

Ecology

Readings

- Smith and Smith Chapter 1.
- Vernadskii "The Biosphere"
- Carruthers "Locusts in the Red Sea"
- Remmert "Ecology: The Basic Concept" Rowe "Biological Fallacy: Life =Organisms" (same document)
- Redox Handout

Evolution of Definitions of Ecology

Ecology = from the Greek root OIKOS, "at home", and OLOGY, "the study of"

Haeckle (1870): "By ecology we mean the body of knowledge concerning the economy of Nature - the investigation of the total relations of the animal to its inorganic and organic environment."

Burdon-Sanderson (1890s): Elevated Ecology to one of the three natural divisions of Biology: Physiology - Morphology - Ecology

Elton (1927): "Scientific natural history"

Andrewartha (1961): "The scientific study of the distribution and abundance of organisms"

Odum (1963): "The structure and function of Nature"

Our Definition: *"Ecology is the scientific study of the processes regulating the distribution and abundance of organisms and the interactions among them, and the study of how these organisms in turn mediate the transport and transformation of energy and matter in the biosphere (i.e., the study of the design of ecosystem structure and function).*

Beyond Fundamental Ecology

Applied Ecology: Using ecological principles to maintain conditions necessary for the continuation of present day life on earth.

Industrial Ecology: The design of the industrial infrastructure such that it consists of a series of interlocking "technological ecosystems" interfacing with global natural ecosystems. Industrial ecology takes the pattern and processes of natural ecosystems as a design for sustainability. It represents a shift in paradigm from conquering nature to becoming nature.

Ecological Engineering: Unlike industrial ecology, the focus of Ecological Engineering is on the manipulation of natural ecosystems by humans for our purposes, using small amounts of supplemental energy to control systems in which the main energy drives are still coming from non-human sources. It is the design of new ecosystems for human purposes, using the self-organizing principles of natural ecosystems.

[Note: The popular definition of ecological engineering is "the design of human society with its natural environment for the benefit of both.". *What is the logical flaw in this definition?*]

Ecological Economics: Integrating ecology and economics in such a way that economic and environmental policies are reinforcing rather than mutually destructive.

Urban ecology: For ecologists, urban ecology is the study of ecology in urban areas, specifically the relationships, interactions, types and numbers of species found in urban habitats. Also, the design of sustainable cities, urban design programs that incorporate political, infrastructure and economic considerations.

Conservation Biology: The application of diverse fields and disciplines to the conservation of biological diversity.

Restoration Biology: Application of ecosystem ecology to the restoration of deteriorated landscapes in an attempt to bring it back to its original state as much as possible. Example, prairie grass.

Landscape Ecology: "Landscape ecology is concerned with spatial patterns in the landscape and how they develop, with an emphasis on the role of disturbance, including human impacts" (Smith and Smith). It is a relatively new branch of ecology, that employs Global Information Systems. The goal is to predict the responses of different organisms to changes in landscape, to ultimately facilitate ecosystem management.

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All these disciplines require an understanding of the "organizing principles" of ecosystems, i.e., their ecology. This involves the detailed study of the structure and function of ecosystems in their undisturbed state, and using their designs to:

- determine the resilience of ecosystem functions to human activities.
- design ecosystems which function in the service of human beings with minimal fossil energy input (ideally none) and minimal waste.
- design the industrial infrastructure.
- integrate the value of "goods and services" of natural ecosystems into the global economic system.

What is "Sustainability"?: There are many definitions of this one, depending on your perspective. Here's ours: *Sustainability is a property of a human society in which ecosystems (including humans) are managed such that the conditions supporting present day life on Earth can continue.*

Ecology and The Future of Biology

"However it is said, the future of biology lies not in the ongoing reduction of biology to molecular tidbits, but in studying biology in its essence; studying the organism and the environment as primary, not derived entities. Both, however, are facets of a single grand problem, the nature of biological organization. Such an emphasis brings to light an entirely different future for biology, one in which understanding the dynamic of the biosphere and the evolution and nature of cellular organization are central issues."

Carl Woese 2006

Levels of Studying Ecology

Biosphere: The earth's ecosystem interacting with the physical environment as a whole to maintain a steady state system intermediate in the flow of energy between the high energy input of the sun and the thermal sink of space (merges with atmosphere, lithosphere, hydrosphere...).

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Biome: Large scale areas of similar vegetation and climatic characteristics.

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Ecosystem: Set of organisms and abiotic components connected by the exchange of matter and energy (forest, lake, coastal ocean). Or, "the smallest units that can sustain life in isolation from all but atmospheric surroundings."

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Community: Interacting populations which significantly affect each other's distributions and abundance (intertidal, hot spring, wetland).

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Population: Group of interacting and interbreeding organisms

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Cell/Organism → Organelle → Molecule → Atom

Principle of Integrative Levels - Emergence

Principle of hierarchical control: As components combine to produce larger functional wholes in hierarchical

series, new properties emerge. That is, one cannot explain all of the properties at one level from an understanding of the components at the one below.

“Emergence is the feedback between micro- and macro-level behaviors. The local dynamics of a set of interacting entities supports an emergent set of global dynamical structures which stabilize themselves by setting the boundary conditions within which the local dynamics operates. That is, these global structures can ‘reach down’ to their own physical bases of support and fine tune them in the furtherance of their own global ends. Such LOCAL to GLOBAL back to LOCAL, inter-level feedback loops are essential to life, and are the key to understanding its origin, evolution and diversity.” [Taylor, CE in Artificial Life II. 1991 Langton, CG, Taylor, C. Farmer. KD, eds. pp. 371-408 Addison-Wesley].

Guide to Readings Why we chose them/Why they are important/ What to look for.

Chapter 1 (Smith and Smith): This is an excellent overview of the field of Ecology, what kind of science it is, how it is structured, how ecologists form and test hypotheses, and why it is important.

Redox Primer: Read in preparation for the next set of lectures and work through examples

Remmert – Ecology: This is my favorite introduction to an Ecology Textbook. I think it captures the “essence” of ecology and should be read and understood before starting an Ecology course. Most important is the last paragraph. We have to remember that the Earth’s ecosystems have not always been hospitable for humans, and most likely will not be at some time in the future. We are but just a ‘blip’ on the evolutionary landscape. It will be a daunting task to sustain the Earth’s ecosystems in a way that will sustain human life on earth. Our understanding of Ecology will have to be a lot better than it is now.

Rowe – Biological Fallacy: Life Equals Organisms: This should get you thinking about what Life is. It’s all perspective, and it is important for us to get out of our rigid view of life that is primarily dictated by our size relative to other living systems. Assume you could “see” energy and individual elements, and think about the how you would describe life if: 1) you sat on the inside of a cell and watched the energy and elements flow through metabolism, and 2) you sat on a space shuttle and watched the energy flow and element cycles of the Earth. What would be similar and different?

Vernadski – The Biosphere (1926): Vernadski was a man ahead of his time, with brilliant insights into how the Earth works. This was the first account of the Earth as an integrated living system, and preceded modern Ecology by decades. You will see that in Vernadski’s view of the Earth, life forces shape the abiotic components of the Earth’s crust.

Study Questions

These example questions are designed to help you understand and think about lectures and readings. these are a guide only. you are not required to hand them in, nor do they necessarily include all of the major concepts covered in class and readings.

- Give an example of “the organism environment interaction being two way” with regard to how organisms change planetary chemistry and physics.
- What is the relationship between ecology and environmentalism? Where does Remmert see ecology fitting in to broader societal problems?
- Why does Remmert call green plants “the first great polluters of the environment”?
- Give an example of an ecosystem, and explain what the associated community would consist of.
- The popular definition of ecological engineering is “the design of human society with its natural environment for the benefit of both.” (Mitsch, 1988). *What is the logical flaw in this definition?*
- Rowe’s “Biological Fallacy” calls in to question using an organism-level perspective on life. Describe how energy flows would look different if you were a) inside a cell or b) in a space ship looking down on earth. Without prior knowledge, what would you call life?
- What does Vernadsky mean by “cosmic forces”? What does he mean by the following statements?
 - The biosphere is the creation of the Sun

- A “chemical calm” would overcome the Earth if life ceased to exist
- “Under the thermodynamic conditions of the biosphere, water is a powerful chemical agent...” but on a dead Earth, water is “...a compound of weak chemical activity”?

Source:http://ocw.mit.edu/courses/civil-and-environmental-engineering/1-018j-ecology-i-the-earth-system-fall-2009/lecture-notes/MIT1_018JF09_Lec01.pdf