

## 2019 Envirothon Soils Training



2012 Envirothon, High Rock Park, Staten Island

**Richard K Shaw**  
Soil Scientist  
USDA-NRCS

# Introduction

## Who Are We?

**U.S. Department of Agriculture  
Natural Resources Conservation Service**

## What Do We Do?

**“Provide leadership in a partnership effort  
to help people conserve, maintain, and improve  
our natural resources and environment.”**



## USDA-NRCS Soil Science

*“Helping People Understand Soils”*

<https://www.nrcs.usda.gov/wps/portal/nrcs/site/soils/home/>

- National Cooperative Soil Survey

**Web Soil Survey**

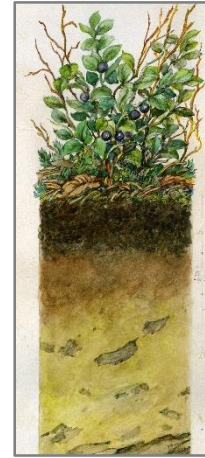
- Technical Soil Services for NYC & NJ

**Provide up-to-date soil information for the urban environment  
with soil maps, site inspections, training, & research**



# Why are Soils Important?

## Ecosystem Services



- **Provisioning services: food, fuel, fiber, raw materials**
- **Regulating services: water flow; carbon & nutrient cycling & storage; waste treatment**
- **Supporting services: habitat and genetic diversity**
- **Cultural services: buildings, roads, playing fields; archive of geologic & cultural heritage; inspiration for art, design, culture**

<http://www.fao.org/agriculture/crops/thematic-sitemap/theme/spi/soil-biodiversity/soil-ecosystems-services/en/>

# What is Soil?



Occum loam, Bronx

- **mixture of mineral and organic materials**
- **forms on the surface of the earth (and other planets)**
- **changes in response to climate and organisms**

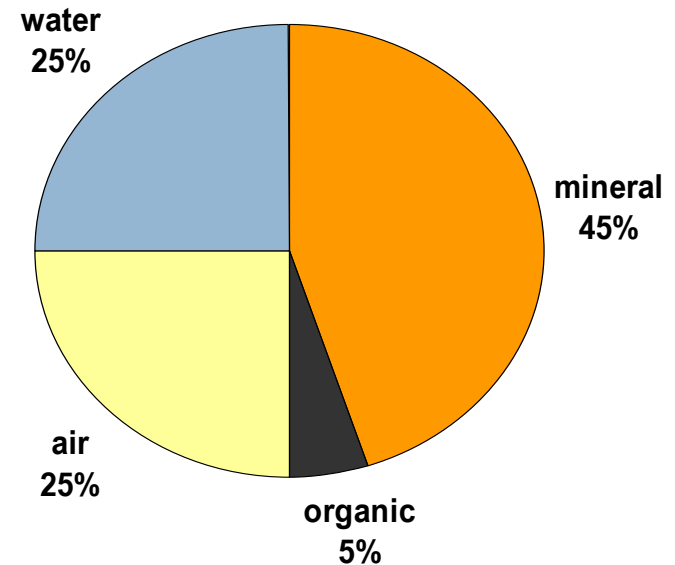
# Soil Components

## Solid space

- **mineral material** (from rocks)
  - **sand, silt & clay sized particles**
- **organic material** (from plants & animals)
  - **various stages of decomposition**

## Pore space

- **air**
- **water**



An ideal agricultural soil  
50% pore space  
50% solid space

# Soil Mineral Components

## USDA Particle Size Classification

### Sand 2 to 0.05mm

- mostly quartz
- low chemical activity
- large pore spaces
- high conductivity or permeability  
(air & water can move rapidly)
- low water holding capacity
- feels gritty



Sand grains

# Soil Mineral Components

## USDA Particle Size Classification

**Silt**      **0.05 to 0.002mm**

- **mostly quartz**
- **low chemical activity**
- **medium pore spaces**
- **medium conductivity or permeability**
- **medium water holding capacity**
- **feels smooth**

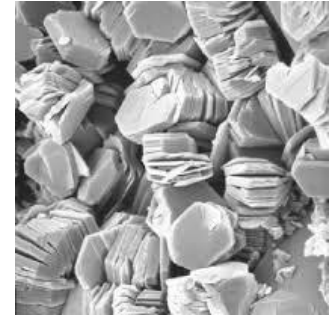


**Silt erodes easily**



# Soil Mineral Components

## USDA Particle Size Classification



clay particles,  
magnified

**Clay < 0.002mm (2 microns)**

- **layer silicates and oxides (Fe, Al)**
- **chemically active**
- **high water & nutrient holding capacity**
- **small pore spaces (but more total pore space!)**
- **low conductivity or permeability (air & water move slowly)**
- **feels sticky & plastic**

# USDA Particle Size Classification

## Coarse Fragments >2mm

### 1) Size

- **Gravel - 2 mm to 3 inches**
- **Cobbles - 3 to 10 inches**
- **Stones - 10 to 24 inches**
- **Boulders ->24 inches**

### 2) Type

- **Natural rocks**
- **Artifacts (human manufactured)**



# Effects of Coarse Fragments

Can create large pore spaces

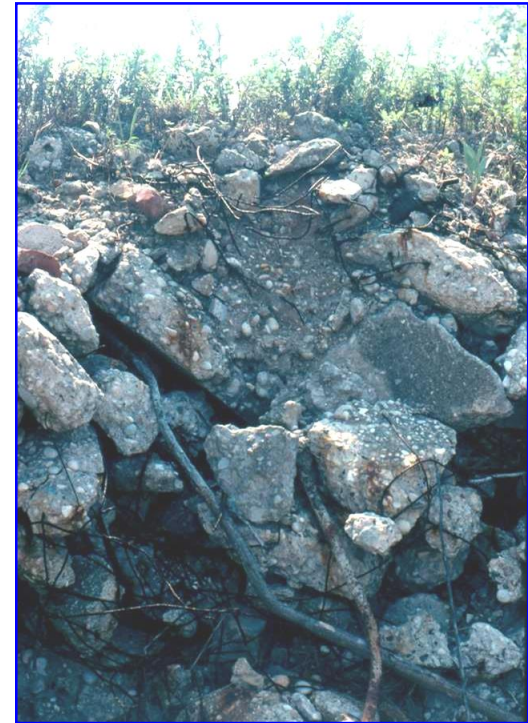
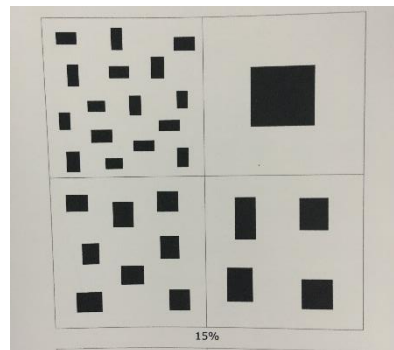
Can decrease water & nutrient holding capacity  
(take up volume)

Some artifacts contain trace metals, PAHs

Some artifacts (e.g., concrete) will raise soil pH

Textural modifier used when  $>15\%$  by volume:

- gravelly
- cobbly
- stony
- bouldery



Inwood cobbly sandy loam,  
Soundview Park, Bronx

# Soil Texture

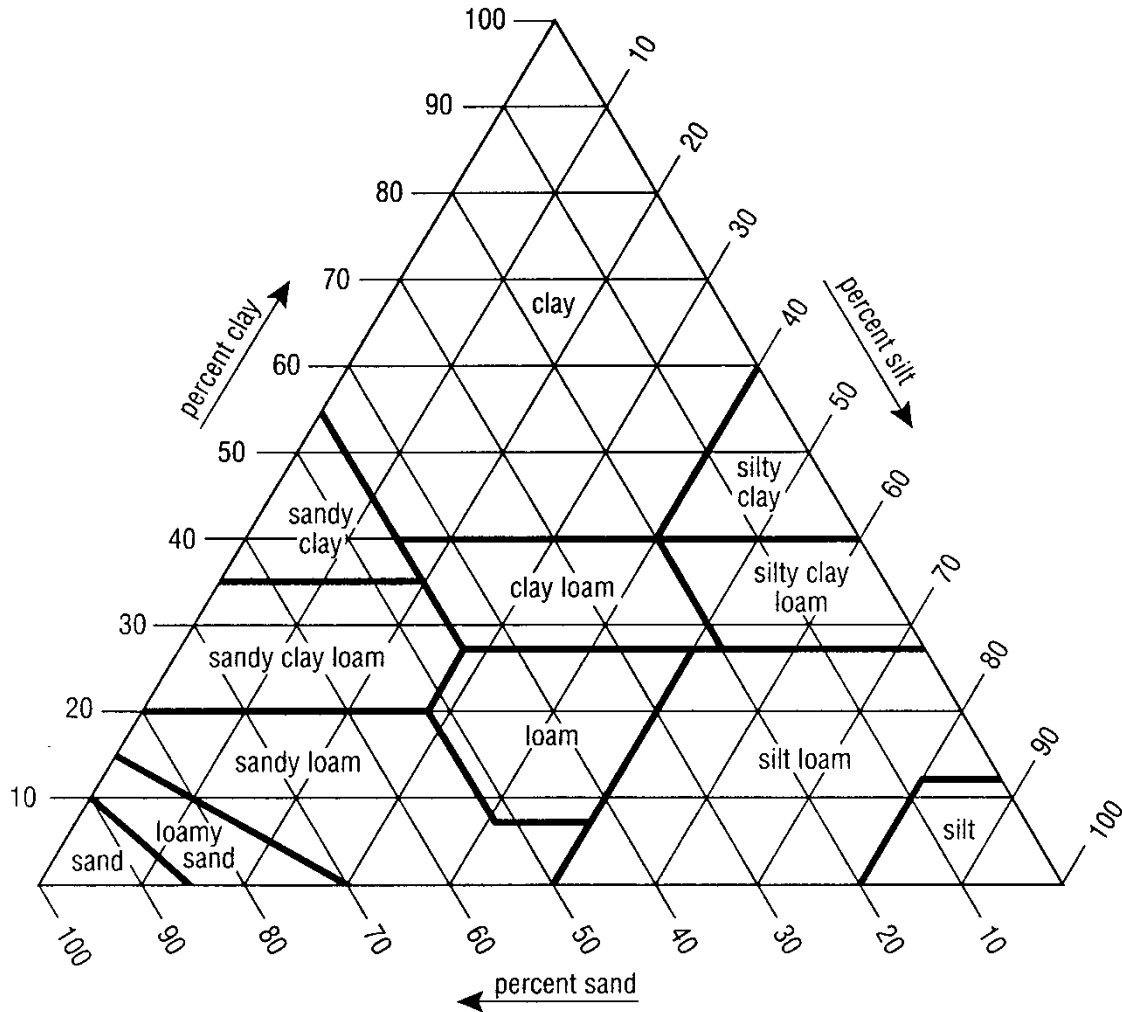
## Relative proportion of sand, silt and clay in a soil

- **Important effect on:**
  - permeability
  - water & nutrient holding capacity
  - soil suitability for many uses.
- **Can be measured by sedimentation**
- **Can be estimated by “feel”**



**Soil Particle Size Analysis**

# USDA Soil Textural Triangle



## 12 textural classes

sand  
loamy sand

sandy loam  
loam  
silt loam

silt  
sandy clay loam  
clay loam  
silty clay loam

sandy clay  
clay  
silty clay

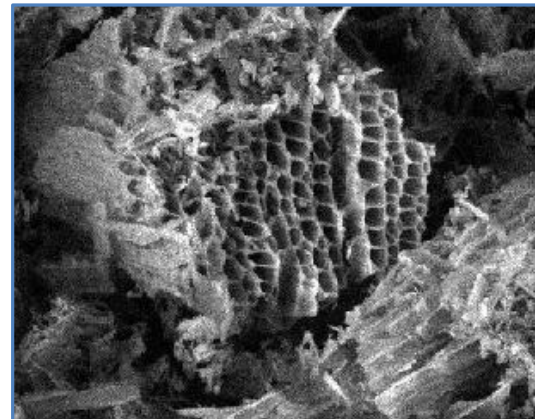
# Soil Organic Matter

(~60% carbon)

- **Living**
    - Microbial biomass
    - Roots
  - **Active fraction**
    - relatively fresh residues
  - **Well decomposed**
    - humus (more resistant)
  - **Black carbon**
    - Byproduct of combustion (charcoal, soot)
- 
- ✓ chemically active
  - ✓ high surface area
  - ✓ high water & nutrient holding capacity
  - ✓ promotes aggregation
  - ✓ reduces plasticity & cohesion
  - ✓ supplies nutrients



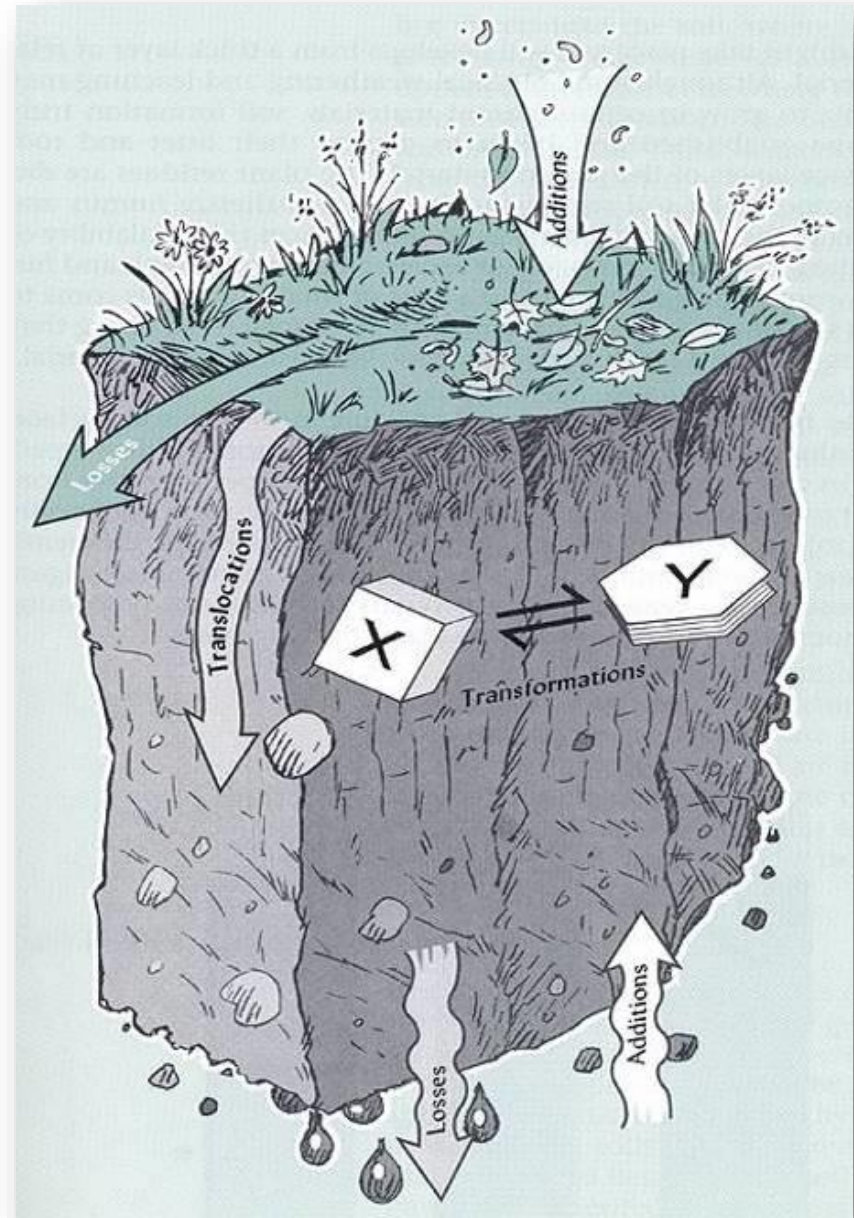
Organic matter from a Staten Island tidal marsh soil



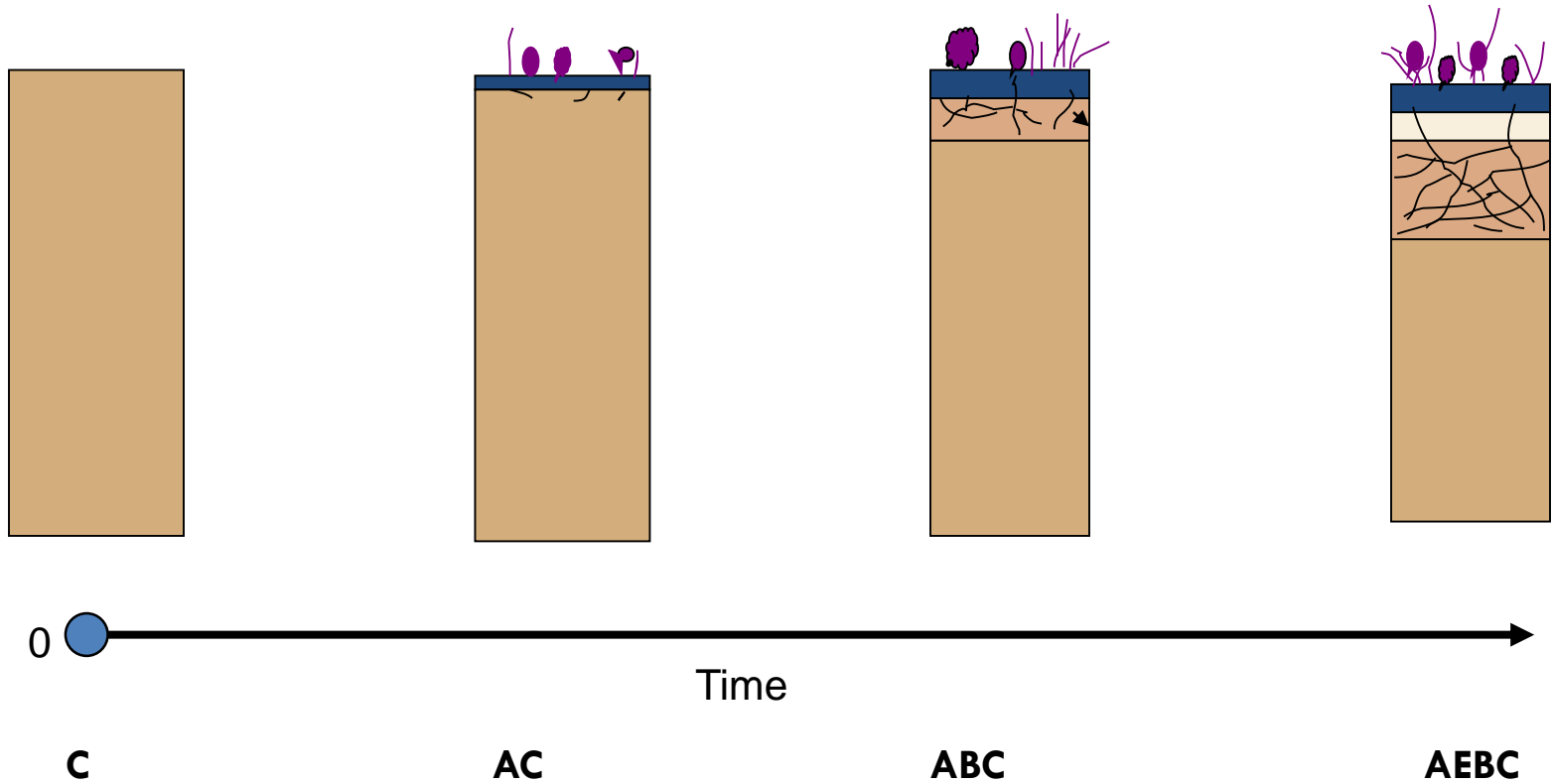
SOM, magnified

## Soil Forming Processes

- **Additions**
- **Losses**
- **Translocations**
- **Transformations**



# Soil Formation





# Why are Soils Different?

## 5 Soil Forming Factors



- 1) **Climate**
- 2) **Organisms**
- 3) **Relief or topography**
- 4) **Parent material**
- 5) **Time**

$$\text{soil} = f(\text{cl, o, r, p, t})$$

# How do soils differ?

## Important Soil Properties

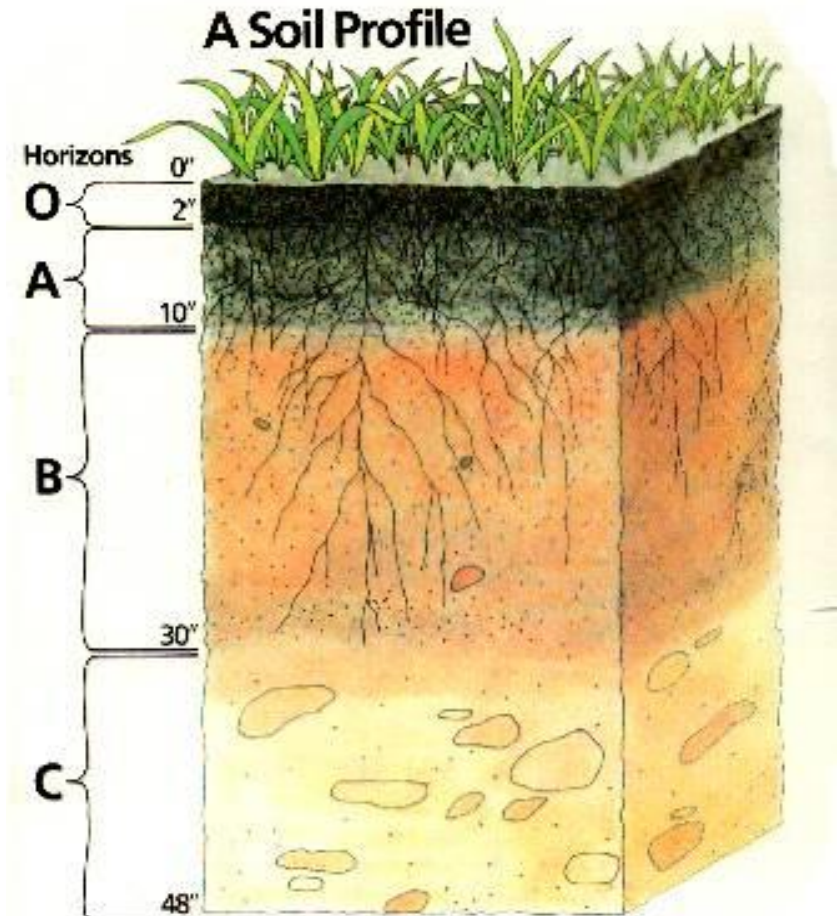
- **Horizonation**
- **Color**
- **Texture (particle size distribution)**
- **Structure (aggregation)**
- **Consistence (firmness)**
- **pH and chemical properties**
- **Depth to water table (wetness)**



Charlton sandy loam,  
Bronx

# Soil Horizons

- O – Dominantly organic material**
- A - Mineral layer with accumulation of organic matter (topsoil layer)**
- B - Development of color & structure (subsoil layer)**
- C – Parent material with no evidence of soil forming processes**



# Soil Color



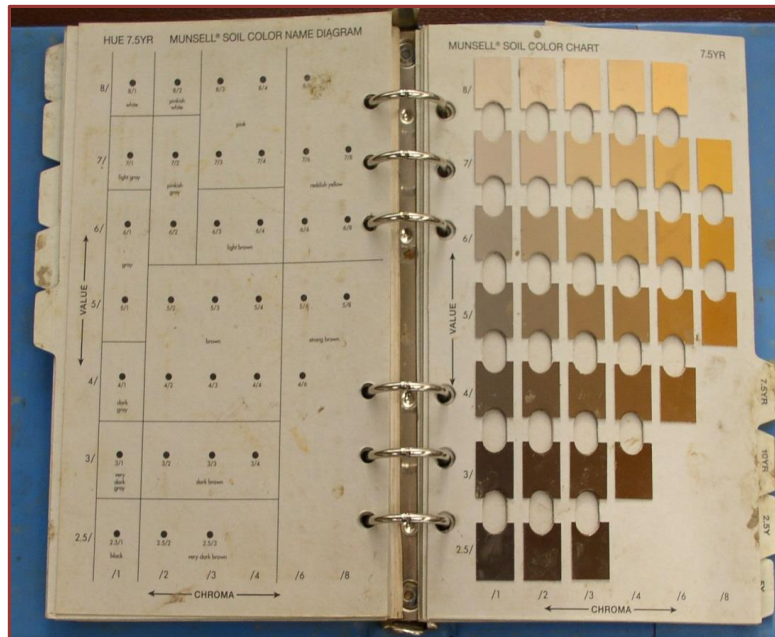
**Boonton loam, Staten Island**

## Important coloring agents in soil:

- 1) **Organic matter**
  - **Darkens the soil (topsoil)**
  
- 2) **Iron**
  - **Brown, red, or yellow iron oxides form in aerated soils**
  - **Can be removed from saturated soils (gray color remains)**

# Soil Color

**Munsell color system**  
**Albert H. Munsell, early 1900s**  
**Boston Normal Art School**



**Described with soil color chart**

- ✓ **Hue (5 major colors\*)**
  - Pages for different hues
- ✓ **Value (lightness/darkness)**
  - Top to bottom of page
- ✓ **Chroma (purity/intensity)**
  - Left to right of page

**\*red, yellow, green, blue, purple**

## Redoximorphic Features

Mottled (spotted) soil colors can be the result of a fluctuating water table.

They are caused by bacteria-driven reduction-oxidation chemical reactions:

- ✓ iron is solubilized when/where the soil is anaerobic (no oxygen);
- ✓ iron will precipitate when/where the soil is aerated.



# Soil Structure

- Aggregation of particles into secondary units
- Influences porosity, erodibility
- Can be affected by management  
(can be an indicator of soil quality)



# Soil Consistence

**Strength and adhesion of soil material**

**or**

**Resistance of soil aggregates to rupture under applied stress.**

**Varies with soil moisture content (e.g., moist, wet, dry) due to cohesive & adhesive forces.**

**Affected by natural processes as well as land use & management practices.**

**Effects on soil water movement, plant rooting.**

**Moist consistence classes:**

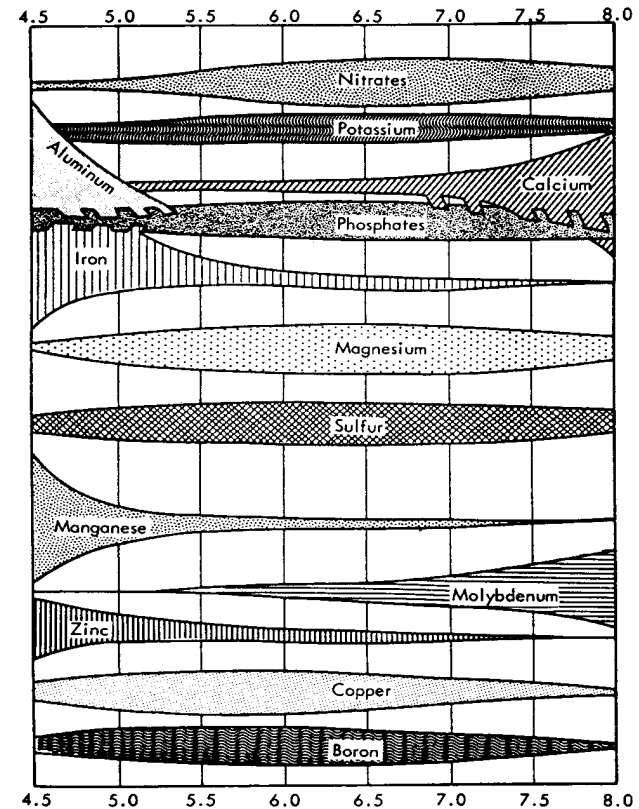
**loose; friable; firm; very firm**



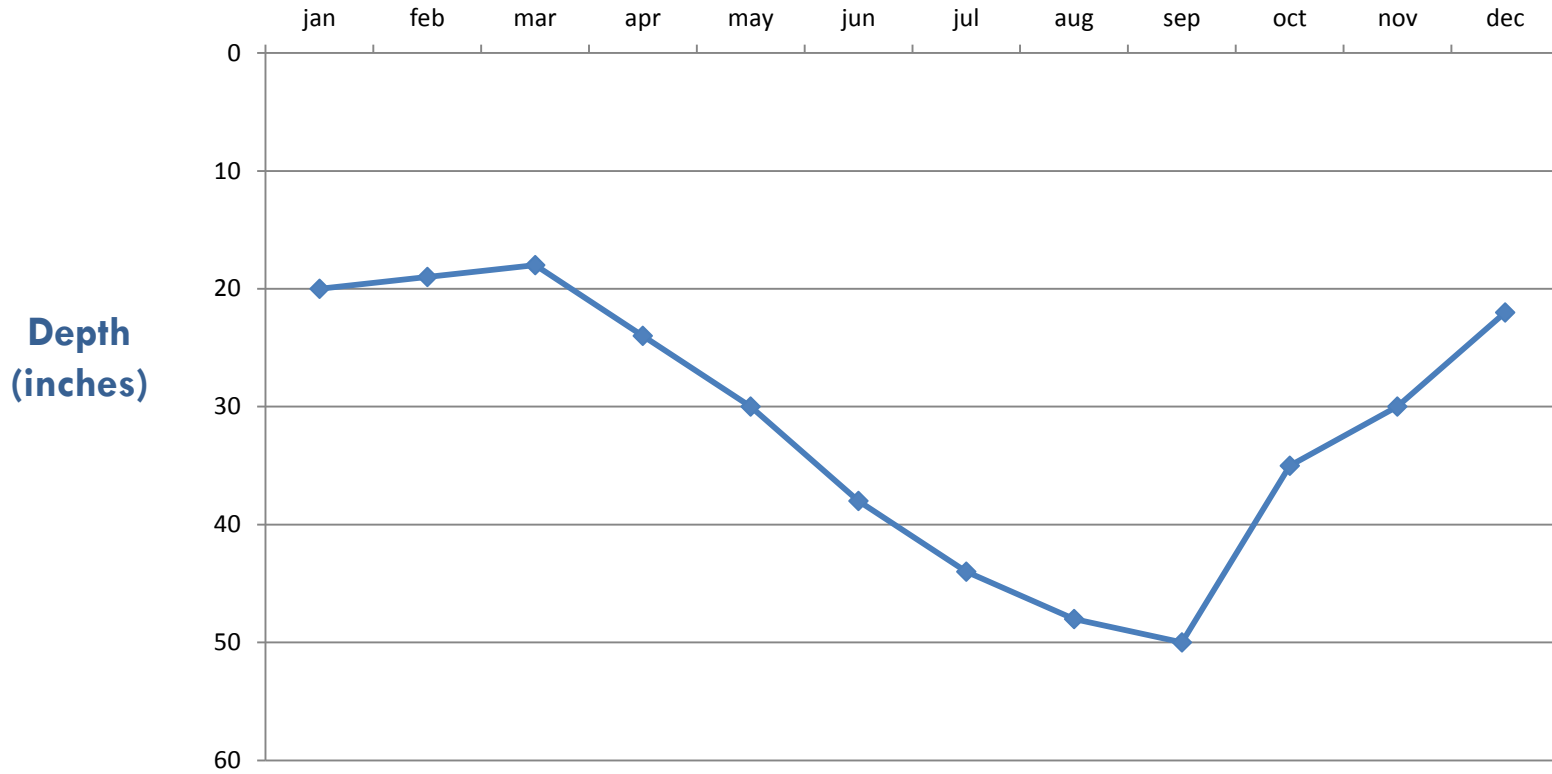


# Soil pH

- **measure of  $H^+$  activity**  
 **$H^+$  and  $Al^{+3}$  vs  $Ca^{+2}$ ,  $Mg^{+2}$ ,  $K^+$**
- **“master variable,” controls:**
  - ion exchange,
  - dissolution/precipitation,
  - oxidation/reduction,
  - adsorption & complexation
- **soils in humid areas naturally acidic**
- **urban soils commonly higher values**
- **easy to measure**



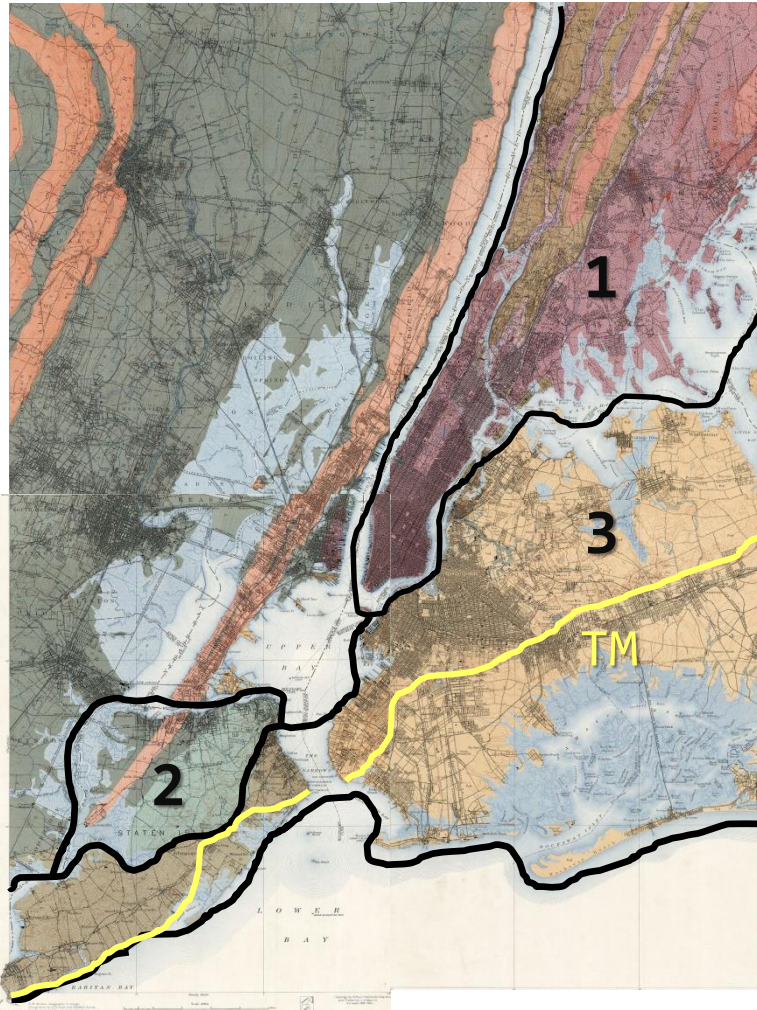
# Seasonal high water table



**Water table depth as measured by piezometer (cased well)**

✓ **Closest to the surface in winter months (non-growing season)**

# NYC - Geomorphic Setting



- **3 Physiographic Provinces**

- 1) New England Upland
- 2) Triassic Lowland
- 3) Atlantic Coastal Plain

- **Glacial deposits**

- shallow & deep till
- terminal moraine TM (edge of ice sheet)
- meltwater deposits

- **Postglacial deposits**

- alluvium
- tidal marsh

- **Anthropogenic disturbance**

- Human-altered materials
- Human-transported materials

**Parent materials**

# NYC Soils

## Extent of human alteration



**Native soil**  
Deerfield loamy sand  
Staten Island



**Clean fill**  
Greenbelt loam  
Bronx



**40% artifacts**  
Laguardia sandy loam  
Bronx



**95% artifacts**  
Mosholu silt loam  
Bronx



**Sealed soil**  
Urban land  
Manhattan

### % of land area

- **Native soils**            **8.8**
  - **Clean fill**                **19.3**
  - **Artifactual soils**      **7.7**
  - **Sealed soils**            **62.6**
  - **Misc. areas**            **1.6**
- rock outcrop, beaches, etc**

## Topographic Map Bronx Park

**Map of relief or surface  
elevation using contour lines**

**Contour lines join points of  
equal elevation**

**Where lines are close together,  
greater change in elevation  
(steep)**

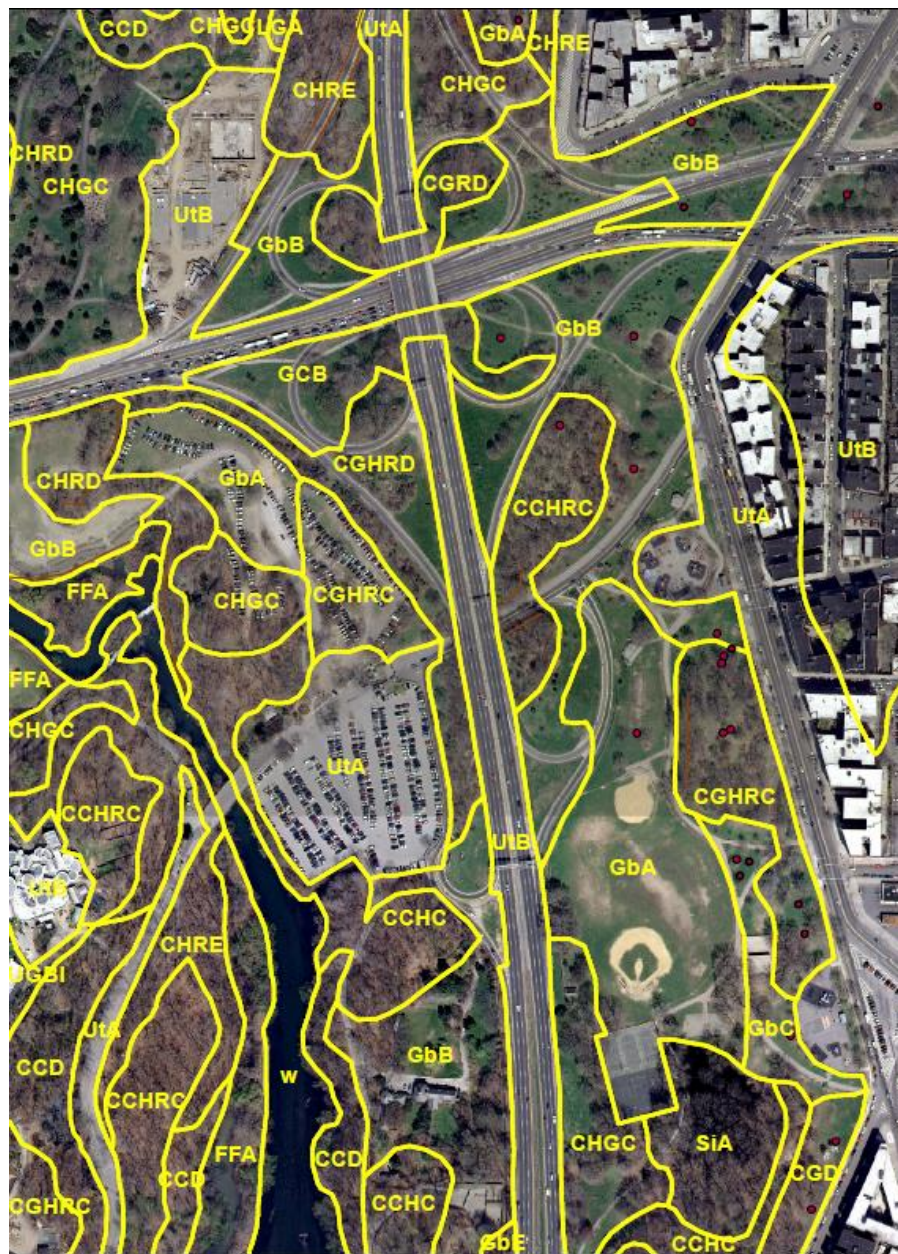
**contour interval here = 2 feet**



# Soil Survey Bronx Park

## Some soil map units

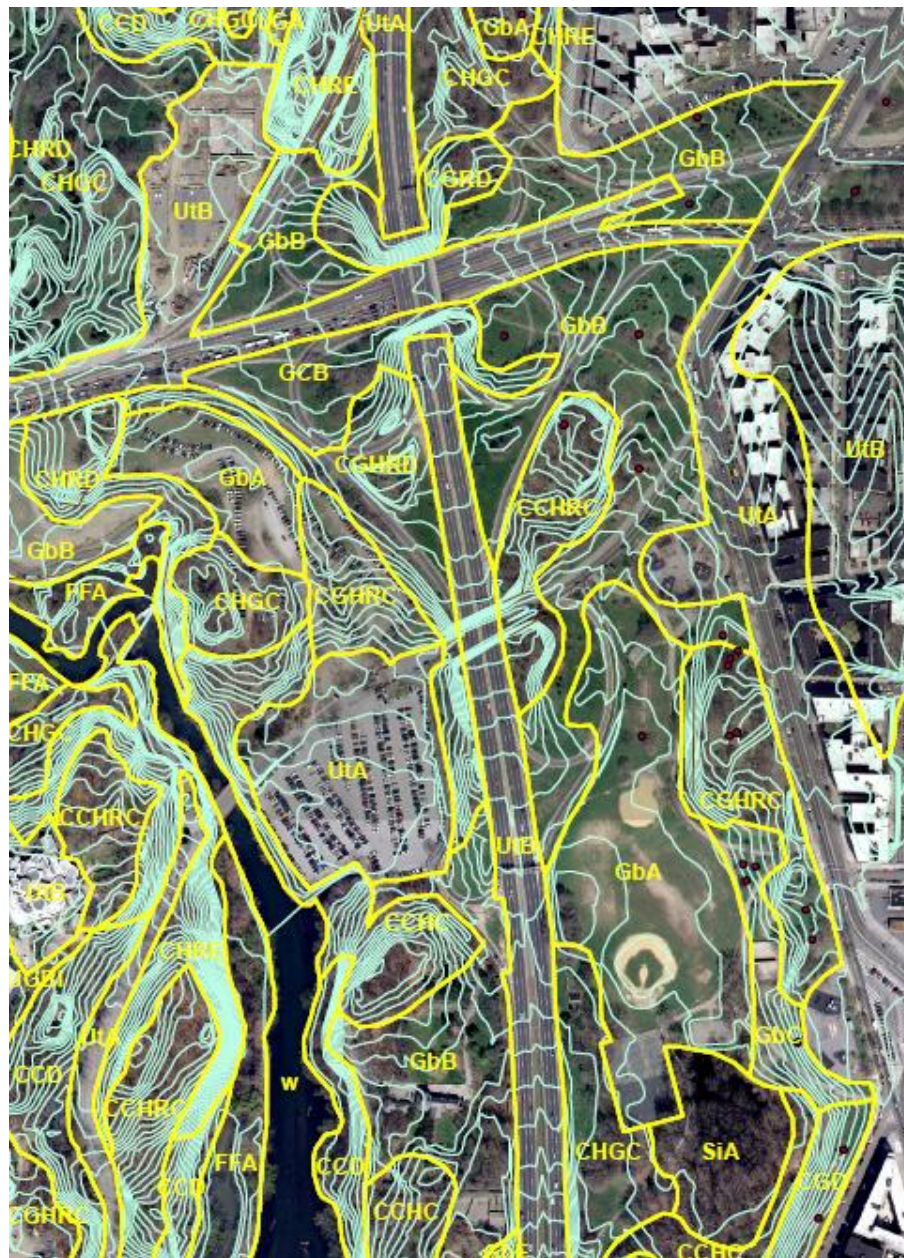
- GbA** Greenbelt sandy loam, 0 to 3 percent slopes
- GbB** Greenbelt sandy loam, 3 to 8 percent slopes
- GCB** Greenbelt-Centralpark complex, 3 to 8 percent slopes
- CCHRC** Chatfield-Charlton-Hollis-Rock outcrop complex, 0 to 15 percent slopes
- CGHRC** Chatfield-Greenbelt-Hollis-Rock outcrop complex, 0 to 15 percent slopes
- SiA** Siwanoy silt loam, 0 to 3 percent slopes



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# Some Soil Survey Information

**SiA – Siwanoy silt loam, 0 to 3 percent slopes**



**Siwanoy silt loam  
Pelham Bay Park**

## Soil Properties

- **Typical Profile: A-B-BC-C-2C horizons; 1 meter of silt loam over loamy sand**
- **pH values 5.2 to 6.2**
- **Drainage Class: Poorly drained**  
(seasonal high water table reaches the soil surface)
- **Parent material: slope alluvium over till**

## Ratings and interpretations

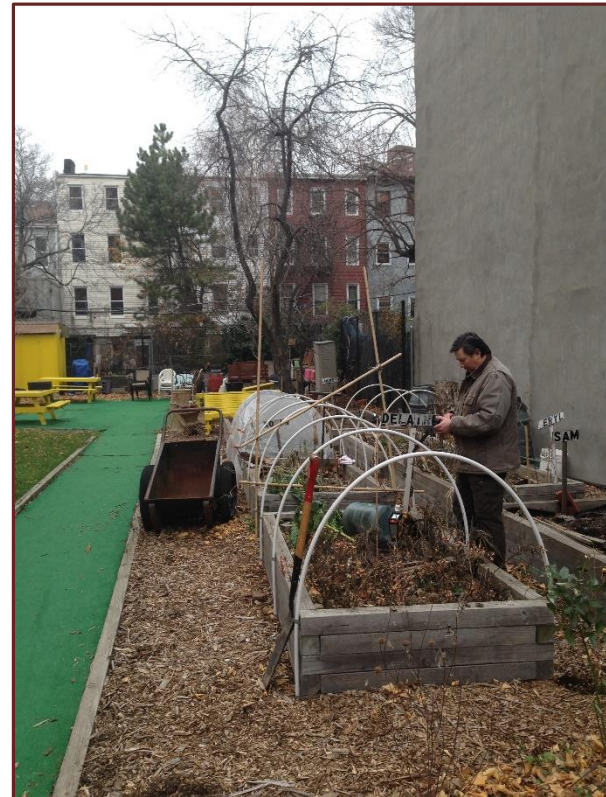
- **Small commercial buildings: very limited (depth to saturated zone)**
- **Playgrounds: very limited (depth to saturated zone)**
- **Potential for windthrow: high (depth to saturated zone)**
- **Septic tank absorption field: very limited (depth to saturated zone)**



# 2019 Environmental Issue

## *“Agriculture & the Environment: Knowledge & Technology to Feed the World”*

- ✓ **Agroecology**
  - **Productivity**
  - **Ecosystem impacts**
  - **Social responsibility**
  
- ✓ **Sustainability**
  - **Conserve resources**
  - **Mitigate climate change**
  - **Reduce erosion**
  - **Soil health**
  
- ✓ **Profitability**
  - **Successful**
  - **Employment opportunities**



Jane Bailey Memorial Garden  
Greene Ave, Brooklyn

## For More Soils Info:

- Soils training materials (city, state, national) at:  
<https://www.soilandwater.nyc/nyc-envirothon.html>
- <http://www.nysenvirothon.org/soil-and-land-use-study-guide/>
- <https://www.envirothon.org/the-competition/curriculum-guidelines>
- General soils info USDA-NRCS site:  
<https://www.nrcs.usda.gov/wps/portal/nrcs/site/soils/home/>
- Questions: [richard.shaw@nj.usda.gov](mailto:richard.shaw@nj.usda.gov)



*"Me future is settled, Willie. I'm gonna be a perfessor on types o' European soil."*

**Bill Mauldin (1921-2003)**  
45<sup>th</sup> Infantry, WWII  
Pulitzer Prize winner