Texas Soils and Geology for Master Naturalists

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“Daddy, which is this — soil or dirt?”
Our Challenge
Always choose your friends carefully
What is Soil?
Soil

- A natural body having properties due to the combined effects of climate and biotic activity, as modified by topography, acting on parent material over time.
• Active Factors
  – Climate
  – Biotic Activity

• Passive Factors
  – Topography
  – Parent Material
  – Time
Climate

• Three factors

• ____________________

• ____________________

• ____________________
Biotic Activity

• Two Major Types of Organisms
  – 1.__________________________
  – 2.__________________________
Microorganism

Decay organic materials
Biotic Activity

• Microorganisms in fertile soil (5% organic matter, a Mollisol, in millions/g soil) degradation

  – Bacteria - 1 to 100
  – Actinomycetes - 0.1 to 1
  – Fungi - 0.1 to 1
  – Algae - 0.01 to 0.1
  – Protozoa - 0.01 to 0.1
Fungal hyphae and mycorrhizae
Acrobeles mariannae, a bacterial-feeding nematode.
March 2002
Macroorganisms

Loosen Soils
Crayfish burrows
Earthworm in burrow.
Topography
What does a soil look like?
<table>
<thead>
<tr>
<th>Horizon Designation</th>
<th>Horizon Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Organic, slightly to highly decomposed</td>
</tr>
<tr>
<td>A</td>
<td>Mineral, mixed with humus, dark colored</td>
</tr>
<tr>
<td>E</td>
<td>Horizon of eluviation of silicate clays, iron and aluminum oxides, etc.</td>
</tr>
<tr>
<td>B</td>
<td>Horizon of alluviation of silicate clays, iron and aluminum oxide, etc.</td>
</tr>
<tr>
<td>C</td>
<td>Unconsolidated, unweathered, geologic material. May be dug with a shovel when moist</td>
</tr>
<tr>
<td>R</td>
<td>Consolidated, unweathered geologic material. Can not be dug with a shovel when moist, rock</td>
</tr>
</tbody>
</table>
Parent Material
Classification of Parent Materials

- Rocks and minerals
  - Formed in place
  - Residual parent material

- Water transported
  - Ice transported
  - Wind transported

- Deposited in lakes → Lacustrine
- Deposited by streams → Alluvial (fluvial)
- Deposited in oceans → Marine
- Deposited by ice → Till, moraine
- Deposited by water → Outwash, Lacustrine, Alluvial, Marine

- Wind transported
  - Deposited by wind → Eolian (Sand, Loessal)

- Accumulation of plant debris → organic
SIMPLIFIED GEOLOGIC MAP OF TEXAS

FIGURE 2

SOURCE:
MAP PREPARED USING AUTOMATED MAP CONSTRUCTION WITH THE ROCKS EQUIPMENT. NATIONAL CARTOGRAPHIC CENTER, FORT WORTH, TEXAS 1980.

JUNE 1980 1056157
Geology of Milam County

- Cenozoic Era (present day to 65 million years ago), Paleogene Period (23 to 65 million years ago), and Eocene (34 to 56 million years ago) to Paleocene (56 to 65 million years ago) Epochs
- Coastal Plain 2/5, Timber land 3/5: Blackland prairie and clay pan areas.
- Coastal Plain: underlain with calcareous deposits of clay and marl, clayey dark colored soils.
- Timber land: underlain with mainly non-calcareous sand and clay, few areas of calcareous materials, sandy light colored soils underlain with red clayey materials.
- Drainage to the southeast.
Soil from Residuum or Residual Soil
Rumple soil, from the Edwards limestone in Central Texas
Alluvium

- Deposited by water associated with streams and rivers
- May have a wide range of soil textures depending upon the energy of the water that is transporting the alluvium
The Shipps soil series developed in clay-rich alluvium of the Brazos River near College Station, TX.

Note the buried A horizon in the lower portion of the pedon.
Coastal Plains Sediments

- A mixture of alluvium from the uplands via streams and rivers delivering sediments to the ocean, and marine sediments deposited by the ocean.
Cross-sectional diagram of coastal plains in North Carolina. From Brady and Weil.
The Spiller series from Brazos County developed from Coastal Plains Sediments.
Loess and Eolian Sands

• Loess is silt to very fine sand that was deposited by wind. Most loess in the US is associated with “choked” streams and rivers carrying sediment from the melting of glaciers. Wind blew the silts from the floodplains and deposited them over existing landscapes.
Wind deposited sediments of the U.S.
Suspension

Saltation

Surface Creep
Active sand dune in Kenedy County, TX.
Roadcut into loess deposit near Vicksburg, Miss.
Soil developed in eolian sands. Note the upper 5 ft of soil is developed in a younger eolian sand deposit and covers the older soil, also developed in eolian sands.
Discuss degree of weathering, how much the parent material has changed, instead of talking about how “old” a soil is.
Soil Orders

- Inceptisol
- Entisol
- Mollisol
- Alfisol
- Aridisol
- Andisol
- Vertisol
- Gelisol
- Histosol
- Spodosol
- Ultisol
- Oxisol
About 1/3 of the soils of Texas developed in Coastal Plains Sediments
Categories in U.S. Soil Taxonomy

- Order (12)
- Suborder (63)
- Great Group (~250)
- Subgroup (~1400)
- Family (~8000)
- Series (~20,000 in U.S.)
<table>
<thead>
<tr>
<th>Heiden clay, 1 to 3% slope; fine, smectitic, thermic Udic Haplustert</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Order - Vertisol (look for formative element at the end)</td>
</tr>
<tr>
<td>• Suborder - Ustert</td>
</tr>
<tr>
<td>• Great Group - Haplustert</td>
</tr>
<tr>
<td>• Subgroup - Udic Haplustert</td>
</tr>
<tr>
<td>• Family - fine, smectitic, thermic Udic Haplustert</td>
</tr>
<tr>
<td>• Series - Heiden</td>
</tr>
<tr>
<td>• Phase - 1-3% slope</td>
</tr>
</tbody>
</table>

Clay is texture of surface horizon
Soil Components

- Mineral: 45% vol, 99% wt
- Organic: 5% vol, 1% wt
- Water: 25% vol, >1% wt
- Air: 25% vol, >1% wt
Soil Mineral Components

- Sand (0.05-2.00 mm): Quartz and feldspars
- Silt (0.002-0.05 mm): Quartz, feldspars, carbonates, oxides, sulfates
- Clay (>0.002 mm): Aluminosilicates, such as smectite, kaolinite, illite, etc.
Figure 3. Modified textural triangle for determining soil texture by the feel method.
Essential Nutrients

• Any element required by plants or animals for normal growth and reproduction.
Increasing concentration of nutrient in plant tissue

- Deficiency symptoms
- Hidden hunger
- Dilution effect
- Sufficiency range
- Critical range
- Incipient toxicity
- Luxury consumption
- Toxic range
- Lethal range
Primary Macronutrients

- Carbon - C
- Hydrogen - H
- Oxygen - O
- Nitrogen - N
- Phosphorus - P, $P_2O_5$
- Potassium - K, $K_2O$
Primary Macronutrients

- Carbon-C
- Hydrogen-H
- Oxygen-O
- Nitrogen-N
- Phosphorus-P, $P_2O_5$
- Potassium-K, $K_2O$

Derived from air and water

Derived from soil
Secondary Macronutrients

- Calcium-Ca
- Magnesium-Mg
- Sulfur-S

Derived from soil
Micronutrients

- Iron-Fe
- Copper-Cu
- Boron-B
- Chloride-Cl
- Cobalt-Co
- Silica-Si
- Manganese-Mn
- Zinc-Zn
- Molybdenum-Mo
- Sodium-Na
- Vanadium-V
- Nickel-Ni

All derived from soil
Stratification of P

Soil depth (in)

P concentration

- Average of upper 6 inches = 60 ppm
- Ave of 1-7 inches = 8.8 ppm
MAGNESIUM deficiency causes whitish strips along the veins and often a purplish color on the underside of the lower leaves.

NITROGEN hunger sign is yellowing that starts at tip and moves along middle of leaf.

POTASH deficiency appears as a browning or drying along the tips and edges of lower leaves.

PHOSPHATE shortage marks leaves with reddish-purple, particularly on young plants.

HEALTHY leaves shine with a rich dark-green color when adequately fed.
Soil Reactivity, Soil pH

- pH = ____________
- Neutral pH = ____
- Alkaline or basic pH = ______
- Acid pH =__________
- Tremendous effect on availability of nutrients to plants.
Soil Reactivity, Soil pH

• All nutrients most available to plants between pH values of 6 to 7 for mineral soils and 5.5 to 6.5 for organic soils

• Availability of most nutrients increases as the pH decreases

• Availability of Mo increases as pH increases

• Fe and Zn are often deficient in calcareous soils (pH > 7.5)
Soil Sampling and Soil Testing
Soil Sample Information Form
# SOIL SAMPLE INFORMATION FORM

**Texas Agricultural Extension Service**

**The Texas A&M University System**

Soil, Water and Forage Testing Laboratory

Please submit this completed form and payment with samples. Mark each soil sample bag with your sample identification and ensure that it corresponds with the sample identification written on this form. See sampling procedures and mailing instructions on the back of this form. (PLEASE DO NOT SEND CASH)

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**SUBMITTED BY:**

Results will be mailed to this address ONLY

Name: 

Address: 

City: 

State: 

Zip: 

Phone: 

County where sampled: 

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**FOR:**

(Optional—will not receive copy)

Name: 

Address: 

City: 

State: 

Zip: 

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**CROP/PLANT INFORMATION** (Required for Recommendations)

<table>
<thead>
<tr>
<th>Laboratory # (For Lab Use)</th>
<th>Your Sample ID</th>
<th>Acreage Represented</th>
<th>Previous Lime or Fertilizer</th>
<th>What Are You Growing: Yield Goal?</th>
<th>Requested Analyses (See Options Listed Below)</th>
<th>How is Forage Used?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Routine Analysis (R)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(pH, Na, P, K, Ca, Mg, Na, S, and Conductivity)</td>
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<td></td>
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<tr>
<td>2. R + Micronutrients (Micro)</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>(Zn, Fe, Cu, Mn)</td>
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<tr>
<td>3. R + Micro + Boron (B)</td>
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<tr>
<td>4. R + Detailed Salinity (Sal)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>5. R + Micro + Sal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. R + Micro + Detailed Lime Requirement (Lime)</td>
<td></td>
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<tr>
<td>8. R + Texture Analysis</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>9. R + Organic Matter</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Note: Organic Matter, Detailed Salinity and Texture may require longer processing times.

*Minimum requirement for establishment

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Describe any specific problems you have observed or want to correct:

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Choose one analysis group per sample

1. Routine Analysis (R) $10 per sample
2. R + Micronutrients (Micro) $15 per sample
3. R + Micro + Boron (B) $20 per sample
4. R + Detailed Salinity (Sal) $25 per sample
5. R + Micro + Sal $30 per sample
6. R + Micro + Detailed Lime Requirement (Lime) $20 per sample
7. R + Micro + B + Lime + Organic Matter + Sal $50 per sample
8. R + Texture Analysis $20 per sample
9. R + Organic Matter $20 per sample

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Form D-494
Procedure for Taking Soil Samples

Taking the Soil Sample (Refer to Figure 1)

- Take one composite sample for every 10 to 40 acres. A separate sample should be taken for:
  - Areas with different soil types
  - Areas with different land uses or fertilizer uses
  - Areas with different terrain
- Approximately 1 pint of the composite soil sample is required for routine analyses.
- Additional sample is required for texture or detailed salinity (submit 2 sample bags marked identically).
- Avoid sampling areas such as small gullies, slight field depressions, terrace waterways, or unusual areas.
- When sampling fertilized fields, avoid sampling directly in fertilized band.

Taking a Composite Sample (Refer to Figures 2 and 3)

- Take a sample from 10 to 15 different areas.
- Use a spade, soil auger or soil sampling tube.
- Clear litter from the surface (do not remove decomposed black material).
- When using a soil auger or sampling tool, make the core or boring 6 inches deep into the soil (3 to 4 inches deep for permanent sod).
- When using a spade:
  - Dig a V-shaped hole and take a 1-inch slice from the smooth side of the hole.
  - Take a 1 x 1 inch core from the center of the shovel slice.
- Repeat in 10 to 15 different places. Put in a clean plastic bucket or other non-metallic container, thoroughly mix and remove a pint (or more if additional tests are desired) as a composite sample representing the whole field or area.
- To improve the nitrate-nitrogen analysis, samples may be air-dried before sending to the laboratory. Do not use heat to dry samples. Completely fill soil sample bag or other suitable pint container. Do not use old vegetable cans, tobacco cans, match boxes, glass containers, etc. to submit samples. Insulate each sample in its own sample bag, or place one sample in each of the bags, label bags as 1 of 2, 2 of 2.

Shipping the Sample and Payment (Refer to Figure 4)

- Complete the information form on the front page (information required for recommendations).
- Please include payment with the sample. Send check or money order made out to Soil Testing Laboratory. DO NOT SEND CASH. Please note that the price is per sample.
- Be sure to keep a record for yourself of the area represented by each sample.
- Be sure that sample numbers on sample bags correspond with sample numbers on the front page.
- Send samples and payment to:

  Soil, Water and Forage Testing Laboratory
  2474 TAMU
  College Station, TX 77843-2474

For further information please contact:
Your local County Extension Service Office
or
Soil, Water and Forage Testing Laboratory
2474 TAMU
345 Heep Center
College Station, TX 77843-2474
Phone: (979) 845-4816

Educational programs conducted by the Texas Agricultural Extension Service serve people of all ages regardless of socio-economic level, race, color, sex, religion, handicap or national origin.
Routine Soil Testing:
* 3 year interval
* Micro’s every other time

Sampling Methods:
* Composite samples
* 3-10 cores around home
* 10-15 cores per field
* Mix and ship immediately
Soil Sample Report Form
Don’t let yourself be tricked by people
Managing Water and Nutrients
Fig. 6.2 Hydrologic Cycle
Conserve Water

- Watering flowerbeds, gardens
- Watering lawn
What’s In a Bag of Fertilizer

- Three numbers, 15-5-10
- First number, % nitrogen as N
- Second number, % phosphorus as $P_2O_5$
- Third number, % potassium as $K_2O$
How Do I Know How Much to Add?

- Assume recommendation was 1-0-0 per 1000 square feet
- Recommendation means to add 1 lb of N, 0 lbs of P$_2$O$_5$, and 0 lbs of K$_2$O per 1000 square feet of lawn
How Do I Know How Much to Add?

- My bag of fertilizer is 13-13-13
- Need 1 lb of N per 1000 square feet
- \[1\text{lb N ÷ 13\% (0.13)} = 8 \text{ lbs of 13-13-13 to get 1 lb of N}\]
- Also when apply the 8 lbs of 13-13-13, you get 1 lb of phosphorus and potassium, that you did not need
- Ratio of nutrients most plants need is 3 to 4-1-2 to 3
How Do I Know How Much to Add?

• New fertilizer bag is 15-5-10 (What is the nutrient ratio?)
• Need 1 lb of N
• OR, $1 \div 15\% \ (0.15) = 7$, thus to get 1 lb of N, I need 7 lbs of 15-5-10.
How Do I Know How Much to Add?

• How much phosphorus and potassium does this 7 lbs have in it?
• For $P_2O_5$: $7 \text{ lbs} \times 5\% \times (0.05) = 0.4 \text{ lbs}$
• For $K_2O$: $7 \text{ lbs} \times 10\% \times (0.1) = 0.7 \text{ lbs}$
• Thus, we added phosphorus and potassium that was not recommended, but less that what we would if we used 13-13-13 (1lb-1lb-1lb).
What is Really in the Bag?

- **N** – ammonium nitrate, $\text{NH}_4\text{NO}_3$, 34-0-0
  - ammonium sulfate, $(\text{NH}_4)_2\text{SO}_4$, 21-0-0
  - urea, $\text{CO(NH}_2)_2$, 46-0-0

- **P** – diammonium phosphate, 18-46-0
  - monoammonium phosphate, 11-48-0
  - calcium phosphates, 0-20-0 to 0-45-0

- **K** – potassium chloride, $\text{KCl}$, 0-0-60
Nutrients with Other Amendments

- Fertilizer with herbicides
- Fertilizer with insecticides
Is There a Problem Adding Too Much Nutrient?
Water Quality and Nutrient Issues

Second Challenge
PLATE 27  Excessive inputs of nitrogen and phosphorus from upstream farmland resulted in the algal bloom that caused this slow-moving coastal plain stream to become choked with a green scum.
Eutrophication

Phosphorus in surface runoff

Phosphorus fertilizes small floating aquatic plants.

Light penetration is reduced.

Reduced submerged aquatic vegetation (SAV)

Plants die off. When they decompose, the water becomes depleted in oxygen.

Some animals die because of lack of oxygen.
• Too much inorganic P can induce Fe and Zn deficiencies
Organic vs inorganic sources of nutrients

- Plants can only take up nutrients in the inorganic form.
- Example: organic N forms are amino acids, inorganic N forms are nitrate ($\text{NO}_3$) and ammonium ($\text{NH}_4$).
- Nitrate is water soluble and moves wherever the water goes.
- Ammonium adheres to the cation exchange sites or is converted to nitrate by microorganisms.
Organic vs inorganic sources of nutrients

- Soil amendments
  - Not regulated in Texas
  - List of organic sources from Master Gardener Handbook page 2-16
  - If it has nutrient analyses on label, can make recommendations
County Soil Survey Report
Soil Survey of Grimes County, Texas
Navasan Series

The Navasan series consists of very deep, moderately well drained, sandy soils on low stream terraces. These soils formed in sandy sediments. Slopes range from 1 to 5 percent.

Typical pedon of Navasan loamy sand, 1 to 5 percent slopes; from the intersection of Texas Highway 39 and Farm Road 1696 north of Iola, 0.4 mile north on Texas Highway 39, about 4.5 miles west on Democrat Road, and 500 feet north of the road in a pasture:

Ap—0 to 6 inches; light brown (7.5YR 6/4) loamy sand, pink (7.5YR 7/4) dry; structureless; single grained; loose, nonsticky, nonplastic; many fine roots; slightly acid; clear smooth boundary.

E1—6 to 30 inches; pink (7.5YR 8/4) loamy sand, pink (7.5YR 8/4) dry; structureless; single grained; loose, nonsticky, nonplastic; common fine roots; slightly acid; gradual wavy boundary.

E2—30 to 65 inches; pink (7.5YR 8/4) loamy sand, pink (7.5YR 8/4) dry; single grained; loose, nonsticky, nonplastic; slightly acid; few fine roots; gradual wavy boundary.

B/E—65 to 75 inches; reddish yellow (7.5YR 6/6) sandy clay loam, reddish yellow (7.5YR 7/6) dry; moderate medium subangular blocky structure; about 40 percent, by volume, pink loamy sand in pockets and tongues; structureless; single grained; loose, nonsticky, nonplastic; few fine roots; slightly acid; clear wavy boundary.

Bt—75 to 85 inches; light brown (7.5YR 6/4) sandy clay loam; common medium distinct red (2.5YR 5/6) and light yellowish brown (10YR 6/4) mottles; moderate medium subangular blocky structure; hard, firm, nonsticky, nonplastic; few fine roots; few patchy clay films on faces of peds; moderately acid; clear smooth boundary.
Other Soil Amendments
Raised Flowerbeds/Gardens

- Use a mixture of topsoil and compost
- Compensate for the nutrients in the compost and topsoil and reduce the amount of nutrients added through other organic sources or inorganic sources
- Evaluate your topsoil before purchasing
He makes grass grow for cattle, and plants for man to cultivate bringing forth food from the earth...Psalm 104:14

• Remember that it is God who pushes tiny shoots of wheat up through the soil, and provides pasture for the livestock to graze. Our own efforts are powerless without the impulse of our creator’s hand.

• Pam Painter, Poseyville, IN

• The Fellowship of Christian Farmers International
Designated Driver

Texas Style