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Chapter Two

Air

Nancy Langston

The air within our lungs ties us to our planet's past and to its precarious future. Each molecule within the atmosphere circulates through the biosphere time and again. Those molecules cross scales, moving inwards through our lungs, and outwards into atmospheric currents that moderate the planet's temperature and protect us from the sun's radiation. Scientists with spare time on their hands have estimated that one to ten molecules breathed by the Buddha in his last breath are making their ways through our lungs right now. The carbon taken up by forests in Brazil once may have moved through your body; the carbon that threatens our shared futures on earth comes from the coal once taken up by plants in ancient forests. Across time and space, the atmosphere connects us all (Fleming et al. 2006: ix–x).

Anxiety about climate change and its potential effects on society dominates contemporary environmental concerns, but it is important to recognize that anxieties about climate are not new. For centuries, climate concerns have been part of discourses about colonization, power, and place. This essay explores the environmental history of air, using climate change as its central theme. It will focus on America, but because the atmosphere escapes national boundaries, and because political concerns about the atmosphere challenge our understanding of these boundaries, I will consider examples outside of America as well. Air encompasses many topics other than climate, of course, and this essay could equally well have focused upon pollution or energy.

The essay will begin with a brief examination of changing climates over earth's deep history, focusing on a few key episodes of abrupt change with powerful repercussions for life on earth. I will then turn to a history of scientific and public concern about climate change, asking when that concern began and what social and political forces shaped it. Finally, I will explore

climate-society interconnections, examining ways that various disciplines have perceived relationships between climate and society, and ways that these understandings may affect current debates over climate change and society. I argue that the seemingly macro scale of climate change has everything to do with the intimate scale of sense of place – and with it, issues of cultural identity that are bound up with history and policy.

Changing Climates

Quantitative understandings of past climates have grown far more detailed in the past four decades. Historians have reconstructed regional and local climates over the last several centuries from archival sources, including diaries, church records, weather station records, and ships' logs. Across longer time scales and broader spatial scales, climate scientists have developed what are called "proxy" data – indirect estimates of past climates that researchers construct from the size of growth rings on trees, the gas vapors trapped in ice cores taken in Antarctica and Greenland and the bed of the ocean, and pollen trapped in peat bogs and lake sediments. Often working collaboratively, scientists have reconstructed climate going back more than 700,000 years, and historians have pieced together remarkably detailed, local climate records for more recent centuries. Being able to reconstruct past climates doesn't necessarily mean that scientists can understand why those climates changed, much less predict how climates might continue to change. For these tasks, climatologists have developed complex computer models, particularly ones known as "general circulation models," or GCMs. Innovations in computing technology have allowed researchers to run increasingly sophisticated analyses that attempt to predict possible future climates by comparing model outputs to reconstructions of past climates (Carey, forthcoming; Weart 2008).

The more information scientists gain about past climates, the more they recognize that climate systems are extraordinarily complex. Interconnected feedback loops among the components of the atmosphere, soils, oceans, plants, and people make climates subject to abrupt, unpredictable changes. Even as climates affect life on earth, living systems affect those climates. Earth's atmosphere has been anything but stable over the history of this planet, and life on earth has been changing the atmosphere ever since single-celled organisms first evolved.

Four and a half billion years ago, the atmosphere contained very little oxygen, far too little to sustain animal life. About three billion years ago, an extraordinary innovation – photosynthesis – transformed the earth's climate. Cells adopted sunlight as an energy source, in the process fixing carbon, releasing oxygen, and creating carbohydrates. By about 2.4 billion years ago, photosynthetic bacteria were producing so much oxygen that the gas created an ozone layer, which in turn absorbed a significant amount of

ultraviolet radiation, allowing cells to leave the ocean surface and colonize land. Some of the first multi-celled organisms evolved the ability to incorporate bacteria and their photosynthetic machinery into their own cells, leading to an explosion of green plants that covered much of the planet quite quickly. The result was a series of evolving feedback relationships that dramatically transformed the earth's atmosphere and climate into a vast, interactive system tying together atmosphere, oceans, rocks, soil, bacteria, plants, and animals. Plants, in other words, through photosynthesis, helped to create the climate and atmosphere that sustains them, and indirectly, ourselves (Morton 2008: 234). The fossil fuels we burn today come from energy trapped three hundred million years ago by photosynthesis. The carbon we give off by burning those fuels is carbon taken from the ancient atmosphere. Each mile we drive, each step we take, is part of an intimate exchange with the climates and ecosystems of the past.

Abrupt climate changes over the past two hundred million years shaped the evolution of earth's plant and animal communities. When dinosaurs walked the earth two hundred million years ago, the carbon dioxide level was more than three times our current level (which is about 360 parts per million), and dense tropical forests spread across much of the globe, creating a warmer, wetter atmosphere. When plate tectonic movements churned up the earth, they altered earth's climates as well. When India collided into Asia, silicate rocks from deep within the earth's crust were exposed to the weathering forces of wind and rain. These chemical weathering processes used up much of the carbon dioxide in the atmosphere, thus cooling and drying the climate and lowering carbon dioxide levels.

As the climate dried, fires increased, which fostered the spread of grasses, which in turn increased fires – a positive feedback loop that resulted in an evolutionary advantage for grasses. In this cooler, drier, climate, open sweeps of savanna grasses were able to replace dense forests, fostering the fire cycles described in detail by the environmental historian Steven Pyne (1997, 2001). As the science writer Oliver Morton puts it, "In the burning world, just over a quarter of the land covered by vegetation is covered by forests; in the world without fire, that more than doubles" (2008: 289–90). Periodic climate changes triggered bursts of evolution and extinction in many mammals, including hominids. Mammals that relied on fruit and browse disappeared early in the transition from forest to savannah vegetation and were not replaced, while those that ate broad leaves and grasses either adapted and persisted by changing their diets to include more grass or disappeared and were replaced by immigrant species with similar diets. Mass extinctions followed abrupt climate changes, yet over evolutionary time, mass speciation led to numerous new species evolving to fill the vacant niches.

Starting about two million years ago, the modern ice age began, with continental glaciers periodically expanding over much of North America. Each glacial cycle lasted for about one hundred thousand years of ice growth,

followed by twenty thousand years of warming, with massive repercussions for individuals and community assemblages in the path of the ice. When the ice retreated, plants regained their hold on formerly glaciated landscapes, shaping climate feedback cycles that chased the ice back even faster. The most recent (but probably not the last) ice age ended abruptly some 11,500 years ago, ushering in what the archeologist Brian Fagan (2004) calls the "Long Summer" of the Holocene Era. It was during this long Holocene summer that human societies in America expanded and diversified. Climatologists once thought the Holocene's climate had been quite stable. New paleoclimate records, however, show that several widespread cooling events occurred, persisting for centuries and recurring every 1,500 to 2,000 years. Megadroughts were also common, affecting regional and continental climates. These climate shifts were often quite abrupt, occurring over just a decade. Between 7,000 to 4,000 years ago, the climate was warmer in Europe and parts of the Americas than it is now, as was also true during the Medieval warm period (AD 1000–1400). During the Little Ice Age (1400 to 1860), the climate was substantially colder in Europe and North America. George Washington and Thomas Jefferson commuted to Washington, DC by sleigh, and the Dutch skated on their canals (deMenocal 2001; Carey, forthcoming; see also Pfister 1980; Richards 2006: 56–88; Lamb 1995; Hulme 2008).

With the expansion of fossil fuel economies, humans began to have profound effects on climate, yet the relationships were rarely simple or direct. In Great Britain, the shift from wood fuels to coal increased carbon dioxide emissions into the atmosphere, but it also slowed deforestation. Without the shift to fossil fuels, fewer of Britain's forests might have survived. With new sources of energy, canals gave way to railroads, steam engines gave way to steam turbines, and eventually they all gave way to the internal combustion engines of the car, truck, and aircraft. These technological innovations unleashed stored energy into the atmosphere, releasing the buried carbon of a hundred million years in just a few centuries, changing the earth's climate cycles in ways that scientists are only beginning to comprehend (Morton 2008: 343).

History of Climate Concerns

The historian James Fleming writes:

> Climate apprehensions did not begin in 1988 or in 1957, or even in 1896. There were colonial, early modern, and even ancient precedents. From a climate discourse steeped in the tradition of literary analogy, through a long and continuing effort to establish positive climate science, we have arrived, late in the twentieth century, at a climate discourse that is again saturated with metaphor, values, and apprehensions. (Fleming 1998: 136)

As historian of science Karen Kupperman (1982) argued, European perceptions of climate shaped colonization of the New World. Fears of American summer heat and humidity and winter cold were balanced by desires for the commodities colonies might offer. Extracting those commodities required extensive monitoring of the new world's actual climates, stimulating the development of a new climate science (Kupperman 1984).

Settlers in the Americas were initially shocked by the continent's extremes of summer heat and humidity, and in the north, by its winter cold. Europeans who stayed at home thought the colonists were foolhardy, risking their health and lives in a climate unsuited to European health. Initial boosters for American colonization attempted to frame the American climate in the best possible terms, but after the cold winter of 1607–8, when so many Jamestown colonists suffered deprivation, disease, and death, the task was more difficult. Then colonists and boosters began to argue that the American climate may not be ideal in its wild state, but that it was susceptible to human intervention. In 1769, the colonist Edward Antill wrote "we are every year fast advancing to that pure and perfect temperature of air, fit for making the best and richest Wines of every kind." Many American patriots agreed, insisting that their efforts would rapidly improve the climate, and that such improvements justified the colonial project. Hugh Williamson of Harvard College wrote in 1811: "While America remained a great forest, inhabited by savages, under the constant dominion of westerly winds, there was not any climate on the eastern coast, in which we could expect a fair skin. By the progress of cultivation, the general course of the winds is materially affected ... as shall prevent the tendency of complexion to the clear brunet." European thinkers such as Peter Kalm the traveler speculated that women were particularly vulnerable to the harsh American climate. Kalm believed "women reached menopause" earlier in America, and many Europeans were convinced the climate was unsuitable for white women, for it "produced degeneracy among the aborigines." Colonists were defensive about such charges, arguing that deforestation would improve the healthfulness of the country, "ventilate" the country, and thus "furnish the most salubrious and consequently valuable situation for settlers" (quoted in Fleming 1998: 23–30).

Even as many observers celebrated climate change, others worried about it. As historian Richard Grove notes in *Green Imperialism* (1995), colonial powers in the eighteenth century expressed grave concerns about Caribbean deforestation and its potential to lead to climate change, particularly to drought. Such desiccation theories led to the first forest conservation policies of many of Britain's colonial states.

Such beliefs about climate change in response to European settlement were met with some skepticism, and that skepticism helped to motivate the growth of climate science in America. The colonial physician Benjamin Rush, for example, agreed that eventually cultivation might ameliorate the

American climate, but noted that initial clearing of forests seemed to have actually made local climates less healthy. Benjamin Franklin, Thomas Jefferson, and other American intellectuals recognized that memories of climate change might be unreliable, and that detailed weather records were critical for the development of a new country under scientific principles. Physicians, natural scientists, and state agencies began to collect, chart, map, and collate weather observations, establishing the foundations of climatology (Fleming 1998).

The drive to standardize and coordinate weather observations created what historians Fleming, Jankovic, and Coen call a meteorological "synopticon." Such science evolved to serve the course of empire and corporations, enabling surveillance and control (Fleming et al. 2006). Markets and military efforts alike required detailed knowledge of climates, in order to plan agriculture, health, and military campaigns. Climate scientists played important roles in nation building. The professionalization of climate science marked important changes in American and European ideas about nature's agency, as well as about links between humans and nature.

The anthropologist Julie Cruikshank discusses Alaskan native beliefs that glaciers have willful agency, responding to human violations of a social order with disastrous consequences. She points out that, foreign as these ideas seem to modern scientists, similar beliefs about sentient landscapes were also part of Western European history. During the eighteenth and nineteenth centuries, European scientists and industrialists rejected such ideas about what Cruikshank calls "a country that listens." With the rise of systematic data collection, beliefs about nature's agency and human influence on climate change lessened, replaced by mechanical models of causation (Cruikshank 2001).

Yet beliefs about human influence on climate did not entirely vanish. In 1896, the scientist Svante Arrhenius showed that changing concentrations of carbon dioxide in the atmosphere could affect the earth's heat budget and surface temperature. Moreover, he also pointed out that such changes might trigger feedback cycles such as changes in glaciation that could lead to even greater climate changes. Three years later, the scientist Nils Ekholm expanded on Arrhenius's work by showing that coal burning could double the concentration of atmospheric carbon dioxide, leading to a change in temperature. More concerned about global cooling than about warming, Arrhenius believed that the burning of fossil fuels could help prevent another ice age (Fleming 2006). In the mid-twentieth century, the British scientist G. S. Callendar documented links among increasing temperatures, increasing emissions of carbon dioxide from human sources, and global warming. As Fleming notes, Callendar's writings "revived the theme of human agency, which had been dormant since the age of Jefferson, pointing out that humanity had sped up natural processes and had become an agent of global change by interfering with the carbon cycle" (2006: 237).

Climate and Society

In 1915 the American geographer Ellsworth Huntington argued that climate determined human "migration, racial mixture, and natural selection" (1924: 3). Above all, climate dictated how civilized a society might become. Temperate climates led to more advanced civilizations; hot climates led to savagery. Carey (forthcoming) notes that Huntington's racism and environmental determinism stigmatized climate studies, discouraging many American historians from its study.

The French historian Emmanuel Le Roy Ladurie's classic *Times of Feast, Times of Famine* (1971) showed that historians could produce climate data that were quantifiable, rigorous, and detailed enough to reconstruct fine climate shifts at local scales. Nonetheless, Ladurie doubted that these climate shifts had important consequences for human history, writing that "in the long term the human consequences of climate seem to be slight, perhaps negligible, and certainly difficult to detect" (11). In the late 1970s, scholars began to challenge Ladurie. The British historian Hubert Lamb (1995), for example, argued that while climate change might not be the major factor shaping events such as wars, climate could still profoundly affect individuals and societies.

A special 1980 issue of the *Journal of Interdisciplinary History* presented a lively debate between scholars who retained Ladurie's skepticism about climate's influence on society, and scholars who agreed with Lamb that climate was indeed a force in human history. In this volume, the historian John Post recognized that attempts to find simple correlations between low temperatures and high mortality rates or crop prices would not be particularly fruitful. European preindustrial societies were able to develop resilience to climate change, a resilience based on the diversity of crops, stored grain, expanding trade, and welfare systems (Post 1980). Such resilience meant that simple correlations would not exist; social and political factors made the relationships between culture and society far too complex to be revealed by statistical analyses. David Fischer (1980) begged fellow historians to take climate seriously nonetheless – not as the only force determining European politics, but as one critical factor among many. Fischer acknowledged that "climate and culture have not been connected through history in one simple, universal causal relationship of the sort which so many scholars have tried in vain to discover." Instead, climate change might lead to "crises of adaptation" during times of rapid or particularly variable climate change (828).

Since the 1980s, scholars have attempted to explore not just direct effects – did climate change cause economic or demographic chaos? – but indirect effects. Some of the most fascinating work has been done by anthropologists and archeologists, who examine the ways that changing climates might influence social networks that in turn influence resilience. The archeologist Brian

Fagan's research on varied European responses to the Little Ice Age examines some of the ways that social institutions, technology, power, perceptions, and culture influenced the different choices that societies made. As Fagan writes: "Climate is, and always has been, a powerful catalyst in human history, a pebble cast in a pond whose ripples triggered all manner of economic, political and social changes" (2004: xiv).

The Little Ice Age's effects on the Norse in Greenland provides an important case study of the complexities of climate and society interactions. In the 1990s, Thomas McGovern and his colleague Astrid Ogilvie had argued that the "impact of climate change, the failure of their pastoral subsistence base, and an inability to adapt were key factors in the end of Norse settlement in Greenland" (Dugmore et al. 2007; see also McGovern et al. 1988; McGovern 1994, 2000; Ogilvie and McGovern 2000). McGovern's thesis was popularized by Jared Diamond, who argued in a *New York Times* op-ed piece that the critical factor leading to the Norse's lack of resilience to climate change was an

> unwillingness to re-examine long-held core values, when conditions change and those values no longer make sense. The medieval Greenland Norse lacked such a willingness: they continued to view themselves as transplanted Norwegian pastoralists, and to despise the Inuit as pagan hunters, even after Norway stopped sending trading ships and the climate had grown too cold for a pastoral existence. They died off as a result, leaving Greenland to the Inuit. (Diamond 2005)

In the last several years, McGovern and his colleagues have revised their earlier views of Greenland Norse responses to climate change. In an important 2007 paper, the archeologists Andrew J. Dugmore, Christian Keller, and McGovern argued that economic changes and patterns of trade, not climate alone, could have marginalized the Norse Greenland settlements, leading to their abandonment. The authors explore the factors creating resilience to environmental change among the Norse, concluding that the social and economic elements that made the Greenland Norse viable for most of the colony's existence were precisely the same factors that led to their collapse during the Little Ice Age.

Rather than being victims of "hide-bound thinking," the Norse developed complex subsistence networks that were excellent at providing resilience during normal environmental fluctuations. Exploiting a wide range of food resources buffered the Norse against normal food shortages, but the system required a great deal of collaboration between households. Such an integrated system, with its ability to cope with small-scale variation, may have been overwhelmed when climate change began to unravel the links between communities (see also Haberle and Lusty 2000; Wigley et al. 1981). In other words, the Greenland Norse might not have collapsed

because their population was too high for the available resources, but rather because their population dropped too low, unraveling the cooperative social structures that they relied upon to survive times of environmental fluctuation. The archeologists are not arguing that climate change was unimportant for the Norse. Rather, social, political, and economic structures mediated the Norse's resilience to climate change.

The Americas

Archeologists and paleoecologists have recently collaborated on studies of the ways cultures in the Americas responded to climate change. As the paleoecologist Peter DeMenocel writes in *Science* (2001), comparing the archeological record of cultural change with detailed Holocene paleoclimate records allows scholars to explore how complex societies responded to climate changes. During the late Holocene droughts, some empires collapsed, while others adapted. Showing that societal changes happen at about the same time that climate changes doesn't necessarily prove that one caused the other, but such correlations suggest avenues for future, more detailed research (Diaz and Stahle 2007).

Researchers have observed that prolonged drought, rather than temperature changes alone, appears to be the key climate factor affecting preindustrial American societies. Megadroughts, or extreme droughts leading to major ecological changes, have been a frequent force shaping environments in the Americas since the retreat of the glaciers. Tree-ring chronologies and lake sediment records from across the United States have helped researchers reconstruct summer droughts extending back to AD 1200. Megadroughts were extremely intense, persisted for decades, and recurred roughly once or twice every 500 years. In California before 1350, even longer, more intense droughts appear in the record.

The Classic Maya in Mexico and Central America 1,200 years ago, the Moche in Peru 1,500 years ago, and the Tiwanaku in Bolivia and Peru 1,000 years ago, were all affected by megadroughts, but they responded in quite different ways. Some societies changed subsistence levels, abandoned cities, and simplified systems of supply and production. Other societies developed more complex political structures to control shrinking water supplies. DeMenocel notes that these events are particularly relevant to modern concerns over climate change because they show both the resilience and vulnerability of complex civilizations to environmental variability.

In a special 2007 issue of the journal *Climatic Change*, scholars from history, paleoecology, and the earth sciences presented research on the potential links between climate change and societal change in the Americas. Larry Benson, Kenneth Petersen, and John Stein investigated the interrelationships among maize cultivation, drought, and settlement in the Chaco

Canyon region of New Mexico. They found that drought had indeed contributed to abandonment and migration. Cultural factors also played a key role, however, because even during a severe drought, some areas would have been viable for growing enough maize to support small populations. Drought alone did not determine migrations, but rather intensified the effects of deforestation, warfare, and religious turmoil (Benson et al. 2007). D. A. Hodell, M. Brenner, and J. H. Curtis explored associations between droughts in the Yucatan Peninsula and several critical Mayan cultural markers over a thousand year period. Their work suggests that a major drought occurred near the end of the Late Preclassic period of Mayan history, coinciding with an increase in deforestation for agriculture. The shift in climate may in turn have shaped Mayan political development, as irrigation became increasingly important for agriculture during the drought. Control of water resources, in turn, contributed to changes in political power during the Classic period (Hodell et al. 2007). Archeologists studying Peru's Moche people in the seventh and eighth centuries collaborated with climatologists studying ice cores in the Andes. They found that prolonged drought and El Niño-Southern Oscillation events occurred just when the Moche people increased human sacrifices, and then abandoned their complex coastal settlements. The fine detail available in the new climate reconstructions helped archeologists make sense of the Moche people's fate (Carey, forthcoming).

The sixteenth-century megadrought across North America may have been one important factor affecting English and Spanish colonization in the New World. Drought, clearly, was not the cause of the demographic collapse of American Indian peoples following colonization. But it may have intensified the epidemiological tragedies of European settlement in the New World. Similarly, the collapse of bison populations on the Great Plains after the Civil War was influenced by both climate change and society. New technologies such as guns and railroads, new economic opportunities, and new political pressures all shaped the human decisions that led to intense market hunting of the bison. Drought, however, led to the bison's lack of resiliency in the face of this intense human predation (Stahle et al. 2007). Decades later on the Great Plains, another ecological catastrophe followed the onset of drought, and this too was shaped by interrelationships between climate and society. As Donald Worster argues in his classic *Dust Bowl* (1979), cultural factors shaped the decisions made by farmers on the southern plains, and those decisions led to greatly heightened vulnerability to drought. Culture, not climate change alone, led to the Dust Bowl.

Scholars in political ecology have recently stressed the ways that power relationships influence the effects of climate change on people. For example, recent research on El Niño-Southern Oscillation (ENSO) events has shown that ENSOs are indeed correlated with famines, particularly in parts of Brazil, as earlier scholars had argued. In *Late Victorian Holocausts* (2001),

the political ecologist Mike Davis demonstrates that the El Niño events did not *cause* the famines; political decisions led to famines. Climate change acted as a trigger, but the structure of the global economy and political decisions led to massive starvation. Discrepancies in power determine access to resources, shaping why some people survive and others die when the climate changes.

Recent Concerns about Global Warming

In February 2007 the Intergovernmental Panel on Climate Change (IPCC) released its report, "Climate Change 2007: The Physical Science Basis." Established by the United Nations to provide decision-makers with an objective source of information about climate change, IPCC reports attempt to find consensus among climate scientists (Solomon et al. 2007). The 2007 IPCC report opened with the statement that the burning of fossil fuels is "very likely" to be responsible for the current climate change trend, an assessment that indicated "more than 90 percent" certainty. The IPCC reports highlighted the overwhelming evidence that the climate was changing, and humans were substantially contributing to those changes.

As soon as the 2007 IPCC reports were released, the denial industry swung into action, offering $10,000 to scientists willing to attack the reports. The historian of science Naomi Oreskes (2007) shows that since the late 1980s, global warming deniers have coordinated a campaign to create doubt and paralysis around climate change. The deniers use many tools to make their case, including advertisements, op-ed pieces, lobbying, and commissioned reports from the few scientists who agree with them. First, they argue that the world isn't warming. Second, they argue that even though the world really isn't warming, any warming that does seem to be happening is entirely natural. And finally, they argue that the human impacts of any warming that did happen would benefit people (at least those in the temperate zones). Oreskes' work shows just how powerful this well-funded campaign has been, particularly in dismantling legislation, eviscerating government reports on climate change, and creating a sense among the public that scientific consensus is lacking.

Abundant parallels exist between the global warming skeptics and an earlier generation's tobacco lobbyists. Not only are the strategies the same; the people, funding sources, hired consultants, and media firms are often the same as well. Oreskes argues that one key political tactic involves manufacturing a fake debate to dispute emerging scientific consensus. The same thing has happened with the consensus that sulfur and nitrogen emissions cause acid rain, the consensus that chlorofluorocarbons cause the hole in the ozone layer, the consensus that cigarette smoking causes cancer, and the emerging consensus on environmental carcinogens. These efforts follow a

similar pattern. First, denialists argue that the science is uncertain. Second, they argue that concerns are exaggerated and the true risks are small, particularly compared to natural risks already existing in the environment. Third, they state that technology will solve the problem, so there's no need for government interference. The campaigns against global warming and public health regulation involve the same institutions, run by the same people, funded by the same sources (Oreskes 2007; see also Begley 2007).

As an earlier section of this essay detailed, concerns about climate change have had a long history. These anxieties had intensified in the 1950s, when both the scientific and the popular press had expressed concerns about warming temperatures, rising sea levels, and their possible effects on agriculture and cities. What the historian of physics Spencer Weart calls "the discovery of global warming" in the twentieth century represented a key shift in post-Enlightenment scientists' views of the earth. For generations, climate scientists had believed that the climate system was a kind of machine, one that we could eventually understand and control if only we developed powerful enough tools. Scientists believed climate changed, but only slowly, driven by forces external to human influence. But as Weart (2008) demonstrates, by the end of the twentieth century, new understandings of climate had emerged. As a physicist, Weart focuses on the efforts of physical scientists to comprehend climate change, paying particular attention to the emergence of modeling technologies. Weart tends to overlook, however, the work of biologists and climate historians who have long explored the roles of biological systems in climate feedbacks (Cushman 2005).

Weart argues that increasingly complex climate models – particularly the GCMs – have been critical in helping scientists understand the unpredictable feedbacks from climate systems. Yet such models are not simple or direct representations of nature; they are filled with assumptions and uncertainties. Models that incorporate human dimensions, for example, often tend to take for granted a set of external factors such trade rules, intervention possibilities, and human behavior, often without acknowledging that these social factors are historically contingent rather than fixed constants (Rayner 2003: 282–3). When policymakers extend these models into social and cultural realms, model assumptions can lead to disastrous oversimplifications.

For example, consider the 1995 IPCC report. This report considers human dimensions of climate change, addressing adaptation responses, decision-making frameworks, equity, and economics. Yet adaptation considerations focus almost entirely on national-level decisions, even though the anthropologists J. McIntosh and colleagues argue that most human adaptation will come at the local or regional scale. Often, these environmental responses are based on local knowledge which remains hidden from national governments (McIntosh et al. 2000: 3–4). People survive by what the anthropologists call "networks of social relations." The large-scale technological problem-solving recommended by model outputs can disrupt such social networks, leaving people vulnerable. In *Intimate Universality* (2006),

James Fleming and colleagues note that climate modelers have grown increasingly enamored of engineering efforts to manage and control human impacts on the climate. The history of intentional climate engineering is riddled with unintended consequences and technological hubris, making Fleming quite wary of such efforts.

Historians rarely believe history can be prescriptive for policy. Yet several themes do emerge from fine-grained studies of historical responses to climate change. Societies use their past experiences of environments – their shared environmental histories – as guides to the future. Environmental memories help people develop ways of living in place, by teaching people how to monitor land use, population levels, and economic activities. But at times of abrupt, unpredictable change, shared environmental histories may become deceptive. Historians can examine the ways people use, and misuse, environmental histories when they are trying to adapt to unpredictable change (Dugmore et al. 2007; McIntosh et al. 2000).

A second central theme is that economic and political structures shape a society's resiliency to climate change. Economies based on exploitation of a wide range of resources may be less vulnerable to gradual climate change because people can shift resources when the climate shifts, but as the Norse example shows, those same economies may become more vulnerable during times of abrupt change. Economies based on commercial exploitation of fewer resources may connect dispersed communities, but that can create increased vulnerability during climate changes, if remote markets upon which a community has come to depend are affected (Dugmore et al. 2007).

A third key theme is that scale matters. On an evolutionary time scale, extinction of species is a perfectly natural process. Species assemblages do continually change, and as the earth's climate warmed at the end of the last ice age, numerous species migrated north, colonizing landscapes freed from the ice. Some species went extinct, unable to adapt to changing environments; other species evolved new forms. The critical difference today is one of scale. These changes now are happening at what the ecologist Sarah Wright calls "break-neck speed. They are slow on our human time scale, but on Earth's time scale they are as sudden and violent ... leaving little time for species to adapt and to maintain their relationships with one another" (2007: 16).

Scale is likewise a critical factor shaping human responses. When the Greenland Norse failed to adapt to climate change, commercial changes in Europe, rather than decisions the Norse made in Greenland, may well have been a key driver that created heightened sensitivity to climate change. Donald Worster argues that many modern, complex societies have learned to adapt to natural variation by concentrating "enough power and wealth at the center in order to overcome most natural vicissitudes. They learn how to create stability out of chaos by sending out money regularly to compensate for local loss" (1999: 68–9). While this helps minimize vulnerability to small fluctuations, such strategies may increase vulnerability to large-scale, abrupt environmental change. Historians can work with

anthropologists to learn which political and social structures have led to more resiliency in the face of abrupt change.

The importance of narratives emerges as another key theme for historians to bring to the conversations about global warming. The anthropologists Sarah Strauss and Ben Orlove, after observing meetings of the UN Framework Convention on Climate Change and the Kyoto Protocol teams, noted that while the teams hoped to alter human actions, their major activities to date had actually been an effort "to construct a shared narrative, a verbal framework that links specific actors, institutions, and political entities" (Strauss and Orlove 2003: 11). Similarly, Patricia Romero-Lankao, a sociologist working with the IPCC teams, stresses the importance of narratives in interpreting the causes of climate change. Narratives are central to the work of environmental historians (Cronon 1992), and our training can help scientists understand the ways competing narratives influence climate change – both the causes and the responses (or lack of responses to evidence of global warming).

Narratives are a way of understanding cause and effect relationships, which help communities construct their perceptions of agency and ethical responsibility. The anthropologist Julie Cruikshank argues that with concerns about global warming, westerners are returning to a sense that humans are engaged in intricate relationships with climate. She locates similar patterns in traditional indigenous narratives. Cruikshank writes: "Narratives underscore the social content of the world and the importance of taking personal and collective responsibility for changes in that world.... In the past, then, things and people were always entangled. In the future, they will be more entangled than ever" (2001: 391).

What's threatened by global warming is not the earth but ourselves. What won't persist is our sense of place and time – our own human histories on this earth. It's the places we love, the relationships we cherish with the species that make their homes in those particular places, that help to make us human. As Wallace Stegner (1992) reminded us, we see the world through our own human eyes, and it's that human vision of the world that is under threat. John Burns, a naturalist in the northwoods of Wisconsin, writes in *Paradise Lost: Climate Change in the North Woods*:

> The climate change scenarios currently projected for Wisconsin at the end of this century utterly boggle the mind. Conservative middle-ground scenarios show Wisconsin becoming the climatological equivalent of Arkansas, whileh Madison's climate will morph into a twin of Oklahoma City.... Meanwhile, the North Woods may gradually transition into an oak savannah. That's so difficult to imagine, so close to what we can only think of as science fiction, that all of us have a great deal of trouble even conceiving of the possibility. Yet there it is, looming on the horizon like the eerie bruised sky that so often precedes a tornado. But how does one address the coming of a tornado, much less the coming of a global environmental upheaval? (Burns 2007: 3)

The potential loss is indeed difficult to comprehend, and the perspectives that historians can bring to the discussion are critical. Who wins, and who loses, when the climate changes? Who has the power to define the terms of the debates over global warming? How can humanistic perspectives help us understand people, places, and landscapes through time?

In a seminar this fall on the past and future of the Great Lakes forests, we closed with a discussion of global warming. One of our seminar members was a forest planner from the Wisconsin Department of Natural Resources, whose job involves trying to plan future forest conditions for the state. She expressed her frustration at how difficult it was to manage forests given the growing uncertainties of global warming. Our forest plans are based on history, she pointed out. Desired future conditions, allowable cuts, silvicultural treatments – they're all based on trying to restore forest types from the past, forest types that we now know are ghosts. They'll never exist again. But if we give up on trying to restore historic conditions, then how can we manage forests? Ecologists tell us to focus on restoring processes, not historic patterns, but global warming is also changing those ecological processes. Are we supposed to give up on the hemlock, the white pines, on Wisconsin's forests altogether?

Ecological historians feel as if they are watching the collapse of ecosystems they spent their careers immersed in learning about, and then in learning to love. Things that to the rest of us seem trivial, or even sweet – a family camping trip with a load of firewood from home, a fishing trip with a can of earthworms for bait – spell disaster to them, because they understand the ecological history of abrupt community collapse. They know that a stick of firewood may well contain several emerald ash borers, and if just a few of those insects get out of the firewood and into the surrounding forest, that could mean 95 percent of our ash trees are dead within five years as the climate warms and trees lose resistance to insect attacks. So much for a key component of the forest (and so much for the cultural associations local Menominee women have with ash trees, which are important for basket making.) The ecologists know that wiggling worms don't all get impaled on fishing hooks. A few squirm free, and havoc results in the hemlock forests, because non-native earthworms transform nitrogen cycling on the forest floor. If you walk with an ecologist in Sylvania Wilderness Area, essentially the last old growth hemlock forest left in the Great Lakes states, you can trace what the ecologists call a "killing wave" of earthworm activity. The combined stresses of insects, invasive species, and climate change may mean that the forests we now know and love are unlikely to persist and unlikely to return, at least within the historic time scales that matter to people.

What then can environmental historians do that scientists and social historians might have a hard time doing, in the face of rapid, irreversible ecological and social transformations? I hope we can do some translation: speak to the ecologists of cultural changes, and speak to other historians of ecological changes, in a language that helps both communities understand that

complex relationships are being unraveled. Global warming challenges us to reexamine what history means to us, when we are changing the earth so quickly that our shared environmental histories are vanishing, possibly never to be witnessed again. Without reference to an ecological past that may no longer resemble our ecological futures, how will we learn to live responsibly in place?

References

Begley, Sharon. 2007. "The Truth About Denial," *Newsweek*, August 13.

Benson, Larry, Petersen, Kenneth, and Stein, John. 2007. "Anasazi (Pre-Columbian Native-American) Migrations During the Middle-12th and Late-13th Centuries – Were they Drought Induced?" *Climatic Change* 83: 187–213.

Burns, John. 2007. *Paradise Lost: Climate Change in the North Woods.* Madison: University of Wisconsin, Center for Biology Education. Available at www.wisc.edu/cbe/assets/docs/pdf/paradiselost/paradise_lost.pdf (accessed January 25, 2009).

Carey, Mark. Forthcoming. "Beyond Weather: The Culture and Politics of Climate History." In Andrew Isenberg, ed. *The Oxford Handbook of Environmental History.* Oxford: Oxford University Press.

Cronon, William. 1992. "A Place for Stories: Nature, History, and Narrative," *Journal of American History* 78 (March): 1347–1376.

Cruikshank, Julie. 2001. "Glaciers and Climate Change: Perspectives from Oral Tradition," *Arctic* 54: 377–393.

Cushman, Gregory T. 2005. "The Discovery of Global Warming (review)," *Technology and Culture* 46: 456–458.

Davis, Mike. 2001. *Late Victorian Holocausts: El Niño Famines and the Making of the Third World.* New York: Verso.

deMenocal, Peter B. 2001. "Cultural Responses to Climate Change During the Late Holocene," *Science* 292: 667.

Diamond, Jared. 2005. "The Ends of the World as We Know Them," *New York Times*, January 1.

Diaz, Henry F. and Stahle, David W. 2007. "Climate and Cultural History in the Americas: An Overview," *Climatic Change* 83: 1–8.

Dugmore, Andrew J., Keller, Christian, and McGovern, Thomas H. 2007. "Norse Greenland Settlement: Reflections on Climate Change, Trade, and the Contrasting Fates of Human Settlements in the North Atlantic Islands," *Arctic Anthropology* 44: 12–36.

Fagan, Brian. 2004. *The Long Summer: How Climate Changed Civilization.* New York: Basic Books.

Fischer, David Hackett. 1980. "Climate and History: Priorities for Research," *Journal of Interdisciplinary History* 10 (4): 821–830.

Fleming, James Rodger. 1998. *Historical Perspectives on Climate Change.* New York: Oxford University Press.

Fleming, James Rodger. 2006. "Global Climate Change and Human Agency." In James Rodger Fleming, Vladimir Jankovic, and Deborah R. Coen, eds. *Intimate*

Universality: Local and Global Themes in the History of Weather and Climate. Sagamore Beach, MA: Science History Publications.

Fleming, James Rodger, Jankovic, Vladimir, and Coen, Deborah R., eds. 2006. *Intimate Universality: Local and Global Themes in the History of Weather and Climate.* Sagamore Beach, MA: Science History Publications.

Grove, Richard. 1995. *Green Imperialism: Colonial Expansion, Tropical Island Edens and the Origins of Environmentalism, 1600–1860.* New York: Cambridge University Press.

Haberle, Simon G. and Lusty, Alex Chepstow. 2000. "Can Climate Influence Cultural Development? A View through Time," *Environment and History* 6: 349–369.

Hodell, D. A., Brenner, M., and Curtis, J. H. 2007. "Climate and Cultural History of the Northeastern Yucatan Peninsula, Quintana Roo, Mexico," *Climatic Change* 83: 215–240.

Hulme, Mike. 2008. "Geographical Work at the Boundaries of Climate Change," *Transactions of the Institute of British Geographers* 33: 5–11.

Huntington, Ellsworth. 1924. *Civilization and Climate* [1915]. 3rd ed. New Haven: Yale University Press.

Kupperman, Karen Ordahl. 1982. "The Puzzle of the American Climate in the Early Colonial Period," *American Historical Review* 87: 1262–1289.

Kupperman, Karen Ordahl. 1984. "Fear of Hot Climates in the Anglo-American Colonial Experience," *William and Mary Quarterly* 41: 213–240.

Ladurie, E. Le Roy. 1971. *Times of Feast, Times of Famine: A History of Climate Since the Year 1000.* Garden City, NY: Doubleday.

Lamb, H. H. 1995. *Climate, History and the Modern World.* 2nd ed. New York: Routledge.

Le Treut, H., Somerville, R., Cubasch, U., Ding, Y., Mauritzen, C., Mokssit, A., Peterson, T., and Prather, M. 2007. "Historical Overview of Climate Change." In S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller, eds. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* New York: Cambridge University Press, pp. 95–127.

McGovern, Thomas H. 1994. "Management for Extinction in Norse Greenland." In Carole L. Crumley, ed. *Historical Ecology: Cultural Knowledge and Changing Landscapes.* Santa Fe, NM: School of American Research Press, pp. 127–154.

McGovern, Thomas H. 2000. "The Demise of Norse Greenland." In William W. Fitzhugh and Elizabeth Ward, eds. *Vikings: The North Atlantic Saga.* Washington, DC: Smithsonian Institution, pp. 327–339.

McGovern, Thomas H. et al. 1988. "Northern Islands, Human Error, and Environmental Degradation: A View of Social and Ecological Change in the Medieval North Atlantic," *Human Ecology* 16: 225–270.

McIntosh, Roderick J., Tainter, Joseph A., and McIntosh, Susan Keech. 2000. "Climate, History, and Human Action." In Roderick J. McIntosh, Joseph A. Tainter, and Susan Keech McIntosh, eds. *The Way the Wind Blows: Climate, History, and Human Action.* New York: Columbia University Press.

Morton, Oliver. 2008. *Eating the Sun: How Plants Power the Planet.* New York: Harper Collins.

Ogilvie, Astrid E. J. and McGovern, Thomas H. 2000. "Sagas and Science: Climate and Human Impacts in the North Atlantic." In William W. Fitzhugh and Elizabeth Ward, eds. *Vikings: The North Atlantic Saga*. Washington, DC: Smithsonian Institution, pp. 385–393.

Oreskes, Naomi. 2007. "The American Denial of Global Warming." Lecture given October 8, 2007 at Scripps Institution of Oceanography, University of California, San Diego. Available at www.uctv.tv/search-details.asp?showID=13459 (accessed November 29, 2008).

Pfister, Christian. 1980. "The Little Ice Age: Thermal and Wetness Indices for Central Europe," *Journal of Interdisciplinary History* 10: 665–696.

Post, John D. 1980. "The Impact of Climate on Political, Social, and Economic Change: A Comment," *Journal of Interdisciplinary History* 10: 719–723.

Pyne, Stephen. 1997. *World Fire: The Culture of Fire on Earth*. New York: Henry Holt.

Pyne, Stephen. 2001. *Fire: A Brief History*. Seattle: University of Washington Press.

Rayner, Steve. 2003. "Afterword." In Sarah Strauss and Benjamin S. Orlove, eds. *Weather, Climate, Culture*. New York: Berg, pp. 282–283.

Richards, John F. 2006. *The Unending Frontier*. Berkeley: University of California Press.

Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K. B., Tignor, M., and Miller, H. L., eds. 2007. *The Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. New York: Cambridge University Press, 2007. Available at www.ipcc.ch/ipccreports/assessments-reports.htm (accessed January 25, 2009).

Stahle, David W., Fye, Falko K., Cook, Edward R., and Griffin, R. Daniel. 2007. "Tree-Ring Reconstructed Megadroughts over North America since AD 1300," *Climatic Change* 83: 133–149.

Stegner, Wallace. 1992. "The Sense of Place." In *Where the Bluebird Sings to the Lemonade Springs: Living and Writing in the West*. New York: Random House, pp. 199–206.

Strauss, Sarah and Orlove, Ben. 2003. "Up in the Air: The Anthropology of Weather and Climate." In Sarah Strauss and Ben Orlove, eds. *Weather, Climate, Culture*. New York: Berg.

Weart, Spencer R. 2008. *The Discovery of Global Warming*. Cambridge, MA: Harvard University Press.

Wigley, T. M. L., Ingram, M. J., and Farmer, G., eds. 1981. *Climate and History: Studies in Past Climates and Their Impact on Man*. New York: Cambridge University Press.

Worster, Donald. 1979. *Dust Bowl: The Southern Plains in the 1930s*. New York: Oxford University Press.

Worster, Donald. 1999. "Climate and History: Lessons from the Great Plains." In Jill Ker Conway, Kenneth Keniston, and Leo Marx, eds. *Earth, Air, Fire, Water*. Amherst: University of Massachusetts Press, pp. 51–77.

Wright, Sarah. 2007. "Hope and Healing in a World of Wounds." In *Paradise Lost: Climate Change in the North Woods*. University of Wisconsin, Center for Biology Education, pp. 16–17. Available at www.wisc.edu/cbe/assets/docs/pdf/paradiselost/paradise_lost.pdf (accessed January 25, 2009).