What is Ecology?

- The study of the interactions between organisms and their environment.
  - Organism – plant, animal, microbe…
  - Environment –
    - Abiotic
      - Non-living components – soil, water, nutrients…
    - Biotic
      - Interactions with other organisms – competition, predation, symbiosis…
  - Examples -

Organizational levels in Ecology

- Organismal –
- Population –
- Community –
- Ecosystem –

Questions at different Organizational levels in Ecology

- **Organismal** – How individuals are affected by their biotic and abiotic environments.
- **Population** – Trends and fluctuations in abundance or density related to biotic or abiotic environment.
- **Community** – How do interactions among species determine distribution and abundance of populations in a particular area or habitat.
- **Ecosystem** – How do patterns of energy, mass and nutrients flow through ecosystems.
Ecology as a science

- Ecology is a science…so what is a science?
- Science – systematic methodology to develop predictive models about the natural world.
  - Seeks to explain natural phenomena
  - Pose, develop and test hypotheses
  - Does not prove anything, refines models that make predictions about the natural world

Properties of hypotheses

- Must be falsifiable
- Must be testable
- Must make a prediction about some natural phenomenon
- Is neither proven or disproven.
- Observations (results of experiments) either support or do not support a hypothesis

Theory vs. “Theory”

- Common language use of theory – conjecture, opinion or speculation
  - E.g. a political pundit has a theory about who will win the presidential election in November 2008
- Scientific use of theory – well tested and supported model describing a natural phenomenon
  - E.g. a scientist, using the theory of gravity, can plot the position and speed of the earth in November 2008
  - A theory is formed from hypotheses that are repeatedly tested and supported.
  - A theory is the highest level of scientific understanding
An Ecological Theory

• Populations will compete for limited resources.
• Turn this into a hypothesis…

Environmentalism

• Environmentalism is not a science
  – A political movement or world view
  – Does not make predictions, test hypotheses
  – Seeks to protect and conserve natural environments
  – Belief that humans have a moral obligation to do no harm
• Not to be confused with the science of conservation biology (a subdiscipline within ecology)
  – The ecological study of rare and endangered species.

History of the Environmental Movement

• Early 1900’s – extinction of passenger pigeon, near extinction of buffalo motivated Woodrow Wilson to form the US National Park System
  – First national parks: Yellowstone and Yosemite
• 1949 – Aldo Leopold – A Sand County Almanac
  – Humans have a moral responsibility to not harm the environment
  – Dangers of pesticide use (DDT)
• Modern environmental groups – Greenpeace, Sierra Club
• 1973 – Endangered Species Act

Ecology and Environmentalism – blurred lines

• Thomas Malthus (1798) – 1st to have concerns about human population sizes and sustainability
• 1st population biologist by extension
Summary

• Ecology is a science
• Conservation biology is a science
• Environmental biology is not a science

• Ecologists or conservation biologists are scientists and may also be environmentalists

• Environmentalists are not scientists, but may also be ecologists or conservation biologists

The most important theory in biology...

• Theory of evolution
• Simply states that the genetic composition of populations changes over time.
• An example -

Natural Selection

• One mechanism for evolution
• Requires the following be true
  – Populations are variable
  – Variations are heritable
  – Variations affect individuals ability to acquire resources
  – Resources are limited, individuals compete, and those who are best at getting resources reproduce the most -> are most fit
• These are all hypotheses, we should be able to design experiments to test their predictions.

Environmental Protection Agency

• Started in December 1970
• Major initiatives
  – Energy star program
  – Car fuel economy ratings
  – Ban of DDT
  – Clean Air Act
  – Water quality monitoring
  – Regulation of hazardous waste disposal
  – Recent change – carbon dioxide
Fitness in the Environment

- In natural selection, all that matters is how many offspring you produce.
- Fitness is not defined by survival
- Fitness is defined by number of offspring produced
  
  - Example
    - Two birds, Bob and Tom, live in a very harsh environment
      - Bob - survives for 5 years, reproduces in three years and produces 6 young
      - Tom - only survives two years, reproduces once, but produces 8 young in one year

Modern Example...

- Drought on island reduced seed abundance
- Bird abundance drops with seed abundance
- Birds with larger beaks can utilize a wider variety of seeds
- Beak size is heritable
- Mean beak size changed during drought
Adaptive Radiation

- Rapid evolution of a group stemming from a single common ancestor

Result: Many species evolve in one place at a time. Open niche space.

Speciation

Habitat A

Habitat B

Colonization

Speciation

Habitat A – favors phenotype A

Habitat B – favors phenotype a

Speciation

Islands - Many Islands
Speciation

Habitat A – favors phenotype A

Habitat B – favors phenotype a

Isolation + different selection pressures -> divergence

Misconceptions about natural selection and evolution

• Is not a random process
• Does not lead to “better” species, it is non-directional – still have primitive sp.
• Can result in very rapid changes, as fast as the environment can change – observed speciating

Natural Selection and Ecology

Ecology is the study of the interactions between organisms and their environment (biotic and abiotic)
Natural selection describes a process through which populations compete for limited resources
• Thus, the sciences of ecology and evolution are very tightly linked.

History of Life on Earth

• Earth formed ~5-6 bya
• Not hospitable for life for 1-2 billion years

• First fossilized life 3.8 bya (3,800,000,000)
Abiotic Synthesis

- Early Earth atmosphere
  - No O2
  - H₂O, H₂, NH₃, CH₄
  - High energy
  - Formed simple amino acids

- Amino acids joined to form the first self-replicating proteins

Stanley Miller and Harold Urey (1953)

Abiotic Synthesis has nothing to do with Evolution

- First fossilized life 3.5-3.8 bya
- Microbial mats
- Early life didn’t fossilize well

Oxygenation of atmosphere

- Evolution of photosynthesis ~3.5 bya
  - Use energy of sun to form carbohydrates
  - Oxygen accumulates in atmosphere
  - Atmosphere transformed from reducing to oxidizing
  - Use of oxygen to fuel metabolism = adaptive radiation

First fossilized life 3.5-3.8 bya

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Evolution of photosynthesis ~3.5 bya

- Use energy of sun to form carbohydrates
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History of Life

• Along with oxygen, earth becomes more stable and livable
  – Ozone (O₃) layer develops
  – Fewer asteroids
  – Less volcanic activity
• Until 700-800 mya when Earth freezes
  – Snowball Earth
  – 10 million years, frozen
  – Simple life under ice near equator survived
  – Volcanic activity release CO₂, nothing to absorb it, global warming melts ice