

Learning to Live with the Dangers of Sudden Environmental Change

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Human communities around the world are increasingly worried about the dangers of sudden environmental change. This book aims to illustrate how the full time depth of human experience can reveal the nature of these dangers and help build long-term sustainable societies. The diversity in human cultures across the past few thousand years is extraordinary, from small groups of hunter-gatherers to chiefdoms and states to empires with populations in the millions. The diversity of environments within which they lived is equally impressive, from deserts and oases through Arctic tundra to tropical rainforests with the greatest biomass and biodiversity of any terrestrial environment. Given this dual diversity, there are no recipes for evaluating how a culture should successfully adapt to its environment. But there is a phenomenon common to both cultures and environment, and that is change. Societies change as populations increase, for instance, and systems of authority emerge and strengthen as egalitarianism fades. In addition, societies affect their environments, sometimes for the better but often to the detriment of soils, flora, and fauna. Environments change on a short-term basis (weather and seasonality) and on a long-term basis (climate), and human societies of all kinds learn to adjust to those changes. Societies adjust to most environmental changes with little difficulty, as flexibility is built into adaptation. However, some changes are of such magnitude that societies are deeply affected by them, and the post-stress society is recognizably different or in some cases simply does not survive.

The most severe environmental changes, which massively impact societies, are often called “natural disasters.” To find a truly and solely natural disaster, we would have to find an event that did not involve people, such as the K/T asteroid impact that killed off the dinosaurs 65 million years ago. Some studies of “natural disasters” emphasize the natural component and neglect the human social component, and, as discussed later, natural scientists and engineers receive most of the funding in disaster research. However, the authors in this book believe deeply that sociocultural factors are essential in understanding risk, impact, resilience, reactions, and recoveries from massive sudden environmental changes. Therefore we prefer the term *disaster* to *natural disaster* when people are involved.

Many disasters originate in the form of a force from nature, such as an earthquake, cyclone, tsunami, volcanic eruption, drought, or flood. But that is half of the story; people and their cultures are the rest of the story and must be as closely studied. How people distribute themselves across the landscape, how they feed themselves, how authority is structured, their perception of risk, their experience with earlier disasters, and the oral or written history of them are all crucial factors in how a society handles a disaster and how it recovers from it, or not.

The documented impacts of disasters have been huge in the past, and with worldwide populations increasing—often dramatically in hazardous zones—impacts are growing in the present and will continue to do so into the future. According to statistics gathered by the United Nations, every year about 200 million people are directly impacted by disasters (Mauch and Pfister 2009). That is seven times the number of people affected by wars per year.

Disasters are the stock-in-trade of many movies and TV shows and are becoming ever more horrendous with increasing special-effects sophistication. Of course, the popular media emphasize death and destruction, panic, looting, and personal suffering of physical and psychological natures. Some disasters are even credited with the end of civilizations. One would hope that the broadcast and print news media would deal with disasters in a more balanced manner, and occasionally they do. But a Central American journalist let one of us (PS) in on what he called international journalism’s best-kept secret: journalists in any country greatly exaggerate the disasters in other countries, so no matter how bad living conditions are in their country, they appear worse elsewhere. Social science studies of disasters do record suffering, but the studies that go beyond the immediacy of the impact generally find remarkable resilience and recovery. In addition, disasters have a creative aspect in that people can learn from them and adjust their culture to be better prepared for them in the future. Oral histories and religious beliefs can incorporate the extreme phenomena, so the precursors can lead to evasive action.

HAZARD-DISASTER RESEARCH

Using disasters as a means to explain major changes in people and their societies is common to many of the world's cultures. The biblical accounts of the flood and Noah's ark saving his family and fauna are known to all. Sumerian and Babylonian flood legends, also destroying evil and saving a few good people and animals, are older than the biblical flood, as they date back well over three millennia. Perhaps the traditional chasm between religion and science has inhibited many social scientists from serious study of disasters, combined with the overly dramatic popular media accounts.

Systematic study of disasters began with the work of Gilbert White (1945), a cultural geographer who studied the Johnstown, Pennsylvania, flood in terms of the physical phenomenon and how people and their culture affected their vulnerabilities. White began the comparative study of disasters in the social sciences, and he contributed an applied dimension of planning to reduce people's risks to future flooding. White's work clarified the distinction between disaster and hazard. The disaster is the actual catastrophic event, while a hazard is a disaster "waiting in the wings" and therefore subject to study, risk perception, and planning for mitigation of impact when the disaster actually occurs. White was the first to combine physical phenomena with cultural factors in an integrated fashion.

As cases grew, patterns were perceived, and as general interest in human ecology surged during the second half of the twentieth century, social scientists saw the need for theory building in the hazard/disaster field. A seminal volume by Ian Burton, Robert Kates, and Gilbert White (1978) contributed a framework for understanding and comparing relationships among people, societies, and sudden massive stresses. In it the authors relate external stresses to adjustments people make and identify three key thresholds. With a relatively minor stress, they suggest the minimal adjustment people make is Loss Absorption, which occurs after the first threshold of Awareness is crossed. Basically, people accept the losses, make minor changes, and get on with their lives. With greater stress the threshold of Direct Action is crossed, and Loss Reduction is the result. People deliberately do what they decide is necessary to deal with the significant changes in their natural and social environments. Still greater stress crosses the threshold of Intolerance, and people decide to take Radical Action. An example of Radical Action would be refugees deciding to migrate from the area of a disaster to a very different area, necessitating major changes in their society, their adaptation, or both.

Current social science research on hazards and disasters owes much to the early work of White and his associates. Their work has stimulated federal funding for hazard-disaster research, but ironically the predominance of support has favored the physical sciences and engineering. David Alexander (1995) surveyed the field and found that 95 percent of funding went to the physical and

technological sciences, leaving only 5 percent for the social sciences. Alexander (1997) also explored the diversity of disciplines conducting disaster research and found a surprising total of thirty, ranging from the humanities through the social sciences to the physical sciences and engineering. The predominance of research focuses on the physical forcing mechanism, the immediacy of the disaster, and technological means of mitigating similar disasters in the future. Relatively rare are longer-term studies that trace the effects of a disaster and human responses to it. Some humanistic scholars in history have begun to do what they consider to be long-term studies of disasters, covering a decade or more (Mauch and Pfister 2009). Archaeologists can certainly expand on that time frame. And all disaster research fields can learn from the patterns and insights Mauch and Pfister provide.

ARCHAEOLOGICAL CONTRIBUTIONS TO DISASTER STUDIES

As long as archaeologists have been excavating settlements and recording stratigraphy, they have encountered evidence of disasters. The evidence takes the form of a volcanic ash deposit, alluvium from flooding, walls collapsed from an earthquake, or loci abandoned because of drought. From the late nineteenth century until fairly recently, ash or flood deposits were viewed as temporal horizon markers or stratigraphic separators of cultural materials. Or in some cases they were examined as disasters, and some were ascribed causality in the decline or collapse of cultures or civilizations. Until recently they were described and interpreted as single cases and dealt with in atheoretical ways. A few surveys and assessments of the field of archaeological studies of disasters have been published, and they provide a means to understand the development of the field and explore ways in which future studies could be conducted.

The earliest survey of archaeological disaster studies was done in the late 1970s (Sheets 1980). That paper pointed out the above-mentioned shortcomings and emphasized the opportunities for archaeologists to do comparative analyses and take advantage of great time depths in studying disasters. It lamented the paucity of studies that combined natural and social science examinations of disasters and their aftermaths. Mary van Buren (2001: 129) conducted a survey of the field two decades later and noted that “archaeological research on disasters had increased substantially since Sheets’ 1980 review of the topic.” She noted the continued contributions by cultural geographers to disaster studies, in particular with the concept of vulnerability—that is, how people perceive hazards, deal with disasters, and recover from them. Vulnerability has economic, religious, political, social, and demographic aspects. These can become acute with the growth of populations as the disenfranchised lowest levels of societies are relegated to the most hazardous locations, in floodplains, for instance. She also noted that modern ecological concepts can contribute

to future research but stated that a limiting factor is the persisting paucity of theory. Sheets (2008) has made some attempts in theory building, comparing three dozen cases of explosive volcanism affecting egalitarian to state-level societies in Middle America and beginning to see some patterns in factors that support resilience and other factors that increase vulnerability.

John Grattan and Robin Torrence (2007: 1) recently conducted a survey of the field and noted a “boom in archaeological research focused on the effects of ancient catastrophes on culture change.” They listed six books published on the topic during the four-year period 1999–2002, and the publications have not diminished since their survey was completed. They note that social factors are handled in a more thorough manner in disaster studies than was the case in past decades. They suggest that disaster studies move beyond emphasizing the “gloom and doom” of the most dramatic immediate impacts. Disasters have creative aspects, as people learn from their experiences and adjust their adaptations. Unfortunately, modernization can lead to the loss of oral history and useful knowledge, an observation that resonates in the chapters that follow.

We take it as a salutary sign that the Geological Society of America is publishing some social science chapters in its geological volumes. For instance, six chapters by social scientists were published on volcanic-human interactions and social issues in the volume *Natural Hazards in El Salvador* (Rose et al. 2004).

LIVING WITH THE DANGERS OF SUDDEN ENVIRONMENTAL CHANGE—ORIGINS OF THIS BOOK

As McGovern’s foreword to this book suggests, the origins lie in a session on Hazards and Disasters at the Global Human Ecodynamics meeting in Eagle Hill, Maine, USA, in October 2009. Preparation for this session began with a month of on-line discussion among the eight contributors focused on three pre-defined themes of challenges, contributions, and future research that culminated in a combined group presentation to colleagues and government representatives at Eagle Hill. Each contributor brought together a combination of historical, archaeological, paleoclimatological, and environmental data from his or her selected case study to examine the role of societal context in the relative experience and varied impact of environmental hazards and disasters. This book maintains this group approach, which, we hope, can facilitate direct comparison between different case studies and enable an informed conceptual understanding of the different ways human communities have lived with the dangers of sudden environmental change. By utilizing the deep time perspectives of our interdisciplinary approaches, this book provides a rich temporal background to the human experience of environmental hazards and disasters.

The book provides eight separate case studies, each examining how one past human community has faced the impacts of sudden environmental change. Different cases of resilience and destruction are presented; as the book develops, it is hoped that key lessons for improved hazard and disaster management emerge.

Each of the case study chapters has a comparable structure and complementary thematic coverage that enables direct comparisons between the actions and reactions of the different human communities involved. The book provides well-researched case studies that cover a broad temporal and spatial spectrum. Research projects range from Arctic to equatorial regions, from deep prehistory to living memory, and from tropical rainforests to desert interiors. However, each chapter is united by the careful examination of how past peoples understood the hazards that threatened them, how they attempted to mitigate the potential impacts, and whether their survival strategies proved successful in avoiding disaster. Each chapter broadly follows the same four themes of key hazards, past impacts, mitigation, and future risks. In each case study, the *key hazards* that faced the past society or societies in question are identified, and the nature of the specific threats and the timescales at which they occurred are explored. The direct and indirect *past impacts* of these hazards are then examined, with particular attention focused on the possibility of both foreseeable and unforeseeable and positive and negative impacts on past societies. There is then a discussion of the ways human communities engaged with potential hazards, and evidence for *mitigation*, *vulnerability*, and *resilience* is revealed. These examples raise important topics for discussion surrounding the sophistication of ecological knowledge that cultures can develop over centuries or millennia, the intentionality of mitigation strategies, and the process of societal decision-making. The time depth of each case study provides an informed perspective for this wider discussion, as thresholds of change and cycles of renewal in the human ecodynamics of past societies are unraveled. Each chapter then looks toward *future risks*, considers the relevance of the past case studies for modern human communities, and assesses the relative threat of hazards and potential lessons from the past for the development of successful resilience strategies in the present.

CONTRIBUTIONS TO HAZARD-DISASTER RESEARCH IN THIS BOOK

The chapters in this book are broadly ordered in relation to the nature of the hazards threatening past societies. The first chapters focus on the impacts of the geological hazards of earthquakes and volcanoes, while later chapters move toward the climatic hazards of extreme weather events and periods of weather variability.

Chapter 1. Fitzhugh's contribution takes us to the Kuril Islands in the Northwest Pacific and examines the impacts of volcanic eruptions, tsunamis, and climate variability on the human populations colonizing and occupying the different islands of this subarctic archipelago. The apparently marginal geographical, environmental, and climatic context of the Kurils provides an informative backdrop to what could be initially assumed to be a particularly exposed and highly vulnerable landscape for past human communities. However, Fitzhugh's research comparing the rich history of sudden environmental change in the region with detailed settlement history of the islands reevaluates these human communities' "vulnerability" to the impacts of local and regional hazards. The wide-ranging interdisciplinary data generated by the Kuril Biocomplexity Project help Fitzhugh provide an informed long-term picture of human ecodynamics on the islands where the past impacts of sudden environmental change can be better understood. The Kuril Islands are volcanically and tectonically highly active, and Fitzhugh provides a thorough examination of the major environmental hazards in the region, analyzing the likely past impacts of these hazards on the different people living on the islands through time. The Kuril Islands also highlight the potential importance of "social" hazards, as disruptions to inter-island networks of social interaction and fluctuating demographic trends can create increased vulnerability to the impacts of "natural" hazards. Furthermore, when Fitzhugh considers the terminal phase of Kuril Island occupation, it is the "social" hazards created by increased interregional interaction that push human populations to the tipping point of abandonment rather than the impact of a major volcanic eruption or tsunami in the region. Therefore this chapter uses a geographical region with a particularly large number of high-frequency environmental hazards to illustrate the complex nature of human vulnerability and show that it is only with an improved understanding of long-term social processes that the nature of human ecodynamics and the impacts of sudden environmental change can be fully understood.

Chapter 2. Sheets picks up on the theme of volcanic hazards raised by Fitzhugh and looks toward a 7,000-year regional picture of Mexico and Central America. Utilizing data gathered over many years of research, Sheets examines a series of case studies selected from a sample of thirty-six volcanic eruptions with known impacts on past societies in the region. Raising awareness of the need for more "social science" in hazard-disaster research, Sheets provides a persuasive argument for the use of these long-term perspectives that look beyond the immediate disaster event and evaluate the mid- to long-term positive and negative impacts on human communities. The case studies in this chapter highlight the potential benefits of capitalizing on past knowledge and integrating Precolumbian mitigation strategies, developed over centuries

or millennia, into the strategic planning of the region's current disaster management community. Sheets works with scaled vulnerabilities that contrast impacts from a natural science and social science perspective. This interplay between the quantifications of threat highlights the current gulf between geophysical stress and human agency in disaster-related research, and this has important implications for management practices. The high social impact on the Barrilles Precolumbian culture caused by the geologically minor Baru volcanic eruption highlights the fact that vulnerability is always contingent on current social relations. The ongoing social conflicts at the time of the eruption stopped potential mitigation strategies, such as temporary migration, traditionally employed by other communities facing larger eruptions elsewhere in the region. Another key lesson that emerges from this chapter is the advantage of a decentralized decision-making process in which local and vulnerable communities and villages have the local knowledge and authority to perceive hazards and mitigate disasters when they occur. This chapter ends with an intriguing discussion regarding the link among hazard and disaster, preparation or failure, and the relative stability of social control—be it in the form of religious or social elites. This link among hazard, disaster, and social elites as mediators with direct or indirect responsibility for the impacts is thought-provoking. It seems clear from the case studies in this book that populations can be quick to apportion blame and can quickly change their allegiance should they feel failed by a social or religious elite in the face of an environmental hazard. This connection among hazard, disaster, and different elements of society is continued in the following chapters.

Chapter 3. Dugmore and Vésteinsson examine the impacts of volcanic eruptions on the Medieval occupation of Iceland, one of the most volcanically active countries in the world. This chapter begins by drawing an interesting comparison between the apparent ambivalence of the Medieval population to volcanic eruptions, based on the literature of the time, and modern-day overdependence on volcanoes as the reason behind periods of social change in Icelandic history. Therefore Dugmore and Vésteinsson investigate the truth behind the alleged impacts of volcanic activity through a more focused geographical perspective that evaluates eruptions on a case-by-case basis. This chapter examines how the past impacts of Icelandic eruptions were shaped by the nature of Icelandic society itself and provides a close examination of the multiple hazards actually created by different volcanic eruptions. The relative threat of these contrasting hazards—including lava flows, ash clouds, fluorosis poisoning, volcanic gases, and volcanogenic floods—is considered in light of the settlement patterns and lifestyles of past communities. The biogeographical contexts of different hazards are considered in careful detail, and concepts of marginality and the crossing of environmental thresholds are discussed. This

chapter highlights some key features in human-environment relations and finishes with an interesting observation surrounding the apparent lack of planned mitigation strategies for volcanic eruptions in Iceland. This lack of preparation for volcanic eruptions is in contrast with the more established planning for the more common hazards created by periods of climatic variability. Therefore this research highlights the periodicity of disasters and the importance of potential parameters for predictability that enabled the development of successful mitigation strategies in Medieval Iceland. This focus on hazards arising from climate variability and periods of climate change is developed in the chapters that follow and provides interesting parallels with the themes of vulnerability, risk and mitigation, and the need for long-term studies of human ecodynamics.

Chapter 4. Cooper brings the theme of accessing past ecological knowledge to the islands of the Caribbean. Island populations in this region have always been vulnerable to the dangers of sudden environmental change, given the region's sensitivity to the highly variable climatic systems of the North Atlantic. This chapter reviews how 5,000 years of indigenous knowledge was effectively lost during the Colonial period, replaced primarily by European-influenced lifestyles that are not always well suited to environmental hazards in the region. Developing a regional interdisciplinary framework for the Caribbean, Cooper focuses on the impacts of cyclones, droughts, and floods caused by fluctuating climatic conditions and rising sea levels. By utilizing archaeological reconstructions of Precolumbian settlement locations, food procurement strategies, and household architecture designs, Cooper considers the relative resilience of Precolumbian lifeways that potentially provide useful mitigation strategies for the Caribbean today. Through a discussion of ethno-historical evidence for Precolumbian belief systems, it is possible to evaluate Precolumbian traditional ecological knowledge and a detailed awareness of the different stages of hazard impact. This research leads us to question how the concept of vulnerability should be applied. In the Caribbean the frequency of disasters highlights the importance of including the speed of reconstruction as part of a more comprehensive understanding of impact that looks beyond the event of the disaster itself and includes longer-term social and ecological processes. This chapter also discusses the potential implementation of improved disaster management strategies that employ past mitigation strategies using an example from an ongoing community project in northern Cuba.

Chapter 5. Sandweiss and Quilter draw our attention to the central Andean coastline of South America and the threat of key hazards in the region exacerbated by the impacts of El Niño Southern Oscillation cycles. The authors develop an innovative approach to the challenges of collecting, collating, and comparing interdisciplinary data that operate at different temporal and spa-

tial scales. Building on case studies developed during fieldwork in the region, Sandweiss and Quilter show how their methodological approaches to interdisciplinary research can help highlight key issues of relative threat and vulnerability in past human communities and suggest key lessons for the development of resilient societies in the region. This study shows how humans living in “extreme environments” can live successfully through the impacts of climate variability and change. Furthermore, these studies highlight the complexity of studying the relationship between sudden environmental change and paleodemography, as past human communities in central and northern Peruvian coastlines thrived during periods of apparent climatic and environmental instability.

Chapter 6. McClung examines the relationship between this early city in the Americas and the impacts of sudden environmental change. Located in a closed hydrological basin, Teotihuacan had a precarious location within a landscape sensitive to variations in seasonal climate and precipitation change. McClung has led an interdisciplinary research project that includes a detailed paleoenvironmental reconstruction of the region. While showing the complexity involved in intensive landscape studies of this kind, the paleoenvironmental picture established in this chapter enables a clear understanding of how key hazards affected human populations living in the region and shows how they were often exacerbated by people. This chapter provides a fascinating early example of the parallels between urban development and increased vulnerability to climatic variability. McClung exposes the entwined relationship among deforestation, urban architecture, irrigation systems, and hazardous flooding that shows the increased risk of exposure created by this early American city. This theme, which parallels social development and changing vulnerabilities to environmental hazards, is developed further in chapter 7, which creates an interesting comparison between urbanization and risk in the New and Old Worlds.

Chapter 7. Paulette focuses his examination of urban development, political competition, and vulnerability to environmental hazards on the Bronze Age urban centers of Mesopotamia. Using case studies of archaeological sites from Northern and Southern Mesopotamia, Paulette bring together a range of interdisciplinary studies to examine the past impacts of key hazards such as droughts, severe winters, floods, soil degradation, and pestilence. Following a thoughtful consideration of the term *resilience*, this chapter develops a well-structured argument surrounding the relative resilience of Bronze Age Mesopotamian societies. Out of this study of urban development in the Near East arise some very interesting lessons for modern-day peoples living in the same area today. First and foremost, Paulette questions the resilience of centralized institutional hazard management systems that can often increase societal

vulnerability to key hazards by implementing ill-conceived mitigation strategies focused on short-term solutions. In addition, Paulette observes a pattern in the increasing distribution of risk to different elements of society in tandem with growing social stratification and the emergence of an elite. Therefore Paulette raises key criticisms surrounding the themes of authority and social hierarchy in disaster management practice that echo some of the ideas Sheets developed around decentralized mitigation management even within state-level societies.

Chapter 8. Nelson and colleagues encourage us to consider aspects of resilience and vulnerability to environmental hazards using carefully selected case studies from the US Southwest and northern Mexico that provide examples of alternative human behavior in the face of similar environmental stress. The enormous body of archaeological data generated in this region is complemented by a uniquely detailed paleoclimatic reconstruction established by over 100 years of dendroclimatological research in the region. This interdisciplinary body of data provides a rare opportunity to look more closely at the cause and effect between social development and the problems created by environmental change. Using the ancestral communities in Mimbres, Hohokam, and Zuni regions of the United States and prehispanic communities around La Quemada in northern Mexico, Nelson and colleagues look at the relative success of different mitigation strategies in the face of precipitation variability over time. These case studies force us to think about the processes behind human decision-making and consider the medium- to long-term consequences of short-term solutions to the impacts of environmental hazards. This chapter provides key lessons for the implementation of mitigation strategies that clearly have direct relevance for modern-day populations living in the Southwest and facing very similar environmental hazards. These lessons from the past include the need to create carefully selected crop diversity that considers the climatic parameters of individual plants. The Hohokam case study also highlights the dangers of social isolation and the importance of maintaining regional interaction networks that enable resource procurement during times of need. Finally, this chapter makes us question whether absolute resilience to climatic variability is ever a realistic prospect for human communities; perhaps we should change the ultimate objective and work toward maximizing the adaptive capacity of human communities to identify and manage the inevitable challenges of environmental change.

Chapter 9. Kohler helps us consider the role of sudden environmental change within the wider framework of human social evolution. Providing an overview of key themes from the different chapters within the historical framework of archaeological thought and practice, Kohler enables the reader

to consider the different chapters in this book from a global perspective. As Kohler points out, the paucity of the archaeological record should not negate the impact sudden environmental change might have had on deep prehistory, and the tendency to average past interpretations of population figures may well hide the boom-and-bust nature of human demography in the past. This overview suggests that perhaps the interactions among hazards, disasters, and human development should be more closely examined, with particular focus on the entwined relationship between “progress” and “vulnerability.”

Chapter 10. Redman provides a global overview within which to consider all of the case studies with their varied spatial and temporal perspectives. This global comparison helps Redman to extract key messages from this book and bring the benefits of the long-term perspective on human-environment relations to the wider ongoing debates within the resilience community. This overview highlights the way different case studies in the book link the frequency of “natural disasters” and cultural ecological knowledge and enables an interesting approach to assessing the relative resilience of modern-day communities. Certainly, this summary suggests there are important lessons to learn from the past when considering the cause and effect between environmental stress and societal change and the paradoxical link between increased societal resilience and increased social vulnerability. Furthermore, Redman helps bring these lessons into a modern context by considering how climatic and environmental hazards differentially impact separate elements of societies over time.

APPLIED ARCHAEOLOGY: HOW RESEARCH CAN AMELIORATE RISK

In this book, all of the contributors argue that the social sciences are crucial to the advancement of disaster studies and furthermore that it is only with the full time depth of human experience that concepts of hazard, risk, impact, and vulnerability can be truly understood. However, there is a benchmark that many in the disaster management community will hold us against, and that is whether there are actually any practical lessons from these studies of the past that can improve hazard management and disaster mitigation in the present. We argue that this book clearly shows that there are. In reading through the chapters, some clear practical lessons emerge regarding settlement location, household architecture, food procurement strategies, social networks, education, and disaster management planning.

The progressivist nature of many modern-day societies often precludes the use of “old-fashioned,” “ancient,” or even “stone age” ideas and technologies. This confidence in the “modern” even persuades many populations on the planet to live a way of life taken from regions with entirely different climates or environmental histories, solely because of recent geopolitical history or mod-

ern fashion. For example, the use of European river valley settlement locations in the Caribbean, adobe brick household architecture in Central America, or rice farming in the semiarid US Southwest can be hazardous transplants. As discussed earlier in this introduction, the importance of knowledge developed over the long term within contextual ecological settings is crucial to improve our understanding of human ecodynamics, and the case studies examined in this book show how this accumulated wealth of human experience can be accessed from deep time and applied to the present.

Settlement Locations

People have always located their settlements in different parts of the landscape. As many archaeologists will tell you, it is not always easy to explain why past communities chose a specific location. However, many chapters in this book highlight the way many prehistoric settlement locations are relatively protected from the past impacts of key hazards. The counterintuitive positioning of settlements on the sides of volcanoes in Iceland is understood following a detailed analysis of different types of volcanic hazard from individual volcanoes that shows how some apparently similar locations in the landscape are in fact far less hazardous than others. Similar themes of potentially secure prehistoric settlement locations are picked up in the Kuril Islands and the Caribbean. While it may not always be possible to simply move modern-day populations, it is interesting to understand why these past settlement locations were more resilient and consider adjusting modern landscapes to re-create past natural hazard defenses. It would be possible to start implementing this plan by simply including these data in current planning guidelines and include zoning restrictions that can begin to decrease risk and improve living conditions in the study areas researched in this book.

Household Architecture

Throughout this book the scaled temporality of past impacts helps to reevaluate the evolving impacts of different hazards. This is particularly important when considering household architecture, as the cost of reconstruction is often just as important as the building's resistance to an initial impact event. This is certainly the case in the Caribbean, where modern and Precolumbian household designs have distinctly contrasting approaches to hurricane protection. Sheets finds similar evidence in Central America but also points out the difficulty in trying to persuade modern El Salvadoreans to live in stilted wooden and thatched houses with mudded walls. Fortunately, the practicalities of implementing successful mechanisms of mitigation are not the key objective of this book, and the task of rebranding "Joya de Ceren architecture" for the

first-time buyer/builder in central El Salvador is another person's job. However, using the different experiences of past human communities to develop the realities of vulnerability even a little can change the way the relative security of straw or brick houses is perceived.

Food Procurement Strategies

Food procurement strategies are some of human societies' most vulnerable elements regarding the impacts of sudden environmental change. Minor variations in climatic conditions, such as late seasonal rains or an early frost, can have a profound impact on dependent human communities. A number of examples in this book highlight the benefits of diversifying resource and subsistence strategies and growing suitable crops within a wider range of likely climatic conditions. But perhaps one of the most important lessons surrounding food procurement strategies is the way human communities often increase medium- to long-term vulnerabilities by adopting short-term solutions to the immediate impacts of environmental hazards. Nelson and McClung provide excellent examples of how investments in food procurement technology to protect communities against the hazard of precipitation variability in fact reduce the longer-term availability of better potential mitigation strategies. This wider relationship among social development, urbanization, environmental degradation, and vulnerability to hazards is a fascinating topic that moves far beyond the scope of food procurement strategies and highlights the importance of linking social development, which relies on permanency in the landscape, with the parallel development of regional networks of social interaction.

Reciprocal Social Networks

The chapters in this book highlight the importance of maintaining inter-regional social networks even, and perhaps especially, during times of plenty to help mitigate the dangers of sudden environmental change. It seems from the case studies in this book that to a certain extent the larger and more reliable the network of social interaction any past human community had, the greater the scale of impact that could be mitigated against. Parallels with modern global crises are important, as the relative availability of charitable relief and reconstruction following the 2004 tsunami in the Indian Ocean and the 2010 monsoon floods in South Asia were dependent on the strength of international relations and relative emotive, social, economic, and political indebtedness. Moving beyond this rather simplistic idea that it is good to have friends when in need, the different case studies in this book also show how important it is to decide which friends it is useful to have and, more specifically, the geographical region and environmental niche in which it would be most advantageous to

have those friends following the impact of a known hazard. Therefore societies need to be careful not only to establish and maintain social networks with communities that are least likely to have been affected by the same hazard but also to consider which key resources will be required for the efficient and swift reconstruction of their community so that risks can be ameliorated.

Education

Intrinsic to the aims of this book is that education is essential to successful disaster management and that the educational approach should be multidisciplinary, spanning the humanities, social sciences, and natural sciences. The importance of education in disaster management strategies is well established, but, unfortunately, so are the problems and limitations of trying to deliver national education policies and disaster management strategies through formal school curricula and radio, print, and television public announcements. This is particularly the case for hazards with low-frequency periodicity and intergenerational return rates that do not always resonate with people's fears and that enable people in San Francisco to sleep soundly at night. Therefore successful hazard mitigation requires that people have an innate hazard awareness enabling them to identify hazards before or as they are happening, understand the likely key impacts, and implement individual- and community-level mitigation strategies to avoid disaster (Crate 2008).

This knowledge base can be hard to establish and maintain, particularly when exacerbated by modern-day issues of demographic mobility and recent global diasporas. Perhaps this increasing distance among individuals, communities, and an understanding of the local environmental context is in fact one of the greatest modern hazards highlighted by this book, as people's ability to prepare for potential hazards has become increasingly difficult, particularly given sustained population increases. Therefore some chapters in this book show that informal knowledge systems—in the form of myth, folklore, ritual practice, and seasonal festivals—while considered unstructured and informal by modern pedagogical standards, actually provide a highly effective vehicle for intergenerational knowledge transfer that can facilitate hazard mitigation for hundreds or even thousands of years. Therefore, framing education within the context of local intergenerational knowledge transfer can help bring together the intergenerational geological timescales of some hazards with the multigenerational human timescales of individual lifetimes.

Disaster Management Planning

This discontinuity between national education policy and local ecological knowledge flags the wider themes of responsibility, authority, and command-

and-control structures for effective hazard management. The Mesopotamian and Central American case studies in this book highlight the way impacts are socially contingent and locally variable, with the same forcing mechanism creating very different impacts in different locations. Therefore community responses to different hazards have to be equally variable to mitigate the specific impacts individuals and local communities face. This suggests that the very nature of a centralized national disaster management authority, as is most common around the world, is intrinsically unable to deal with local variation. Therefore the examples discussed in this book suggest that local nodes of authority (as Sheets phrases it) are the most effective management framework for avoiding disasters at the local level. Thus centralized national disaster management agencies perhaps should not be creating national policy but rather should be coordinating a network of locally organized, community-led hazard management cooperatives that are informed by local knowledge and comparative global case studies to create adjusted strategies targeted to the specific threats identified through long-term research into their local socio-environmental context.

LONG-TERM PERSPECTIVES

This book highlights the ways an improved understanding of the human experience of hazards and disasters, and the timescales and geographical range at which impacts arrive, can improve disaster management planning. This deep time perspective also highlights how complex the process of introducing change into cultures can be, with case studies in this book showing how the introduction of successful short-term mitigation of environmental hazards can increase vulnerabilities over the long term. Therefore disaster planning requires a long-term perspective that considers the quality of life of both present and future generations. An archaeological time span can help create these responsible interventions, as case studies from the past, based on empirical evidence, can help predict the likely consequences of introduced cultural changes and improve disaster management planning over the long term. Sheets has seen how benign improvements in health, sanitation, and medicine in El Salvador, to which nobody would object, resulted in a 3 percent population growth rate. The birthrate was unchanged and the death rate declined consistently because of interventions. Populations doubled in twenty years and then again in another twenty years, with no increase in basic resources to sustain more people. With population control (family planning, contraception) discouraged by religious and political authorities, the result of the benign interventions in a few generations has been greater unemployment, underemployment, and malnutrition than there was in the beginning. Therefore, as well as offering practical suggestions for improved disaster management, we hope the case studies in this book

help generate meaningful discussion of alternative viewpoints and provide a persuasive argument for communities and decision makers to reevaluate the reliance on the modern approach to the “natural” disaster and consider including the past as part of a “social” solution.

FUTURE RESEARCH

All of the chapters in this book highlight the benefit of integrated interdisciplinary research that brings in comparative high-resolution data sets from human, climatic, and environmental perspectives. The case studies in this book show humans’ varied response to different hazards and disasters and suggest that it is possible to evaluate relative risks and vulnerabilities correctly only when the entire timescale of potential impacts is taken into consideration. Therefore future research should focus on bringing together more long-term interdisciplinary studies that can help provide a fuller picture of the diversity and variability of global human ecodynamics.

We hope this book will provide a compelling and cohesive narrative that gives each reader both a rich understanding of key issues and a new perspective on how different human communities have dealt with the hazards and dangers of sudden environmental change. This book should allow people to consider for themselves the key lessons they wish to draw from the past. However, we argue that it is important to consider the scaled nature of impacts because short-, medium-, and long-term impacts often have very different effects on human communities and on different levels of society within those communities. Examples in this book suggest that changes to social networks and lifestyle choices often create the greatest vulnerabilities to environmental hazards over the medium to long term. Therefore it is essential to examine the dynamic interaction between societal development and environmental change and focus on the human experience of disaster. There is perhaps no better way to do this than by utilizing the time depth of human existence to create a worldwide social memory that reveals how different communities with divergent social systems and varied lifestyle choices have always lived with, and often through, the dangers of sudden environmental change.

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SURVIVING SUDDEN ENVIRONMENTAL CHANGE

ANSWERS FROM ARCHAEOLOGY

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