NAME\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Envirothon Soils Notes-Mrs. Weimer

* Soils -An Intro to PA Soils
* Soils record geology and climatic history of an area
* Soil Development
  + Geologic Cycle
    - Soil develops quickly on geologic time scale, but each of the three rock types forms at different rates
    - Phase of cycle where minerals interact closely with life
    - Weathering- \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Soil develops directly above the weathering rock and remains on stable land, but is eroded on unstable land
* Igneous Rock
  + Common in southeast PA
  + Form from solidification of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Examples: granite, pumice, obsidian
* Sedimentary Rocks
  + Form from compaction or cementation of \_\_\_\_\_\_\_\_\_\_\_\_\_
  + Clay 🡪 \_\_\_\_\_\_\_\_\_\_\_\_\_
  + Silt 🡪 \_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Sand 🡪 \_\_\_\_\_\_\_\_\_\_\_\_\_
  + Carbonates 🡪 \_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Metamorphic Rocks
  + Form from pressure and temperature affects on \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Shale 🡪 \_\_\_\_\_\_\_\_
  + Limestone 🡪 \_\_\_\_\_\_\_\_\_\_
* Weathering
  + Factors that effect weathering
    - Temperature fluctuation (freeze/thaw cycles)
    - Erosion by wind, water, and ice
    - Plant roots
    - Chemical reactions with water and air
  + Soil doesn’t often have the same minerals as the bedrock it formed from due to \_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Organic matter-decomposed/ing organisms
  + Parent material- medium in which soil develops
    - Usually weathered rock in PA
    - Decayed organic material in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ area
* Horizon Formation
  + Leaching and redistribution of minerals in the parent material creates horizons (layers)
    - A Horizon= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_- most organic material
    - B horizon= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_- more clay, denser than A
    - C horizon= Parent material, altered organic layer or weathered bedrock
    - R horizon= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Horizon layer sizes vary and can even be absent
* Vegetation
  + Types of plants affect \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Grasses- extensive roots, aerate topsoil and give crumbly texture, full of organics; makes highly productive soil (Midwest US)
  + PA- forested areas, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is main contributor, layer of organics on top, little below and within
  + Plants require specific pH, moisture, texture
* Climate and Time
  + PA- humid climate,\_\_\_\_\_\_\_\_\_\_\_\_ inches annual rainfall
  + Movement of water dissolves minerals and alkaline ions (\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_) creating acidic soil
  + Clay particles move down to subsoil, making it finer than \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Mature soil falls into clumps called\_\_\_\_\_\_\_\_\_\_\_\_\_, takes centuries to develop
  + PA has freeze/thaw cycles in surface soils creating soil with greater maturity (pedologic age) than similar soil in Arctic, but less than tropics
* Formation of PA Soils
  + Bedrock & Topography in PA
    - SE & NW edges - Sand deposits from seashore history; good for growing vegetables
    - SE- metamorphic bedrock, oldest in state; very hard, slow to erode schist, gneiss, quartzite; also igneous intrusions in siltstone that interfere with agriculture
    - Rest of PA- sedimentary, shale, sandstone, limestone from old lakes and seas; run NE to SW
    - Ridges and valleys result from varying rates of weathering/erosion
      * Hard sandstone on ridges, Soft limestone in valleys
* PA Parent Material
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ soils are too dry for crops
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ soils in valleys are productive
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ soils are acidic and nutrient poor but can be farmed with fertilizer
    - Shale areas ruined by strip mining because areas are refilled with mine spoil
    - More acres destroyed by mining in PA than in any other state
    - \_\_\_\_\_\_ law requires topsoil replacement
* Residual soil- form in present location
  + Transported soils- formed elsewhere
    - Transported Soils- Glacial till- jumble of rocks of all sizes
    - Outwash features- settles from \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Glacial soils are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ for farming
    - Aeolian/Loess- deposited by \_\_\_\_\_\_\_\_\_
    - Colluvial- rocks tumble from above
    - Contain fragipans, very dense layers impermeable to water and roots, creating watery soil above
    - Alluvial- deposited from floods, fertile for farming, bad for building due to floods
* Soil Texture
  + Determines how water and air pass through
  + Building requires \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Waste disposal requires drainage and fine material for filtering
  + >2mm Coarse
  + <2 mm Fine
    - Types: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Soil Texture
  + Sand, silt, clay are SIZES not compositions
  + Clay- <0.002mm, sticky slick feel
  + Silt- 0.05-0.002mm, silky or floury feel
  + Sand- 0.05-2mm, gritty feel
* Soil Texture
  + Sands- create large pore spaces, drain rapidly, high bearing strength; too much sand and water drains out
  + Silts-\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ water retention air circulation for agriculture, easily moved by wind
  + Clays- water clings to surface and held between tiny pores, increasing \_\_\_\_\_\_\_\_\_ capacity; bind particles together to make aggregates; too much clay and soil is impermeable; poor for building because of volume changes due to moisture variation
* Active Fractions
  + Soil with the capacity to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Clay has more surface than internal mass
    - Causes electrical forces on surface
    - Dissolved ions are attracted or repelled to clay
    - If dissolved ion is stronger than ion in clay, they swap places=\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Rate of trading ions- \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Organic matter has greater exchange capacity than clay
    - PA soils have more clay than \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - This process is how fertilizer, and the filtering capacity of soil works
* Adsorption
  + Soil Water
  + Moisture and texture determine \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Sand strength increases as water increases
    - Clay becomes \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ as water increases
    - Moist and wet are different!
  + Color is a clue to drainage
    - Gray and orange mottles indicate \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
      * Causes: Shallow bedrock, fragipan, too much clay?
* Soil pH
  + \_\_\_\_\_ best for most crops
  + \_\_\_\_\_ acidic soils to raise pH of PA soils
    - Increased rainfall = decreased pH
* Classifying Soils
  + Soil Series-
    - Grouped into orders, suborders, great groups, subgroups, and families
    - Local soils- combination of unique traits
    - Given soils- limited geographic region
* County Soil survey
  + Reports about soil
  + Contain maps, yield potential, development limitations, soil features
  + Available in books and online
* Bulk Density Moisture/Aeration
  + Weight of dry soil per unit of volume (grams/cm3)
  + Indicates \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Affects infiltration, capacity, porosity, nutrient availability
  + Inherent factors- those that cannot be changed
  + Loose, aggregated, porous, organic soils have lower bulk density
  + Sandy soils have high bulk density due to less pore space
* Composition & Water Availability
  + Bulk Density Moisture/Aeration
  + Bulk density\_\_\_\_\_\_\_\_\_\_\_\_\_\_ with soil depth
  + Can be altered by controlling soil cover, organic matter, soil structure, compaction, and porosity
    - Decrease tillage, use cover crops, apply manure, rotate crops, plant residue crops, no equipment on wet soil, stay on roadways, use plants of varying root depths
* Bulk Density Moisture/Aeration
  + When water-filled pore space exceeds \_\_\_\_\_\_\_
    - Respiration and nitrogen cycling increase
    - Lack of aeration
      * Over \_\_\_\_ denitrification occurs, emitting greenhouse gases and requiring N fertilization
* Bulk Density Moisture/Aeration
  + - High bulk density means low porosity and \_\_\_\_\_\_\_\_\_\_\_\_
    - Lower crop yields and plant growth
    - Less infiltration increasing runoff and erosion
    - Infiltration
      * ability to allow water movement into and through the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
      * Temporary water storage for plants
      * Most effected by factors near the \_\_\_\_\_\_\_\_\_
      * Inches per hour
  + Too low- ponding, erosion, dry soil
  + Too high- nitrogen or pesticide leaching
  + Texture is main inherent factor
  + Clay soils- crack when dry increasing rate, but when moist have low rate
* Infiltration Management
  + Avoid compaction, use ground cover to avoid soil crust, increase organics, contour farming, no till, crop rotation
  + As soil moisture levels increase, infiltration rates \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Soil organic matter binds soil particles together in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, increasing porosity and infiltration
  + Poor infiltration= poor aeration
    - Poor plant function
  + Infiltration Management
  + Improve infiltration by:
    - Avoiding disturbances
    - Using\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Add\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Rotate high residue crops
    - Plant cover crops
    - Contour farming
    - Establish terraces
  + Problems Associated with Infiltration
  + Runoff 🡪 Erosion
    - Carries nutrients, chemicals 🡪 decreases soil productivity
  + Poor soil aeration
  + Poor root function
  + Reduced \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Soil surface is most important in determining infiltration
* Organic Matter
  + Consists of 3 parts
    - Plant residue, small animals
    - Decomposing organic matter
    - Stable organic matter (humus)
  + Holds nutrients, retains moisture, reduces compaction, reduces crusting, increases infiltration
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ on soil surfaces like leaves, manure, and crop residue don’t count as soil organic matter
* Organic Matter
  + Impacts rate of herbicides and soil pH necessary to control weeds
    - How much lime to raise pH?
  + Affected by climate, soil texture
    - Warm, humid climate, aeration increase \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ slows decomposition
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ have 2x organics as forest
  + Grass and roots die back
  + Trees have less root mass, don’t die back, organic material in wood, not returned
* Organic Matter Management
  + Low C/N ratio = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Decompose more quickly
  + High C/N ratios don’t increase organic matter quickly
  + Increase moisture, temperature, and aeration to increase decomposition
    - No till, cover crops, solid manure, no till, reduce erosion, test soil and fertilize accordingly, use perennial grasses
* Organic Effect on Function
  + Nutrient Supply- each percent of organics releases 10-20lbs. N, 1-2lbs. P, 0.4-0.8lbs. S
  + Water holding capacity- sponge-like, holds \_\_\_\_\_\_of weight in water, releases it slowly
  + Soil Aggregation- clumps of soil, improves structure, infiltration
  + Prevents Erosion due to increased \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Estimating Organics Needed
  + Steady state- rate of organic matter addition equals rate of decomposition
  + If addition < decomposition, organic matter declines
  + If addition > decomposition, organic matter increases
  + 10lbs of organic material decompose to form \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_-
* How to Measure Organics
  + Gather multiple samples
  + Moisten dry soil
  + Match color to chart
  + Record data
* Soil pH
  + Measure of alkalinity or acidity
  + Affected by climate, minerals, texture, parent material, topography, organisms,
  + Temperature and rainfall control \_\_\_\_\_\_\_\_\_\_\_\_\_\_ and mineral weathering
  + Generally decreases over time, less effects in dry climates
  + High clay and organics moderate changes
  + Forests are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ than grassland
  + Land conversion causes drastic change
  + Adding N and S decrease \_\_\_\_\_
* Management
  + Lime increases pH, use N and S only as needed, manage irrigation to limit leaching, rotate crops, apply manure with high Ca and Mg biocarbonates, no till
* Problems Related to pH
  + Most crops prefer \_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Nutrient deficiency occurs outside this range
  + Decreased \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Low pH slows N cycle
  + Increased disease
* Management Strategies
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Apply P fertilizer in small amounts
  + Reduce soil/P source contact by banding or injecting
  + Place P fertilizers near plant rows
* Measuring Soil pH
  + Hand test
    - Use at least \_\_\_\_\_ samples due to high variability
    - Sample from 8 inches
    - Rub soil on hands to neutralize
    - Saturate soil with distilled or rainwater
    - Squeeze slurry into cup
    - Use pH test strip by touching tip and allowing capillarity to pull water up
    - Compare color
  + Measuring Soil pH
  + In Lab
    - Sample methods are the same
    - Mix with water in vial, in 1:1 ratio. Shake
    - Repeat pH paper process
* Soil Health Nuggets
  + More organisms in teaspoon of soil, than people on earth
    - bacteria, algae, microscopic insects, earthworms, beetles, ants, mites, fungi, yeasts, protozoa, nematodes
  + Best soil on farms is found \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Undisturbed
  + Tilling (Plowing) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Destroys aggregates, reduces organics, increases erosion
  + Tilling does NOT increase infiltration
    - Pores collapse
  + Organic Matter half gone
    - Prairies were 5.5-6.5% organics, now \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Seeding cocktails of plants is good
    - Mix 6-12 plants for diversity
  + If you want healthy soil, you shouldn’t see it often
    - Keep it covered with living plants
  + Some plant roots grow 3 feet deep in \_\_\_\_days
    - Loosen soil
  + Thomas Jefferson used cover crops
  + More species = more benefits
    - Rotate crops
    - Soil Health
* Capacity of the soil to function
  + Maximize health to produce maximum product at least cost
  + Very intertwined system, actions in one area cause domino effect, and weakens the relationships between the various components
* Symbiotic mutualism
  + Bacteria help acquire \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Fungi form pipelines helping plants acquire nutrients and water
* Soil Health
  + Diversify with Crop Diversity
    - Carbon enters soil through \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ with microbes, and by critters eating dead plants and releasing wastes
    - Rotating crops provides diversity in nutrients to soil cycle
  + Rhizosphere- concentrated microbial activity close to plant roots, increasing nutrient and water cycling
    - The longer rooted plants are in the ground, the more this occurs, so keep fields planted
    - No roots increases the workload on \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Keep soil covered as much as possible
    - Conserves moisture, reduces droplet impact, suppresses weeds, provides habitat, cools soil
    - Shredders like these conditions and their presence increases nutrient cycling
  + Mimic nature
    - \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Create fields like fence rows
    - Use \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Use multiple species (\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ per cover crop)
    - Rotate in legumes (alfalfa, soy beans, clover, etc.) to supply N, then plant corn