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Environmental Change & Challenge

A Canadian Perspective

Sixth Edition

Philip Dearden
Bruce Mitchell
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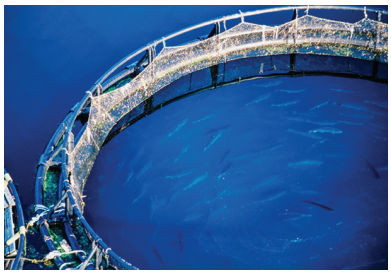

Preface

When we wrote the first edition of *Environmental Change and Challenge* more than 20 years ago, it was already obvious that the two core themes of "change" and "challenge" were going to be major defining characteristics of the twenty-first century. However, since then, the speed and magnitude of change have often been unanticipated, leading to major challenges. Thus, we believe that today these two core themes continue to be relevant, even more so, than when the first edition was published in 1998.

Scientists and social scientists in the mid-1990s were certainly very aware of global climate change, for example, but the rate of such change was expected then to be a concern for the next rather than the current generation. For example, the Arctic Ocean was predicted to be ice-free in 50 to 100 years. However, as a result of colossal ice losses in the Arctic during the last decade, and also in the Antarctic, the prediction has been modified to indicate major changes within a much shorter time frame.

Challenges due to these and other changes will be profound, with local, regional, national, and global implications. Sea levels can be expected to rise more quickly than anticipated, ocean currents will change, more communities will experience flooding, rainfall and temperature patterns will be modified, crops will be affected, and millions of lives will be affected.

The reality of such changes is daunting, and yet also difficult for many people to believe or accept, since it counters many deep-seated beliefs and expectations. Furthermore, some political leaders downplay or reject the findings of natural and social scientists, arguing their results and interpretations are questionable or unproven, even while not providing credible counterevidence to support their views.

Another part of the reality is that treaties were signed with Indigenous peoples for "as long as the rains fall, as long as the rivers flow, as long as the winds blow" because these were the immutable constructs of nature that were reliable. The Earth also was conceived by many as being so large that the impacts of humans would be trifling in comparison. Photos of our lonely planet floating through space, taken from spacecraft, helped to dispel that myth.

A fundamental change has occurred over the past several decades regarding the relationship between humans and the planet. No longer is the planet a vast and wild place in which change occurs on a geological time scale driven by natural forces; instead, it has become the "greenhouse" of the greenhouse gas analogy in which wild nature is being replaced by human constructs, and even the atmosphere and ocean reflect human desires as they become increasingly choked by the wastes of consumer societies. Indeed, the influence of humans on ecosystems has prompted some to call for a new geological epoch to be labelled as the "Anthropocene" to succeed the current epoch (the Holocene), to reflect the impact of humans and their activities on the global environment.

Given the above, there has not been a more critical time when humans should know how the planet works and especially understand processes driving life-support systems. This book was conceived and written with these twin goals in mind: that students should attain a basic appreciation of how the planet works, and also understand the impacts of humanity on its systems, challenges triggered, and potential responses.

The book is also focused primarily on Canada, one of the most magnificent places on Earth. Our geography, people, history and political culture are distinctive. Canadians can and should play a constructive role in what happens globally in terms of the environment. We are the world's second-largest country in terms of area. We also are a rich country. In general, most of our citizens have a high quality of life and value the environment, but we also create some of the highest per capita impacts in the world in terms of carbon dioxide emissions, water use, and waste production. Changes need to take place. And those changes need to happen far more quickly than is currently happening. Our "leaders" have often been willing to make necessary changes, but only if they perceive there is support for them. That support rests on a well informed and engaged populace.

We believe it is critically important that students graduate from our universities and colleges with a greater understanding of the planetary ecosystems that support life, an appreciation of their impacts on ecosystems, and an awareness of what society and individuals can do to help improve the situation. If all university and college graduates came out thus informed and acted on this knowledge to create change in their own lifestyles and society, the prognosis for the future could be more optimistic.

Another significant and relevant trend is a growing appreciation that Indigenous peoples were living in what became Canada long before the first European explorers arrived. The early European explorers, business people, settlers, and political leaders effectively displaced the Indigenous peoples, leaving

a tarnished legacy. Initiatives are being taken to address the inequities created and maintained, but it has been, and is, an incremental and gradual journey. In that context, in this book we use the term "Indigenous" when referring to the pre-European settlers and occupiers of what became the nation of Canada, reflecting an evolution of terms from "Indians," "Natives," and "Aboriginals" to "Indigenous." The term "Indigenous" is inclusive as it refers to three distinct peoples: First Nations, Métis, and Inuit.

This book was written for students taking a first course in environment, to impart an understanding of the biosphere's function and to link basic environmental management principles to environmental and resource problems in a Canadian context. As well, since Canada is just one nation on planet Earth, initiatives and examples from other parts of the world are examined, given that we can learn much from others' experiences. Thus, this book provides both a basic background for those who will go on to specialize in fields other than the environment and a broad platform upon which more specific courses on environment can build.

In developing this book, we had to address inevitable tensions among depth, breadth, and integration. Various approaches can be used to deal with such interactions. We decided for the first edition to organize the book by first introducing a significant case study, and using it to highlight many fundamental challenges that must be addressed; we have continued with this approach through to the sixth edition. We have used the case study to show how science and social science theories, concepts, and methods can be used in a complementary manner. In addition we outline some basic arrangements within Canada related to environmental management, and also how Canada engages at an international scale. Importantly, we draw attention to opportunities for individuals to make a difference in every chapter.

On this foundation, we then created two sections which examine core ideas and methods from science and social science, and alert you to the theories, methods, and techniques that can be drawn upon for examining and resolving problems. From such a platform, we turn in a fourth section to explore and analyze substantive topics—challenges and opportunities related to climate change, oceans and fisheries, forests, agriculture, water, minerals and energy, urban areas, and endangered species and protected areas. When examining any one of these, we often note how issues are similar to, or connect with, issues in one of the other theme areas. For example, in each chapter in this section we consider the implications of the Sustainable Development Goals developed by the United Nations, for concerns ranging from climate change to endangered species and protected areas. In that manner, we strive to achieve an "integrated" approach. And, throughout, we have sought to draw attention to the significance of Indigenous knowledge and experience, and how it, and other types of experiential knowledge, can help to achieve deeper understanding, as well as enhance capacity for problem solving. Finally, in the last section, entitled Epilogue, we reflect on what has been examined in previous chapters and the challenges and opportunities that await us.

In this sixth edition, we have updated information in the fifth edition, as well as incorporated new concepts and ideas, such as strategic lawsuits against public participation (SLAPPs) and ecological forestry. In addition, one new Vision from the Field box is included in each chapter, from either Canadian or international authors. The intent of these boxes is to add other perspectives, and their authors were asked to examine one or more concepts, illustrate it with one or more examples, and reflect on implications for environmental management. Furthermore, we have provided a number of "integrative" case studies, such as the Trans Mountain pipeline example in Chapter 1, which highlight the need to take a holistic or ecosystem approach. And, finally, to encourage you to reflect and consider how you can help in identifying solutions, What You Can Do boxes are included toward the end of each chapter, in which opportunities are identified for you to "make a difference."

Change and challenge are the core themes of this book, and we believe fundamental changes are needed in the way society manages itself and the environment if we are to meet the challenges facing us and to create opportunities. We hope that his book will help to contribute to creating a sustainable and resilient future, and to encourage you to become part of making such a future a reality.

Philip Dearden
Bruce Mitchell
Erin O'Connell

Features

In preparing this new edition of *Environmental Change and Challenge*, we have, from the start, kept in mind one paramount goal: to produce the most dynamic, accessible, and up-to-date introduction to environmental studies available to Canadian students.

This revision builds on the strengths of the highly acclaimed previous editions, and continues to address the needs of today's students by providing them with a thorough understanding both of how our environment is changing and of the challenges faced by Canada and the world.

Epilogue: The Sustainability Revolution

Greta Thunberg is a Swedish schoolgirl. In 2018, no one outside her immediate friends and family knew the 16-year-old. Now her name is known the world over. Sudden fame such as this is not so unusual in this globalized world. Pop stars, footballers, tennis players can rocket to fame within weeks. But this very seldom happens with non-commercial individuals, such as Greta, who offer no one a ride to instant riches, and may in fact curtail the riches of many. So what brought about this change?

Greta became aware of the immense challenges being posed by global climate change and simply could not understand why no effective action was being taken to protect her and others of her generation from these catastrophic impacts. It all seemed so clear to her. First, she converted her skeptical parents. Then she decided she would protest. Inspired by the Florida students who started a school strike to protest lax gun laws that had allowed their schoolmates to be shot and killed, she decided to go on strike. Every day she went to the Swedish parliament with her sign. Greta is articulate, and she knew her stuff—people started to listen at the tail end of a summer that had been ravaged by unprecedented heat in northern Europe. Soon, she was joined by others who shared her concern.

Greta Thunberg speaks at a rally at the Alberta Legislature Building in Edmonton in 2019.

▲ Artit Tongvichit/Shutterstock

Current Changes and Challenges

Coverage of current events—including the Trans Mountain pipeline debate, the activism of Greta Thunberg, the Australian wildfires, and the Paris Agreement—illustrates environmental changes and challenges happening every day all over the world.

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Vision from the Field

Responding to Environmental Challenges in Canada: The Role of Indigenous Jurisdictional Authority

Maggie Low

The increasing recognition of Indigenous rights and title has had significant implications for the jurisdictional arrangements responding to environmental challenges in Canada. Indigenous peoples and their governments are demanding recognition as a distinct order of government, thus challenging the day-to-day realities for natural resource managers and all levels of the Canadian government, including municipal, provincial, and federal.

Court decisions have acted as effective leverage for Indigenous nations wishing to have more power in decisions made about their lands and waters (forestry, mineral, fisheries, etc.). For example, the *Haida v. British Columbia (2004)* and *Taku River Tlingit First Nation v. British Columbia (2004)* decisions defined the "duty to consult" whereby provincial and federal government agencies must meaningfully consult Indigenous peoples before resource development activities occur on their traditional territories or reserve lands. To date, provincial and federal consultation processes—such as environmental impact assessments (EIA)—have been ill-suited to meet the constitutionally protected rights of Indigenous peoples in such consultation processes.

Apart from rights recognized by the Canadian courts, Indigenous peoples in Canada possess inherent rights that flow from their ways of knowing and political and social systems existing before the arrival of European colonists. These inherent rights—including political rights and title to land—are rooted in Indigenous knowledge and laws developed over millennia. Historically, treaty-making between Indigenous nations and Canadian governments over most of Canada's land base was meant to establish a nation-to-nation relationship. However, Canadian governments have normally viewed treaties as extinguishing Indigenous nations' inherent rights in exchange for narrowly defined treaty rights, such as for hunting, fishing, and trapping. Modern treaty processes have also been used to try to bring certainty to questions of land-ownership and who benefits from resource development. To date, Canadian governments have declared ultimate jurisdictional authority over land and resources in Canada.

However, in British Columbia, few historic and present-day treaties have been signed, meaning both Indigenous nations and Canadian governments lay claim to the same land base and waterways. Indigenous nations in BC are asserting their inherent rights and jurisdictional authority over their territories through legal challenges, negotiated political agreements, and activism. By exercising their jurisdictional authority, Indigenous nations in Canada are changing the rules for governments and resource users in significant ways. To exemplify this, I share a story from my time living in Bella Bella, BC, home of Heiltsuk Nation. Heiltsuk Nation holds inherent jurisdiction and governing authority over its territories and (rightfully) consider themselves owners and caretakers of their homelands.

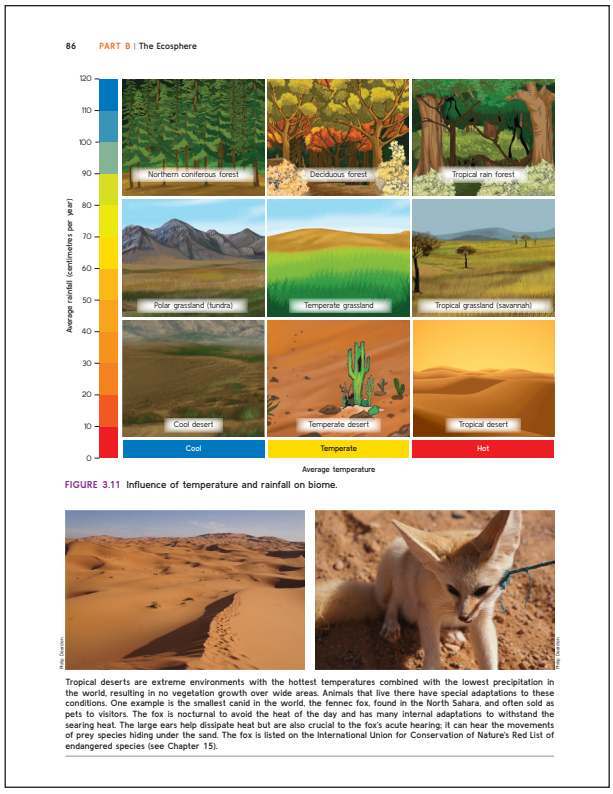
In March 2015, members of the Heiltsuk Nation occupied the office buildings of Fisheries and Ocean's Canada (DFO) on Denny Island for four days to protect one of their primary marine resources, Pacific herring. Herring are a cornerstone of Heiltsuk people's diet, cultural practice, and livelihoods. The peaceful occupation of the DFO offices began when a delegation of Heiltsuk members and supporters hand-delivered an official eviction notice to the DFO staff that read: "Due to Lack of Respect for Heiltsuk Gvi'ilás [Heiltsuk laws], You are Hereby Given a Notice of Eviction from the Heiltsuk Nation." Essentially, the eviction notice instructed DFO to pack up and leave Heiltsuk territory. This action, although seemingly minor, was significant because it implied DFO were only visitors on Heiltsuk territory. As far as Heiltsuk were concerned, DFO had no jurisdictional authority and was no longer welcome to operate on Heiltsuk lands and waters.

In March 2015, members of Heiltsuk Nation and their allies peacefully occupied the offices of the Department of Fisheries and Oceans for four days on Denny Island, BC.

Continued

Fresh National and Global Perspectives

"Vision from the Field" features, including 15 entirely new statements, highlight the work of engaged environmental researchers making a difference in Canada and internationally in areas such as global food security, freshwater fisheries, water ethics, and shark conservation.

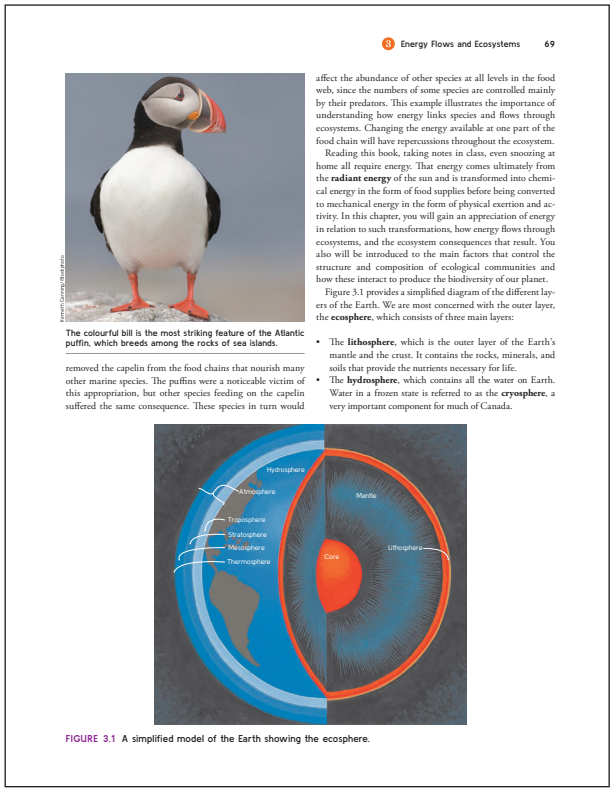


Increased Coverage of Indigenous Peoples

Greater coverage of Indigenous perspectives and the challenges faced by Indigenous Peoples—the disproportionate impacts of climate change on the Inuit, experiences of Indigenous Peoples and Canadian biosphere reserves, Indigenous rights to water, and the role of Indigenous jurisdictional authority—gives students better insight into important current issues.

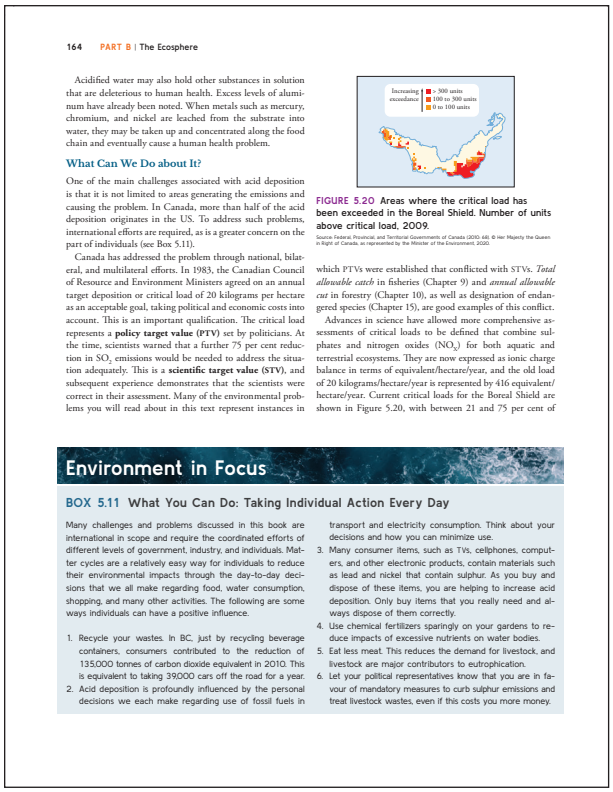
Dynamic Art Program

From carefully chosen images that present the issues in living colour to detailed figures and tables that provide the most up-to-date data, the revised art program complements and augments the discussion in every chapter



Primer on Scientific Concepts

Thorough coverage of the environmental processes that form the Earth's life-support systems helps readers understand essential scientific concepts and recognize the importance of taking a holistic, scientifically informed approach to environmental issues.



164 PART B | The Ecosphere

Acidified water may also hold other substances in solution that are deleterious to human health. Excess levels of aluminum have already been noted. When metals such as mercury, chromium, and nickel are leached from the substrate into water, they may be taken up and concentrated along the food chain and eventually cause a human health problem.

What Can We Do about It?

One of the main challenges associated with acid deposition is that it is not limited to areas generating the emissions and causing the problem. In Canada, more than half of the acid deposition originates in the US. To address such problems, international efforts are required, as is a greater concern on the part of individuals (see Box 5.11).

Canada has addressed the problem through national, bilateral, and multilateral efforts. In 1983, the Canadian Council of Resource and Environment Ministers agreed on an annual target deposition or critical load of 20 kilograms per hectare as an acceptable goal, taking political and economic costs into account. This is an important qualification. The critical load represents a **policy target value (PTV)** set by politicians. At the time, scientists warned that a further 75 per cent reduction in SO_2 emissions would be needed to address the situation adequately. This is a **scientific target value (STV)**, and subsequent experience demonstrates that the scientists were correct in their assessment. Many of the environmental problems you will read about in this text represent instances in which PTVs were established that conflicted with STVs. *Total allowable catch* in fisheries (Chapter 9) and *annual allowable cut* in forestry (Chapter 10), as well as designation of endangered species (Chapter 15), are good examples of this conflict.

Advances in science have allowed more comprehensive assessments of critical loads to be defined that combine sulphates and nitrogen oxides (NO_x) for both aquatic and terrestrial ecosystems. They are now expressed as ionic charge balance in terms of equivalent/hectare/year, and the old load of 20 kilograms/hectare/year is represented by 416 equivalent/hectare/year. Current critical loads for the Boreal Shield are shown in Figure 5.20, with between 21 and 75 per cent of

FIGURE 5.20 Areas where the critical load has been exceeded in the Boreal Shield. Number of units above critical load, 2009.

Source: Federal, Provincial, and Territorial Governments of Canada (2010: 68). © Her Majesty the Queen in Right of Canada, as represented by the Minister of the Environment, 2010.

Environment in Focus

BOX 5.11 What You Can Do: Taking Individual Action Every Day

Many challenges and problems discussed in this book are international in scope and require the coordinated efforts of different levels of government, industry, and individuals. Matter cycles are a relatively easy way for individuals to reduce their environmental impacts through the day-to-day decisions that we all make regarding food, water consumption, shopping, and many other activities. The following are some ways individuals can have a positive influence.

1. Recycle your wastes. In BC, just by recycling beverage containers, consumers contributed to the reduction of 135,000 tonnes of carbon dioxide equivalent in 2010. This is equivalent to taking 39,000 cars off the road for a year.
2. Acid deposition is profoundly influenced by the personal decisions we each make regarding use of fossil fuels in transport and electricity consumption. Think about your decisions and how you can minimize use.
3. Many consumer items, such as TVs, cellphones, computers, and other electronic products, contain materials such as lead and nickel that contain sulphur. As you buy and dispose of these items, you are helping to increase acid deposition. Only buy items that you really need and always dispose of them correctly.
4. Use chemical fertilizers sparingly on your gardens to reduce impacts of excessive nutrients on water bodies.
5. Eat less meat. This reduces the demand for livestock, and livestock are major contributors to eutrophication.
6. Let your political representatives know that you are in favour of mandatory measures to curb sulphur emissions and treat livestock wastes, even if this costs you more money.

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Environment in Focus

BOX 8.5 Sea Ice in the Arctic and Implications for Cruise Tourism

Records show that surface air temperatures are increasing in the Canadian Arctic. The extent of northern hemisphere sea ice has also been decreasing since 1979. One consequence of this is that cruises in Arctic Canadian waters more than doubled between 2005 and 2013.

While ice-free periods may allow easier movement of ships through the Northwest Passage, there may be a false sense of optimism regarding the ease of future shipping. As noted by the Government of the Northwest Territories (2015):

> Even if relatively ice-free in late summer, the Northwest Passage and the Beaufort Sea remain difficult to navigate with their unmarked shallow areas, shifting sand-gravel bars, fog, and dangerous weather. Increasing shipping in the region would require a high preparedness of potential environmental incidents.

Whether such analysis is optimistic or pessimistic depends on one's point of view, but cruise lines have dramatically increased their Arctic business over the past 20 years, including transiting the Northwest Passage—not always successfully. In 2010, one ship ran aground and had to be towed to Kugluktuk, Nunavut, from where the tourists were flown south. A similar incident occurred in August 2018.

Increased tourism also has consequences for communities in Arctic Canada. While opportunities exist for tourists to learn about Inuit culture and traditions, communities tend to be small, ranging from 500 to 3,000 people. The passengers of larger cruise vessels can overwhelm the local population and disrupt daily living activities. Some communities have expressed concerns that they have not seen adequate economic returns to warrant the environmental risks and efforts put forth to welcome cruise tourists. The unpredictability of Arctic weather can also affect vulnerable communities. For example, in 2018, the only two cruise ship visits scheduled for the small community of Ulukhaktok, Northwest Territories, were cancelled due to difficult ice conditions. At least 40 individuals in the community had already trained and prepared to welcome up to 400 tourists from these ships, significantly affecting their incomes in this remote community (Kassam, 2016; Stewart et al., 2016; CBC News, 2018).

An inflatable boat brings tourists ashore in Nunavut from *Clipper Adventurer*, an expeditionary cruise ship in the High Arctic.

Perspectives on the Environment

Glaciers Melting

Under a medium emission scenario, it is projected that glaciers across the mountains of western Canada will lose 74% to 96% of their volume by late century. Most small **ice caps** and ice shelves in the Canadian Arctic will disappear by 2100. Increases in mean air temperature over land underlain with permafrost are projected under all emissions scenarios, resulting in continued permafrost warming and thawing over large areas by mid-century with impacts on northern infrastructure and the carbon cycle.

—Bush et al. (2019: 12)

A pair of trucks drive the Ice Road in the Northwest Territories. Truckers drive the frozen ice highway on the Mackenzie River in the few months it is safe for use.

Emphasis on Solutions

Explorations of global, national, and personal solutions suggest actions that can be taken to move toward more sustainable ways of living.

Fascinating Examples and Perspectives

"Environment in Focus" boxes reveal how concepts, approaches, and theories are applied in a variety of real-world contexts, while "Perspectives on the Environment" boxes provide insightful, thought-provoking quotations from respected thinkers.

Ancillary Resource Center

Online Supplements

Environmental Change and Challenge, sixth edition, is supported by an outstanding array of ancillary materials for both instructors and students, all available on the book's Ancillary Resource Centre (ARC) at www.oup.com/he/Dearden-Mitchell6e.

For Instructors

- **An instructor's manual** includes lecture outlines, suggested classroom activities and topics for class discussion, tutorial activities, and lists of additional resources.
- **A test generator** offers a comprehensive set of multiple choice, short-answer, and essay questions.
- **PowerPoint slides** for use in classroom lectures summarize key points from each chapter.
- **An image bank** includes a wide selection of stunning images that will enhance the vibrancy of slides and handouts.

For Students

- **A comprehensive study guide** includes useful learning tools—including chapter summaries, self-testing quizzes, and more recommended resources—to help students understand important concepts and prepare for tests, essays, and exams.

Acknowledgements

Philip Dearden, Bruce Mitchell, Erin O'Connell

Phil, Bruce, and Erin all express their thanks and appreciation to the Canadian and international authors of the 15 Vision from the Field boxes, one of which appears in each chapter in the sixth edition. Those authors represent a broad mix of backgrounds and experience, and provide thoughtful perspectives about and examples of environmental management in practice that we trust will trigger further and deeper thinking by readers of this book.

Phil Dearden would like to acknowledge the research assistance of Carilia Horning and Shelly Selivanov. The enthusiasm, energy, and keen minds of thousands of inquisitive students over the many years teaching and learning about the environmental challenges we face has always provided the optimism to teach another year, produce another edition, and hopefully contribute to better solutions in the future. Daughters to whom the first editions were dedicated are now actively engaged professionally in addressing environmental challenges and I'd like to thank them, my wife Jittiya, and dog Max for their ongoing support and engagement.

Bruce is grateful to a number of colleagues who shared information, insights, and perspectives: Paul Allen, International Joint Commission, Canada Section, Ottawa; Ellen Bertrand, Director, Heritage Designations and Programs, Parks Canada, Gatineau, Quebec; Brian Johnston, Department of the Environment, Yukon Parks Branch, Whitehorse, Yukon; Peter Labor, Director of Protected Areas and Ecosystems, Nova Scotia Environment, Halifax; Patrick Nadeau, Ottawa Riverkeeper, Ottawa; Gordon Nelson, retired, University of Waterloo; and, Barbara Veale, Director, Planning and Watershed Management, Halton Region Conservation Authority [also called Conservation Halton], Burlington, Ontario.

Dan McCarthy in the School of Environment, Resources and Sustainability; Paul Parker in the Department of Geography and Environmental Management; and Roland Hall in the Department of Biology all at the University of Waterloo, provided photographs which enhance various chapters.

Amanda McKenzie, University of Waterloo, helped in various ways related to "computer support" in the chapters for which Bruce was the lead author. As always, she was competent, constructive, and supportive in providing advice and guidance, all of which was very helpful and much appreciated.

Aimee McKee, Bright's Grove, Ontario, took the photograph of Bruce in the About the Authors section. He is sincerely grateful for the quality of the photograph, and for the care which she took during the photo session.

Finally, he is deeply appreciative of the support, assistance, and thoughtful comments from Joan Mitchell while this edition was being prepared, along with her many other contributions offered consistently and continuously for this book and other initiatives spanning many decades.

Erin would first like to thank Bruce and Phil for inviting her to contribute to the sixth edition and for all the support and patience they provided throughout the writing process. Thanks also to Natasha Barlow for her research expertise, formatting work, and attention to detail when double-checking websites for the chapters in which Erin was the lead author. She would also like to acknowledge all the individuals at various government organizations who responded to queries. Special thanks to Lauren Smith and Nicole Balliston at PolyGone Technologies who provided information and photographs related to microplastics pollution.

Erin would also like to thank all the students she has worked with at the University of Waterloo, both environment and non-environment majors, who have inspired her with their dedication to the environment and the planet, their inquisitive and insightful questions and comments, and commitment to making the world a better place for future generations.

Finally, Erin would like to express gratitude to her family: Andrew, Alex, Saoirse, and her parents, for all their support and patience throughout the preparation of this book.

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Dedication

While we were working on the sixth edition, Erin's daughter, Saoirse Dori, was born on 20 February 2019. With the support of her mother, father, and brother, we dedicate the sixth edition to Saoirse, in the spirit of her representing future generations of Canadians, and reminding us that current decisions have implications for her and others of her generation.

About the Authors

Phil Dearden

I grew up in Britain. Even though home was in one of the wilder parts of Britain, I was always struck with the biological impoverishment of my homeland and dreamed of living in a country where wild nature still existed. My dream was realized when I first came to Newfoundland as a graduate student in the early 1970s. Since that time I have travelled all over Canada, and most of the rest of the world, and have a strong appreciation of the beauty and grandeur of the Canadian landscape.

My main interest is in conservation, and I have taught courses and undertaken research on this topic, mainly based at the University of Victoria, for 40 years. Throughout this period, I have taught large introductory classes in society and environment and loved every minute of it. I have a strong belief that the power of individual actions can help to make a better environmental future and that we need to support non-governmental organizations working in this area. I have held many positions in the Canadian Parks and Wilderness Society, including chair of the British Columbia chapter, and am currently a trustee emeritus.

I am an active field geographer and believe that you have to invest time in the places you are studying to be able to really understand the messages they tell us. Most of my time has been spent in the tropics and particularly Southeast Asia. I have led student field schools to both Africa and Asia.

My main research interest is biodiversity conservation and protected areas with a strong emphasis on marine and coastal environments and interactions with communities. Working with my graduate students, recent research topics include community-based approaches to marine conservation in Myanmar and Thailand, designing climate change–resistant marine protected area networks in Thailand, developing optimal approaches for whale shark watching in the Philippines, scaling up marine protected area networks in the Philippines, and developing community-based approaches to conservation around Serengeti National Park and World Heritage Site in Tanzania. I am a member of the IUCN's World Commission on Protected Areas and have advised many international bodies including the World Bank, Asian Development Bank, IUCN, UNEP, and UNDP on protected area management and conservation strategies.

Sally Snow © 2020

I am the author of more than 250 articles and 11 books and monographs, including (with Rick Rollins and Mark Needham) *Parks and Protected Areas in Canada: Planning and Management* (4th edition, Oxford, 2016). I have also been recognized for excellence in teaching with an Alumni Outstanding Teacher Award and Maclean's Popular Professor recognition at the University of Victoria. In 2018 I received the Award for Scholarly Distinction from the Canadian Association of Geographers. I am leader of the Marine Protected Area Research Group at the University of Victoria (https://mparg.wordpress.com) and enjoy music, sailing, hiking, and just getting out there whenever I get the opportunity.

Bruce Mitchell

I was born and raised in Prince Rupert, a small city on the northwestern coast of British Columbia, whose economy was strongly based on natural resources, especially forests and fish. As a result, from an early age I became aware of the importance of both "natural resources" and the "environment." As a graduate student, I focused on water resources, having learned how critical this resource is for both natural systems and humans. And I always recalled that humans and other living species quickly become vulnerable if access to potable water of suitable quality and quantity is limited. That aspect, as well as the striking vulnerability to both floods and droughts, highlighted that water was, is, and will be a key resource from local to international scales.

As a high school student in Prince Rupert and an undergraduate at the University of British Columbia, I worked summers first at a fish-processing plant and then as a deckhand on a troller that fished mainly for salmon. Both provided first-hand experience with a resource-harvesting industry. However, more importantly, it made me aware of how knowledgeable and skillful people who had not finished their education in the formal school system often were. This experience highlighted that "local" or "experiential" knowledge can provide remarkable understanding and insight. Indeed, this became a lifelong lesson: Experiential knowledge deserves respect and those pursuing science and social science should continuously look to such knowledge to complement and enhance what they believe they know.

Aimee McKee © 2020

Studying geography provided a foundation for me to understand natural systems, as well as the manner in which humans interact with and use them. As time passed, I became more and more convinced that many "natural resource and environmental problems" often were "people problems." I also became aware of the concept of "wicked problems," problems which are ill defined, have no obvious or single correct solution, and for which solutions often cause other, sometimes even greater, challenges. As a result, I focused my attention toward planning and management, always mindful of the need to draw upon both scientific and social science research plus experiential knowledge.

I have published over 165 journal articles and book chapters, 36 books and monographs, 50 reports and commentaries, and edited or co-edited 5 journal theme issues. I also was general editor for the Themes in Resource Management Series, which published 11 books. I have been a visiting professor at 15 universities in various countries, and received the Award for Scholarly Distinction from the Canadian Association of Geographers, as well as a Distinguished Teaching Award from the University of Waterloo. I am a Fellow of Royal Society of Canada and a Fellow of the International Water Resources Association, have been awarded the Massey Medal from the Royal Canadian Geographical Society, and have been an honorary professor at five Chinese universities. I retired in November 2015, and in 2016 became a Distinguished Professor Emeritus at the University of Waterloo.

As a faculty member, I have conducted research in Canada as well as in Australia, China, India, Indonesia, and Nigeria. Working in other countries has made me aware of how important it is to understand the ecological, economic, social, and political contexts within which management of natural resources and the environment occurs. It also has convinced me that, while many problems are formidable, again and again it has been possible to make progress in ameliorating, if not totally resolving, them. Thus, I believe we should be positive. With competence, discipline, commitment, and integrity, we can each contribute to resolving problems and to creating opportunities for our own and future generations.

Erin O'Connell

I grew up in southern Ontario, just outside the city of Kitchener, in a small hamlet surrounded by rolling agricultural fields and cattle grazing off in the distance. As a young child, I also spent many summers in Prince Edward County, Ontario, where my grandparents had previously been small-scale dairy farmers. Along with an innate love for animals, these experiences have underpinned my appreciation for the natural world.

As a graduate student, my interests turned to natural disasters, including earthquakes, tsunamis, landslides, floods, and cyclones, with a particular emphasis on the post-disaster recovery period. The more I have learned about disasters, the more obvious the interconnections between disasters and the environmental issues discussed throughout this book have become. Deforestation on hillslopes can increase the risk of landslides; coastal development can destroy important mangrove forests that act as buffers against tsunamis and storm surge; monoculture agricultural activity can increase the risk of disease and pests, yet agriculture is also affected by disasters like drought, floods, and storms; giant piles of discarded waste have contributed to landslides that destroyed vulnerable communities. The connections go on and on.

During my work in post-disaster recovery, two things have taught me important life lessons. First, I am struck by the optimism of people who have experienced the devastation associated with disasters. Instead of focusing on their loss, the individuals I have met and worked with have concentrated on building a better future for themselves, their families, and their communities. I believe this has strong lessons for how we can respond to some of the environmental challenges discussed in this book. Instead of fixating on how things have been done in the past, we can and should focus on building a more sustainable, better functioning, and more resilient society in the future. Second, I have met many people who appear to have little in terms of material possessions but much in terms of happiness—people who care less about having "more possessions" and who are happy and fulfilled when their basic needs are met and they can spend time with loved ones and contribute to their communities. I believe this also can teach us about where our future lies: not with more "things" but with experiences and connections.


Erin O'Connell © 2020

As a lecturer at the University of Waterloo, I have been teaching the next generation of environment students (and non-environment students) for almost a decade, both in Canada and China. I have published a number of articles and book chapters related to disasters, climate change, and education, and have presented at conferences around the world.

Environmental Change & Challenge

PART A

Introduction

On Spaceship Earth, there are no passengers; we are all members of the crew.

—Marshall McLuhan

The relationship among environment, resources, and society is one of the most important challenges facing humans on Earth. For many of Earth's human inhabitants, this relationship is an ongoing reality as they try to meet their everyday needs for food, water, and shelter. For others, usually urban dwellers in developed countries, this reality often seems distant. Food comes from the supermarket, water is piped into homes, work and home environments have controlled temperature through central heating and air conditioning. Not until disruptions occur in these delivery systems—caused by floods, tsunamis, droughts, ice storms, earthquakes, hurricanes, insect infestations, or similar forces of nature—do many people realize that they, too, depend on the environment for survival.

This first section introduces some basic concepts in Chapter 1 regarding the relationship among environment, resources, and society and the ways by which we try to understand complex natural and socioeconomic systems. There are many ways of knowing about environment. Here we concentrate mainly on the contribution of the natural and social sciences.

Science, especially environmental science, is increasingly a collaborative undertaking. This collaboration involves workers from many disciplines coming together to contribute their understanding of a particular phenomenon. An understanding of acid precipitation, for example, requires input of chemists, biochemists, climatologists, geologists, hydrologists, geographers, biologists, health specialists, economists, and political and legal experts, to name a few. Each discipline has its own expertise and methods of approach, and they can be combined in different ways to yield more effective answers to environmental problems. Even with the use of science, there can be high levels of uncertainty and conflict. How we deal with uncertainty and change is one of the main themes of this book, and this is illustrated in the example of the Trans Mountain pipeline from Alberta to Burnaby in British Columbia, examined in Chapter 1.

Toward the end of Chapter 1, two concepts are examined relating to a vision for the future: sustainable development and resilience. Sustainable development, popularized in 1987 with the publication of *Our Common Future*, the report of the World Commission on Environment and

Development, has provoked much debate because different groups interpret it in ways that favour their values and interests. Despite conflicting views about what sustainable development means, it frequently appears in policies related to the environment and natural resources. Thus, it is important to have a critical appreciation of its strengths and limitations. Resilience is the second concept proposed as a guiding concept for development and environment in the future. Resilience has been gaining in popularity in many areas of the scholarly and scientific literature, but what does it really mean, and how can it be enhanced? Our intent here is to ensure that you understand both these concepts, and their implications.

Needless to say, the global situation is infinitely more complex than sustainability or resilience alone. Thus, Chapter 1 provides an overview of the global situation with regard to environment and society. What are some of the main trends pointing to future directions? Although disagreements exist about the rate and severity of environmental change, few claim that overall conditions are improving. One indicator is population growth. The United Nations (2017) reported that the global population of 7.6 billion people in 2015 was expected to grow to 9.8 billion by 2050 and to 11.2 billion by 2100.

Another important dimension that has only shown growth, however, is resource use, fuelled mainly by the demands of consumers in developed countries—we are reminded of the old comic strip *Pogo* in which the title character, a possum living in a swamp, famously proclaimed, "We have met the enemy, and he is us." If there is one fundamental message that we would like to convey, it is that the power of individuals to make decisions on a daily basis can reduce these pressures. Canadians have much to contribute in this regard, since we are among the most profligate consumers of energy and water in the world and are also among the most prolific producers of waste. Our society has developed into one of the most wasteful on the planet. Only we can turn that around.

In Chapter 2, we explore how governance institutions have historically responded to environmental change and challenge, both internationally and domestically, within Canada. The jurisdictional and governance arrangements for environmental management in Canada strongly influence our relationship with the environment. Such arrangements are rarely taken into account by scientists and environmentalists, but they can be the most important factor when considering how and when a particular problem is going to be addressed. Canada is a large country, and the various levels of government (federal, provincial/territorial, municipal, Indigenous) are complex and often work poorly together. This is compounded by the short-term nature of political leadership and different political parties' various approaches for responding to environmental change and challenge. We also need to consider the roles and responsibilities of the corporate and education sectors.

Whether the context is global, national, or regional, we are interested in measuring our progress in addressing environmental change, in terms of, for example, the UN Sustainable Development Goals and the concept of ecological footprint, both examined in Chapter 2. As noted earlier, however, the situation is very complex, with far more variables, interactions, and changes than can be readily measured. The second chapter thus discusses how we try measuring progress through the use of indicators and outlines various kinds of indicators and their strengths and weaknesses.

The chapter ends with a simple framework that summarizes the process of resource and environmental management. Throughout the book, we return to this framework to illustrate deficiencies in understanding or lack of connection between different elements of the framework.

Part A thus provides an overall introduction to environmental change and challenge with reference to global, national, and regional levels. Most of the remainder of the book concentrates on Canada, although we consider global aspects throughout. Part B provides an overview of the main environmental processes we need to be familiar with to understand many environmental problems. Part C discusses some dimensions and best practices of various aspects of resource and environmental management. In Part D, we discuss various thematic aspects of resource management, such as fisheries, forestry, water, and climate change. The final section (the Epilogue) addresses some of these themes and notes what individuals can do to effect change for the better in the environment of tomorrow.

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1 Environment, Resources, and Society

Learning Objectives

- To appreciate different perspectives related to environment and resources
- To understand the implications for change, complexity, uncertainty, and conflict relative to environmental issues and problems
- To appreciate the concept of "wicked problems"
- To recognize the implications of the Anthropocene
- To understand the nature of human population growth
- To appreciate the impacts of over-consumption on global ecosystems
- To distinguish among disciplinary, cross-disciplinary, multidisciplinary, interdisciplinary, and transdisciplinary approaches
- To learn about various considerations that must be addressed to bring science to bear on environmental and resource problems
- To understand the significance of sustainable development and resilience

Introduction: Change and Challenge

We are currently facing unprecedented concern regarding environmental changes and challenges. In the context of complex global challenges, particularly the changing climate, many people are increasingly concerned about the fate of human society, other species on the planet, and the overall health of the planetary ecosystem. However, some deny climate and other changes are occurring, and resist initiatives designed to slow down or reverse such trends. Yet many of the environmental changes and challenges we face also offer opportunities—if we could perceive them as such.

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Perspectives on the Environment

Climate Change as Opportunity

We have completely mischaracterized our response to the climate emergency as something that doesn't help the economy. You have the biggest global economic opportunity in the history of humankind in moving off fossil fuels as quickly as possible.

—Elizabeth May, Canadian Green Party Leader

Several examples highlight changes, challenges, and opportunities related to resource and environmental management. As an example of a change and opportunity, Reuters (Davey, 2018) reported that in April 2018 more than 40 companies in Britain, including Procter & Gamble, Nestlé, Coca-Cola, and the largest supermarkets had joined the UK Plastics Pact, led by a sustainability group called WRAP (Waste and Resources Action Programme). Its goal was to eliminate by 2025 single-use plastic packaging and to ensure that by then all plastic packaging was reusable, recyclable, or compostable. In addition, the member companies committed to reach a target of recycling or composting 70 per cent of plastic packaging and that all of their plastic packaging would contain an average of 30 per cent recycled content. The UK Plastics Pact aligned with Prime Minister Theresa May's 2018 pledge that by 2042 Britain would eradicate avoidable plastic waste.

Then, on 31 October 2018, the 28 member countries in the European Union (EU) agreed to make illegal the use of specified single-use plastics. In the previous week, an overwhelming majority of EU members had agreed to ban single-use plastic straws, cutlery, cotton swab sticks, and similar items. The EU plans legislation which would be approved and become law in 2021.

In Canada, on 1 January 2018, Montreal became the first major city in the country to ban distribution of plastic bags. The ban focuses on lightweight plastic bags less than 50 microns thick, as well as biodegradable plastic bags containing an additive which causes them to decompose under heat and light. Exceptions are given for thin bags used in grocery stores for wrapping meat or carrying fruit and vegetables. The intent is to change behaviour and have people shift to reusable rather than single-use bags. Merchants were given six months to comply with the ban, after which an individual using non-recyclable plastic bags could be fined up to $1,000 and a store could be fined up to $2,000 for a first offence. In Victoria, British Columbia, a similar ban took effect in July 2018, and various smaller communities had already initiated such bans. On 1 July 2019, the Plastic Bag Reduction Act (Bill 114) came into effect in Prince Edward Island, making it the first province to ban most single-use plastic bags. To encourage the use of reusable bags, for example, the act prohibits PEI businesses from providing plastic checkout bags to their customers for most products.

Companies also are taking related initiatives regarding plastic bags. For example, in August 2019, Sobeys announced that all of its Canadian stores (more than 1,500 across all of its chains) would phase out the use of plastic bags no later than February 2020. The intent is ultimately to stop providing plastic bags in its produce aisles and provide mesh alternatives made from recycled bottles. Thus, many opportunities exist for both the public and private sectors to reduce the amount of plastic being discarded into the waste management system.

At a global scale, pressure on dealing with plastics increased on 31 December 2017 when China decided to stop importing non-industrial plastic wastes (Brooks, Wang, and Jambeck, 2018). It is estimated that 2 million tonnes of plastic were manufactured in 1950, a figure which had grown to 322 million tonnes in 2015. And, only 9 per cent of plastic is recycled at a global scale, with most being placed into landfills or simply discarded, including 4 to 12 million tonnes ending up in oceans. It has been estimated that between 1992 and 2017, China had imported more than 105 tonnes of plastic, and nations such as the United States, Japan, and Germany relied heavily on shipping used plastic to China. With China no longer accepting waste plastics, and other countries such as Thailand, Vietnam, and Malaysia, which also have accepted discarded plastics from other countries, considering restrictions on imports of plastics, pressure will grow on many countries to find innovative ways to handle used plastics.

Another significant initiative began in May 2019, when, after 12 days of negotiations at a United Nations Environment Programme meeting held in Geneva, 180 countries, not including the United States, agreed on a strategy intended to significantly reduce the amount of plastic ending up in oceans (DW, 2019). A legally binding agreement requires these countries to monitor and track thousands of different types of plastic wastes beyond their borders. This new agreement is an update of the Basel Convention of 1989 intended to control hazardous waste, including plastics. As one science advisor commented, "For far too long developed countries like the US and Canada have been exporting their mixed toxic plastic wastes to developing Asian countries claiming it would be recycled in the receiving country. Instead, much of this contaminated mixed waste cannot be recycled and is instead dumped or burned, or finds its way into the ocean" (DW, 2019). The agreement signed in Geneva is intended to change such behaviour.

On 10 June 2019, the Canadian government announced a plan to ban harmful single-use plastics beginning in 2021, to reduce the millions of tonnes of plastic waste annually ending up in oceans. This decision accelerates the timeline to reduce such plastic waste in the oceans; at the 2018 G-7 summit, Canada, along with France, Germany, the United Kingdom,

and the EU signed an Ocean Plastics Charter, committing that by 2040 all plastic produced in each of their countries would be reused, recycled, or burned to generate energy. This initiative is discussed in more detail in Chapter 9.

Water shortages are another challenge in many parts of the world. One example is found in Cape Town, South Africa. After two years (2013 and 2014) of plentiful winter rainfall, drought conditions began in 2015 and continued into 2018. This period of unusually dry weather alerted Cape Town officials to the vulnerability of its water supply system. This challenge was partially driven by the rapid population growth in the city, from 2.4 million in 1995 to an estimated 4.3 million in 2018. Thus, over 23 years the population had grown by almost 80 per cent while water storage capacity had increased by only 15 per cent. A further complication is that a significant proportion of the population lives in "informal settlements," with little or no infrastructure, meaning many homes are not connected to water supply or sewage systems, making those residents highly vulnerable.

In February 2018, Cape Town stated it was likely to become the first major urban city in the world to run out of water. At that time, the six reservoirs providing water to the city were down to 28.7 per cent of their capacity, and it was estimated that "Day Zero" would be 21 April 2018—the date on which the municipal water supply would be shut down. One reason for the announcement of the impending Day Zero was that less than 40 per cent of the city's population had moderated their daily behaviour to use no more than 87 litres per person. However, later that month, city officials stated that, due to a decrease of over 50 per cent in per capita water use, Day Zero was postponed until 4 June, and subsequently announced that it would not occur until sometime in 2019.

Various information campaigns helped to stimulate changes in behaviour. For example, people were asked to limit showers to 90 seconds, to use runoff or "grey water" for flushing toilets to remove faeces, and to flush only occasionally to remove urine. As well, a multi-stage strategy was developed: in the first stage, water was rationed through reduction of water pressure; in later stages, water was available only at 149 identified places, limited to 50 litres per capita per day, to be reduced to 25 litres if necessary. In addition, agricultural users of water curtailed their use by 50 per cent, but with an associated loss of 37,000 jobs tied to agriculture.

Reflecting on the experience, Walton (2018) observed that, following the panic in January 2018, the date of Day Zero steadily was moved further back because total demand, which had been holding at about 600 million litres/day, began to fall and settled at about 500 million due to the various restrictions and higher water rates. In addition, from October 2017 to May 2018 city workers installed over 46,000 water control devices that limited the amount of water entering homes using over 10,500 litres each month.

Walton (2018) also reported that various initiatives were expanding water supply capacity. One project, with construction scheduled from 2019 to the end of 2021, would draw surplus flows during the winter from the Berg River. Another initiative is to drill for groundwater. Three aquifers have been identified, and it was anticipated that drinking water could be drawn from the Cape Flats Aquifer by September 2018. However, this plan failed due to poor water quality in that aquifer, as well as political struggles among government parties.

Several other actions were identified, but would take longer to achieve. At the time of the water crisis, only 8 per cent of the water in Cape Town was being recycled, with the rest being discharged into the ocean. A second approach would be to develop desalinization capacity, the most expensive way (per litre of water) to augment supply. Three very small desalinization units producing 16 million litres per day were scheduled to begin operating in 2018, but these plans were placed on hold. In the longer term, Cape Town will consider constructing a much larger desalinization plant which could produce 120 to 150 million litres daily. Such a plant would provide a reliable but costly source of water, especially because it would use significant energy. In South Africa, coal-fired electricity plants produce 90 per cent of the energy in the country, and such plants use significant volumes of water as well as leaving a very high carbon footprint.

If all these projects were implemented, Walton (2018) stated that by 2021 they would enhance the water supply for the city by 350 million litres per day. In addition to such supply-side solutions, work will continue to reduce consumption of water by residents and businesses in Cape Town. However, it has been recognized that the sharp restrictions on household water use, while manageable in the short term, caused discomfort and thus are not likely to be sustainable. Furthermore, they were seen to further exacerbate inequality, with many households not even having access to running water.

The Cape Town experience is not unique, and such scenarios are likely to become more common in the future. For example, in May 2018, São Paulo, Brazil, was on the verge of a similar crisis, and, closer to home, the east coast of Vancouver Island, with the exception of Victoria, was placed under the most stringent water-use regime in August 2018, with no appreciable rainfall having fallen in the previous two months.

The above examples—reducing use of plastics in Britain, Canada, and elsewhere; the decision by China to stop accepting discarded plastic; and consumption of water in South Africa—were chosen because all of us can relate to them, and individuals can make a difference. However, they also illustrate that while changes in individual behaviour can have an impact, initiatives are often also required in the private and public sectors to place the use of resources and our environmental impact on a different trajectory.

The example from South Africa also illustrates that natural systems can and do change. Furthermore, strong evidence exists that human activities often are a main driving force behind environmental change, and many changes are

Perspectives on the Environment

On Change

There is nothing wrong with "change," if it is the right direction.

—Winston Churchill, British prime minister (1940–5, 1951–5)

There is nothing more certain and unchanging than uncertainty and change.

—John F. Kennedy, president of the United States (1961–3)

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Flooding followed by drought has significantly reduced the grain crop growing in this field in Manitoba.

happening more abruptly and with greater magnitude than previously. They threaten societal well-being, and society needs to respond thoughtfully and deliberately.

Changes also occur as a result of shifts in human values, expectations, perceptions, and attitudes, which may have implications for future interactions between societies and natural systems. The value of the world economy has increased more than sixfold in the past 40 years. This increase was not merely the result of population growth; the chief cause has been increased **consumption**. Expectations have changed. Things seen as luxuries 60 or 70 years ago, such as TVs and automobiles, can now be found in some of the most remote societies on Earth.

Changes in natural and human systems generate challenges. If we wish to protect the integrity of biophysical systems yet also ensure that human needs are satisfied, questions arise about how to determine ecosystem integrity and how to define basic human needs. Such questions force us to think about conditions both *today* and in the *future*. Such questions also remind us that an understanding of environmental and resource systems requires both natural and social sciences. Neither alone provides sufficient understanding and insight to guide decisions.

In this chapter, we begin by examining the Trans Mountain pipeline project, designed to increase capacity to move petroleum products from Alberta to Burnaby in British Columbia. This case study connects not only to the detailed discussion of global climate change in Chapter 8, but also to many other topics throughout the book. It highlights that managing natural resources and the environment involves a mix of considerations, not just technical ones. The case study vividly demonstrates that decisions are often made in the context of changing conditions, conflicting interests and values, trade-offs, and uncertainty. These conditions apply not only to the Trans Mountain proposal or, indeed, to Canada generally, but also to the global stage. In this context, we subsequently provide an overview of some major environmental trends and the main issues that arise. There is no doubt that human population growth is a stress on this planet, but so are the consumption patterns of the more affluent sectors of society. These factors are leading to unprecedented changes in global systems.

The changes taking place are often very complex. It is important that we grasp the essence of major changes and act accordingly. We thus conclude the chapter by explaining what we mean by "environment," "resources," and "society" and then consider alternative ways to understand systems, issues, and problems, as well as identify some key considerations regarding how scientific understanding and insight can be used to inform resource and environmental management and decisions.

Case Study: Trans Mountain Pipeline

Context

The Trans Mountain pipeline project, running from Alberta to the southwestern coast of British Columbia, highlights the reality that resource and environmental management often involves much more than scientific and technical considerations.

Patrick Gillin/Alamy Stock Photo

A rally was held in Vancouver in November 2016 to oppose the Trans Mountain pipeline project.

Indeed, while the proposed pipeline predictably generated protests from certain constituencies, such as environmentalists and some Indigenous peoples, it also triggered major conflict between the provincial governments of Alberta and BC and raised fundamental questions about the role of the federal government in interprovincial resource development projects.

Kinder Morgan announced in May 2012 that it would expand its existing Trans Mountain pipeline from Strathcona County in Alberta, near Edmonton, to Burnaby, BC. The intent was to create additional capacity to allow more petroleum products from Alberta to reach new markets. The project, initially estimated at $7.4 billion ($9.3 billion by mid-2018), would involve a twinning of the 1,150 km pipeline built in 1953 (Figure 1.1). About 980 km of new pipeline would be added, increasing the capacity of 300,000 barrels a day in the original pipeline to 890,000 barrels per day. Almost three-quarters of the route for the new twin pipeline would follow the right of way for the original pipeline, and would create capacity to load about 34 ocean tankers a month at the terminal in Burnaby. A significant motivation was that nearly all oil from Western Canada had been going to only one market—the United States—for a price significantly lower than that in other international markets.

The original pipeline carries refined products, synthetic crude oils, and light crude oils, while the new pipeline would carry heavier oils. Heavy oil, also referred to as bitumen, is too thick and sticky to flow unless heated or diluted with lighter hydrocarbons. As well, it normally contains more sulphur, metals, and heavy hydrocarbons than conventional oil does. A major challenge is that if there is a spill, heavy oil is more difficult to remove from waterways than light crude oil, which floats on the surface of water; much of the heavy oil sinks beneath the surface. In 2018, Canadian researchers found many negative impacts of bitumen on juvenile salmon, including delayed hatching, increased mortality, increased deformities, and changes in growth and energy stores. Almost half the salmon studied died within two months of exposure to bitumen levels equal to those found in the Gulf of Mexico after the 2010 *Deepwater Horizon* spill (Alderman et al., 2018).

FIGURE 1.1 Trans Mountain pipeline route.

Source: Vancouver Sun

Perspectives: Provincial, Federal, and Indigenous

The Trans Mountain project, originally to be built by Texas-based Kinder Morgan, was approved by the federal government in 2016 following a multi-year environmental assessment process. Rachel Notley, leader of the provincial New Democratic Party (NDP) and premier of Alberta from 2015 to 2019, was a strong advocate for the pipeline, given petroleum's significant role in Alberta's economy. In contrast, John Horgan, premier of BC since 2017 and leader of a minority NDP government supported by the BC Green Party, is strongly critical of the pipeline. During the 2017 BC election he committed to oppose the Trans Mountain pipeline twinning unless a guarantee was provided that spills from the pipeline would be cleaned up properly, because the provincial government had a responsibility to protect BC's coastal and inland waters. Although the previous BC Liberal government had approved the pipeline twinning, Horgan's government asked the BC Court of Appeal to decide whether the BC government had authority to create and apply environmental legislation to restrict movement of diluted bitumen through the province. In late May 2019, the Court ruled that the BC government has no such authority because the federal government has exclusive jurisdiction related to interprovincial pipelines. The BC government indicated that it would appeal to the Supreme Court of Canada.

Prime Minister Justin Trudeau has argued that the pipeline is in the national interest and that it is possible to achieve both economic development and protection of the environment. In his view, establishing a price for carbon pollution across the country and creating incentives for development of lower-emission cars, along with investing in public transport infrastructure, would reduce carbon emissions while still facilitating economic development through initiatives such as the Trans Mountain pipeline.

However, his support of the pipeline led some to question his commitment to lowering greenhouse gas emissions to reduce climate change risks (see also Chapter 8). In that context, he claimed that federal support for the Trans Mountain pipeline would in turn ensure Premier Notley's necessary help in developing a national climate change plan. The federal Conservative party, the official opposition, argued that the federal government had constitutional authority related to interprovincial projects such as pipelines, and therefore should move quickly to ensure the twin pipeline was built. In contrast, Jagmeet Singh, leader of the federal NDP, called on the