

McKnight's

Physical Geography

Thirteenth Edition

A LANDSCAPE APPRECIATION

Darrel Hess

Redina Finch

Illustrated by Dennis Tasa



World – Physical

Great Basin	Land features
Caribbean Sea	Water bodies
Aleutian Trench	Underwater features





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Physical Geography

Thirteenth Edition

Geography

A LANDSCAPE APPRECIATION

Darrel Hess

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Covering the most difficult-to-visualize topics in physical geography, students can access the Geoscience Animations by clicking on the related Pearson links in the book or through the **Mastering Geography™** Study Area. Teachers can assign these media with assessments in **Mastering Geography™**.

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- Seamounts & Coral Reefs

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Mobile Field Trip: Introduction to Physical Geography
- 2 Portraying Earth**
Studying Fires Using Multiple Satellite Sensors
- 3 Introduction to the Atmosphere**
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20 Coastal Processes and Terrain

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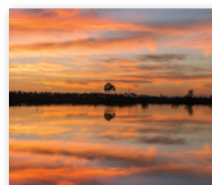
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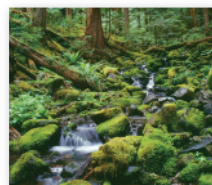
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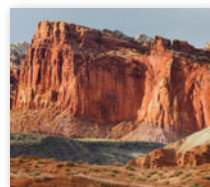
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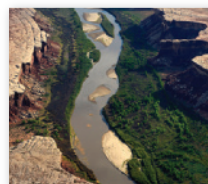
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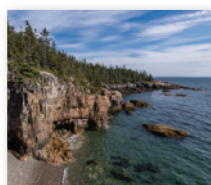
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Preface

McKnight's Physical Geography: A Landscape Appreciation presents the concepts of physical geography in a clear, readable way to help students comprehend Earth's physical landscape. The time-proven approach to physical geography first presented by Tom McKnight more than 35 years ago and carried through 12 editions, now has a new focus in the 13th edition—that of this country's National Parks. The parks, monuments, seashores, and recreational areas that comprise our National Park system serve as a source of inspiration for anyone interested in experiencing natural landscapes. They also provide the perfect introduction to topics that range from Earth's physical features and the processes that form them, to the opportunities they provide for scientific research, and offer a lens through which to view climate change

FEATURES OF 13TH EDITION

Users of earlier editions will see that the overall sequence of chapters and most topics remains the same, with material added and updated in several key areas. Changes to the new edition include the following:

- **NEW** As introduced in Chapter 1, each chapter includes at least one feature that explores a National Park. These include a **Featured National Park** that focuses on one particular aspect or **Snapshots From Our National Parks** that presents a series of images that relate to a particular topic.
- **NEW** In addition to the images incorporated into the National Park features, **Our National Parks** banners highlight more than 90 photographs that appear as numbered figures in the text, each accompanied by a locator map of the park. Also, highlighted with **Science in the Field** banners, photos highlight scientists and researchers at work, many in National Parks.
- **NEW** Each chapter now opens with the image of a National Park that is the subject of **Seeing Geographically in Our National Parks**. This feature tests students ability to analyze and interpret what they see before they begin the chapter and then, at the end of the chapter, asks them to reassess their initial assumptions given what they have learned.

All the features originally introduced in the 12th edition, including many authored by outside contributors, have been retained and updated. These include the following:

- **Global Environmental Change** features written by expert contributors that present brief case studies on natural and human-caused environmental change, exploring important contemporary events and

implications for the future. Topics include *Aerosol Plumes Circling the Globe* and *Changes in the South Asian Monsoon*.

- **Energy for the 21st Century** features cover *Transitioning from Fossil Fuels*; *Solar Energy*; *Wind Power*; *Strategies for Reducing Greenhouse Gas Emissions*; *Biofuels*; *Unconventional Hydrocarbons and the Fracking Revolution*; *Hydropower*; *Geothermal Energy*; and *Tidal Power*.
- **Focus** features focus on science and technology. Topics include *Multiyear Atmospheric and Oceanic Cycles*; *Soil Differences—They're All About Scale*; *Measuring Earth's Surface Temperature by Satellite*; *GOES Weather Satellites*; *Conveyor Belt Model of Midlatitude Cyclones*; *Weather Radar*; and *Earthquake Prediction*.
- **People & the Environment** features include *The Oso Landslide*; *The Great Pacific Garbage Patch*; and *The Future of the Mississippi River Delta*.

The pedagogical features that were a hallmark of the 12th edition have been retained and updated. These include the following:

- *Mobile Field Trip Videos* have students accompany acclaimed photographer and pilot Michael Collier in the air and on the ground to explore iconic landscapes of North America and beyond. "All 22 videos are" available within *Mastering Geography*.
- The entire art program was created by the geoscience illustrator Dennis Tasa and includes more than 800 diagrams and maps, done in Dennis's distinctive, accessible style.
- Each chapter includes a refined learning path, beginning with a series of **Key Questions** to help students prioritize key issues and concepts.
- Throughout each chapter, **Learning Check** questions periodically confirm student understanding of the material.
- The end-of-chapter **Learning Review** includes *Key Terms and Concepts*, *Study Questions*, and *Exercises* plus a capstone activity called *Environmental Analysis* that sends students online to use a variety of interactive science resources and data sets to perform data analysis and critical thinking tasks.

The media assets included in the 13th edition include:

- **NEW** More than 20 *NPS Videos* produced by the National Park Service are included with many of the National Park features and linked by short URLs. Also available within *Mastering Geography*.
- *Project Condor Quadcopter Videos*, take students out into the field through narrated quadcopter footage, exploring the physical processes that have helped shape North American landscapes.
- The book is supported by *Mastering Geography*[™], the most widely used and effective online homework, tutorial, and assessment system for the sciences. Assignable media and activities include *Geoscience Animations*, *Videos*, *Mobile Field Trip Videos*, *Project Condor Quadcopter Videos*, *Encounter Physical Geography Google Earth*[™] *Explorations*, *GIS-inspired MapMaster*[™]

interactive maps, coaching activities on the toughest topics in physical geography, end-of-chapter questions and exercises, reading quizzes, and Test Bank questions.

Chapter updates for the 13th edition include the following:

- In Chapter 1, the introduction of the new national parks theme in a two-page feature *National Parks: Our Geographical Laboratories*.
- In Chapter 3, the chapter was reorganized, placing *Human-Caused Atmospheric Change* at the end of the chapter; data and satellite imagery has been updated.
- In Chapter 4, the material on the greenhouse effect has been updated to reflect current terminology; the figure illustrating adiabatic cooling and warming has been clarified; data and satellite imagery has been updated.
- In Chapter 6, the material on latent heat in the atmosphere has been clarified and now includes an illustration; data and satellite imagery has been updated.
- Chapter 7 includes clarifications in the Midlatitude Cyclones section and discussion and illustrations of some of the latest storms, including Hurricanes Harvey (2017), Michael (2018), and Dorian (2019).
- Chapter 8, Climate and Climate Change, has been thoroughly updated and revised with the latest data and applications.
- Chapter 9, the material on the cryosphere has been updated, along with other data and satellite.
- Chapter 10, image of the 2019 Camp Fire has been included.
- Chapter 11, the material and data on the tropical rainforest has been updated.
- Chapter 13, the Geologic Time Scale has been updated and a discussion of absolute and relative dating has been included in the NPS feature.
- Chapter 14, the new NPS feature includes a timeline of the ongoing eruptions of Kilauea, including the eruption in 2018.
- Chapter 19, maps and data have been updated on glaciers and ice shelves.

TO THE STUDENT

Welcome to *McKnight's Physical Geography: A Landscape Appreciation*. Take a minute to skim through this book to see some of the features that will help you learn the material in your physical geography course:

- You'll notice that the book includes many diagrams, maps, and photographs. Physical geography is a visual discipline, so studying the figures and their captions is just as important as reading through the text itself.
- Many photographs have "locator maps" to help you learn the locations of the many places we mention in the book.
- A reference map of physical features of the world is found inside the front cover of the book, and a reference

map of the countries of the world is found inside the back cover.

- *Science in the Field* photo features highlight the real-world people and professions in geography and science today.
- Each chapter begins with a quick overview of the material, as well as a series of questions—think about these questions as you study the material in that chapter.
- Look at the photograph from a National Park that begins each chapter. The *Seeing Geographically in Our National Parks* questions for this photograph will get you thinking about the material in the chapter and about the kinds of things that geographers can learn by looking at a landscape.
- As you read through each chapter, you'll come across short *Learning Check* questions. These quick questions are designed to check your understanding of key information in the text section you've just read. Answers to the Learning Check questions are found in the back of the book.
- Each chapter concludes with a *Learning Review*. Begin with the *Key Terms and Concepts* questions—these will check your understanding of basic factual information and key terms (which are printed in bold type throughout the text). Then, answer the *Study Questions*—these will confirm your understanding of major concepts presented in the chapter. Finally, you can try the *Exercises*—for these problems you'll interpret maps or diagrams and use basic math to reinforce your understanding of the material you've studied.
- *Environmental Analysis* activities at the end of each chapter will direct you to interactive science resources and data sets for broader data analysis and critical thinking.
- Finish the chapter by answering the *Seeing Geographically* questions at the end of the Learning Review. To answer these questions, you'll put to use things you've learned in the chapter. As you progress through the book, you begin to recognize how much more you can "see" in a landscape after studying physical geography.
- The alphabetical glossary at the end of the book provides definitions for all of the key terms.
- All chapters include URLs that direct you to *Mobile Field Trips*, *Project Condor* Quadcopter Videos, online animations, and other videos. The animations and videos help explain important concepts in physical geography and also provide real-world case studies of physical geography in action. The animations and videos can also be accessed through the Student Study Area in MasteringGeography, and can also be assigned for credit by teachers.

ACKNOWLEDGMENTS

I first want to formally welcome Redina Finch as coauthor of *McKnight's Physical Geography*. Her involvement with the textbook began as a major contributor to the previous edition. Now as coauthor, she took primary responsibility for the revisions of our chapters on atmospheric

science—although her mark is found throughout the book. It is a much better textbook because of her contributions and thoughtful critiques.

Once again Dennis Tasa has done a wonderful job on the illustrations. We've now worked together on four editions, and he continues to impress me with his ability to take rough ideas and turn them into effective and beautiful illustrations.

I am delighted that we are again including the *Mobile Field Trip* videos developed by photographer, writer, pilot, and educator, Michael Collier—many of his videos fit in perfectly with this new edition's focus on our National Parks.

A special nod of appreciation goes to my previous editor, Christian Botting, who first developed the idea of a National Parks emphasis for this new edition of the textbook.

Finally, I offer my deepest gratitude to Development Editor Mary Hill. Her sound advice and critical eye for detail all through the writing and production process has improved this book enormously.

As with previous editions, this book was a collaborative effort incorporating contributions of many scholars who wrote short boxed essays, problem sets, and activities for the book. Many thanks to all who offered their ideas for improvement for this edition, including:

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www.masteringgeography.com

FOR STUDENTS

Physical Geography Laboratory Manual, 13th edition by Darrel Hess. This lab manual offers a comprehensive set of more than 45 lab exercises to accompany any physical geography class. The first half covers topics such as basic meteorological processes, the interpretation of weather maps, weather satellite images, and climate data. The second half focuses on understanding the development of landforms and the interpretation of topographic maps and aerial imagery. Many exercises have problems that use Google

Earth™, and the lab manual website contains maps, images, photographs, satellite movie loops, and Google Earth™ KMZ files. The 13th edition of the lab manual includes both new and revised exercises, new maps, expanded use of Google Earth™, and is now supported by a full Mastering Geography program. www.masteringgeography.com.

Goode's World Atlas, 23rd Edition (0133864642). Goode's World Atlas has been the world's premiere educational atlas since 1923—and for good reason. It features more than 250 pages of maps, from definitive physical and political maps to important thematic maps that illustrate the spatial aspects of many important topics. The 23rd Edition includes more than 160 pages of digitally produced reference maps, as well as thematic maps on global climate change, sea-level rise, CO₂ emissions, polar ice fluctuations, deforestation, extreme weather events, infectious diseases, water resources, and energy production.

Pearson's Encounter Series provides rich, interactive explorations of geoscience concepts through Google Earth™ activities, covering a range of topics in regional, human, and physical geography. Each exploration consists of a worksheet, online quizzes whose results can be emailed to teachers, and a corresponding Google Earth™ KMZ file.

- Encounter Physical Geography by Jess C. Porter and Stephen O'Connell (0321672526)
- Encounter World Regional Geography by Jess C. Porter (0321681754)
- Encounter Human Geography by Jess C. Porter (0321682203)

FOR TEACHERS

Instructor Resource Manual (Download) (0134326385). The manual includes lecture outlines and key terms, additional source materials, teaching tips, and a complete annotation of chapter review questions. Available from www.pearsonhighered.com/irc and in the Instructor Resources area of *Mastering Geography™*.

TestGen® Test Bank (Download) by Steve Stadler (0134326377). TestGen® is a computerized test generator that lets you view and edit Test Bank questions, transfer questions to tests, and print tests in a variety of customized formats. This Test Bank includes around 3000 multiple-choice, true/false, and short answer/essay questions. All questions are correlated against the National Geography Standards, textbook key learning concepts, and Bloom's Taxonomy. The Test Bank is also available in Microsoft Word® and importable into Blackboard. Available in the Instructor Resources area of *Mastering Geography™*.

Instructor Resource on Mastering Geography (0134326369). The Instructor Resource provides a collection of resources to help teachers make efficient and

effective use of their time. All digital resources can be found in one well-organized, easy-to-access place. The IR includes:

- All textbook images as JPEGs, PDFs, and PowerPoint™ Presentations
- Pre-authored Lecture Outline PowerPoint® Presentations, which outline the concepts of each chapter with embedded art and can be customized to fit teachers' lecture requirements
- CRS "Clicker" Questions in PowerPoint™
- The TestGen software, Test Bank questions, and answers for both Macs and PCs
- Electronic files of the Instructor Resource Manual and Test Bank

This Instructor Resource content is also available online via the Instructor Resources section of *Mastering Geography*™.

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Dedication

**For my students over the last 30 years at
City College of San Francisco**

D.H.

**To my students, past, present, and future:
You inspire me!**

R.L.F.

ABOUT OUR SUSTAINABILITY INITIATIVES

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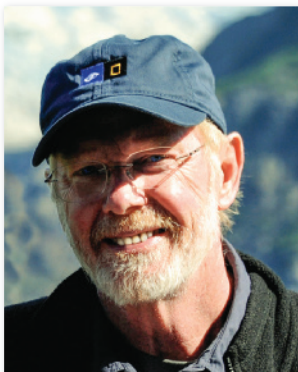
About the Authors



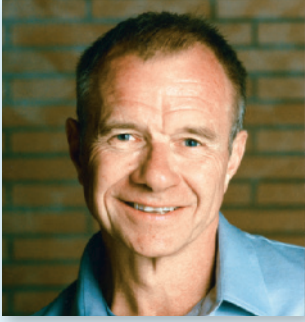
Darrel Hess began teaching geography at City College of San Francisco in 1990 and served as chair of the Earth Sciences Department from 1995 to 2009. After earning his bachelor's degree in geography at the University of California, Berkeley, in 1978, he served for two years as a teacher in the Peace Corps on Jeju Island, Korea. Upon returning to the United States, he worked as a writer, photographer, and audiovisual producer. His association with Tom McKnight began as a graduate student at UCLA, where he served as one of Tom's teaching assistants. Their professional collaboration developed after Darrel graduated from UCLA with a master's degree in geography in 1990. He first wrote the *Study Guide* that accompanied the fourth edition of *Physical Geography: A Landscape Appreciation*, and then the *Laboratory Manual* that accompanied the fifth edition. Along with the 9th edition, he developed the first of four special *California Editions* of the textbook. In 1999 Tom asked Darrel to join him as coauthor of the textbook. Darrel was the 2014 recipient of the American Association of Geographers (AAG) Gilbert Grosvenor Geographic Education Honors. As did Tom, Darrel greatly enjoys the outdoor world. Darrel and his wife, Nora, are avid hikers, campers, and scuba divers.



Redina L. Finch has been teaching introductory and advanced meteorology classes for almost 20 years. She earned a bachelor's degree in physics from the Florida Institute of Technology and a PhD in atmospheric sciences from the University of Illinois, Urbana-Champaign. Redina is involved in science education research and won the Western Illinois University College of Arts and Sciences award for Teaching with Technology in 2014. She is the current editor-in-chief for the National Association of Geoscience Teachers' education magazine, *In the Trenches*. Redina regularly contributes to community service activities, including Science Olympiad, Discovering the World through Science summer camp, Girl Scouts STEM program, and others. She is the Western Illinois University representative to the University Corporation for Atmospheric Research (UCAR), which runs the National Center for Atmospheric Research (NCAR). Redina is also a coauthor of *The Atmosphere: An Introduction to Meteorology*. In her spare time, Redina likes to do almost anything outdoors. People jokingly say that every picture Redina takes has clouds in it. She admits that's probably true! Redina and her husband, Owen, are lucky to have horses in the back yard and the Mississippi River right down the road.



Dennis Tasa attended the Minneapolis College of Art and Design and was then employed at a publishing company, working in book production, design, and illustration. While illustrating a geology textbook for the publisher, a close association with the author spurred an interest in the field of geology. After forming his own business, Tasa Graphic Arts, Inc., his interest in the geosciences continued, illustrating numerous textbooks including physical geography, physical geology, earth science, meteorology, historical geology, and mineralogy. From 1993 to 2018 he expanded his company to include computer software publishing. Working with noted college professors Dennis and his staff created and published award-winning educational programs in the geosciences. Now residing in Taos, New Mexico, in addition to book illustration under DK Tasa, Inc., he and his wife, Karen, enjoy camping, hiking, and painting.



Tom L. McKnight taught geography at UCLA from 1956 to 1993. He received his bachelor's degree in geology from Southern Methodist University in 1949, his master's degree in geography from the University of Colorado in 1951, and his Ph.D. in geography and meteorology from the University of Wisconsin in 1955. During his long academic career, Tom served as chair of the UCLA Department of Geography from 1978 to 1983, and was director of the University of California Education Abroad Program in Australia from 1984 to 1985. Passionate about furthering the discipline of geography, he helped establish the UCLA/Community College Geography Alliance and generously funded awards for both undergraduate and graduate geography students. His many honors include the California Geographical Society's Outstanding Educator Award in 1988, and the honorary rank of Professor Emeritus upon his retirement from UCLA. In addition to *Physical Geography: A Landscape Appreciation*, his other college textbooks include *The Regional Geography of the United States and Canada*; *Oceania: The Geography of Australia, New Zealand, and the Pacific Islands*; and *Introduction to Geography*, with Edward F. Bergman. Tom passed away in 2004—the geographic community misses him enormously.

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Seeing Geographically in Our National Parks

NASA Astronaut Terry Virts took this photograph of Florida from the International Space Station in 2015. Dry Tortugas National Park is the tiny horseshoe-shaped blue patch in the ocean west of the Florida Keys. What might explain the light color of the ocean here? From this distance above the surface, what evidence of human activity can you see?



Introduction to Earth

1

HAVE YOU EVER WONDERED how we know that human activity is changing global climate? Or why Seattle residents need to worry about earthquakes but Miami residents don't? Or why kangaroos are native to Australia but not to China? Or even why the days are longer in summer than in winter? These are the kinds of questions we answer in physical geography.

If you opened this book expecting that the study of geography was going to be memorizing names and places on maps, you'll be surprised to find that geography is much more than that. Geographers study the location and distribution of things—tangible things such as rainfall, mountains, and trees, as well as less tangible things such as language, migration, and voting patterns. In short, geographers look for and explain patterns in the physical and human landscape.

In this book you learn about fundamental processes and patterns in the natural world—the kinds of things you can see whenever you walk outside: clouds in the sky, mountains, streams and valleys, and the plants and animals that inhabit the landscape. You also learn about human interactions with the natural environment—how events such as hurricanes, earthquakes, and floods affect our lives and the world around us, as well as how human activities are increasingly altering our global environment. Many examples come from one of our greatest resources for studying and protecting the natural environment: our National Parks—three are even visible in this image of Florida taken from space: Everglades, Biscayne, and Dry Tortugas.

By the time you finish this book, we hope you'll understand—in other words, appreciate—the landscape in new ways.

As you study this chapter, think about these **KeyQuestions**:

- How do geographers study the world?
- How do we make sense of different environments on Earth?
- How do we describe location on Earth?
- Why do the seasons change?
- How do global time zones work?



Mobile Field Trip videos, created by renowned Earth Science writer, photographer, and pilot, Michael Collier, are virtual field trips that explore physical geography from the air and ground. This first Mobile Field Trip introduces you to the study of physical geography.

Mobile Field Trip
Introduction to Physical
Geography

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The Study of Geography

The word **geography** comes from the Greek words meaning “Earth description.” Several thousand years ago many scholars were indeed “Earth describers,” and therefore geographers, more than anything else. Nonetheless, over the centuries studies veered away from generalized Earth description toward more specialized disciplines—such as geology, meteorology, economics, and biology—so geography as a field of study was somewhat overshadowed. Over the last few hundred years, however, geography reaffirmed its place in the academic world, and today geography is an expanding and flourishing field of study.

Studying the World Geographically

Geographers study how things differ from place to place—the distributional and locational relationships of things around the world (what is sometimes called the “spatial” aspect of things). **Figure 1-1** shows the kinds of “things” geographers study, divided into two groups representing the two principal branches of geography. The elements of **physical geography** are natural in origin, and for this reason physical geography is sometimes called *environmental geography*. The elements of **human geography** are those of human activity; this branch includes such subfields as *cultural geography*, *economic geography*, *political geography*, and *urban geography*. The almost unlimited possible combinations of these various elements create the physical and cultural landscapes of the world that geographers study.

All of the items shown in Figure 1-1 are familiar to us, and this familiarity highlights a basic characteristic of geography as a field of learning: geography doesn’t have its own body of facts or objects that only geographers study. The focus of geology is rocks, the attention of economics is economic systems, demography examines human population, and so on. Geography, on the other hand, is much broader in scope than most other disciplines, “borrowing” its objects of study

from related fields. Geographers, too, are interested in rocks and economic systems and population—especially in describing and understanding their location and distribution. We sometimes say that geography asks the fundamental question, “Why is what where, and so what?”

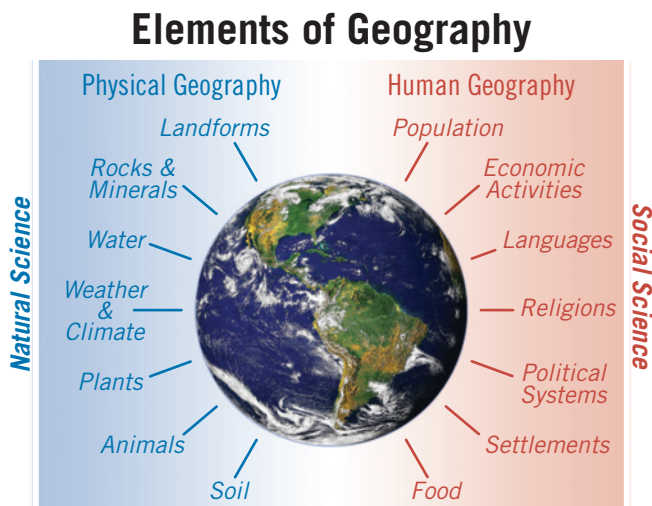
LearningCheck 1-1 What are the differences between physical geography and human geography? (Answer on p. AK-1)

Another basic characteristic of geography is its interest in interrelationships. We cannot understand the distribution of soils, for example, without knowing something about the rocks from which the soils were derived, the slopes on which the soils developed, and the climate and vegetation under which they developed. Similarly, it is impossible to comprehend the distribution of agriculture without an understanding of climate, topography, soil, drainage, population, economic conditions, technology, historical development, and many other factors, both physical and cultural. Because of its wide scope, geography bridges the academic gap between natural science and social science, studying all of the elements in Figure 1-1 in an intricate web of geographic interrelationships.

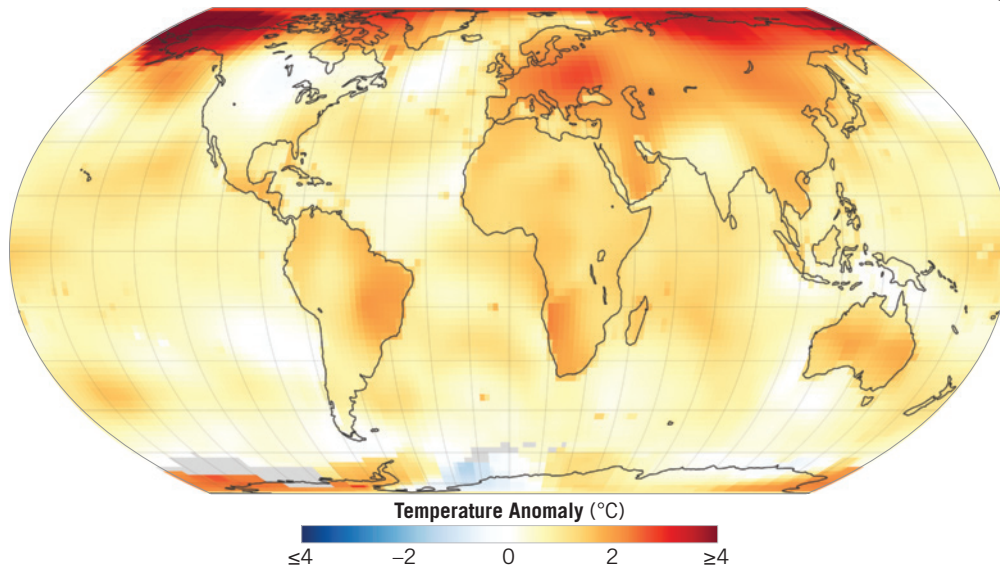
In this book we concentrate on the physical elements of the landscape, the processes involved in their development, their distribution, and their basic interrelationships. As we proceed from chapter to chapter, this notion of landscape development by natural processes and landscape modification by humans serves as a central focus. We pay attention to elements of human geography when they help to explain the development or patterns of the physical elements—especially the ways in which humans influence or alter the physical environment.

Global Environmental Change: Several broad geographic themes run through this book. One of these themes is *global environmental change*—both the human-caused and natural processes that are currently altering the landscapes of the world. Some of these changes can take place over a period of just a few years, whereas others require many decades or even thousands of years (**Figure 1-2**). We pay special attention to the accelerating impact of human activities on the global environment: in the chapters on the atmosphere we discuss such issues as human-caused climate change, ozone depletion, and acid rain, whereas in later chapters we look at issues such as rainforest removal and coastal erosion.

Rather than treat global environmental change as a separate topic, we integrate this theme throughout the book. To help with this integration, we supplement the main text with short boxed essays, such as those titled “People & the Environment” that focus on specific cases of human interaction with the natural environment, as well as boxes titled “Energy for the 21st Century” that focus on the challenge of supplementing—and perhaps eventually replacing—fossil fuels with renewable sources of energy. These essays serve to illustrate the connections between many aspects of the environment—such as the relationships between changing global temperatures, changing sea level, changing quantities of polar ice, and the changing distribution of plant and animal species—with the global economy and human society.



▲ **Figure 1-1** The elements of geography can be grouped into two broad categories. Physical geography primarily involves the study of natural science, whereas human geography primarily entails the study of social science.



◀ **Figure 1-2** Earth’s climate is changing. This image shows the difference in temperature (the temperature anomaly in °C) during the year 2019 compared with the average temperatures for the baseline period 1951 to 1980. (NASA)

Furthermore, in many chapters you’ll see boxed essays titled “Global Environmental Change.” These essays introduce special topics and include activities and questions that will help you understand the scope of both natural and human-caused environmental changes.

Globalization: A related but less obvious theme running through this book is *globalization*. In the broadest terms, globalization refers to the processes and consequences of an increasingly interconnected world—connections among the economies, cultures, and political systems of the world. Although globalization is most commonly associated with the cultural and economic realms, it is important to recognize the environmental components of globalization as well. For example, the loss of tropical rainforest for timber or commercial agriculture in some regions of the world is driven in part by growing demand for commodities in countries far from the tropics (**Figure 1-3**). Similarly, rapid economic growth in newly industrialized countries is contributing to the already high atmospheric greenhouse gas emissions of older industrialized countries. The economies of the world are thus interconnected in their influence on the natural environment.

Because of geography’s global perspective and its interest in both the natural and human landscapes, geographers are able to offer insights into many of the world’s most pressing problems—problems too complex to address from a narrower perspective. For example, the detrimental consequences of climate change cannot be addressed if we ignore the economic, social, historical, and political aspects of the issue. Similarly, global inequities of wealth and political power cannot be addressed if we ignore environmental and resource issues.

Just about everything in the world is in one way or another connected with everything else; geography helps us understand these connections.

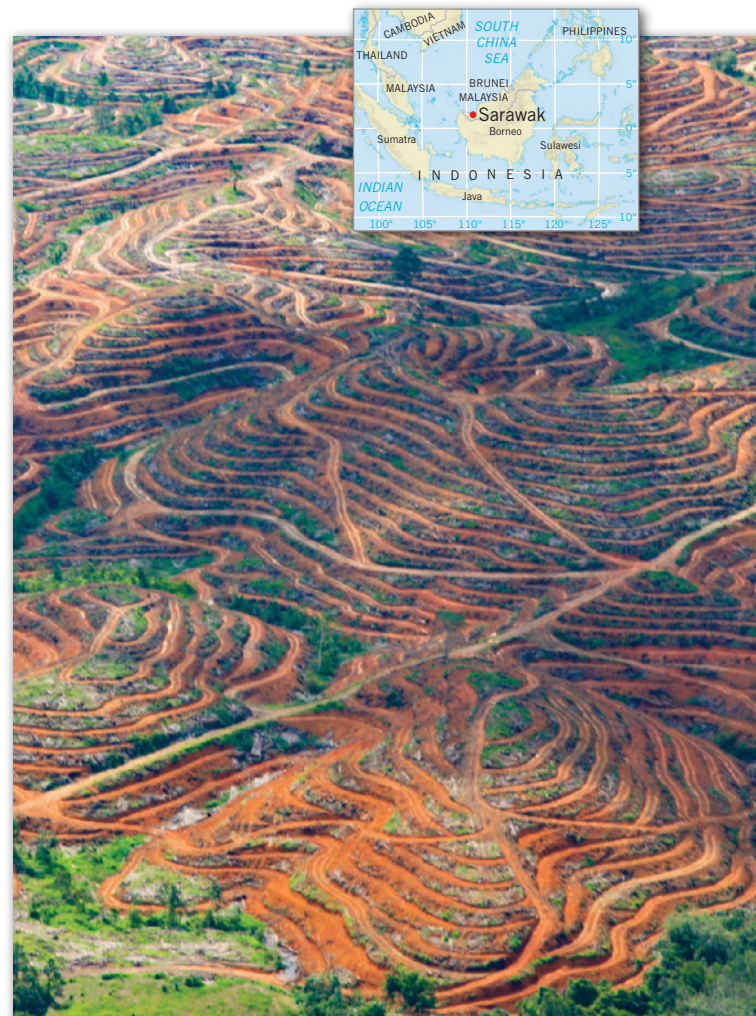
Learning Check 1-2 Why are physical geographers interested in globalization?

Geography in the National Parks

A final theme running through this book is the role of National Parks as places to study, protect, and enjoy all facets of the natural environment. Throughout the book, you’ll

see many topics illustrated with examples from our National Park System. Every chapter begins with an image from a Park and each chapter includes at least one special box featuring a National Park. The first box is an overview of the National Park System itself—see the box *Featured National Parks: National Parks—Our Geographical Laboratories*.

▼ **Figure 1-3** Deforestation in some parts of the tropics is influenced by consumer demand in other parts of the world. This logging operation is in Sarawak, Borneo, Malaysia.



National Parks

Our Geographical
Laboratories

The American writer Wallace Stegner once said that our National Parks are “the best idea we ever had.” Although we can argue that our Bill of Rights, the Emancipation Proclamation, the Nineteenth Amendment, and the Civil Rights Act of 1964 rank higher in terms of American ideals, our National Park System did indeed begin with the distinctly American idea that there are places in our country that belong to all of us, and these places should be protected and preserved for all generations to come.

History of the National Parks: The first step toward our present-day National Park System took place in 1864 when President Lincoln set aside Yosemite Valley and adjacent lands for California to protect (Figure 1-A). In 1872, President Grant signed the act that would lead to the creation of Yellowstone National Park—the first national park in the world (Figure 1-B). The 1906 Antiquities Act allowed a president—with simply a signature—to protect a specific natural, historic, or cultural feature as a National Monument. Over the decades, many National Monuments established in this way, such as Grand Canyon (Figure 1-C) and Death Valley, became full-fledged National Parks. In 1916, the Organic



▲ **Figure 1-A** Yosemite in 1899. African American “Buffalo Soldiers” of the Twenty-Fourth Infantry were the first protectors of Yosemite National Park—before the National Park Service was established, the U.S. Army was responsible for administering National Parks.

Act created the National Park Service (NPS) within the Department of the Interior, with the mission to

... conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

From the National Park Service Organic Act of 1916.

Today the National Park System has more than 400 units. The NPS oversees National Parks, National Monuments, National Seashores, National Recreation Areas, National Memorials, National Historic Parks, National Battlefields, and National Preserves, along with many other components. The differences among these designations relate to how each was established, its purpose, the types of activities permitted, and the kind of protection afforded. These sites range in size from a

single house to areas twice the size of Maryland. In all, about 340,000 square kilometers (130,000 square miles) of land are administered by the National Park Service—an area greater than the entire country of Finland.

Although the mission of the NPS has not wavered over the last century, in some regards what we conserve and how we conserve our natural and historic heritage has evolved. Early on, the Parks were thought of primarily as wild places with little regard for the people originally living there—for example, Native Americans and their settlements were removed from Yosemite Valley by the 1960s. But over time, the NPS has come to acknowledge that even some of the darkest chapters of American history are as important for us to remember and preserve as are wild places; the National Park System now incorporates sites such as the Gettysburg battlefield of the Civil War, the Manzanar internment camp where Japanese Americans were imprisoned during World War II, and Little Rock Central High School where in 1957 nine African American students passed through an angry white crowd to desegregate a public school.

The Parks as Preserves: For physical geographers, the units of our National Park System offer some of the best places in the country to observe processes operating in the natural environment. In many Parks, large tracts of land have been set aside where the landscape is allowed to change with as little influence from people as possible. Parks provide some of the last sanctuaries for animals now gone from the rest of the country; there are expanses of natural grassland not yet tilled under for agriculture; coastlines not yet lined with houses; and



◀ **Figure 1-B** Yellowstone National Park. The Midway Geyser Basin with Excelsior Geyser and Grand Prismatic Spring seen from the air.



▲ **Figure 1-C** Grand Canyon National Park. Visitors at Mather Point along the South Rim.

there are Parks with truly dark skies where city dwellers can glimpse the Milky Way for perhaps the first time in their lives.

The Parks as Laboratories: In addition to being places where we can visit largely unspoiled landscapes, National Parks are also critical laboratories for the study of both natural and anthropogenic (human-caused) environmental change. Within our Parks, we can observe how forest health changes in the decades after a wildfire; how whole ecosystems are altered when a once-extirpated predator is reintroduced; and how a changing climate affects the size of glaciers, the distribution of birds, or the pattern of vegetation.

Because our National Parks include such a variety of environments—from the tropics to the Arctic, and from low deserts to high mountains—the research conducted here will only become more important in the years to come.

Featured National Parks: In this book we illustrate many aspects of physical geography with examples from our National Parks (a term we'll use rather broadly to include any unit in the National Park System). In addition to the many photographs, "Mobile Field Trips" and videos you'll see, we also provide a series of short case studies from the National Parks. These "Featured National Park" boxes

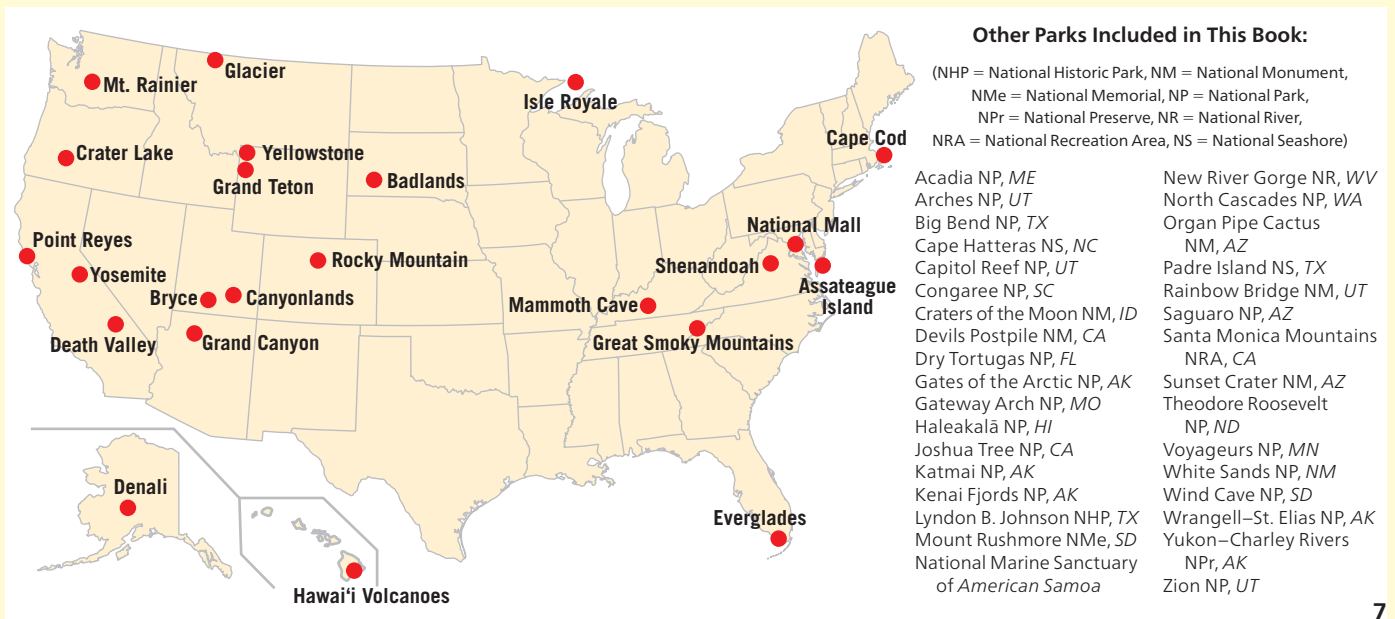
encompass a wide range of topics, environments, and locations within the National Park System (**Figure 1-D**).

The examples in this book only scratch the surface of what you can see and learn about in our National Parks. To find out more about National Parks near you, visit <https://www.nps.gov/findapark>.

Questions

1. Which unit of the National Park System is closest to your home?
2. Why are National Parks important "laboratories" for studying environmental change?

▼ **Figure 1-D** Map showing the location of National Parks featured in this textbook.



Geography and Science

Because physical geography is concerned with processes and patterns in the natural world, knowledge in physical geography advance primarily through the study of science. It is useful for us to say a few words about science in general.

The Process of Science

Science is often described—although somewhat simplistically—as a process that follows the *scientific method*:

1. Observe phenomena that stimulate a question or problem.
2. Offer an educated guess—a *hypothesis*—about the answer.
3. Design an experiment to test the hypothesis.
4. Predict the outcome of the experiment if the hypothesis is supported or if the hypothesis is not supported.
5. Conduct the experiment and observe what actually happens.
6. Draw a conclusion or formulate a simple generalized “rule” based on the results of the experiment.

In practice, however, science doesn’t always work through experimentation; in many fields of science, data collection through observation of phenomena is the basis of knowledge. In some regards science is best thought of as a process—or perhaps even as an attitude—for gaining knowledge. The scientific approach is based on observation, experimentation, logical reasoning, skepticism of unsupported conclusions, and the willingness to modify or even reject long-held ideas when new evidence contradicts them. For example, up until the 1950s most Earth scientists thought it impossible that the positions of continents could change over time. However, as we see in Chapter 14, by the late 1960s enough new evidence had been gathered to convince them that their earlier ideas were wrong—the configuration of continents has changed and continues to change.

Although the term “scientific proof” is sometimes used by the general public, strictly speaking, science does not “prove” ideas. Instead, science works by eliminating alternative explanations—eliminating explanations that aren’t supported by evidence. In fact, in order for a hypothesis to be “scientific,” there must be some test or possible observation that could *disprove* it. If there is no way to disprove an idea, then that idea simply cannot be supported by science.

The word “theory” is often used in everyday conversation to mean a “hunch” or conjecture. However, in science a theory represents the highest order of understanding for a body of information—a logical, well-tested explanation that encompasses a wide variety of facts and observations. Thus, the “theory of plate tectonics” presented in Chapter 14 represents an empirically supported, broadly accepted, overarching framework for understanding processes that operate within Earth.

The acceptance of scientific ideas and theories is based on a preponderance of evidence, not on “belief” and not on the pronouncements of “authorities.” New observations and new evidence often cause scientists to revise their conclusions and theories or those of others. Much of this self-correcting process for refining scientific knowledge takes place through peer-reviewed journal articles. Peers—that is, fellow scientists—scrutinize a scientific report for sound reasoning, appropriate data collection, and solid evidence before it is published; reviewers need not agree with the author’s conclusions, but they strive to ensure that the research meets rigorous standards of scholarship before publication.

Because new evidence may prompt scientists to change their ideas, good science tends to be somewhat cautious in its stated conclusions. For this reason, the findings of many scientific studies are prefaced by phrases such as “the evidence suggests” or “the results most likely show.” In some cases, different scientists interpret the same data quite differently and so disagree in their conclusions. Frequently, studies find that “more research is needed.” The kind of uncertainty sometimes inherent in science may lead the general public to question the conclusions of scientific studies—especially when presented with a simple, and perhaps comforting, nonscientific alternative. However, this very uncertainty often compels scientists to push forward in the quest for knowledge and understanding.

In this book we present the fundamentals of physical geography as supported by scientific research and evidence. In some cases, we describe how our current understanding of a phenomenon developed over time; in other cases we point out where uncertainty remains, where scientists still disagree, or where intriguing questions still remain.

LearningCheck 1-3 Why is the term “theory” sometimes misunderstood by the general public?

Numbers and Measurement Systems

Because so much of science is based on observation and measurable data, any thorough study of physical geography entails the use of mathematics. Although this book introduces physical geography primarily in a conceptual way without the extensive use of mathematical formulas, numbers and measurement systems are nonetheless important for us. Throughout the book, we use numbers and simple formulas to help illustrate concepts—the most obvious of which are numbers used to describe distance, size, weight, or temperature.

Two quite different measurement systems are used today. In the United States, much of the general public is most familiar with the *English System* of measurement—with measurements such as miles, pounds, and degrees Fahrenheit. However, most of the rest of the world—and the entire scientific community—uses the **International System** of measurement (abbreviated **S.I.** from the French *Système International*; also called the “metric system”)—with measurements such as kilometers, kilograms, and degrees Celsius.

TABLE 1-1 Unit Conversions—Quick Approximations

	S.I. to English Units	English to S.I. Units
Distance:	1 centimeter = a little less than ½ inch	1 inch = about 2½ centimeters
	1 meter = a little more than 3 feet	1 foot = about ⅓ meters
	1 kilometer = about ⅔ mile	1 yard = about 1 meter
Volume:	1 liter = about 1 quart	1 quart = about 1 liter
		1 gallon = about 4 liters
Mass:	1 gram = about ⅓₀ ounce	1 ounce = about 30 grams
	1 kilogram = about 2 pounds	1 pound = about ½ kilogram
Temperature:	1°C change = 1.8°F change	1°F change = about 0.6°C change

For exact conversion formulas, see Appendix I.

This book gives measurements in both S.I. and English units. **Table 1-1** provides some quick approximations of the basic equivalents in each; detailed tables of conversion formulas between English and S.I. units appear in Appendix I.

Environmental Spheres and Earth Systems

From the standpoint of physical geography, the surface of Earth is a complex interface where four principal components of the environment meet and to some degree overlap and interact (**Figure 1-4**). These four components are often referred to as Earth's *environmental spheres*.

Earth's Environmental Spheres

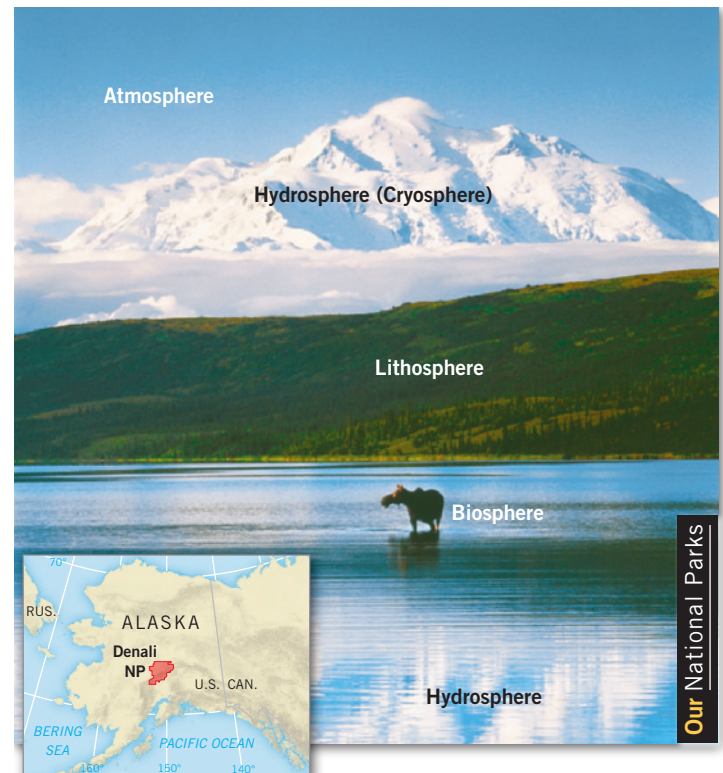
The solid, inorganic portion of Earth is sometimes called the **lithosphere**¹ (*litho* is Greek for “stone”), comprising the rocks of Earth's crust as well as the unconsolidated particles of mineral matter that overlie the solid bedrock. The lithosphere's surface is shaped into an almost infinite variety of landforms, both on the seafloors and on the surfaces of the continents and islands.

The gaseous envelope of air that surrounds Earth is the **atmosphere** (*atmos* is Greek for “air”). It contains the complex mixture of gases needed to sustain life. Most of the atmosphere is close to Earth's surface, being densest at sea level and rapidly thinning with increased altitude. It is a very dynamic sphere, kept in almost constant motion by solar energy and Earth's rotation.

The **hydrosphere** (*hydro* is Greek for “water”) comprises water in all its forms. The oceans contain the vast majority of the water found on Earth and are the moisture source for most precipitation. A subcomponent of the hydrosphere is

known as the **cryosphere** (*cryo* comes from the Greek word for “cold”)—water frozen as snow and ice.

The **biosphere** (*bios* is Greek for “life”) encompasses all the parts of Earth where living organisms can exist; in its broadest and loosest sense, the term also includes the vast variety of earthly life-forms (properly referred to as *biota*).



▲ Figure 1-4 Earth's physical landscape is composed of four overlapping, interacting systems called “spheres.” The atmosphere is the air we breathe. The hydrosphere is the water of rivers, lakes, and oceans, the moisture in soil and air, as well as the snow and ice of the cryosphere. The biosphere is the habitat of all life, as well as the life-forms themselves. The lithosphere is the soil and bedrock that cover Earth's surface. This scene shows Wonder Lake and Denali (formerly Mt. McKinley) in Denali National Park, Alaska.

¹As we will see in Chapter 13, in the context of plate tectonics and our study of landforms, the term “lithosphere” is used specifically to refer to large “plates” consisting of Earth's crustal and upper mantle rock.