Chapter 1

Investigating the Environment

In This Chapter

- Applying a scientific approach
- Studying environmental systems
- Protecting natural resources
- Reducing pollutants in the air and water
- Looking forward to a sustainable future

In its simplest terms, *environmental science* is the study of the air you breathe, the water you drink, and the food you eat. But environmental scientists study so much of the natural world and the way humans interact with it that their studies spill over into many other fields. Whether you're a student in a college course or someone who picked up this book to find out what environmental science is all about, you'll find that the ideas in this book apply to your life.

Like any living creature, you depend on environmental resources. More importantly perhaps is the fact that humans, unlike other living creatures, have the ability to damage these resources with pollution and overuse. This chapter provides a quick overview of the environment, its systems, and its many resources. It also talks about what humans can do to reduce their impact on the environment today and into the future. After all, maintaining the health of the Earth and its resources at both the local and global level is something everyone has a stake in.

Putting the "Science" in Environmental Science

Environmental science draws on knowledge from many different fields of study, including the so-called hard sciences like chemistry, biology, and geol-

ogy and the social sciences like economics, geography, and political science. This section offers a quick overview of some of the scientific concepts, such as how to apply the scientific method to answer questions, that you need to be familiar with as you start your exploration of environmental science. I explain these foundational scientific concepts in more detail throughout the rest of Part I.

Using the scientific method

The *scientific method* is simply a methodical approach to asking questions and collecting information to answer those questions. Although many classes teach it as something that only scientists use, you use it just about every day, too.

You may not write down each step of the scientific method when you use it, but anytime you ask a question and use your senses to answer it, you're using the scientific method. For example, when standing at a crosswalk, you look both ways to determine whether a car is coming and whether an approaching car is going slow enough for you to safely cross the street before it arrives. In this example, you have made an observation, collected information, and based a decision on that information — just like a scientist!

The power of the scientific method is in the way scientists use it to organize questions and answers. It helps them keep track of what's known and what's unknown as they gather more knowledge. This organization becomes particularly important when they study large, complex systems like those found in the natural world. Scientists always have more to learn about the natural world, and using the scientific method is one way that they can follow the path of scientific investigation from one truth to another. Turn to Chapter 2 for more on the scientific method.

Understanding the connection between atoms, energy, and life

Studying the environment includes studying how matter, energy, and living things interact. This is where other fields of study, such as chemistry, physics, and biology, come into play. Here are just a few of the core ideas from these sciences that you need to understand as you study environmental science:

- All matter is made of atoms.
- Matter is never created or destroyed, but it does change form.
- Living matter, or life, is made up of complex combinations of carbon, hydrogen, and oxygen atoms.

- Most of the energy at Earth's surface comes from the sun.
- Energy transfers from one form to another.
- Living things, or organisms, either capture the sun's energy (through *photosynthesis*) or get their energy by eating other living things.

Analyzing the Earth's Physical Systems and Ecosystems

The environment consists of many different systems that interact with one another on various levels. Some systems are physical, such as the *hydrologic system* that transfers water between the atmosphere and the Earth's surface. Other systems are built on interactions between living things, such as predator-prey relationships.

Scientists recognize that systems can be either open or closed. An *open system* allows matter and energy to enter and exit. A *closed system* keeps matter and energy inside of it. Figure 1-1 illustrates both types of systems.

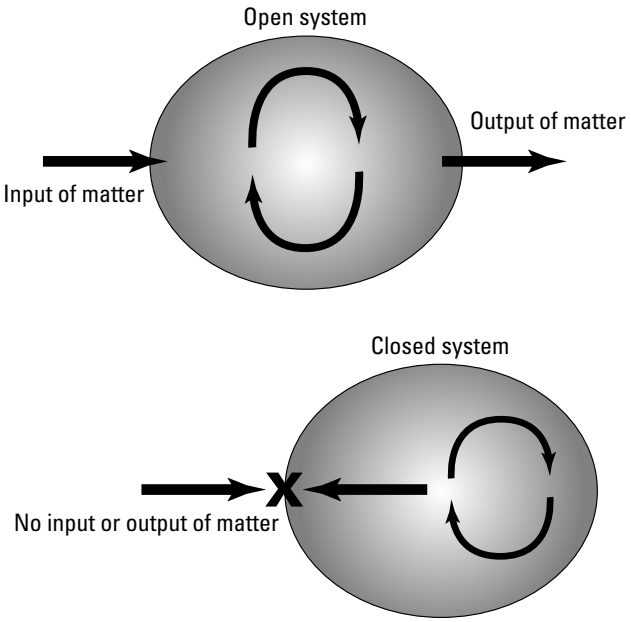

Figure 1-1: Open and closed systems.

Illustration by Wiley, Composition Services Graphics

Very few systems in the natural world are truly closed systems. Scientists view the planet as a closed system in terms of matter (no matter enters or leaves the Earth), but they consider it an open system in terms of energy (energy enters the Earth from the sun). The following sections introduce you to a few of the Earth's other systems that you need to be familiar with. (Part II goes into a lot more detail on the different systems on Earth.)

Sorting the world into climate categories

One of the most important and complex systems that scientists study is the climate. The climate system includes but is actually much larger than local weather systems. Climate scientists observe how different parts of the Earth are warmed by the sun to greater or lesser degrees, and they track how heat from the sun moves around the globe in atmospheric and ocean currents.

The movement of heat and water around the Earth sets the scene for living things. Every living plant and animal has a preferred range of temperature and moisture conditions. The patterns of living communities on Earth are called *biomes.* Scientists define each biome according to its temperature and moisture levels and the types of plants and animals that have adapted to live within those limits. Understanding the complex link between climate factors and the distribution of life on Earth has become even more important as scientists document changes in the global climate and predict more dramatic changes to come. Turn to Chapter 7 for details on global climate patterns and biomes.

Dividing the Earth into ecosystems

Within every biome, scientists recognize various ecosystems, or communities of living organisms and the nonliving environment they inhabit. Studying how matter and energy move around ecosystems is at the core of environmental science. Specifically, scientists recognize that

- Matter is recycled within the ecosystem.
- Energy flows through an ecosystem.

Whether they're small or large, discrete or overlapping, ecosystems provide a handy unit of study for environmental scientists. Because plants are the energy base of most ecosystems (capturing energy from the sun), the type and number of plant species in an ecosystem determine the type and number of animals that the ecosystem can support. See Chapter 6 for details on ecosystems.

Observing the interactions between organisms within an ecosystem

Scientists called *ecologists* are particularly interested in how living things interact within an ecosystem. Plants and animals compete with one another for access to water, nutrients, and space to live. Evolution by natural selection has resulted in a wide array of survival strategies. Here are some examples (see Chapter 8 for more details):

- **Resource partitioning:** When two species, or types of animals, depend on the same resource, they may evolve behaviors that help them share the resource. This is called *resource partitioning.* An example is when one species hunts at night, while another hunts the same prey during the day.
- **Coevolution:** *Coevolution* occurs when a species evolves in response to its interaction with other species. Scientists have documented multiple cases of insects and the plants they feed on (and help pollinate) evolving to become more and more suited to one another over time.
- **Symbiosis:** Organisms that benefit from an interaction with another species live in what scientists call *symbiosis.* Symbiotic relationships between organisms may benefit both individuals, benefit only one while harming the other (such as with a parasite), or benefit one without harming the other.

Supplies Limited! Natural Resources and Resource Management

Environmental scientists do a lot of research to find ways to meet the needs of human beings for food, water, and energy. The environment provides these natural resources, but if their users (namely humans) don't care for them properly, they can be reduced, damaged, or destroyed. Managing natural resources for the use of human beings now while ensuring that the same resources will be available for humans in the future is called *conservation.*

Factoring in food, shelter, and more

People need food, water, air, and shelter to survive. But as human populations have grown into the billions, they've tested the ability of the environment to

provide enough food, fresh water, and shelter. In Part III, I describe methods of sustainable agriculture and water conservation that can help meet the needs of so many people. (So far, there's still plenty of air to go around.)

Other resources that people depend on are less obvious, such as the biological diversity, or *biodiversity,* found in certain regions. Human actions have reduced biodiversity around the world, particularly in *biodiversity hotspots,* or regions with a combination of high levels of diversity and increasing human impacts. In Chapter 12, I explain what biodiversity is and why it's so important.

Thinking about energy alternatives

One of the most critical natural resources that modern living depends on is energy. Energy in most ecosystems streams from the sun every day, but to fuel modern life, humans have tapped into the stored energy of fossil fuels hidden deep in the Earth. Unfortunately, fossil fuel sources of energy are both limited in supply and damaging to the Earth's environment when humans burn them as fuel.

Searching for alternative sources of energy is an important part of environmental science research. Some of the current alternatives to fossil fuels include

- Solar energy
- Wind energy
- Hydro (river) energy
- Tidal and wave energy
- Geothermal heat
- Fuel cell electricity
- Liquid biofuel energy

I describe the pros and cons of these various options and explain how each one can help meet the energy needs of modern life in Chapter 14.

Keeping Things Habitable

Clean air, fresh water, food, and a safe place to live are critical to the survival of human beings. Unfortunately, in most parts of the world, decades of pollution have damaged environmental quality and endangered human health.

How humans can repair the damage already done to air, water, and land resources is the focus of Part IV.

Clearing the air (and water)

You may be familiar with some of the problems caused by air pollution: smog, acid rain, ozone depletion, and lung disease. In Chapter 15, I describe all the ways air is polluted and the results of pollution on ecosystems and human health. Similarly, in Chapter 16, I describe the sources and effects of water pollution.

In both cases, scientists classify the source of pollution as one of the following:

- **Point source pollution:** Point source pollution flows directly out of a pipe or smokestack and is easy to locate and regulate.
- **Nonpoint source pollution:** Nonpoint source pollution enters the air or water from a diluted or widespread area, such as when rainfall washes everything from city streets into nearby waterways via storm drains. This type of pollution is difficult to pinpoint and nearly impossible to regulate.

Tracking toxins and garbage

Toxic substances are all around you — in your home and in the environment. Many identified toxins today were once acceptable chemicals to use in agriculture or manufacturing. In some cases, scientists know the effects of a toxin, and as a result, it's no longer allowed to be used. In other cases, however, research is still being done to determine the danger of chemicals found in many household products.

In some places, toxins have entered the environment from improper waste disposal. Humans have to store (or burn) trash and other manmade garbage somewhere. All too often that garbage ends up in the oceans. I describe the problems related to waste disposal in Chapter 18.

When toxins enter an ecosystem, whether directly or as a byproduct of trash and hazardous waste, they can disrupt the ecosystem and cause harm to living things. Toxins often *bioaccumulate,* or build up in the cells of an organism. In some cases, the toxic substance is present in the environment at harmless levels but becomes more and more concentrated as it moves through the food chain. By the time top predators feed on lower predators, they've been poisoned by the *biomagnification* of the toxin. See Chapter 17 for more details on toxins and the effects they can have on the health of living things.

Influencing climate

These days, few environmental issues appear in the media and politics as often as modern climate change, or global warming. In Chapter 19, I explain how the greenhouse effect on Earth is beneficial and how greenhouse gases, both natural and manmade, change the composition of the atmosphere and affect climate patterns around the globe.

Some of the changes scientists expect with future climate warming include droughts in regions that are already water stressed, rising sea levels, and marine ecosystem disruption. The climate is definitely warming, so I also describe ways that humans can mitigate, or repair, the damage already done and adapt to a future climate that's very different from anything modern human civilization has experienced before.

Imagining the Future

Managing the Earth's resources so that human needs and desires today don't reduce the planet's ability to support future generations is called *sustainability.* The future is in your hands. The choices you make each day and the leaders you choose to create policies determine how people share, use, or abuse the Earth's resources in the coming decades. Regardless of your religious, political, cultural, or national values, you have a stake in your right and the rights of your children to a healthy, clean environment.

Realizing a sustainable economy

Many people think the biggest challenge in making sustainable choices is the cost, and some politicians want you to believe that a sustainable economy will destroy the world. Neither of these views is true. In Chapter 20, I describe some basic economic ideas and offer ways to look at the economy more sustainably. The transition to a more sustainable economy will take time, but in the long run, it'll be worth the effort!

Putting it on the books: Environmental policy

In Chapter 21, I introduce you to some of the most important and effective international agreements on global stewardship. The Montreal Protocol is

one international agreement that was created to protect the environment. Specifically, this agreement reduced the production of ozone-damaging molecules around the world and halted the destruction of the ozone layer.

You may not have realized this, but 50 years ago many of the rivers, lakes, wetlands, and shorelines in the U.S. were much more polluted than they are today. After Congress amended the Clean Water Act in the 1970s, major cleanups began, improving water quality across the nation during the next few decades. These days new issues, such as climate change and environmental toxins, have taken a front seat in environmental science and policy. But no matter what issues are currently taking up the most attention on TV and in scientists' labs, the choices you and I make every day will determine the future health of the global environment.