

# 1 Understanding Environmental Science and Sustainability



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## Learning Outcomes

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After reading this chapter, you should be able to

- Define environmental science.
- Describe the importance of critical thinking, information literacy, and the scientific method.
- Analyze the impact of palm oil plantations on biodiversity and the environment in Borneo.
- Define the core concepts of natural capital and sustainability.
- Define the core concepts of the environmental footprint and the Anthropocene.
- Define the core concepts of uncertainty, scale, risk, and cost-benefit analysis.

## 1.1 Why Study Environmental Science?

Whether we realize it or not, almost every aspect of our daily lives is dependent on and connected to the natural world around us. We are a part of, and not separate from, that natural world. The food we eat, the air we breathe, and the water we drink all originate from the natural world. Perhaps less obvious, the items we use every day—such as the fuel for our cars, the clothes we wear, and our phones and electronic devices—all have their origins in the natural world. At the same time, our everyday actions and use of these products—be it driving, eating, or throwing out the trash—all have an impact on this natural world on which we depend.

The study of environmental science encompasses all of these relationships. At its most basic, **environmental science** is the study of how the natural world works, how we are affected by the natural world, and how we in turn impact the natural world around us.

Our fundamental dependence on the natural world makes the study of environmental science relevant to all of us. Environmental issues—including deforestation, ozone depletion, water pollution, and climate change—affect us all. These issues are also in the news now more than ever, and they are often at the center of heated political debates. Acquiring an understanding of the basic science behind these debates is thus an important part of becoming an educated citizen and forming your own opinion of the issues. And while you may not go on to make a career in environmental science, you will likely find that this discipline intersects with your major or field of study in some way.

The goal of this book is to help you understand the basics of environmental science so that you can further explore and research environmental issues that interest and affect you directly. Because environmental issues can be so complex, developing solutions requires a solid understanding of policy and scientific concepts. In this book, we will apply natural science and social science concepts to the study of environmental issues that are in the news every day. The hope is that you—armed with the knowledge, perspectives, and up-to-date information provided in this book—will begin to form your own, informed opinions on these subjects. Ideally, you will also develop ideas about how you as an individual or society more broadly can take action to address some of the most pressing environmental challenges facing the world today. Ultimately, this book aims to empower you as a student both to grasp the environmental challenges facing the world and to do something about them.

### Outline of the Book

Much of the rest of this chapter, and most of Chapter 2, focuses on introducing you to concepts and ways of thinking that are essential to the study of environmental science and that will appear repeatedly throughout the rest of the book. You can think of these chapters as laying a foundation for your study of specific environmental issues in subsequent chapters. Just as you would not expect to be able to cook or repair cars without the right tools and basic knowledge of those activities, it would be difficult to study environmental issues without the information provided in these first two chapters.



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**The biggest driver of environmental change in today's world is human population growth and rates of consumption, which have increased exponentially in the past 200 years.**

and waste. These chapters involve a heavy emphasis on negative news and challenges, so Chapter 10 aims to end the book on a more upbeat note. While it's true that we face enormous and complicated worldwide environmental problems, it's also true that governments, non-governmental organizations (NGOs), corporations, small companies, schools and universities, and individual citizens are taking steps to address and reverse those challenges. We will examine their stories in hopes of inspiring positive change in our own lives.

With a strong foundation in place, we'll move to the study of human population and material consumption in Chapter 3. Virtually all of the environmental challenges we face are thanks to the growing number of people on the planet and high rates of material consumption among some of those people. In this way, we could say that human population growth and material consumption are the fundamental drivers of environmental change in the world today.

Chapters 4 through 9 focus on specific environmental issues and challenges: management of agricultural and forest resources, freshwater resources, oceanic resources, energy resources, atmosphere and climate,

## Key Definitions in Environmental Science

While we may hear or use the words *environment*, *environmentalism*, and *environmental science* quite often, we might not always appreciate what they mean and how they are used in the study of environmental issues. At its most basic level, the **environment** is everything that surrounds you. This includes all living things (such as animals, plants, and other people), as well as all nonliving things (such as water, rocks, air, and sunlight). A more scientific definition of the environment would be all physical, chemical, and biological factors and processes that affect an organism.

Based on that definition, it should be clear that we are all *a part of* the environment rather than *apart from* it. In fact, one major theme of this book is that, despite all the technological gadgets and scientific advances that attract our attention, we are all fundamentally dependent on the environment for our well-being and survival. The task of sustaining our agricultural resources, forests, water sources, oceans, atmosphere, and climate is not just about “caring” for this creature or “saving” that endangered animal. It's also about saving ourselves and ensuring that we and generations to come can breathe clean air, drink clean water, and live under relatively stable and benign climate conditions.

Because the environment by definition is basically everything, environmental science is a complex and **interdisciplinary** field of study. Environmental science draws together knowledge and concepts from many disciplines—ecology, biology, chemistry, geology, atmospheric science, physics, economics, political science, and other fields—to understand both how we are impacting the environment and what can be done to lessen that impact.

Note that there is a difference between environmental science and environmentalism. **Environmentalism** is a social and political movement committed to protecting the natural world. While many environmental scientists likely consider themselves environmentalists, as *scientists* they adopt a more objective approach to the issues they study. This approach is based in large part on the use of the **scientific method**, an approach to research based on observation, data collection, hypothesis testing, and experimentation. As a student, you are not required or expected to become an environmentalist, but as an educated citizen, you should learn to recognize the critical role played by the scientific method in forming our understanding of the environment and the environmental challenges we face. Such an understanding of the scientific method will help you develop critical-thinking skills and enable you to weigh competing claims and arguments about environmental issues.

## 1.2 Thinking Critically About Environmental Science

Many environmental scientists see their work as largely nonpolitical and noncontroversial. They are attempting to understand how a particular piece of the environment or system—a stream, a wetland, a patch of forest—functions and what might happen to that system in the wake of pollution or some other environmental disturbance. However, because the findings of this environmental research are often used in crafting and implementing environmental policy, environmental science and debates over environmental issues can become highly contentious and political.

Take, for example, the topic of global climate change (which will be covered in more detail in Chapter 8). Thousands of environmental scientists are engaged in research that is in some way related to the subject of climate change. Some scientists study how combustion of fossil fuels or other human activities add greenhouse gases to the atmosphere, others how these gases change the Earth's energy balance and climate systems, and still others how changes to the climate are affecting trees, animals, and other living organisms.

The majority of these scientists would probably not see their work as contentious or political. They are instead usually motivated by scientific curiosity and a desire to pursue knowledge. However, because the sum of these thousands of research efforts points with overwhelming confidence to the realities of global climate change, and because addressing climate change will require changes to all sorts of economic and social behaviors, the efforts of these environmental scientists can become politicized. Because of this politicization, it's important to understand the concepts of critical thinking, information literacy, and the scientific method. Careful application of these approaches to your own study of the environment will help you



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**Environmental scientists aim to understand how different elements of the environment function and how they change in response to other factors, such as pollution.**

develop informed opinions on many issues and help you avoid falling for arguments that are based on opinion and personal belief rather than grounded in facts and scientific evidence.

## Critical Thinking and Information Literacy

**Critical thinking** is the objective analysis and evaluation of an issue to form a judgment. In this case, the key term is *objective analysis*—in other words, analysis that is not based on personal opinion or belief. For example, one of this book’s authors had a student who, while hiking, saw a number of dead birds on the ground near the base of some wind turbines. The student later expressed a conviction that wind power was bad for the environment and should not be used. While there are legitimate reasons to be concerned about the effect of wind turbines on bird (and bat) mortality, this student should also consider what the environmental impact of other forms of electricity production are. In the authors’ region of the country (Pennsylvania), much of the electricity is produced by burning coal. A better example of objective analysis would be a comparison of the environmental impacts of coal mining and coal burning (including the impact on birds and bats) to the impact of wind turbines.

As you engage with the material in this book, and as you do your own research and form your own opinions about environmental issues, keep the following principles of critical thinking in mind:

- *Evaluate the basis for a particular conclusion.* What evidence is being presented to support a claim or an argument, and how was that evidence collected?
- *Keep an open mind.* Attempt to gather information from a variety of perspectives before forming a final opinion.
- *Be skeptical.* While keeping an open mind, ask yourself where information is coming from and how it was developed.
- *Consider possible biases, including your own.* Most scientists strive mightily to avoid the introduction of bias into their work, and the scientific method (described in more detail later) helps them do that.
- *Distinguish between facts and values or opinions.* For example, it is a fact that atmospheric concentrations of the greenhouse gas carbon dioxide now exceed 400 parts per million (ppm) compared to levels of roughly 280 ppm at the start of the Industrial Revolution. However, it’s an opinion or value statement to say that the use of all fossil fuels should be halted immediately to prevent further increases in carbon dioxide concentrations.

A key part of establishing and utilizing critical-thinking skills is to develop what’s often referred to as *information literacy*. **Information literacy** is the ability to know when information is needed and the ability to identify, locate, evaluate, and effectively use that information to address an issue. For our purposes, the most important of these abilities will be locating and evaluating information. The past two decades have witnessed an explosion of information and information sources, and our ability to access that information is becoming easier every day. However, our ability to know where to look for reliable information and to evaluate that information for reliability and usefulness has not kept pace. For example, there are thousands of sources of information on the topic of climate change. Who should you believe? Who

can you trust? We can see how critical-thinking skills are needed for information literacy and how information literacy is required for critical thinking. As you read this book and explore on your own the environmental topics and issues that interest you, ask yourself where information is coming from, how it was gathered, and how reliable it might be. The *Apply Your Knowledge: Is This Information Reliable?* feature box presents one quick opportunity to test your critical-thinking skills.

A less appreciated but nevertheless important skill for environmental analysis and problem solving is **creative thinking**. As scientists examine an environmental issue and ponder its possible causes and consequences, it helps if they can think creatively and with an open mind, as opposed to being locked into one way of looking at the world. Environmental scientists also tap into creative thinking to design effective field experiments that help them better understand the workings of nature. And as we'll see throughout this book, it will take creative thinking and even imagination to develop alternative approaches to meeting our food, water, energy, and other resource needs in ways that do not destroy the environment.

### Apply Your Knowledge: Is This Information Reliable?

Evaluating the quality and reliability of information can be a difficult task, especially when we are considering resources found on the Internet. We live in a world in which opinions are sometimes presented as the unbiased truth, and pretty much anyone with a computer can create a convincing website that is accessible to the entire world.

To highlight some of these challenges, let us explore a website called [Save the Pacific Northwest Tree Octopus](#). At first, the prospect of a tree-dwelling octopus might seem absurd, but nature often surprises us. There are birds that can swim and fish that can fly, so why not an octopus that climbs trees? If you read the article, you might also notice that the information presented is fairly detailed. The author provides a Latin name for this creature, along with measurements that describe tree octopus physiology. There are even photographs and links to additional resources, suggesting that others have documented these creatures in the past.

Despite the website's flashy appearance, it is a total hoax. There is no such thing as a tree octopus, and if we take a closer look at the website, we can see some warning signs that call its information into question. Take a moment to explore the [Save the Pacific Northwest Tree Octopus](#) website on your own, and see if you can find any red flags indicating that the article is unreliable.

*(continued)*

## Apply Your Knowledge: Is This Information Reliable? (continued)

One characteristic of trustworthy information is that it comes from a reputable author or organization. For example, information from a government agency, an institution of higher education, or a peer-reviewed journal is often considered to be more reliable than information from a personal blog. Reliable resources will also provide access to author biographies so that you can tell if the author is an expert on the subject matter. If you look at the author information at the bottom of the tree octopus website, you will notice that the author description is downright silly. There is no indication that the person has any training related to the subject matter.

Reliable resources also need to be fact-checked or backed up with supporting information that is usually identified using links and citations. This website appears to have active links to other resources, but if you follow these links, you will notice that they take you to other hoax websites or to sites that have no mention of tree octopuses.

Finally, reliable sources will be clear about whether their goal is to inform you with factual information or to convince you of a particular argument. A close reading of the material can often tell you if an unreliable resource is trying to convince you of an opinion while appearing to present objective facts. Consider the following sentence from the tree octopus website:

Tree octopuses became prized by the fashion industry as ornamental decorations for hats, leading greedy trappers to wipe out whole populations to feed the vanity of the fashionable rich. (Zapato, n.d., para. 8)

Phrases like “greedy trappers” and “vanity of the fashionable rich” suggest that the author is making judgments about certain actions and groups of people. This is not what we would expect from a well-written article that is intended to present factual information.

Now, take a moment to explore another web resource titled “[Discovery of the First Endemic Tree-Climbing Crab](#).” Once again, the topic sounds bizarre, but if we look closely, the information seems much more trustworthy. The article was produced by an academic institution. The language used in the article appears to be unbiased, and the information can be easily fact-checked using the peer-reviewed journal articles and academic websites that are referenced at the end. This article appears to be a source of reliable information.

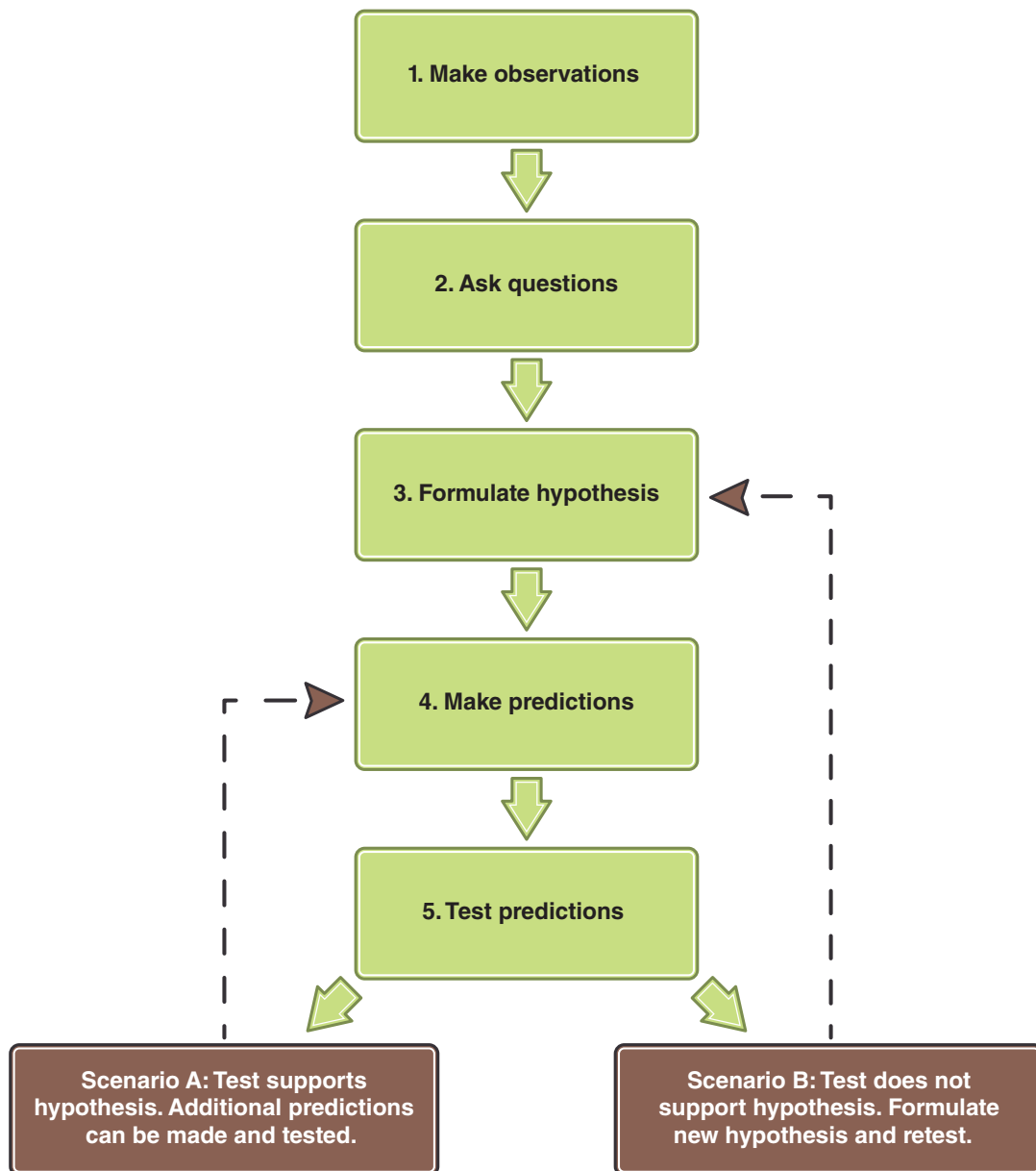
[Save the Pacific Northwest Tree Octopus](#) is a silly example of “bad” information, but the critical-thinking skills we used to evaluate this source can be applied to everything that we read, hear, and watch. If we approach media critically, we’ll be able to recognize the trustworthy information that helps us make better policies and decisions. In your future studies, look for information that is from a trusted source. Look for information that is backed up by quality research and journalism. Finally, look for information that is attempting to inform rather than persuade (unless you are researching opinions, of course).

## The Scientific Method

The use of the scientific method is one way that environmental scientists seek to improve the reliability, usefulness, and relevance of their research. The scientific method is an approach whereby scientists observe, test, and draw conclusions about the world around us in a systematic manner, rather than simply stating opinion. The scientific method consists of a series of five steps, as illustrated in Figure 1.1.

### Figure 1.1: The scientific method

The scientific method is a five-step model used to observe, test, and draw conclusions scientifically.



Scientists begin with simple observations of the world around us. They then form questions based on those observations. For example, environmental scientists might observe the death and decline of numerous trees alongside a major highway and naturally wonder what is causing this to happen. This leads to the third step, the formulation of a hypothesis or hypotheses that might explain the trees' death. Hypotheses can be thought of as a first guess or "hunch" about something, and they help scientists formulate predictions, specific statements that can be tested. In this case, the scientists might form a hypothesis that the trees are dying because of road salt running off the highway in the winter or because of an herbicide sprayed to control weeds on the side of the highway. Based on these guesses, they can take the fourth step in the scientific method and develop specific and testable predictions about how much road salt or herbicide needs to be applied to bring about the same levels of tree death and decline they have observed in nature.

All of these steps lead up to the final step of testing the predictions. To clearly determine what might be killing the trees, scientists devise experiments that attempt to hold conditions constant and then change one variable at a time. In this case, scientists might identify four similar small groves of trees that show no sign of stress or tree death. They might then expose one area to road salt, another to herbicide, and a third to *both* road salt and herbicide, while the fourth area is left alone. (*Apply Your Knowledge: How Does Road Salt Affect Trees?* shows how scientists might record their data.)

Note that regardless of the outcome of these experiments, scientists will typically still do two additional things. First, if the road salt or herbicide appeared to have some impact on the trees, the scientists might refine their predictions to gain a better understanding of why this is happening. This might include adjusting the levels of road salt or herbicide to see if they can better determine at what levels these applications become toxic. If the trees were not affected by the road salt and herbicide, the scientists would be forced to revise their hypotheses or form new ones. Second, scientists typically seek to share their results with others, usually by presenting their research at scientific conferences and publishing articles in professional journals. These presentations and papers are subject to analysis and scrutiny by other scientists, a process known as *peer review*. Scientists also have to explain the methods used in their research so that other scientists can run the same experiments, a process known as *replication*. These two aspects of scientific research, peer review and replication, help ensure the accuracy and legitimacy of the work.

It's important to recognize just how the scientific method can shield scientists from claims of bias. Scientists don't really set out to "prove" anything; instead, they observe, ask questions, hypothesize, predict, test, and usually repeat. Politicians' demands for scientific "proof" are therefore problematic. Environmental policy should be informed by the best science available, as well as other issues such as ethical concerns, economic impacts, and risks involved.

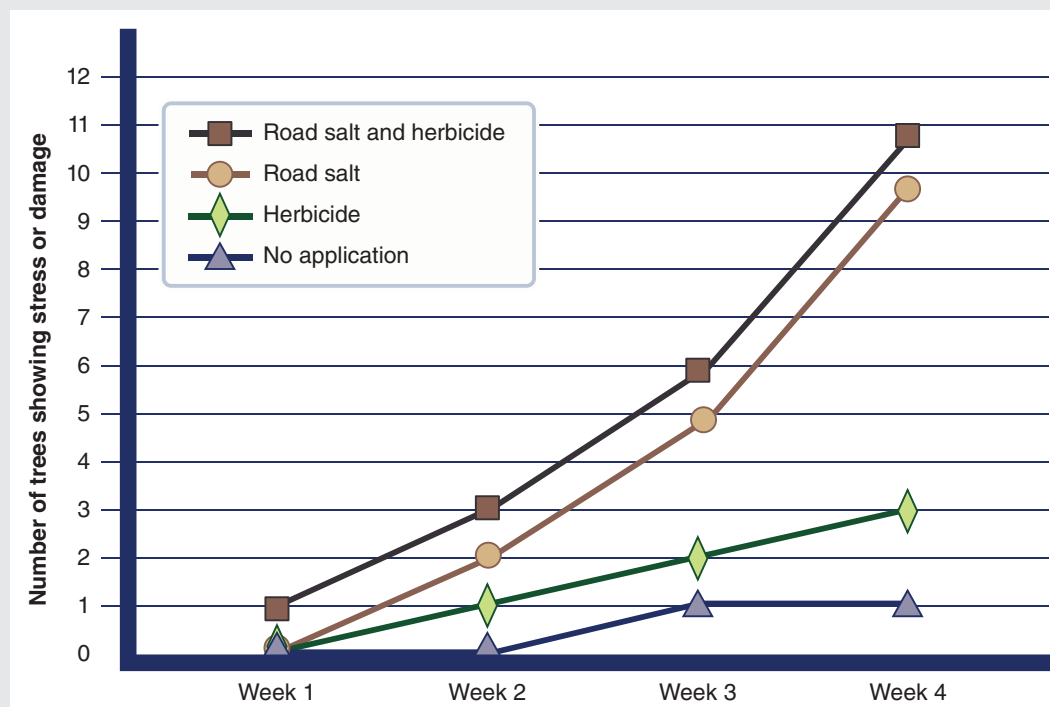
## Apply Your Knowledge: How Does Road Salt Affect Trees?

Environmental scientists make use of many different types of graphs to summarize and present the data they gather in their research. Graphs help in taking enormous amounts of data and information and presenting them in a way that tells a story or makes an argument. Your ability to understand and interpret graphs will be an important part of reading this book and learning environmental science.

Consider the following figures, which show possible results from the road salt/herbicide example used in the discussion of the scientific method. Figures 1.2 and 1.3 report basically the same information on tree death and decline from the experiment in different ways. Figure 1.2 portrays the number of trees that died in the different plots of the experiment *over time*. Figure 1.3 presents overall tree deaths by plot type at the end of the experiment.

### Figure 1.2: Line graph showing tree damage

This graph shows tree damage over time.

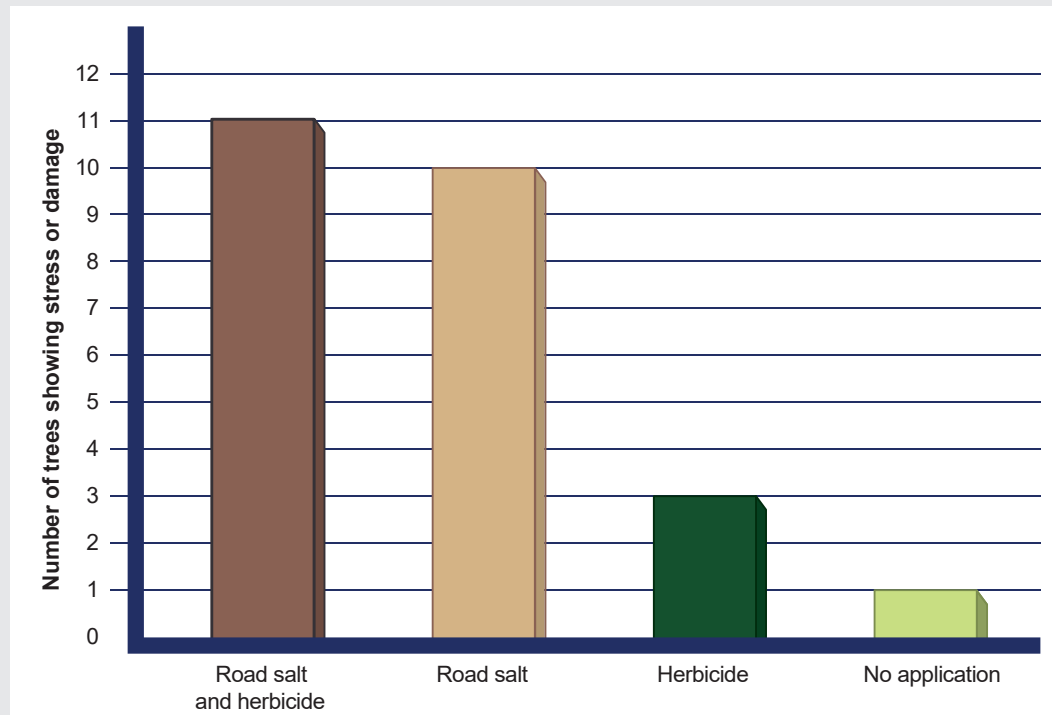


(continued)

## Apply Your Knowledge: How Does Road Salt Affect Trees? (continued)

**Figure 1.3: Bar graph showing tree damage**

This graph shows tree damage by plot type.



Based on the data presented from this experiment, it appears that road salt might be the biggest contributor to tree mortality. Imagine then that the scientists conducted a second experiment with four plots of trees in which they applied different amounts of road salt and measured tree mortality over a 4-week period. Table 1.1 gives information on the amount of road salt applied to each of the four plots and the corresponding tree mortality. Try plotting these numbers on a piece of paper. Draw a straight line that comes closest to connecting each of the four points on the graph. What does the shape and direction of this line tell you about the relationship between road salt application and tree mortality?

**Table 1.1: Amount of road salt and tree damage**

Road salt application (metric tons/hectare)	Tree damage (dead trees per plot)
Plot 1 (1 metric ton/hectare)	2
Plot 2 (2 metric tons/hectare)	5
Plot 3 (3 metric tons/hectare)	8
Plot 4 (4 metric tons/hectare)	12

## 1.3 Case Study: Palm Oil Production and Deforestation in Borneo

Environmental scientists, as well as other natural and social scientists, frequently make use of “case studies” to illustrate important points or concepts. In some ways, case studies are simply formalized stories about a specific place, person, group, or other thing. The case study presented here will help illustrate concepts and terms such as *environment* and *environmental science* and demonstrate how environmental scientists make use of critical-thinking skills and the scientific method in their work. This case study will also be used to explain some of the foundational concepts introduced later in this chapter and in Chapter 2.

### About Borneo

The island of Borneo straddles the equator in Southeast Asia and is the third largest island in the world and the largest island in Asia. The island is divided between Indonesia, Malaysia, and Brunei, with Indonesia controlling roughly 73% of Borneo’s land area, Malaysia 26%, and tiny Brunei just 1% (see Figure 1.4).

### Figure 1.4: Borneo

Located in Southeast Asia, Borneo is known for its high rates of biodiversity, but its rain forests are in decline due to deforestation



Adapted from PeterHermesFurian/iStock/Getty Images Plus

Until very recently, Borneo was sparsely populated, and much of the island was covered in dense tropical rain forests. Because of this, Borneo is known for its extremely high rates of biological diversity, or **biodiversity**—the variety of life and organisms in a specific ecosystem. That variety can be measured by considering the number of *species* found in a particular area. **Species** are groups of organisms that share certain characteristics, interbreed, and produce fertile offspring. In addition to having an incredibly high number of species overall, Borneo is also known for having a large number of **endemic species**—plants and animals that exist in only one specific geographic region. There are dozens of endemic mammal species (such as the proboscis monkey and pygmy elephant), hundreds of endemic birds, and thousands of endemic plant species in Borneo. Rates of biodiversity are so high in Borneo that scientists have identified over 20,000 types of insect species in one small national park alone (Shoumatoff, 2017).

## The Problem

Beginning roughly 50 years ago, Borneo's rain forests began to decline in dramatic fashion. Actions such as logging trees for timber, clearing land for small-scale agriculture, and burning large tracts of forest to clear land for palm oil plantations have reduced the island's forest cover from 75% in the mid-1980s to less than 50% today. Current rates of **deforestation**—clearing of forest areas—in Borneo are estimated to be 1.3 million hectares (over 3 million acres) a year (World Wide Fund for Nature, 2019).

Among the major drivers of deforestation in Borneo, conversion of rain forests to palm oil plantations is currently the most significant. Palm oil is derived from the nuts of the oil palm tree and is now the second most important oil used in consumer products after petroleum. Palm oil is a \$50-billion-a-year industry (Shoumatoff, 2017), and it is used in a vast array of household and consumer products, including cooking oil, snack foods, chocolate, cosmetics (such as lipstick), toothpaste, ramen noodles, shampoo, ice cream, cookies, and soap. It's estimated that palm oil is an ingredient in roughly half of all packaged products sold in modern supermarkets. Millions and millions of acres of rain forest have been cut and burned in Borneo to make way for palm oil plantations, and this deforestation continues today. Because most of us probably consume products made with palm oil, we are all in some way connected to this problem.



*pxhidalgo/iStock/Getty Images Plus*



*Laszlo Mates/iStock/Getty Images Plus*

**Much of Borneo's tropical rain forest has been razed for palm oil plantations.**

## The Impact

Conversion of Borneo's rain forests to palm oil plantations may result in a number of serious environmental and social problems. Many different types of wildlife depend on forests as their natural **habitat**—the place or set of conditions an organism depends on for survival—so deforestation leads to high rates of biodiversity loss and **extinction**, or the total loss of a species. Cutting up rain forests also results in **habitat loss**, driving wildlife species into smaller and smaller areas for survival. Loss of tree cover leads to increased flooding as heavy tropical rains run off cleared hillsides instead of being absorbed by dense forest soils and vegetation. This flooding also results in water shortages later on, since rainwater rushes to rivers and the sea instead of replenishing local groundwater supplies. Lastly, burning of forests worsens climate change in two ways. First, the combustion of trees and other vegetation pours millions of tons of carbon dioxide, a greenhouse gas, into the atmosphere. We'll see in Chapter 8 that increased greenhouse gas concentrations are resulting in global warming and climate change. Second, the ability of those forests to absorb and store vast amounts of carbon from the atmosphere is lost.

Borneo's extremely high rates of biodiversity, combined with the widespread deforestation of the past few decades, make this island one of the world's most important *biodiversity hotspots*. A **biodiversity hotspot** is a region that both has high rates of biodiversity and is experiencing significant environmental destruction. There are roughly 25 regions of the world that scientists have labeled as biodiversity hotspots. Scientists hope that by calling attention to these regions and the **endangered species**—species at risk of extinction—that live there, they can encourage governments, businesses, and private citizens to take action to address the problem before it is too late.

## A Scientific Approach

Let's consider how environmental scientists approach the study of an issue like palm oil production and deforestation in Borneo. First, it's clear that our own understanding of what's happening in Borneo is the result of interdisciplinary research by many different kinds of scientists and experts. Botanists, entomologists, and ornithologists research Borneo's plants, insects, and bird species, respectively. Wildlife biologists examine how deforestation is driving endangered species into smaller geographic areas. Hydrologists seek to understand the impacts of deforestation on flooding and water supplies. Atmospheric scientists and soil scientists attempt to understand how deforestation impacts carbon storage and greenhouse gas emissions from forest soils. Remote sensing specialists use satellite imagery to measure rates of deforestation over time. Environmental health specialists study the impact of pesticide and herbicide spraying of palm oil plantations on local human populations. And social scientists—economists, anthropologists, policy experts—study what's driving deforestation, how local human populations are responding, and what might be done in terms of policies and economic incentives to address this challenge.

All of these scientists and experts apply critical-thinking and information-literacy skills to their work. Most of them also make regular use of the scientific method in defining and carrying out research in their specific areas. For example, a botanist (plant expert) or ornithologist

(bird expert) might conduct research to measure the number and variety of plant and bird species in intact forest areas as well as in forest areas that have been fragmented or disturbed. Hydrologists (water experts) might study rates of water flow and water quality in different river basins that are characterized by different levels of deforestation. These and other scientists working in a setting such as Borneo might care deeply about wildlife and feel terrible about the environmental destruction they see, but they still approach their work in an objective and scientific manner.

## 1.4 Core Theme: Sustaining Our Natural Resources

The remainder of this chapter will focus on introducing you to a series of concepts and terms that will be important as we explore specific environmental issues in subsequent chapters. This foundation of knowledge will provide you with a vocabulary and way of thinking that will help frame the rest of the book. As we discuss these concepts and terms, we will return to the example of deforestation in Borneo to better understand their meaning. We'll start with the concepts of natural capital and sustainable development. These concepts lie at the core of environmental scientists' work, which often focuses on supporting the environment that we all depend on and are all a part of.

### Natural Capital and Ecosystem Services

Most of us have experienced a power outage, an Internet outage, a road closure, or disruption in some service that we depend on in our day-to-day lives. Such disruptions often remind us of the basic infrastructure (such as the power supply, the water supply, and functioning roads) we depend on but usually take for granted. In much the same way, and to an even greater degree, we depend on the natural world, the environment, and the natural systems that make up the environment for our well-being and survival. Yet we seldom if ever really think about that dependence and what it means to our quality of life.

Environmental scientists refer to this natural infrastructure as *natural capital*. **Natural capital** can be defined as natural assets such as trees, soils, streams, oceans, and the atmosphere. Like other forms of infrastructure, because natural capital is all around us, we seldom give it much thought. Take, for example, the tropical rain forests of Borneo. Managed properly, these forests could yield a steady supply of timber, fruit, and other nontimber forest products such as rubber, medicinal plants, and building materials like bamboo. These forests could also be a destination for **ecotourism**, tourism that



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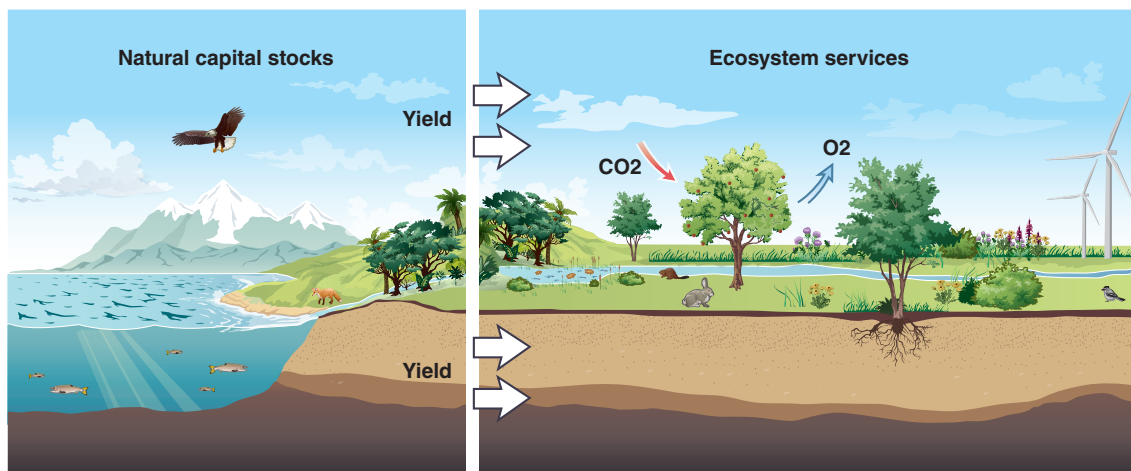
**Ecosystems, derived from the Greek word for home, provide us with areas for recreation, spirituality, and joy.**

focuses on natural environments in an effort to help conserve an area and support the local economy.

But understanding natural capital requires us to think more broadly than just in terms of resources. Even as valuable as all of these things—timber, nontimber products, and tourism—might be, they only scratch the surface of the *real value* humans derive from such ecosystems. These stocks of natural capital, through their normal functioning, generate a flow of life-sustaining **ecosystem services** that are absolutely essential for human survival (see Figure 1.5). We'll learn more about what ecosystems are in Chapter 2, but for now think of them as complex systems made up of both living organisms and nonliving components. For example, forests help purify air and water supplies, help prevent extremes of drought and floods, provide space and conditions for the decomposition of wastes, provide habitat for pollinating insects and birds that are essential to agriculture, and play a critical role in storing carbon and maintaining regional and global climate systems. Even this list is incomplete, and this is only describing the services of one ecosystem. Other systems—grasslands, wetlands, coral reefs, tundra, deserts, coastal systems, and open oceans—all provide their own ecosystem services that are essential to our survival.

### Figure 1.5: Natural capital and ecosystem services

Stocks of natural capital are all around us and generate a flow of ecosystem services and value for humans.



Adapted from "What Is Natural Capital?" by Natural Capital Coalition, n.d. (<https://naturalcapitalcoalition.org/natural-capital-2>).

A simple analogy would be to think of a home. Earth's natural systems, like a home, take care of climate control, air purification, the provisioning of food and water, and waste disposal and purification. They provide us spaces for recreation, spiritual growth, and moments of joy. It's perhaps no accident that the prefix *eco-* in *ecosystem* is derived from the Greek word *oikos*, or "home."

In the chapters ahead, try to apply this analogy and the concepts of natural capital and ecosystem services to issues of soil depletion, deforestation, water and air pollution, overfishing, climate change, ozone depletion, and toxic waste dumping. What are we doing to our home

when we create these problems? How might our actions be destroying natural capital and undermining the very systems we all depend on? What would alternative approaches, those focused on sustaining natural capital, look like?

## Sustainability and Sustainable Development

The concepts of *sustainability* and *sustainable development* come up a lot in discussions of the environment. But what do they really mean? At a basic level, and applied to issues of the environment, **sustainability** is the maintenance of natural systems and an ecological balance. **Sustainable development** brings human and economic needs into the picture and is the achievement of economic objectives without the depletion or destruction of natural systems. In other words, sustainability and sustainable development suggest a balancing act between meeting the needs of humans and maintaining the integrity of our natural environment.

Understanding the concepts of natural capital and ecosystem services means understanding that sustainable development is the *only* way forward for the human species. Development that is *not* sustainable, that destroys or depletes natural systems and natural capital, will only undermine the basic ecological systems that we all depend on. In this sense, it should be clear that viewing economic progress and environmental protection as competing goals is ultimately foolish and misguided. We cannot sustain economic progress and human well-being if, at the same time, we are undermining and destroying the natural infrastructure that makes such progress possible.

Unfortunately, much economic activity and economic development we see around the world today is unsustainable. Think of a business or a household trying to make ends meet. That business or household might be able to balance its books month to month by selling off equipment or other assets, but eventually this approach is not sustainable. Likewise, much of the economic progress in recent decades has been based on liquidating, or using up, natural capital such as oil, coal, soils, forests, fisheries, mineral stocks, and other resources. This economic progress has also generated massive amounts of pollution and waste products, and this pollution is overwhelming the natural ability of many ecosystems to provide air and water purification services. In other words, our current economic progress and economic systems do not meet the definition of sustainability and instead result in natural capital depletion and destruction.

In Borneo, logging for timber, clearing forests for agriculture, and widespread burning of forests to make way for palm oil plantations represent one approach to economic development—but in most cases one that is not sustainable. Overexploitation of timber resources and logging faster than the rate of tree regrowth ultimately reduce the productivity of that forest and make it less valuable over time. They also increase the risk of flooding, reduce water supply, and diminish water quality, all outcomes that actually reduce quality of life and impose costs on society. Likewise, conversion of tropical forests in Borneo to palm oil plantations may result in a short-term boost to the local economy and provide some employment opportunities. However, plantation establishment also results in flooding, water contamination, loss of forest products, and other problems that might very well offset any positive economic gains.

In this way we can see how the concepts of natural capital and sustainability are tightly linked. Sustainable economic development does not depend on the destruction and liquidation of natural systems and natural capital, and therefore it does not undermine people's future ability to enjoy the services and benefits of these systems. Instead, sustainability means that we strive to meet our needs in ways that maintain stocks of natural capital and the ecological integrity of natural systems. Think about this in the chapters ahead as we examine the environmental and ecological impacts of current approaches to food production, energy use, waste management, and other activities. Also try to imagine what a sustainable approach to these activities might look like.

## 1.5 Core Theme: Examining Our Impact

Now that we know *what* we are trying to sustain—natural capital—how do we know if we are actually doing so? What are some indicators that can be used to determine if our economic activities have gone too far and are actually undermining our long-term prospects? This section will introduce two concepts, the environmental footprint and the Anthropocene, that suggest we are overexploiting natural capital on a worldwide basis and undermining long-term prospects for sustainability.

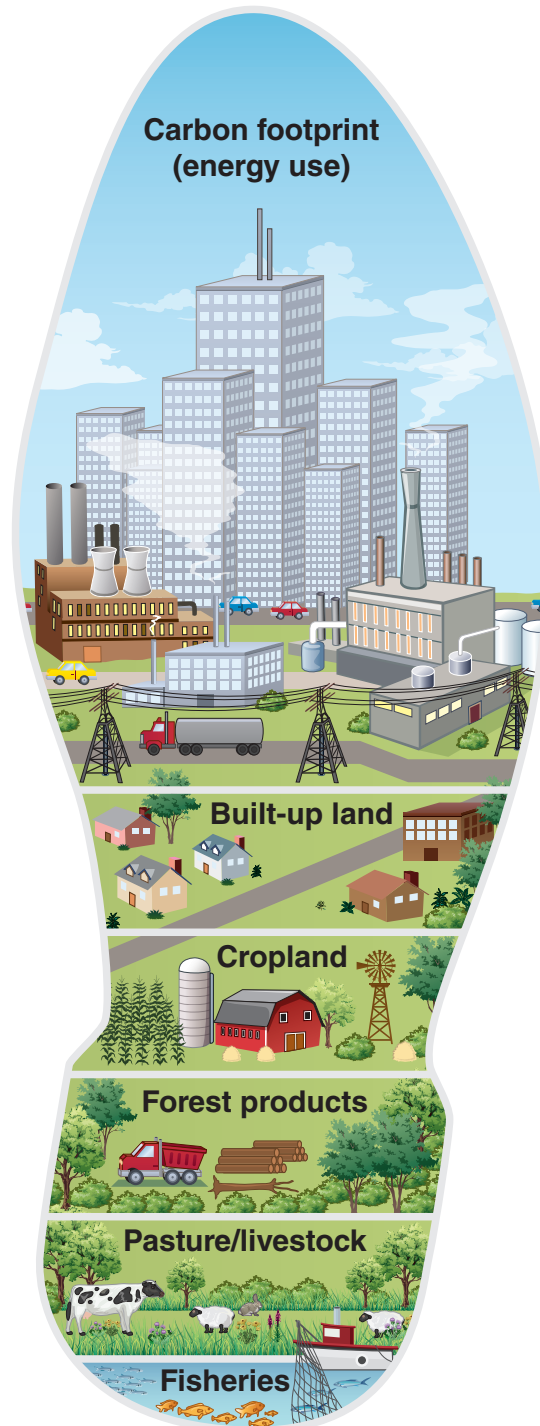
### The Environmental Footprint

Few of us give much thought to the impact we have on the environment. If we do think about our impact, we tend to do so mainly in terms of our immediate surroundings. In reality, our lifestyle and consumption patterns often have far-reaching effects on many parts of the environment in ways that are difficult for us even to imagine. For example, how often do you think about where your water or food comes from? Many of us rely on municipal water systems that might involve pumping water hundreds of miles and running it through a series of filtration and purification systems before distributing it to thousands of households and businesses. Almost all of us depend on commercial food systems that distribute food from all over the world using trucks, boats, trains, and even planes. When you flip a light switch or flush a toilet, do you think about where that electricity comes from or where that waste is going? All of these services are complex systems that require significant energy and resources, and these systems often have wide-ranging environmental impacts.

Because so many of our activities and consumption patterns have environmental and ecological impacts that are invisible to us—out of sight, out of mind—environmental scientists have developed the concept of an *environmental or ecological footprint*. An **environmental footprint** is a measure of how much land area and water is necessary to support an individual or a group of people (see Figure 1.6). For example, how much land and water is needed to grow the food you eat or the timber, paper, and forest products you use? How big of an area is needed to effectively absorb and convert the liquid, solid, and gaseous wastes that you produce every day? Because we consume resources in different ways and live different lifestyles, individuals can have different environmental footprints. In terms of diet, for example, it takes more land and water to produce meat than an equivalent amount of grain or vegetables. Therefore, a person with a heavily meat-based diet is likely to have a larger environmental footprint than someone who eats less meat or is vegetarian.

## Figure 1.6: Environmental footprint

If we were to illustrate the United States' environmental footprint, it might look like this. How much land and water does your lifestyle require?



Adapted from "WWF Report: Global Wildlife Populations Could Drop by Almost 70% by 2020," by WWF, 2016 ([https://www.wwf.org.hk/en/news/press\\_release/?uNewsID=16820](https://www.wwf.org.hk/en/news/press_release/?uNewsID=16820)).

Individual environmental footprints can be summed to determine the overall footprint of a larger group of people, such as a city or an entire country. These cumulative environmental footprints can be measured against the actual amount of land and water resources available to that population in order to determine whether current consumption patterns are sustainable. In other words, the environmental footprint of a given population is a measure of its natural capital use, and by comparing natural capital utilization to natural capital availability, a determination can be made as to whether that population is behaving in a way that meets the definition of sustainability.

Perhaps not surprisingly, the average environmental footprint of a citizen of a country like the United States, Canada, or France is 5, 10, or even 20 times larger than the environmental footprint of a citizen of a less developed country like Indonesia, Ethiopia, or Bangladesh. Furthermore, the overall environmental footprint of developed countries like the United States exceeds the amount of land and water resources available to support their populations on a sustainable basis. In other words, the United States is meeting its current consumption patterns only by drawing down or depleting its own natural capital resources or by “borrowing” those resources from other countries. You could say that our environmental footprint shows that we are running a serious *ecological deficit*. On a global scale, it’s estimated that the entire human population is consuming resources and generating waste products at a rate that would require 1.7 planet Earths to be sustainable (Global Footprint Network, 2019). Obviously, we do not have any other planet Earths available, so we must find ways to reduce the environmental impacts of our activities and consumption if we are to reach a sustainable state.

In terms of our Borneo case study, it’s likely that most residents of that island have relatively small environmental footprints, based on their direct consumption patterns. However, global demand from countries like the United States for low-cost palm oil is driving the process of deforestation for palm oil plantations. This example demonstrates how consumption patterns in one place can have serious environmental impacts in faraway places. As we examine the impact of food production, water management, fishing, energy use, and waste production on the environment in the chapters ahead, try to connect these to your own consumption and resource use patterns. What do you think your own environmental footprint looks like? What steps could you take to reduce it?

### Learn More: Your Environmental Footprint

The Global Footprint Network is the go-to source for information on the idea of environmental or ecological footprints.

- <https://www.footprintnetwork.org/our-work/ecological-footprint>

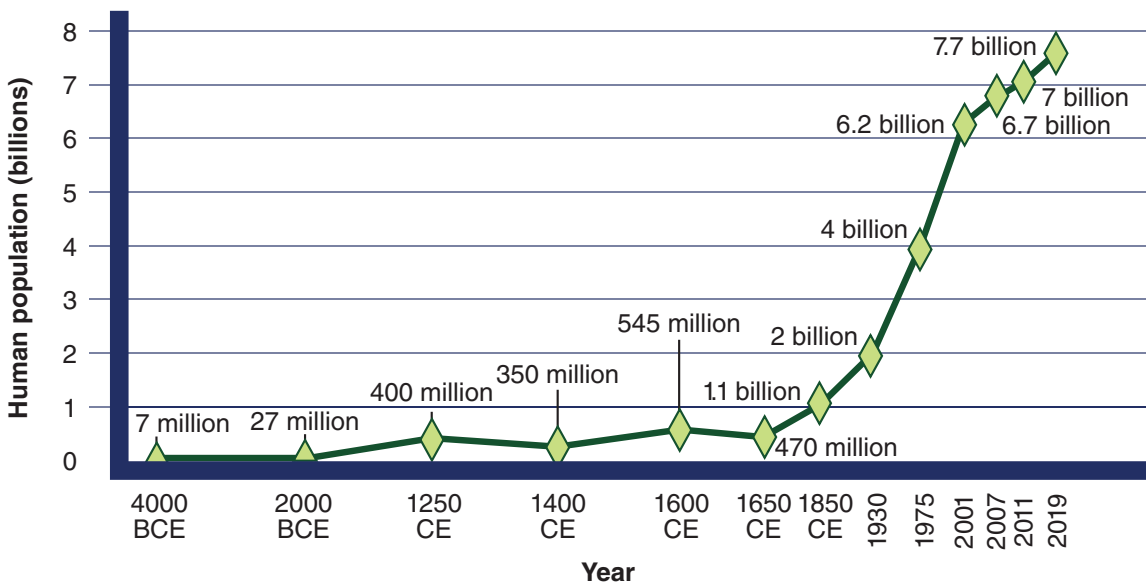
## The Anthropocene and the Sixth Great Extinction

Geologists and earth scientists use a geologic timescale to measure the history of the Earth. One unit of measure in that timescale is an *epoch*, a particular period of time defined by distinctive features or events. For roughly the past 10,000 years, a geologic epoch known as the **Holocene**, the Earth has been a fairly stable place. There have been no major shifts in climate, no global extinction events, and no periods of widespread volcanic activity or changes in ocean chemistry.

These relatively stable conditions have provided the perfect setting for human civilizations to grow and flourish. In that time, the human population of the entire planet has grown from roughly a few *million* people, equivalent perhaps to the current population of Los Angeles, to roughly *7.7 billion* people (see Figure 1.7). In just the past 200 years, the human population has increased by a factor of 8, and the rates of consumption, material and energy use, and waste generation per person have also increased dramatically.

### Figure 1.7: Human population growth

Scientists wonder if Earth can continue to support the current trajectory of human population growth.



Based on data from "Historical Estimates of World Population," by U.S. Census Bureau, 2018 (<https://www.census.gov/data/tables/time-series/demo/international-programs/historical-est-worldpop.html>); "World Population Prospects 2019," by United Nations DESA Population Division, 2019 (<https://population.un.org/wpp>).

As a result of these dual trends—growing numbers of people and increasing rates of material and energy use—some scientists now feel that we are entering a new epoch, one they are calling the **Anthropocene**. The Anthropocene, derived from the prefix *anthropo-*, or “human,” can be defined as a geologic age or epoch during which human activities are the dominant influence on the environment, oceans, climate, and other Earth systems. Humans are literally leaving their mark on the planet, including fundamentally altering the chemical composition of the atmosphere, oceans, and soils; converting vast areas of open space to cities, suburbs, farms, and other forms of development; and driving species to extinction at rates that are 100 to 1,000 times greater than would otherwise be the case.



*naumoid/iStock/Getty Images Plus*

**Human activities are changing the planet. Our choices are affecting the atmosphere, land, oceans, and other species.**

These rapid increases in extinction rates are leading environmental scientists to worry that we are in the early stages of a sixth great extinction. Scientists believe that since life began on Earth, there have been five great extinction events—periods in which a significant percentage (70%–95%) of species were wiped out. The first, known as the Ordovician–Silurian extinction event, occurred roughly 440 million years ago. The most recent, known as the Cretaceous–Tertiary extinction event, occurred 65 million years ago. It takes millions of years to bounce back from extinction events and reach comparable levels of species diversity. But under relatively stable conditions, evolutionary processes create new species faster than others go extinct, and so species diversity will increase over time. Since the last great extinction, the number of species on Earth has grown into the tens of millions. Of these, we know the most about numbers of mammals and birds but far less about the status of fish, reptiles, amphibians, plants, and invertebrates (organisms without a backbone, such as insects). Today, as extinction rates increase and far surpass the rate at which evolution develops new species, we could be losing hundreds if not thousands of species before we have had a chance to fully understand and study their place in an ecosystem.

Unlike the first five great extinction events, which were caused by natural forces like mass volcanic eruptions and meteor strikes, the current crisis is a direct result of human actions. Some of these human actions include pollution, overharvesting and overhunting of species, the introduction of exotic or invasive species into ecosystems, and the effects of human-caused climate change. (These and other causes of biodiversity loss and extinction will be reviewed in greater detail in Chapter 2.) However, the most significant cause of species extinction today is habitat destruction, such as that in Borneo. Widespread conversion of tropical forests to palm oil plantations, soybean farms, and grazing areas for cattle is wiping out habitat for all kinds of species and contributing significantly to the rapid increase in extinction rates on the island.

In the chapters ahead, consider how human activities like agriculture, fishing, logging, mining, energy use, and waste generation might be altering the planet in profound ways. Also consider what these activities might mean for other species and for rates of biodiversity loss. In doing so, consider an idea proposed by the well-known and highly respected evolutionary biologist E. O. Wilson. Wilson calls for a plan that would set aside one half of the planet as permanently protected areas for other species, an idea known as the Half-Earth Project. Wilson and others are convinced that such a bold plan is the only way to avert a sixth mass extinction event. Is such an idea even possible? Can we find ways to meet the needs of a human population soon to exceed 8 billion while leaving room for other species?

### Learn More: The Half-Earth Project

The Half-Earth Project is an effort designed to conserve half of the world so as to protect biodiversity and the ecosystem services it provides. You can learn more about this project here.

- <https://eowilsonfoundation.org/half-earth-project>
- <https://www.half-earthproject.org>

## 1.6 Core Theme: Taking Action

Faced with evidence that our global ecological footprint is already exceeding capacity and that we are moving rapidly toward what could be a sixth mass extinction, how do we change our approach to economic development and meeting our food, water, and energy needs without making things worse? The chapters ahead will present alternative approaches to meeting our needs side by side with a discussion of current approaches. But how do we know if those alternatives are worth pursuing, and how much time do we have to decide whether to pursue them? This section introduces the concepts of uncertainty, scale, risk, and cost-benefit analysis that help environmental scientists and policy makers grapple with these questions.

### Uncertainty and Scale

The concepts of uncertainty and scale play an important role in how we define and address different environmental challenges. *Uncertainty* is a defining characteristic of much of the work done by environmental scientists. The natural systems that these scientists study are often so complex that there are always things they can't be certain about. The scientific method is one important way in which scientists reduce uncertainty. However, some uncertainty and even ignorance will still be present, and it's important to understand this when we examine evidence of environmental problems and the need to address them. Waiting for "scientific certainty" before addressing an environmental challenge, a call often made by politicians in



zanskar/iStock/Getty Images Plus

**Action needs to happen early. If we wait for scientific certainty before addressing issues, then we might face irreparable damage to our environment and its creatures.**

Borneo may be mainly a local scale issue that might be understood and addressed in a fairly direct fashion. If the scale of that deforestation increases, either because of larger clearings or a larger number of small clearings that have begun to connect, then we might move to a regional scale issue with broader impacts. Understanding those impacts and developing ways to address them also grow in complexity.

At this point, deforestation in Borneo has actually reached the level of a national and global scale issue. National governments and international environmental groups are involved in defining and attempting to reduce the problem. Global demand for palm oil and other products is driving deforestation not only in Borneo but also in the Brazilian Amazon and regions of central Africa. Meanwhile, land use practices in Borneo are resulting in biodiversity loss, air pollution, and greenhouse gas emissions that are felt on a global scale.

As we study a variety of environmental issues in the chapters ahead, consider how issues of uncertainty and scale might affect debates about the scope of the problem and possible solutions. Understand that scientists readily acknowledge elements of uncertainty in their work and in what they study, but this does not mean they don't know what they are talking about, nor is it an excuse for inaction. Also consider how environmental issues operate at different scales and whether you can see this in your own actions and their impacts on the environment.

## Risk and Cost–Benefit Analysis

We make decisions about risk in our lives every day. Every time you fly on an airplane, drive a car, walk to work, fall in love, decide to have a family, or enter a business relationship, you incur a risk that something will go wrong. Therefore, whether you are conscious and deliberate in your choices or reckless and haphazard, you are making a personal form of **risk analysis**, or risk assessment.

cases like climate change, is simply an argument for *doing nothing*. Instead of waiting on a certainty that will almost never be achievable, policies and other approaches for addressing environmental problems should be based on the best possible science available at that moment, even if it still includes elements of uncertainty.

The concept of *scale* is also important to consider as you undertake the study of environmental science. Environmental issues occur at many different scales—local, regional, national, and global—and the larger the scale, the more complex and difficult it tends to become to deal with these issues.

For example, small-scale deforestation in

In a similar manner, society must make risk analyses in setting environmental policy. You can see this type of decision making in the news almost every day, along with the political and economic arguments on a local, state, or national level. For any issue, there are a series of simple questions that must be addressed before choosing a path of action.

First, one must ask, “What is the probability that a given activity will cause harm?” Because systems are so complex, it is seldom possible to say action A definitely will cause consequence B. Scientists build models based on experiments and observation and test their models to the best of their ability. Rational nonscientists must then develop a course of action based on the probabilities expressed by the majority of scientists working in the field.

Second, given that outcomes are usually uncertain, one must ask, “What are the consequences if we do nothing?” In our normal lives, we spread a bigger safety net when the consequences are serious than we do when they are minor. If the brakes were likely to fail on your car, you would act more aggressively to get them fixed than you would if the interior dome light were not working. Because outcomes are never certain, we must balance risk and consequence in setting environmental policy.

Finally, one must ask, “What are the costs and risks of choosing other options?” In the case of Borneo, we know with a lot of certainty that current land use practices are not sustainable. We also know that things will only get worse if we do nothing. The real question comes when we consider what other options might exist. Environmental scientists, economists, and other development experts can point to many alternative land use practices and economic models that could help better protect Borneo’s environment while still providing livelihood opportunities to its residents. However, these alternative approaches may do less to enrich certain members of society who hold a disproportionate amount of political power. Alternative approaches might make sense from an overall societal perspective, but they might not be implemented due to local, regional, national, and even global political realities.

One commonly used tool in environmental risk assessment is **cost-benefit analysis**. It costs money to install pollution control in factories, mining operations, automobiles, power plants, and other human-operated systems. These pollution control costs are called *internal costs* because they are borne by the industries that produce specific goods and services. Consumers pay internal costs whenever they turn on electricity, pump gasoline into a car, or buy anything at the store. But if pollution control is nonexistent or inadequate, then everyone has to pay the cost of a dirty and unhealthy environment. Environmental disasters can result in sickness, death, destroyed property, loss of work, reduction of home values, and so on. These societal costs of unregulated pollution are called *external costs*, or *externalities*, because they are outside the activity itself and are not reflected in direct costs. External costs are paid by everyone in society, regardless of what he or she purchases. Thus, if electric generation creates pollution that causes negative health effects, a poor person who uses little electricity pays the same price as a rich person who uses a lot of electricity. In fact, a poor person is likely to pay an even higher price, since many electric power plants and other polluting industrial facilities (such as oil refineries) tend to be located in low-income areas.

Cost-benefit analyses can be used to compare the cost of pollution control with the cost of externalities. For example, as the cost of pollution control increases, the cost of externalities decreases. The total cost to society can be found by combining costs of pollution control and externalities. This total cost typically reaches a minimum when some, but not all, of the

## Bringing It All Together

pollution is controlled. Many suggest that we should strive to achieve this minimum cost even though this approach accepts some pollution, with its possible discomfort, sickness, and even death. They argue that the alternative, more expensive pollution control, will slow economic growth and lead to unemployment, with its own forms of human misery. Others argue that that cost-benefit analysis is flawed because it ignores both the quality and the value of human life. How, they ask, can you place a dollar value on the spiritual quality of a walk in the woods or a swim in a crystal clear mountain stream? How can you measure the economic value of even one life cut short by cancer? If noneconomic costs of pollution are considered, then more pollution control becomes desirable.

No one knows the future. But the outcome will affect every person on the planet. We study environmental science because the issues facing society are complex. There are no absolute answers. But certainly we—as individuals, municipalities, states, countries, and citizens of the world—need to develop scientific, economic, and political policy based on an accurate evaluation of the problems we face today and the future we envision for tomorrow. Certainly, an informed awareness is essential to making the decisions that will affect all of us. As we study specific environmental issues in the chapters ahead, think about how issues of uncertainty, scale, and risk might combine to shape perceptions and attitudes about how best to address that environmental challenge. Also consider whether making use of risk analysis and cost-benefit analysis might help in guiding policy makers to a better resolution of that challenge.

## Bringing It All Together

This opening chapter introduced you to a lot of new terminology, concepts, and ways of seeing the world. The goal is not to just have you memorize what these terms and concepts mean but to provide you with the tools you need to further explore a range of environmental issues presented in the chapters to come. This chapter also provided you with the opportunity to begin to think about your own connection to the environment, in terms of both your dependence and your impact on it. The next chapter will continue to introduce you to concepts and terms important to the study of environmental science. The focus of Chapter 2, however, will be on the field of ecology and establishing a natural science foundation. As we move to Chapter 3 and its focus on human population growth and material consumption, and then to Chapters 4–9 with their focus on specific environmental issues and challenges, see if you can connect and apply the terms and concepts introduced in this chapter to your own understanding of the material.

## Additional Resources

### Our Connection to the Natural World

We seldom think about the important question of whether we view ourselves as *apart from* nature or as *a part of* nature. In this interesting essay, leadership consultant Kathleen Allen asks that question and what the answer might mean for each person's leadership style.

- <https://kathleenallen.net/are-we-a-part-of-nature-or-are-we-apart-from-nature>

This TED Talk argues that nature is not just some pristine wilderness thousands of miles away from where we live, but rather any open space right outside our door. By going out into that space, we can develop a relationship with nature that's good for us and for the planet.

- <https://www.youtube.com/watch?v=hiIcwt88o94>

### **Critical Thinking**

Educator and speaker Michael Stevens has developed something of a cult following around his TED Talks on YouTube videos that deal with how we ask and answer questions. His insights shine a light on how scientists approach their work and use a combination of creative and critical thinking to ask and answer questions about the world around them.

- <https://www.youtube.com/channel/UC6nSFpj9HTCZ5t-N3Rm3-HA>

### **Deforestation in Borneo**

There has been a lot of good coverage of the deforestation issue in Borneo in recent years, including analysis of its causes, history, future trends, and how our own consumption decisions might be implicated in that destruction. This well-written and insightful piece examines the issue and what part you might play in reversing it.

- <https://news.mongabay.com/2018/02/borneo-ravaged-by-deforestation-loses-nearly-150000-orangutans-in-16-years-study-finds>

### **Natural Capital and Ecosystem Services**

Natural capital and ecosystem services can sometimes be difficult concepts to understand. These resources help explain what natural capital and ecosystem services are and why they are so important for human well-being and survival.

- <https://naturalcapitalcoalition.org/natural-capital-2>
- <https://wle.cgiar.org/content/what-are-ecosystem-services>

### **Sustainability and Sustainable Development**

The United Nations is attempting to make the concepts of sustainability and sustainable development a reality through its Sustainable Development Goals. You can learn more about these efforts and the idea of sustainability in general at these sites.

- <https://sustainabledevelopment.un.org/?menu=1300>
- <https://www.undp.org/content/undp/en/home/sustainable-development.html>

### **The Anthropocene and the Sixth Great Extinction**

The idea of the Anthropocene and the question of whether we are now entering this new epoch are being hotly debated among environmental scientists and geologists. Learn more about this concept, and the scientific debate surrounding it, here.

- <http://www.anthropocene.info>
- <https://theanthropocene.org>

## Key Terms

**Anthropocene** A geologic age or epoch during which human activities are the dominant influence on the environment, oceans, climate, and other Earth systems.

**biodiversity** The variety of life and organisms in a specific ecosystem.

**biodiversity hotspot** A region that has high rates of biodiversity and is also experiencing significant environmental destruction.

**cost-benefit analysis** A systematic approach to calculating and comparing the costs and benefits of different policies.

**creative thinking** The ability to analyze and address situations and challenges in new and creative ways.

**critical thinking** The objective analysis and evaluation of an issue in order to form a judgment.

**deforestation** The act of clearing of forest areas.

**ecosystem services** The beneficial resources and processes that ecosystems supply to humans.

**ecotourism** Tourism that is focused on natural environments in an effort to help conserve an area and support the local economy.

**endangered species** Species at risk of extinction.

**endemic species** Plants and animals that exist in only one specific geographic region.

**environment** Everything that surrounds us, including living and nonliving things; all physical, chemical, and biological factors and processes that affect an organism.

**environmental footprint** A measure of how much land area and water is necessary to support an individual or a group of people.

**environmentalism** A social and political movement committed to protecting the natural world.

**environmental science** The study of how the natural world works, how we are affected by the natural world, and how we in turn impact the natural world around us.

**extinction** The total loss of a species.

**habitat** The place or set of conditions an organism depends on for survival.

**habitat loss** The destruction of specific habitats.

**Holocene** The current epoch or geologic time period, roughly the past 10,000 years.

**information literacy** The ability to know when information is needed and the ability to identify, locate, evaluate, and effectively use that information to address an issue.

**interdisciplinary** Pertaining to multiple disciplines, or areas of study.

**natural capital** Natural assets such as trees, soils, streams, oceans, and the atmosphere.

**risk analysis** An evaluation that considers the probability that a given action will cause harm, the consequences of inaction, and the costs and risks of other options. Also known as *risk assessment*.

**scientific method** An approach to research based on observation, data collection, hypothesis testing, and experimentation.

**species** Groups of organisms that share certain characteristics, interbreed, and produce fertile offspring.

**sustainability** The maintenance of natural systems and an ecological balance.

**sustainable development** The achievement of economic development without the depletion or destruction of natural systems.

