Colloquial Meteorology

Liza Piper

Liza Piper teaches History at the University of Alberta.

Prior to the creation of a nationwide network for systematic meteorological observation, farmers, fur traders, scientists, parish priests, travellers, whalers, and many others across Canada kept unofficial records of the weather. Comments on the temperature and wind, the appearance of the sky, and whether it rained or stormed were set down mostly in diaries and journals, but also in letters or reports to friends, family, and superiors. Some unofficial meteorologists had access to thermometers for instrumental temperature observations; just as often they relied upon their own experience of the air outside to note whether it was cool or warm or the hottest day that season. Some of these records cover only a few months or years at a time, others were more diligent and kept detailed notes that span decades.[1] These individuals acted as unofficial weather stations that preceded and continued alongside the state-established meteorological infrastructure, and they engaged in what we can think of as colloquial meteorology. They kept records that combined folk understandings of weather, its origins and effects upon community and economic life, with more systematic observations of temperature, wind speed, and direction. In the environmental history of Canada, knowing about past weather is important in and of itself and as a part of larger studies. Early 21st-century concern over global climate change makes it that much more important to be able to identify climatic variability in the past. For historians interested in questions that involve knowing the character of past environments, for example, if they are interested in the frequency of fires in national parks or in successful harvests as compared to periods of hardship, knowing about past weather conditions can provide essential pieces of the larger puzzles. The easiest way to reconstruct past climates is to use instrumental observations of temperature and other atmospheric conditions that can be readily compared, if necessary, across centuries. Unfortunately, for the lands that later became Canada there are few continuous instrumental or official record sets dating earlier than 1860. In their place, we have instead Canada's colloquial meteorologists. Their observations are not unreliable substitutes for an official instrumental record, but rather constitute a different kind of source material. These sources do pose methodological challenges in interpreting varying degrees of subjective and objective observations of the state of the atmosphere, but more importantly they also offer a wealth of evidence into the intersections of past societies and economies with the natural world.

The Tambora Eruption, 1815

Several years back, an interest in the social, ecological, and economic effects of past environmental disasters led me to study the North American effects of the eruption of the Tambora volcano in 1815. Although less well known than the eruption of Krakatau (Krakatoa) in 1883, Tambora was a volcanic event of much greater magnitude, spewed far more material thousands of metres into the sky, killed over 90,000 people in the Indonesian archipelago, and led to epidemics, famine, a rise in sea level, and ash raining down from the sky.

Volcanic eruptions are known triggers of local and distant climate events. The White River volcanic eruption in Alaska circa 720 C.E. led to ash falls that have been linked to the eastward migration of Athapaskans into the Mackenzie valley. The 1783 Laki eruption in Iceland caused short summers in western Europe and catastrophic weather events leading to hay shortages that forced farmers to cull their cattle herds.[2] In 1970, H. H. Lamb published a comprehensive article on the effects of volcanic dust on the atmosphere. Lamb described how the aerosols ejected in volcanic eruptions are propelled into the atmosphere and carried by global circulation to places far distant from the original eruption site. These aerosols include water vapour, sulphur compounds, and carbon dioxide, as well as broken surface rock of all variety of sizes, and ash formed by the solidification of erupting magma as it comes into contact with the much lower temperatures and pressures found at the earth's surface. Each eruption produces its own unique combination and quantity of aerosols. These aerosols scatter and absorb solar radiation, leading to general cooling in the troposphere—the atmospheric zone closest to the earth.[3] Lamb's volcanic dust veil index indicated that the dust veil from the Tambora eruption had three times the impact of Krakatoa.[4] The known characteristics of the Tambora eruption—its magnitude and the amount of material ejected—made it likely to have had global climate effects.

Some historical work had already been done on the global effects of the Tambora eruption, most of which were felt a year later in 1816, the delay due to the length of time it took the volcanic aerosols to travel away from the eruption site. The most comprehensive research was from Europe, where there was a much longer historical tradition examining the relationship between climate, production, and history. This tradition was most clearly expressed in Emmanuel LeRoy Ladurie's classic text *Times of Feast, Times of Famine* (1967, first English translation 1972) and more generally apparent in the work of the Annales school that considered long-term environmental variability as part of the fabric of historical continuity and change.[5] J. D. Post's *The Last Great Subsistence Crisis* (1977) argued that famines and bread riots in western Europe in 1816 were a direct consequence of the global climate repercussions of the Tambora eruption, which in turn had political, economic, and social effects that endured longer than the bad weather. On the other side of the Atlantic, the evidence for Tambora's impact was strong but far from certain. Henry Stommel and Elizabeth Stommel drew upon instrumental records from New England colleges to suggest that the distant volcano had produced what Yankees called "the year without a summer" in 1816. Canadian researcher C. R. Harington edited a volume on 1816 around the globe, which included several articles from Canada. These articles focused on local and regional impacts of the Tambora dust veil, inquiring what effects the eruption had across the territory that later became Canada.[6]

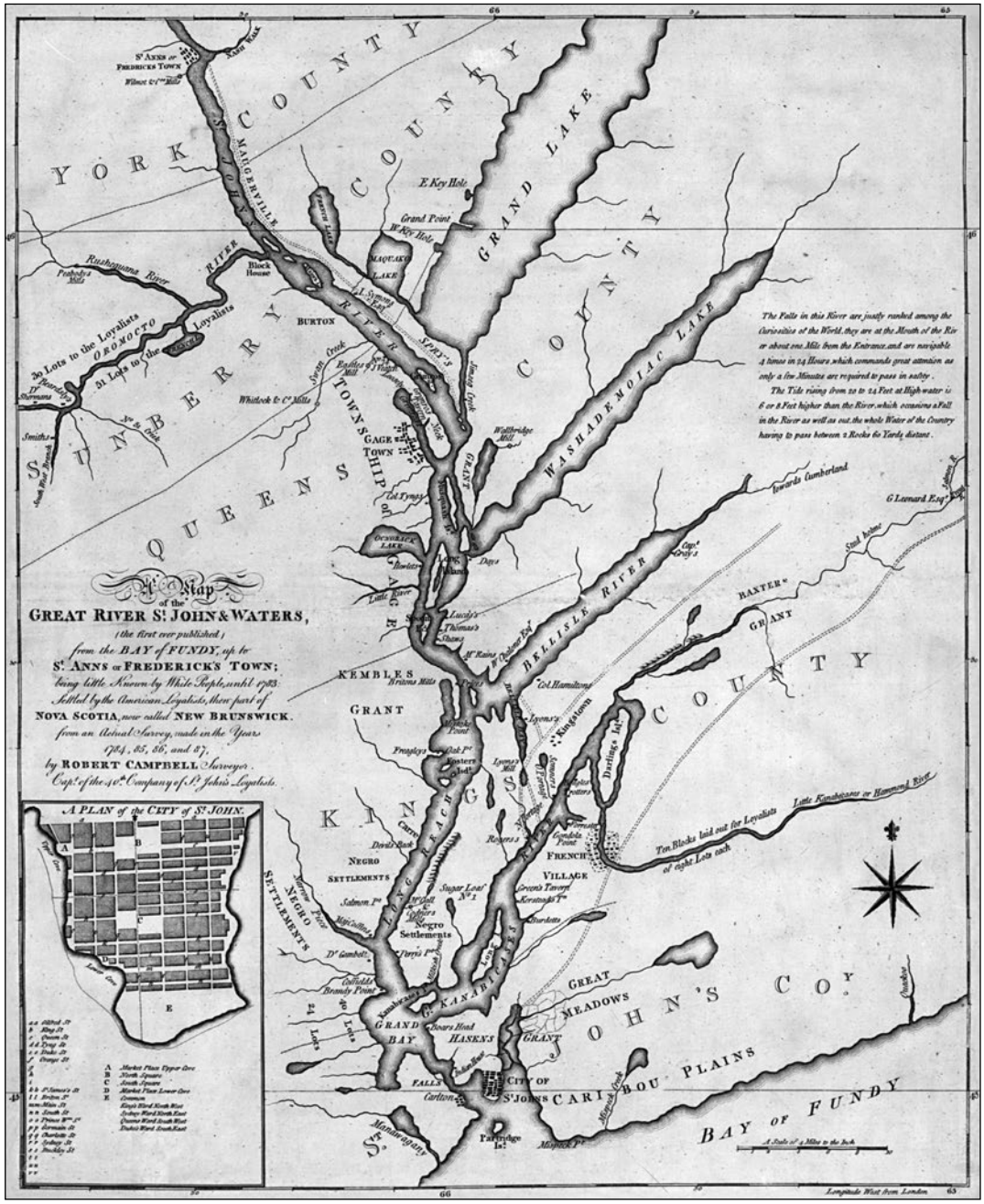
Questions about the socioeconomic consequences of a dramatic shift in the weather, a "year without a summer" within the young British North American colonies, had yet to be answered, or even clearly asked.[7] There was room for further historical work on Tambora's effects in North America. Although events from Western Europe and New England were instructive, the context of settlement in British North America was considerably different, even if strong cultural and economic ties bound the three regions together across the North Atlantic. Moreover, even before asking questions about harvest, subsistence, and social responses to inclement weather, I had to establish whether Tambora's effects had indeed been felt in British North America: as the Harington collection made clear, the degree of local and regional variation meant that though it was quite likely, it was by no means certain that 1816 in Canada was a year without a summer.

Doing Climate History

How could I learn what the weather was in Canada in 1816? How would I know if this weather was exceptional or irregular? Before we go any further, a brief aside to address terminology and its implications. Weather refers to the state of the atmosphere at a given time and place, while climate is an average of the weather of a particular time and/or place. Across Canada, weather can change considerably from day to day, with the most distinctive variations occurring on a seasonal calendar. Canadian climates vary from north to south, and between moderate, humid coasts and dry, extreme interiors. Across time, climate, in contrast to weather, changes slowly. The most dramatic climate changes of recent centuries include the 1550–1850 Little Ice Age—a period of prolonged cold and unpredictable weather across the globe that broadly encouraged the growth of glaciers—and the persistent warming trend of recent decades linked to the industrial production of greenhouse gases.[8] A volcanic eruption, even one on the scale of Tambora, is unlikely to lead to climate change—its effects dissipate as the volcanic aerosols are dispersed by atmospheric circulation. Yet the effects of a volcanic dust veil can be felt for extended periods of time: weeks, months, or even years. To understand the impacts of a volcanic eruption upon a distant environment requires that we know the historic climate of that place, the background conditions against which anomalous weather resulting from a volcanic event would be revealed.

So what was the climate of British North America in the early 19th century? This depends first on the part of British North America that we wish to investigate. For reasons that will become clear, I chose New Brunswick, and within New Brunswick, I examined the lower Saint John River valley, specifically the stretch known as Long Reach, a rich agricultural region in the early 19th century (see Figure 6.1). Maps from the late 18th century indicate that the regional topography has changed little in the two centuries since the Tambora eruption. Long Reach lies on the north side of the Kingston peninsula, just inland from the mouth of the Saint John River, which drains into the Bay of Fundy, and before the westward bend in the river toward Gagetown and Fredericton. The Reach is surrounded by high ground that slopes more sharply to the south, forming bluffs and cliffs. Water drains from the high ground into the finely textured valley soils, which allowed the cultivation of diverse crops. Lying near the North Atlantic coast, air temperature along the Reach reflected the mixing of continental air masses with the temperature-moderating effect of the ocean. Topography and general geography strongly influence local microclimates, which in

Figure 6.1 ROBERT CAMPBELL'S 1788 MAP OF THE SAINT JOHN RIVER



The Lower Saint John River area of southern New Brunswick felt the effects of anomalous weather in 1816–17, as described in Benjamin Crawford's diary. Crawford's farm was in the community of Long Reach, not identified on the map but located just to the east of the stretch of river bearing the same name, in the map's lower centre.

Source: Library and Archives Canada, NMC-000254.

turn shape the weather that people experience on a daily basis. Knowing that these broad features had remained essentially unchanged since 1816 provided a foundation upon which to build a description of the regional climate setting.

Uncovering the rest of the climate picture—the temperature, precipitation, prevailing winds, and cloud cover—proved far more challenging. The same reasons that make British North America an interesting place to look for the effects of Tambora militate against the availability of good meteorological data in this period. The second decade of the 19th century was a period of considerable change for newcomer settlements in British North America. The American Revolution, followed soon after by the Napoleonic Wars in Europe, brought both new economic opportunities and Loyalist settlers to the Atlantic colonies and Upper Canada. Forest resources from Nova Scotia, Prince Edward Island, and the newly created New Brunswick had a competitive advantage in the early 19th century, complemented by exclusive trade opportunities with the British colonies in the West Indies.[9] Commercial activity in the older settlements of the East Coast flourished in the early 19th century; Upper Canada developed more slowly, as it was still in the pioneer stage of agricultural development and had yet to produce reliable agricultural surpluses. To the west in Rupert's Land, the North West and Hudson's Bay companies competed within a flourishing fur trade, but larger newcomer settlements were scarce, with the notable exception of the Red River Colony in southern Manitoba, founded in 1812. In Lower Canada, the most substantial and established of the British North American colonies, the second decade of the 19th century marked the onset of a period of agricultural crisis.[10]

Doing climate history in the midst of such considerable change holds exciting potential. In the early 19th century, many people moved to and across British North America and Rupert's Land, and the climatic conditions they encountered played an important role in where they settled, their economic choices, and their expectations about a new place. As Julie Cruikshank has argued, the hazardous environmental conditions of the Little Ice Age shaped initial colonial encounters in the Canadian North and many of the still-dominant perceptions of the north in the Euro-Canadian imagination.[11] Similarly, Alwynne Beaudoin, among others, demonstrates how early interpretation of the potential of prairie landscapes for agriculture by late-19th century settlers was a product both of newcomer expectations and the exceptionally wet conditions that they encountered.[12] Early settlements were closely tied to local environmental conditions, as the majority of settlers engaged in productive activities that brought them into direct daily contact with the physical and biological world.[13] Colonial environments were, moreover, syncretic cultural landscapes where different folk, spiritual, and scientific attitudes toward nature met. A late 18th-century map of southern New Brunswick illustrates the government lots distributed to the Loyalists along the Saint John and its tributaries, bounded by "Negro Settlements" on the north shore of Long Reach, and the "French Village" farther to the east. The indigenous Micmac and Maliseet residents were excluded from this representation of settlement altogether.[14] Each of these groups held sometimes overlapping, sometimes divergent, cultural perceptions of the role of weather in influencing human affairs and different expectations about the potential of the southern New Brunswick environment. These same perceptions and expectations changed through longer experience on the land and with one another.[15] Similarly, settlers imported and adapted technologies to the local environment. Studying the earliest years in which settler societies forged material and conceptual

relationships to the land can reveal to the environmental historian the long roots of certain attitudes toward nature in a particular place, as well as expose how people made choices in dealing with the challenges posed by an unfamiliar landscape. Amid the stresses of the early settlement period, climate played an especially important role. The questions arising out of the investigation of Tambora's effects in a British North American settlement then become more complex: if we find anomalous weather in 1816, to what extent did it influence the early evolution of community, economy, and relationships to the natural world?

None of this gets us closer to knowing more about local climates in British North America in the early 19th century, however. Although there was rapid economic development and increased settlement in many places, neither factor was conducive to the accumulation of meteorological data necessary to accurately reconstruct regional climates in this period. Instrumental records of past weather are typically considered an ideal source for historical climatology.[16] Certainly, for physical scientists seeking to use information about past climates to model present and future trends, instrumental temperature data can allow for comparisons to be made across centuries. The Celsius temperature scale, developed in the 18th century and based upon the boiling and freezing points of water, meant that 20 degrees Celsius in 1750 and 20 degrees Celsius in 1950 recorded the same temperature.[17] The year 1816 lies well within the modern era of temperature measurement, and while thermometers were in use in British North America at this time, few if any continuous series of instrumental measurements extend back to the second decade of the 19th century. The oldest temperature records for places that lie within the borders of present-day Canada include the highly detailed snapshots provided by European explorers, such as John Richardson, the surgeon and naturalist with the Franklin expedition in the 1820s.[18] Explorers took detailed meteorological measurements while they travelled across the Canadian landscape. Unfortunately, these series rarely offer more than a few years worth of observations. Longer, continuous instrumental records are available from whaling ships, fur trade, military, and mission posts scattered across the Canadian landscape.[19] However, most of these date from the late 19th century, or are from places far away from New Brunswick, the chosen site of study. The first official, government-sponsored meteorological station was established in Toronto in 1839, as part of an imperial effort to accumulate terrestrial magnetism data and improve the data base for forecasting.[20] Throughout the 19th century, official and private forecasting stations were established across Canada, offering an intermittent and widely dispersed historical instrumental record.[21] These sources notwithstanding, instrumental data from Canadian territory is relatively rare.

Environmental historians must know how to use sources and apply methods other than those conventionally employed by historians. This is, arguably, how environmental history can contribute most to the historical discipline: by providing means to allow for the effective practice of interdisciplinarity (drawing upon two or more disciplines for methodological or conceptual insights) as demanded by transdisciplinary subjects (i.e., subjects, like the environment, that transcend traditional disciplinary boundaries). If we are to engage with the natural world as an active agent in Canadian history, then we must draw upon the tools developed by researchers outside archives to investigate the character and dynamics of past environments. In the case of historical climate research, evidence from tree rings, pollen, ice cores, and lake and marine sediments can

indicate climatic change much farther back in the past than the documentary record allows. Archaeological investigations that reveal evidence of extinction and desertion of settlements are useful for examining long-term climate variations.[22] Tree rings are used to reconstruct both past climate and hydrology, and work from the Canadian prairies has supplied a long-term record of drought on the western plains. Unfortunately, unless physical data is available and has been gathered from the particular site of interest, then it cannot provide anything more than a broad-scale, general reconstruction of regional climates.

The combination of physical evidence and instrumental data (from outside British North America) indicates that highly variable weather conditions characterized the climate of New Brunswick in the early 19th century. This highly variable weather was associated with the close of the Little Ice Age, which has been broadly characterized as composed of three distinct periods: "a stormy 'zonal' onset, a calm 'meridional' maximum and a stormy 'zonal' end."[23] To investigate whether Tambora produced further anomalous weather in British North America, within this already varying climatic context, required primary materials that supplied evidence of not only what happened in 1816, but also the longer period in which the weather of that year occurred. In the absence of instrumental data, the ideal source was a record that offered both documentary and proxy evidence of the weather. Documentary evidence presents historical descriptions of weather and events dependent upon weather phenomena and is one of the richest forms of information on past climates.[24] Oral histories can be used in a similar fashion, although they pose more complex challenges with regards to dating. Proxies are changes in the physical or biological world that indirectly describe weather conditions. Proxy information is derived from sources such as the seasonal or annual layers of tree rings, ice cores, and stratified lake sediments. A tree ring does not record the atmospheric temperature in which it was formed; its width, however, indicates the relative length of the growing season.[25] Historical proxies include the dates of ice breakup and freeze-up, which have been studied in detail using the logbooks of Hudson's Bay Company vessels.[26] European environmental historian Christian Pfister has emphasized that pre-industrial people often demonstrated the anomalous character of a season by referring to observed signs in the physical or biological world. These signs reveal the broad ecological repercussions of anomalous weather. Proxy information further indicates strategies of socioeconomic adaptation and instances of susceptibility to extreme and variable weather. As a scientific tool, proxy information is seen as an important but imprecise source of information; for the historian, proxy information exists at the meeting point of climate, ecology, economy, and culture and thus is valuable in ways that abstracted instrumental data is not. Documentary and oral evidence in general intertwine perceptions of natural environments with details of environmental change and thus allow us to interpret the ideas and cultural practices that framed past encounters with weather.

For the predominantly agricultural settlements of British North America, farmers' diaries offer the best potential source material for research. Men and women who lived in pre-industrial farming communities kept daybooks to record accounts, receipts, and expenditures; work begun or completed; and notable community or family events. They also, more often than not, kept a daily record of the weather—whether it snowed or rained, whether it was fine or overcast. Social historians have made extensive use of such diaries as means to access the worlds of

ordinary people whose historical experiences otherwise remain obscured. Farmers' diaries have also been used extensively in conjunction with probate inventories and account books as invaluable sources for economic history. To a lesser extent, climate historians have used the meteorological information commonly found in farmers' diaries to reconstruct past weather.[27] Perhaps part of the reason that farmers' diaries are not more widely used in historical research lies in the not uncommon complaint from historians or genealogists that an extensive diary of information, which they hoped would reveal details of rich community and social life, instead offered little aside from a daily record of the weather. This was precisely the kind of diary I was looking for.

Farmers' diaries are a kind of source material that is commonly preserved, first by family members who appreciate the record of their ancestors and subsequently within archives. Not just any farmer's diary would do, however. To clearly determine the local effects of Tambora in a British North American colony, I needed the diary of a farmer who had kept a daily record both prior to and following 1816. Although I had initially set out to research Upper Canada, the relative youth of many settlements in that colony meant that few diaries survived from the second decade of the 19th century. In the midst of pioneering farm work, settlers rarely had the occasion to keep a daily journal. The most famous narrative of early settler life in Upper Canada, *Roughing It in the Bush,* was published at mid-century and described Susanna Moodie's experiences from the 1830s. History is done at the whim of what is preserved through oral tradition, documentary records, or material artefacts. Chance and circumstance are critical both to the preservation of material as well as their subsequent assessment by a historian. In this instance, I happened upon the diary of a farmer, kept daily from 1801 to 1859. This diary, located in the Provincial Archives of Ontario, chronicled Benjamin Benedict Crawford's farm life in New Brunswick from 1801 until 1838, when he, like many others, migrated with his family from New Brunswick to Upper Canada and continued farming in Oxford township until his death in 1859. This diary provided more than 20 years of evidence of the local climate along Long Reach in southern New Brunswick, extending both before and after 1816.[28]

Benjamin Crawford's Diary

Benjamin Benedict Crawford was born in Westchester County, New York, in 1777 to a Loyalist family, who left New York state in 1783 and headed north with thousands of other refugees to the province of Nova Scotia. James and Rachel Crawford settled along the Lower Saint John River, which the following year became part of Kings County in the new colony of New Brunswick. Benjamin, their third son, married Jane Catherine Lyon, daughter to prominent Loyalist Captain Joseph Lyon, in December 1805. Together Jane and Benjamin raised 13 children on their farm at Long Reach, and Benjamin also served the community for 20 years as a justice of the peace.

Benjamin Crawford first kept a diary on a trip in 1799 to Upper Canada, and his earliest entries are like most visitors' journals: a description of routes travelled, places stopped, things seen. Crawford's diary keeping came to reflect his social sensibility and aspirations as he continued his entries upon his return to New Brunswick in 1801. Jan Golinski has examined how

the appearance of weather diaries in Britain during the Enlightenment expressed a desire to move weather observation out of the realm of superstition and folklore and into a form of scientific study that could reveal "the rule of a benevolent providence over an orderly world."[29] As such, the systematic recording of weather acted as means of imposing order over the natural world and of elevating its observation into a disciplined, spiritual, and intellectual practice. While Crawford, in contrast to Golinski's 18th-century scientists, remained bound to the rhythms of agricultural life, he was also a religious man clearly positioned within the rural elite, as evidenced in his role as a justice of the peace, his relative prosperity, and his social networks.[30] The people whose public and private affairs most commonly appeared in Crawford's diary shared his financial and social status. The Whelpleys, Lyons, and Williams worked similar-sized farms, and Richard Whelpley was captain of the militia. This middling social group stood in contrast to the Acadians, "Blackmen," and "Irishmen" who appeared in the diary either as farm-labourers or as a result of Crawford's work as JP. In keeping his record of weather and farm activities, Crawford produced a systematic record indicating the skill and precision required for his labours, even as the same diary often articulated vernacular knowledge of nature and weather and acted as a repository of local gossip.

Benjamin Crawford did not begin to consistently record the weather until 1810, and his descriptions of weather and the local environment grew more detailed with time. This was in part because he became a better record keeper. In 1812 there are 144 days with no record (39.3 percent). In 1813 this drops to 59 days (16 percent) and continues to fall, such that in the period from 1815 to 1821 Crawford has no record for an average of only five days a year (1.4 percent) with his most regular entries before 1821 kept in 1816, 1817, and 1818.[31] But Crawford's greater attention to weather detail is also a fairly common feature of any diary that records the local environment, as the recorder becomes more confident with time and has access to a past record to remark upon exceptional events in detail or to describe normal conditions. Beginning in December 1814 Crawford began to devote one page to each week, ruling dashed lines along the pages to divide them into equal-sized sections, increasing the precision with which his record was kept. By creating a space to record each day's events, rather than just writing on the days that he remembered or chose to, Crawford ensured that his weather record would become even more precise: on days when nothing of note occurred, he still remarked upon the weather in the designated space.[32] A typical longer entry might include information about the weather, the farm, and local social life; for example, on May 10, 1819, Crawford wrote, "A dry spell of weather; sowed about 3 pecks of wheat and 2 bushels of oats at the upper lot; John Whelpley here to see his people." The single most common entry found in isolation in Crawford's diary was the simple statement "good weather."

By standardizing entries and keeping tallies and summaries for each year, Crawford made it easier to review important dates with an eye to comparing production and activities in the present to those in the past. His diary functioned as a ledger that allowed him to keep track of accounts owed or paid. Crawford purchased oats and potatoes from his neighbours, particularly in years when his hay harvest was poor. In turn, he sold meat and livestock to his neighbours. These purchases were either paid in cash, or notes were given at the time of the transaction and several months later Crawford would record that he and the other party had settled.[33] The first and last

few pages of each diary were devoted to summaries of production and sales, along with miscellaneous notes about cures for illnesses or injuries that his family or friends had suffered during the course of the year, and drafts of material related to his work as justice of the peace. Precision and consistency were important not just to the integrity of the record itself, but as part of the larger function that the diary served in Crawford's life.

Economic and farming life, and by extension the natural environment that these were predicated upon, were the major focus of the diary. Much of the Crawford farm activities focused upon the family's cattle, sheep, and pigs. Between 1806 and 1821 the Crawford farm included on average 12 milk and beef cows, 3 horses, 10 pigs, 2–3 geese that produced between 6 and 20 goslings each year, and at least 20 chickens. In this same time span, the number of sheep on the Crawford farm grew from 14 sheep and 9 lambs to 24 sheep and 19 lambs. The emphasis on livestock reflected the broader economy of southern New Brunswick, which produced pork and cattle for export to Great Britain and the West Indies.[34] Crawford detailed trips to town to sell or purchase goods, as well as the prices paid and the specific amounts in each instance. To maintain the livestock, the Crawfords produced hay and oats, and to maintain themselves and for sale at market, the farm produced buckwheat and wheat. Crawford kept a record of when he sowed his grain, hoed his potatoes, slaughtered calves, and cut hay. Crawford also kept a close eye on the farming and economic activities of his neighbours, including forestry work, which featured increasingly prominently in the life of Long Reach over this period. Crawford's social record of economic activity not only emphasized the communal aspects of pre-industrial labour through frolics or bees, but also represented how Crawford evaluated his own activities and success against the work of others. In August 1821 Crawford noted that "Richard Whelpley sowed his Rye the 7 of September last and it is very good which seemes to be a good time to sow Rye."[35] From 1816 to 1818 Crawford tallied his own salmon catches against those of his neighbour (and Richard's brother) Henry Whelpley. In addition to his own trips to market, Crawford also paid attention to when his family and friends went to Saint John; family and friends could carry goods for him and relay important information about prices.

Just as his diary acted as a record of his farm work, it also served as a place to record his family and social life. The births of his children were noted and tallied, he kept record of illnesses and deaths in his immediate family and among his larger circle of family and friends, and who cared for whom under such circumstances. Visiting featured prominently as one of the main aspects of social life, including day visits or longer stays. Moreover, through his work as justice of the peace, Crawford became closely involved in the intimate lives of much of the community at Long Reach. When an unmarried woman got pregnant and wanted to hold the father-to-be responsible, she would come to the Crawford farm to make her declaration. When a neighbour accused a labourer of stealing, Crawford was directly involved in the matter. Crawford kept note of disagreements, trials, and settlements. His social and economic records were one and the same, as when on August 9, 1820, he noted, "John Williams had a mowing frolick had 14 hands then they had a quarrel at night." In Benjamin Crawford's diary the life of the community is interwoven with observations of natural phenomena, and an account of colonial farming and forestry. The diary thus acts as an ideal source through which to examine the intersection of nature, society, and economy in early 19th century New Brunswick.

Reading Diaries for Weather

At first glance, however, the Crawford diary—like so many other diaries and journals found in archives across Canada—is little more than a dense and relatively uninteresting collection of details: "cold but good weather for hauling wood, fine going to town"; "NW wind cold, Drummer calved."[36] How important is it that we know that a particular cow in southern New Brunswick calved one early April morning almost 200 years ago? The juiciest of the local gossip appeared sparingly in the diaries, and could be made meaningful only with knowledge of the social networks that bound the community at Long Reach together. As Kathryn Carter has observed, "diaries of this type have often been overlooked by scholars because they seem inexpressive and opaque."[37] Here Carter refers to the superficial appearance of such diaries, which on a single page offer no distinctive voice or relevant insight into broader affairs. Yet account books and diaries of this sort can be fairly effective vehicles for past voices, provided that the author was an interesting person or at least an interested observer of her or his world, and that the reader has the patience and time to get to know the author. With the opportunity to spend some time getting to know the diary keeper, the potential of such sources can be enormous.

When doing this kind of research, your first question must be, Is this diary worth your time? In my case, I originally requested to look at all the early 19th-century diaries in the Provincial Archives of Ontario (there were not all that many) as I hoped to use multiple diaries for a more precise reconstruction of the weather from multiple observers across a particular region. To decide whether a diary was a worthwhile source, I turned first to 1816 to see whether any remarkable weather had occurred. This quickly showed which diaries were legible and which diarists were astute observers of the weather, as well as indicating any remarkable weather in that year. The Crawford diary quickly stood out as the best and indeed only worthwhile source for the years of interest. Not only was Benjamin Crawford attentive to weather and strange weather events, but also it was clear that something was amiss in the spring and summer of 1816, as he remarked upon the "Backward weather."[38] Such an initial selection process is not always successful. I have, in other research projects, been fooled by diarists who, over the period of immediate interest, kept a close record of weather but otherwise consistently omitted days or weeks at a stretch. Such inconsistent record keeping limits the value of a diary to the reconstruction of past weather. Travellers' diaries are similarly compromised as travellers move through places, leaving only a brief record from a given site. Furthermore, because they are only visiting, travellers are poorly tuned to exceptional as distinct from regular environmental conditions. Travellers' diaries thus often reveal more about the travellers than about the places they visit. Even a perfectly kept weather record has its limits as an historical source. Descriptions of the weather typically endure even when the diarist finds nothing else worthwhile to record. But this is useful only if weather reconstruction is the sole aim of your project. The real richness of the Crawford diary, which became clear to me only after I had worked with the source for several days, lay in the combined descriptions of weather, environment, society, and economy.

I opted to hand copy the important material from the original diaries. The entire series had been microfilmed but the quality of the microfilm was poor and because the microfilm existed, I did not have permission to photocopy the original text. Moreover, because the originals were

stored in a restricted part of the archives, I did not have permission to use a laptop. So instead, every day I walked across town in the hot and humid Toronto summer to the Archives and sat down with a pencil and notebook copying what I thought was important from Crawford's daily record. I started with the years 1815 through 1817, to ensure that my initial sense of the diaries' worth was correct. Once those three years were complete I then moved back to 1812 and copied the remainder through 1821. I benefited from the tallies and summaries that Crawford kept annually. I did not copy every single detail; even though I was often compelled by Crawford's descriptions of his family life, I knew that such events had no discernible links to the weather. One of the real challenges in doing history, and I would suggest environmental history in particular, lies with knowing where to draw such lines.[39] If you are too restrictive in the notes that you take you can limit your possible research outcomes. Had I recorded only weather observations and grain prices, then my environmental history would have focused exclusively upon markets and the economic effects of the distant Tambora eruption. Instead, I cast widely to try to capture the broader environmental repercussions of the volcano—I paid attention to Crawford's observations of plant growth, cherries ripening, hay harvesting, and ice breakup, as well as his comments on his cattle and the cost of flour. I also paid some attention to social events, hoping that Crawford, particularly with privileged access to community life in his role as JP, would offer some insights into social repercussions of anomalous weather in the young colony of New Brunswick.

The alternative to copying the entries would have been to extract the relevant information directly into a digital database as I read the diary. A "digital database" refers to the form in which data drawn from an historical source is organized using a computer. Digital databases can be relatively straightforward: for instance, a table or spreadsheet with the information organized into columns and rows; or it can involve more complex relationships between multiple tables, text entries, and mapping functions. Directly inputting data is less time consuming, but it is also less flexible: any database constructed prior to reading a diary in detail will not be perfectly suited to the particular original source. In some respects this introduces an important measure of standardization onto the information that is sought. But it also can mean that rather than allowing for quick tallies, dates, or counts of important information, a poorly designed database will force much of the interesting information into an open "comments" field, from which it then has to be extracted in a second iteration of analysis. In this case, the database saves no time as compared to copying out the diary and, I would argue, creates more opportunities for introduced errors. As the form of the database deviates from the form of the original source, it is easier to miss errors in transcription, for example. Moreover, in moving straight to database entries, some of the benefits of "reading" the diary are lost. Copying the diary entries served a wider purpose, as it established rapid familiarity not only with Benjamin Crawford but also with the geography and community of Long Reach. Exceptional events appeared clearly as I grew accustomed to Crawford's tone. It also helped that he was interested in anomalous weather. Descriptions of severe storms often included details about the longer weather context, such as a fierce storm on June 4, 1812, that led Crawford to remark, "this day there was a provecy that the world wood be at an end—the most severe storm that was ever none in June By the oldest inhabitant."[40] Benjamin Crawford was a reliable and knowledgeable guide to the early 19th-century environment and climate of Long Reach.

Sensing Weather in the Past

Conceptualizing the larger weather context required extracting relevant data from the diary entries and organizing it in a manner that made meteorological sense. Documentary records used for historical climatology typically include two kinds of weather-related information: meteorological variables and proxies. Atmospheric scientists measure precipitation, temperature, air pressure, humidity, cloudiness, and wind speed and direction to determine the state of the atmosphere, and where these variables are found in historical documents they can supply the most straightforward climate data. To translate the text within Crawford's diary into atmospheric data, I created 10 tables, one for each year, in which each day was numbered 1 through 365 (or 366 in the leap years) and organized the information into fields for temperature; wind speed and direction; whether it snowed, rained, or stormed; and, if known, how much rain or snow fell, whether the sky was clear or cloudy, and whether the day was dry. I also kept an open field of comments in which to record descriptive detail. These tables provided a broad overview of what information was recorded regularly enough to permit analysis. Crawford most consistently recorded temperature, precipitation, and wind speed and direction.

Crawford described temperature using such adjectives as "cold," "warm," "very hot," "cool," or sometimes less precisely "good weather" or "fine." Obviously, a cold day in June 1814 has no direct degree equivalent in the 21st century. But when temperature was considered as a relative value rather than an absolute, Crawford's record was more forthcoming. To express relative value I needed to translate the descriptions into quantifiable terms. One possibility, if I was interested only in looking at the temperature in 1816 relative to that in 1813 or 1821, was to count the number of cold days as compared to the number of good days (to use just two examples). Distributing these counts across months would ensure that I could capture seasonal variations. However, by only quantifying Crawford's record in reference to the diary itself, I was in danger of perpetuating any weather delusions that Crawford might have had. I needed some kind of external confirmation as to the reliability of the record. The colonial newspaper, the New Brunswick *Royal Gazette* provided one external reference. In 1816 the *Gazette* featured three separate articles that sought to identify causes for the unseasonably cold summer weather.[41] The other opportunity for external validation came in a different approach to the temperature observations. I made a list of the principal terms used to describe the weather and then ordered them from coldest to warmest: dreadful cold, very cold, cold, moderate, cool, dull, fine/pleasant/good, warm, very warm, hot/dreadful warm, very hot. I then set each of these equal to a number, from -5 through $+5$ with 0 equal to "dull." Using these assigned values, that bore no relation to actual temperatures but attempted to capture the variations in weather described by Crawford himself, I charted and analyzed the temperature descriptions on a monthly, seasonal, and annual basis. The accuracy of both the method and of Crawford's temperature observations in general were tested by comparing a graph that averaged these temperature values for the entire period against a graph of temperature normals from the 20th century.[42] The amplitude of the 1812–21 graph was smaller but otherwise mirrored the form of the 20th-century data, indicating that Crawford's observations were broadly reliable. Comparing 1816 to 20th-century climate normals further revealed a sharp depression in temperature in 1816 that lasted into 1817, graphically illustrating the markedly colder weather in 1816.

The other kinds of data available in Crawford's diary posed far fewer methodological problems. Present-day meteorology is more precise but otherwise relies on much the same information that Crawford recorded. Crawford occasionally remarked upon the amount of precipitation that fell, but without the requisite regularity; he did record the days when rain or snow fell, however. Crawford's diary is consistent with, albeit less sensitive than, present instrumental records of precipitation that can register as little as a tenth of a millimetre of rain or snow. I counted the days when precipitation fell and distinguished the kind of precipitation. The same approach was used to assess thunder-, snow-, and rainstorms.[43] Relying upon Crawford's own consistency in what he termed a "storm" provided the foundation for this approach. From these variables I was able to construct an overview of the weather, as recorded in Crawford's diary between 1812 and 1821. The stormiest years in this period were 1812, 1814, and 1817. The absence of summer thunderstorms in 1816 was an expected result of the cooler temperatures that year. Additional research suggested that the exceptionally stormy weather early in the period could also be tied to other wider climate events, either distant eruptions between 1809 and 1814 or to the effects of the North Atlantic Oscillation.[44]

It still remained to understand the significance of this weather relative both to the 1815 volcanic eruption and to the life of the community at Long Reach in this period. The data I had thus far gathered showed patterns and trends—such as the large numbers of storms early in the period, persistent cooling in 1816–17, increased precipitation in 1818, and drought in 1820–21—but it was poorly linked to society and economy. Perhaps it was colder in 1816, but was it just a little cooler or did this weather have an effect on plant growth, animal behaviour, or social life? Proxies offered the potential to reveal the wider ecological and economic repercussions of anomalous weather. But then I had to ask, what were the appropriate proxies to use?

Crawford observed a lot of features of the wider environment and his community but these varied observations were valuable only if he made note of them every, or almost every, year. To organize this diverse information I created tables for descriptions of grains, prices, labour, transportation, social events, and animals. In each table, the date tied the observation to the weather tables, but otherwise the record reflected the different ways that Crawford described his world. Animals principally included farm animals, and entries mention when they reproduced, fell ill, or were slaughtered. Within the database constructed around Crawford's diary, each table focused upon one aspect of the environment, economy, or society at Long Reach. From these tables, it was clear that I could use two proxies, quite common to historical weather records: observations of the freeze-up and breakup of ice (in this instance from along the Saint John River) and the length of the growing season.

The seasonal formation and destruction of ice is a particularly rigorous and important environmental proxy in historical records across Canada, speaking to the significance of this seasonal transformation in Canadian history. Waterways served as the highways of commerce across much of the continent well into the industrial period.[45] The transformation of water from a solid to liquid state and back again signalled the seasonal transition, brought immediate disruption as the transitional period made travel much more dangerous, and involved distinct modes of transport and specific hazards. Yet the formation and breakup of ice in major waterways is a complex

environmental phenomenon that occurs over a period of time (from when the ice first becomes unsafe until the water is completely open) and is contingent upon the morphology of a river or lake in combination with weather conditions.[46] Stormy weather could break up newly formed ice, keeping a waterway open for longer than ice that formed under colder and calmer conditions. Crawford again was a particularly helpful observer. His first and last comment on ice breaking and freezing respectively were taken to signal the dates when the river first opened and finally closed. But Crawford also consistently remarked the date when the spring freshet (the height of meltwaters in the river) reached its peak, when the ice passed Caton's Island, and when the river was fully open. Crawford thus presented a sensitive annual reading of the complicated process of ice breakup and freeze-up.

The complexity of this process offered further insight into the enduring effects of cold weather in 1816. Although the ice broke briefly in January that year, it soon froze over again and remained closed into April, as usual. Twice in the spring of 1816, Crawford commented on the "backward" weather and noted snow on the mountains in June, where he had only ever otherwise noted snow in the fall months. The marked increase in storms in 1817 was concentrated in the winter months (from January to March) and saw more rain and snow than any other year in the decade. The severity of that winter led Crawford to remark that this was "the hardest season that we have ever had for many years."[47] The accumulated snowfall and cold temperatures kept the Saint John River frozen longer in 1817. Crawford described the ice that year "as good I sepose as it ever was known this thirty years past" and the spring freshet "was as high as was ever known" as the meltwaters filled the riverbed.[48] Just as the more complicated record of ice breakup and freeze-up recorded the more enduring impacts of the unseasonable cold of 1816, so too a rather simpler record—that of frog callings—more straightforwardly indicated spring weather conditions along the Reach. Spring peepers need temperatures around 20 degrees Celcius before they will begin their search for a mate. Crawford recorded each year when the frogs began to peep, presenting a strong record of spring temperatures even in the absence of instruments. In 1816 the frogs did not start calling until May 20, almost two weeks later than in any other year except 1817.

The vulnerability of plant life to anomalous weather and the importance of plants to agriculture have ensured plant life a prominent place in global historical climatology. Ladurie's *Times of Feast, Times of Famine* focused upon European tithes and vintage dates, when the grapes were ready to harvest.[49] Agriculture was substantially less well established in early-19th-century New Brunswick, but proxies drawn from plants and crops nevertheless offer detailed insights into the consequences of anomalous weather. The length of the growing season signalled years with consistently colder summer weather and directly linked weather conditions to failed, modest, or flourishing agricultural production.[50] Knowing and accommodating the length of the growing season was essential to skilled agriculture and was measured by the number of days from the last frost to first frost. Crawford kept a record of these dates in each year, revealing dramatic fluctuations in the length of the growing season between 1812 and 1821. The blossoming and ripening dates for strawberries, which grew wild but that Crawford recorded more diligently than his own cultivated produce, reinforced the consequences of the cold weather upon plants. In 1816 the growing season lasted only 86 days, where it usually lasted over 100 days; the strawberries ripened later than any other year, and by September Crawford remarked, "there has not been scarcely any

corn or beens got ripe this season."[51] Grain prices (oats, wheat, and corn) all peaked in 1817, reflecting scarcity in the previous year. Hay reached the highest price peak in April 1817; with livestock still dependent upon the fodder produced in 1816, there were not only increased transactions between Crawford and his neighbours over hay, but also prices reported as high as £12 per ton, where Crawford typically paid around £3 per ton in the same season, revealing that hay was a commodity greatly in demand.[52]

From the proxy and anecdotal evidence available in Crawford's diary in combination with other sources on early-19th-century New Brunswick history, I was able to draw some connections between wider social and economic changes and the anomalous weather. Crawford noted the presence and execution of a witch in the region in August 1816, articulating some of the insecurity and fear that attended the unseasonable weather and its negative effects upon agriculture.[53] Outward migration from the region increased during and after 1816, and transient wage labour came to prevail over communal work in farming and forest harvesting, suggesting how the hard seasons contributed to the instability of the still-young farm economy of southern New Brunswick. Some of those who stayed in Long Reach shifted their efforts from vulnerable corn and hay (used to fodder cattle in the winter months) to hardier oats used to feed sheep. Likewise, work in the woods profited from the cold seasons that made it easier to access and haul lumber. Thus individuals, families, and communities already responding to the hardships of early settlement adapted their economic activities to the limits of the natural environment—limits imposed by inclement weather itself resulting from a far distant volcanic eruption.

Climate in Environmental History

The case of the Tambora volcano and its effects upon the community of Long Reach illustrate how climate and weather are critical and complicated subjects for environmental history. Oceans and landmasses define boundaries, whereas the atmosphere links distant places through global patterns of dispersal and circulation. The far-reaching climatic effects of a single volcanic eruption expose distant connections and help us to recognize how environmental history is the study of local places caught up in global processes. In studying past climate we must always be alert to distinguish between correlations and causation. The coincidence of anomalous weather with momentous historical events should not lead us to make assumptions about cause (exceptional weather) and effect (dramatic event). Instead, the role of weather must be recognized as part of a larger environmental, social, and economic context. Yet the complexity of weather phenomena and their wider socioecological repercussions can thwart ready analysis and interpretation. Climate is often described as a stochastic process, one where outcomes cannot be readily determined but rather appear random because of the degree of complexity involved. This creates not only opportunities to refute findings regarding 20th-century warming trends, but also challenges in attempting to reconstruct past climates and their socioecological consequences, using historical evidence. Although Benjamin Crawford was alert to the strange weather of 1816, it is only with the benefit of historical hindsight that we can see the manifold ways that it affected the environment and economy of Long Reach.

Discussion Questions

1. How can we recognize past climate change or changes in the weather? What kinds of sources can we use to reconstruct past weather and climates?
2. How has climate changed over time? Offer a broad-stroke climate history of Canada. Is there such a thing as a "normal" Canadian climate?
3. How would pre-industrial peoples have perceived the weather differently than we do today? Were they closer to nature?
4. How would climate or weather, as compared to other aspects of the natural environment, influence early settlement?
5. What makes a community vulnerable to changes in the weather?
6. How can we test the reliability of proxy evidence of past climates?
7. Is colloquial meteorology more or less precise than official meteorology?
8. Other key events in Canadian history occurred in 1816. In what is now Manitoba, Métis and members of the Hudson's Bay Company fought at Seven Oaks, a battle precipitated by food shortages. In Lower Canada, an agricultural crisis developed. How could one go about investigating the effects of weather—and, ultimately, the Tambora eruption—on these historical episodes?

Notes

1. The Early Canada Environmental Data project, part of the NiCHE: Network in Canadian History and Environment initiative, seeks to compile and collect such materials in all its different forms.

2. Alwyn Scarth, *Vulcan's Fury: Man Against the Volcano* (New Haven: Yale University Press, 1999); Brian Fagan, *The Little Ice Age: How Climate Made History, 1300–1850* (New York: Basic Books, 2000); D. Wayne Moodie, A. J. W. Catchpole, Kerry Abel, "Northern Athapaskan Oral Traditions and the White River Volcano," *Ethnohistory* 39 no. 2 (Spring 1992): pp. 148–71; John Grattan and Mark Brayshay, "An Amazing and Portentous Summer: Environmental and Social Responses in Britain to the 1783 Eruption of an Iceland Volcano," *The Geographical Journal* 161 (1995): pp. 125–34; Alan Taylor, "'The Hungry Year': 1789 on the Northern Border of Revolutionary America," Alessa Johns, ed. *Dreadful Visitations: Confronting Natural Catastrophe in the Age of Enlightenment* (New York: Routledge, 1999).

3. R. K. R. Vupputuri, "The Possible Effects of the Tambora Eruption in 1815 on Atmospheric Thermal and Chemical Structure and Surface Climate," C.R. Harington, ed., *The Year Without a Summer? World Climate in 1816* (Ottawa: Canadian Museum of Nature, 1992): p. 46. See also G. A. Zielinski, P. A. Mayewski, L. D. Meeker, S. Whitlow, M. S. Twickler, D. A. Morrison, D. A. Meese, A. J. Gow, and R. B. Alley, "Record of Volcanism since 7000 B.C. from the GISP2 Greenland Ice Core and Implications for the Volcano-Climate System," *Science* 264 (1994): pp. 948–55.

4. H. H. Lamb, "Volcanic Dust in the Atmosphere; with a Chronology and Assessment of its Meteorological Significance," *Philosophical Transactions of the Royal Society of London. Series A. Mathematical and Physical Sciences* 266 no. 1178 (July 1970): pp. 425–533.

5. E. LeRoy Ladurie, *Times of Feast, Times of Famine: A History of Climate Since the Year 1000* (New York: Doubleday, 1971); Fernand Braudel, *La Méditerranée et le monde méditerranéen à l'époque de Philippe II,* 6eme ed. (Paris: A. Colin, 1986). See also discussion of Humboldt in Donald Worster, *Nature's Economy: A History of Ecological Ideas,* 2nd ed. (Cambridge, UK: Cambridge University Press, 1994); and how the Enlightenment reshaped attitudes toward nature in general, Roy Porter, *The Creation of the Modern World: The Untold Story of the British Enlightenment* (New York: W. W. Norton, 2000).

6. J. D. Post, *The Last Great Subsistence Crisis in the Western World* (Baltimore: Johns Hopkins University Press, 1977); Henry Stommel and Elizabeth Stommel, *Volcano Weather: The Story of 1816, the Year Without a Summer* (Newport: Seven Seas Press, 1983); C. R. Harington, ed., *The Year Without a Summer?*

7. Two of the articles in the Harington collection did consider some of the social effects of the bad weather linked to Tambora, but in a very limited fashion and without effective reference to the wider historiography. See Timothy Ball, "Climate Change, Droughts and the Social Impact: Central Canada, 1811–20, a Classic Example," and Roger Suffling and Ron Fritz, "The Ecology of a Famine: North-western Ontario in 1815–17," Harington, ed., *The Year Without a Summer?,* pp. 198–201 and 203–217.

8. For comprehensive studies of the Little Ice Age largely focused on the West, see Jean Grove, *The Little Ice Age* (London: Routledge, 2003); Fagan, *The Little Ice Age.* For its impacts in China, see Richard Marks, *Tigers, Rice, Silk, and Silt: Environment and Economy in Later Imperial South China* (Cambridge, UK: Cambridge University Press, 1997): pp. 137–40. See also Raymond S. Bradley and Philip D. Jones, eds., *Climate Since AD 1500* (London and New York: Routledge, 1992).

9. T. W. Acheson, "New Brunswick Agriculture at the End of the Colonial Era: A Reassessment," *Acadiensis* 22 no. 2 (Spring 1993): pp. 5–26; Kris Inwood, ed., *Farm, Factory and Fortune: New Studies in the Economic History of the Maritime Provinces* (Fredericton: Acadiensis Press, 1993); Graeme Wynn, *Timber Colony: A Historical Geography of Early Nineteenth Century New Brunswick* (Toronto: University of Toronto Press, 1981).

10. Arthur J. Ray, *Indians in the Fur Trade: Their Role as Trappers, Hunters, and Middlemen in the Lands Southwest of Hudson Bay 1660–1870* (Toronto: University of Toronto Press, 1974); Theodore Binnema, *Common and Contested Ground: A Human and Environmental History of the Northwestern Plains* (Norman: University of Oklahoma Press, 2001); Douglas McCalla, *Planting the Province: The Economic History of Upper Canada, 1784–1870* (Toronto: University of Toronto Press, 1993); Fernand Ouellet, *Le Bas-Canada, 1791–1840: changements structuraux et crise* (Ottawa: Éditions de l'Université d'Ottawa, 1976).

11. Julie Cruikshank, *Do Glaciers Listen? Local Knowledge, Colonial Encounters and Social Imagination* (Vancouver, University of British Columbia Press, 2005).

12. Alwynne B. Beaudoin, "What They Saw: The Climatic and Environmental Context for Euro-Canadian Settlement in Alberta," *Prairie Forum* 40 no. 1 (1999): pp. 1–40; Douglas Owram, *Promise of Eden: The Canadian Expansionist Movement and the Idea of the West, 1856–1900* (Toronto: University of Toronto Press, 1980); Clinton Evans, *The War on Weeds in the Prairie West: An Environmental History* (Calgary: University of Calgary Press, 2002).

13. For environmental history of the colonial period in the American context, see William Cronon, *Changes in the Land: Indians, Colonists, and the Ecology of New England* (New York: Hill and Wang, 1983); Carolyn Merchant, *Ecological Revolutions: Nature, Gender, and Science in New England* (Chapel Hill: University of North Carolina Press, 1989).

14. See Robert Campbell, *A Map of the Great River St. John and Waters . . . from the Bay of Fundy, up to St. Ann's or Frederick's Town*, engraved by S.I. Neele, NMC-000254 (London, 1788), Libraries and Archives Canada. Although dealing principally with Nova Scotia, see also Barry Moody and Margaret Conrad, eds., *Planter Links: Community and Culture in Colonial Nova Scotia* (Fredericton: Acadiensis, 2001); Neil MacKinnon, *This Unfriendly Soil: The Loyalist Experience in Nova Scotia 1783–1791* (Montreal and Kingston: McGill-Queens University Press, 1986): pp. 106–107.

15. For this process at work in the Great Lakes region, see Richard White, *The Middle Ground: Indians, Empires, and Republics in the Great Lakes Region, 1650–1815* (Cambridge, UK: Cambridge University Press, 1991).

16. For further discussion, see Michael Chenoweth, *The Eighteenth Century Climate of Jamaica: Derived from the Journals of Thomas Thistlewood, 1750–1786* (Philadelphia: American Philosophical Society, 2003).

17. W. E. Knowles Middleton, *A History of the Thermometer and Its Use in Meteorology* (Baltimore: Johns Hopkins Press, 1966). For further discussion of meteorological instruments, see Jan Golinski, "Barometers of Change: Meteorological Instruments as Machines of Enlightenment," William Clark, Jan Golinski, and Simon Schaffer, eds., *The Sciences in Enlightened Europe* (Chicago: University of Chicago Press, 1999): pp. 69–93.

18. See John Richardson, "Appendix No. II: Meteorological Tables—Arranged from the Registers Kept at Fort Franklin by the Officers of the Expedition," Sir John Franklin, *Narrative of a Second Expedition to the Shores of the Polar Sea, in the Years 1825, 1826, and 1827* (London: J. Murray, 1828): pp. lix–clvii.

19. See for example, "Nouvelles diverses—Good Hope, 1884–1887," Oblates of Mary Immaculate, Accession 97.109, box 90 (7), item 1995, Provincial Archives of Alberta; C. W. Sanger, "We Are Now in a Splendid Position for Whales: Environmental Factors Affecting 19th Century Whaling in Baffin Bay," *The Mariner's Mirror* 80 no. 2 (1994): pp. 1159–77.

20. Suzanne Zeller, *Inventing Canada: Early Victorian Science and the Idea of a Transcontinental Nation* (Toronto: University of Toronto Press, 1987); Morley K. Thomas, "A Brief History of Meteorological Services in Canada Part 1: 1839–1930," *Atmosphere* 9 no. 1 (1971).

21. This can be accessed at Environment Canada's "Climate Data Online" at http://www.climate.com weatheroffice.ec.gc.ca/climateData/canada_e.html.

22. Archaeological evidence is particularly important in subarctic and Arctic environments, where climate has acted as a major influence upon mobility, settlement, and survival. See Renée Fossett, *In Order to Live Untroubled: Inuit of the Central Arctic, 1550–1940* (Winnipeg: University of Manitoba Press, 2001) for discussion of climate, determinism, and the Arctic, p. 13; Brádzil, pp. 355–56; P. C. Buckland, T. Amorosi, L. K. Barlow, A. J. Dugmore, P. A. Mayewski, T. H. McGovern, A. E. J. Ogilvie, J. P. Sadler, and P. Skidmore, "Bioarchaeological and Climatological Evidence for the Fate of Norse Farmers in Medieval Greenland," *Antiquity* 70 (1996): pp. 88–96.

23. H. Christian Hass, "Northern Europe Climate Variations during Late Holocene: Evidence from Marine Skagerrak," *Paleogeography, Paleoclimatology, Paleoecology* 123 (1996): p. 121.

24. Ladurie, *Times of Feast, Times of Famine*; Rudolf Brádzil, "Patterns of Climate in Central Europe Since Viking Times," G. Wefer, W. Berger, K. -E. Behre and E. Jansen, eds., *Climate Development and History of the North Atlantic Realm* (Berlin: Springer, 2002): p. 355; Christian Pfister, Rudolf Brádzil, Rüdiger Glaser, Mariano Barriendos, Dario Camuffo, Mathias Deutch, Petr Dobrovolný, Silvia Enzi, Emanuela Guidoboni, Oldřich Kotyza, Stefan Militzer, Lajos Rácz, and Fernando S. Rodrigo, "Documentary Evidence

on Climate in Sixteenth-Century Europe," *Climatic Change* 43 no. 1 (September 1999): pp. 55–110; Hubertus Fischer, Thomas Kumke, Gerrit Lohman, Götz Flöser, Heinrich Muller, Hans von Storch, Jörg F. W. Negendank, eds., *The Climate in Historical Times: Towards a Synthesis of Holocene Proxy Data and Climate Models* (Berlin: Springer, 2004).

25. Scott St. George and Dave Sauchyn, "Paleoenvironmental Perspectives on Drought in Western Canada," *Canadian Water Resources Journal* 31 no. 4 (2006); Harold C. Fritts, *Reconstructing Large-Scale Climatic Patterns from Tree-Ring Data* (Tucson: University of Arizona Press, 1991).

26. A. J. W. Catchpole and Irene Hanuta, "Severe Summer Ice in Hudson Strait and Hudson Bay Following Major Volcanic Eruptions, 1751 to 1889 A.D.," *Climatic Change* 14 (1989): pp. 61–79; A. J. W. Catchpole, "River Ice and Sea Ice in the Hudson Bay Region during the Second Decade of the Nineteenth Century," Harington, ed., *The Year Without a Summer?*, pp. 233–44.

27. Catharine Anne Wilson, "Reciprocal Work Bees and the Meaning of Neighbourhood," *Canadian Historical Review* 82 no. 3 (September 2001): pp. 431–64; Terry Crowley, "Rural Labour," Paul Craven, ed., *Labouring Lives: Work and Workers in Nineteenth-Century Ontario* (Toronto: University of Toronto Press, 1995): pp. 13–104; J. I. Little, "Death in the Lower St. John River Valley: The Diary of Alexander Machum, Jr., 1845–1849," *Acadiensis* 22 no. 1 (Autumn 1992): p. 122; Laurel Thatcher Ulrich, *A Midwife's Tale: The Life of Martha Ballard Based on Her Diary, 1785–1812* (New York: Vintage Books, 1990); Winifred Barr Rothenberg, *From Market-Places to a Market Economy: The Transformation of Rural Massachusetts, 1750–1850* (Chicago: University of Chicago Press, 1992); William R. Baron, "1816 in Perspective: The View from the Northeastern United States," Harington, ed., *The Year Without a Summer?*, pp. 124–44; P. Ø. Nordli, "Reconstruction of Nineteenth-Century Summer Temperatures in Norway by Proxy Data from Farmers' Diaries," *Climatic Change* 48 (January 2001): pp. 201–18.

28. For my complete analysis of the diary, see Liza Piper, "Backward Seasons and Remarkable Cold: The Weather over Long Reach, New Brunswick 1812–1821," *Acadiensis* 34 no. 1 (Autumn 2004): pp. 31–55.

29. Jan Golinski, "Time, Talk, and the Weather in Eighteenth-Century Britain," Sarah Stauss and Benjamin S. Orlove, eds., *Weather, Climate, Culture* (Oxford and New York: Berg, 2003): p. 24; Katharine Anderson, *Predicting the Weather: Victorians and the Science of Meteorology* (Chicago: Chicago University Press, 2005).

30. His farm, inherited from the land grant given to his father, was a standard size, somewhere between 70 and 169 acres.

31. These peak years also reflect Benjamin Crawford's attention to anomalous weather.

32. See also Golinski, "Time, Talk, and the Weather," for discussion of the formalizing of 18th-century weather diaries, pp. 22–23.

33. See for example, *Crawford Family Papers*, Benjamin Benedict Crawford Diary 1814–15, January 6, 1813, MS 796, F 709, Archives of Ontario (AO). Hereafter I will cite diary entries with the abbreviation BBC followed by the date(s) referenced in the text. Where I quote directly from the diary I retain the original spelling, although I insert periods and capitals to indicate what would have been separate notes in any daily entry.

34. Kenneth Norrie and Doug Owram, *A History of the Canadian Economy*, 2nd ed. (Toronto: Harcourt Brace, 1996).

35. BBC, August 7, 1821.

36. BBC, March 29, 1815; May 12, 1813; April 11, 1817.

37. Kathryn Carter, "An Economy of Words: Emma Chadwick Stretch's Account Book Diary, 1859–1860," *Acadiensis* 29 no. 1 (Autumn 1999): p. 44.

38. BBC, April 15, 1816.

39. Environmental history in particular because of the wide range of natural as well as social, cultural, political, and economic occurrences that fall within its purview.

40. BBC, June 4, 1812; See also April 27, 1814; May 19, 1813; and June 24, 1814.

41. "On the Climate," *New Brunswick Royal Gazette* 2 no. 29 (September 1816); "The Sun," *New Brunswick Royal Gazette* 2 no. 12 (May 1816); "Spots on the Sun," 2 no. 21 (July 1816). All three articles associated the inclement weather with increased visible sunspot activity—theories that persist within atmospheric sciences. Douglas V. Hoyt and Kenneth H. Schatten, "A Discussion of Plausible Solar Irradiance Variations, 1700–1992," *Journal of Geophysical Research* 98 no. A11 (November 1993): pp. 18895–906; John A. Eddy, "The Sun and Climate, 1790–1830," Harington, ed., *The Year Without a Summer?*, pp. 9–11.

42. The normals can be found in federal government publications such as Environment Canada, *Canadian Climate Normals/Normales Climatiques au Canada 1951–1980, Temperature and Precipitation/Température et Précipitations: Atlantic Provinces/Provinces de L'Atlantique,* vol. 5 (Ottawa: Minister of Supply and Services Canada).

43. A snowstorm would be tallied twice, for example: once as a storm and once as a day with snow.

44. K. R. Briffa, P. D. Jones, F. H. Schweingruber, and T. J. Osborn, "Influence of Volcanic Eruptions on Northern Hemisphere Summer Temperature over the Past 600 Years," *Nature* 393 (June 4, 1998): pp. 450–55; Fagan, *Little Ice Age*, pp. 24, 169; C. Appenzeller, T. F. Stocker, and M. Anklin, "North Atlantic Oscillation Dynamics Recorded in Greenland Ice Cores," *Science* 282 no. 5388 (October 1998): pp. 446–47.

45. See Arthur J. Ray, *The Canadian Fur Trade in the Industrial Age* (Toronto: University of Toronto Press, 1990); Liza Piper, "Harnessing the Wet West: Environmental and Industrial Order on the Large Lakes of Subarctic Canada, 1921–1960," (Ph.D. Dissertation: York University, 2005).

46. For discussion of methodology, see Catchpole, "River Ice and Sea Ice."

47. BBC, April 1, 1817.

48. BBC, January 24, 1817; May 15, 1817.

49. Fleshy fruits are particularly good indicators of weather because it is not only when they ripen, but also their qualities when ready that can indicate the interaction of multiple weather phenomena. See Stommel and Stommel, *Volcano Weather*, p. 41.

50. William Baron argued that it was the crop failures, rather than just the cold temperatures that produced them, that were the source of 1816's notoriety. Baron, p. 132.

51. BBC, September 11, 1816.

52. £12 appears on March 25, 1817.

53. On August 6, 1816 Crawford recorded in his diary that his neighbour Poll Kimble, wife of William, "is said to be Bewichd" and two weeks later Kimble, and possibly another unnamed witch, were killed. (BBC August 18, 1816). Witchcraft persecution in Europe and New England was often linked to unnatural weather and harvest failures. See Wolfgang Behringer, "Weather, Hunger and Fear: Origins of the European Witch-Hunts in Climate, Society and Mentality," *German History* 13 (1995): p. 7; Carol F. Karlsen, *The Devil in the Shape of a Woman: Witchcraft in Colonial New England* (New York: Norton, 1987).

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