# Chan's ENVS200 Review
## Chapter 11 - The Flux of Energy and Matter Through Ecosystems

THE ROLE OF ENERGY IN ECOLOGY
- Standing crop - bodies of living organisms in a given area
- Biomass - mass of organisms per area, usually in energy per area (joules per sq m)
- Primary productivity - rate at which biomass is produced through photosynthesis (joules per sq m per day)
- Gross primary productivity (GPP) - total fixation of energy through photosynthesis
- Net primary productivity (NPP) - GPP minus Rauto, amount of energy lost as respiratory heat by the autotrophs themselves
- Secondary productivity - rate of production of biomass by heterotrophs (things that can't fix carbon by themselves)
- Net ecosystem productivity (NEP) - GPP minus Rtotal, total respiratory heat loss
- Live consumer system - things that eat plants and other animals
- Decomposer system - things that eat dead things
  - decomposers are bacteria and fungi
  - animals that eat dead things are detritivores

GEOGRAPHIC PATTERNS IN PRIMARY PRODUCTIVITY
- Highest NPP rates in tropical rainforests (only thing big enough in this list to be considered an entire ecosystem), wetlands, estuaries, and giant kelp beds
- Forests and grasslands have intermediate NPP
- Lowest NPP in deserts and subtropical gyres in the oceans
- 1/3 of ice-free land is used for human agriculture (~1/4 world's NPP)
- Total potential NPP without humans is 100 petagrams ($10^{15}$) of carbon a year, slightly more than half from land, slightly less than half from oceans
  - Land is somewhat more productive than oceans

FACTORS LIMITING TERRESTRIAL PRIMARY PRODUCTIVITY
- Solar radiation, carbon dioxide, water, and soil nutrients
- $CO_2$ at 300-400 parts per million
- Terrestrial photosynthesis is very inefficient
  - 0-5J of sun energy per square meter per minute
  - 1% to 3% absorbed at the highest in natural ecosystems, 3% to 10% in crops, 0.01% to 0.02% in deserts
- Precipitation has a big effect, growth is very highly correlated with water availability

- With higher temps, metabolism goes up, and decomposition speed goes up, which allows for faster growth
- Nitrogen and phosphorous are some of the bigger limiting factors with respect to nutrients
  - Both usually limits growth in temperate regions (intermediate aged soils)
  - Phosphorous in hotter regions (old soils)
  - Nitrogen in deserts, tundra, and boreal forests (young soils)

FACTORS LIMITING AQUATIC PRIMARY PRODUCTIVITY
- Aquatic biomes respond extremely well to increases in nitrogen/phosphorous (10-20 times increase)
  - Nutrients play a greater role in the ocean than on land
  - Carbon is more important to land plants because they need structures to hold themselves up
- Highly based on available light
- Subtropical ocean gyres colimited by N and P
- Freshwater lakes limited by P
- Estuaries limited by N
- Iron may also sometimes limited productivity in oceans

THE FATE OF PRIMARY PRODUCTIVITY: GRAZING
- Secondary productivity is reliant on primary productivity
- Each consumption step produces heat (lost energy) as no process is 100% efficient
  - Efficiency is known as “transfer efficiency”
- Consumption efficiency - percentage of total productivity that is eaten by the trophic level above it
  - Herbivores - 5% in forests, 25% in grasslands, 50% in phytoplankton-rich communities
  - Carnivores - 25% to almost 100%
- Assimilation efficiency - how efficient an organism’s digestive system is
  - Bacteria and fungi - almost 100%
  - Also dependent on the type of food eaten - fruits/leaves are easily assimilated whereas tree bark is not
- Production efficiency - percentage of assimilated energy that is incorporated into new biomass
  - Invertebrates - 30 to 50%
  - Microorganisms - 50%+
  - Vertebrate endotherms (cold-blooded) - 10%
  - Vertebrate ectotherms (warm-blooded) - 1 to 5%
- Trophic transfer efficiency = CE * AE * PE
  - 10% on average

THE PROCESS OF DECOMPOSITION

- Immobilization - inorganic element incorporated into organic form
- Mineralization - organic matter back to minerals
- Decomposition - disintegration of dead organic matter (usually done by fungi, bacteria)
- Microbivore - small animals that feed on microorganisms, but not dead matter
- Shredder - aquatic detritivores the feed on coarse particulate organic matter like dead tree leaves
- Collector-filterers - filter small organic matter particles from the flowing water around them
- Decomposers help to prevent the buildup of dead organic matter
  - Help digest things that are otherwise quite hard for other organisms to digest - cellulose and lignin

THE FLUX OF MATTER THROUGH ECOSYSTEMS
- Energy can't be recycled but matter can be
- Recycling phosphorous is important due to the limited supply, and it doesn't really exist in the atmosphere
- 99% of nitrogen is in the atmosphere as N2
- Denitrification - conversion of nitrates to N2 by bacteria
- Nitrification - conversion of ammonium to nitrate
- Heterotrophs mineralize nitrogen to ammonium

NUTRIENT BUDGETS AND CYCLING AT THE ECOSYSTEM SCALE
- Open ecosystem - high exchange of nutrients beyonds its borders, limited recycling
  - coastal salt marshes
- Closed ecosystem - low exchange of nutrients beyond its borders, high recycling
  - subtropical gyres
- Colimitation of phosphorous and nitrogen is more prevalent in closed ecosystems, single element limitation more likely in open ones
- Bedrock weathering is a big source of inorganic nutrients
- Atmospheric deposition is a pretty big nutrient source, especially for bodies of water
  - dryfall - settling of particles without rain
  - wetfall - material dissolved in rain or snow
- A lot of nitrogen comes from atmospheric deposition, very little from weathering of bedrock
- For many ecosystems, nutrients can be lost through stream flow, washed away in water
- Vegetation, preventing the movement of water, can also prevent the loss of nutrients
- Ecosystems can also receive nutrients from upstream (nutrients lost by the ecosystem upstream)
- Estuaries can receive nutrients from both up and downstream as they're the border between rivers and oceans