**Earth Science 2B03 | September 8th | Lecture 1**

* Mark Distribution
  + Lab (3) = 25% Total (7% + 7% + 11%)
  + Midterm = 35%
    - Thursday, October 27th, 2016
  + Final Exam = 40%
* Textbook
  + Elements of the nature and Property of Soils By Brady & Wells
  + The Nature and Properties of Soil By Brady & Wells
    - Older editions are perfectly fine but may differ in page and figure numbers
* Chapter 1
  + \*Almost nothing from chapter 1 comes in an exam\*
  + 10,000 years ago Canada was covered in glaciers
    - Scrapped everything clean and went away
  + Soil slowly develops over thousands of years
  + Top soil (A-Horizon) is rich in nutrients
  + Reddish soil is called the B-Horizon and is caused by weathering
  + Soil slowly change over decades
    - 4 – 5 years is the window of time until we notice change
  + Geology is even slower
  + Climate change did not cause Hurricane Katrina
  + 15 years from now (2030), 40% of the human population will face a water crisis
  + Climate change is real
    - Data proves it

**Earth Science 2B03 | September 12th | Lecture 2**

* Soil is distributed all over Canada
  + Primarily in the prairies
    - Ontario is losing lots of agricultural land
* Regolith: Unconsolidated rock
  + Soils form top of the regolith
* C Horizon: Starting of soil; the original content – stuff you started with it
* Solum: A Horizon + B Horizon
  + Solum is universally used
* B Horizon: Often tinted orange-ish, due to accumulation of iron, magnesium, and calcium. Occurs over a long period time
  + Diagnostic; great for testing the soil and understanding the pedology
* A Horizon is a mineral horizon with a little bit of organic matter
  + Extremely slow formation process
* O Horizon is pure organic matter
  + Biologists would prefer to study this area
* Bedrock soil is called saprolite
* Canada has soil less compared to other places
  + Due to the glaciers scrapping away everything; reset the geological clock
* To get 1 meter of soil, it takes thousands of years. Soil formation takes a long time
* Humans can alter the process of soil formation and speed up its formation
* Engineers refer to soil differently than environmental scientists
  + Engineers use soil to refer to unconsolidated material
* Soil plays a key role in the hydrological cycle
  + Dictates if you can have a septic system
    - Percolation test
      * Organic waste has to seep through the ground at a set rate to allow microbes and other organisms to break down the waste
* Soils differ by area and dictate the growth of life
  + i.e. Desert = almost no life
    - Climate dictates the soil which dictates the vegetation
  + i.e. Deciduous trees in southern Canada and coniferous in northern Canada
* Land farming: Placing organic waste on farms
* Fertilizer changes the biological activity of the soil
  + Short term = Higher crop yield
  + Long term = Degrades soil quality
* Pesticides, herbicides, etc. are harmful
  + i.e. DDT 🡪 Wiped out the raptor (bird) population
* A soil individual = Polypedon
  + Classify soil based off of geological areas
    - Look at land pits and analyze soil composition
      * Used for creating soil maps
    - B Horizon is used for classification
  + An Ae Horizon has been stripped of all its nutrient materials and organic matter
  + An Ah Horizon consists of all the organic matter
* Diffusion occurs due to a concentration gradient
  + Occurs very slowly
* Plants and trees have roots because:
  + Provide stability and support
  + Accumulate nutrients and water
    - Similar to microscopic drainage systems
    - The deeper the roots, the more nutrients and water it can gather

**Earth Science 2B03 | September 15th | Lecture 3**

* Soils can be sand, clay, silts, or a combination of them. In any case, it’s a porous medium
  + Composition of minerals, air, water, and organic matter
    - The pore space (water & air) is the dynamic part. The quantity of each changes based on the climate and condition
      * If it rains, then water quantity rises. When dry, air rises
* Air is:
  + Approximately half of the volume of the soil consists of pore spaces of various sizes which are either filled with air or water
  + When water enters the soil, it displaces from some of the pores
  + Metabolic activity of plant roots, microbes, and soil fauna later the composition of soil air
  + The relative humidity of soil approaches 100% unless the soil is very dry
  + Carbon dioxide in soil air is often several hundred times more concentrated than the 0.03% found in the atmosphere.
  + The amount of composition of air in a soil are determined to a large degree by the water content of the soil
* Soil formation is a complex process that takes place over decades or centuries. The soil pedon is an open, dynamic system that allows additions, removals, transfers and transformations of energy and matter
  + Horizons develop as a result of numerous processes in the soil. These processes are classified into one of the following transformations:
    - Additions
      * i.e. Rain, organic matter, etc.
    - Losses/Removal
      * i.e. Landslides, mudslides, etc.
    - Mixing
    - Translocations
    - Transformations
      * i.e. Chemical reaction changing the the chemistry
  + Organic and mineral master horizons are further divided into distinct horizons by added a suffix to master horizons. Soil pedons have distinct horizons and combinations
* Alluvial (fluvial) deposits are caused by fast moving streams
  + Deposits are not limited to clay, but include sand and silts
* Colluvial deposits are caused by gravity. Gravity causes objects to roll down hills and settle on the bottom
  + i.e. Large rocks
* Till. Moraine deposits are ice related. Basically, all of southern Ontario
* All A horizons have experienced leaching
  + “A” horizons that hasn’t accumulated organic matter but has experienced leeching, is represented by Ae
* Organic matter
  + Soil organic matter consists of living organisms, remains of organisms and organic compounds produced by current and past metabolism in soil
  + Decomposition and nutrient cycling are important activities of soil biomass
  + Organic matter influences physical, chemical, and biological properties of soil
* Water
  + Major transport agent for fluxes within and between terrestrial ecosystems
  + Prerequisite for all active life, and participants in geochemical cycles by weathering geological substrates, by leaching materials to the groundwater and by moving ions and particles through the soil profile
  + Plants and other organisms within soil alter the suite of solutes in percolating water which reach the groundwater system
  + A dynamic equilibrium is maintained, despite the fact that very different types of substances are exchanged and stored. Moves in a predictable way

**Earth Science 2B03 | September 19th | Lecture 4**

* Soil master horizons
  + ‘A’ Horizon: A mineral horizon formed at or near the surface in the zone of removal of materials in solution and suspension, or maximum in situ accumulation of organic carbon, or both
  + ‘B’ Horizon: A mineral horizon used for diagnostic/benchmark, characterized by one or more of the following:
    - 1. An enrichment in silicate clay, iron, aluminum, or humus
      * Only way to confirm the presence of minerals is to test the soil
    - 2. A prismatic or columnar structure that exhibits pronounced coatings or staining associated with significant amounts of exchangeable sodium
    - 3. An alteration by hydrolysis, reduction, or oxidation to give a change in color or structure from the horizons above or below, or both
  + ‘C’ Horizon: A mineral horizon comparatively unaffected by the Pedogenic processes operative in A and B, except gleying, and the accumulation of carbonates and more soluble salts
  + ‘O’ Horizon: An organic layer of matter
  + ‘LFH’ Horizon: L = Leaf litter, H = decomposed leaf/organic matter
* Regosol: Young soils that are lacking a rich and thick ‘B’ Horizon. Only consists of an ‘A’ and ‘C’ horizon
* Brunisol: Weakly developed soils. ‘B’ horizon is present but still under development. Referred to as a Bm horizon. M stands for “melanic”, meaning weak
* Luvisol: Fully developed soil with a proper ‘B’ horizon that can be used for thorough testing. ‘B’ horizon is referred to as Bt, which means it accumulates clay
  + Bt-j means that it’s not good enough to be a Bt, but not as bad as Bm
* Soil Organic Horizons
  + Of-Om-Oh Horizons
    - An organic layer developed mainly from mosses, rushes, and woody materials
      * Of: Least deceomposed organic layer, containing large amounts of well-preserved fiber, and called the fibric layer
      * Om: An intermediately decomposed organic layer containing less fiber than an Of layer and called the mesic layer
      * Oh: The most decomposed organic layer, containing only small amounts of raw fiber and called the humic layer
  + L-F-H Layers: Organic layers developed primarily from leaves, twigs, and woody materials, with a minor component of mosses
    - L: The original structures of the organic material are easily recognized
    - F: The accumulated organic material is partly decomposed
    - H: The original structures of the organic material are unrecognizable
* Common ‘A’ Horizons
  + The horizons of the soil that have been altered by surface-related soil forming processes are called ‘A’ horizons. These horizons are at the top of the soil profile. Suffixes are used to further differentiate ‘A’ horizons
    - Ah: Enriched in organic carbon, because of root senescence and / or soil faunal activity, especially earthworm activity
    - Ahe: A transition between Ah and Ae, with both carbon enrichment and clay depletion
    - Ae: Depleted of clay, and sometimes of iron and organic acids. Normally has a horizontal ‘platy’ structure, and an ash-white colour when dry
* ‘B’ Horizons
  + Normally found below the ‘A’ Horizon(s), and above the ‘C’ horizon(s). Many kinds of ‘B’ horizons can be identified. The most common to Alberta are:
    - Bm: Slightly modified structure and/or colour
    - Bt: Enriched in clay, from Ae above
    - Bn: High Na content in the clays
    - Bnt: A combination of Bn and Bt
    - Bg: Gleyed due to frequent saturation
    - Bfh: Enriched in Fe and organics from Ae above
* ‘C’ Horizons
  + The bottom of a soil pit will have material that has not been modified much by soil forming processes.
    - Ck: Contains free carbonates, from the parent material
    - Cca: Enriched in carbonates, from horizons above
    - Csk: Contains carbonates and salts, normally gypsum
    - Cg: Gleyed and mottled, because it is normally saturated
* Taxa of the Canadian System of Soil Classification
  + Orders
    - Taxa at the order level are based on properties of the pedon that reflect the nature of the soil environment and effects of the dominant, soil-forming processes
      * i.e. Chernozemic [Ecology zones]
  + Great groups
    - Great groups are soil taxa formed by subdividing each order. Each great group carries differentiating criteria of the order to which it belongs. Taxa at the great group level are based on properties that reflect differences in strengths of dominant processes, or major contribution of a process in addition to the dominant one
      * i.e. Black [Climate, vegetation]
  + Subgroups
    - Subgroups are soil taxa formed by subdividing each great group. Therefore, they carry the differentiating criteria of the order and great group. Subgroups differentiate on the basis of the kind and arrangement of horizons that reflect a conformity to the central concept of the great group
      * i.e. Orthic Black Chernozemic [Position in landscape]
  + Family
    - Taxa at the family level are formed by subdividing groups. They carry the differentiating criteria of the order, great group, subgroup. Families are differentiated on the basis of the parent material, characteristics, such as particle size, mineralogy, calcareousness, reaction, and depth, and on soil climatic factors
      * i.e. Fine loamy, mixed, neutral, cool, subhumid [Texture, mineral, pH]
  + Series
    - Taxa are the series level are formed by subdividing the families. Series with a family are differentiated on basis of detailed features of the pedon. Pedons belonging to a series have similar kinds and arrangements of horizons whose color, texture, structure, consistence, thickness, reaction, and composition fall within a narrow range
      * i.e. Angus Ridge [Specific Polypedon properties]
* Soil orders in the Canadian System of Soil Classification
  + Chernozemic
    - Soils that have developed under xerophytic or mesophytic grasses and forbs, or under grassland-forest transition vegetation, in cool to cold, subarid to subhumid climates
      * These soils have dark colored surface (Ah, Ahe, Ap) horizon and a B or C horizon, or both
        + The order consists of, brown, dark brown, black , and dark gray
  + Podzolic
    - Soils of coniferous forests have podzolic B horizons (Bh, Bhf, Bf) in which combinations of amorphous Al, Fe, and organic matter have accumulated
      * The sola are acid an the ion exchange capacity of the B horizons is characterized by pH dependant charge
        + Three great groups are humic P., ferro-humic P., and humic-ferro Podzol
  + Bruniosolic
    - Soils whose horizons are developed sufficiently to exclude the soils from the Regosolic order
      * These soils all have brownish Bm or Btj
        + The four great groups are Melanic B., Eutric B., Sombric B., and Dystric Brunisol
  + Organic
    - Soils that have developed in organic deposits. The majority of organic soils are saturated for most of the year
      * They contain more than 17% organic carbon
      * The four great groups are the fibrisol, mesisol, humisol, and folisol
  + Crysolic
    - Mineral or organic soils of sub-arctice and arctic regions that have permafrost within 1m of the surface
      * There are three great groups – Turbic Cryosol, Static Cryosol, and organic cryosol
  + Solonetzic
    - Soils developed mainly under grass or grass-forest vegative cover in semiarid to subhumid climates
      * The soils have a stained brownish solonetzic B (Bn or Bnt) horizon and a saline C horizon
        + The surface may be an Ap, Ah, Ahe, and / or Ae horizon
        + The order includes the Solonetz, Solodzed Solonetz, and Solod Great groups
  + Luviosolic
    - Soils that may have eluvial (Ae) horizons, and must have illuvial (Bt) horizons in which silicate clay is the main accumulation product
      * These soils develop under deciduous or mixed forest or forest-grassland transition in a moderate to cool climate
        + The order is divided into the Gray Luvisol and the Gray Brown Luvisol Great groups
  + Regosolic
    - Soils having insufficient A or B horizon development to meet the requirements of other orders
      * The order is divided into the Regosol and the Humic Regosol Great groups
  + Gleysolic
    - Soils developed under wet conditions and permanent or periodic reduction
      * These soils have low chromas, or prominent mottling, or both, in some horizons. The Gleysol, Humic Gleysol, and Luvic Gleysol are the three Great groups
  + Vertisolic
    - Clay soils lack the degree of development for other orders and that have deep, wide cracks at sometime during the year and have high bulk density between the cracks
      * These soils have marked shrink-swell tendencies with changes in soil water content resulting in wedge-shaped aggregates and/or evidence of severe disruption of horizons in the solum
* Soil layers
  + Chernozems
    - Fertile black soil rich in humus, with a lighter lime-rich layer beneath. Such soils typically occur in temperate grasslands such as the Russian steppes and North American prairies.
      * Diagnostic layer is ‘A’ horizon
  + Podzol
    - Infertile acidic soil having an ash like subsurface layer (from which minerals have been leached) and a lower dark stratum, occurring typically under temperate coniferous woodland.
  + Gleyed Podzol
    - Gley: Wetland soil that, unless drained, is saturated with groundwater for long enough periods to develop a characteristic gleyic color pattern.
  + Gleysol
    - See above
  + Organic
* The difference between Northern and Southern Ontario is the parent material of soil
  + The soil does not buffer (not calcareous)
* Summary of soil formation
  + The driving variables which control formation of soil or a soil property in undisturbed ecosystems are:
    - 1. Climate
      * Overall affects of climate affects soil. i.e. Temperature, rain, humidity, etc.
      * Soil doesn’t develop (paused) during winter, and only develops under the right set of conditions
    - 2. Vegetation
      * Trees and plants have a massive impact on soil. i.e. Leaves add to the organic matter on soils, which enriches it
    - 3. Parent material
      * The material you start forming on, is a key driving variable to healthy soil.
        + Hard to change. You deal with what you got
    - 4. Topography or relief
      * i.e. Drainage patterns
        + We flatten out hilly lands and plant corn
    - 5. Soil organisms
      * Organisms consume organic matter. i.e. Mice, ants, microbes, etc.
      * Earth worms change soil structure, drainage, etc.
        + i.e. Use of pesticide/herbicides
    - 6. Time
      * Not a driving variable, it’s the ultimate independent variable
        + We can manipulate every other variable, but time

i.e. We can manipulate climate by creating a greenhouse, but never can be manipulate time

* + - * It takes a lot of time for soil to fully develop

**Earth Science 2B03 | September 22th | Lecture 5**

* Spherical soil structure
  + Brittle and breaks up into tiny pieces
  + A-Horizon
  + If you zoom in:
    - Loamy aggregates
      * Can store water and nutrients
    - Coarse sand grains
      * Really low porosity [cannot hold water]
* Soil Structure
  + Granular
    - Surface soils, especially with high organic carbon. Grasslands and soils worked by earthworms
  + Platy
    - Usually related to the structure of the parent material
      * Can also develop in clayey soils due to heavy machinery
    - Common in E-horizons
      * May occur in any part as the profile
      * Often inherited from parent structure
  + Prismatic
    - Usually occur in subsoils in arid and semiarid regions. Also in poorly drained regions with swelling soil clays. Tops are angular and flat
  + Blocky
    - Usually in subsoils. Related to drainage, root penetration, and aeration
  + Columnar
    - Like prismatic except tops are rounded. Common in high sodium soils
* Block like soil
  + Common in B-Horizons
    - May occur in A-Horizon
  + Angular blocky
  + Sub-angular blocky
  + Prism like soil
    - Usually found in B-Horizons
    - Columnar [rounded tops]
    - Prismatic [flat angular tops]
* Plants love soil that is able to freely exchange water and air with the environment
  + Soil texture = particle size distribution
    - The textural triangle
      * Accounts for clay, sand, and silt composition of soil
        + Range from 0 – 100
      * Clay accounts for most of the textural triangle [dominant]
        + Clay is very important

Is sticky

Holds on to nutrients/water

Exchanges nutrients

Traps contaminants

* + - * Heavy clay soils don’t drain very well
      * Loams are great for agricultural soil
        + In the middle – does everything
* Hydrometer method
  + Sand settles the quickest, then silt, and clay takes the longest
  + Density is higher in the stirred up solution
  + Stoke’s law determines how quickly particles fall through water
    - Buoyancy plays a role in how long it takes particles to fall
* Generalized influences of soil separates on some properties and behaviour of soil
  + Chart shows how good each soil is with: holding water, aeration, drainage rate, organic matter level, porosity, etc.
    - i.e. Sand has a low water-holding capacity, but a high aeration rate
      * i.e. Hence sand has a high drainage rate and a poor ability to store nutrients because it holds air more easily than it holds water

**Earth Science 2B03 | September 22th | Lecture 5**

* Bonus question
  + Not on exam, but on
    - What color is the collar that Dr. Smith’s dog wears?
      * Red, black, and hi-vis white
        + Answer must be written “as is”
    - IMPORTANT!!!
* Silt is also slow, just like clay
* Clay is sticky
  + Sand isn’t sticky, and neither is silt
    - It falls apart
* If a system is not isothermal, it is not resistant to heat
* Packing
  + Well sorted, loose packing
    - Lots of pores, big openings
  + Well graded, loose packing
    - Bunch of different sizes together
      * Little pieces fill the voids of big pieces
        + Blocks pores, tiny openings
  + Well sorted, tight packing
* Particle density (Mean density of solids) = PS
  + PS = MS / VS
    - In most mineral soils, the mean density of the particles is about 2.6 – 2.7 gm/cm3, close to the density of quartz
      * Will not be provided, this is a part of the definition
* Dry bulk density = Pb
  + Pb = MS / VT = MS / (VS + Va + VW)
    - The dry bulk density expresses the ratio of the mass of dried soil to its total volume (solids and pores together)
    - In sandy soils, Pb can be as high as 1.6, whereas in aggregated loams and in clay soils, it can be as low as 1.1gm/cm3
    - The bulk density is affected by the structure of the soil, i.e. its looseness or degree of compaction, as well as by its swelling and shrinkage characteristics, which are dependant upon clay content and wetness
* Porosity = n
  + n = VV / VT = (Va + Vw) / (Vs + Va + Vw)
    - The porosity is an index of the relative pore volume in the soil
      * How much of the soil is void space, compared to the sample?
    - It’s value generally lies in the range 0.3 – 0.6 (30% - 60%). Coarse textured soils tend to be less porous than fine textured soils, through the mean size of individual pores is greater in coarse textured soils
    - In clayey soils, the porosity is highly variable as the soil alternately swells, shrinks, aggregates, disperses, compacts, and cracks
    - The total porosity, in any case, reveals nothing about the pore size distribution, which is itself an important property…
* Void Ratio [e]
  + e = (Va + Vw) / Vs = Vv / (VT – Vv) = Vv / Vs
    - The void ratio is also an index of the fractional volume of soil pores, but it relates that volume to the volume of solids rather than to the total volume of soil
      * Void ratio is the generally preferred index in soil engineering and mechanics, whereas porosity is the more frequently used index in agricultural soil physics. Generally, e, varies between 0.3 and 2.0
* Soil wetness
  + The wetness, or relative water content, of the soil can be expressed in various ways: relative to the mass of solids, relative to the total volume, and relative to the volume of pores
    - The various indexes are defined as follows:
      * See below
        + Mass water content, volumetric water content, etc.
* Mass water content [θm] (ALSO REFERRED TO AS GRAVIMETRIC WATER CONTENT)
  + θm = MW / MS
    - This is the mass of water relative to the mass of dry soil particles
      * Mass water content is dimensionless because the units divide out
    - The term dry soil is generally defined as a soil dried to equilibrium in an oven at 105o C. In a mineral soil that is saturated, θm, can range between 25 and 60% depending on the bulk density
    - The saturated water content is generally higher in clayey than in sandy soils. In the case of organic soils, such as peat or muck, the saturated water content on the mass basis may exceed 100%
* Volumetric water content θv
  + θv = VW/VT = VW / (VS + VV)
    - In sandy soils, the value of θv at saturation is on the order of 40 – 50%; in medium textured soils, it is approximately 50% and in clayey soils, it can approach 60%
      * Also unit less. All measurements are unit less so its very important to specify what is being provided
        + θv can never be greater than 1 because the volume of water can never exceed the total volume
    - In the latter, the relative volume of water at saturation can exceed the porosity of the dry soil, since clayey soils swell upon wetting
    - The use of θv rather than ofθm to express water content is often more convenient because it is more directly adaptable to the computation of fluxes and water quantities added to soil by irrigation or rain and to quantities subtracted from the soil by evapotranspiration or drainage. This is because θv also represents the depth ratio of soil water, i.e., the depth of water per unit depth of soil
* Degree of saturation
  + S = VW / Vv
    - This index expresses the volume of water present in the soil relative to the volume of pores. The index S ranges from zero in dry soil to unity (or 100%) in a completely saturated soil
      * However, complete saturation is seldom attained in soils, since some air is nearly always present and may become trapped in a very wet soil
* Air-filled porosity [na] (AKA fractional air content)
  + na = Va / VT = Va / (Vs + Va + Vw)
    - This is a measure of the relative air content of the soil, and as such is an important criterion of soil aeration

**Earth Science 2B03 | September 29th | Lecture 6**

* Air filled porosity (fractional air content) na
  + na = Va / VT = Va / (Vs + Va + Vw)
    - This is a measure of the relative air content of the soil, and as such is an important criterion of soil aeration
* Additional mass and volume relations
  + 1. Porosity (n) and void ratio (e)
    - e = n / (1 – n)

n = e / (1 + e)

* + 2. Volumetric water content
    - θv = nS

S = θv / n

* + 3. Porosity (n) and Bulk density (pb)
    - n = (Ps – Pb) / Ps = 1 – Pb / Ps

Pb = (1 – n) Ps

* + 4. Mass water content (θm) and volumetric water content (θv)
    - θv = θm (Pb / Pw)
    - θm = θv (Pb / Pw)
* Bulk density gradient
  + Histosols have low bulk density
    - 0.1 – 0.6
  + Cultivated clay and silt loams
    - 0.9 – 1.5
  + Compacted glacial till
    - 1.9 – 2.2
  + Particle density of quartz mineral
    - 2.65
* Macropores
* Micropores
* Pore size distribution is very dynamic and can be changed
  + Particle size distribution cannot be changed
* Decreasing bulk density affects pore size distribution
  + It fluffs it up; adds more porosity
    - Large pores are added

Chapter 5: Soil Water Characteristics & Behaviour

* Hydrosphere
* Surface tension of water
  + Water is attracted to itself [cohesion]
    - Water also attracts to select surfaces [adhesion]
      * Accomplishes this by tension = Pulling apart
  + Ability to do work
    - Force/length
* Capillary action
* Small pores have water under higher tension
  + Large pores have water under low tension
    - Big pores drain first

**Earth Science 2B03 | October 3, 2016 | Lecture 7**

* Pressure changes based on how deep you are in the water
  + The deeper you go, the higher the pressure gets
    - -250 is a lower number than -50
* Tension is pulling the same pressure
* There are capillary forces in the pores medium
* Big pores drain first
  + Macro-pores drain first
* Water poured on burnt soil doesn’t get absorbed
  + Repellant soils
    - Push the water back
      * i.e. Very very dry soil
* Small pores fill up with water first, then big pores
* Water pressure = Matric potential
  + Don’t get confused even though the units are different
* Osmotic potential
* Matric potential = Tension
* There’s a relationship between water content in soil and pressure
  + Zero pressure = All pores are filled with water
    - As the big pores drain, the pressure decreases
      * Medium pores drain, the pressure gets more negative
    - Addition of water, enough water, reduces the pressure
  + Hysteresis
    - This graph is constantly changing between dry and wet conditions
* At any given pressure, sand holds less water then loam
  + Remember, pressure can be thought of as a sign of pores
    - Because of pore size distribution
* At any given pressure, clay holds more water than loam or sand
  + Clay has more big pores than sand and loam
* As water content decreases, it is extremely hard for water to move around
  + Explains why plants have a root system
    - Adapted to fetch water and transport it to the plant
      * Similar to a pipe
* You can measure the tension of soil using a tensiometer
  + Measures soil – water pressure
    - It just measures how hard it’s pulling the water out of the soil
* More common way to measure water pressure is a neutron probe
  + Do not ever pull this out of the ground
  + Fast neutrons are shot out and hit the water
    - Lose energy upon contact with the water
      * Machine reads how many thermalized neutrons come back
        + Less = More water
        + More = Less water
* Time Domain Reflectrometry (TDR)
  + Two metal rods about an inch far apart from each other are shoved into the ground
    - Length of probe measures pressure at that depth
      * Invented by a Canadian
  + Super safe
    - Wouldn’t hurt you in any way
* Measure water content head pressure relationship
  + Expensive method
* Water content vs pressure head
  + Not all soils are the same in how they handle water
  + Different soil textures handle water very differently
* Field capacity
  + If you saturate a soil, in spring time, within a day some of water just drains out the soil because of the field capacity
* The field capacity – wilting point = available water

**Earth Science 2B03 | October 6, 2016 | Lecture 8**

* There’s always a meniscus about air and water in soil
  + This creates tension within the soil
* Clay soil is saturated above the water table for several meters
  + Everywhere, all the time
    - They tiny pores hold on to water very tightly
* Coarse sands don’t hold much water
  + Water drains quickly
* Explains why entire ecosystems are different due to soil content and composition
* Gravity induces soils to drain water
  + In one day, gravity drains out most of the water
    - Happens in a couple hours if the sand is coarse
  + Referred to as field capacity
    - Large pores are empty, and small ones are full of water
      * 10 kPa
* Learn how to find out radius size pore number
* Plants use osmosis to transport water across roots
  + Wilting point = Dry soil, just not enough
    - Plants can’t
* Capillary water found in the curved menisci is left after drainage
* -15atm is the reference point for welting point
  + -15atm is the osmotic pressure
* Available water [GOING TO BE ON TESTS]
  + Volumetric water content x100
    - Clay > Clay Loams > Loams > Sand> Coarse sand
      * Sand has very little water at wilting point
        + In finer and finer textured soils, the wilting point increases
  + Sand has the least available water
    - Because the have big pores and water easily drains out
  + Silt loam has the most available water
    - Better than clay and clay loams
  + Overall, loams are the best soils
    - Most productive agricultural places use loams
* Important questions to know
  + Define available water
  + Explain field capacity
  + What size pores are filled and why
  + What is wilting point
  + Nature of water held in soils
    - THIS WILL BE ON ALL TESTS
* Higher organic matter = Higher field capacity
* There’s a difference between wilting point and wilting coefficient
* Welting point goes up because of wilting point

**Earth Science 2B03 | October 17, 2016 | Lecture 9**

* Small pores = Water can’t flow through quickly
* Be able to draw moisture content diagram
  + And briefly describe the graph
* Plants grow roots out to fetch water and nutrients
  + Roots are like veins and arteries for water
    - Cactuses have very large root systems
* Capillarity and gravity affect water
* Coarse material over fine material = Slows down the rate of infiltration
  + Fine over coarse also slows down rate of infiltration

Chapter 6: Soil & The Hydrological Cycle

* Cutting down trees causes erosion
  + Also causes land overflow
    - Water isn’t absorbed by the soil, it runs off the top

**Earth Science 2B03 | October 20, 2016 | Lecture 10**

* In winter, the water changes from liquid to solid
  + This changes the texture and grain size distribution
    - When water freezes it changes free space with solids (ice)
      * Soils can no longer absorb water
        + Due to ice
  + In summer, when the ice defrosts
    - You get a little bit of flooding
    - Or soil replenishment
* Snow is defined as ice crystals
  + Snow is a porous medium
    - It’s not unusual in southern Ontario to have a white Christmas
      * i.e. Having snow on the ground
* An early snowfall changes everything
  + It acts as an insulating layer
    - The soil becomes warm
  + Thermal diffusivity of a snow pack is very low
    - Without this snow pack, soil starts to freeze because heat escapes
* Heavy snowpack, late in the year, plus change in temperature causes massive flooding
  + Experienced this couple of years ago
* Crysolic soils are found in the north
  + Crysolic soils have permafrost
    - Due to global warming there’s a lot more thawing in the soil up north
      * Thawing permafrost releases carbon dioxide and methane
* When the soil is frozen
  + You can’t cultivate anything
    - Canada has shorter growing seasons and less crop yields
* P = ET + SS + D
  + P = Precipitation
  + ET = Evaporation/transpiration
    - We don’t know if it’s evaporation or transpiration
  + SS = Soil storage
    - i.e. Sand does a terrible job at holding water
      * Plants can’t grow or establish their roots
  + D = Drainage
    - Water that goes down deeper
      * Deep percolation
* The soil acts as a storage location, where the water is held
  + Plants can access this water with their roots
    - The ability to hold water is very important
      * i.e. Sand = Almost no life
* Regions
  + Semi arid = Arizona
  + Humid = Temperature
  + Arid = Desert
* In august, crop yields are the greatest
  + Evapo-transpiration increases as the seasons go on
* The seasons dictate when the soil has water and when it’s depleted
  + Monsoons cause massive run-offs
* Canada has a lot of corn crop yields
* Corn causes a lot of evaporation-transpiration as it grows
  + This changes the water budget of the soil
    - Monocultures change the water budget
  + i.e. Removing deciduous trees with corn cultures
* As the climate gets warmer, percolation decreases, and evaporation-transpiration increases
  + Less rain = Less percolation = Plants holding on to water more
    - i.e. Arid region
      * Sahara Desert
* Worms contribute a lot of soil
  + Increase macro-porosity of the soil
    - Allows for better water storage and percolation
  + Worms travel up to 1.5m deep in the soil, creating macro-pores
* We add a lot of chemicals to soils
  + In order to grow crops and increase yields
* We can spread fertilizer on the surface
  + Called broadcasting
    - Just throwing it on the soil
* Another way of adding chemicals is tilling it
  + Involves plowing the soil and mixing it in
    - Water doesn’t transfer chemicals down the soil
* In older suburbs, they have septic system
  + Meaning they have their own on-site sewage system
    - Must be careful what you put down the sink
      * Risk of water table contamination
* Understand nature of soil properties
  + Multiple choice question

**Earth Science 2B03 | October 24, 2016 | Lecture 11**

* Artificial drainage systems: Two general types
  + 1. Surface drainage
  + 2. Internal or subsurface drainage
* Benefits of artificial drainage
  + 1. Increased bearing strength and improved soil workability
  + 2. Reduced frost heaving of foundations, pavements, and crop plants
  + 3. Enhanced rooting depth, growth, and productivity of most upland plants due to improved oxygen supply, and in acid soils, lessened toxicity of manganese an iron
  + 4. Reduced levels of fungal disease infestation in seeds and on young plants
  + 5. More rapid soil warming in spring, resulting in earlier maturing crops
    - Possible due to low moisture content
      * Water has a high heat capacity; harder to warm it up
  + 6. Less production of methane and nitrogen gases that cause global environmental changes
  + 7. Removal of excess salts from irrigated soils, and prevention of salt accumulation by capillary rise in areas of salty groundwater
* Detrimental effects of artificial drainage
  + 1. Loss of wildlife habitat, especially waterfowl breeding and over-wintering sites
  + 2. Reduction in nutrient assimilation and other biochemical functions of wetlands
  + 3. Increased leaching of nitrates and other containments to groundwater
  + 4. Accelerated loss of soil organic matter, leading to subsidence of certain soils
  + 5. Increased frequency and severity of flooding due to loss of runoff water retention capacity
  + 6. Greater cost of damages when flooding occurs on alluvial lands developed after drainage
* Drainage
  + Sometimes springs come out of hills
* Two types of drainage
  + Surface drainage
    - Dig a ditch so water can flow to the soil
      * Disadvantage: Linear depression in the ground can cause many accidents, occupies land, etc.
  + Sub-surface drainage
    - Tiling a field
      * Put perforated pipes in the ground so water can accumulate and flow down the pipe
* Artificial drainage system is more drought tolerant due to the bigger rooting system
  + Artificial drainage system creates better crop yield
    - Crops are healthier, stronger, etc.
* Irrigation
  + Run water between rows using ditches to irrigate crops
    - Disadvantage: Uneven distribution of water
  + Can irrigate crops individually to maximize the usage of water
  + Water in Nevada is more precious, so you need to maximize its use
* Disadvantages of constantly watering a plant
  + Root system won’t develop
  + Water table won’t be recharged
  + Microbial bacteria in soil will affect the soil
  + Lots of salt accumulation
    - Need to add too much water to drain/leech the salts out

Mid-Term Content

* Chapter 7 is not included in the mid-term
* Mid-term is only the first 6 chapters
* Room: LRW – 1007B
* Must know every graph, figure, diagram, etc.
  + Be able to explain them too
* Consists of multiple choice, true/false, etc.
  + Short answers
    - Calculations are fair game
      * Memorize formulas b/c they’re definitions
  + Questions like:
    - What are the advantages and disadvantages of soil drainage?
    - What is available water?
      * Draw a relationship graph
    - What causes pressure and capillarity?
    - What is infiltration?
    - Different types of soil?
  + Use key points, not paragraph
* Support everything with diagrams and graphs
* Be able to link key ideas together

Chapter 7: Soil Aeration & Temperature

* Bonus Question #1
  + Name of the movie that Smith was thinking of the day he gave the bonus question
    - Blues brothers

Soil aeration and temperature

* When it rains, water comes in, and then drains away
  + This causes gas exchange
* On a windy day, there’s more gas exchange between soils and the environment
  + Air permeability
* Diffusion
  + Something moves from high concentration to low concentration
    - Chemical potential gradient
* Soil respiration
  + All of the microbes consume oxygen and produce carbon dioxide
  + CO2 concentrations are higher than O2 in the soil
* We get diffusion from the center of the aggregate
* Averages don’t mean much
  + Variance is more meaningful
    - i.e. Average bulk content
* Soils have multiple locations on a small scale of aerobic and anaerobic locations
  + Certain places have measures of 0, and others of 15
    - Lots of variability within a soil
* We can add organic matter to nurture a microbial community to cause bio-remediation
  + Cure abandon industrial land that is contaminated
    - Must stimulate the microbial community
      * Add nutrients such as nitrogen and oxygen to get the ball rolling
* What happens when you put more organic matter?
  + Less oxygen because microbes are more stimulated
    - Anaerobic process
      * Jump to sulfur from oxygen
* Aerobic process
  + Microbes have enough oxygen
* High chromium in soils is caused by excess organic matter
  + Chromium leeches into the water
* Soils need oxygen
  + Must keep a steady supply of oxygen to prevent unintended outcomes
* There are different plant species
* When you have a shallow water table, you get different plant species
  + Plants compete for water
    - Strong live, weaker die
      * Adaptability
* Available water causes ecosystems to shift
  + Water tables, lakes, etc. affect ecosystems
* We have decreased water table depths, all over the world
  + Affects wildlife drastically
    - Weaker die
* Aeration depends on water table depth [IMPORTANT]
* The concept of change being bad is not a healthy one
  + Boreal forests up North are in constant change
* Change is normal; nothing stays the same
  + Everything shifts/changes
    - We can decide whether it is good or not
* Aerobic/Anaerobic zones
  + Oxygen-rich = Aerobic
  + Anaerobic = Oxgen-lacking
* Different temperatures cause chemical reactions to increase
  + Exponential relationship
  + Microbes can grow more quickly
    - During spring, the microbial community starts establishing themselves
      * Transition of chemicals start
  + We induce temperature manipulation
    - i.e. Greenhouse
* Soil aeration and temperature are related
* Frost heave is important to account for
  + Made of water
  + When you dig a hole to add a fence you need to account for frost heave
    - Must account for freezing depth to prevent fence from coming out of the ground
* We can deliberately heat up soil to clean it up
  + i.e. There is oily-tar-y stuff in the soil. At 100 degrees we can boil off the water and start moving the oil around
    - Kills microbes
  + i.e. Blast radio waves into the soil
  + i.e. Steam injection
  + i.e. Hot air injection
    - Doesn’t work very well
* Hydrophobicity
  + Heating up soil leaves a material that is hydro-phobic

Chapter 8:

* Clay silicate are very very tiny ( <2um)
  + Clay has a huge surface area to volume ratio
* Soil colloids
* This chapter is full of true and false and multiple choice
  + No short/long answers about this
* Kaolinite
  + White china [porcelain] is made out of this
  + 1:1 clay
  + Looks like a stack of cards
    - These are sheet structures
* Mica
  + Can pull off sheets off it
  + Rock does not burn
  + Two types: Biotype, muscovite
    - Washes up on beaches
  + Not very reactive
* Montmorillonite
  + Can expand and contract
  + More detail in the structure
* Fulvic acid
  + Lots of surface area per volume
  + Google this
* Silica clays are made out of tetrahedral layer and octahedral layers
  + Tetrahedral:
  + Octahedral:
* Structure
  + Tetrahedron:
  + .
  + Octahedron:
  + Isomorphous Substitution
    - The replacement of one atom by another similar size in a crystal lattice without disrupting or changing the crystal structure of the mineral. For example, Al3+ 🡪 Si4+ OR Mg2+
* Negative charge on clays creates a cation change capacity of the material
  + Important for holding on to salts and herbicides and pesticides
* 1:1 Type Mineral – Kaolinite
  + Minerals that are made up of one tetrahedral (silica) sheet and one octahedral (alumina) sheet
  + Adjacent layers are bonded by hydrogen bonding, which make the structure fixed
  + No expansion ordinarily occurs between layers when the clay is wetted
  + 1 gram has 10 – 30 m2/g
* How associated the clays are depends on whether the clays are divalent or monovalent
  + Na = Monovalent
  + Ca, Mg = divalent
* Compare divalent to monovalent
* Adding salt to roads adds more monovalent
  + It deflocculates [disperses]
* Adding more divalent causes it to form a card structure
  + Called flocculating, causing it to shrink
* Whether clay shrinks depends on the ratio of monovalent to divalent
* Vertisol
* Bentonite is a swelling clay to seal things
  + We add Na to it so it expands and it seals it up
    - Why we mine it
* 2:1 Type Minerals
  + Two tetrahedral and one octahedral sheet
  + Expanding minerals
    - Smectite groups
    - Swell when wet
    - Large specfifc surface area: 650 – 800
  + Nonexpanding minerals
    - Mica…
    - .
    - .
* Cation exchange is pH dependant
  + Need H+
* The charge on soil colloids
  + ...
  + True/false part
* Adsorbed cations and cation exchange
  + A colloidal complex: a colloidal particle
  + Cation prominence – the order of strength of adsorption
  + Al>Ca>
  + Cation exhcnage
  + Divalents are bound more strongly to the surface
    - Cause things to flocculate
  + Sodium causes things to expand and disperse
* Cation exchange capacity CEC
  + The sum of total of the exchangeable cations that a soil can adsorb
  + Means of expression:
    - Centimol of positive charge per kg of soil
    - CEC of clay > loam > sand
    - CEC of organic soils > mineral soils
  + Clay is the primarily place of cation exchange
    - Clay can absorb organic matter
  + True and false of this
    - Don’t memorize the chart, just get the general idea
* Sorption
  + The tendency of containments to leach into the groundwater is determined by:
    - The solubility of the compound and
    - The soil distribution coefficient Kd: the ratio of the amount of…
  + Not all soils sorption the same
  + As concentration goes up, so does sorption
  + The contaminants front moves slower than the water front
  + Organic matter holds onto water, herbicides, spills, pollutants
    - Contaminated soil cannot grow plants on it
  + In beach sand, contaminants go straight throw and don’t hold in the horizons
* Cation exchange capacity is not permanent, but not enough

Soil classification

* The textbook uses the American classification
  + But we gonna use the Canadian classification
    - All the material is in the notes
      * Learn it to the ‘T’
* A, B, C horizons
  + Bc horizons = Unknown where the B ends and C begins. It’s gradational
  + A horizon is a net loss horizon
    - Stuff comes out of it
  + Ah horizon is where the organic matter is at
  + B horizon is the diagnostic horizon
    - Stuff from the A horizon leeches into the B horizon
  + Bt horizon has clay
  + C horizon is the parent material
  + Luvsolic soil order
* Common A horizons
  + The horizons of the soil that have been altered by surface related soil forming processes are called A horizons…
  + Ah
    - Enriched in organic carbon
  + Ahe
    - A transition between Ah and Ae…
    - E means that it has been leeched out a lot
  + Ae
    - Depleted of clay…
    - Does not have organic matter in it
    - Heavily leached
* B horizons are diagnostic horizons…
  + Bm
    - Weakly developed horizon
    - Slightly modified structure and/or colour
    - On it’s way in becoming alluvsol
    - Is diagnostic soil
    - Found in brunosolics
  + Bh
    - Enriched in clay, from Ae above
  + Bn
    - High Na content in the clays
    - Lack of water because no drainage of Na
    - Found in semi-arid
      * Southern prairies
        + Alberta, Saskatchewan
    - Plants don’t love salt
      * They can tough it out and survive
  + Bnt
    - A combination of Bn and Bt
    - Has accumulation of Na and Clay
      * Dry, salty soil
  + Bg
    - Gleyed, due to frequent saturation
    - Lack of oxygen
    - Gleysolic soil order
  + Bfh
    - Enriched in Fe and organics from Ae above
* C horizon: Thee bottom of a soil pit…
  + Ck
    - Common in Canada
    - Contains free carbonates, from the parent material
  + Cca
    - Enriched in carbonates, from horizon above
    - Secondary carbonates
  + Csk
    - Contains carbonates and salts, normally gypsum
  + Cg
    - Gleyed, and mottled, because it is normally saturated
* O horizon: An organic layer developed…
  + Of
    - Least decomposed organic layer, containing large amounts of well-preserved fiber, and called the fibric layer
  + Om
    - An intermediately decomposed organic layer containing less fiber than Of layer and called the mesic layer
  + Oh
    - The most decomposed organic layer, containing only small amounts of raw fiber and called the humic layer
* L-F-H horizon: Organic layers developed primarily from leaves, twigs, and woody materials, with a minor component of mosses. Found in deciduous woodlands
  + L
    - The original structures of the organic material are easily recognized
    - Made of leaves, bits of broken leaves that get eaten by bacteria
  + F
    - The accumulated organic material is partly decomposed
    - Leaves are broken down even more
  + H
    - The original structures of the organic material are unrecognizable
* The LFH layer is a unique layer on top of all the horizons
  + Not soil, just organic matter
* Lower case suffixes for soil mineral horizons
  + b
    - A buried soil horizon
  + c
    - A cemented (irreversible) Pedogenic horizon. Orstein, placic, and duric horizons are examples
  + ca
    - A horizon of secondary carbonate enrichment where the concentration of lime exceeds that in the enriched parent material
  + cc
    - Cemented (irreversible) Pedogenic concretions
  + e
    - Horizon characterized by removal of clay, Fe, Al or oganic matter
  + f
    - A horizon enriched with amorphous material, principally Fe and Al combined with organic matter.
    - Must have 0.6% of extractable iron
    - Defined by chemical analysis
  + g
    - A horizon characterized by gray colors, or prominent mottling indicative of permanent or periodic intense reduction (oxidation-reduction)
    - Aeg, Btg, Bg, & Cg
    - Bg is diagnostic
    - g means gleyed or glysol
  + h
    - Enriched with organic matter
    - Topsoil
  + j
    - Used when the horizon doesn’t meet the criteria, so a j is added
    - i.e. Aej 🡪 Ae, Btj 🡪 Bt
  + k
    - Presence of carbonates
    - Found in C horizons
  + m
    - Altered by hydrolysis…
  + n
    - Accumulation of sodium. Lots of monovalent cations
    - Ratio of exchangeable Ca to Na is 10 or less
    - Na causes soils to disperse
    - Ca causes soils to flocculate
  + p
    - …
  + s
    - Contains detectable soluble salts
  + sa
    - Accumulation of salts like Mg and Ca
  + ss
    - …
  + t
    - Accumulates clay that must be at least 5cm thick
  + u
    - Disrupted by physical or faunal processes other than cryto/argillipedoturbation
  + v
    - Affected by argillipedoturbation…
  + x
    - Fragipan character
    - Extremely hard to break through
  + y
    - Affected by cryoturbation
  + z
    - Perennially frozen layer
* Google soil profile
* Taxa of the Canadian system of soil classification
  + Orders
  + Great groups
  + Subgroups
  + Family
  + Series
* Soil order
  + Order – Chernozemic
    - Chernozemic is a prairie soil
  + Great group – Black
  + Subgroup – Orthic black chernozemic
  + Family – Fine loamy, mixed, neutral, cool, subhumid
  + Series – Angus Ridge

THE KEY TO CLASSIFICATION

|  |  |  |
| --- | --- | --- |
| A | Does the soil have permafrost within 1m of the surface or within 2m if strongly cryoturbatede | Cryosolic order |
| B | Does the soil have organic horizons? | Organic order |
| C | Does the soil | Vertisolic order |
| D |  | Podzolic |
| E |  | Gleysolic |
| F |  | Solo |
| G |  |  |
| H |  |  |
| I |  |  |
| J | Soil does not meet any criteria | Regosolic order |

Chernozemic

* Soils that have developed under xerophylic or mesophylic grasses and frobs, or under grassland-forest transition vegetation, in cool to cold, sub-arid to sub-humid climates
  + Just know that it develops on grasslands
* These soils have a dark-colored surface (Ah, Ahe, Ap) horizon and a B or C horizon or both, of high base saturation
  + Diagnostic horizon is chernozemic A horizon
* The order consists of brown, dark brown, black, and dark gray, great groups
  + This is a multiple choice question

Podzolic

* Typically seen in the Canadian shield
* Horizon is acidic
* Three great groups are: Humiz Podzol, Ferro-Humic Podzol, And Humo-Ferric Podzol

Brunisolic

* Just starting to develop
* Soil is weakly developed
  + On it’s way to become something else
* Characterized by Bm

Organic

* Soils that have developed organic deposits
* It’s a bunch of organic matter
  + About 30% by weight
* Contain more than 17% organic carbon. The four great groups are the fibrisol, mesisol, humisol, and folisol
  + Remember to mention the 17%

Cryosolic

* Found north of Canada
* Has permafrost within 1m of the surface
* Cryoturbated: Ice, forming and thawing, causes mixing of the material

Solonetzic

* Soils developed manly under grass or grass-forest vegetative in semiarid to subhumid climates
* Have a stained brownish solonetzic B horizon and a saline C horizon
* Surface may be an Ap, Ahe, Ahe and/or Ae horizon
* Order includes the solonetz….
* Bad for agriculture b/c they are too salty

Luvisolic

* Found everywhere, coast to coast of Canada
* Eluvial: Coming out
* Illuvial: Going in
* Develop under deciduous or mixed forest or forest-grassland transition
* Order is divided into the gray luvisol, and the gray brown luvisol great groups

Regosolic

* Insufficient A or B horizon development to meet the requirements of other orders
  + Hasn’t developed enough due to time
* Order is divided into Regosol, and the Humic Regosol great groups

Gleysolic

* Developed under wet conditions and and permanent or periodic reduction
  + Reduction = Oxygen is gone, and S/Fe play the role of oxygen
* Causes water logging
* Once oxygen is used up, it starts to look gray
* Great groups are: Gleysol, Humic Gleysol, and Luvic Gleysol

Vertisolic

* Tend to have big wide cracks and high bulk density in the cracks
* Get large fractures in the soil
  + High bulk densities b/c soil is very dry

Chapter 10: Organisms and ecology of the soil

Multiple choice questions with this chapter

* Fauna
  + macroFauna
  + mesoFauna
  + microFauna
* Flora:
* Organisms are never static and are always changing. Population is always in flux

A typical healthy soil might contain:

* Several species of vertebrate animals
* Half dozen species of earthworms
  + Adding chemicals to the soil, kills them off
* 20 to 30 species of mites
* 50 to 100 species of insects
* Dozens of species of nematodes
* Hundreds of species of fungi
* Thousands of species of bacteria and actinomycetes

A handful of soil has more life than the coral reefs

* All organisms and species interact with each other. The entire system interacts with each other. Disturbing one part, messes up the whole system
* Worm is biased and selective, only eating silt and clay, mainly, and a little bit of sand
  + Worms have evolved this way
* Earthworm casts are 14x more stable than regular soil
* Cation exchange capacity is higher because more clay
* Worms are important for soil development
* Mycorrihzae allows us to seed/stimulate the soil
* Adding chemicals kills off the organisms and affects the feedback loop
* Soil acts as a massive carbon sink
  + About 21100 in soil (5000 in soil and 250 in A)
  + What we do to soil almost never effects how much carbon is in soil
* Soils have about 75% water and 25% dry matter
  + The dry matter is composed of compounds like cellulose, lignin, hemi-cellulose, protein, etc.
    - Cellulose is like fibre to soil
  + The elemental composition of the dry matter is carbon, oxygen, ash, and hydrogen
* Fate of 100g of organic residue
* Soils are not in equilibrium
  + They are slowly, slowly, slowly accumulating more and more carbon over a period of a couple hundred years
* **Exam question: How to classify organic matter?**
* We classify organic matter like this:
  + Biomass: Living organisms (worms
  + Detritus: Identifiable dead tissue (twigs)
  + Humus: Non-living, non-tissue (organic matter)
    - Non-Humic Substances
    - Humic Substances
      * Add a really strong acid to this to get Humin and Humic/Fulvic acids
      * Humin: Solid stuff
      * Humic/Fulvic: Acids
        + These compounds are not identifiable
* Active organic matter
  + Can change within 3 – 4 years
* Slow organic matter
  + Turn-over rate: In the decades
* Passive organic matter
  + Does not change as quickly
  + Turn over rate: 500 – 5000 years
  + The carbon pool is untouched for a long time unless some drastic change happens like erosion
* Carbon pools reduce in the soil within a decade
  + But passive organic matter is nearly untouched
  + Other organic matter layers lose a lot of carbon
* Soil structure is highly dependant on carbon levels and organic matter
* Erosivity is related to organic matter [see below/chapter 14]
* Humans have increased the carbon pools for the active and slow organic matter
  + Soil structure and stability increases
    - Less erosion
    - Soil is stronger
* **DRAW THIS DIAGRAM ON THE FINAL EXAM!!!!**
* **REFER TO HIS LOW AF QUALITY OVERHEAD NOTES**
* If there’s lots of organic matter around, we consume it quickly
* Aerobic bacteria cannot survive in oxygen depleted environments
  + Anaerobic bacteria can
* If we alter the soil, the bacteria will compete, and survive
* We can nurture the microbial community and promote growth
* We need to stimulate the existing microbial community to offset any unwanted reactions
* Follow the massive chart with a bunch of intended and unintended outcomes to understand how soils can change and how to take another approach

Chapter 14: Soil Erosion

ALWAYS A MAJOR QUESTION ABOUT THIS ON THE FINAL EXAM!!!

* Erosion is a rate of loss. The loss of soil per unit of time
* Erosion is when water, wind, etc. transport soil across land, and disrupt it
* Loess plateau of China 🡪 200 t/ha/yr
  + Extremely fine material
* Himalayan foothills of Nepal
* In India, gully erosion results in a loss of 8000 ha of land per year
* In US, it is estimated that erosion costs:
  + On-site: 40 million (farm land)
  + Off-site: 17 billion
    - Communication systems, flooding, siltation of waterways, property damage, etc.
* Subsidize farmers to have less erosion, to minimize off-site damage
  + Pay farmers to make-up for their losses due to erosion minimization
* Remediation (how to reduce erosion)
  + Agronomic: Plant crops different times in the year
  + Management: How to manage the land
  + Mechanical: Tearing flat land so soil doesn’t runoff
* Global land and soil degradation by human activities
  + 40% is plain degradation
  + Only 4% of the due to chemical
  + Brown fields: Fields degraded so much, they are unusable
* For environment, you need to think in decades and centuries
* On-site cost: Occurs on farmlands…
* Off-site cost: Erosion from fields that seeps into…
* Not all soils are susceptible to erosion in the same way
  + Soil with a lower conductivity
* How does hydraulic conductivity affect soil erosion?
* Water is the most powerful eroder
* In southern Ontario, we use Gullies to prevent erosion
  + Even used by the Roman Empire
* You can slow down erosion, but you can’t stop it
* Conservation tillage: Minimizing erosion
  + Meaning: Let’s treat the soil in a way that will minimize erosion as a primary purpose, and still get good yields, and a check from the government
* Soil organic matter [EXAM QUESTION]
  + What is it about organic matter and its affect on soil?
    - It helps soil structure stability
    - It helps keep things together
    - It helps bind together the soil
    - You get more stable structure with higher organic matter content
* Soil structure is important to minimize erosion
  + Stable soil structure
  + Erosivity is how strong a soil aggregate to rain drops
    - High = Many raindrops to break it
    - Low = Few raindrops will break it apart
  + High organic matter = high erosivity
* You get a lot more run-off when you don’t have macro pores
* TILLAGE TECHNIQUE GRAPH [FINAL EXAM MATERIAL]
  + Refer to low quality slides for chart
* No till, chisel plow, moldboard plow
  + Know the difference between them
* How does tillage affect organic matter, bulk density, aggregate stability, available water-holding capacity, hydraulic conductivity?
  + Tillage affects organic matter a lot
  + Bulk density doesn’t change much
  + Organic matter and aggregate stability are directly related
  + Slightly less available water for plowed soil
  + Hydraulic conductivity is lowered with tillage
* Soil erosion [Final Exam Question: YOU NEED TO KNOW THIS SHIT]
  + Universal soil loss equation
  + A = R x K x L x S x C x P
    - It’s not really math, but structured in a useful manner
  + A = Mean annual soil loss
    - How erodible it is
  + R = Rainfall erosivity
    - Is it drizzling or monsoon?
  + K = Soil erosivity index
    - Based on texture, organic matter, permeability/hydraulic conductivity
  + L = Slope length
    - The typography of the field; flat, slope-y, etc.
    - Length of slope contributes to erosion
  + S = Slope steepness
    - Self-explanatory
  + C = Cropping factor (relative to bare soil)
    - What type of crop you put on?
      * Corn is really susceptible to erosion
      * Corn + grass reduces erosion
  + P = Conservation practice factor
    - How you go about putting the crops on
      * Contouring, strip-cropping
* HALF THE MARKS = REPRODUCE THE CHART
* OTHER HALF = WHY IT MATTERS
* What is erosion? [DRAW THE DIAGRAM FOR THE EXAM]
  + Detachment
    - Erosivity: The impact of the water droplets
  + Transport
    - Moved by water, down the slope
  + Deposition
    - Gets deposited somewhere, off or on-site
* There will always be erosion, nothing you can do about it
* Erosion works on all scales
* Takes quite the time
* Water has the ability to transfer soil particles quite well
* Transport and deposition affect off-site; the more important part and expensive
  + Why we subsidize farmers; to reduce erosion with less crop yields
* TALK ABOUT SOIL STRUCTURE AND HOW STABILITY AFFECTS EROSION
* DRAW THIS ON FINAL EXAM TOO
  + Sheet erosion
    - Tiny towers of silt with a stone on top
    - Does not happen in clay because clay is sticky
  + Rill erosion
    - Few centimeters deep holes in the soil
  + Gully erosion
    - Same as rill but much larger
    - Can’t drive a tractor across it

**BE ABLE TO LINK ALL THESE IDEAS TOGETHER BECAUSE OF BIG QUESTION ON FINAL EXAM!!!**

**BE ABLE TO REPRODUCE ANY FIGURE/DIAGRAM HE HAS TALKED ABOUT!!!**

* Water erosion
  + Does way more damage
  + Costly to manage with high off-site cost
* Wind erosion
  + Blows finer materials like dust
  + Affects crops by damaging them and burying them
* Wind erosion only blows around finer materials, and water erosion blows around larger materials
* Talk about detachment process of wind/water erosion
* Saltation:

Chapter 20: Global Soil Quality As Affected By Human Activities

* Quality of organic matter greatly affects soil structure which affects erosion
* Canada has great wheat production due to crop improvement

ALWAYS A QUESTION ABOUT ORGANIC MATTER ON FINAL EXAM

* Active organic matter
* Passive organic matter
* A quarter of land across the world has been degraded in terms of soil quality
* Fertilizers make soil unusable over a long period of time

EXAM REVIEW

* Introductory stuff is jargon
* Emphasize on the B horizon
* A is top soil
* Think about soil pedons and soil series
* Think about mass balances, about water, organic matter, etc.
  + Addition, loses, transformed, etc.
* Midterm will not reappear on final exam
* Summary of soil formation
* Anytime you see a summary overheard, it is on the final exam
  + i.e. Summary of soil formation
* Textural triangle is important AF
* Know all equations by heart, will not be given
* Calculation questions are pulled from labs
* Know some additional equations
* Capillarity is important
  + Diagrams are good! Draw this shit
* Water content and pressure head relationships
* Time domain Reflectrometry is a multiple question
  + Measures volumetric water content = TRUE
* Big pores drain first, capillarity and why?
  + Hydraulic conductivity
* Available water and texture
  + Field capacity and wilting point
* The concept of coarse layers over fine layers and fine layers over coarse layers
  + Both scenarios cause water to slow down
    - T/F MC question
* Soil structure and infiltration rates
  + Stable and unstable soil structure changes infiltration rates and causes erosion
* To get an A+, link ideas
  + Ideas of erosion and organic matter and linking them together
* In Canada, soils freeze. Matters in Canadian context and relates to water availability and soil structure
* Macro-pores and draw the diagram
* Short answer and T/F are the first half and long answers are the second half of the course
* Know about clay structures; silicates and cation exchange capacity
* KNOW the ten soil orders of Canada
  + i.e. Regosolic
    - Don’t forget the ‘IC’
* Know all of the subscripts of the soil
  + Will show up in T/F and explanations
    - i.e. Bt = Diagnostic horizon
* Must know basic structure of Canadian system
  + Orders, great groups, subgroups, family, series, etc.
* Know more information about the soil orders
  + i.e. Where are they found?
* How does biology affect soil? What do we do to mess with biology that affects soils?
  + Bacteria affects soil
* SOIL ORGANIC MATTER!!!
  + Know ALL diagrams!!! This is key!!!
  + Organic matter is really important. It affects the planet
  + Without organic matter we don’t even have soils
* EROSION!!!
* When talking about soil, know about Time
  + This is the A+ answer
    - Acknowledge the longer time-frame
* Climate change, Soil degradation take a lot of TIME
* Soil erosion, talk about it and its implications and gullies, and tractors, etc.
  + WRITE THE UNIVERSAL SOIL LOSS EQUATION DOWN
  + Organic matter affects soil stability and soil erosion
* Soil erosion by wind, water, etc.
  + Mention both or one depending on the question
* Types of organic matter: Active and passive, etc.
* Available water
* Diagrams are important AFFFFF

M/C is only worth 15% of exam

Exam: 2.5 Hours

Calculations are similar to mid-term

Format: Multiple choice, true/false, calculations, medium question, and two LONG answers

FINAL EXAM LOOKS LIKE MIDTERM

THERE ARE 3 LONG ANSWERS

This stuff is not on the exam:

* Man-made chemicals are never good for the environment
* Chemicals are terrible for soils
* DDT is a prime example of chemicals gone bad
  + Weakened the egg shells of birds
* Metals are harmful for the human body
  + Al causes Alzihmers
* Geog 3