Visualizing Environmental Science

Biodiversity and Conservation

Chapter 15

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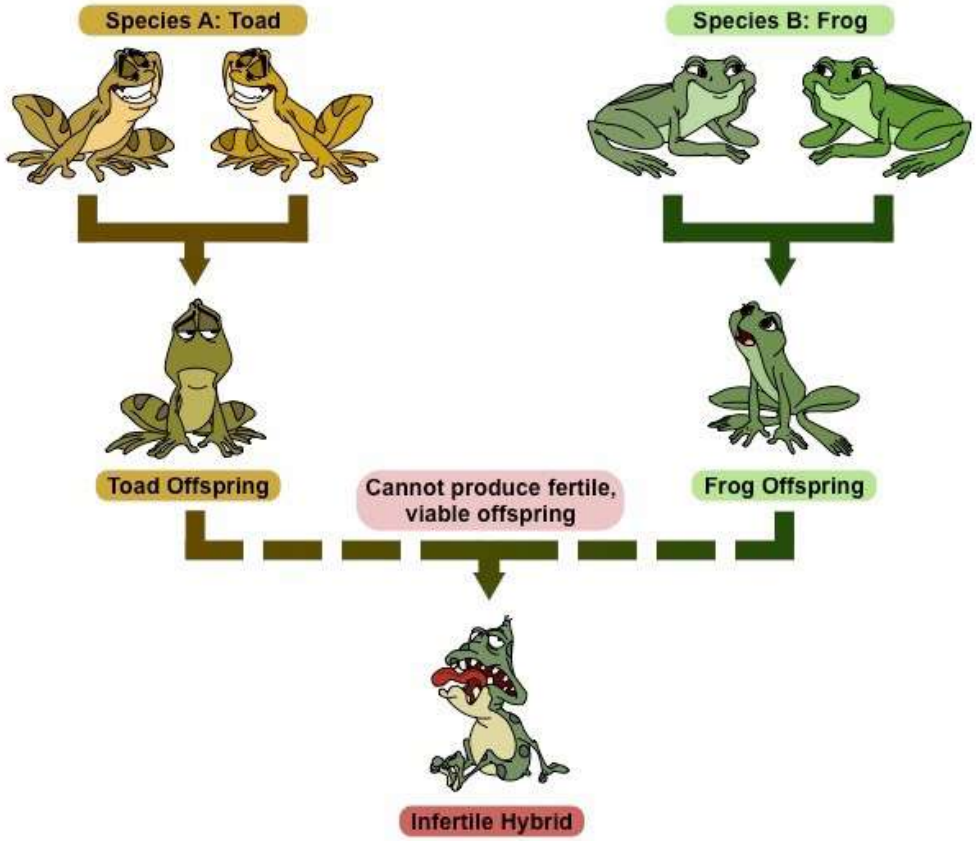
Species Richness and Biological Diversity

- Species
  - A group of distinct organisms that are capable of interbreeding with one another in the wild but that do not interbreed with organisms outside their group



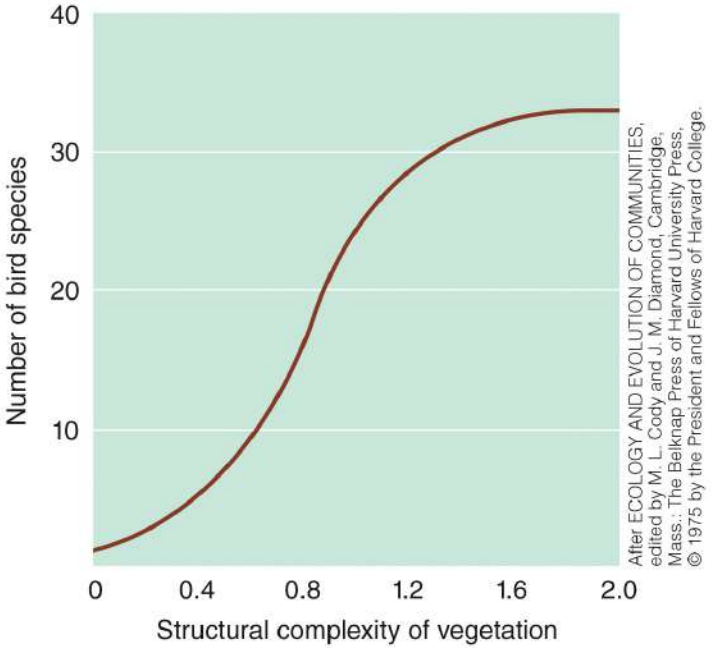
How Many Species Are There?

- How many species inhabit the Earth?
  - More than 1.6 million species scientifically named and described as of late 2015
    - 350,000 plant species
    - 64,000 vertebrate animal species
    - 800,000 insect species
  - Species richness is inversely related to environmental stress
  - Usually greater at the edges of adjacent communities than at the center of a community
  - Geologic history affects species richness
    - Areas with repeated disruptions to climate tend to have lower species richness

How Many Species Are There?

- Species richness
  - The number of different species in a community
  - Varies from community to community
  - Inversely related to isolation of community
    - Species have difficulty reaching and colonizing isolated places (e.g., islands)

Effect of community complexity on species richness



The structural complexity of chaparral vegetation in California (x-axis) is based on vegetation height and density, from low complexity (very dry scrub) to high complexity (woodland). Note that species richness in birds increases as vegetation becomes more structurally complex

Why We Need Biodiversity

- Biodiversity
  - The number and variety of Earth's organisms
  - Three components
    - Genetic diversity
    - Species richness
    - Ecosystem diversity
- Humans depend on thousands of species for survival
  - Insects for pollination, pest control
  - Bacteria and fungi for food, medicines, and important biological processes

Why We Need Biodiversity

- Ecosystem services and species richness:
  - The activities of all organisms in an ecosystem are interrelated
    - When one species declines, other species linked to it may either decline or increase in number
  - Increased species richness improves ability of a community to withstand environmental disturbances
    - Species richness also provides the community with resilience, the ability to recover quickly to its former state following an environmental disturbance.

Why We Need Biodiversity

- Ecosystem services
  - Ecosystems supply humans with many important environmental benefits such as clean air, clean water, and fertile soil

Ecosystem services • Table 15.1

Ecosystem	Services provided
Forests	Purify air and water Produce and maintain soil Absorb carbon dioxide (carbon storage) Provide wildlife habitat Provide humans with wood and recreation
Freshwater systems (rivers and streams, lakes, and groundwater)	Moderate water flow and mitigate floods Dilute and remove pollutants Provide wildlife habitat Provide humans with drinking and irrigation water, food, transportation corridors, electricity, and recreation
Grasslands	Purify air and water Produce and maintain soil Absorb carbon dioxide (carbon storage) Provide wildlife habitat Provide humans with livestock and recreation
Coasts	Provide a buffer against storms Dilute and remove pollutants Provide wildlife habitat, including food and shelter for young marine species Provide humans with food, harbors, transportation routes, and recreation

Sources: Adapted from environmental services listings provided by the FAO, the EPA, the USDA, and The U.S. Global Change Research Program.

Importance of Genetic Diversity

- The maintenance of a broad genetic base is critical for the long-term health and survival of each species
  - Unfortunately, many agricultural crops have been developed with significant genetic uniformity in order to optimize production
  - This can lead to disease and pest susceptibility
  - Crossing these strains with more genetically diverse plants can reintroduce resistant genes into the plants

Importance of Genetic Diversity

- Evolution has taken hundreds of millions of years to produce genetic diversity we see today
- Diversity may hold solutions to today's problems and to problems we have not begun to imagine
  - Genetic resources of organisms are important to the pharmaceutical industry
    - Many of the best-selling prescription drugs in U.S. are natural products slightly modified, or synthetic chemicals derived from natural chemicals produced by organisms

Endangered and Extinct Species

- Extinction
  - The elimination of a species from Earth
  - Natural part of life
    - Background extinction
      - Continuous low level of extinction of species, normal process
    - Mass extinction
      - Large number of species disappear during a relatively short period of geologic time
  - Although extinction is a natural process, it can be greatly accelerated by human activities
    - Human population growth has disrupted habitats
    - Biodiversity is disappearing at an unprecedented rate
      - 100 to 1000 times the natural rate of background extinction

Endangered and Extinct Species

- 23,000 plant and animal species threatened with extinction in 2015
  - 26% of mammals
  - 13% of birds
  - 41% of amphibians
  - 11,000 plant species

Endangered and Threatened Species

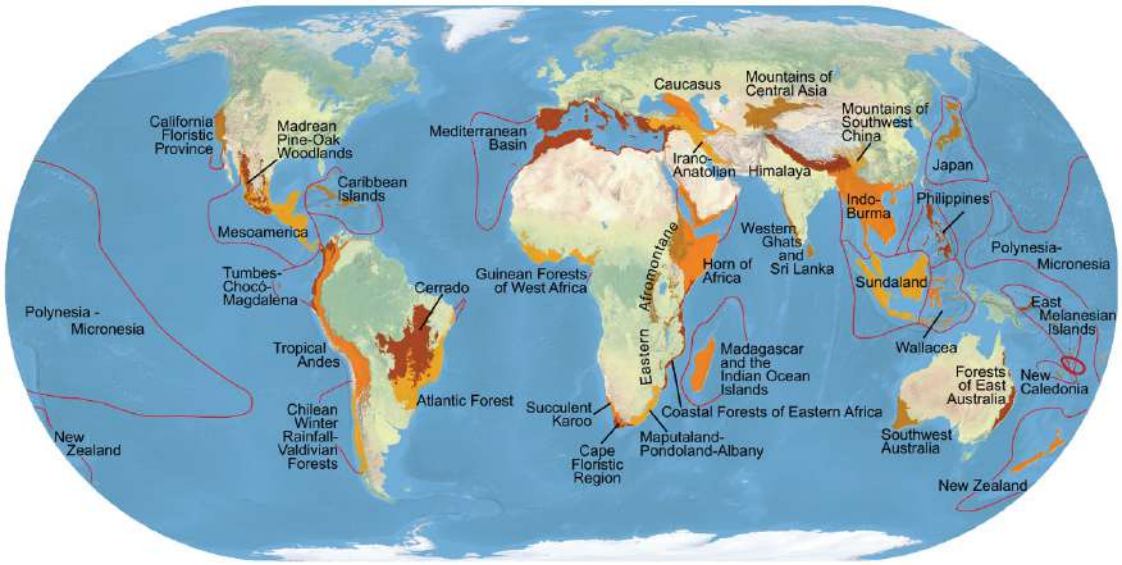
- The Endangered Species Act legally defines what endangered and threatened species are
  - Endangered species
    - A species in imminent danger of extinction throughout all or a significant portion of its range
  - Threatened species
    - A species whose population has declined to the point that it may be at risk of extinction
- Endangered and threatened species represent a decline in biological diversity because as their numbers decrease their genetic variability is severely diminished
  - Lower genetic diversity heightens the risk of extinction

Areas of Declining Biological Diversity

- Declining biological diversity is a concern throughout the U.S., but is most serious in
  - Hawaii (435 listed species at risk); at least 2/3 of native forests are gone
  - California (307 listed species at risk)
- – Severe problem in tropical rain forests
  - Forest are being destroyed for human settlements, banana plantations, oil and mineral exploration, etc.
  - Home to thousands or millions of species
  - Many species are endemic (native to/confined to a particular region), not found anywhere else in the world
  - Deforestation has a disruptive effect on evolution

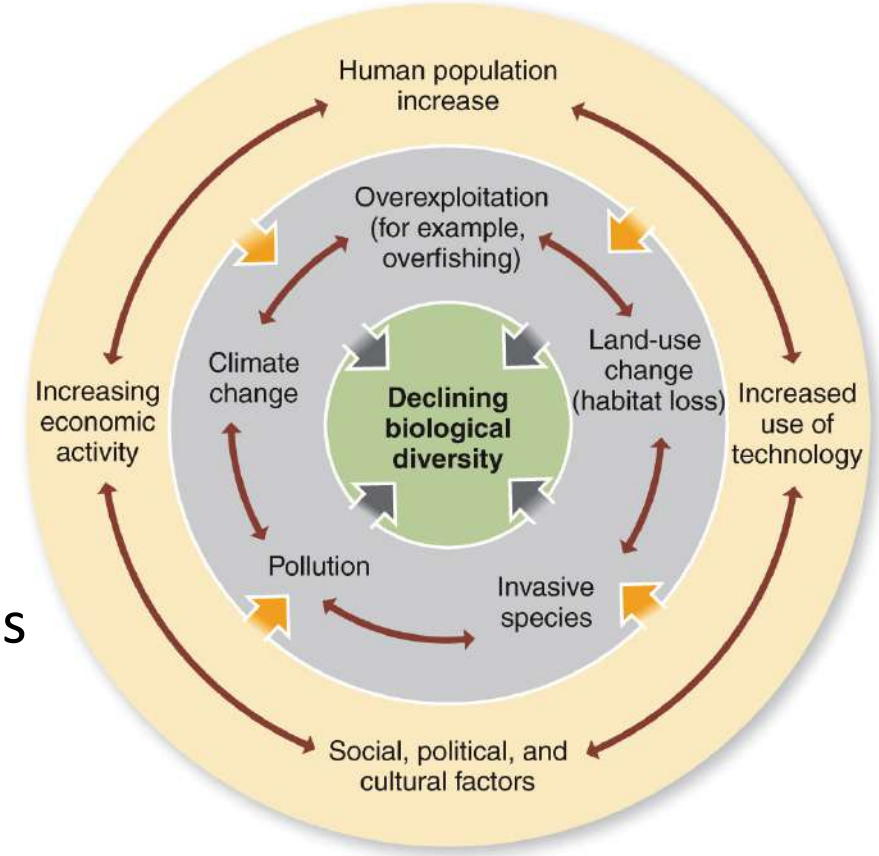
Earth's Biodiversity Hotspots

- Biological hotspots are relatively small areas of land that contain an exceptional number of endemic species and are at high risk from human activities
  - 35 biological hotspots around the world
  - Many hotspots are tropical forests, some are mostly/solely islands, and others are isolated by deserts or mountain ranges



Human Causes of Species Endangerment

- Loss of habitat is the greatest threat to biological diversity, followed by
  - Pollution
  - Spread of invasive species
  - Overexploitation
- All of this is caused by
  - Growth of human populations
  - Economic activity
  - Uses of technology
  - Social, political, cultural factors



Causes of declining biological diversity

Human Causes of Species Endangerment

- Most species facing extinction today are endangered due to the destruction, fragmentation, or degradation of habitats due to human activities
  - Humans alter habitats when they use or inhabit an area
    - Building roads, buildings, bridges
    - Clearing forests for agricultural use of land or timber
    - Draining and filling wetlands for building
    - Mining for minerals or fuel
    - Recreational use of land
  - Agricultural use of land has the greatest footprint and widest ecological influence on natural ecosystems

Human Causes of Species Endangerment

- Habitat fragmentation
  - The breakup of large areas of habitat into small, isolated patches (islands) due to human use of land
- Pollution and climate change
  - Human produced acid precipitation, ozone depletion, climate change degrade even otherwise undisturbed wilderness habitats
  - Climate change linked to biodiversity declines

Scott S. Warren/National Geographic Creative

Human Causes of Species Endangerment

- Invasive species
  - Foreign species that spread rapidly in a new area if free of predators, parasites, or resource limitations that may have controlled their population in their native habitat
  - Compete with native species for food and habitat
  - Introduction of non-native (invasive) species into an ecosystem where it did not evolve often upsets the balance among the organisms living in that area and interferes with the ecosystem's normal functioning

Endangered and Extinct Species

- Overexploitation
  - Sometimes species become endangered or extinct as a result of deliberate efforts to eradicate or control their numbers
  - Illegal hunting/poaching endangers many larger animals, such as the cheetah, elephant, tiger, rhino
  - Commercial harvesting of live organisms has endangered many bird species
  - Many plants are also endangered by overcollection

Case Study

- Protecting rare species: Tiger vs. condor
  - Tiger
    - Only about 3200 tigers remain in the wild, down from 100,000 a century ago
    - Illegally hunted
    - Loss of habitat due to fragmentation
    - Competition from humans for same prey species
    - No coordinated commitment to save wild tigers
  - California condor
    - Populations decimated by habitat loss, DDT, poaching, etc.
    - In 1982, all 22 remaining condors were captured and placed in captive breeding program
    - As of 2016, 425 condors exist, with more than half now again living wild