THE MEASURE OF MOISTURE

TOP
Loam soil at wilt point.

CENTER
Loam soil at field capacity.

BOTTOM
Saturated loam soil.

WHEN SPECIFYING A SOIL, YOU NEED TO KNOW HOW IT HOLDS WATER.

BY JAMES R. URBAN, FASLA

Most projects don't have a soil scientist as a consultant, which leaves landscape architects to make important field decisions during construction. We need to specify soil moisture as part of the process of installing and compacting soils, and managing soil moisture is a critical part of plant establishment afterward. Working with wet soils can damage the performance of those soils, and allowing root balls to dry out can create tree stress problems that may impact tree growth far beyond the guarantee period.

Soil, grading, and planting specifications often require that soils not be delivered, worked, or graded when wet, muddy, or dry. Some specifications include references to soil moisture, using terms such as **optimum soil moisture, field capacity, wilt point,** or **saturated.** What do these terms mean? And how can landscape architects in the field, with no time to send samples to a lab, determine how moist the soil is?

Landscape architects need to understand soil moisture terms so they can make their specifications accurate and defensible.

There are a number of ways to measure soil moisture, and there are different systems to express the results. The differences are important and can be confusing. When most people think of how much moisture is in soil, they usually think of it as a percentage. Soil with 5 percent moisture may be dry and 25 percent may be wet. But there are

CRITICAL SOIL MOISTURE TERMS

Macropores: Large spaces between soil particles or spaces within the soil structure that are large enough to allow water to move under the influence of gravity.

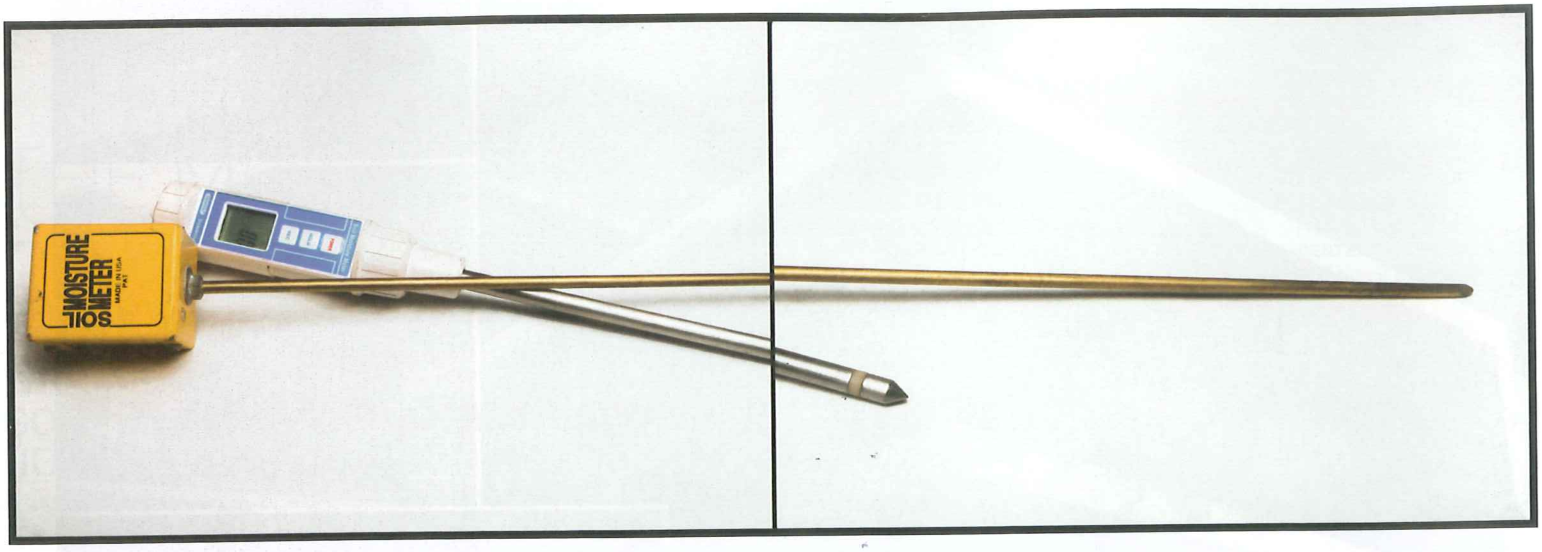
Micropores: Small spaces around and between soil particles that hold the water by surface tension and capillary action against the force of gravity.

Gravity water: Water in macropores that moves relatively rapidly downward or sideways under the influence of gravity.

Capillary water: Water in micropore space that moves very slowly up, down, or sideways under the influence of capillary forces.

Soil texture: The percent of sand, silt, and clay in the soil.

Soil structure: Soil particles stuck together by organic glues, roots, and clay to form larger structures in the soil, called soil peds. Soil structure is the primary building block in the creation of macropores.



ABOVE
The Digital Soil Moisture Meter DSMM500 has an 8-inch probe and the Lincoln Soil Moisture Meter has a 24-inch probe.

BELOW
These volumetric readings are approximate starting points to interpret meter readings. All soil types are USDA soil nomenclature, and the soil is assumed to have 2.5 percent organic matter with density and structure suitable for root growth.

two ways to express percent moisture: Volumetric moisture is where the total volume of the soil, including the pore space, is 100 percent, and the total volume of the water is a percentage of the total volume.

Gravimetric moisture is where the total mass of the soil, including the water, is 100 percent, and the mass of the water within the soil is calculated as the percent moisture. Because soil weighs more than water, the percent water in a gravimetric calculation will be smaller than the same sample calculated volumetrically. The gravimetric method is often used by scientists in research reports.

Soil moisture can also be expressed as soil water potential, which measures the energy that it takes to move water from one place to another. Scientists like to use water potential to discuss water as it takes into consideration many factors in a single metric, and the result for similar water states in different soil types is the same value.

But the vast majority of the tools and methods available to measure gravimetric moisture or soil water potential are too cumbersome, time consuming, or expensive to have a field application for landscape architects during a site inspection. The measuring tools easily available to a contractor or a landscape architect are those that measure volumetric moisture.

Soil moisture meters that measure volumetric soil moisture as a function of electric conductivity in the soil are relatively cheap and easy to use. Although these tools are not sufficiently accurate for scientific purposes, they are very good for establishing relative soil moisture levels. A good moisture meter that gives reasonably reliable data will cost about $250 or more. These meters will typically read around 50 percent when the soil is totally saturated. Moisture meters that are far cheaper, $15 to $100, are available, but these give much more approximate readings.

I use two meters. The Digital Soil Moisture Meter DSMM500 by General Tools & Instruments ($250) is a reasonably precise volumetric soil moisture instrument. The biggest drawback to this meter is the short, eight-inch-long probe that makes it difficult to look at water deeper in the soil. Often a perched water table or other drainage problem may be deeper than the surface layer. To look at water deeper in the soil profile, I use the Lincoln Soil Moisture Meter by LIC ($105). LIC's meter is an industry standard for an inexpensive meter and can be purchased with a 36-inch-long probe that allows deeper measurements. It has a relative scale of 0 to 10 (dry to wet) but does have a calibration screw on the back of the meter. I simply

VOLUMETRIC SOIL MOISTURE BY SOIL TYPE

SOIL TYPE	PERMANENT WILT POINT	FIELD CAPACITY
Sand, loamy sand, sandy loam	5–8%	12–18%
Loam, sandy clay, sandy clay loam	14–25%	27–36%
Clay loam, silt loam	11–22%	31–36%
Silty clay, silty clay loam	22–27%	38–41%

Source: "Soil Water Characteristic Estimates by Texture and Organic Matter for Hydrologic Solutions," by K. E. Saxton and W. J. Rawls, *Soil Science Society of America Journal*, vol. 70, September–October 2006.

CHARLES STECK

ABOVE
Loam soil at field capacity.

BELOW
Saturated loam soil.

insert the General meter and the LIC meter into the soil to the same depth and calibrate the LIC to read the same as the General. I also use a soil auger to look at relative soil moisture to any depth the auger can reach using the method noted below for observing soil moisture by appearance. The two systems, meters and appearance, work well together in the field.

Soil texture, soil structure, percentage of organic matter, and compaction all play a role in the percentages of volumetric soil moisture measured at **permanent wilt point** and **field capacity,** the two critical benchmarks to finding the limits of **plant-available water.** Adding compost to soil will increase the available water about 10 percent above the values in the table as dry weight soil organic matter rises up to 7.5 percent. Soil mixes of sand, soil, and compost are closest to sandy loam or loamy sand, but often soil organic matter will be higher than 2.5 percent in the final mix owing to the large amount of compost.

Optimum soil moisture levels for compaction must be determined from a proctor curve prepared by an engineering soils laboratory, but they are normally between 10 percent and 18 percent, or slightly above the **wilt point** of the soil.

Because of the wide range of factors that affect volumetric soil moisture, the percentages in the table are only a guide. In the field, using visual and physical indicators may help in refining the discussion if a soil is too wet or too dry.

Landscape architects can develop the skill to check soil moisture just by feeling and observing its appearance. As the soil approaches wilt point, it becomes lighter in color. If you're unsure what the color should be when there is adequate moisture, add water to a small sample and compare it to the actual soil color. Dry soil will tend to become dusty when crushed. Soil clumps with higher percentages of clay and silt will become harder to crush when dry, whereas clumps of soil with high percentages of coarse sand, particularly most sand-based soil mixes, will fall apart more easily.

As soil approaches field capacity, it will become much more plastic and moldable and will leave a slight muddy impression on your hand when it's squeezed. Above field capacity, the soil will start to look shiny, with free water coating the soil, and your hand will become muddy. As the soil nears total saturation, samples will become fluid.

Using correct terminology and citing referenced volumetric soil moisture levels are important parts of the specification process. Checking soil moisture and moisture within the soil of tree root balls during construction, planting, and maintenance should be a regular part of the construction observation process. Landscape architects need to have the equipment and skills to do this—they shouldn't have to rely on laboratory analysis.

JAMES R. URBAN, FASLA, IS A LANDSCAPE ARCHITECT WHO SPECIALIZES IN URBAN TREES AND SOILS AND A CONSULTANT TO OTHER LANDSCAPE ARCHITECTS.

MOISTURE TERMS FROM DRY TO WET

Wet, dry, muddy: All undefined slang terms.

Oven dry: The point where there is no moisture in the soil, generally only used in laboratory test discussions and rarely found in field soil conditions.

Permanent wilt point: A level of soil moisture that is so low the plant will not recover unless water is added. It varies with plant type and soil type.

Wilt point: Considered slang by soil scientists, this is often used to describe the point where a plant begins to wilt.

Optimum soil moisture: When used in geotechnical specifications, this is the level of moisture where the greatest degree of compaction can be achieved in a proctor test. This test compares actual or specified compaction as a percentage of the maximum compaction that can be obtained within the proctor test protocol. In agricultural soil discussions this is a slang term and has no definition.

Plant-available water: Soil water between the permanent wilt point and field capacity.

Field capacity: The point where the gravity water has drained out of the soil, usually one to three days after the end of the application of water depending on soil type.

Saturated soil: The point where the soil macropores are filled with water. There is a considerable difference in the percent of soil moisture between the point when a soil is beginning to be saturated and when it is totally saturated.

CHARLES STECK