Quick Overview of Environmental Science

Environment: the total of our surroundings
- All the things around us with which we interact:
  - Living things
    - Animals, plants, forests, fungi, etc.
  - Nonliving things
    - Continents, oceans, clouds, soil, rocks
  - Our built environment
    - Buildings, human-created living centers
  - Social relationships and institutions

Humans and the world around us
- Humans change the environment, often in ways not fully understood
- We (and all life) depend completely on the environment for survival
  - Increased wealth, health, mobility, leisure time
  - But, natural systems have been degraded
    - i.e., depletion, pollution, erosion and species extinction
  - Environmental changes threaten long-term health and survival
- Environmental science is the study of:
  - How the natural world works
  - How the environment affects humans (and other life forms) and vice versa

Natural resources: vital to human (& all life) survival
- Natural resources = substances and energy sources needed for survival and other uses
  - Renewable resources:
    - Perpetually available: sunlight, wind, wave energy
    - Renew themselves over short periods: timber, water, soil, hot springs
    - Some can be destroyed if used faster than renewed (unsustainably)
- Nonrenewable resources: can be depleted
  - Oil, coal, minerals, ancient ground water, some soil

Global human population growth
- More than 6.7 billion humans
- Why so many humans?
  - Agricultural revolution
    - Stable food supplies
  - Industrial revolution
    - Urbanized society powered by fossil fuels
    - Sanitation and medicines
    - More food
    - Humans learned to completely dominate and control the environment for their own purposes

Thomas Malthus and human population
- Thomas Malthus (1766-1834)
  - Population growth must be restricted, or it will outstrip food production
  - Starvation, war, disease
- Neo-Malthusians
  - Population growth has disastrous effects
  - Paul and Anne Ehrlich, *The Population Bomb* (1968)
  - 200 years later still hasn’t happened; wrong or yet to come?
**Question**

Which is closest to your sense or viewpoint?

- A. Human population will continue to grow; technology will solve problems that arise (cornucopian viewpoint)
- B. Human population will continue to grow; disaster will occur with many deaths (Neo-Malthusian viewpoint)
- C. Humans will learn to control our population; standards of living will continue to increase
- D. Humans will learn to control our population, but somewhat too late; standards of living will decline
- E. Other, or no viewpoint at this time

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**Garrett Hardin’s Tragedy of the Commons (1968)**

- Example of cows grazing on common meadow
- Resource users will increase use until the resource is gone
- Unregulated exploitation leads to resource destruction
- Applies to any common ownership: e.g. Soil, air, water, forests, fish, buffalos
- Basically privatizes profit and socializes loss!
- **Solution?**
  - Governmental regulations?
  - Private ownership?
  - Voluntary organization to enforce responsible use?

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**The “ecological footprint” (aka “ecological Impact”)**

- The environmental impact of a person or population
  - Amount of land, water, air, energy, etc. used
  - for both raw materials and to dispose/recycle waste
- **Problem**: humans have surpassed the Earth’s capacity

*We are currently using more of the planet’s resources than are available on a sustainable basis!*

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**Environmental science**

… can help us avoid mistakes made by past civilizations.

*The lesson of Easter Island: people may have annihilated their culture by destroying their environment. (or maybe Europeans killed them?!) Can we act more wisely to conserve our resources or are we doomed?*

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**Environmental science: how does the natural world work?**

- Environment ➔ impacts ➔ Humans
- It has an applied goal: developing solutions to environmental problems
- An interdisciplinary field
  - Natural sciences: information about the world
  - Environmental Science programs
  - Social sciences: values and human behavior
  - Environmental Studies programs

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**What is an “environmental problem”?**

- The perception of what constitutes a problem varies between individuals and societies
- Ex.: DDT, a pesticide
  - In developing countries: welcome because it kills malaria-carrying mosquitoes
  - In developed countries: not welcome, due to health risks
Environmental science is not environmentalism

• Environmental science
  - The pursuit of knowledge about the natural world
  - Scientists must remain objective: be willing to change their minds when facts demand it

• Environmentalism
  - A social movement dedicated to protecting the natural world

The nature of science

• Science:
  - A systematic process for learning about the world and testing our understanding of it
  - A dynamic process of observation, testing, and discovery
  - The accumulated body of knowledge that results from this process

• Science is essential
  - To sort fact from fiction
  - Develop solutions to the problems we face

Applications of science

Policy decisions and management practices

Technology

Energy-efficient methanol-powered fuel cell car from DaimlerChrysler

Restoration of forest ecosystems altered by human suppression of fire

Not obvious assumptions hold!

• So many things in life seem unpredictable and not caused by anything
• Over 400 years humans have found some things that are predictable and governed by understandable laws: these are the subject of science. Other things (e.g. ethics/politics) are not.
• Mathematics is the main modeling tool: numbers are key, testability is key, reproducibility is key

The scientific method

• A technique for testing ideas with observations
• Assumptions:
  - The universe works according to unchanging natural laws
  - Events arise from causes, and cause other events
  - We use our senses and reason to understand nature’s laws

• A scientist makes an observation and asks questions of some phenomenon
• The scientist formulates a hypothesis, a statement that attempts to explain the scientific question.
• The hypothesis is used to generate predictions, which are specific statements that can be directly and unequivocally tested.
• The test results either support or reject the hypothesis; scientists must be willing to give up their ideas when experiments show they are wrong.
Experiments test the validity of a hypothesis

Manipulative experiments yield the strongest evidence (can prove causality)
- But, lots of things can’t be manipulated

Natural or correlational tests show real-world complexity
- Causality not proven so much more evidence needed. Counter-examples are important.

Science is an amazing human development

- Allows life work of genius’s to be recorded and used as a starting point for next generation of scientists
- Has moved us far, far beyond the experience and capability of an individual
  - Electronics, lasers, MRI, DNA, radio, space craft, airplanes, modern medicine, atomic bomb, GPS, etc., etc.
- Allows us to prove true and gain acceptance for even extremely unpopular or dangerous (to ruling power) ideas
  - Earth not center of universe, humans arose from evolution, plate tectonics, etc., etc.

The scientific process is part of a larger process

- The scientific process includes peer review, publication, and debate
- A consistently supported hypothesis becomes a theory, a well-tested and widely accepted explanation
- With enough data, a paradigm shift – a change in the dominant view – can occur

Drivers of the problems: Population & consumption

- Human population growth at root of most environmental problems
  - The growth rate has slowed, but we still add more than 200,000 people to the planet each day
- Our consumption of resources has risen even faster than our population growth.
  - Life has become more pleasant for us so far
  - However, rising consumption amplifies the demands we make on our environment.

Question

Are scientists subject to the same political/belief biases as the rest of the population?

A. Yes
B. No
C. Other

Question

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A. Yes
B. No
C. Other
Ecological footprints are not all equal

- The ecological footprints of countries vary greatly
- The U.S. footprint is almost 5 times greater than the world’s average
- Developing countries have much smaller footprints than developed countries
- Example: U.S. uses 25% of the world’s energy, but only contains 5% of the people. We use 5 times our “fair” share of energy.

Methods of the Past have not been optimal

- Input is amount of resources used (causes depletion)
- Output is waste afterward (usually causes pollution)
- In the past effort has focused on dealing with output since pollution/toxics has been main concern. Increasing input was taken for granted as standards of living rose.
- In future reducing input may be best method: reduces both depletion and pollution. But will comfort level of humans go down?
- Conflict between developing and developed regions.

We face challenges in agriculture

- Expanded food production led to increased population and consumption
- It’s one of humanity’s greatest achievements, but at an enormous environmental cost
  - Nearly half of the planet’s land surface is used for agriculture (most non-sustainably)
  - Chemical fertilizers
  - Pesticides
  - Erosion
  - Changed natural systems

We face challenges in pollution

- Waste products and artificial chemicals used in farms, industries, and households

Each year, millions of people die from pollution; Many species are being depleted or driven to extinction; ecosystems destroyed

We face challenges in climate

- Science has firmly concluded that humans are changing the composition of the atmosphere
- The Earth’s surface is warming
  - Melting glaciers
  - Rising sea levels
  - Impacted wildlife and crops
  - Increasingly destructive weather

Since the Industrial Revolution, atmospheric carbon dioxide concentrations have risen by 37%, to the highest level in 650,000 years; science says this must change the climate; and the worst is yet to come.

We face challenges in biodiversity

- Human actions have driven many species extinct, and biodiversity is declining dramatically
  - We are at the onset of a mass extinction event

Biodiversity loss may be our biggest environmental problem; once a species is extinct, it is gone forever
The Millennium Ecosystem Assessment

- A comprehensive scientific assessment of the condition of the world’s ecological systems
- Major findings:
  - Humans have drastically altered ecosystems
  - These changes have contributed to human well-being and economic development, but at a cost
  - Environmental degradation could get much worse
  - Degradation can be reversed, but it requires much work
- Check out www.millenniumassessment.org

Our energy choices will affect our future

- The lives we live today are due to fossil fuels
  - Machines
  - Chemicals
  - Transportation
  - Products
- Fossil fuels were created millions of years ago and are a one-time bonanza; supplies will certainly decline

We have used up ½ of the world’s oil supplies; how will we handle this imminent fossil fuel shortage?

Sustainable solutions exist

- Thinking long term, we should develop solutions that enable both our quality of life and the environment
- Organic agriculture
- Technology
  - Reduces pollution
- Biodiversity
  - Protect species
- Waste disposal
  - Recycling
- Alternative energy/fuels

Are things getting better or worse?

- Many people think environmental conditions are better
  - Cornucopians: Human ingenuity will solve any problem
- Some think things are much worse in the world
  - Cassandras (aka neo-malthusians): predict doom and disaster
- How can you decide who is correct?
  - Are the impacts limited to humans, (or just your nation? Are other organisms or systems involved?
  - Are the proponents thinking in the long or short term?
  - Are they considering ALL the costs and benefits?

Sustainability: a goal for the future

- How can humans live within the planet’s means?
  - Humans cannot exist without functioning natural systems
- Sustainability
  - Leaves future generations with a rich and full Earth
  - Conserves the Earth’s natural resources
  - Maintains fully functioning ecological systems
- Sustainable development: the use of resources to satisfy current needs without compromises future availability of resources
  - May require substantial changes to the ways things are done; but humans have made many large changes in the past ( horses to cars, end of slavery, women’s rights, electronic communication, etc.)

But how to move towards sustainability?

- Humans seem never to have done it! (tragedy of the commons)
- Idea: Regulations requiring paying true costs (e.g. fees for clean-up, carbon dioxide emission, habitat destruction, resource depletion, etc., adjusted to motivate change (how to set prices and avoid black markets?)
- Idea: Policies to change technologies, reduce usage, substitute resources with less impact (e.g. solar energy, recycled paper, local agriculture, home insulation, etc.)
- Policies to reduce human population (e.g. educate women, reduce poverty, make contraceptives available)
- Individual efforts (do they matter? Example of redwood)
- Will these things happen? Will they be enough?
Conclusion

• Environmental science helps us understand our relationship with the environment and informs our attempts to solve and prevent problems.
• Identifying a problem is the first step in solving it
• Solving environmental problems can move us towards health, longevity, peace and prosperity
  - Environmental science can help us find balanced solutions to environmental problems

QUESTION: Review

The term “environment” includes

a) Animals and plants
b) Oceans and rivers
c) Soil and atmosphere
d) All of the above are included in this term

QUESTION: Review

Adding various amounts of fertilizer to plants in a laboratory is a ____ type of experiment

a) Correlative
b) Natural
c) Manipulative
d) Rare

QUESTION: Weighing the Issues

Which do you think is the best way to protect commonly owned resources (i.e., air, water, fisheries, forests)?

a) Sell the resource to a private entity
b) Voluntary organizations to encourage responsible use
c) Governmental regulations to enforce responsible use
d) Don’t do anything rash; let nature run its course

QUESTION: Weighing the Issues

Do you think the rest of the world can have an ecological footprint as large as the footprint of the United States?

a) Yes, because we will find new technologies and resources
b) Yes, because the footprint of the United States is not really that large
c) Definitely not; the world does not have that many resources
d) It does not matter; it’s not that important

1. A large piece of ordinary paper is folded in half 45 times. How thick is it after folding?
   A. 2 inches
   B. 2 feet
   C. 2 miles
   D. 2 million miles
2. Do you consider yourself a cornucopian or a neo-Malthusian?
   A. Cornucopian
   B. Neo-Malthusian
   C. In between
   D. Don’t know
   E. Don’t care

3. For a theory to be "scientific" it must
   a. be proven true
   b. be testable, i.e. be able to be proven false
   c. be widely accepted by the majority of the population
   d. be widely accepted by the majority of other scientists
   e. be able to explain a wide variety of phenomena

QUESTION: Interpreting Graphs and Data
According to this graph, what has happened to the population over the last 500 years?
   a) It has grown exponentially
   b) It has grown linearly
   c) It has decreased
   d) It has slowed down recently

QUESTION: Interpreting Graphs and Data
What happens if test results reject a hypothesis?
   a) The scientist formulates a new hypothesis
   b) It shows the test failed
   c) The hypothesis was supported
   d) The predictions may not have been correct

QUESTION: Review
Which of the following is correct about the term “environmentalism”?
   a) It is very science-oriented
   b) It is a social movement to protect the environment
   c) It usually does not include advocacy for the environment
   d) It involves scientists trying to solve environmental problems