General Biology: Global Ecology And Conservation Biology

AI-Generated Study Guide

(Based on lectures delivered by Dr. Ty C.M. Hoffman)

I. Scope of Global Ecology and Conservation
The study of global ecology focuses on ecology at the largest scale and incorporates conservation biology, often highlighting the ways human activity is negatively impacting the planet.

II. Species Diversity and Extinction
• Undiscovered Species: No one knows the precise number of species currently existing. Approximately 2 million species have been named and discovered. However, estimates of total species range from 5 million up to 100 million or more. The discovered species represent only a small fraction of the total.
• Ongoing Extinction: The exact number of species will never be known because species are continuously going extinct even as new ones are discovered.
• Web of Life: All species are interconnected directly or indirectly in a "web of life." No species lives in isolation.
• Rate of Extinction: While extinction occurs naturally at a background level, the primary concern is the drastic increase in the rate of extinction, which is predominantly caused by human activity.
• Critically Endangered Species: These species are on the brink of extinction, sometimes numbering fewer than 100 individuals (e.g., the river dolphin or Philippine eagle). For a sexual species, finding only one individual means extinction is inevitable.

III. Levels of Biodiversity
Biodiversity involves three hierarchical levels:
1. Genetic Diversity: The variety of DNA within a single population or between different populations of the same species.
2. Species Diversity: The diversity measured at the species level, composed of two components:
  - **Species Richness: The total number of different species in a given area.**
  - **Relative Abundance: The number of individuals belonging to each species.**
3. Ecosystem Diversity: The variety of different kinds of ecosystems found across the overall biosphere (e.g., biomes).

IV. Four Major Causes of Ecological Decline

Four major ways human activity increases the extinction rate and damages global ecological health:

1. Habitat Loss:

- **This is the loss of homes for organisms, mainly due to humans converting wild land for agriculture and housing.**
- **Fragmentation: A severe type of habitat loss where large wild spaces are broken into numerous small chunks, creating smaller and smaller ecological islands. Fragmentation is highly damaging.**

2. Introduced Species:

- **Species introduced intentionally (e.g., Kudzu intended to control soil erosion, but it overran native species) or accidentally (e.g., rodents or mollusks carried on vehicles).**
- **Introduced species often outcompete native organisms, severely impacting the web of life.**

3. Overharvesting:

- **Elephants: Poaching for ivory is driving elephants to near extinction. Laws against poaching are often insufficient if they are not enforced, highlighting the need to eliminate the market by ensuring people refuse to buy ivory.**
- **Bluefin Tuna: Became instantly valuable in the 1980s when a lucrative market was created for them as sushi fish. Intentional fishing caused the population to drop by 80% in 10 years, initiating a vicious circle where scarcity increases value, which, in turn, increases hunting pressure.**

4. Global Change: Large-scale changes affecting the biosphere, including:

- **Acid Precipitation (pH Change): Acid rain, snow, or sleet is caused by airborne sulfurous compounds (often from burning diesel fuel) reacting with water to form acids.**
  - **Biological Impact: Changes in pH (or temperature) can change the confirmation (three-dimensional shape) of proteins, causing them to denature and lose their function, interfering with the normal processes of organisms, including crucial producers. Legislative action in the past has proven capable of reducing acid precipitation.**

V. Extinction Vortex and Conservation

- **Extinction Vortex: A cycle of conditions that accelerates decline once a population size becomes small enough. It refers to an irreversible process, like water spinning down a drain.**
- **Small Population Effects: The decline speeds up as the population size gets smaller due to:**
  - **Genetic Drift: Random elimination of individuals has a disproportionately severe effect on small populations.**
  - **Inbreeding: Mating between related individuals becomes more likely, increasing the chances of offspring being homozygous recessive for harmful alleles. This reduces fitness and further decreases the population size, tightening the vortex.**
- **Rescue Example: Injecting genetic variability into a small population (e.g., the Illinois prairie chickens, whose eggs were not hatching) by introducing individuals from larger populations can halt the vortex.**

• Ecological Edges and Corridors:
◦ Edge: A boundary where conditions change abruptly, fragmenting the landscape and creating ecological islands.
◦ Edge Effects: Many species are not adapted to live near edges, and fragmentation (natural or human-caused) pushes these species toward extinction.
◦ Corridors: Artificial bridges built to allow organisms to migrate safely between fragmented habitats (e.g., across a road), helping maintain species health.
• Biodiversity Hotspots: Specific ecosystems globally (like coral reefs) that have exceptionally high biodiversity but are also facing high extinction rates. Conservation efforts are prioritized in these hotspots because resources are insufficient to address all problems simultaneously.
• Minimum Viable Population (MVP): The minimum number of individuals required for a species to remain viable (survivable) and avoid an extinction vortex. For example, the long-term survival of the apex consumer grizzly bear requires an MVP of 500 individuals, necessitating a massive area of land that conflicts with private ownership.
• Zoned Reserve System (Costa Rica): A conservation success story where government legislation established federally protected parks surrounded by private lands (zones) that must operate under regulations designed to preserve biodiversity, often capitalizing on tourism as an economic incentive.

VI. Human-Caused Ecological Disasters
• Eutrophication and Dead Zones: In aquatic or marine environments, runoff of unnaturally high amounts of nitrates (from agricultural fertilizers) causes phytoplankton (producers) to rapidly multiply. This population explosion leads to an increase in zooplankton (consumers). The subsequent high rate of cellular respiration by zooplankton depletes the oxygen (O_2) in the water, creating a dead zone unlivable for fish and other macroscopic life (e.g., the Gulf of Mexico dead zone).
• Biological Magnification: The process by which the concentration of toxins (e.g., PCBs, DDT) increases successively at higher trophic levels. Organisms at the top of the food web accumulate drastically high concentrations because they eat many lower-level organisms throughout their lives, even if the toxin concentration in the background environment is tiny. This level can interfere with biological processes, such as the ability of birds to develop hard eggshells.
• Pharmaceutical Contamination: Potent exogenous signal molecules (drugs) used by humans and livestock enter waterways. Even tiny concentrations can have devastating effects, such as skewing the male-to-female sex ratio in fish populations.

VII. Global Warming and the CO_2 Crisis
• Mechanism: Greenhouse gases (CO_2 and others) allow shortwave radiation from the sun to pass through, heating the Earth. However, they block the longwave radiation (infrared heat) remitted by the warmed Earth, trapping heat and increasing the global average temperature.
• Fossil Fuel Problem: Historically, CO_2 levels were stable because naturally occurring CO_2 (from respiration) was a carbon swap (taken in by plants, released by consumers).

Modern global warming is caused by burning fossil fuels, which releases ancient carbon previously locked out of the cycle, drastically increasing the atmospheric CO_2 level. This increase is following an exponential curve.

• Ocean Acidification: The ocean absorbs large amounts of excess atmospheric CO_2, temporarily mitigating temperature rise. However, CO_2 dissolved in water forms carbonic acid, increasing the concentration of hydrogen ions and thus increasing the ocean's acidity (lowering the pH). This puts highly sensitive ecosystems, like coral reefs, at high risk.

• Plant Range Migration: Due to global warming, plant species need to migrate their ranges (by seed dispersal over generations) northward to cooler environments. Calculations show that they cannot migrate fast enough to keep up with the projected rate of temperature increase.

VIII. Human Population and Consumption

• The Root Problem: Out-of-control human population growth is the primary driver of all major ecological problems, as increasing numbers of humans require more resources and land, intensifying fragmentation and destruction.

• Historical Growth: The human population remained below 1 billion for most of history but has recently grown exponentially, approaching 8 billion.

• Energy Use: The United States population is a small fraction of the world's total population but uses a disproportionately massive fraction of the world's energy. American per capita energy use is extremely high, contributing significantly to global warming.