Preface

"Civilization exists by geological consent, subject to change without notice."

Will Durant, American philosopher and writer (1885–1981)

We have a troubled relationship with our home planet. While we depend on it for the air we breathe, the water we drink, the soil that grows our crops, and the minerals and energy we consume, we also exploit and despoil its resources with little thought for the future. We're rapidly depleting freshwater aquifers and mineral deposits that took the Earth thousands to millions of years to develop. Too often, we build our homes, factories, and power plants in vulnerable areas, next to earthquake faults, volcanoes, and low-lying areas prone to flooding. We use energy in ways and amounts that have harmful consequences. Rather than choosing to fit ourselves into the planet's ecosystem and use its resources sparingly, we have chosen a more confrontational approach.

Astronomical observations suggest that numerous planets in our galaxy have the conditions necessary for life. Given the immense size and age of our galaxy, we might expect that at least a few of these planets have developed advanced civilizations, but there is no evidence of this. The conundrum is known as Fermi's Paradox, after atomic scientist Enrico Fermi, who famously said, "Where is everybody?" Astronomer Carl Sagan speculated that any planet that developed an advanced civilization would soon destroy itself, either through war or environmental degradation.

Politicians and diplomats have the job of preventing war. Scientists have the job of educating the public and government officials about the planet and its ecosystems, and how we can do a better job of "fitting in" to our environment. Designing, locating, and building our infrastructure so that it's tough enough to meet nature's demands, but is also kind to the planet's ecosystems, are important aspects of fitting in. This book describes some of our most important successes and failures in these areas.

In the last decade, three major disasters unfolded in areas where I have some professional background: the 2005 flooding of New Orleans associated with Hurricane Katrina; the 2010 earthquake in Haiti; and the 2011 earthquake and tsunami in Japan. I had worked in New Orleans and Haiti prior to those two events, doing research on the geological processes that ultimately contributed to the disasters (subsidence and sea level rise in New Orleans; plate motion and earthquake strain accumulation in Haiti). In the two cases I worked on directly, I was struck by the fact that scientists "in the know" knew these disasters were inevitable, but felt powerless to do anything about them. The public was largely ignorant, and government officials, policy makers, and in Haiti's case, aid agencies, were focused on issues deemed more immediate. Many businesses were uninterested or even hostile to the warnings of scientists. Similar problems appear to apply to Japan's recent nuclear disaster and to many environmental issues. A big part of the problem is communication, or more specifically, its lack. Many scientists are not very good at communicating their knowledge of risk to the public, including the long-term consequences of building things in harm's way or designing them to inadequate standards. Equally culpable, some politicians, some members of the media, and some members of the public are not especially good at listening to scientists who discuss these issues. Scientific literacy seems to be on the decline in modern society, which is odd given our increasing use of and dependence on technology that ultimately comes from science. Aspects of the current debate about energy use and global warming similarly reflect poor communication among scientists, policy makers, the media, and the public, and failure of the last three groups to adequately consider long-term trends.

This book attempts to address these problems. It discusses issues on the boundary between science, business, and government, including costs, risks, and mitigation strategies for natural and human-made hazards. I describe examples where scientists have been called on to give policy advice on these hazards, why this advice is sometimes taken and sometimes ignored, and the economic and human consequences of following or ignoring that advice. I describe examples where scientists got things right and where they got things wrong. I suggest some reasons why humans tend to ignore obvious, long-term problems; suggest how scientists might overcome this tendency; and make specific suggestions on how to improve information flow, decision making, and transparency. In addition to hind-casts (in-depth forensic analysis of past disasters, known to my critics as Monday morning quarterbacking), I also make some forecasts. Some of these forecasts will be controversial, but hopefully will spur debate, additional research, and much-needed public and private action.

This book has three main themes, all related to natural or human-made disasters: the importance of communication, the importance of understanding long-term processes and time scales, and the economic consequence of failure. I'll wrestle with what long-term means in later chapters, but for now let's define it as anything longer than a typical human life span. The concept of time lag is another recurring theme. It's used to explain why cities are often located in areas now considered unsafe (Chapter 3), why the price of oil goes through such large swings (Chapter 6), and why it's so difficult for scientists to explain the dangers of global warming (Chapter 8).

Like most authors, I have some biases. I am a geologist, so I tend to view many issues through the prism of Earth science and the common sense approach inherent to my discipline. Although the book aims at a global focus, I live and work in the US, a country that – because of its size, location, and geologic setting – experiences many natural hazards, including hurricanes, tornadoes, earthquakes, tsunamis, and volcanic eruptions. This range of extreme natural phenomena makes the country a useful "natural laboratory" for some of our discussions.

This book doesn't focus exclusively on natural hazards, nor does it provide a catalog of disasters. Rather, I focus on a few examples to illuminate common themes. Natural disasters, as well as the human-made kind, often share several features, including poorly designed infrastructure. Shining a spotlight on these common features can curb catastrophes for future generations. Otto von Bismarck, chancellor of Prussia and later Germany in the late 19th century, once said, "Only a fool learns from his own mistakes. The wise man learns from the mistakes of others." My hope is that this book will help all of us learn from past mistakes.

The book is intended for a general audience. High school math – or better yet, simple common sense – is adequate preparation. Throughout the book, separate sections ("Boxes") provide further detail for interested readers; consider it my attempt at a "Director's Cut". An online appendix entitled "Exercises for Students " is available as an electronic supplement from the publisher. It includes additional background material and example problems that are suitable for introductory undergraduate classes in natural hazards, geology, geography, climate change, and environmental science.

Chapter 1 gives an introduction and overview of major issues. Some of these are covered in more detail in later chapters, such as the cost of the earthquakes in Japan and

Haiti, and the various missteps that contributed to these horrific disasters. Chapter 2 discusses what I mean by the term "natural hazard" and describes the underlying science. Readers with a background in Earth science will be familiar with most of this material. This chapter also makes the case that natural and human-made disasters are not so different. Both often have root causes in things like bad design, bad engineering, bad management, or failure to think long term. The solutions to preventing both types of disasters are also often similar (improved infrastructure). Chapter 3 looks at why our scientific understanding of hazards does not always translate into effective action. I emphasize the importance of having a good long-term record when assessing a given hazard, and I provide an introduction to the measurement techniques that scientists use to obtain these records. Chapter 4 applies the lessons of Chapters 2 and 3 to the recent Japanese earthquake, tsunami, and nuclear plant failure, and describes an eerily similar event that took place years earlier that should have been a wake-up call for the nuclear industry. I argue that both nuclear disasters were preventable given knowledge available at the time, a position that remains controversial. Chapter 5 describes the possibility of future earthquake and tsunami disasters in several other areas, including the US Pacific Northwest; Geneva, Switzerland; and Istanbul, Turkey.

Chapter 6 considers the larger issue of nuclear power relative to other power sources, including coal, and uses this issue to introduce the concept of relative risk. I argue that nuclear power should remain on the energy table as an important carbon-free option, a stance that is not popular with many environmentalists. Chapter 7 discusses flood disasters, including examples from the US (Galveston, Texas and New Orleans, Louisiana) and Bangladesh, and considers how future flood risk will be exacerbated by sea-level rise. Chapter 8 reviews the cause of sea-level rise (global warming) and how this topic got to be so contentious. This chapter makes the case that global warming has similarities to some of the other more immediate disasters discussed in earlier chapters by focusing on the themes of scientific communication and the importance of considering long-term processes and economic consequences. Improved infrastructure (in this case for transportation and energy generation) is also relevant. The last chapter offers specific solutions, including a summary of recommendations.

Communication is a major theme of this book and is mentioned in almost every chapter. It is a two-way street: It is important for scientists and engineers to clarify complex subjects and crucial for the media, the public, and government officials to be active and engaged listeners. Communication also means different things to different people, and there are different levels of communication, from being informed to being strongly engaged. At the most basic level, it means transferring useful information. In several places, I assert that scientists need to do a better job of transferring information into the public domain. As an example of a deeper level of communication, a citizen activist could take information from this book, such as the scientific and engineering background related to the Japanese earthquake and nuclear disaster, or the environmental consequences associated with coal-fired power plants, and use it to influence public policy.

Notes and References

Most nonfiction books and scientific articles make extensive use of footnotes and references that list relevant published work. While this allows interested readers to follow up on specific issues and gives proper credit to previous researchers, it can also make for cumbersome reading.

Here I've avoided footnotes and most references within the text wherever possible. Instead, relevant work for each chapter is compiled at the end of the book. In most cases, the link between specific points in the text and a given author's work should be clear from the title. In cases where this is not clear, I have either called out specific references in the text, with the author's last name and publication year in parentheses, or made a comment in the reference list itself.

Color Figures

In order to keep make the book more affordable, figures are reproduced in black and white. The original versions of some of these figures are in color. The color versions for most of these are available on the author's web site (http://labs.cas.usf.edu/geodesy/).

Conflicts of Interest

Throughout the book, and especially in the last chapter (Solutions), I make a case for transparency, particularly with regard to funding sources. If people have access to more information and are aware of potential conflicts of interest when experts give their opinion, then better, more informed decisions can be made. So here goes for me: In the last two decades, I have received research funding from the US National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), the Office of Naval Research (ONR), the Department of Energy (DOE), and British Petroleum (BP). I have also received an honorarium from the American Association of Petroleum

Geologists (AAPG) for a series of public lectures. I have been involved in the governance of two scientific organizations, the American Geophysical Union (AGU) and the American Association for the Advancement of Science (AAAS), and am also a member and Fellow of the Geological Society of America. Where specific conflicts exist, I will call them out in the text, usually beginning with the phrase “full disclosure”.