Ecology and Environmental Health

(as of Environmental Health Special Lecture (2) on 13 Oct. 2022)

- <u>Agenda of today's lecture</u>
  - Ecology: the interactions between biological organisms and their biotic/abiotic environments can be quantified and described
  - Humans exist within (are not separated from) ecosystem and ecological interactions
  - Ecosystem functioning <- material cycles + energy flow (as biological and physical components interact both hierarchically and circular feedback loops) <- largely altered by human activities // in turn, the pace of global climate change and its public health impacts increase
  - Ecosystem functioning -> toxins/pathogens are broken down <u>or</u> concentrated / those become environmental health risk <u>or</u> not
  - Biodiversity -> ecosystem functioning (eg. system capacity to regulate weather, break down hazardous agents, ...)
  - Populations
    - minimum size limit <- resource availability and intrinsic characteristics
    - maximum size limit <- extrinsic environmental factors
  - Rapid environmental change (<- human population growth, unplanned development, overexploitation of natural resources) -> ecosystem change, including emerging/reemerging infectious diseases → Negative feedback as ARC

Ecology and Ecosystem

- Ecology
  - derived from *οἶκος* (ancient Greek); household/place to live
  - the study of interactions between organisms and environments
  - natural history -> natural selection / evolutionary biology -> social-ecological systems perspective / resilience theory -> sustainability (eg., conservation biology, SDGs)
- Three different but complementary perspectives: ecosystem ecology, community ecology, and population ecology
  - Ecosystem ecology: functional entity, formed by interactions of living organisms with physical environment
    - Collection of ecosystems -> <u>biosphere</u> (occurs at the edge of <u>geosphere</u>, <u>hydrosphere</u>, and <u>atmosphere</u>)
  - Community ecology: Interactions of species (competition, predation, symbiosis [parasitism, mutualism, commensalism]); emphasis on specie's composition and diversity (eg., succession → see, Fig. 2.3)
  - Population ecology: Population level processes; emphasis on population dynamics and regulation, and on interspecies interactions
    - Human ecology is a kind of population ecology

Source: Frumkin [Ed.] 3rd Ed. (2016)

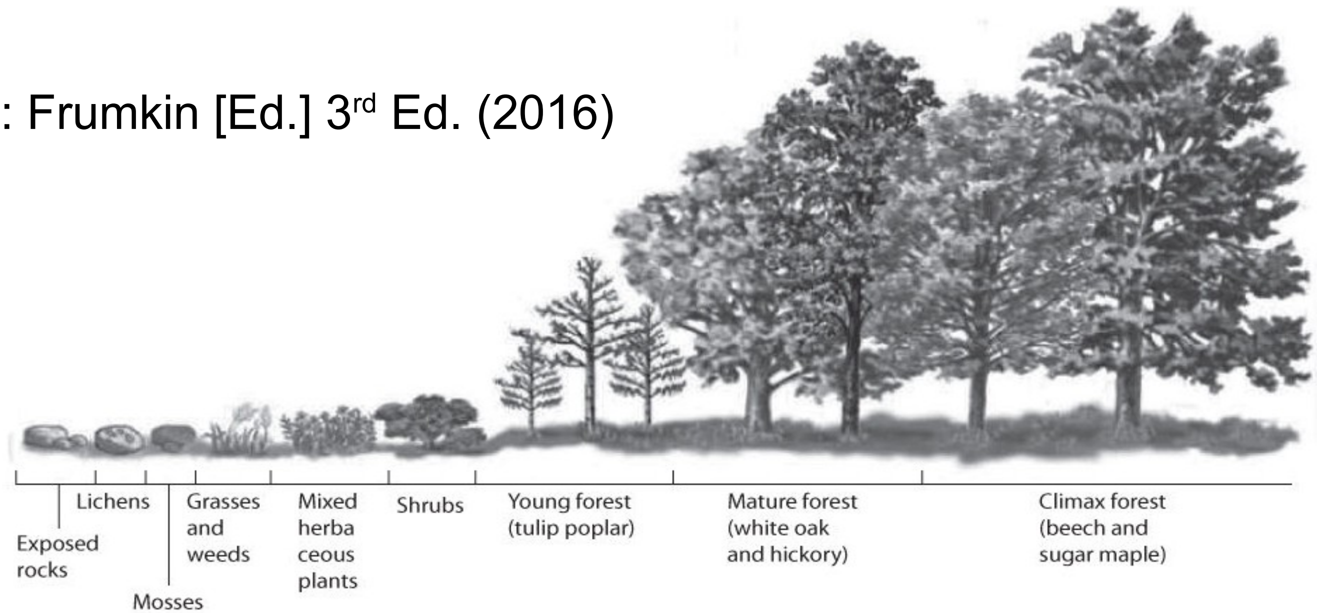
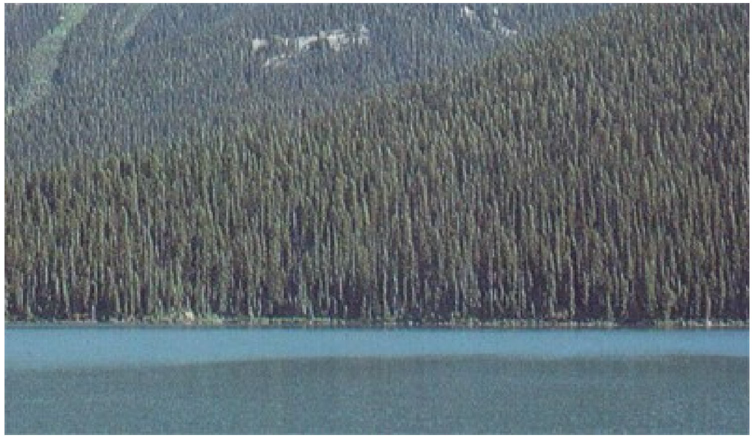


Figure 2.3 A Classical Model of Ecological Succession in a North American Forest Ecosystem

Biomes

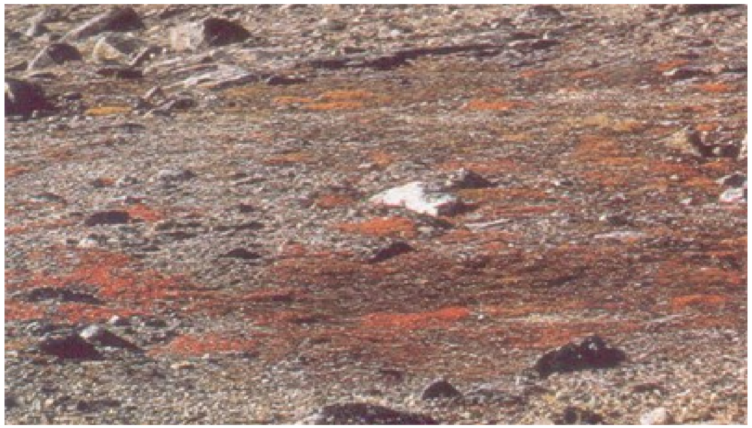
- Mostly determined by temperature and precipitation
  - marine ecosystems / freshwater ecosystems / terrestrial biomes / domesticated ecosystems
- Only human beings can live in any biome



Boreal Conifer Forest

Temperate Forest

Tropical Rain Forest



Tundra

Tropical Semi-arid Grassland (Savanna)

Desert

Interaction between human and environment

- Ecosystem: a system in which all organism populations have relationship with physical-chemical environment, which in turn generates **<u>trophic stages</u>** (in food web), biodiversity and material cycles (hydrologic cycle, carbon cycle, nitrogen cycle --- ecosystem services) with energy flow (lost through work and dissipated as heat at each step of biological food chain).
- Humanized (domesticated) ecosystem: physical-chemical environments are largely affected by human-beings
  - Human made chemicals (eg. PCB) remain longer in the ecosystem, which cause **bioaccumulation** and **biomagnification** in higher consumers, subsequently make toxic effects on them.
- How to consider humanized ecosystem
  - Habitat+Resource+Environmental factor → Human (Shosuke Suzuki)
  - Human ↔ [Language, Technology, Social organization] ↔ Environment (Tsuguyoshi Suzuki)
- Very complex, so that systems thinking is needed

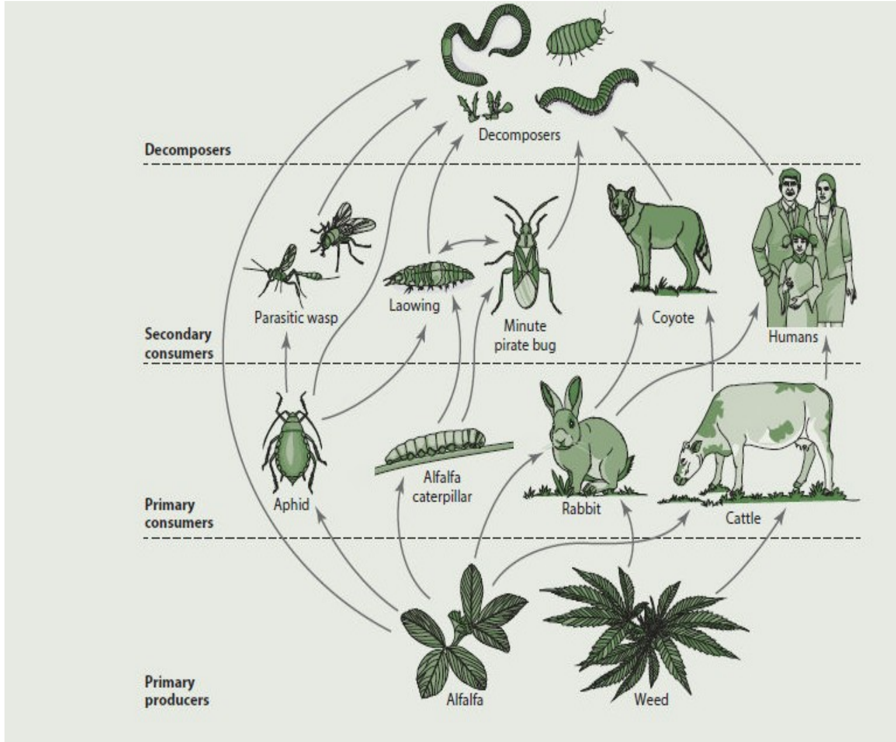
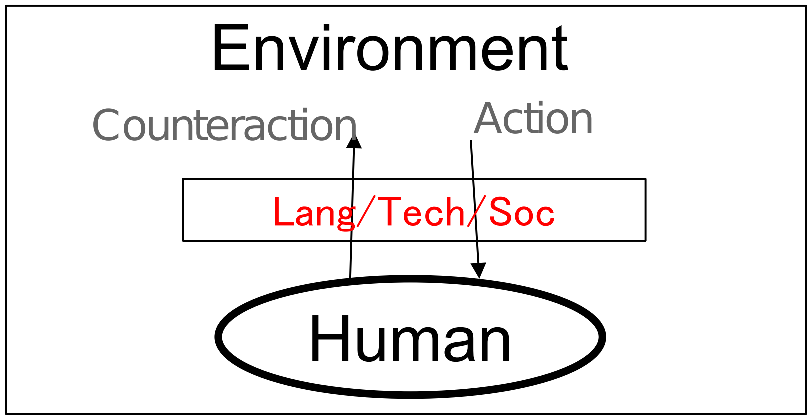


Figure 2.1 A Food Web in a North American Terrestrial Food Ecosystem

Source: Frumkin [Ed.] 3rd Ed. (2016)



Ecosystem services such as
* Provision of clean water
* Waste recycling
* Regulation of infectious diseases
* Regulation of climate

Some ecosystem ideas

(Source: Frumkin [Ed.], 2016)

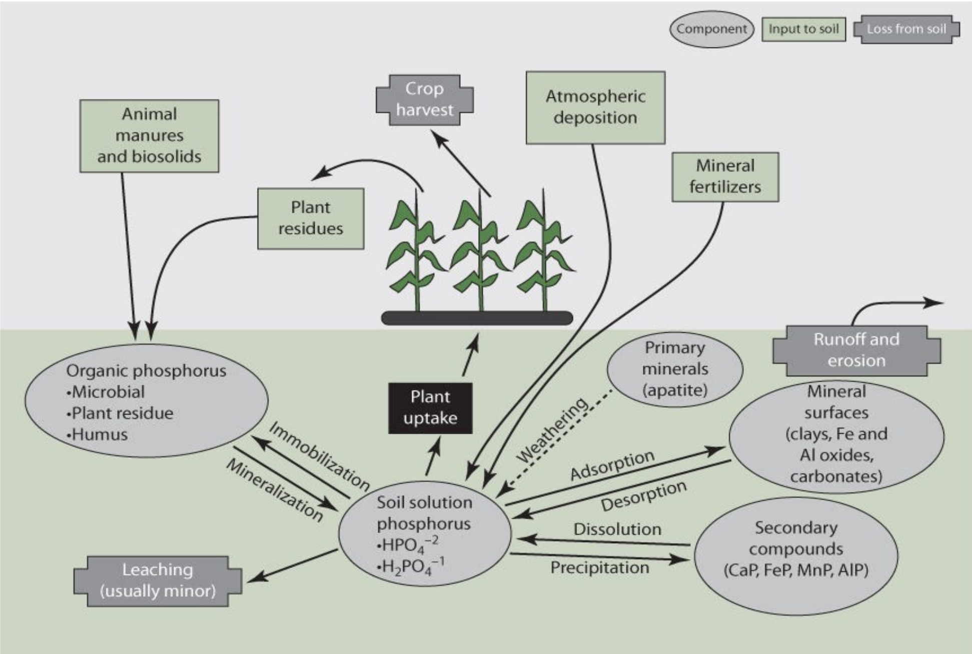


Figure 2.4 The Phosphorus Cycle

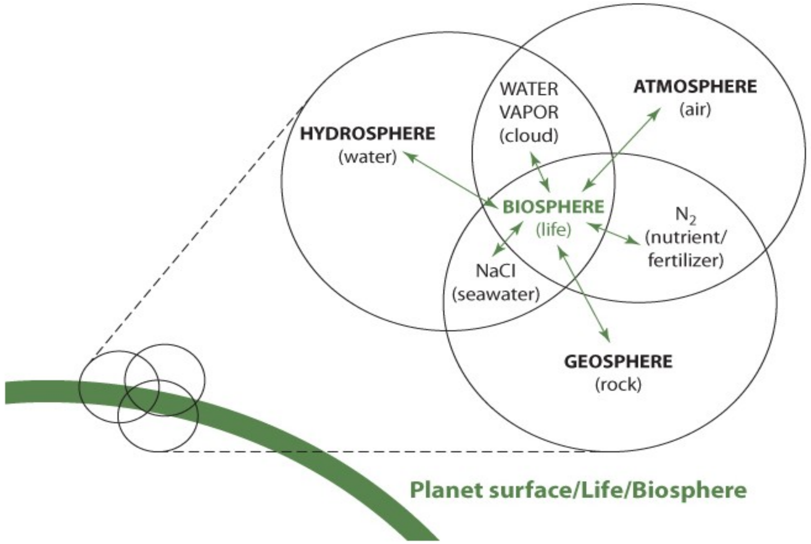


Figure 2.5 Transactions Between Atmosphere, Geosphere, and Hydrosphere Provide a Basis for the Earth's Capacity to Support Life

Source: Adapted from Parkes & Weinstein, 2004.

Ecological integrity is not just a feature of a sustainable ecosystem; it also indicates that the ecosystem can continue to provide human benefits, as depicted in Figure 2.8.

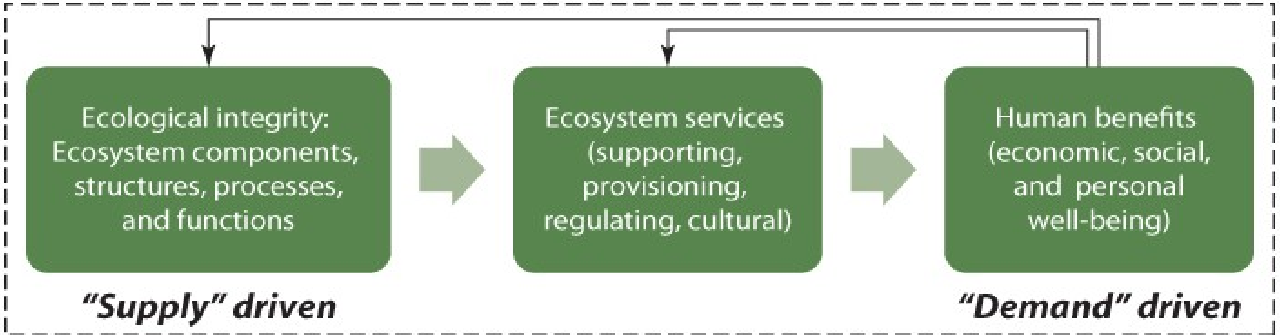


Figure 2.8 Ecosystems as Settings for Human Health and Well-Being

Homeostasis

- Living organism needs metabolism (chemical reactions) within the body which requires non-extreme temperature, pressure, humidity
  - Nonhuman organisms are adapted to their specific biomes (cf. dried water-bears and sleeping chironomid's larvae in cryptobiosys status)
  - Humans can make microenvironments (eg. cloths) and/or largely modify environments with technology to keep homeostasis within the body where chemical reactions occur.
- Homeostasis
  - Stressor (changes in external environments) stimulates organisms; can be regarded as anything disturbing homeostasis
  - Living organisms have "negative feedback" to keep homeostasis against perceived stressor.
    - In humans, homeostatic actions are not only biological but also artificial (using technology)
    - Carry-over of negative feedback returns out to external environment
  - Material cycle between the body and external environment through exposure, absorption, distribution, metabolism and excretion; the pathways are <u>not fixed</u>

Communities and species

- Habitat diversity
- Species-area relationship: in log-log scale, number of viable species are positively correlated with area [Darlington's rule (1957)]
- Niche: "Multidimensional ecosystem space in which a species exists (its habitat) and also what it does"
- Biological invasion: "A large-scale movement of animals or plants intro areas where they were previously absent or uncommon"
  – Frequently occurs under humanized ecosystem
- Barry Commoner's laws (1971)→

Approx.Area	Species	Species	Index No.
mi^2	(Approximate)	(Actual)	**k**
4	5	5	0
40	10	9	1
(400)	(20)	--	(2)
4000	40	39--40	3
40000	80	76--84	4

Darlington's rule (1957), Table 17: cited from http://math.hws.edu/~mitchell/SpeciesArea/speciesAreaText.html

Example of invasion > Fire ant, found in Fukuoka, Source: https://www.japantimes.co.jp/news/2017/08/07/reference/japan-working-hard-douse-fire-ant-invasion/#.W72hZvaYRhE

Table 2.3 Links Between Ecology and Systems Thinking as a Basis for Health

Barry Commoner's laws of ecology	Corresponding systems attributes
Everything is connected to everything else.	Interconnectedness and complexity. Emergence and emergent properties.
There is no such thing as a free lunch.	Interrelationships and reciprocity.
Nature knows best.	Integration. Knowing comes from the whole as much as the parts. Feedbacks and self-organization.
Everything must go somewhere.	Nestedness: nothing exists outside its ecology. Interdependence, cycling, nonlinearity, and uncertainty. Rethinking of waste as a part of ecological processes.

Negative feedback in human population

- Human population has "**adaptive renewal cycle**", from r phase (growth and exploitation under low stored capital and connectedness), through K phase (conservation) and Ω phase (release), to α phase (reorganization)
- Recently the importance of adaptive management (a system of cyclical monitoring and adjusting), the central idea of ecosystem management is recognized
- Density dependent regulation is related with carrying capacity and logistic growth. Also related with emerging infectious diseases, which is also related with biodiversity.

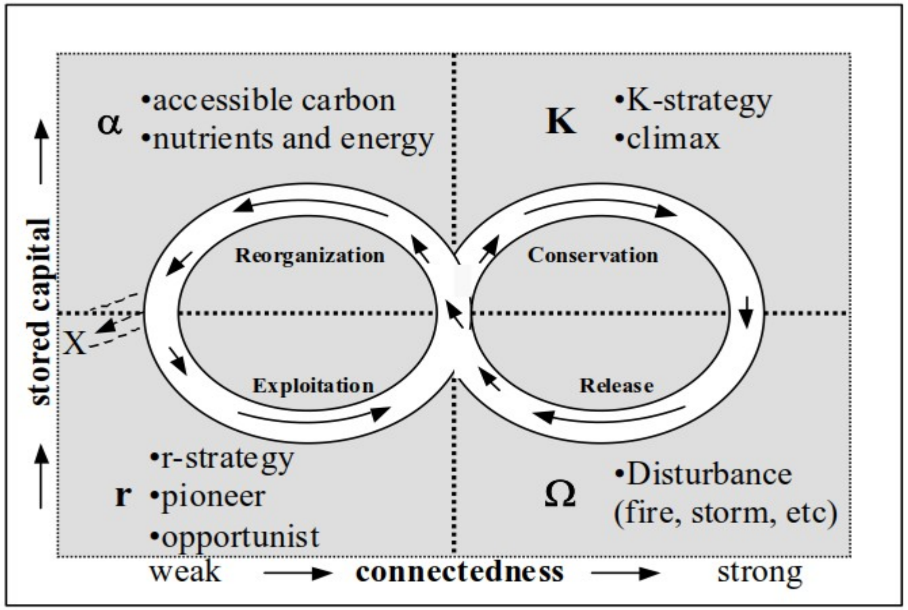


Fig. 1. The four ecosystem functions of the Adaptive Renewal Cycle (r, K, Ω, α) and the flow of events among them (Source: Holling 1986).

Cited from: Colding J, Folke C, Elmqvist T (2003) *Tropical Ecology*, 44(1): 25-41. https://www.researchgate.net/publication/239832504_Social_institutions_in_ecosystem_management_and_biodiversity_conservation