Solutions for Environmental Science 16th Edition by Miller

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Solutions

CHAPTER 1
THE ENVIRONMENT AND SUSTAINABILITY

Outline

1.1 What are some key principles of sustainability?

A. Environmental science is a study of connections in nature.
   1. The environment includes the sun and all living and nonliving things with which an organism interacts.
   2. Environmental science studies how the earth works, our interaction with the earth, and ways to deal with environment problems and live more sustainably.
   3. Ecology studies the relationships between living organisms, and their interaction with the environment.
   4. Environmentalism, or environmental activism, is a social movement dedicated to protecting life support systems for all species.

B. Nature's survival strategies follow three principles of sustainability.
   1. Life depends on solar energy.
   2. Biodiversity provides natural services.
   3. Chemical/nutrient cycling means that there is little waste in nature.

C. Sustainability has certain key components.
   1. Life depends on natural capital, natural resources, and natural services.
   2. An inexhaustible resource is continuously renewed and expected to last (e.g., solar energy).
   3. A renewable resource is replenished in days to several hundred years through natural processes. (forests, grasslands, fish populations, freshwater, fresh air, and fertile soil).
   4. Sustainable yield is the highest rate at which a renewable and non-renewable resource can be used indefinitely without reducing its available supply.
   5. Some resources are not renewable.
      a. Nonrenewable resources exist in fixed quantities.
         i. Exhaustible energy (coal and oil).
         ii. Metallic minerals (copper and aluminum)
         iii. Nonmetallic minerals (salt and sand).
   6. Ecosystem services are natural services provided by the ecosystem that support life and human economies for free.
   7. Many human activities can degrade natural capital. However, solutions are being found and implemented.
   8. Conflicts arise when environmental protection has a negative economic impact.
   9. Conflict resolution involves trade-offs and compromises.
   10. Sustainability begins at personal and local levels.
   11. Sustainable solutions: Reduce, reuse, and recycle.

D. Economics, politics, and ethics provide us with three additional principles of sustainability.
   1. Full-cost pricing involves finding ways to include harmful environmental and health costs of producing in market prices
   2. Win-win solutions based on compromise and cooperation
   3. Responsibility to leave the earth as good or better than it was inherited.

E. Rich and poor countries have different environmental impacts.
   1. Developed countries include the high-income ones, such as the U.S. and Canada.
   2. Developing countries include the low-income ones, such as China and India.

1.2 How are we affecting the earth?

A. People have a better quality of life.
   1. Human activities affect atmospheric temperature, ocean temperature and acidity, and species survival and extinction.
   2. Humans learned how to extract enormous amounts of energy.
   3. Computers were invented, allowing for instantaneous and global communication.
   4. Life spans are increasing, infant mortality is declining, and education is on the rise

5. The food and water supply is generally safer and more abundant.

B. We are living unsustainably.
   1. Environmental, or natural capital, degradation is occurring.
   2. We have solutions to these problems that can be implemented.

C. The tragedy of the commons: overexploiting shared renewable resources.
   1. In 1968, the biologist Garrett Hardin called the degradation of openly shared resources the *tragedy of the commons*.
   2. Reducing degradation.
      a. Reduce use by government regulations.
      b. Shift to private ownership.

D. Ecological footprints: our environmental impacts.
   1. Ecological footprint is the amount of biologically productive land and water needed to supply a person or country with renewable resources and to recycle the waste and pollution produced by such resource use.
   2. Per capita ecological footprint is the average ecological footprint of an individual in a given country or area.
   3. Ecological deficit means the ecological footprint is larger than the biological capacity to replenish resources and absorb wastes and pollution.
   4. Humanity is living unsustainably.
   5. Footprints can also be expressed as number of Earths it would take to support consumption.

E. IPAT is another environmental impact model
   1. In the early 1970s, scientists Paul Ehrlich and John Holdren developed the IPAT model.
   2. I (environmental impact) = P (population size) × A (affluence/person) × T (technology's beneficial and harmful effects).

F. Cultural changes our ecological footprints
   a. Humans found more reliable sources of food.
   2. Industrial-medical revolution
      a. People invented machines for mass production.
      b. Learned to extract energy from fossil fuels.
      c. Learned how to grow large quantities of food.
   3. Information-globalization revolution
      a. Developed new technologies.
      b. Access to information and resources on a global scale.
   4. Sustainability revolution Agricultural revolution
   5.
      a. Avoiding degradation and depletion of natural capital.

1.3 What causes environmental problems?

A. Experts have identified four basic causes of environmental problems:
   1. Population growth.
   2. Unsustainable resource use.
   3. Poverty.
   4. Excluding environmental costs from market prices.

B. The human population is growing exponentially at a rapid rate.
   1. Human population is increasing at a fixed percentage so that we are experiencing doubling of larger and larger populations.
   2. Based on the current increase rate there will be 9.9 billion people by 2050.
   3. We can slow population growth by reducing poverty and promoting family planning.

C. Affluence has harmful and beneficial environmental effects.
   1. Wealth results in high levels of consumption and waste of resources.
   2. The average American consumes 30 times as much as the average consumer in India and 100 times as much as the average consumer in the poorest countries.
   3. Affluence has provided better education, scientific research, and technological solutions, which result in improvements in environmental quality (e.g., safe drinking water).

D. Poverty has harmful environmental and health effects.

1. Poverty occurs when the basic needs for adequate food, water, shelter, health, and education are not met.
2. One in every five people live in extreme poverty (<$1.90/day), and more are susceptible.
3. Poverty causes harmful environmental and health effects.
   b. Environmental degradation caused by need for short-term survival.
   c. Malnutrition.
   d. Inadequate sanitation and lack of clean drinking water.
   e. Severe respiratory disease (inadequate ventilation of heat sources).
   f. High rates of premature death for children under the age of 5 years.

E. Prices of goods and services due not include harmful environmental and health costs.
   1. A company's goal is often to maximize the profit.
   2. Often consumers do not know the damage caused by their consumption.
   3. Government subsidies may increase environmental degradation.
   4. There are ways to include harmful costs of goods and services.
      a. Shift from environmentally harmful to beneficial government subsidies.
      b. Tax pollution and waste heavily while reducing taxes on income and wealth.

F. People are isolated from nature.
   1. Rapidly shifting from rural to urban living.
   2. Increased used of cell phones, computers, and other electric devices.
   3. Isolation leads to nature deficit disorder.

G. People have different views about environmental problems and their solutions.
   1. Everyone has their own environmental worldview—a set of assumptions and values reflecting how you think the world works and what your role should be.
   2. Environmental ethics are beliefs about what is right and wrong with how we treat the environment.
   3. Planetary management worldview holds that we are separate from and in charge of nature.
   4. Stewardship worldview holds that we can and should manage the earth for our benefit, but that we have an ethical responsibility to be caring and responsible managers.
   5. Environmental wisdom worldview holds that we are part of, and dependent on, nature and that nature exists for all species, not just for us.

H. The rise of environmental protection in the United States
   1. In the early 20th century, the conservationist movement was split into two factions:
      a. The preservationist view wants public lands untouched.
      b. The conservationist view promotes management of public land for human benefit.
      c. The U.S. government established the United States Environmental Protection Agency (EPA) in 1970.
      d. Since the 1980s, there has been backlash against environmental laws and regulations from landowners and corporations.

1.4 What is an environmentally sustainable society?

A. Environmentally sustainable societies protect natural capital and live off its income.
   1. Increase reliance on renewable resources.
   2. Protect earth's natural capital.

B. We can work together to solve environmental problems.
   1. Trade-off solutions provide a balance between the benefits and the costs.
   2. Individuals matter especially in success of bottom-up grassroots action.

Concepts

1.1 What are some key principles of sustainability?

CONCEPT 1.1A Life on the earth has been sustained for billions of years by solar energy, biodiversity, and chemical cycling.

CONCEPT 1.1B Our lives and economies depend on energy from the sun and on natural resources and ecosystem services *(natural capital)* provided by the earth.

1. Define **natural capital**. Make a list of several local examples of depleting or degrading behaviors that impact our environment. Analyze which of these behaviors humans are currently shifting away from.

2. Define **sustainable society**.
3. Describe how **natural services** work to recycle materials. Draw the relationship among solar energy, **nutrient cycling**, and **biodiversity**. Provide a specific **nutrient cycling** example.
4. Distinguish between the following terms: **inexhaustible**, **renewable,** and **nonrenewable resources** and specify the importance of **reduce, reuse,** and **recycle** for the **nonrenewable resources**.

CONCEPT 1.1C We can live more sustainably by following six principles of sustainability.

1.2 How are our ecological footprints affecting the earth?

CONCEPT 1.2A Humans dominate the earth with the power to sustain, add to, or degrade the natural capital that supports all life and human economies.

CONCEPT 1.2B As our ecological footprints grow, we are depleting and degrading more of the earth's natural capital.

1. Distinguish between **point** and **nonpoint sources** of pollution. Describe two local examples of each type and suggest/recommend solutions to reduce or eliminate these problems.
2. Distinguish between **pollution prevention** and **pollution cleanup**. Evaluate the effectiveness of these two approaches in decreasing **pollution**. List four causes of environmental problems.
3. Give 3 examples of resources that have been degraded due to the tragedy of the commons.
4. Calculate your **ecological footprint** at www.myfootprint.org and evaluate the long-term consequences of continuing to live in your current style.

1.3 Why do we have environmental problems?

CONCEPT 1.3A Basic causes of environmental problems are population growth, wasteful and unsustainable resource use, poverty, avoidance of full-cost pricing, and increasing isolation from nature.

CONCEPT 1.3B Our environmental worldviews play a key role in determining whether we live unsustainably or more sustainably.

1. What is affluenza? List several behaviors that you have observed that are signs of affluenza. What are the long-term consequences of continued high levels of consumption?
2. Describe several environmental problems associated with poverty. Distinguish between **developed countries** and **developing countries**.

1.4 What is an environmentally sustainable society?

CONCEPT 1.4 Living sustainably means living off the earth's natural income without depleting or degrading the natural capital that supplies it.

1. Define **sustainable yield**. Describe the relationship between **sustainable yield** and environmental **degradation**. Describe the "tragedy of the commons."
2. Define **biodiversity**. Briefly describe your community's **biodiversity**. Analyze the relationship between **biodiversity** and human life.

Key Terms

biocapacity
biodiversity
biological capacity
biomimicry
chemical cycling
earth-centered environmental worldview
ecological footprint
ecology
ecosystem
ecosystem services
environment
environmental activism
environmental degradation
environmental ethics
environmental science
environmental worldview
environmentalism
environmentally sustainable society
exponential growth
exhaustible resource
full-cost pricing
human-centered environmental worldview
inexhaustible resource
less-developed countries
life-centered environmental worldview
malnutrition
more-developed countries
natural capital
natural capital degradation
natural income
natural resources

nonrenewable resource
nutrient cycling
nutrients
per capita ecological footprint
poverty
principles of sustainability
renewable resource
scientific principles of sustainability
solar energy
species
subsidies
sustainability
sustainability revolution
sustainable yield
win-win solutions

Teaching Tips

Ask students to look up their hometown's 1990 and 2000 census population at www.census.gov; or let the students know that around 1900, the world population was approximately 2 billion and around 1975, approximately 4 billion, then ask them what our current population is. Ask them how these numbers have influenced their quality of life. Use this dramatic change in population to introduce the core case study—Learning from the Earth.

- Use the Core Case Study at the beginning of the chapter to solidify the students' understanding of sustainability and biomimicry. Content within the chapter refers to the Core Case Study at multiple points and provide examples on how tie in discussion of the material.
- Using the notion of exponential population growth, move on to ask them how long this unchecked population growth can go on.
- Discuss the impacts population growth will have on the sustainability of Earth's resources (e.g., food, space, and non-renewable resources). With a bit of coaxing, this should lead to a discussion of environmental problems and solutions. Discuss the concept of the tragedy of the commons.
- Discuss how different cultures distribute resources, then ask the students (1) how their parents distributed the family resources, such as groceries, tuition money and entertainment expenses and (2) how the students handle their own resources.
- Stress the idea of a sustainable society, how this type of society can grow, and humans' effect on Earth.
- In addition, introduce and develop the topic of pollution, its sources, and solutions to pollution. Lastly, emphasize the principles of sustainability.

Discussion Topics

1. What are the UN population projections and how might these population changes influence sustainability?

2. Define poverty and specify several geographic areas struggling with poverty. Discuss several causes of poverty. Suggest possible strategies to address the current situation.

3. Discuss the current research, development, and distribution of new technologies in the United States that can contribute to living more sustainably (e.g., alternate fuel sources).

4. State of the world: Use the annotated bibliography of current resources to summarize the state of the world and the most important areas of environmental concern.

5. What is one form of pollution or environmental degradation, and describe its existence in different countries, choosing one incident as a case study.

6. How have cultural views of the human-environment relationship influenced a sustainable-Earth worldview? What about indigenous cultures? Discuss attitudes toward nature; distribution of labor, power, and wealth; relationships between the sexes; social structure; and political style.

7. How has energy consumption and use of materials throughout history changed in relation to increases in population size?

8. What variables influence a person's quality of life? What are the minimum requirements for each person to have a "good" quality of life? What is a "good life"? Does increased resource consumption improve quality of life?

9. What is the history of conflict among pollution control, environmental degradation, and employment in the United States? List possible cases of interest such as the automobile industry and fuel efficiency standards, the spotted owl and the logging industry, and offshore drilling and the oil industry.

10. Is the United States overpopulated? What is the difference between people overpopulation and consumption overpopulation?

11. Do you feel a part of or apart from nature?

12. Do you think technology can solve our environmental problems?

13. Do you think human ingenuity, technology and substitutes for materials that are being used up quickly can create a good life for Earth's people?

14. When poor economic growth accompanies population growth, poverty increases. How does the use or misuse of natural/renewable resources affect poverty? How does this poverty affect the environment? How can the use of common property affect resources?

15. Why is a U.S. citizen's "ecological footprint" so much larger than that of someone in a less developed country?

16. What are some technological resources that compromise the environment, and some that are environmentally beneficial?

Activities and Projects

1. Create an environmental movie list: each student submits a movie title, description, and how it is related to environmental science. Students can give a brief presentation about the movie and show a 1-minute, or less, scene from the movie to the class.

2. Compare your family size and resource consumption to that of your parents or grandparents. Make a table of the class data and generate some statistics (e.g., average family size, average water usage, and average number of household cars).

3. As a class project, "adopt" a country. Assign teams of students to investigate various aspects of the nation's physical, population, economic, social, political, and other characteristics as well as lifestyle and life quality. Allocate class time for periodic, brief reports, and discussions of research results.

4. Find and share with the class songs, essays, poems, paintings, and literary passages that are strongly pro- or anti-technology/environment.

5. As a class exercise, make lists of the beneficial and harmful consequences that have resulted from America's adoption of automobile technology. Survey the class to see how often students travel by walking, bicycle, public transit, or by car. Collect data on the mpg of students' cars and average number of miles driven/year. Discuss any changes in driving habits caused by the increase in gas prices.

6. As a class project or extra-credit exercise, contact the local Department of Transportation (DOT) and find out if they offer an *Adopt-A-Highway* program. Adopt a stretch of highway and have the students pick up litter. Students can keep tallies of the different types of litter collected (e.g., metal cans, snack

food wrappers) and prepare a pie chart and report to submit to the DOT. Alternatively, students can do a similar project on your campus.

7. Find and share with the class songs, folklore, literary passages, and artwork that reflect U.S. land-use values and ethics as they have evolved from the frontier era to the present. Be sure to include Native American works. What can be discerned about the relationship of humans to nature in different cultures through their expressions of art?

8. Have your students devise a way to diagnose affluenza and recommend cures for the problem.

9. Have your students survey four of their friends or family members to determine their worldview. Pool the class data and create a bar chart. Discuss factors that might affect a person's worldview, such as age, profession, level of education, or cultural or ethnic background.

Attitudes and Value Assessment

1. Are we living on our planet in a sustainable manner?

2. Is the world overpopulated? Have you experienced countries that you felt to be overpopulated? Have you seen videos of countries that you felt to be overpopulated?

3. Is your local community overpopulated? What do you feel are the costs and benefits of the population size of your community?

4. Do you feel that the size of the human population is one of the top environmental issues?

5. Should something be done to reduce poverty? Will a reduction in poverty help our planet be more sustainable?

6. Do you think the rate of resource consumption is too high?

7. Do you consume too many resources? Should your ecological footprint be regulated?

8. Do you think it's important to change your consumption patterns?

9. What kinds of changes do you think would improve the quality of life on Earth?

10. What kinds of changes are you willing to make to decrease your resource consumption?

11. Would decreasing your resource consumption improve your own quality of life?

12. What kinds of changes do you think industrialized countries might make to improve the quality of life?

13. What is your environmental worldview?

Laboratory Skills

Wells, Edward. *Lab Manual for Environmental Science.* 2009. Lab #2: The Tragedy of the Commons—A Classroom Simulation Exercise.

Wells, Edward. *Lab Manual for Environmental Science.* 2009. Lab #21: Why is Your Footprint So Big?

News Videos

Sacrificing the environment for energy?; Brooks/Cole Environmental Science Video Library 2010 with Workbook, ©2012, DVD ISBN-13: 978-0-538-73495-0

Additional Videos

Planet Earth: ***The Future: Living Together*** (Documentary, 2007). Companion to the BBC nature documentary Planet Earth. Three episodes: "Saving Species," "Into the Wilderness," and "Living Together."

Reinventing the World (Documentary, 2000). Explores some of the biggest challenges facing us today, including urban sustainability.
http://www.bullfrogfilms.com/catalog/rtw.html

Human Footprint (National Geographic Documentary, 2008). This video looks at the total impact one human can have on the planet in their life.
http://channel.nationalgeographic.com/channel/human-footprint/

Kilowatt Ours: A Plan to Re-Energize America (Documentary, 2008). Examines the source of our electricity, problems caused by energy production and ways to conserve energy.
http://www.videoproject.com/Kilowatt-Ours.html

Web Resources

Center for Sustainable Economy
Ecological footprint quiz.
http://www.myfootprint.org/

Earth 911.org
Environmental and sustainability resources.
http://earth911.org/

Online Community for the Environment
Many resources.
http://www.envirolink.org/

Center for Ecoliteracy
Educational sources on Sustainable living
http://www.ecoliteracy.org/

Eartheasy
Many resources.
http://www.eartheasy.com/

Digital Integration

Correlation to Global Environment Watch

Consumption	Overpopulation
Ecological Footprint	Poverty
Environmental Philosophy	Sustainability

Correlation to Explore More

Sustainability

Suggested Answers to End of Chapter Questions

Answers will vary, but these represent phrases from this chapter. The following are examples of the material that should be included in possible student answers to the end of chapter questions. They represent only a summary overview and serve to highlight the core concepts that are addressed in the text. It should be anticipated that the students will provide more in-depth and detailed responses to the questions depending on an individual instructor's stated expectations.

Review

Core Case Study

1. What is sustainability? What is biomimicry? Explain why learning from the earth is key to learning how to live more sustainably.

- Sustainability is the capacity of the earth's natural systems and human cultural systems to survive, flourish, and adapt to changing environmental conditions into the very long-term future.
- Biomimicry describes the effort to understand, mimic, and catalog the ways in which nature has sustained life.
- Given that life has been sustained on earth for about 3.8 billion years, earth is a remarkable example of a sustainable system.

Section 1.1

2. What are the three key concepts for this section? Define **environment**. Distinguish among **environmental science, ecology**, and **environmentalism (environmental activism).** Define species. What is an **ecosystem**? Define **solar energy**, **biodiversity**, **nutrients**, and **chemical cycling (nutrient cycling)**; and explain why they are important to life on earth.

- The key concepts for this section are:
  - Nature has sustained itself for billions of years by relying on solar energy, biodiversity, and nutrient cycling.
  - Our lives and economies depend on energy from the sun (*solar capital*) and natural resources and natural services (*natural capital*) provided by the earth.
  - We could shift toward living more sustainably by applying full-cost pricing, searching for win-win solutions, and committing to preserving the earth's life-support system for future generations.
- The environment is everything around us.
- Environmental science is an interdisciplinary study of how humans interact with living and nonliving parts of their environment.
- Ecology is the biological science that studies how organisms, or living things, interact with one another and with their environment.
- Environmentalism is a social movement dedicated to protecting the earth's life-support systems for all forms of life.

- Every organism is a member of a certain species: a group of organisms that have distinctive traits and, for sexually reproducing organisms, can mate and produce fertile offspring.
- An ecosystem is a set of organisms within a defined area or volume interacting with one another and with their environment of nonliving matter and energy.
- Nature has sustained itself with solar energy, biodiversity, and chemical cycling.
- Solar energy warms the earth and provides energy for plants to produce nutrients. All life on earth depends upon solar energy.
- Biodiversity is the variety of organisms, the natural systems in which they live and the natural services that they provide.
- Nutrient cycling is the circulation of nutrients, or chemicals necessary for life, from the environment (mostly from soil and water) through organisms and back to the environment
- Solar energy, biodiversity, and chemical cycling are the three scientific principles of sustainability. These three natural factors play key roles in the long-term sustainability of the planet's life.

3. Define **natural capital**. Define **natural resources** and distinguish among **inexhaustible, renewable**, and **nonrenewable (exhaustible) resources**. What is **sustainable yield**? Define **ecosystem services** and give two examples of each. Give three examples of how we are degrading natural capital. Explain how finding solutions to environmental problems involves making trade-offs. Explain why individuals matter in dealing with the environmental problems we face. What are three economic, political, and ethical **principles of sustainability**? What is **full-cost pricing** and why is it important? Describe the role of Janine Benyus in promoting the important and growing field of biomimicry.
   - Natural capital—the natural resources and natural services that keep us and other forms of life alive and support our economies.
   - Natural resources are materials and energy in nature that are essential or useful to humans.
   - These resources are often classified as:
     - inexhaustible or expected to last forever (such as solar energy)
     - renewable, or a resource that can be replenished through natural processes, and thus can be used repeatedly (such as air, water, soil, plants, and wind)
     - nonrenewable (exhaustible), or exists in a fixed amount, (such as copper, oil, and coal).
   - Sustainable yield is the highest rate at which people can use a renewable resource indefinitely without reducing its available supply.
   - Ecosystem services are the natural services in nature such as purification of air and water and climate regulation, which support life and human economies.
   - Natural capital degradation occurs when the natural resources and services are being used faster than nature can restore them. For example,
     - human activities add pollutants to air and chemicals and waste to rivers, lakes, and oceans faster than they can be cleansed naturally.
     - Plastics and synthetic materials can poison wildlife and disrupt nutrient cycling.
     - Simplified crop plantations that replace biologically diverse forests require large and costly inputs of energy.
   - Solutions to natural degradation, such as reducing energy consumption, reducing resource use and advocating a reduction in population growth, may require economic changes and life-style modifications.
   - Individuals matter because data suggest that it takes only 5–10% of the population of a community, country, or the world to bring about major social change, and significant social change can occur in a much shorter time than most people think.
   - Three social science principles of sustainability are full-cost pricing, win-win solutions, and responsibility to future generations.
   - Full-cost pricing includes the harmful environmental and health costs of producing and using goods and services in the market prices.
   - Janine Benyus coined the term biomimicry. She also set up the nonprofit Biomimicry Institute, developing a curriculum for K-12 and university students and a 2-year program to train professionals. In addition, Benyus established a network of scientists, engineers, architects, and designers called Biomimicry 3.8.

4. Define and distinguish between **more-developed countries** and **less-developed countries**; and give an example each of a high-income, middle-income, and low-income country.

- The United Nations classifies the world's countries as economically more developed or less developed based primarily on their average income per person. High-income countries include the United States, Canada, Japan, Australia, New Zealand, and most countries of Europe. Middle-income countries include China, India, Brazil, Thailand, and Mexico. Low-income countries include Congo, Haiti, Nigeria, and Nicaragua.

Section 1.2

5. What are the two key concepts for this section? How have humans improved the quality of life for many people. How are humans living unsustainably? Define and give three examples of **environmental degradation (natural capital degradation)**. About what percentage of the earth's natural or ecosystem services have been degraded by human activities? What is the tragedy of the commons? What are two ways to deal with this effect?

- The two key concepts for this section are:
  - Humans dominate the earth with the power to sustain, add to, or degrade the natural capital that supports all life and human economies.
  - As our ecological footprints grow, we are depleting and degrading more of the earth's natural capital.
- Humans have learned how to use wood, fossil fuels, the sun, wind, flowing water, and geothermal energy for enormous amounts of energy supply. Humans have also invented computers, increased lifespans, decreased infant mortality, cleaner air and water, and food supply is generally more abundant and safer.
- Environmental degradation is when the use of a renewable resource exceeds its natural replacement rate, causing the available supply to shrink. Examples include climate change, soil erosion, aquifer depletion, decreased wildlife habitats, species extinction, and declining ocean fisheries.
- According to the 2005 UN *Millennium Ecosystem Assessment*, about 60% of the earth's natural or ecosystem services have been degraded.
- The tragedy of the commons is the environmental degradation of openly shared renewable resources. One solution is using a shared renewable resource at a rate well below its estimated sustainable yield by using less of the resource, regulating access to the resource, or both. Another possible solution is to convert open-access renewable resources to private ownership; this is not practical for global resources such as the atmosphere and the oceans.

6. What is an **ecological footprint**? What is a **per capita ecological footprint**? What is **biocapacity,** or **biological capacity**, *and what is an ecological deficit*? Use the ecological footprint concept to explain how we are living unsustainably. What is meant by upcycling? What is the IPAT model for estimating our environmental impact? Explain how three major cultural changes taking place over the last 10,000 years have increased our overall environmental impact. What would a **sustainability revolution** involve?

- An ecological footprint is the amount of biologically productive land and water needed to indefinitely supply the people in a particular country or area with renewable and non-renewable resources and to absorb and recycle the wastes and pollution produced by such resource use.
- A per capita ecological footprint is the average ecological footprint of an individual in a given country or area.
- If the total ecological footprint for a city, a country, or the world is larger than its biological capacity to replenish its renewable resources and absorb the resulting wastes and pollution, it is said to have an ecological deficit. In other words, its people are living unsustainably by depleting

natural capital instead of living off the renewable supply of resources and ecosystem services provided by such capital.

- Upcycling acknowledges our growing ecological footprints and the need to reduce them, but it stresses that in pursuing our activities and in creating products and services, we need to consider how we can improve some aspect of the environment while we serve our needs and wants.
- The IPAT model shows how population size (P), affluence (A), or wealth, as measured by rates of resource consumption per person, and the beneficial and harmful environmental effects of technologies (T) help to determine the environmental impact (I) of human activities.
- Over the last 10,000 years, three major cultural changes have increased our overall environmental impact.
  - Agricultural revolution: Humans learned how to grow and breed plants and animals for food, clothing, and other purposes. As a result, villages formed. Reliable sources of food also allowed people to live longer and produce more offspring that survive to adulthood.
  - Industrial-medical revolution: Machines were invented for the large-scale production of goods in factories. As a result, people learned how to extract energy from fossil fuels and grow large amounts of food. Medical advances also allowed people to live longer, healthier lives.
  - Information-globalization revolution: Developed new technologies for gaining rapid access to all kinds of information and resources.
- A sustainability revolution involves learning to live more sustainably by avoiding degradation and depletion of the natural capital that supports all life. It would also involve restoring degraded natural capital and using lessons from nature to shrink our ecological footprints while increasing our beneficial environmental impacts.

Section 1.3

7. What are the two key concepts for this section? Identify five basic causes of the environmental problems that we face. What is **exponential growth**? What is the rule of 70? What is the current size of the human population? About how many people are added each year? How big is the population projected to be in 2050? Summarize the potentially harmful and beneficial environmental effects of affluence.

- The two key concepts for this section are:
  - Major causes of environmental problems are population growth, unsustainable resource use, poverty, avoidance of full-cost pricing, and increasing isolation from nature. Our environmental worldview plays a key role in determining whether we live unsustainably or more sustainably**.**
- Five basic causes of environmental problems are:
  - population growth
  - wasteful and unsustainable resource use
  - poverty
  - failure to include the harmful environmental and health costs of goods and services in their market prices
  - increasing isolation from nature
- Exponential growth occurs when a quantity such as the human population or pollution increases at a fixed percentage per unit of time, for example 2% per year. Exponential growth starts off slowly. But after only a few doublings, it grows to enormous numbers because each doubling is twice the total of all earlier growth.
- The rule of 70 is that the doubling time of the human population or of any growing quantity can be calculated by using the rule of 70: doubling time (years) = 70/annual growth rate (%).
- There are currently about 7.4 billion people with about 89.7 million being added each year. By 2050, there may be 9.9 billion people.
- Affluence can support high levels of consumption which can waste and degrade resources.
- Affluence can allow for better education, which can lead people to become more concerned about environmental quality. It also provides money for developing technologies to reduce pollution, environmental degradation, and resource waste.

8. What is poverty and what are three of its harmful environmental and health effects? About what percentage of the world's people struggle to live on the equivalent of $1.90 a day? About what percentage struggle to live on $3.10 a day? How are poverty and population growth connected? List three major health problems suffered by many of the poor.

- Poverty is a condition in which people are unable to fulfill their basic needs for adequate food, water, shelter, health care, and education.
- According to the World Bank, about 900 million people—almost three times the U.S. population—live in extreme poverty, struggling to live on the equivalent of less than $1.90 a day
- About one of every three, or 2.5billion, of the world's people struggles to live on less than $3.10 a day.
- To many poor people, having more children is a matter of survival. Their children help them gather firewood, haul water, and tend crops and livestock. The children also help to care for their aging parents, most of whom do not have social security, health care, and retirement funds. This daily struggle for survival is largely why populations in some of the poorest countries continue to grow at high rates.
- Three health problems suffered by the poor include malnutrition, illness from lack of access to clean water, and health issues from outdoor air pollution.

9. Explain how excluding the harmful environmental and health costs of production from the prices of goods and services affects the environmental and health problems we face. What is the connection between government subsidies, resource use, and environmental degradation? What are two ways to include the harmful environmental and health costs of the goods and services in their market prices? Explain how a lack of knowledge about nature and the importance of natural capital, along with our increasing isolation from nature, can intensify the environmental problems we face. What is an **environmental worldview**? What is **environmental ethics**? What are five important ethical questions relating to the environment? Distinguish among the **human-centered**, **life-centered**, and **earth-centered environmental worldviews**. What are three levels of biomimicry? List seven key biomimicry principles. Summarize the rise of environmental conservation and protection in the United States.

- Because the prices of goods and services do not include most of their harmful environmental and health costs, consumers and decision makers have no effective way to evaluate these harmful effects.
- Although subsidies help to create jobs, and stimulate economies, environmentally harmful subsidies encourage the depletion and degradation of natural capital.
- Two ways to include the harmful environmental and health costs of the goods and services in their market prices over the next two decades would be to shift from environmentally harmful government subsidies to environmentally beneficial subsidies, and to tax pollution and waste heavily while reducing taxes on income and wealth.
- Because people live isolated from nature, they are unaware of the amounts of wastes and pollutants they produce, where these wastes and pollutants go, and how they affect the environment.
- An environmental worldview is your set of assumptions and values reflecting how you think the world works and what you think your role in the world should be.
- Environmental ethics, the study of varying beliefs about what is right and wrong with how we treat the environment, provides useful tools for examining worldviews.
- Five important ethical questions relating to the environment can include:
  - Why should we care about the environment?
  - Are humans the most important species on the planet?
  - Do people have an obligation minimize activities that cause extinction of other species?
  - Should people try to protect all or just some species?
  - How do we decide which animals to protect from extinction?

  - Do humans have an ethical obligation to pass the world on in the same or better condition than what they inherited?
  - Regardless of race, gender, age, national origin, income, social class, or any other factor, should every person be entitled to equal protection?
  - Should we seek to live more sustainably? If so, how?
- There are three major categories of environmental worldviews: human-centered, life-centered, and earth-centered.
  - A human-centered environmental worldview sees the natural world primarily as a support system for human life
  - According to the life-centered environmental worldview, all species have value as participating members of the biosphere, regardless of their potential or actual use to humans.
  - The earth-centered environmental worldview holds that we are part of, and dependent on, nature and that the earth's life-support system exists for all species, not just for us.
- Three levels of biomimicry are:
  - Mimicking the characteristics of species that enhance long-term survival.
  - Mimicking the processes that species use to make parts that benefit long-term survival without making toxic by-products or without using high-temperature and high-pressure manufacturing processes.
  - Mimicking long-term survival strategies and beneficial environmental effects.
- The seven key biomimicry principles are:
  - Life runs on sunlight.
  - Life doesn't waste energy.
  - Life adapts to changing environmental conditions.
  - Population control and adaptation depend on biodiversity.
  - Life creates no waste. Outputs from one organism are resources for others.
  - Life doesn't pollute its own environment.
  - Life doesn't produce chemicals that cannot be recycled by the earth's chemical cycles.
- Early conservationists such as Teddy Roosevelt, John Muir, Aldo Leopold, and Rachel Carson paved the way for the environmental legislation of the late 1960s and 1970s and the eventual creation of the Environmental Protection Agency

Section 1.4

10. What is the key concept for this section? What is an **environmentally sustainable society**? What is **natural income** and how is it related to sustainability? What are two pieces of good news about making the transition to a more sustainable society? What are this chapter's three big ideas?

- Living sustainably means living off the earth's natural income without depleting or degrading the natural capital that supplies it.
- An environmentally sustainable society meets the current and future basic resource needs of its people in a just and equitable manner without compromising the ability of future generations to meet their basic needs.
- Natural income means the renewable resources such as plants, animals, and soil provided by the earth's natural capital. Living off natural income means not depleting or degrading natural capital.
- Two pieces of good news are that we have the ability to create a sustainable future by making good environmental choices now, and that people alive today are part of the 21st century's transition generation who have the ability to create a sustainable future.
- This chapter's three big ideas are:
  - Rely more on renewable energy from the sun, including indirect forms of solar energy such as wind and flowing water, to meet most of our heating and electricity needs. In addition, protect biodiversity by preventing the degradation of the earth's species, ecosystems, and natural processes.
  - Full-cost pricing—harmful environmental and health costs need to be included in the market prices of goods and services.

- Commit to finding win-win solutions. Do not disrupt the earth's natural chemical cycles by overloading them with harmful chemicals or by removing natural chemicals faster than cycles can replace them. Leave the planet's life-support system in the same or better condition than we inherited.

Critical Thinking

1. Why is biomimicry so important? Find an example of something in nature that you think could be mimicked for some beneficial purpose. Explain that purpose and how biomimicry could apply.

   Answers may vary and can be used as a class discussion on how nature can be beneficially mimicked. The core idea of biomimicry is that we can learn from nature by emulating its time-tested characteristics, processes, survival strategies, and beneficial environmental effects in order to enrich and sustain humanity.

2. What do you think are the three most environmentally unstable components of your lifestyle? List two ways in which you could apply each of the six principles of sustainability (Figures 1.2 and 1.7 and inside back cover of book) to making your lifestyle more environmentally sustainable.

   Answers may vary and can be used as a class discussion on how best to evaluate sustainability, compare ecological footprints. Some examples of answers include reducing energy consumption and relying more heavily on solar energy, reducing resource use and recycling when possible, and advocating a reduction in population growth.

3. For each of the following actions, state one or more of the three scientific principles of sustainability that are involved: (a) recycling aluminum cans; (b) using a rake instead of a leaf blower; (c) walking or bicycling to class instead of driving; (d) taking your own reusable bags to the grocery store to carry your purchases home; and (e) volunteering to help restore a prairie and other degraded ecosystems.

   The three key factors are *solar energy*, *biodiversity*, and *chemical cycling*. All the examples could be connected to all three key factors.

   (a) Nutrient Recycling/Reliance on Solar Energy: In nature, there is no waste, so recycling the aluminum soda can mimic nutrient recycling. Since less energy is used in the aluminum recycling process than starting from raw materials such as bauxite, recycling makes us less dependent on nonrenewable energy sources.
   (b) Reliance on Solar Energy: As no electrical or gasoline energy is expended by using the rake, we are less dependent on nonrenewable energy sources such as coal to generate the electricity to power the leaf blower.
   (c) Reliance on Solar Energy/Biodiversity: By not using gasoline to drive the car, you are relying more on renewable rather than nonrenewable energy and positively impacting biodiversity in areas where oil drilling is having harmful ecological effects.

   (d) Nutrient Recycling/Biodiversity/Reliance on Solar Energy: If you use a reusable grocery bag made from organically grown hemp, bamboo, or cotton, you will be relying on solar energy rather than nonrenewable energy sources that may have been used to make a plastic bag, which may or may not be recyclable; while paper is recyclable, using paper bags can affect the biodiversity of forest lands.
   (e) Biodiversity/Nutrient Recycling: By restoring degraded ecosystems, you will be enhancing biodiversity and also helping the future recycling of nutrients from the plantings.

4. Explain why you agree or disagree with the following propositions:
   a. Stabilizing population is not desirable because, without more consumers, economic growth would stop.

b. The world will never run out of resources because we can use technology to find substitutes and to help us reduce resource waste.
c. We can shrink our ecological footprints while creating beneficial environmental impacts.

Student answers will vary depending on their viewpoint but could include:

Disagree: The earth has a finite amount of resources. With an ever-increasing number of consumers, the economy may eventually reach a maximum as these resources are diminished and the cost of goods skyrockets. This would cause a greater disparity between rich and poor people and end up promoting increased poverty rather than increased wealth.

Agree: Companies like 3M have reduced their waste by selling their generated waste products to other companies that can use the materials for their own manufacturing processes. With an increase in such technology in the future, more materials have the potential to be reused and recycled indefinitely.

5. Should nations with large ecological footprints reduce their footprints to decrease their harmful environmental impact and leave more resources for nations with smaller footprints and for future generations?

   Student answers will vary, but the benefit of such questions is that the instructor can facilitate a discussion that could help the students come to terms with the feelings they have on the issue and take the necessary steps to minimize their own ecological footprint. The instructor can help the students see how answers such as being indifferent to the issue lead to a perpetuation of the problem, and answers may bring about a change in their own lifestyle.

6. When you read that at least 19,000 children of ages 5 and younger die each day (13 per minute) from preventable malnutrition and infectious disease, what is your response? How would you deal with this problem?

   Student answers will vary. The instructor could lead a discussion in which each student is asked to explain their answer. Through this discussion, more students may see a possible answer and be spurred into action.

7. Explain why you agree or disagree with each of the following statements: (a) humans are superior to other forms of life; (b) humans are in charge of the earth; (c) the value of other forms of life depends only on whether they are useful to humans; (d) all forms of life have a right to exist; (e) all economic growth is good; (f) nature has an almost unlimited storehouse of resources for human use; (g) technology can solve our environmental problems; (h) I don't have any obligation to future generations; and (i) I don't have any obligation to other forms of life.

   Student answers will vary and the instructor has the opportunity to lead a discussion where each student can elaborate on their own particular viewpoint. Some comments may include:

   (a) Humans *are* superior to other life forms as we have the capability to modify our environments to suit our own needs and desires, setting us apart from the rest of the animal world. Humans *are not* superior to other life forms as we are the only species capable of causing wide-spread environmental disasters.

   (b) Humans *oversee* the earth. No other species can manipulate the environment and exploit nature for food and energy sources to the same extent.

   (c) Some species need to exist because they may be beneficial to other species in their ecosystem. Just because they may not benefit humans directly, they do so indirectly by helping to maintain the biodiversity and stability of ecosystems. In addition, some people believe that other species may have aesthetic, moral, and ethical value.

(d) Some species have a right to exist, especially if they benefit us; but what about those species that cause disease and death? We should wipe out all the bacteria and viruses that kill us, as they should not exist, and only leave the "good" organisms around.

(e) Economic growth is good for everyone. For example, the people of the United States and Europe benefit from being able to buy cheap goods that are manufactured in China; the Chinese people have jobs, so everyone wins. Some students may believe that economic growth is bad because it can hurt the environment; building housing developments means cutting down trees and destroying homes of many animals.
(f) This is true only if we use the resources in a sustainable way. If *everyone* on the planet used and consumed resources at the same rate as the people of the United States, we would run out very quickly and need more than one Earth to provide the resources for all of us. So, the resources we have are not unlimited.

(g) Technology may be able to solve some of our environmental problems such as reducing the emissions from smokestacks. The impact technology will have on the future is speculative. Breakthroughs in hydrogen fuel cell technology may greatly reduce the world's dependence on oil and may lead to increased sustainability in terms of energy use.

(h) The concept of sustainability depends upon having an obligation to future generations. If we do not take the future into account by looking at our actions of today, we will not be leaving a healthy planet for our children and our children's children.

(i) We need to consider the needs of humans who, after all, are the most important species on the planet, and we need to do whatever we can to make sure we survive even if it does mean a few other species go extinct.

8. What are the basic beliefs within your environmental worldview? Record your answer. At the end of this course, return to your answer to see if your environmental worldview has changed. Are the beliefs included in your environmental worldview consistent with the answers you gave for Question 7? Are your actions that affect the environment consistent with your environmental worldview? Explain.

   Student answers will vary. This question provides the instructor with the basis for a discussion on individual worldviews and allows for each student to consider his/her own current beliefs. It is hoped that by the end of the course, everyone in the class will have gained a greater understanding of the environment and increased his/her environmental literacy. The question also gives the instructor the chance to discuss specific *actions* individual members of the class can take to make sure that if they "talk the talk" they also "walk the walk" from an environmental perspective. This will help students individually, as well as the class as a whole, to live consciously and possibly to minimize their ecological footprint.

Doing Environmental Science

Students are asked to use the Internet to estimate their own ecological footprint. Students are guided to analyze their own ecological footprint, list the three ways in which they could reduce their ecological footprint, try one way of reduction for a week, write a report on the change and then list three ways they could increase their beneficial environmental impact. Answers will vary.

Global Environment Watch Exercise

Go to your MindTap course to access the GREENR database. Use the information on pages 9 and 10 in this chapter to choose one more-developed country and one less-developed country to compare their ecological footprints. Use the "World Map" link at the top of the page to access information about the countries you have chosen to research. Once on the country page, view the "Quick Facts" panel at the right. Click on the ecological footprint number to view a graph of both the ecological footprint and biocapacity of each country. Using those graphs, determine whether these countries are living sustainably or not. What would be some reasons for these trends?

Answers will vary but more-developed countries will have larger ecological footprints than less-developed countries. Factors that determine whether a country is living sustainably or not include the size of the per capita ecological footprint and the size of the ecological biocapacity.

Ecological Footprint Exercise

If the *ecological footprint per person* of a country or the world is larger than its *biological capacity per person* to replenish it renewable resources and absorb the resulting waste products and pollution, the country or the world is said to have an *ecological deficit*. If the reverse is true, the country or the world has an *ecological credit* or *reserve*. See Figure 1.11 for a map of the world's ecological debtor and creditor countries. Use the data to the right to calculate the ecological deficit or credit for the countries listed. (As an example, this value has been calculated and filled in for the world.)

1. Which three countries have the largest ecological deficits? For each of these countries, why do you think it has a deficit?

The two countries with the largest ecological deficits are the United Arab Emirates (-7.3 hectares per person) and Israel (-4.3 hectares per person). The United Arab Emirates has a large ecological deficit because it has the largest per capita ecological footprint of any country in the world. Israel has a large ecological deficit because it has a high per capita ecological footprint, but also because it has a low ecological biocapacity to replenish its renewable resources and absorb the resulting waste products and pollution due to its growing population and large consumption of resources and land.

2.Rank the four countries with ecological credits in order from the highest to the lowest credit. For each country, why do you think it has an ecological credit?

The four countries that have ecological credits are Russian Federation (2.2 hectares per person), Canada (6 hectares per person), Brazil (6.5 hectares per person), and Australia (7.5 hectares per person, ranked in that order. Answers may vary, but one consistency in the four countries is a low population.

3. Rank the countries in order from the largest to the smallest per capita ecological footprint.

Countries listed in order of largest to smallest per capita ecological footprint:

United Arab Emirates	8.0	0.7	-7.3
Israel	4.6	0.3	-4.3
Japan	3.7	0.7	-3.0
United States	6.8	3.8	-3.0
United Kingdom	4.0	1.1	-2.9
Germany	4.3	2	-2.4
South Africa	2.5	1.2	-1.3
Mexico	2.4	1.3	-1.1
India	0.9	0.4	-0.5

Bangladesh	0.65	0.35	-0.3
Denmark	4.0	4.0	0
China	0.5	0.8	0.3
Russia	4.4	6.6	2.2
Canada	7.0	13	6.0
Brazil	2.5	9	6.5
Australia	7.5	15	7.5