NANCY LANGSTON

paradise lost: CLIMATE CHANGE, BOREAL FORESTS, AND ENVIRONMENTAL HISTORY

JUST BELOW THE ARCTIC lies the boreal forest, 16 million square kilometers of conifers that stretches across North America, Scandinavia, and Russia. The boreal forest makes up one of the world's largest terrestrial ecosystems, yet few scholars have explored its interconnected human and ecological histories. In *Smithsonian* magazine, the artist Robert Bateman calls the boreal forest the "completely forgotten" ecosystem.[1] While boreal forests have largely escaped the scholarly gaze, they haven't escaped the attentions of commercial forestry concessions, eager to find new sources of pulp to satisfy the world's growing appetite for paper. And now, as concerns about global warming capture public attention, they are becoming key sites of conflict.

Ecologically, boreal forests share certain important constraints. They exist in places with extremely cold winter climates and short growing seasons, and they tend to grow on nutrient-deprived, poorly drained soils. These are disturbance-prone ecosystems; wind, fire, and insect activity have historically played roles in shaping these forests. The scales of these disturbances, however, are changing. Fire intensities are increasing, insect epidemics are intensifying, and toxic chemicals are saturating the aquatic ecosystems that make up such an important part of boreal landscapes.[2]

For much of the twentieth century, during the development of scientific forest management, foresters had portrayed boreal forests as naturally unhealthy forests,

Nancy Langston, "'Paradise Lost: Climate Change, Boreal Forests, and Environmental History," *Environmental History* 14 (October 2009): 641-650.

impoverished by their particular climates, soils, and disturbance regimes. Intensive management, foresters believed, might be able to rescue these forests from their own native unhealthiness, bringing them into a more modern and vigorous condition. In the past two decades, ecologists and environmentalists have challenged these views of boreal forest health, while introducing new metaphors of health and vulnerability into the conversation. Portrayals of the boreal forest have changed from a place of sickness, unhealthy cold, and dangerous airs, to the lungs of a world imperiled by global warming.[3]

Ecologists now argue that boreal forests are worth protecting because they make up one of the world's significant carbon reservoirs. Boreal regions contain just under 15 percent of the global land surface, but they contain over 30 percent of all terrestrial carbon, stored largely in the soil. Low soil temperatures promoted the formation of permafrost and peat, and low decomposition rates in the cold temperature meant high rates of carbon sequestration. Yet these boreal carbon stores turn out to be quite vulnerable to climate change. As temperatures rise, carbon decomposes faster, and peat and permafrost release their carbon.[4] One of the great carbon sinks of the world may tip into becoming one of the great carbon sources of the world, a positive feedback loop that could affect the health of human and natural communities throughout the globe.

In its introduction to a proposed planning process for the boreal forest, the Ontario government writes: "Ontario's Far North Boreal Forest is one of the last, great, undeveloped spaces on the planet and a vital carbon sink. ... It is also one of the world's largest intact ecosystems. ... The Far North Boreal Forest has remained virtually undisturbed by humans since the glaciers retreated. But as pressure for new resources and new places to live increases, that will likely change. ... Scientists have said that in order to preserve a healthy ecosystem in the Far North, a minimum of half of the land be protected."[5] The modern rhetoric of conservation planning, in other words, posits the forest's natural condition as a paradise about to be lost. An "essentially untouched" landscape is about to be sickened by development, unless planners step in to protect it and restore it for climate change mitigation.

But is forest management really changing in the region? What are the legacies of history that we need to consider before embarking on ambitious new plans to manage boreal forests for climate change mitigation? Will the new management regimes really look any different from the old management—or will they only be more of the same, with new language to justify them? Looking at changing rhetorics of disturbance can help us approach these questions.

Disturbances have always been part of boreal forest ecology. Eastern spruce budworm moths lay their eggs during the summer on conifer needles, particularly balsam fir (*Abies balsamea*) and white spruce (*Picea glauca*). Caterpillars overwinter and in the spring feed upon the trees, killing the trees if enough budworm are present. Large-scale infestations of the eastern boreal forest occur in cycles of roughly thirty-five years. The timing and extent of those infestations depends on many things: spring weather (the caterpillars particularly like warm dry springs); host populations (large expanses of mature balsam fir provides an excellent food source for an exploding caterpillar population).

While these insect cycles are natural, after World War II, they began to complicate commercial efforts to "fully utilize" the boreal forest for pulp and paper production. Dead trees and massive fires signaled an unhealthy forest that required the presence of scientific foresters who could step in and restore the forests to health. When the spruce budworm populations exploded in the late 1940s, foresters were armed with new technologies made possible by the war. DDT could be sprayed over millions of acres from planes released from military service. Aerial spraying of DDT did indeed suppress budworm populations, but only temporarily. By killing off 95 percent to 98 percent of the spruce budworm in an area, DDT spraying kept the budworms from killing off all the local spruce and fir. But for the 2 to 5 percent of budworms that had managed to escape each DDT spraying, those surviving trees offered a super-abundant food source that stimulated insect reproduction. Budworm epidemics had, historically, collapsed quickly, when budworm killed off their own food supply. But now DDT actually prolonged the budworm cycles, leading to ever more defoliation and ever more spraying of DDT in an attempt to control the outbreaks.[6]

When foresters tried to manage the boreal forests by removing small-scale natural disturbances, they appear to have increased the intensity and frequency of large-scale disturbances. Clear-cutting, replanting with susceptible species such as white spruce, fire suppression, and pesticides may have only led to bigger budworm outbreaks. For example, the infestation of 1910-1920 defoliated 10 million hectares. The infestation of 1945-1955, when DDT was first used heavily, defoliated more than twice the earlier infestation: 25 million hectares. And the infestation of 1968-1985 defoliated even more: 55 million hectares. As a comparison, the combined area of New York, Pennsylvania, Maryland, West Virginia, Virginia, and North Carolina is about 57 million hectares.[7]

DDT spraying didn't stop the budworm, but it did ignite concerns about the environmental effects of massive spray campaigns in the boreal forests. In *Silent Spring*, Rachel Carson wrote of the "rivers of death" created by the intense DDT spraying in the boreal forests of New Brunswick that began in 1952. The Miramichi River, once the most abundant Atlantic salmon run in the world, became what Carson called "a picture of death and destruction."[8] She described the spraying: "So in 1954, in the month of June, the planes visited the forests of the Northwest Miramichi and white clouds of settling mist marked the crisscross pattern of their flight. The spray—one half pound of DDT to the acre in a solution of oil—filtered down through the balsam forests and some of it finally reached the ground and the flowing streams. ... Soon after the spraying had ended there were unmistakable signs that all was not well. Within two days dead and dying fish, including many young salmon, were found along the banks of the stream. ... All the life of the stream was stilled. Before the spraying there had been a rich assortment of the water life that forms the food of salmon and trout. ... But now the stream insects were dead, killed by the DDT, and there was nothing for a young salmon to eat."[9]

After *Silent Spring* was published in 1962, another five years would pass before aerial spraying of DDT ended in New Brunswick. In those five years, 12.5 million pounds of DDT were sprayed each year over the boreal forests of that one province alone. Not until 1985 did the Canadian government completely ban the use of DDT in forestry (although existing stocks could be used until 1990).

In the chapter "Rivers of Death," Carson focused on DDT's acute poisoning of fish and insects, while noting that DDT and other pesticides might possess the potential to alter sexual development and reproduction. In Carson's era, no one understood how pesticides might be affecting sexual reproduction, but we now know that DDT is one of many endocrine-disrupting chemicals that can unravel the networks that weave together hormone systems and fetal development. DDT was only the first of many endocrine-disrupting pesticides sprayed in the boreal forest. In New Brunswick alone, some 220 million pounds of pesticide were sprayed between 1952 and 1990 in the effort to combat spruce budworm. Other synthetic chemicals continue to leach into Carson's Miramichi River. As the biologist Inka Milewski notes, "effluent from the pulp and paper mill, plywood mill, groundwood mill, leachate from former and current industrial chemical dumps, and sewage outfalls create a formidable soup of chemicals through which fish must pass on their way up the river or out to sea. In addition, while the magnitude of pesticide spraying has declined, herbicides are still sprayed to control "nuisance" vegetation in upper reaches of the Miramichi watershed."[10] Many, if not all, of these chemicals are endocrine disruptors, so while they may not directly kill fish, they can compromise their immune systems and change reproduction.

DDT clearly affected wildlife within the boreal forest, but it also had profound effects on creatures living continents away. In the 1950s, George Woodwell was a young botany professor at the University of Maine, when the forests he was studying in northern Maine were doused with DDT. Woodwell grew concerned, and his investigations showed that only half the DDT sprayed from the planes actually landed in the forests below. The rest seemed to vanish, and Woodwell set out to figure where it went. He learned that the DDT solution dried into tiny crystals that could be easily dispersed on air currents, and eventually be deposited tens of thousands of miles away. DDT residues, Woodwell learned, were appearing not just in boreal lakes, but also in the tissues of seals as far away as Antarctica.[11]

Much of the DDT used in the 1950s and 1960s within the boreal forests quickly made its way into the bodies of fish and people. Some of it, however, landed on the snows of Antarctica and the Arctic, where the crystals froze into the ice sheets and were immobilized, unable to cause harm. Until recently, that is. Global warming is now releasing those legacies of history back into the flesh of polar wildlife and from there into people. The scientist Heidi N. Geisz and her colleagues estimate that up to 2 to 8.8 pounds of DDT are released into coastal waters annually along the Western Antarctic Ice Sheet from glacial meltwater—a discovery with potentially profound consequences for ecosystem health.[12]

Even when toxic chemicals such as DDT are banned, their legacies persist. DDT is not the only example. In the 1990s, Canadian biologists were startled to find that levels of the pesticide toxaphene were increasing in the bodies of lake trout that swam in the cold clear lakes of the boreal forest—and also in the bodies of people who ate those fish. Toxaphene is a potent endocrine disruptor that can upset reproduction of both the fish and the wildlife and the people who eat that fish.

High toxaphene levels were puzzling because levels of other persistent organic pollutants had been steadily decreasing in Lake Superior and other boreal lakes since the 1980s, after bans on their use had been instituted in North America. Toxaphene had also been banned in Canada in the early 1980s, but levels of the chemical were for some reason extraordinarily high—far higher than levels of PCBs, and other better-known chemicals such as DDT. Lake Superior is cold, vast, and isolated from industrial centers. Of all the Great Lakes, it is easily the cleanest, and in many ways it seems almost pristine. So why would toxaphene be highest in this particular lake, in a region where the chemical had never been produced and had hardly even been used? And what might that contamination mean for one of the great recovery stories of modern conservation: the restoration of Lake Superior fisheries?

Decades earlier, in the 1950s, lake trout in the Great Lakes had been driven to the verge of extinction. With intensive fishing harvests, invasion by sea lampreys and alewives, and accumulation of persistent organic pollutants that affected reproductive health, the cumulative effects had led to a collapse of lake trout populations, with economic, cultural, and health consequences for Native peoples and for whites alike. But, in one of the great recovery stories of conservation, commercial fishing restrictions and the banning of many persistent organic pollutants led to a substantial recovery. By the late 1980s, breeding populations appeared to have recovered in Lake Superior. Finding a decade later that lake trout were newly contaminated with toxaphene unsettled fisheries biologists deeply. Where was that toxaphene coming from?

Researchers initially suspected the culprit was pulp mills lining the Canadian shores of Lake Superior near Thunder Bay, where deforestation of regional boreal forests had begun in the 1980s. The harvests supplied a growing paper industry, which dumped pulp mill wastes directly into Lake Superior. Those wastes contained chlorine and pine oils, which could combine under certain natural conditions to form toxaphene. But even after those waste products were regulated, contamination continued. Researchers soon suspected that the chemical was coming, not from local, contemporary sources, but instead from sources much more distant in time and place. The remote boreal forest was not nearly as remote as researchers had perceived.

Researchers now believe that the chemical continues to be volatized from old cotton fields in the American South, and that global wind currents may also be transporting toxaphene still used in Africa into Lake Superior and other boreal lakes—where it finds its way into fish, and eventually into the people eating that fish.[13] Among those most concerned are indigenous communities who live along the shores of Lake Superior. Fish is particularly important for the health of fetuses and young children, and eating fish is of great cultural significance. But its potential contamination forces communities to make trade-offs between their beliefs and possible harm to themselves. How much fish do you eat when it's culturally important? How much do you eat when you're pregnant? These are difficult dilemmas posed by changes in ecosystem health. Contaminants transform more than the health of lakes, fish, and forests; they also transform cultural identities as well.

Global warming, like toxic burdens, is transforming ecological relationships within boreal ecosystems. Insect epidemics are worsening, as increasing temperatures reduce the frequency of late spring frosts, which means that budworm may have more time to reproduce in a given year. Changing climates also appear to be decoupling budworm population cycles from those of its predators, both parasites and birds. For example, three of the warbler species that feed on budworms may be shifting north at faster rates than are the budworms, making the birds less likely to control outbreaks. Rising temperatures, drought conditions, and insect damage is likely to increase fire frequency and intensity. Changes in fire frequency not only decrease carbon storage, but they can lead to major ecosystem shifts: namely, a shift to grassland or grass/shrubland in areas currently dominated by the southern boreal forests. Current research suggests that boreal forest in Saskatchewan may well be replaced by grassland vegetation by the end of the century.[14]

In Canada, conservationists now warn that less than 8 percent of the boreal forest is protected from development, while more than half has been opened for harvests by logging companies, usually by clear cutting. In June of 2003 the Standing Senate Committee on Agriculture and Forestry called for action to conserve Canada's boreal forest because it is "increasingly under siege."[15] Even as environmental groups and Canadian senate committees call for protection of the boreal forest, commercial ventures are moving quickly to utilize its resources, as new technologies make previously non-commercial forests accessible for harvest. Nearly 2 million acres of boreal forest in Canada are now harvested each year, and 65 percent of that goes to pulp and paper.[16]

The Canadians have offered protections to some boreal forests, but those have been largely focused on the northernmost reaches of the boreal forest, where logging has less commercial viability. The southern boreal forest is still slated for logging, but that's where the highest diversity of birds and other wildlife is found. And that's also where models predict the boreal forest will be most stressed by climate change.

Some paper companies are quite explicit about their goals for the boreal forest: get what's left before it's gone. Why let perfectly good fiber go to waste, especially if the forest is going to die anyway as the climate warms? Provincial forest managers, however, have adopted the rhetoric of natural disturbance. In Ontario, for example, outside the provincial parks, most of Ontario's southern boreal is slated to be harvested within the century. The Ministry of Natural Resources argues that they need to open these forests to commercial logging in order to "renew the forest." The Ministry's forestry webpage reassures the public: "The Ministry of Natural Resources has developed forest policy and management approaches to emulate natural disturbance. Emulating natural disturbances includes regenerating Ontario's forests in natural patterns, ensuring that the needs of wildlife species are met and healthy, diverse ecosystems are sustained. … Clear-cuts are a critical component of emulating natural disturbances." In this vision, clear-cuts no longer level the forest. They "create desirable habitat for wildlife species. … Wildlife species of the boreal forest have evolved in forest patterns that have largely been shaped by wildfire. Existing wildlife species will benefit from forest management practices that emulate natural disturbance patterns."[17]

What does this actually mean in practice? In Ontario, the provincial ministry approves clear-cuts that range up to 12,483 hectares in size—a massive clear-cut—justified by the rhetoric of natural conditions. Other forestry publications urge planners to shift species composition of the boreal forest from white spruce to rapidly growing species less vulnerable to climate change and budworm. Genetically modified trees are particularly promising, one government document suggests.[18] As the document argues, "under conditions of climate change, maintaining species and ecosystem diversity in the western boreal forest may require increasingly intensive management policies."[19] So, as the environmental historian Brian Donahue suggests, "while scientific and cultural understanding of the forest may be turning in a new direction, actual management may be running more strongly than ever in the same old direction."[20]

Disturbances, like climate change, are indeed part of the natural processes that have shaped boreal forests since the retreat of the glaciers, and emulating natural disturbances is indeed a worthy goal for foresters. Much as we might long for a paradise lost, we know that there's no past state of perfect health, stability, and balance to which we can return. Scale, however, matters. Even though disturbance and extinctions are perfectly natural, we are now facing a different magnitude of change. The ecologist Sarah Wright writes: "Assemblages of species are continually cycling, as some forms wink out and others better suited to a changed environment emerge. As the Earth's climate warmed following the retreat of the glaciers, species migrated northward to colonize areas newly hospitable to them, just as they do today; probably, some species were locally extirpated from their southernmost extremes as conditions became too warm there. But the critical difference today is that these changes are happening at 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."[21]

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 argued. "All our desired future conditions, all our allowable cuts, all our silvicultural treatments—they're all based on trying to restore forest types from the past, forest types that we now know are ghosts. We live in ghost forests. 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. Do we just give up on the southern range of the boreal forests? On balsam fir, birch, and white spruce in the north woods of Wisconsin?"[22]

What's threatened by global warming is not only the earth, but also 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. The naturalist and artist Mary Burns asks, "What will our woodlands be like without the ethereal call of the hermit thrush or the "zee-zee-zee-zu-zee" of the black-throated green warbler tumbling down through the hemlocks? Who will usher in spring when the white throated sparrow's "Oh, sweet Canada, Canada, Canada" no longer wakes us?"[23]

The atmosphere ties us to our planet's past and to its precarious future. Each molecule of air that we breathe has circulated 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 spruce in the boreal forests may once have moved through your ancestors' bodies; the carbon in the atmosphere that threatens our shared futures on earth come from the coal once taken up by plants in ancient forests.[24] Across time and space, the atmosphere connects us all, and it is those connections that environmental historians are uniquely qualified to illuminate.

Without reference to an ecological past that may no longer resemble our ecological futures, how will we learn to live responsibly in place? Global warming challenges us to re-examine 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.

President's Talk, delivered at ASEH conference, Tallahassee, February 2009

***Nancy Langston**, president of ASEH, is professor in the Nelson Institute for Environmental Studies and the Department of Forest and Wildlife Ecology at the University of Wisconsin-Madison. She has recently completed an environmental history of endocrine disruptors, titled* Toxic Bodies: Endocrine Disruptors and the Lessons of History, *which is forthcoming from Yale.*

NOTES

1. Robert Bateman, Quoted in Katy June-Friesen, "Art for Nature's Sake," *Smithsonian*, December 2006, 29-30. For a useful essay on Canada's forest historiography, see Graeme Wynn, review of Ken Drushka, *Canada's Forests, a History*, Richard A. Rajala, *Feds, Forests, and Fire: A Century of Canadian Forestry Innovation*, and Richard A. Rajala, "Up-Coast: Forests and Industry on British Columbia's North Coast, 1870-2005," *Environmental History* 12 (October 2007): 1,016-21. This October 2007 special issue of *Environmental History* on Canada provides a valuable entry into the literature.

2. For example, see Ben Bond-Lamberty, et al., "Fire as the Dominant Driver of Central Canadian Boreal Forest Carbon Balance," *Nature* (2007): 89-92; and Stephen Pyne, *Awful Splendour: A Fire History of Canada* (Vancouver and Toronto: UBC Press, 2008).
3. For insights on the links between landscapes and health, I am indebted to Conevery Bolton Valencius, *The Health of the Country: How American Settlers Understood Themselves and Their Land* (Basic Books, NY: 2002); Gregg Mitman, "In Search of Health: Landscape and Disease in American Environmental History," *Environmental History* 10 (April 2005): 184-210; and Linda Nash, "*Inescapable Ecologies: A History of Environment, Disease, and Knowledge* (Berkeley and Los Angeles: University of California Press, 2006). For insights on science and northern environments, Stephen Bocking's work is invaluable, particularly "Science and Spaces in the Northern Environment," *Environmental History* 2007 (October 12): 867-94, and *Nature's Experts: Science, Politics, and the Environment* (Rutgers University Press, 2004).
4. Eric S. Kasischke, "Boreal Ecosystems in the Global Carbon Cycle," in *Fire, Climate Change, and Carbon Cycling in the Boreal Forest*, ed. Eric S. Kasischke and Brian J. Stocks (New York: Springer, 2000), 19-30.
5. Office of the Premier, "Protecting a Northern Boreal Region One-and-a-half Times the Size of the Maritimes," http://www.premier.gov.on.ca/news/Product.asp?ProductID=2358 (last accessed 4/25/09).
6. As the botanist George Woodwell noted: "spraying half a pound of DDT in oil per acre could reduce that year's budworm population by 95 to 98%, but next year the remaining population would explode. Spraying only prolonged the outbreak, in fact, because while it kept the trees from dying, that meant the few remaining insects had unlimited food, and their populations could explode": see "Toxic Food Web," in *Life Stories: World-Renowed Scientists Reflect on their Lives and the Future of Life on Earth*, ed. Heather Newbold (Berkeley and Los Angeles: University of California Press, 2000), 74.
7. Nicholas Bolgiano, "Cause and Effect: Changes in Boreal Bird Irruptions in Eastern North America Relative to the 1970s Infestation," "Spruce Budworm and the 1970s," *American Birds* 58 (2005): 26-33. Online at http://www.audubon.org/bird/cbc/pdf/104_026-33BUDWORMfeature.pdf.
8. Rachel Carson, *Silent Spring* (New York: Houghton Mifflin, 1962), 131.
9. Ibid.
10. Inka Milewski, "Rivers of Death Revisited: A Tribute to Rachel Carson," online at http://www.elements.nb.ca/theme/artists/inka/milewski.htm.
11. Woodwell, "Toxic Food Web," 77; G. M. Woodwell and F. T. Martin, "Persistence of DDT in Soils of Heavily Sprayed Forest Stands," *Science* 145 (1964): 481-83.
12. Heidi N. Geisz, et al., "Melting Glaciers: A Probable Source of DDT to the Antarctic Marine Ecosystem," *Environmental Science & Technology* 42 (2008): 3958-62.
13. Melvin Visser, *Cold Clear and Deadly: Unravelling a Toxic Legacy* (East Lansing: Michigan State University Press, 2007).
14. Saskatchewan Environmental Society, "Climate Change and Saskatchewan's Boreal Forest: A Saskatchewan Environmental Society Fact Sheet," Dec. 2003. Online at http://www.environmentalsociety.ca/issues/forests/climate-change-boreal.pdf.
15. Ibid.
16. T. Edward Nickens, "Paper Chase," *Audubon,* January-February 2009. Online at http://audubonmagazine.org/features0901/habitat.html.
17. Ontario's *State of the Forest Report* 2006, "Indicators of Forest Sustainability," http://www.mnr.gov.on.ca/MNR_E005239.pdf (last accessed 4/25/09). For other Ontario forestry ministry publications that discuss emulating natural disturbances, see: http://www.mnr.gov.on.ca/en/Business/Forests/2ColumnSubPage/241068.html and http://

www.mnr.gov.on.ca/en/Business/Forests/2ColumnSubPage/STEL02_166047.html.

18. J. Thorpe, N. Henderson, and J. Vandall, *Ecological and Policy Implications of Introducing Exotic Trees for Adaptation to Climate Change in the Western Boreal Forest* (Saskatchewan Research Council Publication 11776-1E06, Saskatoon, Saskatchewan, 2006), 3. A summary is available at http://www.parc.ca/pdf/research_publications/renamed/SD2008_03.pdf.
19. Ibid.
20. Personal communication, Brian Donahue.
21. Sarah Wright, *Paradise Lost? Climate Change in the North Woods* (Madison: University of Wisconsin, Center for Biology Education, 2007), 16; http://www.wisc.edu/cbe/assets/docs/pdf/paradiselost/paradise_lost.pdf).
22. Anonymous, personal communication, December 2008.
23. Mary Burns, *Paradise Lost?*, 35.
24. James Rodger Fleming, Vladimir Jankovic, and Deborah R. Coen, Introduction to *Intimate Universality: Local and Global Themes in the History of Weather and Climate* (Sagamore Beach, MA: Science History Publications, 2006), ix-x.