Nature's Stories? Pursuing Science in Environmental History

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In our evolving relationship with nature—the subject matter of environmental history—scientists and scientific knowledge have often played large roles. Consider a few glimpses of a particular place: the Mackenzie Delta region, where the Mackenzie River meets the Arctic Ocean. In the early 1930s, Alf Erling Porsild, a botanist, travelled across the delta by canoe and dogsled, assessing the terrain for reindeer herding, which he hoped would become a new local livestock industry. But 20 years later, scientists and technicians had very different objectives, flying in to build Distant Early Warning (DEW) radar stations to watch for Soviet bombers, as the region became a front line of Cold War confrontation—an episode we also encounter in Matthew Evenden's Chapter 14 of this volume. Then, after another two decades, the region became something else again: oil and gas strikes excited industrialists and politicians, and ships and helicopters carried scientists seeking these resources while assessing the impacts of pipelines and other infrastructure on the local environment. But eventually most of them also left, even as the DEW stations became abandoned relics, and experiments in reindeer herding faded into memory. By the 1990s, Inuit hunters and government biologists were busy surveying beluga whales and other wildlife—species that have always been and are still, as Lyle Dick notes in Chapter 5 of this volume, an essential source of food for local residents. Other kinds of scientists were also appearing in the region, including some assessing the local impacts of warming, connecting phenomena like melting permafrost to global environmental change. The essential point is that in the environmental history of the Mackenzie Delta region—the diverse ways in which this environment has been understood, used, and transformed—scientists have often played leading roles.

For environmental historians, science is in part something to be studied: the history of humanity's relationship with nature includes the history of scientific knowledge and practice, as well as the influence of scientists on how we exploit or protect the planet. But science is also a tool, a chief means by which historians and scientists themselves reconstruct the past. Environmental historians draw on several scientific disciplines, from ecology to geology, to piece together the history of earth and life. The focus of this chapter is on these dual identities of science: as subject and tool. However, it is also worth noting science's third role in environmental history, at least according to some historians: moral inspiration. According to Donald Worster, science, by describing the "coherence, pattern, and integrity of nature," should also guide our conduct in relation to nature.[1] Yet these diverse roles of science—as research subject, tool, and moral guide—have some contradictory implications, which imply some challenges for doing environmental history.

Applying Science in Environmental History

For many environmental historians, science is chiefly a device with which to look into the past to construct a history of environmental change. As Worster noted some time ago, "before one can write environmental history one must first understand nature itself," and this, he suggested, required guidance from the sciences.[2] Many historians have since agreed that nature should itself be seen as a major source of historical evidence, and that science is needed to ensure that this evidence is interpreted correctly.

Science can provide a wealth of information regarding past environments. Scientists of several disciplines—geologists, biologists, biogeographers, paleoecologists, among others—have assembled a rich and detailed record of the history of earth and life. This record encompasses change at the largest scales: 3 billion years of evolution and extinction of species, punctuated by asteroid impacts, volcanic eruptions, and other cataclysms; the rise and erosion of mountain ranges; the spreading of continents and sea floors; and the advance and melting of ice sheets. Scientists have also perceived changes on smaller scales: the scattering of species across new landscapes, sometimes eliminating those species already present; changes in ecosystems as the climate warms or cools, or as a result of wind storms, fire, or other local disturbances; and ecological succession, as when a farm field is abandoned and slowly returns to forest. These smaller changes have often been tied to larger phenomena by intricate relations of cause and effect. Humanity itself, of course, has also become an increasingly important force of change—as landscapes have been cleared for agriculture; as timber, fish, minerals, and other resources have been exploited; and as our release of wastes into the air, water, and soil have accelerated—and the resulting impacts have also been described by scientists.[3]

Scientific knowledge can contribute not only narratives of change, but also new ways of understanding these changes. For example, ecologists are now gaining a deeper understanding of how species interact across entire landscapes, creating shifting patterns of abundance. Environmental historians can draw on these insights in understanding why flora and fauna have changed over time, particularly in relation to changing patterns of human settlement. As Emily Russell has explained, only with an ecologist's knowledge of plant succession can one understand exactly what happens when an agricultural field is abandoned, and why the forest that replaces it may be very different, depending on whether the field was abandoned during a dry or a wet period.[4] Stéphane

Castonguay and Diane St. Laurent illustrate this in Chapter 15, demonstrating how knowledge of succession can help in identifying which forests along the Saint-François River were planted, and which were the product of natural regeneration. Similarly, historians studying the salmon fisheries have learned from biologists that these fish range widely in their travels, from the headwaters of rivers to the open Pacific, and as a result these historians avoid trapping the stories they tell within national boundaries that are meaningless to salmon.[5] More generally, insights into evolution—evident, on human scales, in the domestication and transformation of useful species, and in how mosquitoes and other insects gain resistance to insecticides—are essential to understanding the environmental history of agriculture and disease.[6]

Scientific knowledge can often, in fact, give historians a better understanding of events than what was available to those alive at the time. For example, to understand the 19th-century industrial city, and why people were so anxious to gain access to reliable supplies of clean water, or (if they could afford to) to move into suburbs or the countryside, it helps to be aware of modern medical knowledge about the relation between polluted water and once-dreaded diseases such as cholera.

Some of the most ambitious and influential works in environmental history have drawn on scientific insights, particularly from ecology. In *Changes in the Land,* William Cronon combined conventional written sources with ecological science to understand how the landscape of New England was transformed during settlement. Alfred Crosby's *Ecological Imperialism* applied ecological models of competition to explain why the import of new species into a continent—as occurred when European settlers arrived in the Americas—had such devastating impacts on both the humans and other species they encountered there. More recently, Jared Diamond's best-selling *Guns, Germs, and Steel* attempted a global explanation of how and why civilizations emerged, at least in part, in response to ecological constraints and opportunities imposed by different continents. In these, as in many other historical accounts, water, air, fish, soil, animals—nature itself, in other words—is given a voice, and this voice is often in the language of science.[7]

These books provide quite sweeping general accounts, but science can also be applied effectively in efforts to reconstruct the history of environmental change and human activities in specific places. Two good examples are Stephen Pyne's use of knowledge of the fire ecology of particular species, such as the ponderosa pine, and of particular places, such as the African grasslands, the Brazilian coastal forest, the Swedish boreal forest, or the hills of Greece, to explain how and why these habitats have changed over time; and Joseph Taylor's use of our current scientific understanding of the El Niño climate phenomenon to account for fluctuations in salmon runs that occurred several decades ago.[8]

Using Other People's Work

It's a fallacy that history and science don't have much in common—that they are two cultures, on opposite sides of the division between the humanities and the sciences. In fact, they share a great deal, including how they define questions, use evidence, and draw conclusions.[9] Nevertheless, historians must also remember that most scientific knowledge was not created with them in mind. Scientists have their own reasons for studying the past. And, as when any tool is used for a purpose other than that originally intended, there can be risks in applying science to environmental history.

What are scientists trying to accomplish when they study the past? In fact, they may have any of several possible goals in mind. First, the history of the earth and life is itself considered central to the work of such fields as paleontology, geology, and evolutionary biology. In these disciplines, scientists ask historical questions, seeking to understand the "agents of change"—ice, water, tectonic forces, competition among plants or animals—that drive the history of the earth and the evolution of species. And the questions scientists ask regarding these agents may be entirely unlike those that historians would consider relevant.

Second, scientists have also realized that a historical perspective is necessary for understanding the world today. For example, most ecologists will agree that while the features of a landscape—including its geology and soil types—as well as the climate will influence what species may grow where, the particular local history, including the movement of species into and out of the region, and any changes caused by human activities such as land clearing will determine what species will actually be present.[10] But here again, this objective focused on understanding the present differs from historians' ambitions to explain past events.

Besides understanding the past and present, scientists can also have some practical purposes in mind when they study history. For example, to help guide restoration of a damaged ecosystem, ecologists typically seek to identify its original "reference condition"—often taken as the state of the ecosystem before humans began modifying it significantly. And more generally, because ecosystems often change, the management of a natural area can also be more effective when it is informed by an understanding of its history. Jasper National Park, for example, is an area protected as much as possible from change as a result of human activities. Yet it is also in the character of the forests and other habitats of the park that they will change naturally over time, and sometimes management practices such as controlled burns are undertaken to encourage this change.[11]

Finally, scientists consider historical information useful in understanding how humans are changing the environment today. This is especially evident in research on climate change. By examining ice cores from Greenland and Antarctica, which contain within them a record of both the earth's changing temperatures over the last several thousand years, and the content of the global atmosphere, the unprecedented nature of today's climate as a result of greenhouse gases can be demonstrated. Historical evidence thus plays a role in today's global environmental debates. But this also illustrates how, in reconstructing the past, scientists have different goals in mind than do historians. Given their aim of assembling a record of environmental change, scientists will focus on assembling an accurate set of data, and they will have less concern for what these data can tell us about how humans have thought about or related to nature in the past. Similarly, if scientists have some practical purpose in mind, this will also influence the kinds of historical questions that they ask. For example, restoration ecologists studying the history of a habitat may not aim to identify all aspects of past ecological conditions, but only those that are required by whatever species they want to restore.

Doing Historical Science

Scientists use a variety of techniques when they reconstruct the ecological history of a place. We will review briefly a few of these, identifying the key questions and forms of evidence that scientists concern themselves with. (William J. Turkel also describes, in Chapter 17 of this volume, some ways in which scientists examine the material traces of the past.) It is also important, however, to note that these techniques require advanced training and experience, and so are not generally practised by historians themselves. What historians can do, though, is be aware of the possibilities and limitations of these techniques, so that they can draw on scientists' work, discuss their results with them, and perhaps even collaborate with them.

Some of the best historical information can be obtained from layers of sediment deposited underwater, particularly in lakes. As material is blown or washed into a lake from the surrounding landscape, it settles to the bottom, preserving both inorganic matter, such as clay and silt, as well as tiny traces of life, especially pollen and spores. By taking core samples of the sediment (usually by lowering a long metal tube, often in winter, to take advantage of the stable platform provided by lake ice), and by then analyzing these samples and determining the order in which materials were deposited, scientists can deduce a history of changes in the local environment. Pollen deposits can be especially useful, as they are usually abundantly available and well preserved in a variety of sediment types. The basic idea is that pollen species preserved in the sediment indicate what plant communities once surrounded the lake. Changes in the abundance of these species may indicate both natural changes (such as those due to climate change), and changes caused by human activities, such as land clearing and crop production. For example, much of our knowledge of the history of the landscape of southern Ontario has been gained through analysis of the well-preserved sediments of Crawford Lake, northwest of Toronto near the Niagara Escarpment. These sediments tell the story of 1,000 years of Iroquois agriculture, European settlement, land clearing, and climate change.[12] But care must also be taken in interpreting these records: plants that release a great deal of pollen, or that are taller, will be far better represented in the record than those that do not produce as much, or that grow near the ground.[13]

Besides pollen, sediment may also contain the remains of organisms that once lived within the lake itself, and they too can tell stories. For example, a shifting abundance of diatoms (a type of algae) can indicate changes in the climate or in the chemistry of the water. Analysis of the sediment itself can also tell us much. Layers of glacial deposits, interspersed with layers with organic content, can aid in reconstructing the history of ice ages. Sediment deposits can also hint at the local history of erosion—whether as a result of natural factors, or caused by manipulation of the landscape by humans. Analysis of traces of charcoal can suggest the local history of fires.

A second class of scientific techniques is known as dendrochronology: the analysis of tree rings. Everyone has counted rings to see how old a tree was when it was cut, but these rings have far more to tell us than just age. Trees are ideal natural archives; they live for centuries, their rings can be dated accurately, and changes in the local environment become coded into variations in the rings themselves: their width, density, and chemical content. Environmental changes that leave a trace in tree rings include variations in climate, as well as a variety of human and ecological events, such as the growth and death of trees, fire, and insect outbreaks. For example, tree-ring analysis is being applied in Jasper National Park to understand how trees have expanded onto alpine meadows over the last century, and to predict how this expansion may continue as the mountain climate warms.[14] Tree-ring analysis may be most useful in reconstructing the history of disturbances, especially fire: by studying burn scars, and tabulating the ages of trees in a stand, fire episodes can be accurately dated. But as with sediments, care must be taken in interpreting this evidence. Conclusions depend on various assumptions regarding chance conditions, local ecology, and other factors that can also influence the patterns of tree rings.[15]

Many other scientific techniques are used in reconstructing the history of the planet. For example, lichens can be used to date changes in the landscape or the age of ancient buildings.[16] As I have noted, another widely used technique (especially in climate research) is the analysis of ice cores from locations such as Greenland, where ice has accumulated over long periods of time. The relative abundance of the different isotopes of oxygen, and the amount of carbon dioxide and methane preserved in ice bubbles, can indicate temperatures and the content of the atmosphere in the past.

These techniques depend on certain principles of reasoning. A key one is the assumption that processes that have acted in the past are similar to those we can observe today. This principle makes it possible to reason historically on the basis of contemporary scientific knowledge (it was a foundational principle for Charles Darwin, the epitome of the historically minded scientist). However, it can also limit the range of explanations that are considered likely—it might exclude as a possible explanation, for example, catastrophes such as asteroid impacts that, while not observed today, may have been significant in the past.

A second principle is the use of multiple lines of evidence. Just as Ruth Sandwell emphasizes in Chapter 7 of this volume the need to use lots of different kinds of evidence when doing microhistory, so can several scientific methods provide a critical check on conclusions derived from any one. Multiple lines of evidence can also be essential to understanding not just what happened, but why, particularly in relation to the impact of human activities. For example, the historical role of humans in fire history can be deduced by combining burn-scar evidence from tree rings with other forms of evidence, such as written records or interpretation of landscape features. Often, in fact, other forms of evidence will be needed to make sense of scientific data. For example, while analysis of pollen deposits in sediment can demonstrate a shift in the dominant vegetation of a region, dating this shift precisely, or explaining why it happened (land clearing for agriculture, perhaps?) would require other kinds of evidence, such as historical documentation of settlement patterns.

The History of Science and the Environment

So far, we have been examining science as a tool: something to be used in our study of the history of the environment. But science has its own history as well. It changes, as scientists invent new ways of studying nature, as new data accumulate, and as scientists think up new ways of interpreting this information. An essential feature of this history is that it has many ties with the broader currents of history. In fact, science has been central to some of the most important events in world and environmental history. Consider a few of these: the expansion of empires and nations, the growth of modern cities, and the emergence of the idea of a global environment. The field sciences were essential to the formation and expansion of empires. As various European powers—the British, French, and others—established colonies around the world, their armies and administrators were accompanied by botanists, geologists, and other scientists whose task it was to identify natural resources and research opportunities. In doing so, they contributed to the larger political purpose of empires: extending control over colonies and their peoples.[17]

The same kind of phenomenon—of science in the service of the state—was often evident in the formation of new nations. Canada is a good example: various scientific disciplines that could help in identifying useful natural resources such as minerals, good soil, or plants—what Suzanne Zeller described as the "inventory sciences"—were central to forming and justifying the idea itself of a transcontinental nation.[18] This was a major reason why, even before Confederation, some of the first agencies set up by the Canadian government, such as the Geological Survey, were all about using science to extend the authority of the young nation over its immense territory. More generally, we can see how science has been tied closely to power over the environment, whether this is exercised by empires or by nations.

Interesting connections between government, the environment, and science can also be seen in the history of cities. As Michèle Dagenais and Joanna Dean explain in chapters 12 and 13, respectively, part of the environmental history of cities has been their responses to various challenges as they have grown, such as that of providing clean water and disposing of waste. These responses have often implied a parallel evolution in the sciences that are applied to managing the urban environment. I certainly found this when I examined the environmental history of Toronto in the decades after 1945. In this postwar era, the city grew very rapidly, encountering as it did a variety of environmental challenges, including the need to expand systems for water supply and sewage disposal, build new neighbourhoods, and protect life and property from natural hazards such as floods. Responding to these challenges required several kinds of scientific and technical expertise, from civil engineering to community planning to river-valley management. Each of these forms of expertise also became closely associated with the public and private institutions that managed and encouraged the city's growth.[19]

Nowadays, it is common to refer to our "global environment," especially when we talk about environmental problems such as climate change. Yet this global perspective is also a product of recent events in both science and politics. In the early 1950s, scientists began to track the global movement of radioactive fallout that had been released by the testing of nuclear weapons. By the following decade, the environment had become a major political issue, and by 1970, the *Apollo* astronauts had brought back the first photos of the Earth from space. These images became a powerful symbol of our unique and fragile world. Now, with increasing evidence of climate change, science is reinforcing the sense that to understand our environment, it is necessary to think and act globally. In other words, science is having political consequences, just as much of the science that led to a global perspective was itself a product of the Cold War.

A key observation from this brief account of a few episodes from the history of science and the environment is worth emphasizing: science does not exist in some separate realm, but has always been closely tied to political and economic power. These ties have not always been with powerful interests, either: in *Silent Spring,* Rachel Carson used science to criticize how various interest groups had power over decisions about pesticides, and to urge that these decisions be opened up so that more people could participate in them.[20] A related observation is that science is not only about describing nature, but also contributes to creating new kinds of natures. An empire forms new trading relationships, a nation expands over new territory, a complex city grows up, or a "global environment" captures peoples' imaginations—these are all cases in which new ideas about nature took shape, and in every case science played a major role. These examples also hint at the kinds of issues encountered in studying the environmental history of science.

Studying the Environmental History of Science

I was originally a science student, but then shifted to the history of science (where I found that a background in science can be helpful, but is not essential, when studying its history). When I began studying history, I decided for my Ph.D. dissertation to study the recent history of ecology. I had read that environmentalists considered ecology as both information and inspiration—that this scientific discipline provided, in effect, the intellectual capital of the environmental movement. And I wanted to see if this was true.

As time went on, I also found (as usually happens in research), that I had to revise my project, developing a more specific focus than simply the historical relations between ecology and environmentalism. I decided to concentrate on the history of ecology since the 1940s. I also formulated several questions about recent ecology that I hoped would make the story of interest to other historians. One was about the agenda of the discipline: how do ecologists choose the research they do? Another related to the social context of the science: were the choices made by ecologists influenced by public concerns about the environment? A third concerned the places in which ecologists did their research: did the natural setting, and the institutions in which they work, make a difference?

I also realized that I couldn't answer these questions through conventional historical methods, such as a biography of an ecologist, or the study of a single research institution. Instead, I decided on a comparative approach. This meant following the histories of ecology at four sites, in three countries: Great Britain's Nature Conservancy (until about 1970 both the chief British ecological research institution, and owner and manager of a network of nature reserves); the Oak Ridge National Laboratory in Tennessee (a very large nuclear research centre, and also a major site for ecological research); the Hubbard Brook Ecosystem Study in New Hampshire (a reserve set aside for forestry research, where several influential studies of watershed ecosystems took place); and the University of Toronto and the Ontario government, which together pursued much research on the fisheries of the Great Lakes.

The advantage of comparing these four sites became apparent once I tried to understand how ecologists chose what research they would do. Their choices varied widely. British ecologists often focused on research that could help develop new ways of managing nature reserves. Oak Ridge ecologists studied the ecology of radioactive materials, with an eye to understanding the environmental impacts of nuclear power and nuclear weapons. At Hubbard Brook ecologists studied the effects of harvesting and acid rain on forest ecosystems. And in Ontario they put together an understanding of the effects of fishing, pollution, and other factors on the Great Lakes ecosystem. But beyond these differences, there were some common features. In all these places ecologists spoke some of the same language: about ecosystems, the movements of energy and nutrients, and the dynamics of populations.[21]

What this curious combination—of both local issues, and more general theoretical concerns—led me to understand was just how complicated has been the relation between scientists and public concerns. Ecologists were not simply driven to do whatever research was demanded by society; but neither did they exist in some kind of remote ivory tower. Ecologists (like scientists generally) developed their own identity, with their own questions and methods, which they tried very hard to assert: they wanted very much to demonstrate that they had a distinctive body of knowledge about nature. But they also tried to relate their research to public concerns, and to the particular local settings in which they were working, such as nature reserves, forests, or the Great Lakes. (Some of the same kinds of dynamics are exhibited elsewhere in this volume: in Joanna Dean's account in Chapter 13 of how urban foresters responded to the concerns raised by Rachel Carson about DDT, and in William J. Turkel's explanation in Chapter 17 of how local conditions affect scientific research.) This interaction between the general preoccupations of ecologists, and their local settings, resulted in a highly diverse array of ties between their scientific methods and ideas, the nature they studied, and particular environmental values.[22] Context mattered—and so I had to avoid making generalizations about whether ecology is, or is not, related to environmentalism. I ended the project with an outcome often seen in historical research: not so much with an answer, but at least a better way of asking the question.

Strategies for Studying the History of Science

Studying the history of science in relation to the environment involves a series of steps. The first step is understanding how scientific knowledge itself evolves. A good place to start is with the scientific literature, the reports published by scientists that appear in journals and conference proceedings. To make this enormous literature more manageable, it can be helpful to begin by focusing on a single scientist—perhaps one who clearly had some influence on the wider field—and then expand outward, using that scientist's lists of references to understand what kinds of information he or she considered relevant to the problems being studied. Read carefully, scientific reports provide an immediate record of the evolving knowledge base of a field, as well as insights into methods, and into how scientists placed their work within the larger context of their field. Review articles are also often very helpful: they indicate scientists' views of the overall development of the field, including which innovations in ideas or methods they consider most significant. Textbooks summarize the evolving body of knowledge within a discipline. However, all these materials, while useful, also raise issues of interpretation. A scientific paper, for example, provides a distorted view of how science is actually done, capturing little or nothing of the hesitations, mistakes, and dead ends that are a normal part of any research. And as always, it is necessary to consider the intentions of the author, as well as her intended audience.

The published scientific literature is essential, but it is a window onto only part of the history of science. In recent decades, historians of science, while still interested in how knowledge evolves, have also shifted their attention toward understanding not only the product, but also the process, of science. One dimension of this is the evolving methods of science—what scientists actually do in the lab or in the field. This involves understanding scientists' "material practices": their manipulation of research materials, such as field sites, soil samples, or the contents of test tubes; their use of techniques and technologies such as experimentation in the lab or field, computer modelling, interpretation of aerial photos, distribution and collection of salmon tags—every practice, in short, by which scientists generate knowledge that others will see as reliable. Another dimension of the scientific process is scientists' efforts to justify and explain their research to various audiences, including those who fund the research, apply its results to practical situations, or read about it in the media or elsewhere. For both dimensions, attention to the relations between scientists and specific environments—that is, how their material practices and their communication efforts reflect the places in which they work—can be a step toward writing a genuine environmental history of a science.

For the pursuit of these dimensions of science, a wide range of materials are relevant, such as scientists' letters to each other, memos to administrators, drafts of scientific reports, annual research reports, proposals to funding agencies, and articles written for the popular press. These may be available in archives, or, in the case of more recent material, in scientists' files. Interviews can also be valuable: scientists are usually willing to discuss such questions as why they chose certain research directions, or what results have been especially important. While results must be interpreted with caution (given selective or faulty memories), interviews can serve well as sources of ideas and hypotheses. Interviews can also enable access to unpublished but valuable "grey" literature: often only the scientist herself and a few colleagues may have copies of reports published in very small quantities. But a cautionary note is also necessary: scientists usually have their own view of how their field developed and, indeed, their view of the nature of science itself—and so they may dispute the account provided by a historian.

Another valuable way of understanding scientific practices is to visit the terrain in which research has been done. Doing so serves as a reminder that scientists do not study "nature," but specific places in nature: a lake, a forest, or a field. It also makes it possible to understand the physical conditions and opportunities as experienced by the scientists themselves, to understand more completely how they viewed the research possibilities that were open to them, and to understand how science consists of both knowledge and practice, each closely associated to the other.

My own experience in writing the history of the Hubbard Brook Ecosystem Study in New Hampshire can illustrate some possibilities.[23] The study area extends over several hundred hectares of forest, drained by several streams and a lake. Since its origins in 1963 several dozen scientists and students have worked at the site, accumulating an enormous knowledge of the forest, for both theoretical and practical purposes—particularly for understanding the impacts of forest cutting and acid rain. To understand how this research had developed, I followed several strategies. These strategies emerged not according to some overall plan, but simply as opportunities appeared:

1. Study of research papers, particularly review articles and books, to get a sense of how new questions, and new knowledge, emerged in the course of the study. These papers also provided insights into how the scientists themselves viewed the development of their project. Finding these papers was aided by the study having published its own comprehensive bibliography.

2. Statistical analysis of the entire body of research produced at Hubbard Brook to understand how certain aspects of the project, including its goals and research subjects, and the makeup of its participants (their backgrounds and institutions) had changed over time.
3. Study of funding proposals and memos, to understand how the project leaders viewed the future of their project, and how they justified the project to other scientists and to the institutions supporting their work.
4. Interviews with several scientists, in which I asked them about many aspects of their work, such as what they considered their most important results, and what kinds of questions they could ask at Hubbard Brook that they could not elsewhere.
5. Exploration of the area, by car and on foot, with and without the guidance of the scientists, to get a "feel" for the site. This especially helped suggest areas for follow-up research regarding how specific environmental details, such as the particular relations between the forest and the streams, affected the research.
6. Attendance at the annual meeting of all project participants, to get a sense of how scientists worked and communicated with each other.

It was a challenge to keep straight the evidence from this variety of sources, as the history of the Hubbard Brook research project and my own objectives gradually came into focus. Perhaps most important were the endless iterations between learning new things about what the scientists had done and then using this new information to frame new research strategies and questions.

Science as a Tool and a Topic

As I've outlined, science can be essential to doing environmental history: it is both a tool for reconstructing changes in the environment and itself a topic of historical study. But this dual significance also raises some challenges—in fact, some of the biggest challenges with which environmental historians deal. Stephen Pyne, who studies the environmental history of fire, has described the situation in colourful terms: "Done right, science and history can combine like epoxy into an unbreakable bond. Done poorly, they become an unstable compound, a vial of intellectual nitroglycerin ready to blow its handler to oblivion with the first stumble."[24]

What Pyne is referring to are the dual roles of science in history—tool and topic—and the fact that these contradict each other. Using science as a tool depends on stability: that is, on being confident that the scientific information or techniques one is applying are reliable, and not likely to be soon proven mistaken. In contrast, study of the history of science incessantly undermines this stability, by describing how scientific research is not only a disinterested and objective search for universal truths, but also a set of practices tied to particular times and places, that have various relationships with their social contexts, and that produce knowledge that is often later revised or rejected. Given this contradiction, it is no wonder that historians often struggle with what to do about science. As another historian, Gregg Mitman, has asked, for "a field in which place has figured so centrally in its narratives, why has environmental history been so reticent to see scientific knowledge about nature as a historical product of particular material and social relations?"[25]

Historians need to know two things about science to navigate this contradiction. The first is that there are many potential uncertainties and sources of bias in scientific information. For example, while, as we have seen, sedimentary records are valuable in reconstructing past environments, they also have various limitations: only certain organisms will make their way into the sediment, and only a sample of those will be preserved. There are similar biases in the rest of the scientific record—for example, in traces of forest fires recorded in tree rings, or in ecological evidence of species migrations. These examples illustrate how scientists must make many choices as they interpret the evidence provided by nature, expanding the fragmentary information available into a fuller interpretation of the past. In making these choices, they are influenced by their own training, experience, and values. The consequence is that all approaches to scientific study provide knowledge of past environments that is both incomplete and is shaped by today's ideas about how to interpret that record.

These questions of interpretation and bias are not specific to scientific study in the past, but are intrinsic to science as it is applied today. Scientists often provide contrasting views of nature—because of differences in professional background, divergent views of how to interpret uncertain evidence, or economic or political biases. These biases can reflect, for example, where scientists work: one employed by a biotechnology firm may have a different view of genetically modified foods than does one who advises environmental organizations. Similarly, a forestry company scientist may disagree with a university conservation biologist as to the ecological impacts of industrial forestry. This is why there are often intense controversies about science and the environment: scientists themselves often disagree about, say, the health implications of toxic chemicals or genetically modified foods, the potential implications of industrial forestry, or climate change. In all but the simplest cases, there is always room for interpretation, and hence for scientists to disagree.[26] We can see this occurring in other chapters in this volume: as Matthew Evenden explains in Chapter 14, maps are not only objective representations of the world, but also reflect the intentions and priorities of geographers and cartographers; similarly, as William J. Turkel describes in Chapter 17, scientific knowledge of a local environment can be shaped by the economic value of that knowledge.

The second thing to keep in mind is that science changes as new knowledge is accumulated, and previously accepted "facts" are revised or rejected. For example, limnologists (scientists who study lakes) once, but no longer, believed that lakes have a kind of life cycle: initially low in nutrients, becoming over time more nutrient-rich, slowly filling with sediments, and eventually becoming a marsh and then dry land. Given how knowledge changes, Worster's advice to historians is sensible: "be careful not to borrow . . . ideas of nature unthinkingly or innocently from outmoded textbooks or discarded models."[27]

As a practical example of how historians experience these challenges, consider what would be involved in reconstructing the environmental history of caribou in northern Canada. Caribou have long been an important food source for northern natives. They have also been central to northern politics, and particularly to the relations between natives and government authority. In particular, government scientists often argued that caribou populations were in decline, and therefore that both native hunting and wolves (the major nonhuman predator of caribou) had to be controlled. Understanding how caribou populations have changed over time would be essential to understanding the environmental history of the species, and of northern Canada generally. But although caribou scientists have, since the 1940s, generated a series of estimates of these populations, these estimates cannot be relied on by historians, because, in hindsight, they appear to be the product not just of empirical observations, but of interpretations guided by various assumptions regarding scientific practice, native culture, and the caribou themselves. (Lyle Dick illustrates the problem when he notes in Chapter 5 how a 1960 estimate of the Peary caribou population of 25,802 may have been off by up to 50,000.) As a result, in the absence of other information, it is likely now no longer possible to reconstruct the history of caribou populations.

Beyond these challenges, the environmental historian needs to be aware of several pitfalls in using science to reconstruct the historical record. The first relates to applying today's knowledge in explaining past environmental phenomena. While this knowledge can open up a wider range of explanations, it also presents the temptation to see the knowledge of a previous time as simply incorrect or ignorant, discouraging the necessary effort to understand it on its own terms, not least as a potentially significant motivating factor in decisions and actions taken at that time. A related risk is that of adopting a simplistic and misleading perspective on how scientific knowledge changes: as a simple progression from ignorance to current knowledge. Such a perspective can be an obstacle to understanding what actually happened, because it encourages myths about the straightforward application of new knowledge. An interesting example is the story, often repeated in textbooks, of how in 1854 John Snow, a London doctor, ended a cholera epidemic simply by removing the handle of a pump that had been supplying contaminated water. This classic tale is convincing because Snow was apparently applying knowledge about disease and sanitation in a way that seems, from our perspective, to have been both rational and practical—simply common sense. But the account also distorts and simplifies the actual complexity of Snow's role in emerging ideas about disease and sanitation—there was apparently no sudden revelation about these problems when Snow removed the handle.

A third potential snare in using science is that it may privilege explanations that can be framed in scientific terms over those that may be attributed to political, social, or other, more intangible, factors. (This also commonly happens in environmental controversies today, when participants use scientific evidence to support their positions, even when they are in fact motivated by other considerations.) For example, a historian seeking to understand why the farms of a region were abandoned may decide to rely on a physical explanation such as soil exhaustion or climate change, because the supporting evidence has a convincing air of inevitability. Other factors, such as changing technologies or markets, may be seen as more conjectural, and hence as less persuasive, regardless of their actual significance. In short, scientific explanations may appear more persuasive, but that doesn't mean they are necessarily more accurate.

Finally, using science should not imply neglecting other forms of environmental knowledge. As Lyle Dick reminds us in Chapter 5, science is not the only way of knowing the world: particularly in northern Canada, indigenous knowledge can provide some of the deepest insights into wildlife and landscapes. There is also a rich history of observations and experience of the environment gained by everyone other than scientists, simply in the course of everyday life and work. As Joy Parr showed recently, incorporating this "street-level" knowledge—even of smells—can make a historical account much richer.[28] Much of the available knowledge of local change is getting more organized and accessible, particularly through an increasing array of community-based networks of environmental monitoring. A model for these is the century-long database of historic patterns in bird populations produced through the National Audubon Society's Christmas Bird Counts.

Conclusions

Science can be useful in environmental history: by providing new forms of evidence that enhance the historical record, and by suggesting new questions and new ways of explaining events. But as I've also noted, there are various challenges involved in using scientific evidence. In practice, science represents a massive amount of useful information. And while it is appropriate to be aware of how scientific knowledge is produced for particular purposes within specific political and environmental contexts, that does not mean that much of this knowledge has not been tested and found reliable. Just like any other kind of evidence, and particularly that created with different purposes in mind than those of historians, this information can be used pragmatically in building reasonable and persuasive accounts of the past. Nevertheless, a critical perspective is also necessary, informed by a basic understanding of how scientists go about their work.

Having confidence in using science is also a matter of being realistic, and not pursuing goals that go beyond the limits of the available scientific (and other kinds) of evidence. This means avoiding the temptation to pursue grand generalizations about humanity's relations with the planet. Instead, it is more productive to focus on understanding how peoples' relationships with their local environment have changed over time, always keeping in mind that context, local details, and chance encounters matter a great deal in determining what happened, and why. As William Cronon once explained, the purpose of studying environmental history is not so much to identify universal laws regarding the relationship between human conduct and the environment, but to tell stories that can illuminate this relationship, and perhaps generate new ways of thinking about it.[29]

Thinking in these terms—of telling stories—can also be a useful reminder that historians have different purposes than do scientists. While historians seek to understand the evolving relationship between people and their environment, scientists are most often concerned with understanding the world today, for reasons both theoretical and practical, and human activities are generally of concern to them only to the extent that they have an impact on nature. This difference also means that historians must examine scientific results not only as scientists do—as sources of data—but also as texts to be subjected to the same kinds of critical analysis as are applied to any other historical evidence. This includes understanding the purposes of the scientists, how and why they chose certain methods over others, the assumptions that guided their interpretation of the data, and any other considerations that could influence the results.

And finally, it is worth remembering that historians need not just take from scientists. They have something to offer in return: a more sophisticated understanding of science and scientific knowledge. Studying its history makes clear how science is far more than just a matter of describing nature. It is a highly social, and often political, phenomenon that gains its meaning not only through its interaction with the natural environment, but also through its relations with the rest of society. Scientists often find that to accomplish their work—whether they are creating new knowledge or using this knowledge to solve practical problems—requires not only skills in the field or lab, but also an understanding of how scientists themselves form a community that is itself tangled up in the politics and values of their society. As they navigate their way through these tangles, scientists can receive much guidance from the stories told by historians.

DISCUSSION QUESTIONS

1. Is it a contradiction for environmental historians to view science as both a tool and a subject of study? What risks are involved in using science as a tool in environmental history? What kinds of questions might one ask when writing the environmental history of a science?
2. For what kinds of historical events might science be the only source of evidence? For what kinds of historical events could the historian combine scientific evidence with other forms of evidence?
3. How might science provide better insights into past events than would be available to those who were alive at the time?
4. While scientists and historians may share an interest in the same past events and processes, they may ask very different questions about them. Discuss this statement.
5. What kind of roles does historical evidence play in current environmental issues and challenges? What principles of reasoning do scientists use in interpreting evidence of historical change? Why must scientific evidence from the past—pollen sediments, for example—be interpreted with care?
6. Why can it be said that science has political consequences? How is it possible for competent scientists to disagree about their descriptions of nature?
7. What is meant by the "material practices" of science? Do these material practices matter to the outcome? Should they? Why or why not?
8. What does the idea of "stories" tell us about how historians and scientists have different objectives?

NOTES

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