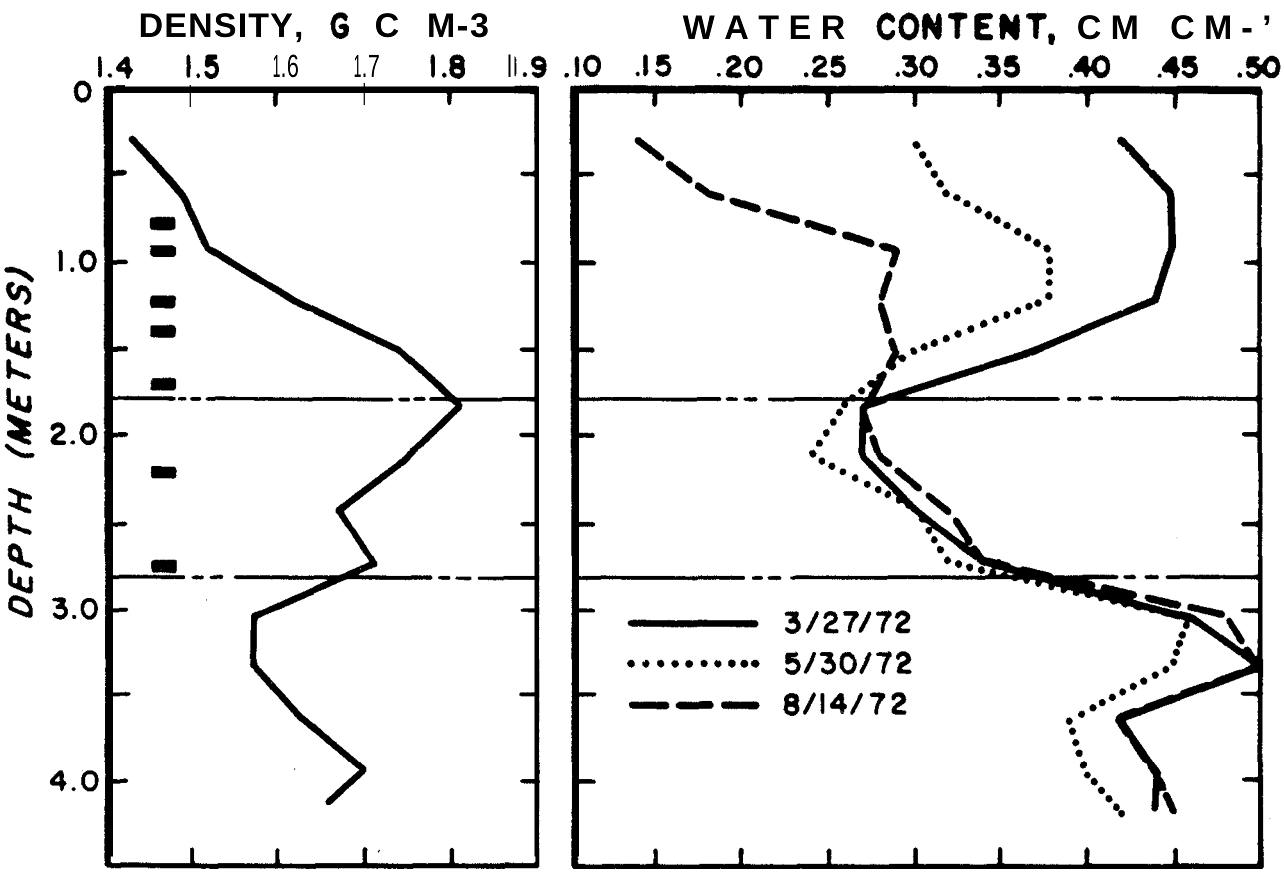

Figure 2.—*Dry density profile and soil moisture profiles representative of typical wet, intermediate, and dry conditions in the study* **area.** *The lines at 1.8 and 2.8 m indicate the impermeable zone. Depth of piezometer cavities are* **indicated along the left** *side* **of the figure.**

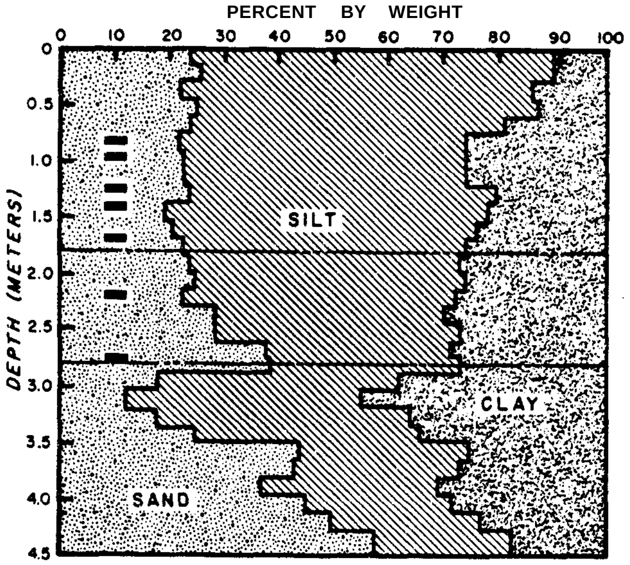

Figure 3.—*Particle-size distribution by 15-cm depth increments.*

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