Wetland Restoration on the Texas Gulf Coast

by Dan Keesee, USDA-NRCS State Wetlands Specialist, Temple, Texas

Vertisol Soils

Heavy clay and high pH

The central concept of Vertisols is clay soils that form deep, wide cracks for some time during the year, and slickensides. Vertisols shrink when dry and swell when wet.

Along the upper coastal plain of Texas, shrink-swell clays are the major component of the soil landscape. Taxonomically, these soils are classified as Vertisols and those soils in Vertic sub-groups. Within the 12 counties roughly comprising the upper coast of Texas, in an area of over 11,000 square miles, over 6,000 of those square miles are mapped as Vertisols and soils in Vertic sub-groups. Almost six of every ten acres are mapped as heavy, shrink-swell clays.

When these soils are dry, cracks up to several inches wide extending three feet or more deep form at the surface. Through the cracks, water enters the soil very rapidly, but due to the soil's shrink-swell nature, the cracks close or seal rapidly as the soil moistens. Once the cracks close, water enters these soils very slowly. Within these soils' profiles, evidence of the shrink-swell phenomena manifests itself in the formation of slickensides, which are stress surfaces produced by soil masses sliding past each other.

Despite the difficulties associated with manipulating Vertisols and soils with Vertic sub-groups, they are productive soils that have been extensively cultivated along the Texas coastal plain. Due to their relatively flat slopes and capability to efficiently pond water, many areas were cultivated for rice. Historically, huge swaths of these areas supported tall-grass prairies with woody vegetation generally confined to limited areas along watercourses.

Wetland restoration on these soils presents numerous challenges, particularly when the vegetative restoration effort focuses on establishing woody vegetation. Several inherent soil properties, including their capability to retain and pond water, their soil reaction or pH, and the shrink-swell phenomena, can work directly and indirectly against the establishment of both naturally occurring and planted seedlings on these soils. Overcoming these limitations requires special design, extra maintenance, and costly alteration. Results are often less than expected.

Generally sticky when wet and hard when dry, Vertisols require special cultivation practices. Their movement can tilt trees; throw out-of-line fence posts, and telephone and power poles; and break pipelines, highway pavements, and masonry foundations.

The shrink-swell phenomenon is complex, dynamic, and incompletely understood. Its expressions are gilgai, cyclic horizons, surface cracking, and slickensides.

Within Vertisols, internal movement affects the thickness of soil horizons, which can vary widely within a pedon. For example, a black A horizon may be absent on micro-knolls but more than 40 inches thick in micro-depressions 20 feet away.

In soils, shrink-swell processes are related to total and fine clays content, and mineralogy. Generally, Vertisols have high total and fine clays contents.

By itself, moisture change is insufficient to induce all vertic properties. To produce movement along slickensides, there must be confining pressure, provided by the soil material above the slickensides.

Shrink-swell potential may be reduced by a mixture of organic matter and carbonates.

Predominantly, natural vegetative communities associated with Vertisols are grasslands, savannahs, open forests, or desert shrub.

With plenty of rainfall or irrigation water and appropriate management practices, most Vertisols are suited to mechanized farming. World-wide, large areas of Vertisols are not farmed because their cultivation requires too much energy. This is a major limiting land-use characteristic of Vertisols.

Soil profile typifying the extreme variability found in Vertisols. Soil movement affects the thickness, color, structure, and orientation of horizons found within a Vertisol profile, differences which occur over distances of only a few feet.

Gilgai produced by the expansion and contraction of soils is a distinctive form of micro-relief associated with undisturbed Vertisols.

Ponded water in an area mapped as Pledger clay.

An area mapped as Vertisols and, generally, reflecting the broad, flat coastal plain landscape along the Texas gulf coast.

Restoration Challenges with Vertisol Soils

Along the Texas gulf coast, both hand-planted and naturally occurring seedlings face a soils environment often hostile to their survival. Particularly for those finding themselves on Vertisols or soils with vertic features, characteristics inherent to those soils can pose an uncertain future for a seedling struggling to establish itself.

Initially, a seedling might be encouraged by the prospect of a future on such soils. Both are deep, productive soils with high levels of nutrients to help a seedling grow straight and tall. Usually, the soil surface is nearly level so rainfall does not drain away quickly. In fact, in many areas, drainage systems remove excess surface water.

However, as is often the case, nature cuts both ways. Vertisols and soils with vertic features are deep soils, but the soil material is heavy clays with a high shrink-swell potential. Additionally, their soil chemical environment often makes it difficult for a seedling to access their plentiful nutrients.

For reasons generally related to the clays found in Vertisols, as they dry, cracks form at the surface and extend into the soil profile. Often two inches or more wide, these cracks can extend 2-3 feet or more into the soil. When it rains, water enters and fills the cracks very quickly, but, again, primarily due to the nature of the clays, as they wet, the soil expands and the cracks close. After that, water enters these soils very slowly. Since they are nearly level, excess water does not flow away quickly and ponds on the soil surface.

For a seedling, the shrink-swell phenomenon creates harsh conditions. Clay contraction and expansion has a tendency to tear and prune roots at a time when the seedling needs all the roots it can get. Clay contraction and expansion also limits the supply of water available to the seedling, often at a critical juncture in its life. Water ponding on the soil surface depletes a soil's oxygen supply, making it even tougher for a seedling to survive.

Additionally, the chemical environment in Vertisols makes life difficult for a seedling, particularly if the seedling is of a species not adapted to life in these soils. As the soil reaction or pH rises above 7 or neutral, nutrients such as iron, phosphorus, and manganese are chemically altered and are not available for use by a seedling. The lack of these nutrients creates a condition in the seedling called chlorosis which affects its ability to manufacture the sugars necessary for survival.

For seedlings of those species adapted to life along the Texas gulf coast, growth and reproduction in Vertisols and soils with vertic features hinges on their ability to withstand the soil forces to which they are exposed, while extracting from the soil the resources necessary to sustain themselves. For example, to survive in high pH environments, they must be either very efficient in nutrient use or obtain more nutrients from those soils than non-native or poorly adapted species.

Lake Charles series

Area mapped: 784,431 acres (1,226 square miles)

Typical pedon

Horizon	Depth (inches)	pH	Slickensides	Pressure faces
A1	0 – 8	slightly acid		
A2	8 – 20	slightly acid		common
Bss1	20 – 35	slightly acid	common, prominent	many
Bss2	35 – 50	neutral	common, prominent	many
Bss3	50 – 70	slightly alkaline	common, prominent	common
2C	70 – 80	moderately alkaline		

Pledger series

Area mapped: 252,731 acres (395 square miles)

Typical pedon

Horizon	Depth (inches)	pH	Slickensides	Pressure faces
Ap	0 – 5	slightly alkaline		
A	5 – 20	slightly alkaline		
Bss1	20 – 30	slightly alkaline	common, prominent	many
Bss2	30 – 50	moderately alkaline	common, prominent	many
BCss	50 – 80	moderately alkaline	common, prominent	

Bernard series

Area mapped: 314,496 acres (804 square miles)

Typical pedon

Horizon	Depth (inches)	pH	Pressure faces
Ap	0 – 6	slightly acid	
Btg1	6 – 22	slightly acid	
Btg2	22 – 35	neutral	few grooved and polished, 2-3 inches across
Btg3	35 – 50	mildly alkaline	few grooved and polished, 2-3 inches across
Btg4	50 – 60	moderately alkaline	
BC	60 – 78	moderately alkaline	

Properties of Vertisol soils common on the Texas Gulf Coast.

References

Cregg. B. Reducing soil pH in landscapes. Available on-line at https://sharepoint.cahnrs.wsu.edu/blogs/urbanhort/archive/2010/03/22/reducing-soil-ph-in-landscapes.aspx. Accessed May 2012.

Kuhns, M., and B. Koenig. Preventing and treating iron chlorosis in trees and shrubs. Available on-lin at http://forestry.usu.edu/htm/city-and-town/tree-care/preventing-and-treating-iron-chlorosis-in-trees-and-shrubs. Accessed 2012.

Miller, W.L., and A.L. Bragg. 2007. Soil characterization and hydrological monitoring project, Brazoria County, Texas, bottomland hardwood Vertisols. USDA-NRCS, Temple, TX.

Soil survey staff. 1999. Soil taxonomy. 2nd edition. USDA handbook 436.

Soil survey staff (USDA-NRCS). Official soil series descriptions. Available on-line at http://soils.usda.gov/technical/classification/osd/index.html. Accessed 2012.

Soil survey staff (USDA-NRCS). Soil quality/soil health assessment. Available on-line at http://soils.usda.gov/sqi/assessment/assessment.html.

USDA-NRCS. 2012. Conservation practice general specifications: tree/shrub establishment (Code 612). Available on-line at electronic Field Office Technical Guide. http://efotg.sc.egov.usda.gov/references/public/TX/tx612Spec2006.pdf.

Leaves of chlorotic (left) and healthy red maple trees growing only a short distance from each other along a soil pH gradient. Foliar sampling confirmed a manganese (Mn) deficiency. Leaf color changed from dark green to bright yellow over a distance of about 30 feet. The pH increase over that distance span was only about 0.5 pH units, but since the pH scale is logarithmic, that increase represents a significant shift. Foliar Mn decreased from 60 to 10 ppm as the pH increased.

Contact information:

Dan Keesee, USDA–NRCS,

101 S Main ST, Temple, Texas 76501 USA.

Phone: (254) 742-9833.

E-mail: dan.keesee@tx.usda.gov.