Ecosystem Ecology

1. Overview of material and energy flows in ecosystems
2. Primary production
3. Secondary production and trophic efficiency
4. Ecological Pyramids
5. Nutrient cycling

Trophic levels—energy flow through ecosystems

- Autotrophs: primary producers
- Heterotrophs: consumers
  - Primary, secondary, tertiary
- Decomposers
- Food webs depict complex relationships: omnivores? Many cross trophic levels

Productivity and energy

- **Production** is the amount of energy stored by a trophic level (kilocalories/sq meter). **Productivity** is a rate.
- **Gross productivity**: amount of energy taken in by photosynthesis or by consuming the bodies of other orgs.
- **Net primary productivity**: amount of energy left after losses due to autotrophic respiration are taken into account. Available to heterotrophs (next trophic level)
- **Primary productivity**: is a measure of how much energy an ecosystem has to work with.
- **Net community productivity**: is net primary minus heterotrophic respiration.
Secondary production

- ‘net’ = Amount of chemical energy in consumers’ food that is converted to their own new biomass during a specific time: growth and reproduction
- Production efficiency: Fraction of energy stored in food NOT used in respiration or waste elimination
- Assimilation of 1<sup>st</sup> Production: Energy used for growth, reproduction, and respiration
- Production efficiency: net secondary production/Assimilation of 1<sup>st</sup> Production = \( \frac{33}{(33+67)} = 33\% \)

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**Figure 54.10** Energy partitioning within a consumer trophic level of the food chain. *Secondary production* is the amount of chemical energy in a consumer’s food that is converted to their own new biomass during a specific time: growth and reproduction.

**Figure 54.14** Food energy available to the human population at different trophic levels. Is it more efficient to eat vegetarian? In other words, does it take more corn to feed a vegetarian or a meat-eater? Why?

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**Figure 54.5** An idealized pyramid of net productivity.
Ecological pyramids

- **# individuals.** Often first level is largest, but not always. Note that secondary carnivores are almost always less numerous.
- **Biomass:** usually greatest at the bottom level: plants can store organic matter better than heterotrophs.
- **Energy:** 10% transferred at each level. 90% of energy eaten in food by consumers is not stored as body structures (as in trees), but is lost in waste or used in maintaining the animal (eg lost in respiration). All that they do requires energy.

![Ecological pyramids](image)

Why is the world green?

- Plant defenses (the world is prickly and it tastes bad)
- Limits to herbivores: predators, parasites, diseases, abiotic factors, nutrient requirements

![Why is the world green?](image)

Chemical cycling

Elements accumulate in three major places
- In the bodies of living organisms
- In exchange pools: readily available water soluble reserves of a mineral nutrient, such as nitrates in soil water easily taken up by plants
- Reservoirs: harder to get to places such as air, bones of animals, shells etc.
Productivity and energy

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- **Gross productivity**: amount of energy taken in by photosynthesis or by consuming the bodies of other orgs.
- **Net productivity**: amount of energy left after losses due to respiration are taken into account.
- **Primary productivity** is a measure of how much energy an ecosystem has to work with.
- **Net community productivity** is net primary minus heterotroph respiration.

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**Figure 54.8** A general model of nutrient cycling

**Figure 54.9** The water cycle

**Figure 54.10** The carbon cycle

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Carbon Cycle

- **Global scale**
- **Balance of respiration releasing CO₂ into atmosphere and photosynthetic assimilation of C and release of O₂**
- **Historically**: net sequestration of C in fossils
- **Since industrial revolution**: net release of CO₂ from burning fossil fuels

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**Figure 54.17** The carbon cycle. Remember: burning of fossil fuels and wood is creating a net addition of CO₂ to the atmosphere each year.
Figure 54.17. The nitrogen cycle. Notice the long-term importance of nitrogen-fixing bacteria. However, keep in mind that most nitrogen cycling takes place locally among organisms, soil, and water through decomposition and reassimilation.

Nitrogen Cycle

- Animals can only use nitrogen from organic compounds, plants mainly use NO$_3^-$ and can’t use N$_2$
- Bacteria important in releasing N from detritus, converting to NH$_4^+$, NO$_2^-$ to more usable forms
- Short term: local cycles in soil dominate
- Long term: N$_2$ fixation from atmosphere (global)

Serpentine soils provide a refuge for native plants adapted to their lack of nutrients, like these plants on Coyote Ridge.

What do you think will happen (and already has started to happen) to these native plant refuges as San Jose expands south into Coyote Valley?
Phosphorous Cycle

- Mostly local: soil particles bind phosphates
- Only one significant chemical form, no gaseous state
- Weathering of rocks
- In ocean it accumulates in sediments and makes it back to land through geologic processes

Some of the best long-term thorough studies of nutrient cycling in ecosystems are taking place at Hubbard Brook Experimental Forest in New Hampshire. Concrete dams (left) were constructed to help measure water and nutrient runoff from watersheds. Watersheds were logged at different intensities (right) to understand the impact of forest trees on nutrient cycling.