Chan's ENVS200 Review

Chapter 4 - Climate and the World's Biomes

THE WORLD'S CLIMATE

- Climate is a result of differential heating of the planet from sunlight
  - Secondarily by interaction of the atmosphere with mountains and the ocean
  - Equator is hottest because sunlight hits it at close to 90 degrees
- Hadley cells
  - Air heats at equator
  - Rises about 10-15 km
  - Redistributed northbound and southbound
  - Descends back to the ground at ~30 degrees north/south
  - Comes back to equator, completing the cycle
- Polar cells
  - Similar cyclical air movement at the poles
- Ferrel cells
  - Somewhat more complex air movement between the poles and the equator
- Coriolis effect
  - Things that are at the equator are moving faster than things near the pole because the earth is fatter at the equator
  - Earth spin applies a force on air perpendicular to the spin direction and axis of rotation
  - As such, air in New York is pushed southwest, moving from area of lower speed to area of higher speed (south), and opposite to spin direction (west, as the earth spins from left to right, assuming North is up and South is down)
  - Air from Cape Town, South Africa, would be moved northwest instead
- Warm air can hold more moisture, which is why the equator is rainier than the poles
- Tall mountains can cause rain-shadows, where the physically block clouds from moving past them
- The "wobble" of earth's tilt causes season changes
- Ocean currents are also good at redistributing heat
  - Current movement driven both by coriolis effect and surface winds

TERRESTRIAL BIOMES

- Biome - an area with recognizable characteristics (vegetation, temperature, precipitation, etc.)
  - Identifiable "at a glance" - don't need to identify particular species to know you're in a desert or a tropical rainforest
- Latitude/longitude are some determinants of which biome an area may belong to
  - Elevation also plays a role due to decreasing temperature (-6.4 C per 1km up)
- Tropical rainforests have the greatest biodiversity of all biomes

    - Primary production - amount of photosynthesis per area * time (800g of carbon fixed per square meter per year in the tropical rainforest)
        - Results from high amounts of sunlight and regular, abundant rainfall
    - Epiphytes are plants that climb on/grow on things to reach sunlight (vines, figs)
    - Tropical rainforests are very species-rich - almost never dominated by one or a few species
    - Diversity of plants allows for diversity of herbivores
    - High amount of rainfall and high temperature allows dead leaves and other plant matter to decay extremely quickly, so soil is always full of nutrients
- Savanna
    - Also warm like the tropics, but rain is only reliable some times of the year (driven by Hadley Cells)
    - Mostly grassland and scattered small trees, no big trees as the trees really only grow during the rainy season
    - Plant development also limited by grazing and fires
        - Frequent fires limits the growth of long-growing trees and lets plants with short growth times like grasses prosper
    - Rainy/dry season makes abundance of food cyclical as well
- Temperate grassland
    - Natural vegetation for large swaths of land everywhere except Antarctica
    - Includes praries, pampas, and steppes
    - Seasonal drought
    - Lots of invertebrates (like grasshoppers)
    - Grazing animals like bison or antelope
    - Much of the original temperate grassland has been turned into agricultural farmland (wheat, barley, corn, etc.)
        - Most transformed by humans
- Desert
    - Extremely little precipitation
    - Plants are usually one of two types
        - Opportunistic - spring into action when water is available, grow and reproduce very quickly
        - Long-lived - slow physiological processes, cacti and other small shrubby plants that can tolerate long periods, usually use the CAM metabolic process
    - Low diversity of animal life as well
- Temperate forest
    - Usually deciduous trees (lose leaves in the fall/winter)
    - Lots of plants on the forest floor, flowers and herbs that grow quickly before the trees can regrow their leaves and cover the sunlight
    - Usually a mixture of long-lived species (red oaks, sugar maples, etc.)
- Boreal forest
    - Coniferous trees (needly, don’t lose their ‘leaves’)

    - As temperatures get colder, biodiversity lowers
        - More mixtures of species when it's not as cold
        - Far north, usually single-species forests like spruce
    - Usually has some sort of permafrost (permanent drought except when the sun can melt the water in the soil)
    - Low diversity makes these forests susceptible to disease or parasite outbreaks
- Tundra
    - Even colder, no more trees, just shrubs and small plants
    - Permafrost dominant
    - Very little life, down to a hundred or so non-lichen/moss (higher plants) species in Greenland, and two higher plant species in Antarctica
    - Cold severely limits decomposition

AQUATIC ECOSYSTEMS ON THE CONTINENTS

- Streams and rivers
    - Linear, unidirectional flow
    - Streams join together to form a river, which can join to form bigger rivers
    - Water comes from a watershed, the land area where the water is from (whether it's groundwater, rain runoff, or both)
    - Vegetation of the watershed affects the stream itself
        - ex. Streams shaded by forests mean that there can be little algae growth in the stream
    - Colder water can carry more oxygen which allow for certain species to live (like trout)
    - Riparian trees are ones that have adapted to grow along streams where there's lots of water
    - Converting forests with streams in them to agriculture can fuck up the temperature of the stream, thereby affecting what can live in it
        - Organic matter from leaves is lost
        - Dissolved nutrients therefore goes down
        - Algal and plant growth in the water increases
    - Stream/river width can expand depending on rainfall conditions
- Lakes and ponds
    - Relatively stationary water
    - Water in a lake/pond can stay there for months up to decades
    - Ponds are smaller and usually shallow, which means rooted plants can grow quite well as light reaches the bottom
    - Lakes are bigger (but not necessarily always deeper)
        - Deep lakes means phytoplankton (and their predators, zooplankton) can dominate
        - Can have "layers" of temperature if the lake is deep enough
            - Transition zone is called thermocline
    - Surfaces of lakes can be quite productive due to being heated by the sun
- Wetlands

- Perpetually or frequently waterlogged soil
- If trees dominate, it's called a swamp
- Marshes/fens are dominated by grasses
- Bogs are dominated by mosses
- Plant production is extremely high in wetlands as there's never a lack of water and nutrients (except bogs, which are usually fairly acidic)

OCEAN BIOMES

- 4 to 11 km deep
- Rate of production is about half that of terrestrial biomes on average
- Defined generally by amount of light and amount of nutrients
- Light penetrates from <50m to up to 200m (photic zone)
  - Photosynthesis no longer possible below the photic zone
- Deep ocean
  - Food chain fuelled by dead stuff dropping down from the photic zone
  - Very rich in both nutrients and carbon dioxide
  - About 4 degrees C, so slow decomposition of organic matter
  - Many tiny invertebrates with extremely slow metabolic processes - some can live for decades
  - Hot vents from cracks in the crust pump out extremely hot water with reduced chemical substances (ex. hydrogen sulphide)
    - Some bacteria specialized to eat these chemicals
- Subtropical gyres
  - Large masses of semi-isolated surface water moving in circular currents
  - Five in total, about half the surface area of all the oceans
  - Lowest productivity of any aquatic ecosystem
  - Water is clear and blue, large photic zone, but very little phytoplankton, very little exchange in water from its own currents vs. the "outside"
  - Very little nutrients, but oddly enough, high biodiversity
  - Tiny phytoplankton get eaten by tiny zooplankton, and eaten all the way up the food chain
  - Fairly low efficiency in consumption since the food chains are so long
- Coastal upwelling systems
  - Nutrient-rich deep ocean waters move UP into the photic zone
  - Primary productivity is very high, lots of (fairly big) phytoplankton, which limits light penetration
  - Caused by strong winds blowing perpendicular to coast lines and the coriolis effect
  - Low biodiversity
- Nearshore coastal marine ecosystems
  - Right near the shore
  - Essentially beach areas
  - Intertidal zone - submerged at high tide but exposed during low tide

    - Both algae and animals are affected by the physical forces of waves, and by the extremes caused by low/high tides (air temperature fluctuates much easier than water temperature)
    - Barnacles and mussels do well in rocky shores where they can attach themselves to things
        - Sandy and muddy shores are home to mollusks and worms, which bury themselves in the mud and feeding by filtering the water that washes over them
    - Littoral zone - always submerged (below low tide mark) but still shallow
        - Lots of primary producers like kelp or seaweed
        - Highest rates of production on earth, exceeding 1kg of carbon per square meter per year
- Estuaries
    - Where the rivers meet the sea, mixture of fresh and salt water
    - Salinity gradient makes it so that only specialized plants/animals can live in it
    - Prone to low-oxygen, or even no-oxygen conditions
    - Usually where sewage from cities gets dumped