

History

SAMPLER

INCLUDING

Chapter 1: Historiography of the History of Science
From *A Companion to the History of Science*

Edited by Bernard Lightman

Chapter 6: Conservation and Preservation
From *Losing Eden: An Environmental History of the American West*

By Sara Dant

Chapter 22: Climate Change in Global Environmental History
From *A Companion to Global Environmental History*

Edited by J. R. McNeill and Erin Stewart Mauldin



WILEY Blackwell

CHAPTER ONE

Historiography of the History of Science

LYNN K. NYHART

Over the past 35 years or so, the subject matter, people, places, and processes associated with history of science have grown vastly. Exaggerating only slightly for effect, an older predominant history of science might be captured by the image of a tree of scientific ideas rooted in the base of Western culture (perhaps extending downward earlier to ancient Egypt and Babylonia); the task of the historian of science was to trace the tree's growth and branching. Today a more fitting image would be of the history of science as a densely tangled bank of people and material things teeming with social, cultural, economic, and religious life, that covers the globe. The historian's task now is to tease out how certain forms of knowledge and practice within this mass of activity came to be understood as "science;" what has sustained science socially, culturally, and materially; and who has benefitted and who has suffered in its formation. What happened in the past did not change: what we expect professional historians of science to know and care about has.

The four parts of this volume—Roles, Places and Spaces, Communication, and Tools of Science—reflect broad analytical categories central to today's history of science. They cut across historical periods, geographical locations, and sciences to provide a common vocabulary that helps tie our far-flung history together. Rather than reproduce these categories in the present essay, I sketch out some of the historiographic trends that made it possible—even commonsensical—to use them to thematize contemporary history of science scholarship written in English.

I focus first on the social constructionist turn of the late 1970s and early 1980s, and its consequences for how we think about the nature of scientific knowledge and who is involved in its making. I then turn to the subsequent (re-)formulation of approaches to answering two fundamental questions in our field. One focuses on *making* scientific knowledge, asking "How is scientific knowledge constructed in a given context?" Historians' answers to this question since the early 1990s have become increasingly attentive to scientific practice, its settings and material culture. A second question focuses on *moving* scientific knowledge. As James Secord (2004, 655) put it, "How

and why does [scientific] knowledge circulate? How does it cease to be the exclusive property of a single individual or group and become part of the taken-for-granted understanding of much wider groups of people?” Scholars working on this question have highlighted the tropes of communication and circulation, and indeed often question the very distinction between making and moving.

Recent history of science has been profoundly shaped by its historians’ interactions with scholars from other disciplines across and between the social sciences and humanities. In these exchanges, historians of science have both given and received, but they have often shied away from direct theoretical statements in favor of a more empiricist style that integrates analytical insights into narrative structures. Within the broad themes of this essay, I highlight works that articulate or exemplify analytical approaches and conceptual tools that might be applicable to different places and periods. While these often originate from individual authors, I have been particularly struck by the importance of thematic journal issues and that most maligned of genres, the multi-authored edited volume. Thematic volumes are notoriously hard to get published, yet they can raise the visibility of an approach or topic well above the level of the individual article or even book, and give a sense for the significant conversations in which our community participates. The liveliness of these conversations is evidenced by the large number of collective works cited in the present essay—and also, of course, by this volume, which as a whole attests to the community-based nature of the history we make.

Constructing Scientific Knowledge, Socially

Since the late 1970s, historians of science have gradually come to accept a predominantly social constructionist account that views the development of scientific knowledge as depending heavily on particulars of local circumstances, people, epistemes, and politics, and that doesn’t necessarily drive ever closer toward a single truth. Although historians of science had long been interested in recovering earlier knowledge systems and the means by which they were transformed over time (e.g. Kuhn 2012), social constructionism offered new tools for doing so. The sociologists of the “Edinburgh School” and the “Bath School” developed many of these tools in the 1970s and early 1980s; despite differences in approach, they broadly articulated what was known as the “Strong Programme” of the social construction of scientific knowledge. (For retrospective analyses of the early situation, see Golinski 2005; Shapin and Schaffer 2011; Kim 2014; Soler et al. 2014).

The new sociologists of scientific knowledge participated in a broader postmodern rejection of our unmediated access to reality, often associated with other critiques of science’s truth value. Michel Foucault (especially 1970, 1973) challenged historians to understand how the structures of knowledge, discourse, and institutions instantiated forms of power (the entire bundle called “epistemes”) that were virtually invisible to those living inside their regimes. Since he offered no clues as to how one episteme turned into another, and little in the way of specific empirical evidence for his provocative claims, Foucault’s work remained largely (if importantly) inspirational. From a different direction, feminist scientists would soon expand the purview of social constructionist criticism of science (Bleier 1984; Fausto-Sterling 1992). Uneasy with both the implications of radical social constructionism and the “all-seeing” stance

represented in standard claims to objectivity, however, Sandra Harding (1986) and Donna Haraway (1988) developed, respectively, the crucial ideas of standpoint epistemology and “situated knowledges.” Haraway (1988, 590) in particular advocated the “partial perspective,” which lent the authority of agency to individuals previously without standing and demanded communal effort to arrive at shared reliable knowledge.

Such perspectives collectively challenged the received view of history of science in two fundamental ways. First, they demonstrated that scientific knowledge was *constructed* by human beings, not discovered in nature. Second, this process was not the work of individual minds but was ineluctably *social*. The implications for history were profound.

If knowledge of nature is made, not arrived at, then we should not expect that science will progress toward a pre-existing universal truth. One important implication is that the truth value of a claim in the past cannot be assessed by what we now believe to be true—an account of the success or failure of a scientific claim must be neutral with respect to that outcome. Evaluations of success must depend on other grounds—social, political, rhetorical—and both successes and failures must be treated similarly. In the 1980s cutting-edge historians of science adopted these principles of “neutrality” and “symmetry” (Bloor 1976), taking up the challenge of treating the outcomes of scientific controversies as determined not by the truth winning, but by social interactions.

The paradigmatic example of this sociological-historical approach is Steven Shapin and Simon Schaffer’s *Leviathan and the Air-Pump* (1985). They interpreted the contest between Robert Boyle and Thomas Hobbes as not just over the existence and nature of the vacuum and its experimental proof, but over what sort of knowledge would be counted as scientific (or, more properly, “natural philosophical”), and what adjudged not. The very division between “science” and “non-science” was at stake, and the winner not only won the specific controversy but also the right to claim what kind of knowledge would be constituted as authoritative (experimental knowledge), who would be considered a natural philosopher in the future (Robert Boyle), and who would not (Thomas Hobbes).

Developing the commitment to neutrality with respect to the outcome of a controversy led Martin Rudwick to take a different tack. His *Great Devonian Controversy* (1985) experimented with a radically anti-teleological narrative of controversy, persuasion, and power that steadfastly resisted letting the reader know how this geological story came out until its end. It thereby called attention to the conventions of histories that anticipate the outcome, challenging readers to problematize the very structure of historical narrative and to recognize the contingency of the development of science.

Both books also forcefully showed the extent to which the construction of scientific knowledge was *social*, in the sense of involving many people (see also Smith 1998 on the collective “discovery” of the conservation of energy). The diversity of kinds of people included in this social reckoning has only expanded over time. If Michael Ruse was innovatively broad, in his 1979 *Darwinian Revolution: Science Red in Tooth and Claw*, for including over a dozen British male natural philosophers as the relevant community that helped to make the revolution in Darwin’s name, its scope seems narrow today, when we see that revolution as preceding Darwin in many of its

features (Desmond 1992; Secord 2000) and extending far into nineteenth-century British and European culture (e.g. Beer 1983; Glick and Engels 2008)—and indeed cultures worldwide (Pusey 1983; Elshakry 2013).

The key second claim of social constructionism, then, was that the development of science involved many people, doing many different kinds of things. As microsociological laboratory studies demonstrated the centrality of postdocs, graduate students, and technicians to making knowledge (Latour and Woolgar 1979), historians wondered, Who were the “invisible technicians” of the past (Shapin 1989; Hentschel 2007)? How were the social relations of knowledge production managed, and how did these change over time?

Feminist scholars observed that European women were in fact also involved in many aspects of making knowledge about nature, though only exceptionally afforded opportunities to “do science” in ways we easily recognize (Schiebinger 1989; Findlen 1993; Terrall 1995). Women participated in science as patrons and *salonnières*, as illustrators, as teachers of children, as popular writers (Shteir 1996), and as partners working with their scientific husbands (Pycior, Slack, and Abir-Am 1996) long before “careers” in science were generally available to women. As historians looked beyond European laboratories and the social structures that surrounded and sustained them, they found not only women but also men who helped make science in the field in these and other ways as well—as servants, collectors, and taxidermists; as translators, providers of local or indigenous knowledge, and other sorts of go-betweens; and as experimental subjects. (See Part I, “Roles,” in this volume.) The peoplescope of contributors to science has grown accordingly.

As the kinds of people recognized as involved with science have diversified, the notion of the “scientist” itself has undergone new scrutiny, most prominently with the development of the idea of scientific *personae* (Daston and Sibum 2003). This concept simultaneously offers a theorized way to differentiate among kinds of scientists, describe certain collective patterns of scientific behavior, and offer an intermediate level of analysis between the individual and the institution. The “scientist as expert” has spawned a distinctive specialist literature as well (Lucier 2008; Broman 2012; Klein 2012). To be sure, more traditional biography has hardly disappeared from the history of science—indeed, four of the eleven winners of the History of Science Society’s Pfizer Prize for best scholarly book between 2003 and 2013 were biographies (Terrall 2002; Browne 2003; Antognazza 2009; Schäfer 2013). Historians have also been inspired to revisit how scientific biographies themselves are constructed—by scientists (Otis 2007), by admirers (Rupke 2005), and by historians (Söderqvist 2007).

Doing Scientific Things with Scientific Things: Practice and Materiality

Historians of science today do not write only about scientists and others producing and supporting science. They write about the *stuff* of science: about glassware, computers, fruit flies, oceans, books, diagrams, maps, models, and particle accelerators. They write about theory, too—but their goal is less often to elucidate how scientists derived their theories than to present a broader historical web of scientific and cultural practices that in turn are solidly embedded in the physical world. This rich material tapestry has

been woven together from diverse strands: the social-constructionism-inspired turn to experimental practice; the formerly distinct scientific instrument tradition; attention to natural history collections and fieldwork; and interdisciplinary studies of material culture.¹

The central feature, which gained heft from the social constructionism of the 1980s, has been the turn toward practice (Soler et al. 2014). Literary postmodernists of the period might declare with Derrida that all thought is discourse, and thus all products of thought were forms of text, amenable to deconstruction. Not so analysts of science. Shapin and Schaffer (1985, 25), for instance, bent far backward to call written arguments “literary technologies,” which along with material and social technologies established scientifically legitimate “matters of fact” in the Scientific Revolution. To them, seeing science as constructed meant focusing attention on the physical, material means of that construction. Since the 1980s, broader trends have helped to keep historians’ attention on the materiality of science. The digitization and virtualization of our academic and social world has wrought renewed appreciation for physical things, while at the same time, ever-increasing awareness of our dependence on a rapidly degrading nature has lent new urgency to that appreciation. We can no longer afford to attend primarily to theory.

Attention to materiality is not new to the history of science. An older Marxist tradition insisted on the central role of material and economic needs in shaping science (Bernal 1971). Separately, a long tradition studied historical scientific instruments; with its valuation of object-connoisseurship connected to art history and museum work, this was often treated as a sideline in the field. Then in the mid-1990s, scholars of material culture—mostly working in museums—made new claims for their importance to the study of history of science and technology (Lubar and Kingery 1993; Kingery 1996). Combined with the history of science’s new focus on practice, this helped push instruments and other materials toward the center of the field (van Helden and Hankins 1994).

Analyses of the material nature of scientific practice have looked different as they intervened in different historical subspecialties. In early modern studies, for instance, such analyses have carried forward the theme of the “scholar-craftsman” union (Zilsel et al. 2000; Roberts, Schaffer, and Dear 2007; Long 2011); a similar concern with the relationship between abstract knowledge and craft knowhow has animated recent work on ancient and non-Western understandings of nature (e.g. Robson 2008; Schäfer 2011). In the history of modern physics, the study of experimental practice challenged the historiographic dominance of theoretical physics. As Peter Galison (1997) has argued, developments in theoretical and experimental physics have not been yoked together; tracing the history of experimental physics, its instruments and material practices, yields new historical narratives that change our picture of “physics”—even challenging its unity as a science.

In the history of twentieth-century experimental life sciences, attention to practice and material culture led to new ways of thinking about the unique tools for investigating living processes (Clarke and Fujimura 1992). Robert Kohler’s iconic *Lords of the Fly* (1994) analyzed the Morgan school of *Drosophila* geneticists, showing how the organisms themselves began to drive the systems of investigation (and indeed, the entire “moral economy” of the school) and analyzing how the scientists responded. Subsequent scholarship further refined analyses of knowledge-making systems

involving people, model organisms and organic materials, and experimental set-ups in the life sciences (e.g., Rheinberger 1997; Creager 2002; Landecker 2007).

Historical studies of experimental practice, then, have shared a focus on the use of instruments and experimental systems that extend our senses and manipulate nature to tease out its processes, their underlying structures, and, ultimately, their laws. Historians of natural history have attended to quite different aspects of material practice, including not only the life and work of scientists in “the field” (Kuklick and Kohler 1996; Vetter 2011) as they searched for natural objects and materials, but also the practices of collection and preservation, and the organization of specimens into ordered collections (Heesen and Spary 2002; Endersby 2008; Johnson 2012). Here, the history of science has intersected with the history of museums and collections, and with the broader material culture perspective that museums have promulgated (Nyhart 2009; Alberti 2011; Poliquin 2012).

Such approaches have drawn attention to the spatial dimensions of scientific practice—another aspect of its materiality closely intertwined with social organization (Finnegan 2008). Modern scientific activity typically takes place in recognized kinds of venues: observatories, laboratories, museums, and “the field” are perhaps the four most prominent categories (see Part II, “Places and Spaces,” this volume). Each of these has evolved over time and developed characteristic forms of social organization and practices, though historians have repeatedly noted how permeable and variable these sites are (e.g., Gooday 2008). This focus may be understood as part of a broader interdisciplinary “spatial turn” visible recently across the humanities and social sciences (e.g., Warf and Arias 2008). Geographers have offered taxonomies of scientific spaces and places that draw useful distinctions (such as that between particular locations in the world—Brazil, say—and kinds of places—such as “the tropics”), and have called attention to important differences in the scales at which spatial analysis of science may be undertaken (see esp. Livingstone and Withers 2011). Spatial and geographical language—referring to actual places, kinds of places, and metaphors of place and mapping—now provides a prominent vocabulary and mode of analysis among historians of science.

Moving Knowledge Around: Communication and Circulation

A long-accepted tenet of the social constructionist history of science is that scientific knowledge begins locally. If this is the case, then how does it spread? Over the last three decades historians have pursued this fundamental question in many directions, and the analysis of the ways in which people, ideas, and artifacts travel and communicate to move science around has yielded an especially rich set of intellectual tools.

The communicative practices within and surrounding science are central to its spread, and writing is the practice historians have studied longest and most deeply. For decades, if not centuries, historians of science have analyzed texts. In the 1980s rhetoricians joined them to examine anew both the persuasive strategies of scientists and the forms of scientific publication, especially the scientific article (e.g., Bazerman 1988; Dear 1991; Gross, Harmon, and Reidy 2002). Unpublished (if not always private) forms have also received scrutiny, especially as they reflect the broader social structures in which they were embedded, such as the correspondence network or the archive (Hunter 1998; van Miert 2013).

Beyond its rhetorical dimensions, the historical study of science communication has been transformed by the dramatic expansion and increasingly sophisticated historiography of “popular science” (often conflated with “science popularization”). An older, diffusionist model tended to treat popular science as a watered-down version of “real” science, popularizers as lesser lights who lacked the chops to do their own research, and readers as a passive audience. This has given way to a perspective in which both writers for the general public and that public itself are treated as active cultural interpreters and knowledge-makers worthy of study (Cooter and Pumfrey 1994). James Secord (2000) has shown just how far one can take this approach, with his classic study *Victorian Sensation*, which treats Robert Chambers’ 1844 *Vestiges of the Natural History of Creation* as a remarkably fluid text: he shows how its many editions developed in conversation with its critics, while also illuminating localized styles and cultures of reading. More recently, Topham (2009) has suggested considering science popularization more seriously as an actor’s category, while Daum (2009) has proposed a broader historiographic transformation that would consider popular science as part of a larger notion of public knowledge.

Daum has rightly criticized the existing historiography of popular science for its parochial focus on nineteenth-century Britain—a trend reinforced by the large number of literary scholars of Victorian culture who have reached out to meet historians of popular science, especially (though not exclusively) via a mutual interest in the genre of the general periodical (e.g., Cantor et al. 1994; Cantor and Shuttleworth 2004; Lightman 2007). It is refreshing, therefore, to see innovative analyses of popular science being developed for new contexts such as the twentieth-century Soviet Union and China, where the relationships among public science, the state, and forms of identity have been both fraught and different from British-inflected Western assumptions (Andrews 2003; Schmalzer 2008; Fan 2012a).

Communication has a material history, too, explored powerfully through its print culture. Historians of science have come to view books, atlases and encyclopedias, journals, and popular magazines not just as vehicles of scientific information but also as objects whose physical attributes offer important historical clues to the authors, artists, engravers, printers, publishers, and patrons who contributed to making the printed scientific work (and thus further expand the cast of characters involved in producing science). The material object also provides clues to which sorts of readers might have had access to it and where, how they might have read it, and indeed the broader culture of reading of which the work was a part. As the technologies and economics of printing and publication have changed, so, too, have the associated cultures of print (Johns 1998; Secord 2000; Apple, Downey, and Vaughan 2012).

Historical analysis of scientific communication extends beyond the study of writing. The history of “non-verbal communication in science” (Mazzolini 1993) has become increasingly broad and varied, and its analyses now often combine with those of other forms of scientific communication, analyzed within the overlapping interdisciplinary fields of visual, print, and material culture of science (Fyfe and Lightman 2007; Hopwood, Schaffer, and Secord 2010; Jardine and Fay 2013; Messbarger 2013; Hopwood 2015; cf. Topper and Holloway 1980). These non-verbal aspects have even become fully integrated into topics once judged exclusively philosophical, as demonstrated by Daston and Galison’s *Objectivity* (2007). As the present volume illustrates, the study of science’s communicative practices also encompasses in-person forms of

transmission such as lectures and demonstrations, distance media like radio and television, and a host of visual and material forms that often blur the already soft lines among the technical, the didactic, and the popular.

Although the distinction between “making” and “moving” knowledge has some utility, a considerable body of literature demonstrates its superficiality. Historians and anthropologists have long recognized that scientific knowledge changes when moving from one place to another; thus, moving knowledge means, at the very least, re-making it in some ways. Older rubrics for this process included *knowledge transfer*, *reception*, and (following an older sociological tradition) *diffusion* (Dolby 1977). All these earlier terms placed the primary agency on a source understood to be scientific, which is then differentially adopted by recipient cultures. It is now appreciated how inadequate this perspective is: there is always more knowledge-making going on at the “receiving” end.

The analysis of linguistic translation is an obvious way in to understanding problems of cultural translation and transfer, tracking what remains more or less the same and what is transformed when ideas are brought into new cultural environments. Such analyses challenge the longstanding assumption that scientific knowledge is merely transposed in linguistic translation, and not transformed at all (Elshakry 2008). The nitty-gritty details of translation indicate some of the cultural challenges. What was the German professor–translator H. G. Bronn, Europe’s highest paleontological authority, to make of Darwin’s pigeon breeds, with their impossible names, and Darwin’s easy assumption that these would help win over his audience to evolution (Gliboff 2008)? How much more was transformed beyond language in the centuries-long projects of translating Greek texts into Arabic (and commenting on them), which produced new documents that themselves served as the sources subsequently translated into Latin in medieval Europe and the Mediterranean! While later cast as the “rediscovery” of an ancient Classical heritage that was merely routed through the ancient Near East, scholars have shown how misleading this story is—how it ignores the power, autonomy, and creative contributions by the many cultures of western Asia and the Near East to what we call “science,” and the many transformations accompanying translation (Montgomery 2000; Iqbal 2012). Textual translation was further complicated when the writing systems, visual culture, and technologies of text production differed (Fu 2012).

The complex relationship between moving and making scientific knowledge goes beyond the alterations undergone in transit. Analysts of science have argued in different ways that the movement of knowledge itself has been essential to making it scientific. One argument, focused especially on laboratory knowledge, goes roughly like this: for something to be true, it must be true in more than one place; hence the importance of replicating results. Drawing on this logic, historians and sociologists have examined how scientists have worked to recreate “the same” conditions and techniques in different places in order to render the laboratory a “placeless place” in which scientists might successfully replicate results and thus create empirically based assent (Gieryn 2002; Kohler 2002 and sources cited therein). Here, science is simultaneously made and moved by homogenizing and spreading its techniques and environments.

Another perspective has focused on how certain kinds of objects and information—in the sociologist Bruno Latour’s (1987) term, “immutable and combinable

mobiles”—have been extracted from “elsewhere” and brought together in specific “centers of calculation.” At these centers—typically Western, metropolitan, and more powerful than the diffuse locations from which the objects come—scientists do the work that would yield the knowledge called “scientific.” Such historical attention to the forging of scientific knowledge through the centralized accumulation, organizing, analysis, and classification of objects and information has increased along with attention to the natural-historical sciences, and more broadly, with what Lorraine Daston has called the “Sciences of the Archives” (see http://www.mpiwg-berlin.mpg.de/en/research/projects/DeptII_Daston-SciencesOfTheArchives).

A third, increasingly prominent, approach has participated in broader historiographic trends of studying the global movements of people, things, and ideas. Much of this work has gone under a general framework of (Western) science and (European) empire. It has highlighted the mutual accommodations made among Western scientists (especially naturalists), commercial interests, Christian missions, and expansionist states, as well as appropriations of indigenous materials and knowledge (e.g. Schiebinger 2004; Schiebinger and Swann 2004; Delbourgo and Dew 2007; Bleichmar et al. 2009; Mitman and Erickson 2010).

In one of the most ambitious of these accounts, Harold Cook (2005) has argued that the Scientific Revolution itself should be located in the constellation of values encouraged by the early modern Dutch commercial empire, which valorized an interest in detail and “matters of fact” that served both the global commerce undertaken by Dutch traders and, as it turns out, science. In Cook’s picture, the knowledge that came to be considered scientific emerged from global interactions of people, organisms, and things that filtered back to Europe through circuitous and often contingent networks. In this view, “science” is not made in one place and then spread to another, nor is it located primarily in the organization of bits of information into complex systems at the metropole by leading knowledge producers. Rather, it is the historical product of many different people who themselves contributed, not always voluntarily, to a culture that valued things, their description, and the making of scientific meaning around them.

This sort of account has often been connected with the term “circulation” (e.g., Raj 2007; Terrall and Raj 2010; Lightman, McOuat, and Stewart 2013). This term has been used to emphasize the agency of those formerly considered merely passive instruments in the spread of scientific knowledge (either as receivers or as those whose local knowledge was appropriated), opening up analytical space to acknowledge their interests and their creative, knowledge-generating work. Such analyses have highlighted reciprocal interactions among historical actors, sometimes involving “go-betweens” (Schaffer et al. 2009), often at sites where “trading zones” (Galison 1997) existed or hybrid knowledge cultures persisted (Kohler 2002; Gómez 2013).

In conjunction with a global perspective, the circulation metaphor does important work: it displaces the unidirectionality of older center-periphery models centered on western Europe and the US, and flattens the status difference these models imply, elevating the status of non-Western contributors to Western knowledge and also the non-Western cultures and knowledge systems themselves. It also offers a new big-picture framework under which to unite a plethora of local studies. Because science has for so long been considered an exclusive product of the West, this is a salutary development.

Yet this vocabulary of global “circulation” and “flows” of knowledge has generated criticism from scholars such as Warwick Anderson, who has somewhat sardonically dubbed it the “hydraulic turn” (2014, 375). Fan (2012b, 252) has articulated the concern: “The image of circulation tends to impose too much unity, uniformity, and directionality on what was complex, multidirectional, and messy. . . . [It also] doesn’t encourage a critical analysis of, say, power relations in science.” Fan, Anderson, and others would prefer more attention to specific sites of resistance and stories of conflict, to remind us that, in historically specific situations, those “flows” may meet significant “blockages” worthy of our attention.

Scaling History of Science

The world covered by historians of science is bigger, more densely populated, and more complex than it once was. How shall we manage this multileveled intellectual terrain? How can we avoid getting lost in its lush vegetation? As we have seen, current high-visibility scholarship seeks to bind the local and the global through tropes of motion, bypassing well-worn social categories, such as the state and civic institutions, that operate at intermediate levels. Following people and objects around, as they travel the globe, allows the historian to collapse low and high levels of resolution into a single story, which is very appealing. Yet the broad range of intermediate levels of analysis should not be forgotten (Kohler and Olesko 2012). Attending to scales of analysis may in fact help us negotiate the tensions over global circulation mentioned above: a high-level focus on broad patterns tends to gloss over non-hegemonic voices, while lower levels of specificity bring them out. (See Misa 2009 for a similar analysis in history of technology.) Moreover, intermediate levels are crucial for tackling other leading questions not addressed in this essay, such as the comparative history of demarcation, which asks “How has science calved off historically from other activities into its own cultural field?” “How has such demarcation been supported socially and economically?” and “How has it been maintained (or not) in the face of contestation?”

As historians, we must attend to temporal scale as well. Localized stories often take place at the scale of a human lifespan or less, while questions about periodization remain a staple of mid-range temporal analysis. Scholarship on science and history extending temporal scales of analysis to yet broader expanses is emerging around us, drawing on archaeology, anthropology, and environmental history (Robin and Steffen 2007; Robson 2008; Safier 2010). It remains to be seen whether this scalar challenge is one historians of science are willing to take up, and if so, how.

The landscape of the history of science is one we simultaneously inhabit and cultivate: as both science and our broader cultural concerns continue to change, so, too, will the history of science. But the fundamental shift that has taken place since the late 1970s appears to be permanent. Historians of science now treat science as something that has been produced historically and contingently, not arrived at through an increasing recognition of truths. It has emerged instead through the cultivation of particular values that have sustained the investigation of the material world around us, in different directions at different times and places. People undertaking the activities we call “science” have created cultural space for themselves by advancing and taking advantage of new institutions and communicative forms; these in turn have been

sustained by the commitments and livelihoods of many people who are not themselves “scientists.”

Indeed, the science we depict is deeply embedded in its surrounding culture (even when scientists and spokesmen for science have argued otherwise)—yet that culture itself is typically not closed, but instead engaged in constant exchange with other cultures, feeding the wellsprings of scientific innovation, power, and conflict.

All of this makes the history of science a buzzing, dynamic field of action. Whether we examine it from close up, deep inside the tangle, from a mid-range that resolves certain actors and structures while leaving others fuzzy, or from a more distant view focused on large-scale patterns, our intellectual challenge is to explore diverse narrative and explanatory paths through this terrain. Our practical challenge is to illuminate these paths using all the tools we have available—academic monographs and articles, exhibitions, living history reconstructions and performances, films, podcasts, and the sweep of possibilities offered by new media—to invite others, not always historians of science, to come along with us.

Endnote

- 1 New attention to bodies in feminist and gender studies and the history of medicine forms a parallel topic that is unfortunately beyond the scope of this essay.

References

- Alberti, Samuel J. M. M. 2011. *The Afterlives of Animals: A Museum Menagerie*. Charlottesville: University of Virginia Press.
- Anderson, Warwick. 2014. “Making global health history: The postcolonial worldliness of biomedicine.” *Social History of Medicine*, 27, No. 2: 372–84.
- Andrews, James T. 2003. *Science for the Masses: The Bolshevik State, Public Science, and the Popular Imagination in Soviet Russia, 1917–1934*. College Station, TX: Texas A&M University Press.
- Antognazza, Maria Rosa. 2009. *Leibniz: An Intellectual Biography*. Cambridge: Cambridge University Press.
- Apple, Rima D., Gregory John Downey, and Stephen Vaughn. 2012. *Science in Print: Essays on the History of Science and the Culture of Print*. Madison, WI: University of Wisconsin Press.
- Bazerman, Charles. 1988. *Shaping Written Knowledge: The Genre and Activity of the Experimental Article in Science*. Madison, WI: University of Wisconsin Press.
- Beer, Gillian. 1983. *Darwin’s Plots: Evolutionary Narrative in Darwin, George Eliot, and Nineteenth-Century Fiction*. London: Routledge & Kegan Paul.
- Bernal, J. D. 1971. *Science in History*. 4 vols. Cambridge, MA: MIT Press.
- Bleichmar, Daniela, Paula De Vos, Kristin Huffine, and Kevin Sheehan (eds.) 2009. *Science in the Spanish and Portuguese Empires, 1500–1800*. Stanford, CA: Stanford University Press.
- Bleier, Ruth. 1984. *Science and Gender: A Critique of Biology and Its Theories on Women*. New York: Pergamon.
- Bloor, David. 1976. *Knowledge and Social Imagery*. London: Routledge & Kegan Paul.
- Broman, Thomas. 2012. “The semblance of transparency: Expertise as a social good and an ideology in enlightened societies.” *Osiris*, 2nd series, 27: 188–208.
- Browne, Janet. 2003. *Charles Darwin: The Power of Place*. Princeton, NJ: Princeton University Press.

- Cantor, Geoffrey N., Gowan Dawson, Graeme J. N. Gooday, Richard Noakes, Sally Shuttleworth, and Jonathan R. Topham. 2004. *Science in the Nineteenth-Century Periodical: Reading the Magazine of Nature*. Cambridge: Cambridge University Press.
- Cantor, Geoffrey N., and Sally Shuttleworth. 2004. *Science Serialized: Representation of the Sciences in Nineteenth-Century Periodicals*. Cambridge, MA: MIT Press.
- Clarke, Adele, and Joan Fujimura (eds.) 1992. *The Right Tools for the Job: At Work in Twentieth-Century Life Sciences*. Princeton, NJ: Princeton University Press.
- Cook, Harold John. 2007. *Matters of Exchange: Commerce, Medicine, and Science in the Dutch Golden Age*. New Haven, CT: Yale University Press.
- Cooter, Roger, and Stephen Pumfrey. 1994. "Separate spheres and public places: Reflections on the history of science popularization and science in popular culture." *History of Science*, 32: 237–67.
- Creager, Angela N. H. 2002. *The Life of a Virus: Tobacco Mosaic Virus as an Experimental Model, 1930–1965*. Chicago: University of Chicago Press.
- Daston, Lorraine, and Peter Galison. 2007. *Objectivity*. New York: Zone Books.
- Daston, Lorraine, and Heinz Otto Sibum (eds.) 2003. "Scientific Personae". Special Issue, *Science in Context*, 16, No. 1–2.
- Daum, Andreas W. 2009. "Varieties of popular science and the transformations of public knowledge: Some historical reflections." *Isis*, 100: 319–32.
- Dear, Peter Robert (ed.) 1991. *The Literary Structure of Scientific Argument: Historical Studies*. Philadelphia: University of Pennsylvania Press.
- Delbourgo, James, and Nicholas Dew (eds.) 2007. *Science and Empire in the Atlantic World*. London: Routledge.
- Desmond, Adrian. 1992. *The Politics of Evolution: Morphology, Medicine, and Reform in Radical London*. Chicago: University of Chicago Press.
- Dolby, R. G. A. 1977. "The transmission of science." *History of Science*, 15: 1–43.
- Elshakry, Marwa. 2008. "Knowledge in motion: The cultural politics of modern science translations in Arabic." *Isis*, 99: 701–730.
- Elshakry, Marwa. 2013. *Reading Darwin in Arabic, 1860–1950*. Chicago: University of Chicago Press.
- Endersby, Jim. 2008. *Imperial Nature: Joseph Hooker and the Practices of Victorian Science*. Chicago: University of Chicago Press.
- Fan, Fa-ti. 2012a. "Science, state, and citizens: Notes from another shore." *Osiris*, 2nd series, 27: 227–49.
- Fan, Fa-ti. 2012b. "The global turn in the history of science." *East Asian Science, Technology and Society*, 6, No. 2: 249–58.
- Fausto-Sterling, Anne. 1992. *Myths of Gender: Biological Theories about Women and Men*. Revised edition. New York: Basic Books.
- Findlen, Paula. 1993. "Science as a career in Enlightenment Italy: The strategies of Laura Bassi." *Isis*, 84: 440–69.
- Finnegan, Diarmid A. 2008. "The spatial turn: Geographical approaches in the history of science." *Journal of the History of Biology*, 41: 369–88.
- Foucault, Michel. 1971. *The Order of Things: An Archaeology of the Human Sciences*. New York: Pantheon Books.
- Foucault, Michel. 1973. *The Birth of the Clinic: An Archaeology of Medical Perception*. London: Tavistock.
- Fu, Liangyu. 2012. "Indigenizing visualized knowledge: Translating Western science illustrations in China, 1870–1910." *Translation Studies*, 6, No. 1: 78–102.
- Fyfe, Aileen, and Bernard V. Lightman (eds.) 2007. *Science in the Marketplace: Nineteenth-Century Sites and Experiences*. Chicago: University of Chicago Press.

- Galison, Peter. 1997. *Image and Logic: A Material Culture of Microphysics*. Chicago: University of Chicago Press.
- Gieryn, Tom F. 2002. "Three truth-spots." *Journal of the History of the Behavioral Sciences*, 38, No. 2: 113–32.
- Gliboff, Sander. 2008. *H. G. Bronn, Ernst Haeckel, and the Origins of German Darwinism: A Study in Translation and Transformation*. Cambridge, MA: MIT Press.
- Glick, Thomas F., and Eve-Marie Engels (eds.) 2009. *The Reception of Charles Darwin in Europe*. London: Bloomsbury Academic.
- Golinski, Jan. 2005. *Making Natural Knowledge: Constructivism and the History of Science*. Chicago: University of Chicago Press.
- Gómez, Pablo F. 2013. "The circulation of bodily knowledge in the seventeenth-century Black Spanish Caribbean." *Social History of Medicine*, 26, No. 3: 383–402.
- Gooday, Graeme. 2008. "Placing or replacing the laboratory in the history of science?" *Isis*, 99: 783–95.
- Gross, Alan G., Joseph E. Harmon, and Michael Reidy. 2002. *Communicating Science: The Scientific Article from the 17th Century to the Present*. New York: Oxford University Press.
- Haraway, Donna. 1988. "Situated knowledges: The science question in feminism and the privilege of partial perspective." *Feminist Studies*, 14, No. 3: 575–99.
- Harding, Sandra. 1986. *The Science Question in Feminism*. Ithaca, NY: Cornell University Press.
- Heesen, Anke te, and E. C. Spary (eds.) 2002. *Sammeln als Wissen: das Sammeln und seine wissenschaftsgeschichtliche Bedeutung*. Göttingen: Wallstein.
- Hentschel, Klaus. 2008. *Unsichtbare Hände: Zur Rolle von Laborassistenten, Mechanikern, Zeichnern u. a. Amanuenses in der physikalischen Forschungs- und Entwicklungsarbeit*. Diepholz: GNT-Verlag.
- Hopwood, Nick. 2015. *Haeckel's Embryos: Images, Evolution, and Fraud*. Chicago: University of Chicago Press.
- Hopwood, Nick, Simon Schaffer, and James A. Secord (eds.) 2010. "Seriality and scientific objects in the nineteenth century." *History of Science*, 48, No. 3–4: 251–85.
- Hunter, Michael (ed.) 1998. *Archives of the Scientific Revolution: The Formation and Exchange of Ideas in Seventeenth-Century Europe*. Woodbridge: Boydell Press.
- Iqbal, Muzaffar (ed.) 2012. *Studies in the Making of Islamic Science: Knowledge in Motion*. Aldershot: Ashgate.
- Jardine, Nicholas, and Isla Fay (eds.) 2013. *Observing the World through Images: Diagrams and Figures in the Early-Modern Arts and Sciences*. Leiden: Brill.
- Johns, Adrian. 1998. *The Nature of the Book: Print and Knowledge in the Making*. Chicago: University of Chicago Press.
- Johnson, Kristin. 2012. *Ordering Life: Karl Jordan and the Naturalist Tradition*. Baltimore: Johns Hopkins University Press.
- Kim, Mi Gyung. 2014. "Archeology, genealogy, and geography of experimental philosophy." *Social Studies of Science*, 44, No. 1: 150–62.
- Kingery, W. David (ed.) 1996. *Learning from Things: Method and Theory of Material Culture Studies*. Washington, DC: Smithsonian Institution.
- Klein, Ursula (ed.) 2012. "Artisanal-scientific experts in eighteenth-century France and Germany." *Annals of Science*, 69, No. 3: 303–433.
- Kohler, Robert E. 1994. *Lords of the Fly: Drosophila Genetics and the Experimental Life*. Chicago: University of Chicago Press.
- Kohler, Robert E. 2002. "Labscapes: Naturalizing the lab." *History of Science*, 40, No. 4: 473–501.
- Kohler, Robert E., and Kathryn M. Olesko. 2012. "Introduction: Clio meets science." *Osiris*, 2nd series, 27: 1–16.

- Kuhn, Thomas S. 2012. *The Structure of Scientific Revolutions: 50th Anniversary Edition*. Chicago: University of Chicago Press.
- Kuklick, Henrika, and Robert E. Kohler (eds.) 1996. "Science in the field." *Osiris*, 2nd series, 11: 1–265.
- Landecker, Hannah. 2007. *Culturing Life: How Cells Became Technologies*. Cambridge, MA: Harvard University Press.
- Latour, Bruno, and Steve Woolgar. 1979. *Laboratory Life: The Social Construction of Scientific Facts*. Beverly Hills, CA: Sage Publications.
- Latour, Bruno. 1987. *Science in Action: How to Follow Scientists and Engineers through Society*. Cambridge, MA: Harvard University Press.
- Lightman, Bernard V. 2007. *Victorian Popularizers of Science: Designing Nature for New Audiences*. Chicago: University of Chicago Press.
- Lightman, Bernard V., Gordon McOuat, and Larry Stewart (eds.) 2013. *The Circulation of Knowledge between Britain, India and China*. Leiden: Brill.
- Livingstone, David N., and Charles W. J. Withers (eds.) 2011. *Geographies of Nineteenth-Century Science*. Chicago: University of Chicago Press.
- Long, Pamela O. 2011. *Artisan/Practitioners and the Rise of the New Sciences, 1400–1600*. Corvallis, OR: Oregon State University Press.
- Lubar, Steven, and W. David Kingery (eds.) 1993. *History from Things: Essays on Material Culture*. Washington: Smithsonian Institution Press.
- Lucier, Paul. 2008. *Scientists and Swindlers: Consulting on Coal and Oil in America, 1820–1890*. Baltimore: Johns Hopkins University Press.
- Mazzolini, Renato G. (ed.) 1993. *Non-Verbal Communication in Science prior to 1900*. Firenze: L.S. Olschki.
- Messbarger, Rebecca. 2013. "The re-birth of Venus in Florence's Royal Museum of Physics and Natural History." *Journal of the History of Collections*, 25: 195–215.
- Misa, Thomas J. 2009. "Findings following framings: Navigating the empirical turn." *Synthese*, 168: 357–75.
- Mitman, Gregg, and Paul Erickson. 2010. "Latex and blood: Science, markets, and American empire." *Radical History Review*, 107: 45–73.
- Montgomery, Scott L. 2002. *Science in Translation: Movements of Knowledge through Cultures and Time*. Chicago: University of Chicago Press.
- Nyhart, Lynn K. 2009. *Modern Nature: The Rise of the Biological Perspective in Germany*. Chicago: University of Chicago Press.
- Otis, Laura. 2007. *Müller's Lab*. Oxford: Oxford University Press.
- Poliquin, Rachel. 2012. *The Breathless Zoo: Taxidermy and the Cultures of Longing*. University Park, PA: Pennsylvania State University Press.
- Pusey, James Reeve. 1983. *China and Charles Darwin*. Cambridge, MA: Harvard University Asia Center.
- Pycior, Helena M., Nancy G. Slack, and Pnina G. Abir-Am (eds.) 1996. *Creative Couples in the Sciences*. New Brunswick, NJ: Rutgers University Press.
- Raj, Kapil. 2007. *Relocating Modern Science: Circulation and the Construction of Scientific Knowledge in South Asia and Europe, 1650–1900*. Basingstoke: Palgrave Macmillan.
- Rheinberger, Hans-Jörg. 1997. *Toward a History of Epistemic Things: Synthesizing Proteins in the Test Tube*. Stanford, CA: Stanford University Press.
- Roberts, Lissa, Simon Schaffer, and Peter Dear (eds.) 2007. *The Mindful Hand: Inquiry and Invention from the Late Renaissance to Early Industrialisation*. Amsterdam: Koninklijke Nederlandse Akademie van Wetenschappen.
- Robin, Libby, and Will Steffen. 2007. "History for the Anthropocene." *History Compass*, 5, No. 5: 1694–1719. doi:10.1111/j.1478-0542.2007.00459.x.

- Robson, Eleanor. 2008. *Mathematics in Ancient Iraq: A Social History*. Princeton, NJ: Princeton University Press.
- Rudwick, Martin John Spencer. 1985. *The Great Devonian Controversy: The Shaping of Scientific Knowledge among Gentlemanly Specialists*. Chicago: University of Chicago Press.
- Rupke, Nicolaas A. 2005. *Alexander von Humboldt: A Metabiography*. New York: Peter Lang.
- Ruse, Michael. 1979. *The Darwinian Revolution: Science Red in Tooth and Claw*. Chicago: University of Chicago Press.
- Safer, Neil. 2010. "Global Knowledge on the Move: Itineraries, Amerindian Narratives, and Deep Histories of Science." *Isis*, 101: 133–145.
- Schäfer, Dagmar. 2011. *The Crafting of the 10,000 Things: Knowledge and Technology in Seventeenth-Century China*. Chicago: University of Chicago Press.
- Schaffer, Simon, Lissa Roberts, Kapil Raj, and James Delbourgo (eds.) 2009. *The Brokered World: Go-Betweens and Global Intelligence, 1770–1820*. Sagamore Beach, MA: Science History Publications.
- Schiebinger, Londa. 1989. *The Mind Has No Sex? Women in the Origins of Modern Science*. Cambridge, MA: Harvard University Press.
- Schiebinger, Londa. 2004. *Plants and Empire: Colonial Bioprospecting in the Atlantic World*. Cambridge, MA: Harvard University Press.
- Schiebinger, Londa, and Claudia Swan (eds.) 2004. *Colonial Botany: Science, Commerce, and Politics in the Early Modern World*. Philadelphia: University of Pennsylvania Press.
- Schmalzer, Sigrid. 2008. *The People's Peking Man: Popular Science and Human Identity in Twentieth-Century China*. Chicago: University of Chicago Press.
- Secord, James A. 2000. *Victorian Sensation: The Extraordinary Publication, Reception and Secret Authorship of Vestiges of the Natural History of Creation*. Chicago: University of Chicago Press.
- Secord, James A. 2004. "Knowledge in transit." *Isis*, 95, No. 4: 654–72.
- Shapin, Steven. 1989. "The invisible technician." *American Scientist*, 77: 554–63.
- Shapin, Steven, and Simon Schaffer. 1985. *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*. Princeton, NJ: Princeton University Press.
- Shapin, Steven, and Simon Schaffer. 2011. *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life. With a New Introduction by the Authors*. Princeton, NJ: Princeton University Press.
- Shteir, Ann B. 1996. *Cultivating Women, Cultivating Science: Flora's Daughters and Botany in England, 1760–1860*. Baltimore: Johns Hopkins University Press.
- Smith, Crosbie. 1998. *The Science of Energy: A Cultural History of Energy Physics in Victorian Britain*. Chicago: University of Chicago Press.
- Söderqvist, Thomas. 2007. *The History and Poetics of Scientific Biography*. Aldershot: Ashgate.
- Soler, Léna, Sjoerd Zwart, Michael Lynch, and Vincent Israel-Jost (eds.) 2014. *Science after the Practice Turn in the Philosophy, History, and Social Studies of Science*. London: Routledge.
- Terrall, Mary. 1995. "Émilie du Châtelet and the gendering of science." *History of Science*, 33: 283–310.
- Terrall, Mary. 2002. *The Man Who Flattened the Earth: Maupertuis and the Sciences in the Enlightenment*. Chicago: University of Chicago Press.
- Terrall, Mary, and Kapil Raj (eds.) 2010. "Circulation and Locality in Early Modern Science." Special Issue, *British Journal for the History of Science*, 43, No. 4.
- Topham, Jonathan R. 2009. "Introduction [to Focus Section: Historicizing popular science]." *Isis*, 100: 310–18.
- Topper, David R., and John H. Holloway. 1980. "Interrelationships between the visual arts, science and technology: A bibliography." *Leonardo*, 13, No. 1: 29–33.

- Van Helden, Albert, and Thomas L. Hankins (eds.) 1994. "Instruments." *Osiris*, 2nd series, 9: 1–250.
- Van Miert, Dirk (ed.) 2013. *Communicating Observations in Early Modern Letters (1500–1675): Epistolography and Epistemology in the Age of the Scientific Revolution*. London: Warburg Institute.
- Vetter, Jeremy (ed.) 2011. *Knowing Global Environments: New Historical Perspectives on the Field Sciences*. New Brunswick, NJ: Rutgers University Press.
- Warf, Barney, and Santa Arias (eds.) 2008. *The Spatial Turn: Interdisciplinary Perspectives*. London: Routledge.
- Zilsel, Edgar, Diederick Raven, Wolfgang Krohn, and R. S. Cohen. 2000. *The Social Origins of Modern Science*. Dordrecht: Kluwer Academic Publishers.

Conservation and Preservation

“I want to drop politics absolutely for four days and just be out in the open with you.” In 1903, this charming and unusual request came to John Muir from none other than President Theodore Roosevelt. Muir could not resist. That summer, the two men set out on an intimate three-night camping trip through the spectacular scenery of Yosemite Park in California to “talk conservation” (see Figure 6.1). Although Yosemite Valley and the Mariposa Grove belonged to the state at the time, Muir hoped to convince the commander-in-chief that both deserved protection within the national park. While the specifics of their talks and rambles remained private, the outcome of their adventure was not only the federal preservation of Yosemite Valley and Mariposa Grove and a preliminary outline for what would become the Antiquities Act, but also effusive declarations of respect and affection from both men. “I shall always be glad that I was in the Yosemite with John Muir,” Roosevelt wrote, while Muir simply gushed: “I fairly fell in love with him.” As this rapprochement illustrates, these two men, who often appear as oversimplified adversaries – Roosevelt the Conservationist versus Muir the Preservationist – in fact aligned closely on many key environmental issues. Both men dedicated their lives to protecting the scenic wonders of nature and both viewed wilderness as a necessary respite from civilization. By the time he left office, Roosevelt had created 5 national parks (many influenced by Muir), 18 national monuments, 55 national bird sanctuaries and wildlife refuges, and 150 national forests. “We are not building this country of ours for



Figure 6.1 President Theodore Roosevelt and John Muir atop Glacier Point in Yosemite during their formative May 1903 camping trip. Source: Reproduced with permission of the National Park Service.

a day,” Roosevelt avowed, “It is to last through the ages.” Muir’s writings and advocacy ultimately established his legacy as the “Father of the National Parks,” and his biographer Donald Worster has argued that Muir’s mission was nothing less than “saving the American soul from total surrender to materialism.” But for all their points of agreement, the two men also had their differences. Ironically, Yosemite would provide the setting for both their happy 1903 camping expedition and their apocryphal showdown over damming the park’s Hetch Hetchy Valley.

As the twentieth century dawned, exploitative market demands and the West’s resource-based colonial-like status continued – acerbic writer Bernard DeVoto labeled the early West “the plundered province,” but the region began

to assert its own unique identity as a result of its extensive public lands. This federal variation on “commons” comprised of forest reserves, parks, monuments, and wildlife refuges quickly became the distinguishing hallmark of the American West and began to establish a new way to “value” nature beyond commodification. In 1889, a former Secretary of Interior, Carl Schurz, had railed that Americans were “a spendthrift people recklessly wasting [their] heritage” and saddled with “a government careless of the future”; four years later, Frederick Jackson Turner ominously warned that “the frontier has gone and with it has closed the first period in American history.” So, what was next? Roosevelt and Muir. Together these two men personified the foundational ideas, conservation and preservation that would shape both thought and policy about the natural environment of the West well into the twenty-first century.

Public commitment to protecting natural resources grew through the first two decades of the twentieth century as one of the central issues championed by Progressives. As a political ideology, Progressivism sought to improve the human condition through governmental reforms designed to redress the social inequalities that emerged as the nation rapidly urbanized and industrialized. Although it began at the local and state levels as a kind of municipal housekeeping, Progressive reform had become a full-fledged national phenomenon by the turn of the century. Avid modernizers, Progressives typically held white, middle-class values, used science and statistics to support their causes, promoted efficiency and education, and viewed government, especially at the federal level, as a positive instrument for social change. Progressivism also had a strong religious undercurrent that attempted to reconcile Protestant morality with capitalism and democracy to promote a kind of Christian stewardship of the nation and its resources. Never a really unified “movement” per se, Progressivism championed reforms as diverse as temperance, birth control, urban sanitation, anti-child labor laws, settlement houses, anti-prostitution campaigns, women’s rights, and environmental protection.

In this final area, Progressive concerns about the limits of the nation’s natural resources prompted two different, if related, responses: conservation and preservation. While by the late twentieth century these two terms had become interchangeable in popular parlance (along with “environmentalism”), at the beginning of the century each had a very unique meaning and associated values. Essentially, conservation advocated the wise *use* of nature, while preservation advocated the protection of nature from exploitation.

The first of these, conservation, was utilitarian and emphasized the role of science and rational planning in the efficient development and use of natural resources, especially in the West. Conservationists advocated protecting resources for the good of the nation to ensure that they would always be available for future consumers. Theodore Roosevelt and his chief forester Gifford

Pinchot would become the most high-profile advocates for this idea, which arose out of concerns about the nation's declining timber supplies. The myth of inexhaustibility in the nation's forests had begun to reveal its perfidy as early as the 1870s with the stark deforestation of the Great Lakes region. Interior Secretary Schurz had lamented that "the destruction of our forests is so fearfully rapid that if we go on at the same rate, men whose hair is already gray will see the day when ... there will be no forest left worthy of the name." He was right. By the 1890s, the avaricious take had also stripped many West Coast forests of their prize trees to feed housing booms in San Francisco and Los Angeles, and provide milled timber to east coast markets. Congress had responded with the 1891 Forest Reserve Act, discussed in the previous chapter, which empowered the president to set aside/conservate "forest reserves" for the future. The subsequent 1897 Organic Act reinforced this conservation agenda by stipulating that the reserves were designed to "furnish a continuous supply of timber for the use and necessities of citizens of the United States." In 1898, President William McKinley appointed the 33-year-old Pinchot to preside over these holdings, and by the turn of the twentieth century, the system comprised more than 47 million acres.

In 1901, McKinley's assassination suddenly thrust Vice President Theodore Roosevelt into the Oval Office. At the news, one conservative senator purportedly lamented, "Now look! That damned cowboy is president," but for the West, the elevation of the "cowboy" proved a fortuitous promotion. Progressives now had a powerful new ally in the White House, and so did Pinchot. An early and avid advocate for protecting the wild places of the American West, the once-frail president had used ranching and hunting in the region to reinvent his sickly eastern self as a virile and manly "cowboy" and so shed early effeminate nicknames such as "Jane-Dandy" and "Punkin-Lily." In the early 1880s, Roosevelt made several trips to the Dakotas, even buying a couple of ranches, and working on them, which allowed him to "harden" himself, bulk up, shed childhood ailments like asthma, and even swap out his squeak for a voice "hearty and strong enough to drive oxen." "Cowboy" was apt. In 1887, as part of his effort to protect the very West that Turner and Buffalo Bill would soon warn was vanishing, Roosevelt co-founded the Boone and Crockett Club, named after frontiersmen Daniel Boone and Davy Crockett, to "promote the conservation and management of wildlife, especially big game, and its habitat." A kind of grown-man's Boy Scouts, the Club's socially elite membership advocated ethical hunting and sportsmanship and began lobbying for the protection/conservation of wild animals – at least the ones these sportsmen liked to hook and shoot – and American masculinity. As good Progressives, they believed that the federal government served as the best steward of the public's natural resources and guardian against rampant capitalist exploitation.

As President, Roosevelt was in a unique position to implement change. By the end of his administration, the nation could boast 51 wildlife refuges and 4 game preserves in 17 states and 3 territories that protected birds from the hat plume trade as well as the few remaining bison and elk herds. Roosevelt had a number of prominent allies in his quest to protect the West's charismatic megafauna, including William Temple Hornaday, prolific author, taxidermist, and director of the New York Zoological Park. Like Roosevelt, Hornaday had grown alarmed by the near extermination of bison and other western game species and became a convert to conservation. "Here is an inexorable law of Nature," Hornaday wrote, "to which there are no exceptions: No wild species of bird, mammal, reptile or fish can withstand exploitation for commercial purposes." Hornaday's pithy "law" certainly applied to almost all of the natural resources of the West. Roosevelt concurred.

In 1905, Roosevelt set aside the nation's first large game wildlife reserve, the Wichita National Forest and Game Preserve in Oklahoma, as a cooperative bison restoration effort between the federal government and Hornaday, who donated 15 of the zoo's captive bison to reestablish the species. Indeed, if any one person deserves credit for rescuing bison from the brink of extinction, it's Hornaday. His book *Our Vanishing Wildlife*, published in 1913, passionately called for wildlife reform; the "birds and mammals now are literally dying for your help," he warned. By 1919, thanks in large part to Hornaday's activism, the great American bison had begun its slow rebound to ecological health, from a frighteningly low point of a few hundred wild individuals, to nine growing herds. In 1905, Roosevelt had also consolidated several federal agencies into the Bureau of Biological Survey (which in 1940 became the Fish and Wildlife Service) to manage the growing reserve system. The agency's focus, however, remained the protection of fish and game, not predators, which they continued to exterminate in astonishing numbers. It would take the ecological imagination of later men like Aldo Leopold, a forester who embraced both conservation *and* preservation, to begin seeing things whole, rather than as a piecemeal attempt to protect trophy species and eliminate their predators. But the wildlife refuges constituted a start and an important foundation upon which the coming environmental movement could build.

In 1905, the same year that he organized the Bureau of Biological Survey, Roosevelt transferred the country's "forest reserves" into a newly minted United States Forest Service, renamed them "national forests," and designated Pinchot Chief of the Forest Service. Significantly, the Department of Agriculture housed the Forest Service, an assignment befitting the utilitarian/conservation mission of the new agency. Trees were a crop, and the Service would manage them accordingly. Pinchot himself argued that "the object of our forest policy is not to preserve the forests because they are beautiful ... or because they

are refuges for the wild creatures of the wilderness. The forests are to be used by man. Every other consideration comes secondary."

A classic Progressive, Pinchot combined a formal education in forest management with practical experience gleaned from his family's private estate. Pinchot adhered to "the gospel of efficiency" – an almost religious dedication to the scientific management of the forests (as a crop) to ensure "that the water, wood, and forage of the reserves are conserved and wisely used for the benefit of the home builder first of all." This "multiple-use" philosophy sought to avoid the "tragedy of the commons" by regulating cutting, mining, grazing, and recreation to ensure that the forests could be both used *and* saved, the hallmark of efficient conservation. The national forest system flourished under Roosevelt and by the end of his tenure in the White House, he had set aside 150 national forests. In the West, Pinchot endeavored to counter the heavy hand of this new, often resented federal landlord by creating a hierarchical US Forest Service that placed much of the administrative responsibilities and decisions in the hands of local rangers and regional supervisors. But ultimately, the agency bowed to efficiency of scale, and Pinchot frequently gave preferential treatment to large cattle and timber operations over small resource users because it made good conservation, if not democratic, sense. In the end, he argued, conservation meant "the greatest good" to "the greatest number in the long run." Like many of the West's natural resources, timber acted as a commodity and the market determined its ultimate value; scientific management of the forests made them profitable.

Not all Progressives followed Pinchot's utilitarian lead, however, and an important, and often competing, ideology emerged at the turn of the century called preservation. Preservationists advocated the protection of nature for its own sake and for the physical and spiritual health of people rather than purely for economic utility. This was the argument of John Muir, who believed that "the hills and groves were God's first temples." In many ways, Muir serves as an illustrative transitional figure between the Romanticism of the nineteenth century and the environmentalism of the twentieth. Both Romantics and Transcendentalists like Henry David Thoreau and Ralph Waldo Emerson had emphasized the primacy of the imagination and emotions, celebrated the individual, and waxed rhapsodic about the wonders of nature. Muir's writings certainly bore the imprint of these influences. Born in Scotland in 1838, Muir and his family immigrated to America when he was 11. A curious, if eclectic, student, Muir took college courses in the sciences and read Thoreau, Emerson, and George Perkins Marsh, absorbing natural history and developing an abiding appreciation for "the infinite lavishness and fertility of Nature." For several years, he traipsed across much of the West, including Alaska, studying at what he called "The University of the Wilderness." By the 1870s, he made his living as "John of the Mountains," writing about wilderness and the West's wild

places he had come to love. Like many Progressives, Muir believed that the federal government could most effectively and efficiently protect these natural wonders.

As historian Thomas Wellock has argued, "Muir blended the idealism of Henry David Thoreau with the political activism befitting a modern lobbyist." In classic Progressive fashion, Muir co-founded the Sierra Club in 1892 as an organization "to explore, enjoy, and render accessible the mountain regions of the Pacific Coast; to publish authentic information concerning them; to enlist the support and cooperation of the people and the government in preserving the forest and other natural features of the Sierra Nevada Mountains." He also cultivated friendships with businessmen/powerbrokers like Edward Harriman, head of the Southern Pacific Railroad, President Roosevelt, and even Pinchot, because they had the political and financial clout to translate his advocacy into action, as the opening Yosemite anecdote illustrates. These pragmatic alliances also reveal that the divide between conservation and preservation could often be more imagined than real.

During the Roosevelt years, however, conservation won the day. The American West was still developing economically and serving as a national resource warehouse, so that Muir's preservationist ideals seemed a luxury, even a "waste," to many people in the region and the nation. The Sierra Club and Muir continued to lobby for the protection of "sublime" nature, but these more romantic notions about the environment would not attain primacy in the West or the United States as a whole, until after World War II, when tourism became a mass phenomenon, and middle class and even blue collar Americans began taking vacations to enjoy the "wilderness." Nowhere was this triumph of conservation more evident in the West than in the push for reclamation, the effort to use irrigation to "reclaim" arid lands. Despite the federal government's best efforts and intentions to distribute western lands cheaply and quickly via the Homestead Act and others like it, settlers inevitably ran up against the vexing aridity of much of the West: too dry to dry-farm and too vast to irrigate. Progressives once again turned to the federal government for assistance and, in 1902, Congress passed one of the most influential laws for the West: the Newlands Reclamation Act.

The Reclamation Act alluded to the vision of John Wesley Powell, who had vigorously advocated for a West settled and developed around watershed basins managed by the federal government (see Chapter 4). Powell's proposals may have been too restrictive for gung ho settlers, but in the Progressive Era, the idea that the federal government should fund large-scale water projects – dams, canals, irrigation – found many adherents. In contrast to Powell's plan, though, reclamation endeavored to bring water to the people instead of settling people where there was water. Essentially "multiple use" for rivers, reclamation promoted the rational, efficient development of water

resources to manage power and provide irrigation, flood control, navigation, and recreation. Indeed, the reclamation movement tugged hard at long-held, core American values: it promised to make the desert bloom, promote Jeffersonian democracy by providing for the yeoman farmer, and prevent corporate monopolies. As one of reclamation's biggest boosters Elwood Mead proclaimed, "the result will determine whether Western agriculture will be corporate or cooperative; whether rivers shall become an instrument for creating a great monopoly, as the dominant element of Western society, or be a free gift to those who make a public return for their use."

With the Progressive Roosevelt in the White House, the reclamation movement gained momentum. Roosevelt explained how reclamation fit within the conservation movement in a December 1901 speech written by Pinchot: "The forests alone cannot ... fully regulate and conserve the waters of the arid region. Great storage works are necessary to equalize the flow of streams and to save the flood waters." Conserving water for future *use*. Congress agreed and six months later it passed the historic Newlands Reclamation Act, named after Senator Francis Newlands of Nevada, the act's sponsor. The act created the federal Reclamation Service, soon renamed the Bureau of Reclamation, within the Department of Interior, provided for all states on or west of the 100th meridian (Texas was added in 1906) to receive federal funds for reclamation projects, and proclaimed its intention to serve the small family farmer by limiting access to reclaimed water exclusively to local residents irrigating between 40 and 160 acres of land. The optimistic act also stipulated that the projects would pay for themselves within 10 years through land sales and farmer payments. Not surprisingly, western states chafed at federal control over western resources, and so to mollify them, the Reclamation Act also provided for a strange hybrid of federal funding for reclamation projects and state control over the water they conserved. Social critic DeVoto summed up the West's arrangement: "Get out and give us more money." Reclamation represented a utopian, democratic vision of the West not wholly incompatible with Powell's. And like most utopian visions, it was doomed to failure, as corporate agribusiness and booming cities soon monopolized the water intended for small family farms.

Reclamation projects did spur western settlement, however; settlers filed by far the largest number of homestead patents ever in the first 20 years of the twentieth century, and reclamation water accounted for nearly 30% of the irrigated acreage in the 11 western-most states. In its first five years, the Bureau began about 30 projects in western states. But the fiscal and environmental costs proved excessive. Farmers' meager profits left them unable to repay the high costs of dams and irrigation projects. To address this problem, Congress began to stray from the actual language of the act, first by extending repayment periods out to four decades, then by making the building loans

interest-free, and finally by allowing the debts to linger, in some cases, until the present day. According to one estimate, "86 percent of the total reimbursable construction costs have not been and will not be repaid." It was an awesome tax-payer subsidy. But not to the intended small farming families. Like the Homestead Act before it, reclamation quickly came to benefit entrepreneurs, who identified water as *the* lucrative western commodity.

Cheap land plus cheap water proved a powerful lure to agribusiness speculators, who snapped up 160-acre parcels and took advantage of a reclamation loophole that allowed families to collectively manage each member's individual (maximum) holding and then lease the entire landmass to corporate farmers. In other words, a family of six could claim six separate 160-acre land parcels and the federally subsidized reclamation water to irrigate it, and then lease all 960 acres and the cheap water to an agribusiness entrepreneur. The bigger the "family," the bigger the leased land/water parcel. Like earlier Homestead Act "dummy" claims, these reclamation sleight-of-hand maneuvers undermined the act's original Jeffersonian intent to support small farmers. California speculators elevated the subterfuge to a near art form. Lobbyists for the state's development managed to convince Congress to exempt the entire Imperial Valley from the acreage limitations stipulated in the act, while agribusiness farmers in the Central Valley circumvented the same restrictions when the Army Corps of Engineers built their hydraulic system. Throughout the West, the Army Corps often competed with the Bureau of Reclamation for federal funding to build, among other things, dams, canals, and flood control projects. The Army Corps' water, it turned out, was not bound by reclamation laws. Ultimately, neither were federal bureaucrats, who found it increasingly inconvenient, if not impossible, to enforce the act's limitations.

In his influential book, *Rivers of Empire*, environmental historian Donald Worster argues that the legacy of the 1902 Newlands Act was the development of a "hydraulic society," where ownership and control of the West's massive reclamation infrastructure became consolidated into the hands of an oligarchic elite comprised of large western land owners and federal technocrats from the East. Instead of the utopian, democratic ideals the act seemed to embody, Worster argues, the massive scale of arid lands reclamation created a "coercive, monolithic, and hierarchical system, ruled by a power elite based on the ownership of capital and expertise." In the West, capitalism had captured the water. Los Angeles and San Francisco certainly fit this description. Growing and thirsty, their grasping for water added another layer of complexity to the West's environmental history, and they provide two provocative non-federal illustrations of Worster's thesis.

William Mulholland personified Worster's "power elite" and he had a vision for Los Angeles. For the City of Angels to become a thriving metropolis,

it would need water ... lots of it. And as the head of that burgeoning city's Department of Water and Power, Mulholland was painfully aware that the go-go growth of Los Angeles was quickly outstripping the thirst-quenching ability of the Los Angeles River. He also understood the basic premise of western water law: first in time, first in right. The answer to LA's aridity riddle, Mulholland realized, lay 200 miles north of Los Angeles on the eastern side of the Sierra Nevadas in the Owens River Valley. There, small farmers eagerly awaited the kind of federal reclamation promised by the Newlands Act that would make their desert bloom. Mulholland had a different idea ... one that would make LA bloom instead.

In 1905, after securing a vaguely worded municipal bond issue for the "purchase of lands and water and the inauguration of work on the aqueduct," the City of Los Angeles began quietly buying up Owens Valley farmland and the riparian/water rights-of-way along the Owens River. By the time local residents figured out the hijacking scheme, it was too late. Mulholland supervised construction of the 233-mile-long, gravity-powered Los Angeles Aqueduct that took the river south and *over* the mountains into Los Angeles (see Figure 6.2). Along the way, it also provided irrigation to the San Fernando Valley, just north of the city. Developers and investors in on Mulholland's confidential plan snapped up dirt-cheap soon-to-be-irrigated property in the San Fernando Valley before its real value became apparent. On November 5, 1913, when the water began to flow, Mulholland, like a good oligarch, empirically declared: "There it is; take it."

So what about the "small family farmer" whom reclamation was supposed to support? Ever the pragmatic and efficient Progressive conservationist, Roosevelt embraced the "greatest good of the greatest number" reasoning and threw his support behind the Owens River water transfer as "a hundred or thousandfold more important and more valuable to the people as a whole." Federal reclamation abandoned the Owens Valley and doomed its farmland to aridity. The loss of the river also devastated the local Owens Valley environment. The Owens Lake ecosystem, which once served as an important rest stop for millions of migrating waterfowl, shriveled into a parched alkali flat that still generates debilitating dust storms. A second LA Aqueduct, built in the 1970s, further exacerbated the situation by siphoning off the valley's springs and seeps and withering groundwater-dependent vegetation and the valley's lush meadows. Although two environmental lawsuits and court-levied fines finally forced the city to restore water to a 62-mile stretch of the Owens River in 2007, desertification had already taken a heavy toll. In an area that receives less rainfall than Phoenix, saltbrush and tumbleweeds now flourish where native grasses and wildflowers once thrived. Today, the Owens River supplies between 30 and 50% of distant Los Angeles' water needs and the dried-out local lakebed constitutes one of the largest sources of dust pollution in the United States.



Figure 6.2 A portion of pipeline in the Jawbone Siphon of the Los Angeles Aqueduct, San Fernando Valley, California, engineered by William Mulholland to transfer water from the Owens Valley more than 200 miles south to thirsty Los Angeles. Source: Reproduced with permission of the Los Angeles Department of Water and Power.

As recently as 2014, one resident complained that “the city of Los Angeles regards Inyo County as a resource colony to be exploited to whatever means they see fit. They are taking all the water they possibly can. Water tables are dropping precipitously.” Los Angeles built the aqueduct in spite of farmers and ranchers who bombed and vandalized it in the so-called California Water Wars of the 1920s. And in the end, the Owens River flowed out of its valley into a concrete ditch and made a distant metropolis, not the desert, bloom. In 1890, 50 000 people had called Los Angeles “home”; by 1900 that number had doubled to 100 000; and by 1910, the population had exploded to 320 000. As Worster concludes, “the smaller, weaker party lost out to the more powerful one while the federal government looked on and abetted.”

For John Muir and Theodore Roosevelt, the sometimes conflicting objectives of conservation and preservation, evident in the Owens Valley,

came into even sharper focus in the Hetch Hetchy Valley of Yosemite. Once again, the catalyst was water. Like Los Angeles, the city of San Francisco sought a reliable source that could slake its thirst for decades into the future. In 1903, city officials proposed damming the Tuolumne River in the Hetch Hetchy Valley in Yosemite National Park to create a public water supply. It was classic conservationism. Outraged, Muir and the Sierra Club protested vigorously, arguing that such a proposal violated the *preservation* mandate of the park. Following the devastating earthquake and ensuing calamitous fires of 1906, however, San Francisco's quest took on a new urgency; the city needed a bigger, better, more reliable source of water. The Roosevelt administration, largely at the prodding of utilitarian-minded Pinchot, agreed, and shifted its support to the proposal.

The Hetch Hetchy clash pitted two different visions of the valley against one another: Muir and other preservation activists, who hoped to promote nature tourism and scenic protection through the development of hotels and campgrounds, versus conservationists, who wanted to dam the valley to create a public water supply and thwart avaricious private utility companies that could ransom power to the highest bidder. Both sides slung epithets. Muir blasted his opponents as "Satan and Co." and "temple destroyers" who were beholden to the "Almighty Dollar." Dam supporters ridiculed preservationists as "short-haired women and long-haired men" and argued that the economic utility of damming Hetch Hetchy outweighed the sentiments of tourists, who could always go marvel at Yosemite Valley. Conservation won this round. In 1913, Congress passed the Raker Act authorizing the city's construction of O'Shaughnessy Dam, completed a decade later, and the creation of the Hetch Hetchy Reservoir. Muir was devastated; he died the next year. Yosemite and the Range of Light may have brought Roosevelt and Muir together to hike and camp in 1903, but Hetch Hetchy demonstrated that sometimes conservation and preservation were irreconcilable. In the early twentieth-century West, the development/exploitation mindset still prevailed, although sometimes by the hands of westerners themselves, and a full-blown commitment to preservation was only a faint glimmer in the distant future.

The Hetch Hetchy fight may have broken Muir's spirit, and perhaps even his heart, but preservationists emerged from it more powerful and influential than ever before, and ironically their loss in Yosemite helped ensure that other parks, like the Grand Canyon, would not suffer such a fate. Unlike federal and municipal reclamation, the parks movement allowed conservation/use and preservation to overlap extensively. Conservationists championed national park "use" for the enjoyment and moral and physical health of visiting tourists, while preservationists celebrated federal protection of scenic wonders. By the time Roosevelt took the presidential oath of office, the United States had already committed itself to the idea of parks for the people, particularly in the

West where the federal government still held and controlled much of the land. In 1872, Congress had set aside Yellowstone as the first national park and assigned its administrative duties to the Department of Interior. In 1886, when the agency proved unable to keep poachers and squatters out of the park, the US Army took over and expanded its jurisdiction over the next two decades to include each newly added western jewel such as Yosemite, Sequoia, General Grant (which later became Kings' Canyon), Mount Rainier, Crater Lake, and Glacier.

Progressives enthusiastically embraced the park concept and so did Roosevelt, especially after 1906 when Congress passed the Antiquities Act. The Antiquities Act gave the president extraordinary and unchecked executive authority to by-pass the cumbersome congressional park designation process and unilaterally set aside "historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest" as national monuments. Roosevelt, and his successor William Howard Taft, wasted little time putting the new law into action; Devil's Tower, El Morro, Montezuma's Castle, Petrified Forest, Chaco Canyon, Lassen Peak, Grand Canyon, Jewel Cave, Natural Bridges, and Mount Olympus all came into the system as western national monuments. Significantly, these first parks and monuments were visually stunning *and* economically marginal, so setting them aside didn't jeopardize western development. During Roosevelt's tenure alone, from 1901–1909, the conservation president set aside 18 national monuments and 5 national parks, which in addition to national forests, wildlife preserves, and refuges, protected approximately 230 000 000 acres of public land. By 1911 the number of national parks and monuments administered by various governmental agencies had swollen to nearly 40. The time had clearly come to create a new agency to manage this public resource "commons" collectively rather than individually.

The national parks have been called "America's best idea," and it makes sense that their organizational genesis lies in the Progressive Era. The Hetch Hetchy fight had demonstrated the vulnerability of the parks, and the effort to establish an agency to manage them had gained serious momentum by the time Woodrow Wilson came into the White House in 1913. Support for such a federal agency ran the gamut from governmental administrators to tourist organizations. But the complaint of borax millionaire Stephen Mather finally tipped the scales. In the summer of 1914, Mather visited Sequoia and Yosemite national parks and became incensed at their poor management. He wrote of his concerns to his friend, Secretary of Interior Franklin Lane, who responded quite simply: "If you don't like the way the parks are being run, come on down to Washington and run them yourself." Mather took the bait. As someone who had been on the losing side of the Hetch Hetchy fight, Mather understood that both he and the parks needed to finesse a delicate balance between

conservation and preservation, and so Mather began a national campaign of articles and photographs to drum up support for a federal parks agency.

In 1916, Mather's crusade triumphed when Congress passed and President Wilson signed the National Park Service (NPS) Organic Act and named Mather as its first Director. The NPS's stated mission was "to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." This hybrid and often contradictory assignment would prove difficult to carry out in the long run. With "tourism" as its prime directive, the newly minted Park Service struggled to reconcile protecting the sublime and providing pit toilets.

Furthermore, the aesthetic appreciation for nature borne out of leisure experiences such as hiking, camping, hunting, and fishing sometimes gave conservationists and preservationists an elitist perspective. Although the creation of the park system seemed to reinforce core democratic values of community and openness, the parks themselves were really only accessible to



Figure 6.3 Cliff Palace, Mesa Verde. Once home to ancestral Pueblo peoples, Mesa Verde became a national park in 1906 when President Theodore Roosevelt set it aside to "preserve the works of man." Source: Reproduced with permission of the National Park Service.

those with the financial resources to travel and explore. Not until the post-war boom in the 1950s and 1960s would travel to the national parks become a mass phenomenon. Moreover, conserving nature for recreation and tourism at times meant *preventing* subsistence users from hunting, gathering, fishing, and utilizing timber resources. In other words, parks tended to benefit the middle and upper classes at the expense of non-whites and the rural poor. Policies of Indian removal at Yellowstone, Glacier, and Yosemite, for example, attempted to create a “pristine” and “safe” wilderness experience for park visitors as part of a larger attempt to “protect” nature. Buffalo Bill’s Wild West had already primed audiences with a nostalgic western Indian mythology, but these romantic portrayals only resonated once Native peoples no longer constituted any real threat or danger. Interestingly, all three parks were willing to pay Native peoples to “play Indian” as “tourist bait” for visitors, so long as this controlled contact constituted the extent of their presence in the park. To be sure, several of the new national parks and monuments protected Indian sites such as Mesa Verde, Chaco Canyon, and Gran Quivira, but they were all *ruins*, the silent, ghostly, abandoned reminders of an ancient America that had long since vanished (see Figure 6.3). Tourists expected that *their* parks would be uninhabited, and that required dispossession. Yet for all its shortcomings and seeming frivolity to many who labored in the West, public lands tourism nevertheless served as a cultural common denominator and the region’s iconic landscapes, flora, and fauna proved especially captivating.

Both the conservation and preservation movements represented an important shift in the relationship between the federal government and the nation’s public lands. Prior to the Progressive Era, the government’s primary objective had been putting public lands into private hands through massive incentive programs such as the Homestead Act and the 1872 Mining Law. Now, however, the federal government aggressively set aside lands in the public domain with the specific goal of *preventing* their conversion into private property. By doing so, the government, through its various land-management agencies, ensured that it would continue to be a dominant presence in the West. In the end, the twin Progressive Era reform impulses of conservation and preservation sought to remedy open-access exploitation through federal oversight and regulation and avoid the “tragedy of the commons” dilemma. National forests, wildlife preserves, reclamation, and parks – a kind of federal “commons” – would ensure that no matter how zealously individual Americans pursued their own economic and self-interest, there would always be sufficient natural resources to fuel the nation’s growth and development, and sublime landscapes where one could discover, as Muir evangelized, “that wildness is a necessity; and that mountain parks and reservations are useful not only as fountains of timber and irrigating rivers, but as fountains of life.”

Suggested Reading

- Marshall E. Bowen, "Crops, Critters, and Calamity: The Failure of Dry Farming in Utah's Escalante Desert, 1913–1918," *Agricultural History*, Vol. 73, No. 1 (Winter 1999), 1–26.
- Lincoln Bramwell, "When the Mountains Roared: The 1910 Northern Rockies Fires," *Montana: The Magazine of Western History*, Autumn 2010, 54–69, 96.
- Douglas Brinkley, "TR's Wild Side," *American Heritage*, Vol. 59, No. 3 (Fall 2009), 26–35.
- Bernard DeVoto, "The West Against Itself," in Douglas Brinkley and Patricia Nelson Limerick, eds, *The Western Paradox: A Conservation Reader* (New Haven: Yale University Press, 2001), 45–73.
- Benjamin Heber Johnson, "Conservation, Subsistence, and Class at the Birth of Superior National Forest," *Environmental History*, Vol. 4, No. 1 (January 1999), 80–99.
- Robert B. Keiter, *To Conserve Unimpaired: The Evolution of the National Park Idea* (Washington DC: Island Press, 2013).
- Robert H. Keller, Jr and Michael F. Turek, *American Indians and National Parks* (Tucson: University of Arizona Press, 1999).
- Tom Knudson, "Outrage in Owens Valley a Century after L.A. Began Taking its Water," *The Sacramento Bee*, January 5, 2014. www.sacbee.com/2014/01/05/6046630/outrage-in-owens-valley.html (accessed February 4, 2016).
- Curt Meine, "Roosevelt, Conservation, and the Revival of Democracy," *Conservation Biology*, Vol. 14, No. 4 (August 2001), 829–831.
- John Muir, "The Wild Parks and Forest Reservations of the West," in Fred D. White, ed., *Essential Muir: A California Legacy Book* (Berkeley: Heyday Books, 2006).
- David A. Nesheim, "Profit, Preservation, and Shifting Definitions of Bison in America," *Environmental History*, Vol. 17, No. 3 (July 2012), 547–577.
- Mark Reisner, *Cadillac Desert: The American West and its Disappearing Water* (New York: Penguin Books, 1993). See also the June of 2000 PBS four-part documentary by the same name.
- Robert W. Righter, *The Battle over Hetch Hetchy: America's Most Controversial Dam and the Birth of Modern Environmentalism* (New York: Oxford University Press, 2005).
- Mark David Spence, *Dispossessing the Wilderness: Indian Removal and the Making of the National Parks* (New York: Oxford University Press, 1999).
- Ian Tyrrell, *Crisis of the Wasteful Nation: Empire and Conservation in Theodore Roosevelt's America* (Chicago: University of Chicago Press, 2015).
- James Wilson to The Forester [historians believe Gifford Pinchot authored the letter for Wilson's signature], 1 February 1905, Forest History Society. www.foresthistory.org/ASPNET/Policy/Agency_Organization/Wilson_Letter.aspx (accessed February 4, 2016).
- Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985).
- Donald Worster, "The Troubled Nature of Wealth," in *A Passion for Nature: The Life of John Muir* (New York: Oxford University Press, 2011).
- Michael J. Yochim, "Beauty and the Beet: The Dam Battles of Yellowstone National Park," *Montana: The Magazine of Western History*, Vol. 53, No. 1 (Spring 2003), 14–27.

CHAPTER TWENTY-TWO

Climate Change in Global Environmental History

SAM WHITE

The study of past climate change has recently emerged both as a critical topic in global environmental history and as its own interdisciplinary subject of historical research. As global warming has raised awareness of current and future climate issues, it has also raised questions about earlier climate fluctuations, their impacts, and how societies have coped with change and variability. Drawing on new methods and evidence, researchers around the world have begun to reconstruct past climates and their role in human history. This growing field has shed new light on important historical developments, and in time may offer new perspectives and lessons for the challenge of global warming.

Background, Methods, Concepts

The study of climate in human affairs reaches back to the earliest works of history. Ancient authors such as Herodotus described hot and cold “climes” and pondered their impact on the character and constitution of societies. Such ideas persisted through the Middle Ages and into works of Enlightenment thinkers such as Montesquieu and Voltaire. In the late nineteenth and early twentieth centuries, the study of climate sometimes merged with notions of racism and racial hierarchy, producing simplistic climatic explanations of history, as in the work of Elsworth Huntington. Such “climate determinism” produced a backlash among subsequent scholars, many of whom have resisted climatic explanations ever since.¹

Nevertheless, with recent advances in climatology and especially the discovery of global warming, climate has resurfaced as a serious subject for archeologists and historians. Scholars as far back as Edward Gibbon (1737–94) may have noted differences between past and present temperatures, but only in the mid-twentieth century did researchers assemble firm evidence of significant historical climate change. Studies of the Little Ice Age (see below) by Fernand Braudel, Gustav Utterström, and Emmanuel Le

Roy Ladurie in the 1950s opened the first serious debates about climate and history in early modern Europe.² By 1958, measurements of rising atmospheric carbon dioxide began to support theories of a man-made greenhouse-gas effect, an idea first proposed in the 1890s. These discoveries spurred the development of increasingly detailed and sophisticated scientific measurements of past and present climate, which have continued ever since.³ At the same time, a handful of scholars began the painstaking work of compiling and then verifying and quantifying written observations of past weather. By gathering and analyzing this data, researchers since the 1980s have forged a new interdisciplinary field known as “historical climatology,” which seeks to reconstruct past climates and their role in human history.⁴

In general, historical climatologists have used three types of evidence: instrumental measurements, climate proxies, and written records. Weather instruments such as the thermometer offer the most accurate information, but these only date back to the seventeenth century and only in a few parts of the world. Therefore, most climate reconstructions rely on so-called proxies, which are physical records of past climates. For instance, dendroclimatologists drill cores from old trees to measure their annual growth rings. If the size of these growth rings lines up well with some weather variable – such as spring temperature or summer rainfall – then climatologists can calibrate the correlation with modern instrumental data and extrapolate back in time, using older growth rings as a “proxy” for preinstrumental measurements. Apart from tree rings, researchers now employ a wide variety of proxies, including ice cores, cave deposits, lake sediment layers, and buried pollen. In some instances historical climatologists can also make use of written sources describing the weather, which range from diaries to chronicles to official archives.

These different types of historical evidence present different strengths and weaknesses. For instance, tree-ring measurements are often very precise, but they usually only date back a few hundred years. Pollen samples and bore holes can offer thousands of years of data but only at a low resolution – the average temperature for each century but not each season. Ice cores, on the other hand, can provide thousands of years of data at high resolution, but they are found in very cold places where few people have lived. Written records can provide very specific information about weather events, but the descriptions are often subjective and hard to quantify. To overcome these limitations, historical climatologists must combine and compare a range of sources to form a complete and accurate picture.

While most climatologists focus on large patterns of global warming, researchers in historical climatology usually deal with particular climate events and weather systems that have had the greatest impact on human society. For instance, northern European countries were traditionally most affected by extreme winters or cold, wet summers that could ruin their grain crops. Inhabitants of Mediterranean and Middle Eastern lands, on the other hand, have been more vulnerable to spring droughts. Almost half the world’s population, in South and East Asia, has traditionally depended on the success or failure of annual monsoon rains to grow crops like rice.

To understand changes and fluctuations in these weather patterns, researchers look for external factors (or “forcings”) that can alter the earth’s climate. Over very long timescales, for instance, changes in the earth’s orbit known as Milankovitch cycles have played a role in the beginning and end of ice ages. Over shorter timescales, volcanic eruptions, slight variations in solar radiation, and now the emission of greenhouse gasses have all affected basic weather patterns. At the same time, natural fluctuations in

important climate cycles such as the North Atlantic Oscillation, the El Niño–Southern Oscillation (ENSO) over the Pacific, and the migration of the Intertropical Convergence Zone (ITCZ) of rain and low pressure over the equator have all contributed to climate variability from year to year.

Over the past few decades, historical climatologists have made significant progress in reconstructing and understanding both long-term shifts and also shorter fluctuations and extremes in past climate. In the years ahead, the greatest challenge for the field will be to better integrate those discoveries into our understanding of global history. Presently the level of historical analysis often falls short of the level of climatological analysis, and popular historians and some climatologists have made hasty and dramatic conclusions about climate and the collapse of civilizations. Nevertheless, a growing number of archeologists and historians have now begun to rethink their subject in light of new information from historical climatology. Their work has continued to uncover the more subtle, contingent, and sometimes unexpected ways that climate has shaped the human past. In the following sections, this chapter outlines some major findings of historical climatology and current theories regarding the role of climate in human history.

Climate in Prehistory

Humans first evolved in an ice-age world far colder and drier than the present. For more than 90 percent of our species' existence, this unfavorable climate made farming and permanent settlements impossible, dictating our ancestral nomadic hunter-gatherer lifestyle. Extreme cold during a "glacial maximum" roughly 73,000 years ago – probably the result of a tremendous eruption of Mt. Toba – may even have produced the population and genetic bottleneck that led to emergence of modern *Homo sapiens* from our archaic predecessors.⁵ It was these modern humans, sometimes known as Cro-Magnon, who emigrated from Africa and colonized the still glacial earth between c. 50,000 and 14,000 years ago.

Ice-age climate fluctuations probably played a major role in one of our early ancestors' greatest environmental impacts. As humans occupied a mostly steppe and tundra world, populations developed a culture of large-game hunting. Mounting archeological evidence suggests that some combination of human predation and climate fluctuations led to the extinction of many large genera of mammals and birds, including most of the largest species in Australia and the Americas, such as mammoths and giant ground sloths.⁶

The North American extinctions in particular corresponded with dramatic fluctuations in global temperature as the last ice age gave way to the current interglacial, known as the Holocene. This transition took place when slight changes in the earth's orbit warmed the northern hemisphere, causing glaciers to retreat in a positive feedback loop, as newly exposed land and sea released more CO₂ and absorbed more solar radiation, warming the earth more and causing yet more ice to melt. However, when the ice sheets collapsed too quickly, the rapid outflow of freshwater into the North Atlantic could shut off the warm Gulf Stream, which is driven by sinking salty water. These episodes, known as Heinrich Events, produced periods of sudden cooling called stadials. The largest stadial occurred around 18,000 to 14,700 years ago, followed by the warmer Bølling-Allerød interstadial, which was followed in turn by another cold spell called the Younger Dryas about 12,700 to 11,900 years ago.⁷

During warm episodes, rising global temperatures and precipitation fostered denser human populations and richer, more complex material cultures. Sometimes referred to

as the Mesolithic, the period at the end of the Pleistocene and start of the Holocene witnessed the emergence of societies with more diverse resource use (such as fishing), more complex technologies (such as pottery), and eventually permanent settlements in place of nomadic hunting and gathering.⁸ The relationship between climate change and the origins of agriculture, which began in the Fertile Crescent sometime after 10,000 BCE, remains more complex and contested. On the one hand, agriculture would have been all but impossible during the ice age. On the other hand, archeologists remain divided on whether agriculture was a natural outcome of more favorable climate and denser settled populations in the Holocene, or a specific social response to the onset of more difficult conditions during the Younger Dryas, which may have forced some populations to concentrate on gathering grains. Implicit in this debate is the issue of whether climate fluctuations are inherently harmful or whether such environmental challenges can spur creative, productive human responses.⁹

The first few millennia after the Younger Dryas marked a so-called climate “optimum” of warmth and strong monsoon rains, which reached even into the Sahara and Middle East. However, climatologists have discerned a significant cold and drought event around 8,200 years ago, and then a widespread deterioration of climate around 6,000 years ago. This Mid-Holocene Transition from roughly 4000 to 3000 BCE witnessed a shift to drier conditions in much of the world, including North Africa, the Middle East, the Indus region, and possibly northern China and Peru. At this time more arid conditions may have forced populations to migrate to fertile river valleys, perhaps driving the emergence of the world’s first city-states and empires, such as Sumer and Harappa. This theory proves especially persuasive for the rise of civilization in Egypt, where climate refugees from the Sahara would have contributed to social stratification and agricultural specialization in the crowded Nile Valley.¹⁰

Climate and Crisis in the Ancient World

By 3000 BCE, global climate had settled more or less into modern patterns. Nevertheless, climate fluctuations on a smaller scale continued to play a major role in human history, especially in the first city-states and empires of the Middle East. As archeologists have observed, more complex political and economic systems, though usually more adaptable to small annual variations, risk greater catastrophe during serious climate fluctuations – much as settlers along a river can build levees to survive small floods but then risk getting trapped if the water overtakes them in a major deluge.¹¹

The strongest evidence for such a climate disaster comes from around 2200 BCE. This episode, perhaps the result of a volcanic event, witnessed major droughts from North Africa through North India and possibly into China. Although some archeologists including Karl Butzer have cautioned against broad historical inferences, others such as Harvey Weiss have made a compelling case that serious climate deterioration drove economic and political crises in Egypt, Syria, Mesopotamia, and possibly parts of China and the Indus civilization of present-day Pakistan.¹² Other scholars have proposed a second major climate disaster in the late bronze age (c. 1200–1100 BCE) associated with mass migrations in both the eastern Mediterranean and northern China. However, this theory has not yet received as much evidence or support.¹³

By the late first millennium BCE, Europe and the Mediterranean had entered into another climate optimum. Evidence from European tree rings points to warm summers and more reliable spring rains from around 300 BCE to 250 CE, during the expansion and

peak of the Roman Empire. Starting in the late third century CE, tree ring and speleothem (cave deposit) studies indicate that the climate became cooler, drier, and more erratic. Although there is little direct historical evidence, this climate deterioration may have played a role in Celtic and Germanic invasions and the crisis and collapse of the western Roman Empire over the following two centuries.¹⁴ China, too, may have suffered from a period of colder climate during the collapse of the Han dynasty (206 BCE–220 CE) and the centuries of political fragmentation that followed.¹⁵

Other historical climatologists have discerned a worldwide climatic disaster in the 530s CE. A combination of ice-core data and Byzantine eyewitness accounts indicates that a major volcanic eruption launched a veil of dust and sulfates into the upper atmosphere and created unusual “dry fogs” in the Mediterranean region. This atmospheric anomaly may have been the cause of serious harvest failures in the Byzantine Empire. The weakened famine refugees may in turn have spread the so-called Plague of Justinian (541–2), which killed a large part of the Byzantine population. While the Byzantines were the worst affected, the impact of the eruption reached around the world: The same event has also been associated with serious droughts in the rising Maya civilization in the Yucatán, perhaps the cause of the so-called “Maya hiatus” of population loss and settlement abandonment c. 530–630 CE.¹⁶

Medieval Warm, Medieval Cold

Between the disasters of the 530s and the onset of the Little Ice Age 1,000 years later, climate shifts continued to play a significant role in human history. Whereas historians and climatologists once wrote of a “medieval warm” period, most have now adopted the term “medieval climate anomaly” to reflect the considerable complexities and variations of this era. While certain regions in certain periods did enjoy unusually warm and favorable climate, others proved less fortunate.¹⁷

The early Middle Ages witnessed episodes of severe cold in much of the northern hemisphere. Climatic deterioration and poor harvests likely played a role in the decline of population and agriculture in Europe’s so-called dark age of the fifth and sixth centuries CE; and observers during the Carolingian period also recorded frequent storms and flooding.¹⁸ In China, volcanic weather in the 630s and 930s brought severe cold to the north, causing famines in the Tang kingdom (618–907) and in neighboring Turkic empires.¹⁹ Other volcanic eruptions may have contributed to a series of major droughts in Yucatán over the late ninth century, at the peak of the classic Maya civilization.²⁰ While much debated by scholars, mounting evidence suggests that these droughts, combined with pervasive food shortages and environmental pressures, precipitated widespread population loss and the abandonment of most Maya urban centers.²¹

The high Middle Ages, from around 1000 to 1300 CE, brought a period of unusually warm and favorable climate to northern Europe. While poor seasons occurred from time to time, generally dry summers and mild winters contributed to more reliable harvests, underpinning the population expansion and urban growth of the age. While not comparable to present global warming, European temperatures were on the whole distinctly higher than in the centuries immediately before or following. China, too, may have enjoyed a period of relative warmth throughout the later Song dynasty (960–1279).

Yet in other parts of the world, this period proved less favorable. In Central Asia, for instance, much of the era was marked by a strong Siberian high-pressure cell, creating unusually severe winters.²² Historian Richard Bulliet has argued that this

cooling drove the Seljuk Turks to invade Iran and Anatolia in the eleventh century;²³ and Chinese historical climatologists have found correlations between these periods of unusual cold and drought and nomad migrations on China's northern and western frontiers.²⁴ Furthermore, this period of general warming witnessed frequent strong "La Niña" conditions, which brought more reliable rains to much of South and East Asia, but also more frequent and severe droughts to the Americas.²⁵ In the Andes, ice-core and lake sediment data indicate that the climate turned more arid in the late ninth century. While the evidence is much debated, severe droughts and falling lake levels in the twelfth century may have brought about the collapse of the Tiwanaku civilization, whose agriculture relied on irrigation from Lake Titicaca.²⁶ (In subsequent centuries, the warming trend may have contributed to the rise of other Andean civilizations, such as the Inca, who relied on high-altitude terraced fields for food production.²⁷) In the southwestern US, tree-ring studies reveal intense recurring droughts in the twelfth and thirteenth centuries, coming at the peak of the Hohokam and Anasazi civilizations. These droughts probably undermined their delicate irrigation systems for growing maize, which forced them to abandon their major population centers.²⁸

Following this period of generally higher temperatures, much of the world underwent another phase of cooling in the early to mid-1300s. The change came most abruptly to northern Europe, which suffered a succession of extremely cold, wet springs and summers in the 1310s. The harsh weather brought a succession of bad harvests followed by widespread pestilence in cattle and sheep. In countries already facing strong population pressure from the previous centuries of growth, these disasters unleashed the Great Famine, with widespread mortality.²⁹ The ecological pressures, poor climate, and chronic malnutrition of the early fourteenth century have also been implicated in the rapid spread of the Black Death of the 1340s, in which a third of Europe's population may have died. More recently, historian Timothy Brook has identified a similar phase of climatic deterioration, harvest failures, and famines leading up to the Black Death and the collapse of the Yuan dynasty (1271–1368) in China.³⁰

Perhaps the most closely studied episode of this period has been the crisis of Viking settlements in the North Atlantic. Taking advantage of the unusual warmth during the tenth and eleventh centuries, Scandinavian Vikings had sent expeditions across northern Europe and beyond, reaching Iceland and then Greenland and even Newfoundland. Wherever they landed, the colonists brought their European livestock and pastoral practices with them. The Vikings (and their sheep, pigs, and cattle) who settled in these remote outposts then encountered overwhelming hardships during cold spells of the 1300s and 1400s. First the Western and then the Eastern Greenland settlements either migrated or succumbed to starvation once their animals had died in the long winters. In Iceland, meanwhile, clearance for fuel and pasture had caused severe deforestation and erosion during the first period of settlement. In the cold fourteenth and fifteenth centuries, the Icelanders suffered serious famine and population loss, forcing them to diversify from pastoralism into fishing.³¹ Therefore, some scholars have looked to the histories of Viking Greenland and Iceland as parables of the dangers of cultural conservatism and the importance of flexibility and adaptation to environmental changes. Others, however, have pointed instead to the Vikings' relative success in preserving these difficult colonies for more than three centuries.³²

Along with the colder temperatures of the fourteenth and fifteenth centuries came a return to more persistent El Niño conditions and consequently monsoon failures in the

Pacific region. In Cambodia, the Angkor civilization with its vast temple complexes had relied on elaborate hydraulic works to support its rice agriculture. During the fourteenth and early fifteenth centuries, severe droughts may have undermined Angkor's irrigation and food production, precipitating foreign invasions and then the abandonment of the kingdom.³³ In the South Pacific, meanwhile, these El Niños may have helped Polynesian sailors colonize the last remote islands by slowing or even reversing the normal easterly trade winds. However, subsequent El Niño-related droughts may also have contributed to the crises that soon overtook many new island settlements once they had depleted their easiest available natural resources.³⁴

The Little Ice Age

As the last great global climate anomaly before modern global warming, the Little Ice Age of the late sixteenth to early eighteenth centuries has received the most detailed research by both climatologists and historians. Over the past decades, a range of studies have confirmed the existence of a general cooling phase, lowering temperatures on average by perhaps 1 to 2 degrees Celsius (1.8 to 3.6 degrees Fahrenheit). The precise cause of the Little Ice Age remains uncertain, but a combination of solar forcing and volcanic activity could probably explain most or all of the climatic anomaly.³⁵ The Little Ice Age was not just cold but often highly variable: historical climatologists have now identified distinct phases and regional variations in climate throughout this period. While Europeanists have led the field, research on the Little Ice Age has now spread to other parts of the globe, opening new insights into the role of climate in the modern-era world.

During the late fifteenth and sixteenth centuries, an interval of relatively warm and stable climate had helped promote the growth of agriculture and population across Eurasia. By the late 1500s, populations in Europe, China, and the Middle East had more than recovered from the Black Death and were once again facing rising prices and shortages of land, leaving them vulnerable to the onset of the Little Ice Age. In northern Europe in particular, historians have used more detailed records of weather, prices, and vital statistics to demonstrate strong links among the cold wet springs and summers of the later sixteenth century and frequent crop failures, inflation, vagrancy, and high mortality.³⁶ Even relatively advanced European economies, such as that of England, suffered real famines during the 1580s and 1590s following poor grain harvests. Only the highly urbanized and commercialized Dutch population seems to have weathered the Little Ice Age without substantial economic or demographic losses. Detailed written sources from the Ming dynasty (1368–1644) also indicate an unfavorable climate shift during this period, bringing more droughts in the north and floods along the major river valleys of central and southern China.³⁷

At the turn of the seventeenth century, following a major eruption of Mt. Huaynaputina in 1600, the Little Ice Age entered into one of its coldest phases.³⁸ In Russia, Chester Dunning has argued that a period of extreme winters, harvest failures, and famine in 1601–3 helped turned a political succession crisis into the widespread outbreak of vagrancy, violence, and civil war over the following decade known as the Time of Troubles.³⁹ The severe cold also reached North America, likely contributing to the high mortality of some of the first European settlements in present-day Canada and the US. English colonies at Roanoke (1585) and Jamestown (1607) also had the misfortune to begin during one of the deepest droughts in Virginia for the past millennium.⁴⁰

Perhaps the worst climate-related crisis of this period occurred in the Ottoman Empire, which then ruled most of the Middle East, Balkans, and North Africa. The population of Ottoman lands had roughly doubled since the late 1400s, creating serious population pressure and inflation in some regions by the later sixteenth century. From the late 1560s to 1580s, the onset of the Little Ice Age brought a succession of severe winters and spring droughts, creating several waves of harvest failures and shortages. In the 1590s, the eastern Mediterranean underwent its longest drought in the past 600 years, causing widespread famine. At the same time, a disease of livestock wiped out most of the sheep and cattle in Anatolia, the Balkans, and the Crimea. Locked in a difficult war with the Habsburg Empire, the Ottoman state imposed high taxes and requisitions on the starving peasantry, fueling a major uprising in Anatolia called the Celali Rebellion (1596–1610). Recurring Little Ice Age drought and cold contributed to the widespread violence, flight, and famine that followed, which left much of the Ottoman countryside depopulated by the early 1600s.⁴¹

These events foreshadowed a wider outbreak of disasters in the mid-seventeenth century sometimes called the “general crisis.” Recent research implicates the role of Little Ice Age climate anomalies in this contemporary wave of famines, wars, and rebellions across much of the globe.⁴² China suffered decades of unprecedented cold, drought, and famine, which hastened the fall of the Ming dynasty and the conquest of the Manchu Qing in the 1640s. A third or more of the country’s population may have died in the disasters.⁴³ In the West African Sahel, at the edge of the Sahara, serious recurring droughts disrupted agriculture and commerce. The range of tsetse flies, which are fatal to livestock, retreated south with the drier climate, depriving the region’s farmers of their natural protection against pastoral invaders and desert raiders on horseback.⁴⁴ In western Europe, ongoing Little Ice Age weather events and harvest failures contributed to the high mortality of the Thirty Years War (1618–48) and possibly the outbreak of political disorders including the French Fronde and the English Civil War.⁴⁵

The last major phase of the Little Ice Age from around 1680 to 1710 is often identified with the “Maunder Minimum” of low sunspot activity. Europe experienced some of its coldest winters of the past millennium, contributing to another wave of harvest failures and high prices. Scotland and Finland suffered severe cold and famines in the 1690s in which a tenth and fifth of their respective populations may have perished.⁴⁶ In the Ottoman Empire, a return of freezing winters and erratic precipitation brought more famine and unrest, derailing a potential recovery from the disasters of the late sixteenth and early seventeenth centuries.

The Little Ice Age also witnessed a high occurrence of strong El Niños, some bringing serious monsoon failures to South and Southeast Asia.⁴⁷ Mughal India lost millions in famines of the 1630s and 1680s. In Indonesia, a succession of droughts and epidemics aggravated a demographic and economic crisis of the mid-seventeenth century, as the Dutch East India Company seized control of the region’s trade.⁴⁸ In parts of Spanish America, particularly Mexico and the American Southwest, the late 1500s and 1600s also brought a number of significant droughts, some leading to serious food shortages and popular unrest.⁴⁹

Beyond these economic and political crises, historians have only just begun to explore the cultural dimensions of climate change in the early modern world. Some early modern European art, for instance, reveals the impression of harsh Little Ice Age winter landscapes, including Pieter Brueghel’s famous *Hunters in the Snow*. Likewise, the second act of Shakespeare’s *A Midsummer Night’s Dream* describes contemporary volcanic

weather anomalies, including hazy skies, warm winters, cold summers, harvest failures, and murrains, belying the play's lighthearted comedy. Recently, German historical climatologist Wolfgang Behringer has looked for further evidence of a Little Ice Age mentality in everything from changes in clothing and architectural styles to the rise of witchcraft trials and the spread of severe religious doctrines in the late 1500s.⁵⁰

From the Little Ice Age to Global Warming

Over the 1700s and 1800s, the unusual cold of the Little Ice Age gave way to the more moderate temperatures of the early twentieth century, against which climatologists now measure the onset of global warming. However, volcanic events and strong El Niños produced several more episodes of severe erratic weather. For instance, the 1783 eruption of Laki in Iceland not only brought famine to that island, but created volcanic weather around the northern hemisphere, including unusual cold and harvest failures in Europe, especially Ireland, and in the northern US and Canada.⁵¹ Following the eruption, an extreme El Niño event of the late 1780s and 1790s brought serious droughts to India, Japan, Mexico, Peru, and France, among other countries. Millions died of famine around the world; and these natural disasters likely contributed to popular uprisings including the French Revolution.⁵² El Niño droughts of the 1790s also brought hardship to the first British settlers of Australia – a country that has struggled to practice agriculture in its unpredictable ENSO-influenced climate ever since.⁵³ During the 1810s, another wave of volcanic activity brought a brief return of Little Ice Age weather, culminating in the 1815 Tambora eruption and famous “year without a summer” in 1816. Parts of Europe and America witnessed frosts well into June and July, creating what one historian has described as “the last great subsistence crisis in the Western world.”⁵⁴ Other major climate-induced disasters of the modern age include a series of major El Niños, tropical monsoon failures, and famines over the late 1800s that Mike Davis has termed “Late Victorian Holocausts,”⁵⁵ and the intense droughts of the 1930s that contributed to the American Dust Bowl.⁵⁶

During the past century, however, human activities have overtaken natural variability as the leading cause of climate change. Although some climatologists such as William Ruddiman would trace human impacts on the environment all the way back to prehistoric deforestation and agriculture,⁵⁷ the most notable man-made effects have come from fossil fuels since the Industrial Revolution. By the 1890s, Swedish physicist Svante Arrhenius predicted that burning coal would create an atmospheric “greenhouse effect,” and by the 1930s, British meteorologist Guy Stewart Callendar found data to argue that global warming had already begun. Since 1957, when measurements first began, the level of heat-trapping carbon dioxide in the atmosphere has risen from roughly 315 to 390 parts per million; and global temperatures have begun to rise swiftly beyond levels seen in the last millennium, a trend most visible since the 1990s. Projections for the twenty-first century point to a further rise of 2 to 4 degrees Celsius (3.6 to 7.2 degrees Fahrenheit), depending on further greenhouse-gas emissions, with consequences that could range from severe droughts to stronger storms to more frequent heat waves.⁵⁸

Beset by scientific complexities and political controversies, global warming has thus far proven a difficult subject for historians. Nevertheless, some notable studies of twentieth-century climate change already point to some of the challenges to be faced and possible patterns for future climate crises. For instance, Michael Glantz and

collaborators have emphasized the persistent problems of population pressure and short-term thinking driving unsustainable agriculture in semi-arid lands, now faced with the prospects of more severe and frequent drought.⁵⁹ In his history of melting glaciers and glacial lake outbursts in Peru, Mark Carey has stressed not only the immediate loss of lives and property in the disasters but the way in which these disasters have been used to promote outside political and economic agendas, without always addressing local risks and vulnerabilities.⁶⁰ As the record of climate change and impacts grows, the historiography of global warming will certainly expand as well, opening a new field of study for environmental historians.

Conclusion

Like other environmental factors from disease to natural disasters, climate has proven a powerful if often overlooked force in the human past. From prehistory to present times, climate changes have played a part in human evolution and migration, the rise and fall of civilizations, the success and failure of colonies, and the stability and crisis of states and empires. At times, climate changes have had a swift and decisive historical impact, especially in vulnerable populations and marginal environments. However, as this survey suggests, the role of climate in history has usually been more complex and contingent. The consequences of climate change and variability have depended on local environmental, economic, and political conditions, and, in many cases, the links between climate and history remain uncertain or unproven.

Even more so than other topics in environmental history, the study of climate in history has been and will be propelled by its contemporary relevance in a world of rising temperatures. Already, historical examples point to certain themes in the human experience of climate changes that may prove relevant for the future: the critical role of a few key weather patterns, the dangers of difficult environments, the social dimensions of climate disasters, and the importance of cultural and political flexibility in the face of change. In time, with more detailed and comparative studies of past climate, crisis, and adaptation, historians may be in a position to offer, if not specific policies, then at least parallels and parables for the challenges of global warming.

Notes

- 1 C. Glacken, *Traces on the Rhodian Shore: Nature and Culture in Western Thought from Ancient Times to the End of the Eighteenth Century*, Berkeley, University of California Press, 1967; J. Fleming, *Historical Perspectives on Climate Change*, New York, Oxford University Press, 1998.
- 2 G. Utterström, "Climatic Fluctuations and Population Problems in Early Modern History," *The Scandinavian Economic History Review* 3, 1955, pp. 3–47; E. Le Roy Ladurie, *Times of Feast, Times of Famine: A History of Climate since the Year 1000*, New York, Noonday Press, 1971.
- 3 On the history of global warming science, see S. Weart, *The Discovery of Global Warming*, Cambridge, MA, Harvard University Press, 2008.
- 4 For an overview of studies and methods, see e.g., R. Brázdil, C. Pfister, H. Wanner, et al., "Historical Climatology in Europe: The State of the Art," *Climatic Change* 70, 2005, pp. 363–430.
- 5 S. H. Ambrose, "Late Pleistocene Human Population Bottlenecks, Volcanic Winter, and Differentiations of Modern Humans," *Journal of Human Evolution* 34, 1998, pp. 623–51.

- 6 For a summary of evidence, see e.g., P. Koch and A. Barnosky, "Late Quaternary Extinctions: State of the Debate," *Annual Review of Ecology, Evolution, and Systematics* 37, 2006, pp. 215–50.
- 7 B. Fagan provides an overview for a popular audience in *The Long Summer: How Climate Changed Civilization*, New York, Basic Books, 2004. For recent theories of glacial cycles, see G. Denton, "The Last Glacial Termination," *Science* 328, 2010, pp. 1652–6.
- 8 For an excellent popular overview of Mesolithic climatology and archeology, see S. Mithen, *After the Ice: A Global Human History 20,000–5000 BC*, Cambridge, MA, Harvard University Press, 2003.
- 9 For an overview of theories see A. M. Rosen, *Civilizing Climate: Social Responses to Climate Change in the Ancient Near East*, Lanham, MD, AltaMira Press, 2007.
- 10 N. Brooks, "Cultural Responses to Aridity in the Middle Holocene and Increased Social Complexity," *Quaternary International* 151, 2006, pp. 29–49; D. Anderson, K. Maasch, and D. Sandweiss, *Climate Change and Cultural Dynamics: A Global Perspective on Mid-Holocene Transitions*, London, Elsevier, 2007.
- 11 Fagan, *The Long Summer*.
- 12 H. Dalfes, G. Kukla, and H. Weiss (eds.), *Third Millennium B.C. Climate Change and Old World Collapse*, Berlin, Springer-Verlag, 1997. On China, see also C. An, "Climate Change and Cultural Response around 4000 cal. yr. bp in the Western Part of Chinese Loess Plateau," *Quaternary Research* 63, 2005, pp. 347–52.
- 13 For the Mediterranean see, e.g., R. Bryson, H. Lamb, and D. Donley, "Drought and the Decline of Mycenae," *Antiquity* 48, 1974, pp. 46–50; and J. Neumann, "Climatic Changes in Europe and the Near East in the Second Millenium BC," *Climatic Change* 23, 1993, pp. 231–45. For a further overview of climate shifts in the ancient Middle East, see A. S. Issar, and M. Z. Zohar, *Climate Change: Environment and Civilization in the Middle East*, Berlin, Springer, 2004. For China, see C. C. Huang, "Climatic Aridity and the Relocations of the Zhou Culture in the Southern Loess Plateau of China," *Climatic Change* 61, 2003, pp. 361–78.
- 14 U. Büntgen, W. Tegel, K. Nicolussi, et al., "2500 Years of European Climate Variability and Human Susceptibility," *Science* 331, 2011, pp. 578–82; and I. Orland, M. Barmathews, N. Kita, et al., "Climate Deterioration in the Eastern Mediterranean as Revealed by Ion Microprobe Analysis of a Speleotherm that Grew from 2.2 to 0.9 ka in Soreq Cave, Israel," *Quaternary Research* 71, 2009, pp. 27–35.
- 15 E.g., B. Yang, A. Braeuning, K. R. Johnson, and S. Yafeng, "General Characteristics of Temperature Variation in China during the Last Two Millennia," *Geophysical Research Letters* 29, 2002, pp. 1324–7.
- 16 For an overview of historical climatology in the 530s, see J. Gunn, *The Years without Summer: Tracing A.D. 536 and Its Aftermath*, Oxford, Archaeopress, 2000.
- 17 On the debate over medieval temperatures, see, e.g., R. S. Bradley, M. K. Hughes, and H. F. Diaz, "Climate in Medieval Time," *Science* 302, 2003, pp. 404–5.
- 18 Büntgen, Tegel, Nicolussi, et al. "2500 Years of European Climate Variability and Human Susceptibility"; F. Cheyette, "The Disappearance of the Ancient Landscape and the Climatic Anomaly of the Early Middle Ages: A Question to be Pursued," *Early Medieval Europe* 16, 2008, pp. 127–65; P. Dutton, "Thunder and Hail over the Carolingian Countryside," in D. Sweeney (ed.), *Agriculture in the Middle Ages: Technology, Practice, and Representation*, Philadelphia, University of Pennsylvania Press, 1995, pp. 111–37.
- 19 J. Fei, J. Zhou, and Y. Hou, "Circa ad 626 Volcanic Eruption, Climatic Cooling, and the Collapse of the Eastern Turkic Empire," *Climatic Change* 81, 2007, pp. 469–75; J. Fei and J. Zhou, "The Possible Climatic Impact in China of Iceland's Eldgjá Eruption Inferred from Historical Sources," *Climatic Change* 76, 2006, pp. 443–57.
- 20 For recent reconstructions of the Maya droughts see, e.g., D. A. Hodell, M. Brenner, and J. H. Curtis, "Climate and Cultural History of the Northeastern Yucatan Peninsula, Quintana Roo, Mexico," *Climatic Change* 83, 2007, pp. 215–40.

- 21 There is an extensive literature on the Maya collapse. R. Gill makes the case for drought in *The Great Maya Droughts: Water, Life, and Death*, Santa Fe, NM, University of New Mexico Press, 2000; D. Webster favors a multicausal environmental explanation in *The Fall of the Ancient Maya*, London, Thames and Hudson, 2002. For a recent synthesis, see J. Yaeger and D. A. Hodell, "The Collapse of Maya Civilization: Assessing the Interaction of Culture, Climate, and Environment," in D. H. Sandweiss and J. Quilter (eds.), *El Niño, Catastrophism, and Cultural Change in Ancient America*, Cambridge, MA, Harvard University Press, 2008, pp. 187–242.
- 22 R. D'Arrigo, et al., "1738 Years of Mongolian Temperature Variability Inferred from a Tree-Ring Width Chronology of Siberian Pine," *Geophysical Research Letters* 28, 2001, pp. 543–6.
- 23 R. Bulliet, *Cotton, Climate, and Camels in Early Islamic Iran: A Moment in World History*, New York, Columbia University Press, 2009.
- 24 E.g., J. Fang and G. Liu, "Relationship between Climatic Change and the Nomadic Southward Migrations in Eastern Asia during Historical Times," *Climatic Change* 22, 1992, pp. 151–69.
- 25 See, e.g., B. Rein, A. Lückge, and F. Sirocko, "A Major Holocene ENSO Anomaly during the Medieval Period," *Geophysical Research Letters* 31, 2004, L17211.
- 26 E.g., C. R. Ortloff and A. L. Kolata, "Climate and Collapse: Agro-Ecological Perspectives on the Decline of the Tiwanaku State," *Journal of Archaeological Science* 20, 1993, pp. 195–221; and M. Binford, "Climate Variation and the Rise and Fall of an Andean Civilization," *Quaternary Research* 47, 1997, pp. 235–48. For opposing views, see, e.g., C. L. Erickson, "Neo-Environmental Determinism and Agrarian 'Collapse' in Andean Prehistory," *Antiquity* 73, 1999, pp. 634–42; and P. R. Williams, "Rethinking Disaster-Induced Collapse in the Demise of the Andean Highland States: Wari and Tiwanaku," *World Archaeology* 33, 2002, pp. 361–74.
- 27 A. Chepstow-Lusty, "Putting the Rise of the Inca Empire within a Climatic and Land Management Context," *Climate of the Past* 5, 2009, pp. 375–88.
- 28 E.g., L. Benson, K. Petersen, and J. Stein, "Anasazi (Pre-Columbian Native-American) Migrations during the Middle-12th and Late-13th Centuries – Were They Drought Induced?," *Climatic Change* 83, 2007, pp. 187–213.
- 29 For a narrative, see W. Jordan, *The Great Famine*, Princeton, NJ, Princeton University Press, 1996.
- 30 T. Brook, *The Troubled Empire: China in the Yuan and Ming Dynasties*, Cambridge, MA, Belknap Press, 2010, chapter 3.
- 31 For an overview, see, e.g., the articles in W. Fitzhugh and E. Ward (eds.), *Vikings: The North Atlantic Saga*, Washington, DC, Smithsonian Institution Press, 2000.
- 32 Cf. J. Diamond, *Collapse: How Societies Choose to Fail or Succeed*, New York, Viking, 2005, and J. Berglund, "Did the Medieval Norse Society in Greenland Really Fail?," in P. A. McAnany and N. Yoffee (eds.), *Questioning Collapse: Human Resilience, Ecological Vulnerability, and the Aftermath of Empire*, New York, Cambridge University Press, 2010, pp. 45–70.
- 33 B. M. Buckley, K. J. Anchukaitis, D. Penny, et al., "Climate as a Contributing Factor in the Demise of Angkor, Cambodia," *Proceedings of the National Academy of Sciences* 107, 2010, pp. 6748–52.
- 34 P. D. Nunn, "Environmental Catastrophe in the Pacific Islands around A.D. 1300," *Geoarchaeology* 16, 2000, pp. 715–40, and P. D. Nunn, and J. M. Britton, "Human–Environment Relationships in the Pacific Islands around A.D. 1300," *Environment and History* 7, 2001, pp. 3–22.
- 35 E.g., T. Crowley, "Causes of Climate Change over the Past 1000 Years," *Science* 289, 2000, pp. 270–7, and M. Mann, "Global Signatures and Dynamical Origins of the Little Ice Age and Medieval Climate Anomaly," *Science* 326, 2009, pp. 1256–60.
- 36 For an overview of such research, see C. Pfister and R. Brázdil, "Climatic Variability in Sixteenth-Century Europe and Its Social Dimension: A Synthesis," *Climatic Change* 43, 1999, pp. 5–53.

- 37 Brook, *The Troubled Empire*.
- 38 S. L. De Silva and G. A. Zielinski, "Global Influence of the AD 1600 Eruption of Huaynaputina, Peru," *Nature* 393, 1998, pp. 455–8; A. Schimmelmänn, M. Zhao, C. C. Harvey, and C. B. Lange, "A Large California Flood and Correlative Global Climatic Events 400 Years Ago," *Quaternary Research* 49, 1998, pp. 51–61.
- 39 C. Dunning, *Russia's First Civil War: The Time of Troubles and the Founding of the Romanov Dynasty*, University Park, PA, Pennsylvania State University Press, 2001.
- 40 D. W. Stahle, M. K. Cleaveland, D. B. Blanton, et al., "The Lost Colony and the Jamestown Droughts," *Science* 280, 1998, pp. 564–7; D. Blanton, "Drought as a Factor in the Jamestown Colony, 1607–1612," *Historical Archaeology* 34, 2000, pp. 74–81.
- 41 S. White, *The Climate of Rebellion in the Early Modern Ottoman Empire*, New York, Cambridge University Press, 2011.
- 42 For an overview, see G. Parker, "Crisis and Catastrophe: The Global Crisis of the Seventeenth Century Reconsidered," *American Historical Review* 113, 2008, pp. 1053–79.
- 43 Brook, *The Troubled Empire*. For regional studies, see also P. Perdue, *Exhausting the Earth: State and Peasant in Hunan, 1500–1850 AD*, Cambridge, MA, Harvard University Press, 1987; and R. B. Marks, *Tigers, Rice, Silk, and Silt: Environment and Economy in Late Imperial South China*, New York, Cambridge University Press, 1998. For physical records of climate change and correlation with dynastic cycles, see D. D. Zhang, C. Y. Jim, G. C.-S. Lin, et al., "Climatic Change, Wars and Dynastic Cycles in China Over the Last Millennium," *Climatic Change* 76, 2006, pp. 459–77.
- 44 G. E. Brooks, *Landlords and Strangers: Ecology, Society, and Trade in Western Africa, 1000–1630*, Boulder, CO, Westview Press, 1993; J. Webb, *Desert Frontier: Ecological and Economic Change along the Western Sahel, 1600–1850*, Madison, University of Wisconsin Press, 1995. For more recent reconstructions of West African precipitation, see T. Shanahan, "Atlantic Forcing of Persistent Drought in West Africa," *Science* 324, 2009, pp. 377–80.
- 45 See, e.g., E. Le Roy Ladurie, *Histoire humaine et comparée du climat, vol. 1, Canicules et glaciers (XIII^e-XVIII^e siècles)*, Paris, Fayard, 2004, chapter 8.
- 46 On the climatology of the late Maunder Minimum, see, e.g., J. Luterbacher, R. Rickli, E. Xoplaki, et al., "The Late Maunder Minimum: A Key Period for Studying Decadal Climate Change in Europe," *Climatic Change* 49, 2001, pp. 441–62. On the Scottish and Finnish famines see Le Roy Ladurie, *Canicules et glaciers*, chapter 9.
- 47 R. Grove and J. Chappell, "El Niño Chronology and the History of Global Crises during the Little Ice Age," in R. Grove and J. Chappell (eds.), *El Niño: History and Crisis*, Cambridge, White Horse Press, 2000, pp. 5–34.
- 48 A. Reid, "The Seventeenth-Century Crisis in Southeast Asia," *Modern Asian Studies* 24, 1990, pp. 639–59; P. Boomgaard, "Crisis Mortality in Seventeenth-Century Indonesia," in T. Liu, J. Lee, D. S. Reher, et al. (eds.), *Asian Population History*, New York, Oxford University Press, 2001, pp. 191–220.
- 49 See especially G. Endfield, *Climate and Society in Colonial Mexico*, London, Wiley-Blackwell, 2008.
- 50 W. Behringer, *A Cultural History of Climate*, Cambridge, Polity, 2010.
- 51 See, e.g., R. B. Stothers, "The Great Dry Fog of 1783," *Climatic Change* 32, 1996, pp. 79–89.
- 52 See R. Grove, "Global Impact of the 1789–93 El Niño," *Nature* 393, 1998, pp. 318–19.
- 53 J. Gergis, D. Garden, and C. Fenby, "The Influence of Climate on the First European Settlement of Australia: A Comparison of Weather Journals, Documentary Data and Palaeoclimate Records, 1788–1793," *Environmental History* 15, 2010, pp. 485–507; T. Sherratt, T. Griffiths, and L. Robin (eds.), *A Change in the Weather: Climate and Culture in Australia*, Canberra, National Museum of Australia Press, 2005.
- 54 J. D. Post, *The Last Great Subsistence Crisis in the Western World*, Baltimore, The Johns Hopkins University Press, 1977.

- 55 M. Davis, *Late Victorian Holocausts: El Niño Famines and the Making of the Third World*, New York, Verso, 2001.
- 56 S. D. Schubert, M. J. Suarez, P. J. Pegion, et al., "On the Cause of the 1930s Dust Bowl," *Science* 303, 2004, pp. 1855–9.
- 57 W. F. Ruddiman, *Plows, Plagues, and Petroleum: How Humans Took Control of Climate*, Princeton, NJ, Princeton University Press, 2005.
- 58 Intergovernmental Panel on Climate Change, *Fourth Assessment Report*, New York, Cambridge University Press, 2007.
- 59 M. H. Glantz (ed.), *Drought Follows the Plow: Cultivating Marginal Areas*, New York, Cambridge University Press, 1994.
- 60 M. Carey, *In the Shadow of Melting Glaciers: Climate Change and Andean Society*, New York, Oxford University Press, 2010.

References

- Ambrose, S. H., "Late Pleistocene Human Population Bottlenecks, Volcanic Winter, and Differentiations of Modern Humans," *Journal of Human Evolution* 34, 1998, pp. 623–51.
- An, C., "Climate Change and Cultural Response around 4000 cal. yr. BP in the Western Part of Chinese Loess Plateau," *Quaternary Research* 63, 2005, pp. 347–52.
- Anderson, D., Maasch, K., and Sandweiss, D., *Climate Change and Cultural Dynamics: A Global Perspective on Mid-Holocene Transitions*, London, Elsevier, 2007.
- Behringer, W., *A Cultural History of Climate*, Cambridge, Polity, 2010.
- Benson, L., Petersen, K., and Stein, J., "Anasazi (Pre-Columbian Native-American) Migrations during the Middle-12th and Late-13th Centuries – Were They Drought Induced?," *Climatic Change* 83, 2007, pp. 187–213.
- Berglund, J., "Did the Medieval Norse Society in Greenland Really Fail?," in P. A. McAnany and N. Yoffee (eds.), *Questioning Collapse: Human Resilience, Ecological Vulnerability, and the Aftermath of Empire*, New York, Cambridge University Press, 2010, pp. 45–70.
- Binford, M., "Climate Variation and the Rise and Fall of an Andean Civilization," *Quaternary Research* 47, 1997, pp. 235–48.
- Blanton, D., "Drought as a Factor in the Jamestown Colony, 1607–1612," *Historical Archaeology* 34, 2000, pp. 74–81.
- Boomgaard, P., "Crisis Mortality in Seventeenth-Century Indonesia," in T. Liu, J. Lee, D. S. Reher, et al. (eds.), *Asian Population History*, New York, Oxford University Press, 2001, pp. 191–220.
- Bradley, R. S., Hughes, M. K., and Diaz, H. F., "Climate in Medieval Time," *Science* 302, 2003, pp. 404–5.
- Brázdil, R., Pfister, C., Wanner, H., et al., "Historical Climatology in Europe: The State of the Art," *Climatic Change* 70, 2005, pp. 363–430.
- Brook, T., *The Troubled Empire: China in the Yuan and Ming Dynasties*, Cambridge, MA, Belknap Press, 2010.
- Brooks, G. E., *Landlords and Strangers: Ecology, Society, and Trade in Western Africa, 1000–1630*, Boulder, CO, Westview Press, 1993.
- Brooks, N., "Cultural Responses to Aridity in the Middle Holocene and Increased Social Complexity," *Quaternary International* 151, 2006, pp. 29–49.
- Bryson, R., Lamb, H., and Donley, D., "Drought and the Decline of Mycenae," *Antiquity* 48, 1974, pp. 46–50.
- Buckley, B. M., Anchukaitis, K. J., Penny, D., et al., "Climate as a Contributing Factor in the Demise of Angkor, Cambodia," *Proceedings of the National Academy of Sciences* 107, 2010, pp. 6748–52.
- Bulliet, R., *Cotton, Climate, and Camels in Early Islamic Iran: A Moment in World History*, New York, Columbia University Press, 2009.

- Büntgen, U., Tegel, W., Nicolussi, K., et al., "2500 Years of European Climate Variability and Human Susceptibility," *Science* 331, 2011, pp. 578–82.
- Carey, M., *In the Shadow of Melting Glaciers: Climate Change and Andean Society*, New York, Oxford University Press, 2010.
- Chepstow-Lusty, A., "Putting the Rise of the Inca Empire within a Climatic and Land Management Context," *Climate of the Past* 5, 2009, pp. 375–88.
- Cheyette, F., "The Disappearance of the Ancient Landscape and the Climatic Anomaly of the Early Middle Ages: A Question to be Pursued," *Early Medieval Europe* 16, 2008, pp. 127–65.
- Crowley, T., "Causes of Climate Change over the Past 1000 Years," *Science* 289, 2000, pp. 270–7.
- Dalfes, H., Kukla, G., and Weiss, H. (eds.), *Third Millennium B.C. Climate Change and Old World Collapse*, Berlin, Springer-Verlag, 1997.
- D'Arrigo, R., et al., "1738 Years of Mongolian Temperature Variability Inferred from a Tree-Ring Width Chronology of Siberian Pine," *Geophysical Research Letters* 28, 2001, pp. 543–6.
- Davis, M., *Late Victorian Holocausts: El Niño Famines and the Making of the Third World*, New York, Verso, 2001.
- De Silva, S. L., and Zielinski, G. A., "Global Influence of the AD 1600 Eruption of Huaynaputina, Peru," *Nature* 393, 1998, pp. 455–8.
- Denton, G., "The Last Glacial Termination," *Science* 328, 2010, pp. 1652–6.
- Diamond, J., *Collapse: How Societies Choose to Fail or Succeed*, New York, Viking, 2005.
- Dunning, C., *Russia's First Civil War: The Time of Troubles and the Founding of the Romanov Dynasty*, University Park, PA, Pennsylvania State University Press, 2001.
- Dutton, P., "Thunder and Hail over the Carolingian Countryside," in D. Sweeney (ed.), *Agriculture in the Middle Ages: Technology, Practice, and Representation*, Philadelphia, University of Pennsylvania Press, 1995, pp. 111–37.
- Endfield, G., *Climate and Society in Colonial Mexico*, London, Wiley-Blackwell, 2008.
- Erickson, C. L., "Neo-Environmental Determinism and Agrarian 'Collapse' in Andean Prehistory," *Antiquity* 73, 1999, pp. 634–42.
- Fagan, B., *The Long Summer: How Climate Changed Civilization*, New York, Basic Books, 2004.
- Fang, J., and Liu, G., "Relationship between Climatic Change and the Nomadic Southward Migrations in Eastern Asia during Historical Times," *Climatic Change* 22, 1992, pp. 151–69.
- Fei, J., and Zhou, J., "The Possible Climatic Impact in China of Iceland's Eldgjá Eruption Inferred from Historical Sources," *Climatic Change* 76, 2006, pp. 443–57.
- Fei, J., Zhou, J., and Hou, Y., "Circa AD 626 Volcanic Eruption, Climatic Cooling, and the Collapse of the Eastern Turkic Empire," *Climatic Change* 81, 2007, pp. 469–75.
- Fitzhugh, W., and Ward, E. (eds.), *Vikings: The North Atlantic Saga*, Washington, DC, Smithsonian Institution Press, 2000.
- Fleming, J., *Historical Perspectives on Climate Change*, New York, Oxford University Press, 1998.
- Gergis, J., Garden, D., and Fenby, C., "The Influence of Climate on the First European Settlement of Australia: A Comparison of Weather Journals, Documentary Data and Palaeoclimate Records, 1788–1793," *Environmental History* 15, 2010, pp. 485–507.
- Gill, R., *The Great Maya Droughts: Water, Life, and Death*, Santa Fe, NM, University of New Mexico Press, 2000.
- Glacken, C., *Traces on the Rhodian Shore: Nature and Culture in Western Thought from Ancient Times to the End of the Eighteenth Century*, Berkeley, University of California Press, 1967.
- Glantz, M. H. (ed.), *Drought Follows the Plow: Cultivating Marginal Areas*, New York, Cambridge University Press, 1994.
- Grove, R., "Global Impact of the 1789–93 El Niño," *Nature* 393, 1998, pp. 318–19.
- Grove, R., and Chappell, J., "El Niño Chronology and the History of Global Crises during the Little Ice Age," in R. Grove and J. Chappell (eds.), *El Niño: History and Crisis*, Cambridge, White Horse Press, 2000, pp. 5–34.
- Gunn, J., *The Years without Summer: Tracing A.D. 536 and Its Aftermath*, Oxford, Archaeopress, 2000.

- Hodell, D. A., Brenner, M., and Curtis, J. H., "Climate and Cultural History of the Northeastern Yucatan Peninsula, Quintana Roo, Mexico," *Climatic Change* 83, 2007, pp. 215–40.
- Huang, C. C., "Climatic Aridity and the Relocations of the Zhou Culture in the Southern Loess Plateau of China," *Climatic Change* 61, 2003, pp. 361–78.
- Intergovernmental Panel on Climate Change, *Fourth Assessment Report*, New York, Cambridge University Press, 2007.
- Issar, A. S., and Zohar, M. Z., *Climate Change: Environment and Civilization in the Middle East*, Berlin, Springer, 2004.
- Jordan, W., *The Great Famine*, Princeton, NJ, Princeton University Press, 1996.
- Koch, P., and Barnosky, A., "Late Quaternary Extinctions: State of the Debate," *Annual Review of Ecology, Evolution, and Systematics* 37, 2006, pp. 215–50.
- Le Roy Ladurie, E., *Histoire humaine et comparée du climat, vol. 1, Canicules et glaciers (XIII^e-XVIII^e siècles)*, Paris, Fayard, 2004.
- Le Roy Ladurie, E., *Times of Feast, Times of Famine: A History of Climate since the Year 1000*, New York, Noonday Press, 1971.
- Luterbacher, J., Rickli, R., Xoplaki, E., et al., "The Late Maunder Minimum: A Key Period for Studying Decadal Climate Change in Europe," *Climatic Change* 49, 2001, pp. 441–62.
- Mann, M., "Global Signatures and Dynamical Origins of the Little Ice Age and Medieval Climate Anomaly," *Science* 326, 2009, pp. 1256–60.
- Marks, R. B., *Tigers, Rice, Silk, and Silt: Environment and Economy in Late Imperial South China*, New York, Cambridge University Press, 1998.
- Mithen, S., *After the Ice: A Global Human History 20,000–5000 BC*, Cambridge, MA, Harvard University Press, 2003.
- Neumann, J., "Climatic Changes in Europe and the Near East in the Second Millenium BC," *Climatic Change* 23, 1993, pp. 231–45.
- Nunn, P. D., "Environmental Catastrophe in the Pacific Islands around A.D. 1300," *Geoarchaeology* 16, 2000, pp. 715–40.
- Nunn, P. D., and Britton, J. M., "Human–Environment Relationships in the Pacific Islands around A.D. 1300," *Environment and History* 7, 2001, pp. 3–22.
- Orland, I., Barmatthews, M., Kita, N., et al., "Climate Deterioration in the Eastern Mediterranean as Revealed by Ion Microprobe Analysis of a Speleotherm that Grew from 2.2 to 0.9 ka in Soreq Cave, Israel," *Quaternary Research* 71, 2009, pp. 27–35.
- Ortloff, C. R., and Kolata, A. L., "Climate and Collapse: Agro-Ecological Perspectives on the Decline of the Tiwanaku State," *Journal of Archaeological Science* 20, 1993, pp. 195–221.
- Parker, G., "Crisis and Catastrophe: The Global Crisis of the Seventeenth Century Reconsidered," *American Historical Review* 113, 2008, pp. 1053–79.
- Perdue, P., *Exhausting the Earth: State and Peasant in Hunan, 1500–1850 AD*, Cambridge, MA, Harvard University Press, 1987.
- Pfister, C., and Brázdil, R., "Climatic Variability in Sixteenth-Century Europe and Its Social Dimension: A Synthesis," *Climatic Change* 43, 1999, pp. 5–53.
- Post, J. D., *The Last Great Subsistence Crisis in the Western World*, Baltimore, The Johns Hopkins University Press, 1977.
- Reid, A., "The Seventeenth-Century Crisis in Southeast Asia," *Modern Asian Studies* 24, 1990, pp. 639–59.
- Rein, B., Lückge, A., and Sirocko, F., "A Major Holocene ENSO Anomaly during the Medieval Period," *Geophysical Research Letters* 31, 2004, L17211.
- Rosen, A. M., *Civilizing Climate: Social Responses to Climate Change in the Ancient Near East*, Lanham, MD, AltaMira Press, 2007.
- Ruddiman, W. F., *Plows, Plagues, and Petroleum: How Humans Took Control of Climate*, Princeton, NJ, Princeton University Press, 2005.
- Schimmelmann, A., Zhao, M., Harvey, C. C., and Lange, C. B., "A Large California Flood and Correlative Global Climatic Events 400 Years Ago," *Quaternary Research* 49, 1998, pp. 51–61.

- Schubert, S. D., Suarez, M. J., Pegion, P. J., et al., "On the Cause of the 1930 Dust Bowl," *Science* 303, 2004, pp. 1855–9.
- Shanahan, T., "Atlantic Forcing of Persistent Drought in West Africa," *Science* 324, 2009, pp. 377–80.
- Sherratt, T., Griffiths, T., and Robin, L. (eds.), *A Change in the Weather: Climate and Culture in Australia*, Canberra, National Museum of Australia Press, 2005.
- Stahle, D. W., Cleaveland, M. K., Blanton, D. B., et al., "The Lost Colony and the Jamestown Droughts," *Science* 280, 1998, pp. 564–7.
- Stothers, R. B., "The Great Dry Fog of 1783," *Climatic Change* 32, 1996, pp. 79–89.
- Utterström, G., "Climatic Fluctuations and Population Problems in Early Modern History," *The Scandinavian Economic History Review* 3, 1955, pp. 3–47.
- Weart, S., *The Discovery of Global Warming*, Cambridge, MA, Harvard University Press, 2008.
- Webb, J., *Desert Frontier: Ecological and Economic Change along the Western Sahel, 1600–1850*, Madison, University of Wisconsin Press, 1995.
- Webster, D., *The Fall of the Ancient Maya*, London, Thames and Hudson, 2002.
- White, S., *The Climate of Rebellion in the Early Modern Ottoman Empire*, New York, Cambridge University Press, 2011.
- Williams, P. R., "Rethinking Disaster-Induced Collapse in the Demise of the Andean Highland States: Wari and Tiwanaku," *World Archaeology* 33, 2002, pp. 361–74.
- Yaeger, J., and Hodell, D. A., "The Collapse of Maya Civilization: Assessing the Interaction of Culture, Climate, and Environment," in D. H. Sandweiss and J. Quilter (eds.), *El Niño, Catastrophism, and Cultural Change in Ancient America*, Cambridge, MA, Harvard University Press, 2008, pp. 187–242.
- Yang, B., Braeuning, A., Johnson, K. R., and Yafeng, S., "General Characteristics of Temperature Variation in China during the Last Two Millennia," *Geophysical Research Letters* 29, 2002, pp. 1324–7.
- Zhang, D. D., Jim, C. Y., Lin, G. C.-S., et al., "Climatic Change, Wars and Dynastic Cycles in China Over the Last Millennium," *Climatic Change* 76, 2006, pp. 459–77.

Further Reading

Historical climate change is a highly diverse multidisciplinary field with now thousands of publications scattered among many periodicals and presses. Key articles on past climate regularly appear in major scientific journals such as *Nature* and *Science* and in specialist periodicals such as *Climate Change* and *Climate of the Past*. The references for this chapter provide a small representative sample. Unfortunately, there is still no standard introductory text for students. The pathbreaking work of H. Lamb, *Climate, History, and the Modern World* (London, Routledge, 1995), is now somewhat dated. W. Behringer's *A Cultural History of Climate* (Cambridge, Polity, 2010) covers mostly European climate history, with a focus on the cultural history of the Little Ice Age. Brian Fagan has written several short histories (of uneven quality) summarizing research on different periods of climate change for a popular audience. Another popular history – J. Diamond's *Collapse* (New York, Viking, 2005) – argues for the role of climate in the downfall of Viking Greenland, the Maya, and the Anasazi. Several of the best European histories remain untranslated: R. Glaser's *Klimageschichte Mitteleuropas* (Darmstadt, Primus Verlag, 2001) covers Germany; C. Pfister's *Wetternachbesserung: 500 Jahre Klimavariationen und Naturkatastrophen* (Bern, Paul Haupt, 1999) examines Switzerland; and E. Le Roy Ladurie *Histoire humaine et comparée*, 3 vols. (Paris, Fayard, 2004–9), offers a broad survey of climate and history in Europe over the last millennium. The extensive research of environmental historian Richard Grove and various collaborators has explored the role of El Niños in history, especially in South and Southeast Asia. Among other environmental and political histories emphasizing the role of climate, see (in the reference list) Marks (1998) and Brook (2010) on China, Brooks (1993) and Webb (1995) on Africa, and Bulliet (2009) and White (2011) on the Middle East.