Chapter 1

Science and Sustainability: An Introduction to Environmental Science

Chapter Objectives

This chapter will help you:

Define the term *environment* and describe the field of environmental science

Explain the importance of natural resources and ecosystem services in our lives

Discuss the effects of population growth and resource consumption

Characterize the interdisciplinary nature of environmental science

Understand the scientific method and the process of science

Diagnose and illustrate some of the pressures on the global environment

Evaluate the concepts of sustainability and sustainable development

Lecture/Reading Outline

I. Our Island, Earth

1. The astronaut's view of Earth suggests that its systems are _____ and _____.
2. Increases in _____, _____, and _____ alter our planet and damage the systems that keep us alive.

A. Our environment surrounds us.

1. Our _____ consists of all the living and non-living things around us.
2. It encompasses _____ – structures and living spaces – as well as _ such as plants and animals.
3. The fundamental insight of environmental science is that we humans are a ___ of the natural world, not _____ from it, and we are _____ on a healthy, functioning planet.

B. Environmental science explores our interactions with the world.

1. _____ is the study of how the natural world works, how our environment affects us, and how we affect our environment.
2. Environmental scientists study issues of central importance to our world and its future. Rapidly changing _____ demand that we act now to solve problems.

C. We rely on natural resources.

1. _____ are the various substances and energy sources we need to survive. Our island, Earth, is finite and bounded, and it places limitations on the availability of these resources.
2. _____, such as sunlight, wind, and wave energy, are essentially inexhaustible while others, such as timber, water, and soil, can be replenished by the environment over periods varying from months to decades.
3. In contrast, resources such as mineral ores and crude oil are formed more slowly than we use them and are considered to be _____. Once we deplete them, they are no longer available.
4. Renewability is a _____. Some renewable resources may turn nonrenewable if we deplete them too drastically. _____ from underground aquifers faster than it can be restored is an example of this.

D. We rely on ecosystem services.

1. Earth's natural systems provide _____ such as air and water purification, climate regulation and plant pollination. We could not survive without these processes.
2. We have degraded nature's ability to provide these services by _____, _____, and _____.

E. Population growth amplifies our impact.

1. _____ phenomena triggered remarkable increases in the Earth's population, from less than a million people for most of its history to over 6.9 billion today.
2. The _____ occurred around 10,000 years ago as humans transitioned from a hunter-gatherer lifestyle to an agricultural way of life.
3. The _____ began in the mid-1700s. It was a shift from rural, agricultural life to an urban society provisioned by mass-produced manufactured goods and powered by _____.
4. Environmental science tries to answer the question of _____ of the planet can sustain current and future populations.

F. Resource consumption exerts social and environmental pressures.

1. The "tragedy of the commons."
   a. _____ analyzed how people approach resource use.
   b. Resources that are open to unregulated exploitation, the "commons," will eventually be depleted. Hardin called this the _____.

c. He disputed the economic theory that individual _____, in the long term, serves the public.

2. Our ecological footprint.

a. Mathis Wackernagel and William Rees developed the concept of the _____. It expresses the environmental impact of an individual or a population by the cumulative amount of land and water required to provide the raw materials they consume and to recycle the waste they produce.

b. The ecological footprint is the sum of the amount of Earth's surface "used" once all _____ and _____ impacts are totaled.

c. Wackernagel and his colleagues used these calculations to determine that we are depleting our resources about 30% faster than they are being replenished. _____ describes the actions of humans surpassing the planet's productive capacity.

G. Environmental science can help us avoid past mistakes.

1. Most great _____ have fallen after degrading their environments, leaving devastated landscapes behind.

2. The stakes are _____ than ever today. If we cannot forge sustainable solutions, there will be global societal collapse.

II. The Nature of Environmental Science

1. Scientists seek to understand how Earth's natural systems function and how we are influencing those systems.

2. Solutions are *applications* of environmental science. A.

Environmental science is an interdisciplinary pursuit.

1. Environmental science is an _____ field, drawing techniques from multiple disciplines and bringing their research into a broad synthesis.

2. An interdisciplinary approach to addressing environmental problems can produce effective and lasting solutions.

3. Environmental science is broad because it encompasses both the _____ sciences and the _____ sciences. Environmental _____ is often used to describe programs that incorporate the social sciences extensively.

B. People vary in their perception of environmental problems.

1. A person's age, gender, class, race, nationality, employment, and educational background can all affect whether he or she considers an environmental change a "_____."

2. In other cases, people from different cultures and homelands may vary in their _____ of problems.

3. Economic status can affect both your _____ of risk and how you _____ to that knowledge.

C. Environmental science is ***not*** the same as environmentalism.

1. _____ is a social movement dedicated to protecting the natural world from undesirable changes brought about by human choices.
2. _____ is the pursuit of knowledge about the environment, how it works, and our interactions with it.

III. The Nature of Science

1. Modern scientists describe _____ as a systematic process for learning about the world and testing our understanding of it.
2. Knowledge of science and technology is increasingly important as our society becomes more dependent on it for the crucial elements of transportation, communications, medicine, and agriculture.
3. This knowledge is important because it allows society to make informed decisions.

A. Scientists test ideas by critically examining evidence.

1. Scientists make observations, take measurements, and design tests to determine if ideas are supported by evidence.
2. An explanation that resists attempts to disprove it is accepted as a true explanation.

B. Science advances in different ways.

1. Most scientific work is _____ or _____ based on information gathering.
2. If enough is known about a subject, scientists pursue _____, trying to answer specific questions.

C. The scientific method is the traditional approach to science.

1. The _____ is a technique for testing ideas with observations. It includes several assumptions and a series of interrelated steps.

2. The assumptions are:

   a. The universe functions in accordance with fixed natural laws.

   b. All events arise from some cause and, in turn, cause other events.

   c. We can use our senses and reasoning abilities to detect and describe natural laws.

3. The steps of the scientific method are:

   a. Make observations.
   b. Ask questions. Determining which questions to ask is one of the

most important steps in the investigation process.

c. Develop a hypothesis. A _____ is a statement that explains a phenomenon or answers a scientific question.

d. Make predictions. A _____ is a specific statement that can be directly and unequivocally tested.

e. Test the predictions. An _____ is an activity designed to test the validity of a hypothesis; it involves manipulating _____, or conditions that can change. The _____ is the variable that the scientist manipulates, while the _____ is the one that depends on the first variable. Scientists conduct _____ by controlling for the effects of all variables except the tested one. Often, controlled experiments have a _____ area that is manipulated and another that is not, called a _____.

f. Analyze and interpret results. Scientists record _____ from their studies and analyze the data using statistical tests to see if the hypothesis is supported. If the results disprove a hypothesis, the hypothesis is rejected and a new one may be proposed. If the repeated tests fail to reject a particular hypothesis, it will ultimately be accepted as true.

D. We can test hypotheses in different ways.

1. A _____ is an experiment in which the researcher actively chooses and manipulates the independent variable.

2. When variables cannot be manipulated - climate change is an example of this - a _____ is performed. In such experiments, researchers test their hypothesis by searching for _____, a statistical relationship between variables.

3. Natural experiments provide evidence that is weaker than manipulative experiments but can still make for strong science.

E. The scientific process does not stop with the scientific method.

1. Peer review. Research results are submitted to a journal for publication. Other scientists who specialize in the subject area are asked to provide comments and critiques and judge whether the work merits publication. This process is known as _____.

2. Conference presentations. Scientists frequently present their work at professional conferences and receive informal comments on their work prior to publication.

3. Grants and funding. Most scientists spend considerable time writing grant applications to private foundations or government agencies for support of their research. These applications are also usually subjected to peer review. Conflicts of interest sometimes arise when results are in conflict with the interests of the funding agency. This has occurred in the

case of private industry funding. Government agencies have also occasionally suppressed findings to avoid policy implications.

4. Repeatability. The careful scientist may test a hypothesis repeatedly in various ways before submitting it for publication. After publication, other scientists will attempt to reproduce the results in their own analyses.

5. Theories. If a hypothesis survives repeated testing by numerous research teams, it may be incorporated into a _____. A theory is a widely accepted, well-tested explanation of one or more cause-and- effect relationships that has been extensively validated by a large amount of research. In science, a theory is not speculation or hypothesis.

6. Applications. Knowledge gained from scientific research may be applied to help fulfill society's needs and address society's problems. A correct social response may still be difficult even when the scientific information is clear, however.

F. Science may go through "paradigm shifts."

1. A _____ is a dominant view regarding a topic, based on the facts and experiments known at that time.

2. Thomas Kuhn argued that science goes through periodic revolutions in which one dominant view is abandoned for another as more information becomes available.

IV. Sustainability and the Future of Our World

A. Achieving a sustainable solution is vital.

1. The primary challenge in our increasingly populated world is how to live within our planet's means. This is the challenge of _____.

2. We have been drawing down Earth's _____, its accumulated wealth of resources, 30% faster than it is being replenished. This cannot be sustained.

B. Population and consumption drive environmental impact.

1. The ways we modify the environment have been influenced by the steep and sudden rise in human population.

2. Our consumption of resources rises even _____ than our population.

3. Large differences in the benefits of rising _____ exist among the World's nations. The discrepancies in income lead to large differences in the ecological footprint of citizens from different nations.

C. We face challenges in agriculture, pollution, energy, and biodiversity.

1. Advances in technology have enabled us to grow more food per unit of land. Extensive use of chemical fertilizers and pesticides, and their resulting runoff and pollution, along with the widespread conversion of

natural habitats, are some environmental costs of conventional agriculture.

2. Synthetic chemicals pollute land, water, and air. Pollution causes the death of millions of people and significant loss of wildlife.
3. Our most pressing challenge might be the looming specter of global climate change. Our use of fossil fuels in concert with deforestation has increased the amount of carbon dioxide and other gases in the atmosphere, bringing warming to its highest level in at least 800,000 years.
4. Overharvesting, the introduction of nonnative species, and habitat alteration cause serious problems with _____ -- the number and diversity of living things -- which is declining dramatically, as well as on other ecological systems. The _____ clearly states that we have degraded many environmental systems.

D. Our energy choices will influence our future enormously.

1. Our reliance on fossil fuels, while bringing us material affluence, has intensified virtually every impact that we have on the environment.
2. In addition to the environmental problems caused, we will soon have to deal with the depletion of these fuels and the energy crisis that this could precipitate.

E. Sustainable solutions abound.

1. Renewable energy and efficiency efforts are gaining ground.
2. Legislation and technological advances are decreasing pollution in wealthier countries.
3. Advances in conservation biology enable scientists and policymakers to work together to protect habitat and organisms. Soil conservation, irrigation, and organic methods are improving agriculture.
4. Steps to reduce greenhouse gas emissions are increasing.

F. Are things getting better or worse?

1. Some environmental thinkers, whose views are characterized as _____, claim that the quality of human existence is improving.
2. Others prophesize imminent doom. These people are often called _____.
3. What questions do we need to ask to discover the likely realities?

G. Sustainable development involves environmental protection, economic well-being, and social equity.

1. Our civilization cannot exist without an intact natural environment. Portrayals of environmental protection as threatening people's economic and social

needs fail to account for the importance of environmental quality. It is also the poorest members of our society who suffer most from the degradation of the environment.

2. Development in an economic sense describes the use of natural resources for economic advancement. _____ is the use of these resources in a manner that does not compromise the future availability of resources. Otherwise, future generations may not have the present quality of life.
3. Interpretations of the phrase *sustainable development* vary. To meet the goals of the original United Nations definition, we need to satisfy a _____, which encompasses economic advancement, environmental protection, and social well-being.
4. Environmental science holds the key to answering the question of whether we can develop in a sustainable way.

V. Conclusion

A. Finding effective ways of living peacefully, healthfully, and sustainably on our diverse and complex planet will require a thorough scientific understanding of both natural and social systems.

B. Identifying a problem is the first step in devising a solution to it.

C. Science in general and environmental science in particular, can help efforts to develop balanced and workable solutions to the many challenges we face and to create a better world for us and our children.

Key Terms for Chapter 1

agricultural revolution
biodiversity
Cassandras
control
controlled experiment
Cornucopian
correlation
data
dependent variable
descriptive science
ecological footprint
ecosystem services
environment
environmentalism
environmental science
environmental studies
experiment
hypothesis
hypothesis-driven science
independent variable
industrial revolution
interdisciplinary
manipulative experiment
Millennium Ecosystem Assessment
natural capital
natural experiment
natural resources
natural sciences
nonrenewable natural resources
observational science
overshoot
paradigm
peer review
prediction
probability
renewable natural resources
science
scientific method
social sciences
sustainability
sustainable development
theory
tragedy of the commons
treatment
triple bottom line
variables