

HUMANS AND SUSTAINABILITY: AN OVERVIEW

Chapter 1

Environmental Problems, Their Causes, and Sustainability

Chapter Outline

CORE CASE STUDY A Vision of a More Sustainable World in 2065

1-1 What Are Some Principles of Sustainability?

1-2 How Are Our Ecological Footprints Affecting the Earth?

CASE STUDY China's Growing Number of Affluent Consumers

1-3 Why Do We Have Environmental Problems?

1-4 What Is an Environmentally Sustainable Society?

Individuals matter: Tuy Sereivathana: Elephant Protector

TYING IT ALL TOGETHER A Vision of a More Sustainable Earth

Key Concepts

1-1 A Nature has been sustained for billions of years by relying on solar energy, biodiversity, and chemical cycling.

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.

1-1C 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.

1-2 As our ecological footprints grow, we are depleting and degrading more of the earth's natural capital.

1-3A Major causes of environmental problems are population growth, unsustainable resource use, poverty, avoidance of full-cost pricing, and increasing isolation from nature.

1-3B Our environmental worldviews play a key role in determining whether we live unsustainably or more sustainably.

1-4 Living sustainably means living off the earth's natural income without depleting or degrading the natural capital that supplies it.

Key Questions and Case Studies

CORE CASE STUDY: A Vision of a More Sustainable World in 2065

Contemporary society faces many environmental problems. Sustainability is the capacity of natural systems and cultural systems to survive and flourish indefinitely. As we look to the future, our actions today are pivotal to our ultimate sustainability.

1-1 What are some of the principles of sustainability?

A. Three goals of environmental science are:

1. To learn how nature works
2. To understand how we interact with the environment
3. To find ways to address environmental problems and embrace sustainability

B. Environmentalism is a social movement dedicated to protecting life support systems for all species.

C. A path toward sustainability includes three overarching themes:

1. Reliance on solar energy
2. Biodiversity
3. Chemical or nutrient cycling

- D. *Resources* can be taken from the environment to meet our needs or wants.
 - 1. Perpetual resources are continuously available (sunlight).
 - 2. Renewable resources can be replenished in the foreseeable future (forests, fertile topsoil).
 - 3. Non-renewable resources are found in fixed quantities and are not renewable on a human time scale.
- E. Economic growth is an increase in a nation's output of goods and services, measured by gross domestic product (GDP).

1-2 How are our ecological footprints affecting the earth?

- A. The process of depleting resources is known as environmental degradation or natural capital degradation.
- B. Pollution is any presence in the environment that is harmful to health or survival of humans or other organisms.
 - 1. Biodegradable pollutants break down over time and nonbiodegradable pollutants cannot break down.
 - 2. Pollutants can have three kinds of effects:
 - a. They disrupt or degrade life-support systems for humans or other species.
 - b. They damage wildlife, human health, or property.
 - c. They create nuisances.
 - 3. There are two ways to deal with pollution:
 - a. Pollution cleanup
 - b. Pollution prevention
- C. The Tragedy of the Commons describes the overuse or degradation of freely available resources. The cumulative effect of many users exploiting a common resource can degrade it such that no one can benefit from it.
- D. Ecological footprint
 - 1. The amount of biologically productive land and water needed to supply renewable resources and absorb waste for people in a given area.
 - 2. Humanity's ecological footprint exceeds by at least 30% the earth's biological capacity to support life.
- E. IPAT summarizes environmental impact
 - 1. $\text{Impact (I)} = \text{Population (P)} \times \text{Affluence (A)} \times \text{Technology (T)}$.

CASE STUDY: China's Growing Number of Affluent Consumers

The number of affluent consumers is rising rapidly, as people in underdeveloped countries attain a middleclass lifestyle. China is already a leading consumer of many resources, and its economy and population are continuing to grow at a rapid rate. Thus, its ecological footprint and overall level of resource consumption are expected to continue to grow.

- F. The ecological tipping point refers to an irreversible shift in the behavior of a natural system. We currently face three potential tipping points:
 - 1. The collapse of fish populations from overfishing
 - 2. Species extinction from overharvesting and habitat destruction.
 - 3. Climate change from burning coal and oil
- G. Culture describes a society's knowledge, beliefs, technology and practices
 - 1. Three major cultural changes have occurred in human history
 - a. Agricultural revolution
 - b. Industrial-medical revolution
 - c. Information-globalization revolution
 - d. And now a fourth, called the *sustainability revolution*

1-3 Why do we have environmental problems?

- A. Four major causes of environmental problems are:

1. Population growth
2. Wasteful resource use
3. Poverty
4. Poor environmental accounting
- B. Exponential growth occurs when a population increases by a fixed percentage per unit of time.
- C. Affluence results in high levels of consumption.
 1. Affluence can lead to an unsustainable addiction to acquiring material things.
 2. Affluence can lead to better education, improved health, and more resources to address environmental issues.
- D. Poverty occurs when people are unable to fulfill their basic needs.
 1. Poverty conditions in heavily populated areas can have significant environmental impacts.
 2. Pollution and environmental degradation can have severe impacts on the poor. Three significant health issues are:
 - a. Malnutrition
 - b. Inadequate sanitation and access to safe drinking water
 - c. Respiratory disease
- E. Environmental worldviews and ethics determine the way people view the seriousness of environmental problems.
 1. The planetary management worldview holds that nature exists to meet our needs.
 2. The stewardship worldview holds that we manage the earth, but that we also have an ethical responsibility to be stewards of the earth.
 3. The environmental worldview holds that we are connected to nature and that nature exists for all species equally.

1-4 What is an environmentally sustainable society?

- A. An environmentally sustainable society meets the current and future basic resource needs of its people in a just and equitable manner by protecting natural capital and living off its income.
 1. The shift to sustainability involves building social capital, which involves bringing together people with different views and values and finding common ground.
- B. Individuals matter
 1. It takes only 5-10% of a community to bring about major social change.
 2. Significant social change can occur very rapidly.

Teaching Tips

Large Lecture Courses:

What are the greatest environmental problems facing the world today? List student responses on the board, and ask them to suggest what the consequences of these problems might be for them and their families. Then perform the same brainstorming activity by focusing on the local region only. Ask the students to suggest reasons for any discrepancies between the two lists, such as local industries or activities. Use this exercise as an opportunity to highlight the main themes that will be touched on during the rest of the course and textbook, and to show the students the ways in which environmental issues permeate their own lives.

Small Lecture Courses:

Ask students to get in small groups of three to six students each. Have each group rank what they perceive to be the three greatest environmental crises facing their generation. For each, they should list the reasons why that issue is so important. Then, have the groups place their original list on the board, and facilitate a debate between groups over which issue is most pressing and why. Use this exercise to illustrate the complexity of environmental issues, insofar as the public is generally not in agreement as to cause, severity, or potential solutions.

Key Terms

biodiversity	environmentally sustainable	per capita ecological
biodegradable pollutants	society	footprint
culture	exponential growth	per capita GDP
developed countries	gross domestic product	perpetual resource
developing countries	(GDP)	planetary management
ecological footprint	input pollution control	worldview
ecological tipping point	less-developed countries	point sources
ecology	more-developed countries	pollution
economic development	natural capital	pollution cleanup
economic growth	natural income	pollution prevention
environment	natural resources	poverty
environmental degradation	natural services	recycling
environmental ethics	nondegradable pollutants	renewable resource
environmental science	nonpoint sources	resource
environmental wisdom	nonrenewable resources	reuse
worldview	nutrient cycling	social capital
environmental worldview	organisms	species
environmentalism	output pollution control	stewardship worldview
		sustainability
		sustainable yield

Term Paper Research Topics

1. Population: UN population projections.
2. Poverty: definition, roots, worldwide distribution, changing the current situation.
3. Technology: research, development, and distribution of new technologies in the United States.
4. State of the world: bibliography of current resources summarizing the state of the world and the most important areas of concern.
5. Pollution and environmental degradation: one form of pollution or environmental degradation, and its existence in different countries or choose one incident as a case study.
6. Computer modeling methods: *Limits to Growth* by Meadows and Meadows; today's global climate models.

7. National: national efforts to address environmental needs; *Blueprint for the Environment*.
8. Global: global attempts to address the environment and the economy; the UN document *Our Common Future*.

Activities and Projects

1. As a class project, "adopt" a developing 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.
2. 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 students pick up litter. Students can keep tallies of the different types of litter collected (metal cans, snack food wrappers, etc.) and prepare a pie chart and report to submit to the DOT.
3. As a class exercise, compute the cost of a hamburger, a movie ticket, a single-family home, and/or other commodities 30 years in the future, assuming the current inflation rate.
4. As a class exercise, compile a list of resources that are considered important today but were not recognized as resources 100 years ago. What are some things that have ceased to be significant resources during the last 50 years? What resources of the present will probably be of little value 50 years from now?
5. Have the class make a list of changes in your community's environment that have occurred over the last 10 years. Have them vote on which changes they consider desirable and which undesirable. Discuss the changes on which there is least consensus about desirability. Clarify the differences in values that underlie differences in students' responses.
6. Have students assume roles as futurists and predict life as it will be in the year 2025.
7. Have your students write scenarios describing what everyday life would be like in the United States after a transition is made to an earth-wise society. Identify areas of consensus and disagreement.
8. As a class exercise, have each student write out and hand in anonymously a list of the essential components of "the good life." Read some or all of the lists aloud to the class. Write a composite list on the blackboard and discuss each component in terms of sustainable-earth values and guidelines.

Suggested Answers to End of Chapter Questions

Review Questions

1. Core Case Study. Summarize the authors' vision of a more sustainable world, which could be attainable by 2065.
 - A small but growing number of people had begun shifting to more environmentally sustainable lifestyles by 2018. By 2065, the loss of species and degradation of land had slowed to a trickle. The atmosphere, oceans, lakes, and rivers were cleaner. Energy waste had been cut in half.
 - By 2050, significant atmospheric warming and the resulting climate change had occurred as many climate scientists had projected in the 1990s. However, the threat of further climate change and air and water pollution had begun to decrease because of greatly reduced energy waste and the gradual shift in human use of energy resources from oil and coal to cleaner energy from the sun, wind, flowing water, and other renewable resources.
2. Section 1-1. What are the key concepts for this section? Define sustainability. Define environment. Distinguish among environmental science, ecology, and environmentalism. Distinguish between an organism and a species. What is an ecosystem? What are the three scientific principles of sustainability derived from how the natural world works? What is solar energy and why is it important to life on the earth? What is biodiversity and why is it important to life on earth? Define nutrients. Define chemical or nutrient cycling and explain why it is important to life on the earth.
 - Key concepts: Nature has been sustained for billions of years by relying on solar energy, biodiversity, and chemical cycling. Our lives and economies depend on energy from the sun and on natural resources and ecosystem 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.
 - The three scientific principles of sustainability are: (1) dependence on solar energy, (2) Biodiversity, and (3) chemical cycling.
 - Solar energy is the energy imparted to the earth system by the sun. The sun warms the planet and provides energy that plants use to produce nutrients. The sun also powers indirect forms of solar energy such as wind and flowing water.
 - Biodiversity is the variety of genes, organisms, species, and ecosystems in which organisms exist and interact. The interactions among species provide vital ecosystem services and keep populations from growing too large.
 - Nutrients are chemicals that plants produce that are necessary for their own life processes as well as those of other organisms.
 - Chemical cycling is the circulation of chemicals necessary for life from the environment, through organisms, and back to the environment. Organisms must recycle chemicals continuously in order to survive.

3. Define natural capital. Define natural resources and natural services, or 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 social science principles of sustainability? What is full-cost pricing and why is it important?
- Natural capital is the natural resources and natural services that keep us and other species alive and support human economies.
 - Natural resources are materials and energy in nature that are essential or useful to humans. Examples of natural resources include water and oil.
 - Ecosystem services are processes provided by healthy ecosystems. Examples of ecosystem services include renewal of topsoil and pollination.
 - We degrade natural capital by cutting down trees faster than they can grow back, replacing diverse and sustainable forests with croplands, and adding harmful chemicals and wastes to streams and oceans faster than they can cleanse themselves.
 - The search for environmental solutions often involves conflicts. In these cases it is important to make trade-offs, where both sides get something out of the deal.
 - History has shown that almost all of the significant changes in human systems have come from the bottom up, through the collective actions of individuals and from individuals inventing more sustainable ways of doing things. Thus, sustainability begins with actions at personal and local levels.
 - The three social science principles of sustainability are: (1) full-cost pricing, (2) win-win solutions, and (3) a responsibility to future generations.
 - Full-cost pricing involves adding detrimental costs to the environment and human health to the prices of goods and services. Full-cost pricing would give consumers better information about the environmental impacts of their lifestyles, and it would allow them to make more informed choices about the goods and services they use.
4. What is a resource? Distinguish between an inexhaustible resource and a renewable resource and give an example of each. What is the sustainable yield of a renewable resource? Define and give two examples of a nonrenewable or exhaustible resource. Explain why the suggested priorities for more sustainable use of nonrenewable resources are, in order: Refuse, Reduce, Reuse, and Recycle. What percentage of the metals and other nonrenewable materials that we use could be reused or recycled? Distinguish between more-developed countries and less-developed countries and give an example of a high-income, a middle income and a low-income country.
- A resource is anything we can obtain from the environment to meet our needs and wants.
 - Inexhaustible resources have continual supplies, and renewable resources will be replenished as long as we do not use them too rapidly. Solar energy is perpetual and wood resources are renewable.
 - Sustainable yield is the highest rate at which a resource can be used without indefinitely reducing its available supply.
 - Nonrenewable resources are resources that exist in a fixed quantity, such as copper or oil.
 - Each of the suggested priorities for more sustainable use of nonrenewable resources helps to extend supplies and to reduce the environmental impacts of using these resources. Recycling should be the last resort.
 - We could recycle at least 80% of the metals and other nonrenewable materials that we currently use.
 - The United Nations classifies countries as economically developed or developing based primarily on their degree of industrialization and their per capita GDP PPP. Most developed countries are highly industrialized and have a high per capita GDP PPP. Some developing

countries are middle- income and moderately developed while others are low-income and least developed. The United States is a high-income country, Brazil is a middle-income country, and Haiti is a low-income country.

5. Section 1-2. What is the key concept for this section? Define and give three examples of environmental degradation (natural capital degradation). About what percentage of the earth's natural or ecosystem services has been degraded by human activities? Define pollution. Distinguish between point sources and nonpoint sources of pollution. Distinguish between pollution cleanup and pollution prevention and give an example of each. What is the tragedy of the commons? What are two ways to deal with this effect? Explain why they don't work for some systems.
 - Key concept: As our ecological footprints grow, we are depleting and degrading more of the earth's natural capital.
 - Natural capital degradation involves using resources at an unsustainable rate. Examples include forests shrinking, topsoil eroding and deserts expanding.
 - About 60% of the earth's natural or ecosystem services have been degraded by human activities.
 - Pollution is a presence in the environment that is harmful to the health, survival or activities of humans or other organisms.
 - Point sources have single identifiable sources, whereas nonpoint sources are dispersed.
 - Output control involves cleaning up after the pollutants have been released. And may involve physically removing a pollutant from the environment, while input control involves reducing or eliminating the production of pollutants, which may involve trapping the pollutants before they are released and then properly disposing of them.
 - The tragedy of the commons is environmentally degrading many openly shared renewable resources.
 - One way to deal with the degradation of shared resources is to use a shared or open-access renewable resource at a rate well below its estimated sustainable yield by using less of the resource, regulating access to the resource, or doing both. Another is to convert shared renewable resources to private ownership. Some resources, however, cannot be converted to private ownership.
6. What is affluence? What is an ecological footprint? What is a per capita ecological footprint? Compare the total and per capita ecological footprint s of the United States and China. Use the ecological footprint concept to explain how we are living unsustainably in terms of the estimated number of planet earths that we need to sustain ourselves now and in the future.
 - Affluence is wealth.
 - Ecological footprint refers to the amount of biologically productive land and water needed to provide the people in a particular country or area with an indefinite supply of renewable resources and to absorb and recycle the wastes and pollution produced by such resource use.
 - The per capita ecological footprint is the average ecological footprint of an individual in a given country or area.
 - The total ecological footprint for the United States in millions of hectares is 2810 versus 2050 for China. The U.S. per capita ecological footprint was about 6 times larger than China's per capita footprint.
 - We are living unsustainably by over extracting resources, and not allowing adequate time for the processes of recycling and regeneration. Today we are using one and one-half of the earth's supply of resources.

7. What is the IPAT model for estimating our environmental impact? Explain how we can use this model to estimate the impacts of the human populations in less-developed countries and more developed countries. Describe the environmental impacts of China's new affluent consumers. Describe three major cultural changes that have occurred since humans were hunter-gatherers and how they have increased our overall environmental impact. What would a sustainability revolution involve?
- Impact (I) = Population (P) × Affluence (A) × Technology (T)
 - In less-developed countries, population tends to be a larger issue, while consumption is less of an impact. On the other hand, in more-developed countries, it is consumption that drives up the overall impact, with population being less of an issue. Technologies can either increase or reduce the overall impact in both cases.
 - China's newly affluent consumers are putting immense pressure on the earth's potentially renewable natural capital and its nonrenewable resources.
 - The three major cultural changes have been the agricultural revolution, the industrial-medical revolution, and the information-globalization revolution. The industrial revolution allowed humans to cultivate more crops and produce goods in factories. The information-globalization revolution allowed humans to access information and resources rapidly on a global scale.
 - A sustainability revolution would involve learning to more sustainably with smaller ecological footprints during this century.
8. Section 1-3. 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? How many people are added each year? How many people might be here by 2050? How do Americans, Indians, and the average people in the poorest countries compare in terms of consumption? What are two types of environmental damage resulting from growing affluence? How can affluence help us to solve environmental problems? What is poverty and what are three of its harmful environmental and health effects? About how many of the world's people struggle to live on the equivalent of \$1.25 a day? How many try to live on \$2.25 a day? Explain the connection between poverty and population growth. List three major health problems suffered by many of the world's poor.
- Key concepts: Major causes of environmental problems are population growth, unsustainable resource use, poverty, avoidance of full-cost pricing, and increasing isolation from nature. Our environmental worldviews play a key role in determining whether we live unsustainably or more sustainably.
 - Some basic causes of environmental problems are:
 1. Population growth.
 2. Unsustainable resource use
 3. Poverty
 4. Exclusion of harmful environmental costs from the market prices of goods and services.
 5. Increasing isolation from nature.
 - Exponential growth occurs when a quantity such as the human population increases at a fixed percentage per unit of time.
 - Exponential growth occurs when a quantity such as the human population increases at a fixed percentage per unit of time, such as 1% or 2% per year. The rule of 70 is: doubling time (years) = 70/annual growth rate (%).
 - There are now about 7.1 billion people on the earth. About 84 million are added each year.
 - The exponential rate of global population growth has declined some since 1963. Nevertheless, unless death rates rise sharply, there will probably be 9.3 billion of us by 2050

(up from 6.9 in 2010).

- The average American consumes about 30 times as much as the average Indian and 100 times as much as the average person in the world's poorest countries.
- Growing affluence results in high levels of consumption and unnecessary waste of 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.
- Poverty occurs when people are unable to meet their basic needs for adequate food, water, shelter, health, and education.
- Poverty has a number of harmful environmental and health effects. People who are desperate for short-term survival people deplete and degrade forests, soil, grasslands, fisheries, and wildlife, at an ever-increasing rate. They do not have the luxury of worrying about long-term environmental quality or sustainability. Other problems include malnutrition and lack of access to clean drinking water.
- About 900 million people live on less than \$1.25 per day. About 2.6 billion people live on less than \$2.25 per day.
- Poverty can drive population growth, as people in poor regions often have more children to ensure that they will have assistance with daily work as well as someone to care for them in old age.
- Three major health problems faced by the world's poor are malnutrition, limited access to adequate sanitation facilities and clean drinking water, and severe respiratory disease from breathing smoke from open fires or poorly vented stoves.

9. Explain how excluding the harmful environmental and health costs from the prices of goods and services affects the environmental 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 that we use in their market prices? Explain how lack of knowledge of the nature and importance of natural capital and our increasing isolation from nature can intensify the environmental problems that we face. What is an environmental worldview? What are environmental ethics? Distinguish among the planetary management, stewardship, and environmental wisdom worldviews

- Excluding the harmful environmental costs in the prices of goods and services can hurt the environment because the consumer does not realize the value being lost.
- Environmentally harmful subsidies encourage the depletion and degradation of natural capital.
- Two ways to include harmful environmental and health costs in 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.
- Lack of knowledge of natural capital prevents us from understanding the importance of reducing our ecological footprints.
- Environmental worldview is a 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 are beliefs about what is right and wrong with how we treat the environment.
- World view:
 - The planetary management worldview holds that we are separate from and in charge of nature, that nature exists mainly to meet our needs and increasing wants, and that we can use our ingenuity and technology to manage the earth's life-support systems, mostly for our benefit, indefinitely.

- The 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, or stewards, of the earth. It proposes that we should encourage environmentally beneficial forms of economic growth and development and discourage environmentally harmful forms.
 - The environmental wisdom worldview holds that we are part of, and dependent on, nature and that nature exists for all species, not just for us.
10. Section 1-4. What is the key concept for this section? What is an environmentally sustainable society? What is natural income and what does it mean to live off of natural income? Describe Tuy Sereivathana's efforts to prevent elephants from becoming extinct in Cambodia and to reduce the country's poverty. What are two pieces of good news about making the transition to a more sustainable society? Based on the three scientific principles of sustainability and the three social science principles of sustainability, what are three important ways to make a transition to sustainability as summarized in this chapter's three big ideas? Explain how we can use the six principles of sustainability to move us closer to the vision of a more sustainable world described in the Core Case Study that opens this chapter.
- Key concept: Living sustainably means living off the earth's natural income without depleting or degrading the natural capital that supplies it.
 - An environmentally sustainable society is one that 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 is the renewable resources such as plants, animals, and soil provided by the earth's natural capital. Living sustainably means not depleting or degrading the earth's natural capital.
 - Tuy Sereivathana directs the Cambodian Elephant Conservation Group, devoted to reducing poaching and helping farmers work together to use low-cost and innovative ways to protect their crops without having to kill elephants. He has helped farmers set up nighttime lookouts for elephants. He taught villagers to scare raiding elephants away by using foghorns and fireworks and using solar-powered electric fences to mildly shock them. He also encouraged farmers to stop growing watermelons and bananas, which elephants love, and to grow crops such as eggplant and chili peppers that elephants shun.
 - The first piece of good news is that research by social scientists suggests that it takes only 5–10% of the population of a community, a country, or the world to bring about major social change. Second, such research also shows that significant social change can occur in a much shorter time than most people think.
 - We can transition to a more sustainable society by relying more on renewable energy, protecting biodiversity, and helping to sustain the earth's natural chemical cycles by reducing the production of wastes and pollution.
 - The use of the principles of sustainability can help to reduce our ecological footprints, sustain the earth's natural capital, and make a transition to more sustainable lifestyles and economies.

Critical Thinking

The following are examples of the material that should be contained in possible student answers to the end of chapter Critical Thinking 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.

1. Do you think that you are living unsustainably? Explain. If so, what are the three most environmentally unsustainable components of your lifestyle? List two ways in which you could apply each of the three **principles of sustainability** (Figure 1-2) and each of the three social science **principles of sustainability** (Figure 1-5), to making your lifestyle more environmentally sustainable.

Answers may vary. Some examples 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. Other answers might include supporting full-cost pricing, responsibility to future generations, and striving for win-win results.

2. Do you believe a vision such as the one described in the Core Case Study that opens this chapter is possible? Why or why not? What, if anything, do you believe will be different from that vision? Explain. If your vision of what it will be like in 2065 is sharply different from that in the Core Case Study, write a description of your vision. Compare your answers to this question with those of your classmates.

Student answers will vary based upon their own perspective.

3. For each of the following actions, state one or more of the four scientific principles of sustainability (Figure 1-17) 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; **(e)** volunteering to help restore a prairie; and **(f)** lobbying elected officials to require that 20% of your country's electricity be produced by renewable wind power by 2020.

- (a) Nutrient Recycling/Reliance on Solar Energy: In nature there is no waste, so recycling the aluminum soda can mimic nutrient recycling. As less energy is used in the aluminum recycling process than starting from raw materials such as bauxite, we are 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, we rely more on renewable rather than nonrenewable energy and positively impact biodiversity in areas where oil drilling is having harmful ecological effects.
- (d) Nutrient Recycling/Biodiversity/Reliance on Solar Energy: If we use a reusable grocery bag made from organically grown cotton, we rely 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; using paper bags can have an effect on the biodiversity of forest lands.
- (e) Biodiversity/Nutrient Recycling: By restoring habitat you will be enhancing biodiversity and also helping the future recycling of nutrients from the plantings.
- (f) Reliance on Solar Energy/Biodiversity: Promoting the use of renewable energy sources complies with the principle of relying on solar energy, and less reliance on nonrenewable sources such as coal and oil that adversely affect biodiversity in the extraction of these materials.

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.

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

a. Disagree: The earth has a finite amount of resources. With ever-increasing numbers of consumers the economy may eventually max out as these resources are diminished and the costs skyrocket. This would lead to greater disparity between rich and poor people and end up promoting increased poverty rather than increased wealth.

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

5. What do you think when you read that the average American consumes about 30 times more resources than the average citizen of India? Are you skeptical, indifferent, sad, helpless, guilty, concerned, or outraged by this fact? Do you think that these differences in consumption have led to problems? If so, describe them and propose some possible solutions.

Student answers will vary; 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 such as concern may bring about a change in personal lifestyle.

6. When you read that at least 19,000 children age 5 and younger die each day (13 per minute) from preventable malnutrition and infectious disease, how does it make you feel? Can you think of something that you and others could do to address this problem? What might that be?

Student answers will vary. The instructor could lead a discussion in which each student is asked to explain their answer. Through this discussion students 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)** based on past extinctions and the history of life on the earth over the past 3.5 billion years, all forms of life eventually become extinct so we should not worry about whether our activities cause their premature extinction, **(e)** all forms of life have the inherent right to exist, **(f)** all economic growth is good, **(g)** nature has an almost unlimited storehouse of resources for human use, **(h)** technology can solve our environmental problems, **(i)** I do not believe I have any obligation to future generations, and **(j)** I do not believe I have any obligation to other forms of life.

Student answers will vary. The instructor can take the opportunity to lead a discussion where some students elaborate on their own particular viewpoint.

8. What are the basic beliefs of your environmental worldview? Record your answers. Then 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 to Question 7 above? 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 their own current beliefs. It is hoped that by the end of the course, everyone in the class has gained a greater understanding of the environment and increased their environmental literacy. It also provides 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 to minimize their ecological footprint individually, as well as the class on the whole.

Ecological Footprint Analysis

If the *ecological footprint per person* of a country or of the world (Figure 1-13) is larger than its *biological capacity per person* to replenish its 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*. Use the data below to calculate the ecological deficit or credit for the countries listed and for the world. (For a map of ecological creditors and debtors see Figure 6, p. S00, in Supplement 6).

Place	Per Capita Ecological Footprint (Hectares per person)	Per Capita Biocapacity (Hectares per person)	Ecological Credit (+) or Debit (-) (Hectares per person)
World	2.2	1.8	-0.4
United States	9.8	4.7	
China	1.6	0.8	
India	0.8	0.4	
Russia	4.4	0.9	
Japan	4.4	0.7	
Brazil	2.1	9.9	
Germany	4.5	1.7	
United Kingdom[[Could be deleted to save space if needed]]	5.6	1.6	
Mexico	2.6	1.7	
Canada	7.6	14.5	

Data from WWF *Living Planet Report 2006*

1. Which two countries have the largest ecological deficits? Why do you think they have such large deficits?
2. Which two countries have an ecological credit? Why do you think each of these countries has an ecological credit?
3. Rank the countries in order from the largest to the smallest per capita ecological footprint.

Answers

Place	Per Capita Ecological	Per Capita Biocapacity	Ecological Credit (+)
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	Footprint (Hectares per person)	(Hectares per person)	or Debit (-) (Hectares per person)
World	2.2	1.8	-0.4
United States	9.8	4.7	-5.4
Canada	7.6	14.5	+6.9
United Kingdom	5.6	1.6	-4.0
Germany	4.5	1.7	-2.8
Russia	4.4	0.9	-3.5
Japan	4.4	0.7	-3.7
Mexico	2.6	1.7	-0.9
Brazil	2.1	9.9	+7.8
China	1.6	0.8	-0.8
India	0.8	0.4	-0.4

Data from WWF *Living Planet Report 2006*

1. Which two countries have the largest ecological deficits? Why do you think they have such large deficits?

The United States has an ecological deficit of -5.4 hectares per person, and the United Kingdom has an ecological deficit of -4.0 hectares per person. This is likely due to affluence and overconsumption.

2. Which two countries have an ecological credit? Why do you think each of these countries has an ecological credit?

Brazil has an ecological credit of +7.8 hectares per person and Canada has an ecological credit of +6.9 hectares per person. This may be due to low population sizes relative to available resources.

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

U.S.
Canada
United Kingdom
Germany
Russia
Japan
México
Brazil
China
India