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