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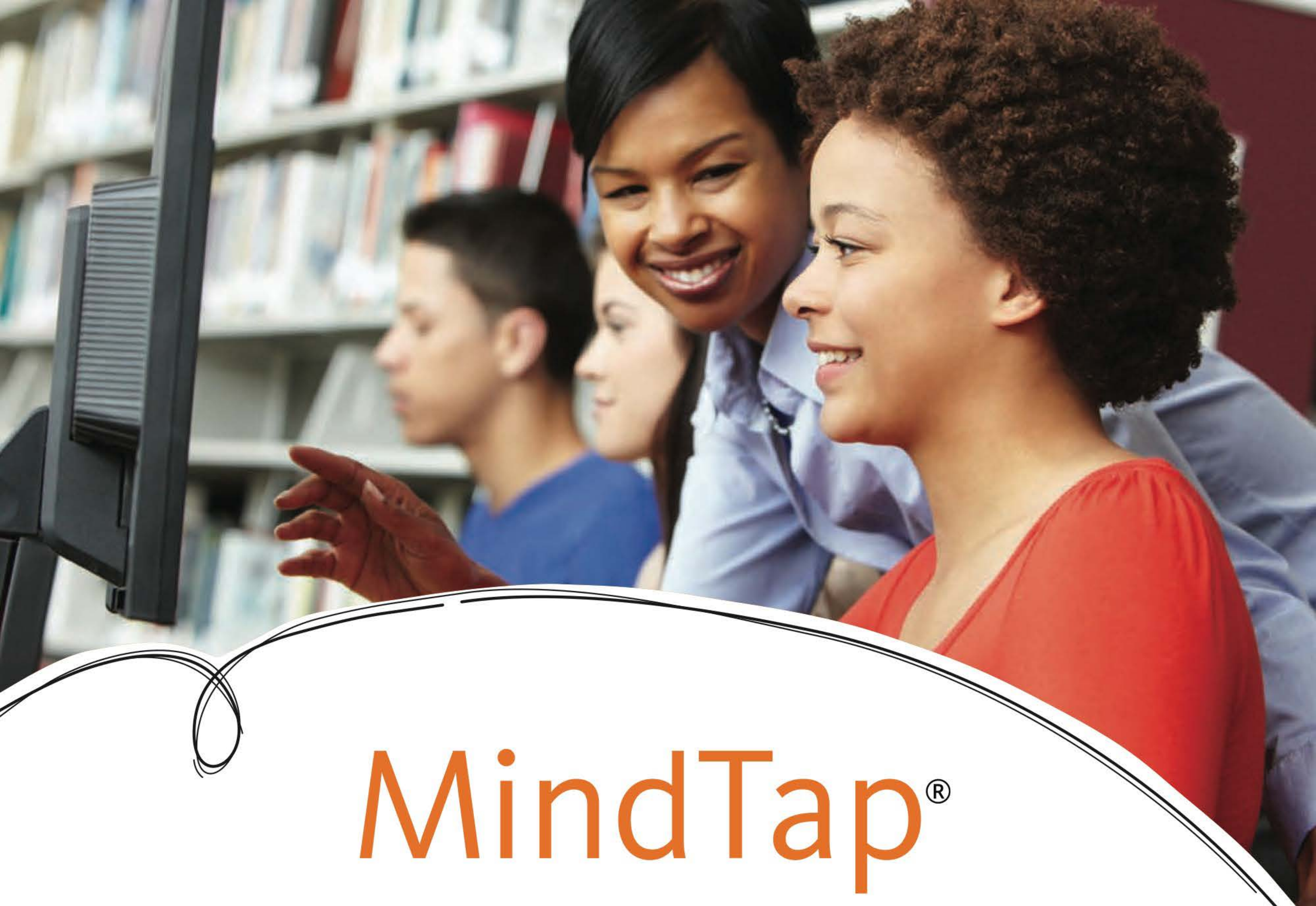
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OUR ENVIRONMENT

A Canadian Perspective

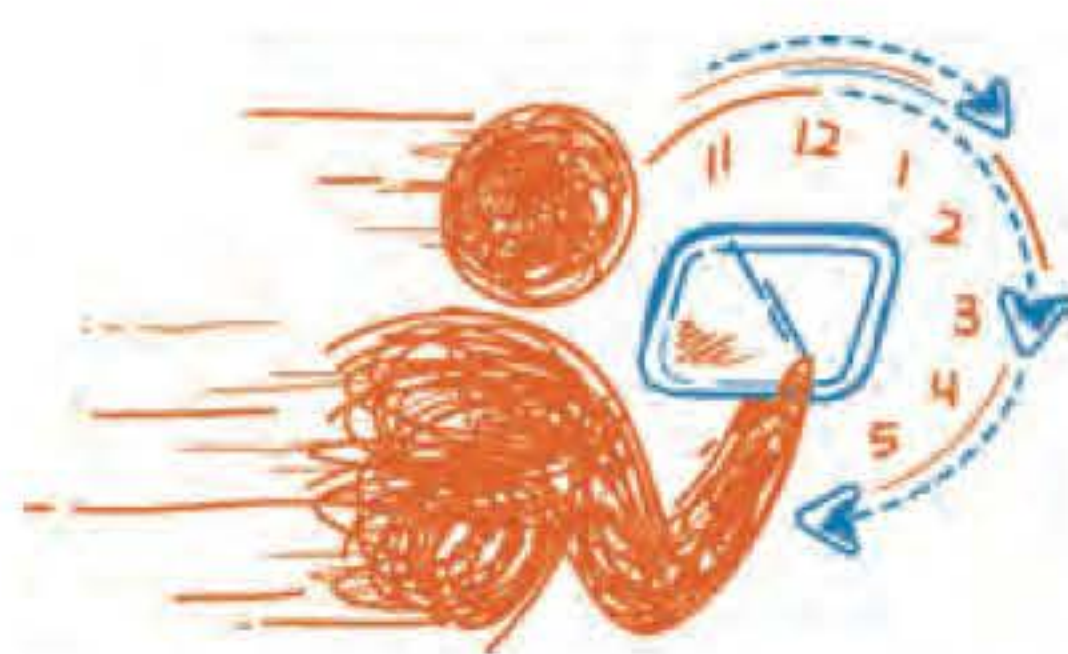
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OUR ENVIRONMENT

A Canadian Perspective

FIFTH EDITION

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by Dianne Draper and Ann P. Zimmerman

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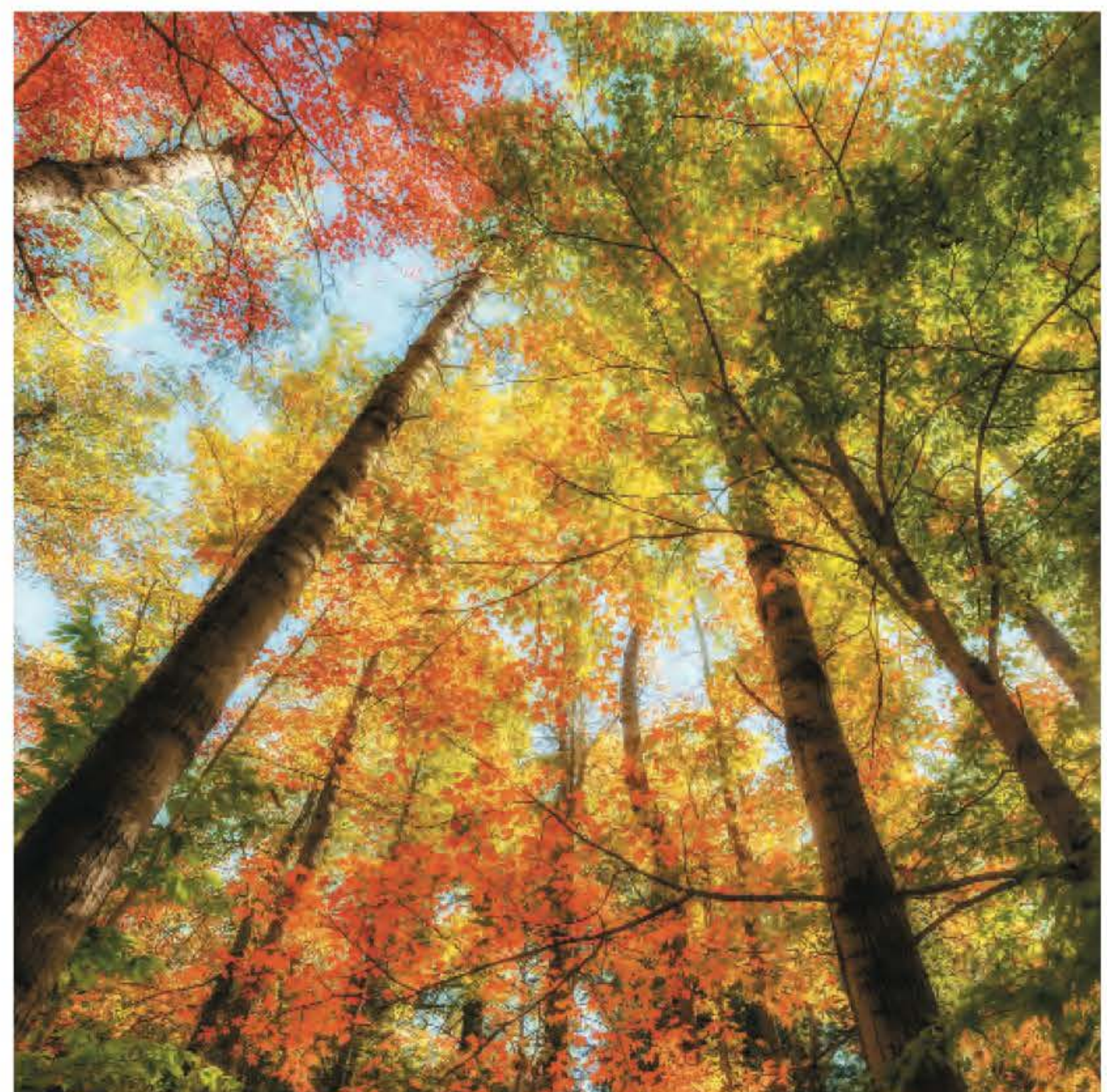
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Dianne Draper is a full professor in the department of geography at the University of Calgary, Alberta. She is the founding author of *Our Environment: A Canadian Perspective*. She is recognized for her research in sustainable tourism, ecotourism, and tourism growth management, as well as planning and policy in water resources and coastal zone management. Her current research focuses on governance and quality of life issues in tourism and other communities as they work toward sustainability, and on managing growth and its impacts on communities, including wildlife, water resources, and parks and protected areas.

Ann Zimmerman

University of Toronto

I started my academic career at the University of Toronto in 1976 in what was then the Department of Zoology. My first assignment was to teach ZOO471: Limnology or the physics, chemistry, and biology of freshwater ecosystems. The department was an epicentre of freshwater research and I was soon invited to join the Lake Ecosystems Working Group, which over

the next decade focused on both basic and applied research in Ontario lakes. The issue of acid rain quickly brought home to me the interdisciplinary nature of this environmental issue. My broadening interest in environment—writ larger than I had previously recognized—brought me into contact with colleagues in departments as diverse as philosophy, economics, and sociology, in addition to the science departments in our faculty, and with individuals in the faculties of medicine, applied sciences, forestry, and architecture.

The university was recognizing the desirability of finding ways to work collaboratively across the disciplines interested in environment and I had the opportunity to work with numerous colleagues as the founding director of the Division of the Environment, a unit that has subsequently morphed into the university's School of Environment. One of the courses I had already developed—ENV200 or Global Change: Science and Environment—became the introductory course for the division's B.A. program. I was also able to contribute to ENV234: Environmental Science, the foundation course for our B.Sc. program.

These experiences culminated in my last administrative position at the university: founding director of our newly acquired research centre: the Koffler Scientific Reserve at Jokers Hill. I retired after my term there but remain engaged with the academic community as Professor Emerita, a position that has afforded me the luxury of time to contribute to this edition of *Our Environment*.

PREFACE

The fifth edition of this book represents something of a departure from previous editions. I began using *Our Environment* in my Global Change course in 1998, the first year it was published. I had been relying on U.S. environmental texts up until then, and while the science may be the same, the issues and our approaches to them differ from those of our southern neighbours. I have used all four editions since, and when I was presented with the opportunity to collaborate with Dianne on this fifth edition, I could not pass up the opportunity to tweak the text to better serve my students—students interested in the environment, but not intending to pursue environmental science.

Environmental problems are often first identified by scientists who provide the data that can guide environmental policy/management, so this fifth edition expands its coverage of the scientific evidence underpinning environmental issues. Nevertheless, a long time may elapse between the first observations of an issue and the emergence of an effective political response. Consequently, the text continues to provide examples of successes and still covers barriers to effective policy implementation.

Sometimes issues are resolved relatively quickly—removal of phosphorus from various detergents or replacements for chlorofluorocarbons, for example. Other issues such as acid rain can take a decade or more to address. Highly complex issues—loss of global biodiversity or global environmental change—remain unresolved. Important in moving these issues forward has been and will continue to be both environmental professionals and an informed public.

This book is intended as an introduction. Whether students are taking only one general course on environmental issues or intend to specialize in this area, my hope is that you will find this text helpful.

In addition to a richer explanation of the science that underpins many environmental issues, this edition adds a chapter on Canada as well as chapters on managing resources, waste management, health and risk, and re-arranges others. Instructors will note that there are now 18 shorter chapters organized into four sections. Part I includes five chapters: Environmental Change, Human Relationships with Nature, Science and Environment, Our Planet, and the new chapter on Canada. This new chapter includes information on our geography, geology, and climate; our governance structure and its implications for environmental responsibilities; and examples of special places in our country. Part II contains six chapters on resources, including biodiversity. Part III deals with legacy and common pool resources: atmosphere, climate, energy, and mining. Part IV looks to the future: managing wastes, hazards and health, and urbanization,

culminating in the way forward. Detailed information on all the chapters is included in the following section on Organization.

There are some new features in each chapter as well. *Offsets*, quotations or explanations relevant to the chapter material, are clearly demarked with a coloured stripe and a distinct typeface. The *Chapter Debate* asks students to think about a controversial issue attendant to the chapter's topic. *Why It Matters* encapsulates important questions characterizing a particular topic and why we need to understand it. More information is available in the section entitled 'New in the Fifth Edition'.

Features

Our Environment, fifth edition, contains several special features to help students. Each chapter begins with a list of *Chapter Learning Outcomes* so that students are aware of the concepts they will come to understand as they read and study the chapter. *Why It Matters* raises important questions about chapter topics and why we need to understand them. *Offsets* appear throughout the chapters to provide additional explanations or quotations relevant to the material. *Key terms* appear in bold throughout the text; definitions for these terms are found in the *Glossary*. *Our Environment* and the *EnviroFocus* boxes identify a range of personal interest/impact issues, from a list of Canada's special places to proposals to re-wild North American ecosystems, the challenges in managing the discharge of municipal sewage, our ocean environment, and the competition between wild species and humans for habitat.

Each chapter ends with a *Making a Difference* case study that provides not only real illustrations of environmental problems but also demonstrates how people have applied the principles and concepts discussed in the text to the resolution of environmental issues at various geographic scales. These cases are intended to help students understand how economic, social, political, and environmental elements interconnect, and how they relate to our scientific and traditional ways of understanding our environment. Finally, they graphically illustrate that individual actions matter. *Chapter Debates* at the end of Chapters 2 through 18 ask students to think critically about issues related to the chapter, and the *Chapter Questions* at the end of each chapter will engage students while developing observational and critical thinking skills. A list of References containing research sources also appears at the end of each chapter.

Organization

Part I: Our Environment

Here we introduce the key concepts and processes fundamental to understanding our environment.

Chapter 1: Environmental Change discusses the accelerating rate of environmental change and the important concept of sustainability. It introduces students to the concept of the Anthropocene, Paul Crutzen's popularization of an approach that discriminates between the early Holocene's human impacts—small scale and local—and the more recent massive impacts of industrialized society. It discusses the differences in Earth's recovery from natural as opposed to anthropogenic impacts. It then turns to a discussion of the nuances of "sustainable development." It starts with a history of awakening environmental concerns, highlighting Canadian perspectives—particularly our critical roles at the 1992 Earth Summit and the opening of divergent perspectives among Canadians by the time we reach Rio +20. *Making a Difference 1* is a tribute to the late Bob Hunter, a founding member and first president of Greenpeace. *EnviroFocus 1* proposes the need for a transformation of society, echoing ecotheologian Wendell Barry's observation that you can't have healthy humans on a sick planet.

Chapter 2, Human Relationships with Nature, suggests ways humans are both a part of and apart from nature. It introduces the concept of critical thinking, expands on world views, and discusses environmental decision making with its attendant risks of unintended consequences. This chapter now also includes an updated human demography section. *EnviroFocus 2* addresses the Earth Charter, while *Making a Difference 2* features the work of citizens' panels. The *Chapter Debate* asks how environmental policy and management are affected by world views.

Chapter 3, Science and Environment, discusses various "ways of knowing." It explains the positivist epistemology of science and the misunderstandings that can occur when the differences among the operational protocols of various disciplines are not recognized. It briefly introduces Thomas Kuhn and the concept of the scientific paradigm along with Karl Popper and the falsifiable hypothesis. Other topics include scientific measurement, statistical significance, significant figures, and inductive and deductive reasoning. There are sections on meta-analysis, weight of evidence, and the precautionary principle. The chapter introduces complexity and general systems theory, non-linearity, and chaos. It includes a section on how research becomes knowledge: choosing a journal, peer review, open access journals, and journal and author impacts. It closes with a section on misunderstandings about science—particularly the issue of false equivalency in the media. *Making a Difference 3* features the partnership between David Suzuki and the NHL's Andrew Ference on energy conservation. *EnviroFocus 3* discusses the value of long-term research. The *Chapter Debate* asks about the balance between individual and group rights with respect to voluntary versus mandatory vaccination.

Chapter 4, Our Planet, discusses matter and energy and Earth's formation. It then discusses Earth's major compartments: the atmosphere, lithosphere, hydrosphere, and biosphere. The chapter includes energy flow, nutrient cycles, and stress responses and introduces concepts of evolution, adaptation, natural selection, speciation, and extinction. It closes with a section on working with nature. *Making a Difference 4* features Buzz Holling and his work on adaptive management and ecosystem resilience. *EnviroFocus 4* discusses the role of patch dynamics in ecological restoration. The *Chapter Debate* asks whether the expense and risks from sudden sea level rise warrant a more aggressive response than seen previously.

Chapter 5, Canada, is a new chapter. It opens with a discussion of Canada's climate, geology, and geography, and how our current boundaries came to be established. This is followed by a section highlighting special ecosystems from each province and territory (*EnviroFocus 5*). It ends with a discussion of Canadian governance structures, constitutional federalism, Indigenous rights, environmental protection, and fiscal federalism, and their impact on the environmental responsibilities of different levels of government. *Making a Difference 5* features the work of the Group of Seven and its influence on development of a new paradigm for Canadian art. The *Chapter Debate* asks how we should proceed with exploitation of shale gas.

Part II: Ecological Resources

Here we introduce populations, habitats, their relationships to each other, and the environment.

Chapter 6, Managing Ecological Resources, is a new chapter that focuses on the assessment and sustainable management of resources. It covers the history of resource management and environmental assessment, including the implications of the status of the previous government's changes to the Canadian Environmental Assessment Act. (It is important to note that the 2015 federal election came toward the end of the writing of this fifth edition. Some things have already changed under the new government and more changes will occur. Check out the Twitter feed [https://twitter.com/DrZ_environment or @DrZ_environment] for updates.) The chapter introduces the concept of environmental risk assessment, ecosystem-based management, and the increasing use of co-management and reliance on traditional ecological knowledge (TEK). Concepts such as life-cycle assessment, economic valuation of nature, and environmental performance indicators are also discussed. *Making a Difference 6* features Professor Emeritus Henry Regier, a central figure in the development of ecosystem management. *EnviroFocus 6* outlines the adoption of ecosystem management for the Great Bear Rain Forest. The *Chapter Debate* asks whether we should place economic valuation on ecosystem services.

Chapter 7, Biodiversity, covers both international and Canadian biodiversity issues, discusses how biodiversity is assessed and measured, and why it is important. It covers how humans impact

biodiversity and approaches to protecting it, both internationally and specifically in the Canadian context. *EnviroFocus 7* covers Pleistocene re-wilding or the value in replacing the ecological roles of long extinct species. *Making a Difference 7* features the Canadian Centre for DNA Barcoding. The *Chapter Debate* asks about the ethics of removing feral species from ecosystems.

Chapter 8, Agroecosystems, discusses Canada's agricultural land base and agricultural food and non-food production (e.g., biofuels). It covers the environmental impacts of conventional agriculture, international and Canadian policy responses to those environmental impacts, and what is needed to move agriculture to a more sustainable basis. *Making a Difference 8* features the Canadian Young Farmers Forum (CYFF). *EnviroFocus 8* talks about genetically modified organisms (GMOs). The *Chapter Debate* discusses the environmental dilemma of locally versus globally sourced foods.

Chapter 9, Fresh Water, discusses the ecological behaviour and natural capital value of freshwater ecosystems: lakes, rivers, wetlands, and groundwater, as well as freshwater fisheries. It then moves to a discussion of fresh water as a resource: water supply, usage, quality, quantity, and management. The chapter closes with a discussion of other important water issues: water as a source of conflict, water as a hazard, and water for recreation. *EnviroFocus 9* features the rehabilitation of the Sydney, Nova Scotia, tar ponds. *Making a Difference 9* features Dr. David Manz, inventor of the BioSand Water Filter (BSF). The *Chapter Debate* discusses how scarce freshwater resources might be allocated.

Chapter 10, Oceans and Fisheries, covers Canada's three marine environments—Arctic, Atlantic, and Pacific oceans—as well as issues particular to each system and Canada's rights and responsibilities under the United Nations Convention on the Law of the Sea. It then turns to marine fisheries, in both international and Canadian contexts, and further highlights significant environmental issues impacting ocean environments. *Our Environment 10-11* highlights Ron Sparrow and his ultimately successful fight in the Supreme Court for recognition of Aboriginal rights. The Sparrow decision means Aboriginal rights with respect to natural resources supersede those of the provinces, territories, and the federal government. *EnviroFocus 10* discusses the Franklin Expedition and its implications for the sovereignty of the Northwest Passage. *Making a Difference 10* features Professor Daniel Pauly and his Sea Around Us Project, which offers solutions to stakeholders on addressing the impact of fisheries on the marine ecosystem. The *Chapter Debate* asks whether we should eat farmed salmon. The issue of the recent approval of GMO salmon—the first genetically modified animal—can be accessed at the Twitter feed: https://twitter.com/DrZ_environment or @DrZ_environment.

Chapter 11, Forests and Forestry, discusses the status of global as well as Canadian forests and the importance of the natural capital value of forests over and above timber harvest. It then turns to forest harvest practices and the development of sustainable approaches to that harvest. *EnviroFocus 11* presents

hemp as a sustainable alternative to wood. *Making a Difference 11* highlights Merv Wilkinson and his stewardship of Wildwood Forest, an internationally recognized model of sustainable forestry. The *Chapter Debate* features perspectives on managing the boreal forest.

Part III: Commonly Held and Legacy Resources: The Overview

Here we introduce issues around our atmosphere and climate, energy, and mining. While different from the ecological systems of Part II, each is nevertheless associated with significant environmental issues, many of which are linked.

Chapter 12, Atmosphere and Climate, explains the organization and behaviour of the atmosphere, human impacts on it (climate change, loss of stratospheric ozone, gains in tropospheric ozone, and acid precipitation), and Canadian as well as international responses to protect it. *EnviroFocus 12* deals with the implications of climate change for Canada's Arctic. *Making a Difference 12* features Kali Taylor and the organization StudentEnergy. The *Chapter Debate* asks whether geoengineering the climate is a good policy choice, given the apparent intractability of mitigation strategies.

Chapter 13, Energy, was written by Dr. Lucy Sportza, Universities of Guelph and Toronto. It covers fossil fuels and their environmental impacts, nuclear energy and its issues, and hydro power. It then turns to new, renewable technologies and incentives for their adoption. *Our Environment 13-2* is a snapshot of energy in Canada and around the world. *Making a Difference 13* features Thomas Berger and the MacKenzie River Pipeline Inquiry. The *Chapter Debate* asks whether we should be drilling for oil and gas in the Arctic.

Chapter 14, Minerals and Mining, was also written by Dr. Sportza. The chapter covers the nature and distribution of Canada's non-fuel mineral resources, the impacts of their extraction on the environment, current international and Canadian responses to these impacts, and the challenges of developing a sustainable approach to mining. *EnviroFocus 14* discusses underground gardening in exhausted mineshafts. *Making a Difference 14* features MiningWatch Canada, an ENGO dedicated to ensuring mining practices support both sustainable communities and the health of ecosystems. The *Chapter Debate* asks whether mining is a net benefit or loss for the Northwest Territories.

Part IV: Getting to Tomorrow: The Overview

In this last part of the book, we look toward the future.

Chapter 15, Waste, is a new chapter that discusses Canadian waste streams and their management. Given that everything in nature is a resource for something else, the chapter asks how humans could move to a zero waste society. *EnviroFocus 15* describes how Nova Scotia attained a waste diversion rate more than twice the national average. *Making a Difference 15* highlights Nova Scotia and its energy reduction program, which

is almost twice that of other provinces. The *Chapter Debate* asks whether landfills or energy to waste incinerators are a better choice for dealing with waste.

Chapter 16, Environmental Hazards and Human Health, is also a new chapter. It introduces the social determinants of health, causes of illness, acute and chronic disease, morbidity, and mortality. It also addresses the health risks from exposure to toxic chemicals and introduces the concepts of risk: assessment, management, and perception. *EnviroFocus 16* highlights the emerging issue of Lyme disease. *Making a Difference 16* profiles Pierre Gosselin, lead author on the first Canadian study of the health impacts of climate change. The *Chapter Debate* asks whether actuarial risk assessment or risk perception lie at the heart of the failure to adopt the GMO golden rice.

Chapter 17, Cities, discusses our urbanizing world, its environmental conditions and trends, and the implications for cities as models of sustainability. *EnviroFocus 17* features urban agriculture. *Making a Difference 17* profiles Peter Halsall, CEO of the Canadian Urban Institute, and a leader in the development of more sustainable urban environments. The *Chapter Debate* asks whether the “smart” city is an over-hyped concept driven by our appetite for big data and technology vendors with deliberate or unacknowledged/unknown biases, or a better approach to engaging citizens and managing issues like resource consumption, health care, water, waste management, and transportation.

Chapter 18, The Way Forward, asks what kind of a world we want to leave to future generations and how we get there. *EnviroFocus 18* discusses the Talloires Declaration and its implication for the role of universities in environmental education, research, policy formation, and information exchange necessary to reach that future world. *Making a Difference 18* highlights the Co-operators Youth Program for Sustainable Leadership and its goal of empowering university and college students across Canada to be effective agents for change. The *Chapter Debate* focuses on approaches to sustainable management of common pool resources.

New in the Fifth Edition

The fifth edition of *Our Environment* contains significant changes and updates throughout. This edition contains enhanced coverage of the science that underpins many environmental issues. Often the historical backdrop to issues is included to help students appreciate the political machinations that complicate or even obstruct resolution of environmental issues. The text now has 18 shorter chapters, grouped into four parts, including four new chapters: Canada (Chapter 5), Managing Ecological Resources (Chapter 6), Waste (Chapter 15), and Environmental Hazards and Human Health (Chapter 16).

In addition to updating every chapter with current topics and information, several new features have been added to help students actively engage in their studies. The *Why It Matters* section at the beginning of every chapter summarizes important

questions about the chapter topics and why we need to understand them. *Offsets* offer explanations or quotations relevant to the material under discussion, and the *Chapter Debates* at the end of the chapters ask students to think about a controversial issue related to chapter topics. Finally, the fifth edition contains all new critical thinking *Chapter Questions* at the end of each chapter. The Twitter feed hopes to keep students up to date.

The following list of specific chapter changes highlights some of the new key and updated topics and examples that have been included in the fifth edition.

Part I: Our Environment

Chapter 1 Environmental Change

- New coverage of the Anthropocene, the rate of environmental change, sustainable development, Rio, and pathways to a sustainable future.
- Added boxed features include the International Union for the Conservation of Nature (IUCN), Rio+10 the Kingston Declaration, and a profile of Bob Hunter.

Chapter 2 Human Relationships with Nature

- New boxed features cover topics including land banking, Europe’s old-age dependency and immigration, the Earth Charter, and citizens’ panels.

Chapter 3 Science and Environment

- New coverage of alternatives to reductionist science, Earth system science (complex systems, feedback, non-linearity, emergence, chaos), and research and knowledge (peer review, choosing a journal, journal and author impact, and open-access journals).
- Added boxed features include Aldo Leopold’s “Land Ethic”; Thomas Kuhn and Karl Popper on the falsifiable hypothesis and scientific prediction; Canadian Roger Tomlinson, inventor of GIS; the acquisition of scientific knowledge; and systems thinking.

Chapter 4 Our Planet

- New coverage of the formation of Earth (age calculation, structure, and processes).
- Addition of numerous figures to illustrate the rock cycle, mid-Atlantic Ridge, tectonic changes, compartments of the hydrologic cycle, radiation budget, trophic pyramid, and cladogram.
- New boxed features include entropy and time, a discussion of Earth’s timeline, the Keystone Species concept, and the biosphere.

Chapter 5 Canada

- New dedicated chapter covering Canada’s climate physiography and special ecosystems in each province and territory. It also discusses Canada’s Indigenous peoples, governance, and resource revenues, as well as the role of the Supreme Court in environmental issues.

- Hot topics such as the issue of exploitation of shale gas are discussed in the *Chapter Debate*.
- New boxed features cover the Canadian court system, justiciable issues and environmental law, and offshore resource issues in Newfoundland and Labrador as precursors to the Atlantic Accord.

Part II: Ecological Resources

Chapter 6 Managing Ecological Resources

- This new chapter focuses on the assessment and sustainable management of resources. It covers important and timely topics including environmental assessments, environmental risk assessment, ecosystem management, co-management, stewardship, assessing ecological resources, traditional ecological knowledge (TEK), and life-cycle analysis.

Chapter 7 Biodiversity

- This chapter is now earlier in the book and includes new sections covering species at risk (*in situ* and *ex situ* conservation), international strategies to protect biodiversity, and Canadian law, policy, and practice. It discusses how humans impact biodiversity and Canadian and international approaches to protecting it.

Chapter 8 Agroecosystems

- New *Our Environment* boxes highlight important topics and issues such the life-cycle analysis of corn ethanol, wind erosion, dust bowls and Badlands, integrated pest management (IPM), lab-cultured meat, prairie and heritage conservation areas, the World Trade Organization, and agricultural reform.

Chapter 9 Fresh Water

- Expanded and updated coverage of ecological behaviour and natural capital value of fresh water ecosystems and important water issues related to water as a source of conflict, water as a hazard, and water for recreation.
- New maps of Canada's heritage rivers, Canada's five major drainage systems, and the watershed of the Great Lakes and the areas of concern.
- Updated figures of global sectoral trends in water use and annual water use by country.

Chapter 10 Oceans and Fisheries

- Expanded and updated coverage throughout the chapter of Canada's three marine environments and the environmental issues impacting ocean environments.
- New coverage of ocean geography, sewage treatment, by-catch, the Pacific halibut fishery and ITQs, and the Marine Stewardship Council can be found in the *Our Environment* boxed features.
- New figures illustrate the principle of maximum sustainable yield, arrival of factory ships off the Grand Banks and increased cod harvest, voluntary NAFO quotas for cod, and the commercial extinction of the cod fishery.

Chapter 11 Forests and Forestry

- New boxed features highlight important topics, including temperate rainforests and the Acadian forest and private woodlots in the Atlantic provinces.
- New section covering Forest 2020 and tree plantations discusses the issue of meeting the world's need for wood and simultaneously managing forests for ecological sustainability.
- Several new or updated tables, including estimated deforestation in Canada by sector, harvested and regenerated (2009–2011); Canada's participation in international and national forestry initiatives; and Canada's EPI performance.
- New maps and photos of tropical and temperate rainforests, temperate deciduous forest and taiga forest, the provincial and territorial forested areas, and the Carolinian Forest.

Part III: Commonly Held and Legacy Resources: The Overview

Chapter 12 Atmosphere and Climate

- More comprehensive coverage of the atmosphere, human impacts on it (climate change, loss of stratospheric ozone, gains in troposphere ozone, and acid precipitation), and Canadian as well as international responses to protect it.
- Added boxes on hot topics such as implications of climate change for Canada's Arctic and the *Chapter Debate* asking whether geoengineering the climate is a good policy choice.
- New figures and illustrations include estimates for seven climatic forcing functions, Earth's weather and climate, and GHG emissions in Canada.
- Added maps of drought levels in B.C., world rainfall levels, and air pollution issues.

Chapter 13 Energy

- New sections on offshore and northern oil and gas development, fossil fuels and their environmental impacts, and limited pipeline infrastructure in Canada including two controversial proposals: Keystone Pipeline System and the Energy East Pipeline. A new map of Canada's oil and gas transportation infrastructure is also provided.

Chapter 14 Minerals and Mining

- Updated coverage of the International Council on Mining and Metals (ICMM) report outlining the issues the industry must address in order to adapt to climate change.
- Expanded coverage of the impacts of Canada's mineral extraction on the environment and the associated futures challenges of developing a sustainable approach to mining. *Making a Difference 14* discusses MiningWatch Canada, an ENGO dedicated to ensuring mining practices support

both sustainable communities and the health of ecosystems. The *Chapter Debate* asks whether mining is a net benefit or loss for the Northwest Territories.

- New maps and photos of clusters in the Canadian Mining Industry, Slave Geological Province, and the Ring of Fire mineral belts.

Part IV: Getting to Tomorrow: The Overview

Chapter 15 Waste

- New chapter that discusses Canadian waste streams and their management and how humans could move to a zero waste society.
- *Our Environment* boxed features cover hot topics such as landfills, zero waste, electricity generation and waste water, microbeads, the National Pollutant Release Inventory (NPRI), e-waste, mercury poisoning, and dangerous dumpsites. Other important topics covered include Nova Scotia's waste diversion rate and how the province's successful energy reduction program made it by far the most successful in Canada.

Chapter 16 Environmental Hazards and Human Health

- New chapter covering the social determinants of health, causes of illness, acute and chronic disease, morbidity, and mortality. Other important topics discussed are the health risks from exposure to toxic chemicals; vaccinations; cholera; ecological medicine; risk assessment, management, and perception; and Lyme disease.
- Important coverage of the first Canadian study by Pierre Gosselin of the health impacts of climate change.

Chapter 17 Cities

- Expanded and updated discussion of urban environmental conditions and trends, including topics such as 3D printers, robots, and urban agriculture.
- New coverage profiling Peter Halsall, CEO of the Canadian Urban Institute, and leader in the development of sustainable urban environments. The *Chapter Debate* asks whether the “smart” city is an over-hyped concept driven by technology vendors.

Chapter 18 The Way Forward

- Current coverage of important issues such as the need to reconceptualize environmental challenges, the deficit equilibrium, sustainable communities, and the challenges to sustainability.
- Updated coverage of the Talloires Declaration and its implication for the role of universities in the education, research, policy formation, and information exchange, and new coverage of the four Es that foster sustainable development.
- New boxed features include discussions of Co-operators Youth Program for Sustainable Leadership, the deficit equilibrium, the bottom billion, and challenges to sustainability.

Instructor Resources



The **Nelson Education Teaching Advantage (NETA)** program delivers research-based instructor resources that promote student engagement and higher-order thinking to enable the success of Canadian students and educators. Visit Nelson Education's **Inspired Instruction** website at <http://www.nelson.com/inspired/> to find out more about NETA.

The following instructor resources have been created for *Our Environment: A Canadian Perspective*, fifth edition. Access these ultimate tools for customizing lectures and presentations at www.nelson.com/instructor.

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NETA PowerPoint

Microsoft® PowerPoint® lecture slides for every chapter have been created by Silviya Stefanovic, University of Toronto. There is an average of 35 slides per chapter, many featuring key figures, tables, and photographs from *Our Environment*. NETA principles of clear design and engaging content have been incorporated throughout, making it simple for instructors to customize the deck for their courses.

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Visit <http://www.nelson.com/student> to start using **MindTap**. Enter the Online Access Code from the card included with your text. If a code card is *not* provided, you can purchase instant access at NELSONbrain.com.

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Dianne Draper
Calgary, Alberta

Ann Zimmerman
Toronto, Ontario

PART I

Our Environment

The five chapters in Part I of this book introduce the key concepts and processes fundamental to understanding our environment. Chapter 1 discusses the accelerating rate of environmental change and the important concept of sustainability. Chapter 2 examines world views with respect to the relationship of humans and nature, and also human population growth and Earth's carrying capacity. Understanding environment means learning about science and its protocols for discovering new knowledge, the subject of Chapter 3. Chapter 4 discusses the building blocks of nature, the complex system of the biosphere, and ecosystem responses to stress. In Chapter 5, the focus is on Canadian issues with relevance to the environment.

Environmental Change

“The International Space Station is a phenomenal laboratory. Yet I often thought, while silently gazing out the window at Earth, that the actual legacy of humanity’s attempts to step into space will be a better understanding of our current planet and how to take care of it. People . . . need to see and internalize an accurate global vision of place and individual accountability, to recognize the problems that face us all and . . . see the wisdom and opportunity that come from a more universal sense of responsibility.”

Hadfield (2013, para. 20)

Marko Kovacevic/Shutterstock.com





CHAPTER LEARNING OUTCOMES

After studying this chapter you should be able to

- explain the concept of the anthropocene era and the anthrosphere
- understand sustainable development
- appreciate performance monitoring in the environment
- describe the focus of the Millennium Development Goals and the post-MDG development framework
- recognize the importance of individuals in our efforts to develop a more sustainable world

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Why It Matters

Canada is a special place, but we have lots to learn if we are to keep it special. We're incredibly rich in fresh water, although we often fail to appreciate how little of that water is actually renewable. We have an incredible wealth of natural resources but we need to be better stewards in their management. We border three oceans, but we've allowed what was our foremost fishery to succumb to economic extinction. We harbour one of the world's last three frontier forests but can't agree on a sustainable approach to its utilization. We face a challenge: many of our activities, whether in Canada or elsewhere are rapidly altering both Earth's beauty and its ecological functioning. We are slowly learning to think and act differently, choosing to live our lives so that we help to sustain, rather than degrade, our planet. However the evidence suggests we are running out of time to transform our societies.

This textbook focuses on learning about the impacts of human activities on the quality of our environment. We will learn how environmental and social scientists understand the changes that are happening in our environment, and about the actions we can take toward achieving sustainability for the Earth and its inhabitants. The purpose of this book is to help us think critically about the environmental challenges that face us as Canadians and global citizens. It provides examples of efforts that individuals, groups, industries, and government are making to solve problems and improve the ways we interact with ecosystems. It also is critical of actions that degrade ecological integrity.

Many environmental problems are significant ones, and sometimes people feel powerless to change them. However, it is important to remember that both individual and combined actions do make a difference. Each one of us can improve our knowledge

of how the world works so that our decisions and actions reflect an understanding of our reliance on the ecosphere. Industries and governments also need to be challenged to develop new approaches to conserving the planet's basic life-support systems. In their provocative book, *Deep Green Resistance: Strategy to Save the Planet* (2011), Aric McBay, Lierre Keith, and Derrick Jensen pondered the question of where answers on genuine environmental protection might lie. Their answer: vaguely “somewhere between being the change we wish to see and a hundredth monkey of hope” (p. 3). This book captures ideas from across that spectrum.

1-1 The Anthropocene

All of recorded human history has taken place in a 12 000-year time frame since the last ice age, a 12 000-year period that geologists call the Holocene. However, it is just in those fleeting moments since the Industrial Revolution, that humans have started to impact the Earth on a global scale. In recognition of that impact, Paul Crutzen, a Nobel Laureate for his work on stratospheric ozone depletion, began popularizing the term **anthropocene** to discriminate between the early Holocene's human impacts—small scale and local—and the more recent massive impacts of industrialized society. Vitousek et al., 1997, have estimated that 30–50 percent of the land surface of Earth has been transformed by human activities.

In an article in the journal *Environmental Science and Technology*, Zalasiewicz et al. (2010) describe the outcomes of human processes that they believe will leave a lasting mark on the planet, specifically, impacts extending more than a million years:

- increases in greenhouse gases and associated global change
- ocean acidification
- sea level rise
- increased rates of species extinctions
- urbanization

These among other benchmarks make it clear that we live on a human-dominated planet.

If the anthropocene is the time frame of massive human impact on the Earth, the **anthrosphere** is the place where these impacts first occur. However, they spread quickly to the Earth's other spheres: the atmosphere, hydrosphere, and lithosphere (Manahan, 2013). These human-caused impacts on the environment are known as **anthropogenic** effects.

“The escalating implications of humanity's actions on planet Earth have propelled a movement to label the past 300 years of the current geological epoch as the *Anthropocene*. Coined by ecologist Eugene

*Zalasiewicz, J., M. Williams, A. Smith, T.L. Barry, A.L. Coe, P.R. Bown, P. Brenchley, D. Cantrill, A. Gale, P. Gibbard, F.J. Gregory, M.W. Hounslow, A.C. Kerr, P. Pearson, R. Knox, J. Powell, C. Waters, J. Marshall, M. Oates, P. Rawson, and P. Stone. 2008. Are we now living in the Anthropocene? *GSA Today*. 18(2): 4–8.

Stoermer, and promoted by Nobel Prize recipient Paul Crutzen (an atmospheric chemist who discovered the effects of ozone-depleting compounds), the term recognizes that the force of human behaviour on Earth has been so profound that Earth has left its natural geological epoch. In 2008, the Stratigraphy Commission of the Geological Society of London agreed to initiate the lengthy formal process to adopt the term ‘anthropocene’.”*

Zalasiewicz et al. (2008, p. 7)

1-2 Accelerating Rate of Environmental Change

Television, video, and YouTube bring us face to face with images of fleeing environmental refugees as ecological deterioration overtakes their homelands. We see the tragic consequences of war, oil spills, forest fires, air, and water pollution for both humans and the environment. Canadian news media have carried stories about the shrinking Arctic ice pack, severe smog events, contaminated water supplies, and food-borne diseases. These and many others all carry the same message: human activity is driving environmental change (Figure 1-1a–e). The UK newspaper *The Independent* featured two additional lines of evidence: (1) humanity's devastating effect on the planet, as shown in 19 photos, and (2) Earth Day, with pictures showing how we are killing our planet. You may view both of these at <http://www.independent.co.uk/news/world/humanitysdevastating-effect-on-the-planet-in-19-photos-10225680.html>

While Earth's natural history reveals periods of major global environmental change: continental drift, meteor impacts, glaciation, or volcanic eruptions that have destroyed species



Marlena Rogowska

FIGURE 1-1A

Although Bike To Work Day attracts thousands of riders across the country, Montréal is the only Canadian city ranked among the top 20 in the 2015 Copenhagenize Design Company's report on bike-friendly cities. Commuting by bicycle is one example of individuals taking personal responsibility for reducing consumption. Industry and government must also develop sustainable approaches to conserve resources.

**FIGURE 1-1B**

In June 2013, over 20 cm of rain fell on the watersheds of southwest Alberta in less than 48 hours, leading to the worst floods in Alberta's history. Calgary, High River, Canmore, Lethbridge, and eight other municipalities were among those impacted. Climate change may mean that storm frequencies and volumes will change. (See Chapter 12.)

**FIGURE 1-1C**

As much as 99 percent of Canada's tall grass prairie has been lost to agricultural conversion and fire suppression. Manitoba has Canada's largest remaining block of this ecosystem. Fire is a necessary disturbance mechanism for some ecosystems. (See Chapters 4, 6, and 7.)

**FIGURE 1-1D**

Justice Murray Sinclair, chair of the Truth and Reconciliation Commission, explicitly referenced the role of traditional ecological knowledge (TEK) among the contributions of Canada's Aboriginal people. TEK is increasingly contributing to our understanding of the management of natural resources. (See Chapters 2 and 6.)

**FIGURE 1-1E**

The precautionary principle and adaptive management are both important elements in setting the total allowable catch (TAC) for a particular fishery. In treating decisions as operating hypotheses and subject to change, adaptive management poses challenges to our legal system, which traditionally relies on precedence, *res judicata* (matters once judged cannot be re-judged) and *functus* (once rendered, decisions cannot be changed). (See Chapters 9 and 10.)

and ecosystems, these impacts differ from what we see from anthropogenic impacts—particularly with respect to recovery. The hundreds of thousands or even millions of years of relative stability following these natural events afford time during which some species recover, some may die out, and new species may move in to take advantage of newly available resources. In contrast, human population growth, and economic and industrial development are sudden events in the context of geologic time and, in many cases, are unremitting. Humans may be able to adapt behaviourally to these changes; however, the time frame is too short for non-human species to adapt evolutionarily.

Consider the following examples of natural and anthropogenic change. The first example is of the natural changes that followed the eruption of Mt. St. Helens, in the state of Washington on May 18, 1980 (Figure 1-2a–c). The mountain erupted in a massive blast of steam, lava, and ash that wiped out every living thing within

**FIGURE 1-2A**

Mt. St. Helens, Washington, before the eruption in May 1980.

**FIGURE 1-2B**

A view after the eruption in May 1980.

**FIGURE 1-2C**

A photo taken later from the scorch zone; 31 years ago trees were instantly killed here by the blast of hot air. It will take another 80 to 100 years, but this forest is recovering.

12 kilometres (km) and eventually spread ash and debris over 600 square kilometres (km²). Four hundred metres of the top of Mt. St. Helens disappeared, and mudflows roared down the slopes at an estimated 150 kilometres per hour (km.hr⁻¹). Fifty-seven people were killed. Yet 30 years later, Mt. St. Helens is recovering. You can view a series of annual satellite photos of the Mt. St. Helens area that run from 1979 to 2013 at <http://earthobservatory.nasa.gov/Features/WorldOfChange/sthelens.php>.

The second and third examples concern anthropogenic change: two forests cleared by human activities and not recovering. Fossil evidence shows that Iceland was once heavily forested. Successive glaciations significantly reduced tree cover, and at the beginning of the present interglacial period, probably only three tree species of any significance were present: birch, aspen, and willow. When the Norse arrived in the 11th and 12th century, these woodlands covered 25–40 percent of Iceland. The Norse began to cut trees for fuel, for building materials, for pasture for sheep and for other agricultural products. Most importantly, trees

were the raw material for charcoal used in the iron foundries. By 1850, tree cover in Iceland was reduced to an estimated 1 percent of its original expanse. As there were no local seed sources, trees were unable to re-establish naturally. Introduction of non-native seedlings in an attempt to recreate a forested environment was attempted, but unsuccessful. Iceland's current focus is on regeneration of native species. Unfortunately, unregulated grazing combined with the collapse of the Icelandic Krona has meant that Iceland remains at 1.5 percent forest cover and has been unable to meet its target of 5 percent reforestation (Eysteinnsson, 2013).

The stump plains in the state of Michigan are another example of a forest that has not recovered after human actions interfered with ecosystem regeneration. Here selective logging for white pine in the 1830s and 40s left enormous debris piles or slash—limbs or other woody debris left after logs were cut—that eventually caught fire. The resins in the wood generated intensely hot fires that destroyed the organic content of the soil and incinerated seeds. These areas have proved extremely resistant to rehabilitation and restoration for over 150 years (Figure 1-3).

Fire is another disturbance that has differential effects depending on where it occurs. Fire is a natural disturbance in many grassland and forest ecosystems (Chapter 11). The plants of these systems are dependent on periodic fires and some plant species actually require fire to stimulate their reproduction. In contrast, desert plants have adaptations that allow them to deal with the heat and drought of their environment, but fire has never been sufficiently frequent or wide-ranging to select for adaptations that would protect desert plants from fire. So, unlike plants that evolved in fire-frequent ecosystems, desert plants are easily killed by fire. They have not developed the thick bark or cork layers that protect their delicate tissues.

An invasive weed known as Sahara mustard has moved into the desert areas of the southwest United States, displacing the formerly dominant native creosote bush. Mustard is not grazed by desert herbivores, so dead plant material builds up high fuel

**FIGURE 1-3**

An area of stump barren in the Kingston Plains region of Michigan in 1968. Compare this photo to the regeneration at Mt. St. Helens.