

Welcome to the Eighth Edition of *Elemental Geosystems* and the study of physical geography! In this text, we examine the powerful Earth systems that influence our lives and the many ways humans impact those systems. Physical geography involves the study of Earth's environments, including the systems that form the landscapes, seascapes, atmosphere, and ecosystems on which humans depend. In this second decade of the 21st century, our natural world is changing, and the scientific study of Earth and its environments is more crucial than ever.

Consider as examples the following events and the questions they raise for the study of Earth's systems and physical geography. This text provides tools for answering these questions and addressing the underlying issues.

- In October 2012, Hurricane Sandy made landfall along the U.S. East Coast, hitting New York and New Jersey at high tide with hurricane-force winds and record storm surges. The storm cost 110 human lives and over \$42 billion in New York State alone, approaching \$100 billion in damages overall. What atmospheric processes explain the formation and movement of this storm? Why the unprecedented size and intensity? How does this storm relate to record air and ocean temperatures?
- In March 2011, a magnitude 9.0 earthquake and resultant 10- to 20-m (33- to 66-ft) tsunami devastated Honshu Island, Japan—at US\$309 billion, Earth's most expensive natural disaster so far. Why do earthquakes occur in particular locations across the globe? What produces tsunami, and how far and fast do they travel? How have prevailing winds and ocean currents dispersed tsunami debris across the Pacific?
- In 2014, the U.S. National Park Service finished the deconstruction of two dams on the Elwha River in Washington—the largest dam removals in the world to date. The project will restore a free-flowing river for fisheries and associated ecosystems. How do dams change river environments? Can rivers be restored after dam removal?
- In 2011, the world released 2.4 million pounds of carbon dioxide (CO₂) into the atmosphere every second, mainly from the burning of fossil fuels. This “greenhouse gas” contributes to climate change by trapping heat near Earth's surface. Each year atmospheric CO₂ levels rise to a new record, altering Earth's climate. What are the effects on Earth systems?

Physical geography uses a *spatial* perspective to examine processes and events happening at specific locations and follow their effects across the globe. Why does the environment vary from equator to midlatitudes and between tropical and polar regions? What produces the patterns of wind, weather, and ocean currents? How does solar energy influence the distribution of trees, soils, climates, and human populations? In this book, we explore those questions, and more, through geography's unique perspective.

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Perhaps more than any other issue, climate change has become an overriding focus of the study of Earth systems. The past decade experienced the highest air temperatures over land and water in the instrumental record. In response, the extent of sea ice in the Arctic Ocean continues to decline to record lows. At the same time, melting of the Greenland and Antarctica Ice Sheets is accelerating; together, they now lose more than three times the ice they lost annually 20 years ago. As sea ice and ice sheets melt, sea level is rising. Elsewhere, intense weather events, drought, and flooding continue to increase. In presenting the state of the planet, *Elemental Geosystems* surveys climate change evidence and considers its implications. In every chapter, we present up-to-date science and information to help you understand our dynamic Earth systems. Welcome to an exploration of physical geography!

In this chapter: We begin with a look at the science of physical geography, which uses an integrative spatial approach, guided by the scientific process, to study Earth systems. The role of humans is an increasingly important focus of physical geography, as are questions of global sustainability as Earth's population grows.

Physical geographers study the environment by analyzing air, water, land, and living systems. Therefore, we discuss systems and the feedback mechanisms that influence system operations. We then consider location on Earth as determined by the coordinated grid system of latitude and longitude, and the determination of world time zones. Next, we examine maps as critical tools that geographers use to display physical and cultural information. This chapter concludes with an overview of technologies that are adding exciting new dimensions to geographic science: the Global Positioning System, remote sensing from space, and geographic information systems.

The Science of Geography

Geographic science is concerned with much more than place names. **Geography** (from *geo*, “Earth,” and *graphein*, “to write”) is the science that studies the relationships among natural systems, geographic areas, and human society and culture, and the interdependence of all of these, *over space*. These last two words are key, for geography is a science that is in part defined by its method—a special way of analyzing phenomena over space. In geography, the term **spatial** refers to the nature and character of physical space, its measurement, and the distribution of things within it.

Geographic concepts pertain to distributions and movement across Earth and how these processes interact with human actions. Given this spatial perspective, the concerns of geographic science are traditionally divided into five themes: **location, region, human–Earth relationships, movement, and place**, each illustrated and defined in **Figure 1.1**. These themes provide a framework