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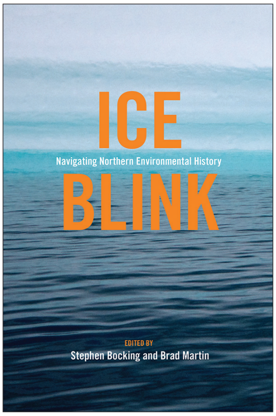

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Toxic Surprises: Contaminants and Knowledge in the Northern Environment

Stephen Bocking

In 2003, Sheila Watt-Cloutier, chair of the Inuit Circumpolar Conference, described her people's reaction to the discovery of elevated levels of contaminants in their bodies: "Imagine the shock, confusion, and rage that we initially felt when evidence of high levels of persistent organic pollutants was discovered in our cord blood and nursing milk in the mid-1980s. … We were being poisoned—not of our doing but from afar." Inuit shock and outrage would eventually energize negotiations toward a global convention restricting these pollutants.[1]

Scientists were also surprised. In 1987, Eric Dewailly, an environmental health researcher, found contaminants in breast milk from women in Nunavik (northern Quebec); this, he recalled, "belied all logic."[2] The following year, a study concluding that Inuit of Broughton Island (then in the Northwest Territories, now in Nunavut) were exposed to contaminants in their food generated intense media coverage and urgent responses from government officials.[3]

These episodes were pivotal events in the history of northern contaminants. They provoked intensive research on their distribution and effects, new environmental and health policies and practices within Canada and in the circumpolar north, and global negotiations. Along the way, the conduct of science in the north was reconsidered and reshaped, as was the relationship between Aboriginal peoples, experts, and governments.

This history echoes several themes in the history of northern Canada. The presence of contaminants exemplified increasing human impacts on the northern environment, and the reality that the region is not isolated from the global environment. Scientists surveyed contaminants in the atmosphere, ecosystems, and species, and sketched their implications for environmental and human health—extending their historical role as interpreters of the north for audiences elsewhere. Official responses epitomized the influence of government administration on relations between humans and the northern environment. Aboriginal communities and institutions asserted their own perspectives on contaminants and food—extending into a new realm the assertion of their right to self-determination.

As we have seen, the discovery in the 1980s of contaminants provoked surprise, implying that this was a novelty. Yet there had been numerous previous instances of contaminants being discovered in the northern environment. Pilots in the 1950s, biologists and toxicologists in the late 1960s and early 1970s, atmospheric scientists in the mid-1970s—all were surprised to find substances that did not "belong" in the region. Contaminants were discovered several times, by separate communities of scientists, often where they did not expect them: in the atmosphere, in ecosystems, and in human bodies. Looking back, these surprises puzzled them: they wondered why, for example, it took so long to connect the presence of contaminants in arctic animals to the risk they may pose to Inuit who eat them.[4] These surprises can also tell us much about northern science. They are hints of what Michelle Murphy has called "regimes of perceptibility"—the combinations of scientific and social phenomena that determine which hazards will be visible, and which will remain invisible.[5] For historians seeking to probe these regimes, contaminants are a useful analytical tool: just as ecologists track the movement of substances to understand the structure of ecosystems, historians can track the movement (and lack of movement) of contaminants knowledge to describe the evolving structure of the scientific community and its relations with other communities, including governments and Aboriginal peoples.[6] Tracking knowledge reveals its uneven distribution among scientific and professional disciplines;

just because some scientists know something does not imply that all do. Instead, distinct strands of knowledge proliferated, linked to evolving disciplines and environmental circumstances.

This history of surprises can also tell us about the influence of ideas about the north. Foremost amongst these ideas is that of a pristine northern environment, protected by distance—a perspective inspired by the historical notion of the north as remote, unknown, and unspoiled.[7] This notion has been remarkably durable; even after a century of incidents of northern contamination, at mines, DEW Line sites, and other locations, it still persisted among scientists, expressed even amidst discussions of arcane technical topics, such as the chemistry of organic compounds or the details of atmospheric dynamics. As one scientist noted in the 1990s, "we are accustomed to regarding the Arctic and Antarctic as remote, unpolluted, and undisturbed areas of the world."[8] Conversely, once northern contaminants became evident, it became seemingly obligatory for scientists to remind their readers that the region was "no longer pristine."[9] Indeed, their presence in the north now carries rhetorical force. In his foreword to *Our Stolen Future*, a 1996 book that presented the dangers of global pollutants, Al Gore emphasized how humans "in such remote locations as Canada's far northern Baffin Island now carry traces of persistent synthetic chemicals in their bodies." Theo Colborn and her coauthors also discussed arctic contaminants in a chapter titled "To the ends of the Earth"—their presence demonstrating that "there is no safe, uncontaminated place."[10] To observers elsewhere, contaminants in the remote north have global implications: if they are there, they must be everywhere.

Contaminants exist at the most intimate scale: in the relations between people and food; and the most expansive: across the circumpolar region, and throughout the planet.[11] They include radionuclides (still present decades after the end of atmospheric nuclear testing), metals such as mercury, lead, and cadmium, and to a lesser extent arsenic and selenium, and persistent organic pollutants (POPs), such as PCBs, DDT, and many other synthetic compounds. Their sources are scattered across the landscape: mines (as John Sandlos and Arn Keeling discuss in their chapter), DEW Line sites, and, in the Russian arctic, discarded nuclear reactors and other relics of the Cold War. A few toxic substances, including metals such as mercury, cadmium, and arsenic, are present in local geological formations, and so are considered "natural."[12]

My focus, however, is on contaminants that originate in distant places, and are transported to the north through the atmosphere. Their ubiquity and extreme mobility make it difficult to place boundaries around them: they do not create contaminated sites that can be avoided, but entire "landscapes of exposure."[13] It is similarly difficult to limit the environmental history of northern contaminants. Like contaminants elsewhere, their presence is the result of diverse causal factors that expand outward from the substances themselves to encompass the global distribution of modern industry and agriculture—from electrical transformers that leak PCBs to farmers that use insecticides. Their history could even extend to Monsanto's marketing department, which after 1929 facilitated the global distribution of PCBs as a useful but toxic industrial chemical, or to Paul Hermann Müller's laboratory in Basel, where in 1939 he demonstrated DDT's insecticidal properties. The presence of these and other substances in the north underlines the role of the political economy of modern industry and agriculture in making their use a seemingly rational choice.

Those who study contaminants have defined their topic in several ways: in terms of international relations, foreign and circumpolar policy, or public health and environmental justice. Contaminants are not only physical matter, but social, political, and cultural phenomena. They raise interesting questions regarding scientific expertise and Aboriginal knowledge and their application to policy development and international negotiations, the definition of acceptable levels of exposure, risk, and uncertainty, and issues of equity, choice, trust, and power.[14]

Insights into contaminants elsewhere can be applied (albeit with care) to the north. From historians of science, we can learn about the place of science in political and regulatory contexts, its evolving disciplinary structure, and the links between scientific knowledge and other ways of thinking about the world. Work on the history of the field sciences is particularly relevant, including studies of the production of reliable knowledge in complex environments, and the relations between science in the field and in the laboratory. In addition, the construction by field scientists of a vertical dimension of the environment—whether downward, in oceanographic or geological research, or upward, in mountain research—presents interesting parallels with scientists' inclusion of the atmosphere as part of the northern environment.[15]

The insights generated by environmental historians can help us interpret the links between knowledge, peoples' actions, and non-human actors, including the atmosphere, animals, and contaminants, while reminding us that however contaminants are understood—as poisons, waste, or pollution—they are historically situated; that is, they are the product of particular ways humans have of organizing the world. Among these ways are the various scales that humans apply when defining a problem, whether as a local, national, or global issue. Each of these scales has political implications. Working with medical historians and historians of science, environmental historians have also considered how to include the human body within the history of the environment. Finally, environmental historians remind us—as Watt-Cloutier did—that these substances have moral implications. They demonstrate the fallacy of assuming that modern industry can be kept separate from the rest of nature, or that we can isolate our own bodies from the changes we impose on the rest of the world.[16]

Research by geographers is also relevant. For example, recent work on the geography of air can illuminate the intersections between institutions, economic activity, and the movement of atmospheric matter. Studies in the historical geography of science can demonstrate the significance of place and movement to the production and application of contaminants knowledge; like contaminants themselves, knowledge about them is located in specific places, and can move.[17] In summary, by applying all these perspectives to the history of contaminants we can achieve a better understanding of two essential themes in northern history: the dynamics of knowledge, both scientific and Indigenous; and the relationships—material, cognitive, and political—between the north and the rest of the globe.

Northern contaminants must also be examined in the context of the region's political and ecological history: the extension of government authority, development of resource industries, emergence of public health and environmental concerns, evolving scientific knowledge, assertion of Aboriginal rights and self-determination, and negotiation of regional and global treaties.[18] Northern contaminants have attracted the attention of many specialists—atmospheric chemists, wildlife biologists, toxicologists, and health scientists—who defined certain features of the north as of particular interest: the atmosphere, feeding relationships between species, and the relationship between Aboriginal peoples and country foods. This history demonstrates the power of scientific disciplines, institutions, and ideologies to shape perceptions of the north. Indigenous people have also developed their own interpretations, relating contaminants to how they understand the landscape, food, and health. The history of northern contaminants thus links with numerous themes in northern environmental history, including Aboriginal perceptions of landscape, as discussed in this volume by Hans Carlson and Paul Nadasdy, and the importance of food, as Liza Piper explains in her chapter. The history of northern contaminants is thus a history of diverse approaches to making sense of the world.

The history of northern contaminants knowledge also exhibits a series of striking transformations—in how they were defined and studied, how their consequences were understood, and whose knowledge about them was considered trustworthy. Contaminants often contradicted expectations. In doing so, they forced scientists, officials, and Aboriginal peoples to reconsider how they understood the northern environment and its relations to the rest of the world. Contaminants provide an opportunity to consider how the north itself is defined: as a place that is distinctive, yet embedded within political and environmental systems that extend far beyond its boundaries. Like climate change (as Emilie Cameron explains in her chapter in this volume), they require historians to consider how to write the environmental history of a globalized Arctic.

Northern Contaminants: First Observations

There were early hints of Arctic contamination. Norwegian explorer Fridtjof Nansen was among the first observers: during his Fram Polar Expedition of 1892–96, he noted dark stains on the ice—possibly, he thought, traces of air pollution.[19] In 1933, Charles and Anne Lindbergh collected samples of spores and pollen during flights over Labrador, Baffin Island, Greenland, and adjacent waters, demonstrating that winds could carry microorganisms (and presumably other particles) as far as the Arctic.[20] However, the first sustained observations of the arctic atmosphere came in the 1950s. During the Cold War, the Arctic became subject to aerial surveillance, and in 1956 J. Murray Mitchell, a climatologist, recorded the observations of US Air Force pilots flying weather reconnaissance missions.

They were surprised to encounter patches of haze hundreds, sometimes thousands of kilometres wide. According to Mitchell's summary, they saw a "grey-blue hue in antisolar directions, and a reddish-brown hue in the direction of the sun"—a visual account illustrating how the haze was of interest solely in relation to flying, navigation, and reconnaissance. He termed it "Arctic haze," signalling that the phenomenon was specific to this region.[21]

As Ken Wilkening has noted, the Inuit word "poo-jok" refers to "mist or haze," indicating, he suggests, an awareness of arctic haze.[22] Northerners have considered haze a familiar phenomenon: "People understand very well how things travel in air … we've always known. In the summer some days the sky gets very hazy in a certain way. It's quite distinctive and elders will comment that there must be a fire in the south. Sometimes we can smell the smoke, last year the smoke from a fire in Northern Manitoba travelled straight up here—we could smell it for days on the wind."[23] However, Mitchell also stressed that arctic haze was only visible from the air, not the ground—a view consistent with the assumption during this era of the superiority of airborne over ground-based observations.[24] Thus, even if Inuit had already perceived this haze, it was only because of the post-war extension of aviation throughout the High Arctic, and the Air Force's concerns regarding pilot vision, that it became "visible"—that is, a phenomenon worth noting in official records.

This was also the era of above-ground nuclear weapons testing by the United States, the Soviet Union, and Great Britain. During the 1950s, awareness grew that, contrary to official reassurances, radioactive fallout could travel long distances. This awareness stemmed from both tragic accidents (such as radiation poisoning suffered by the crew of the *Lucky Dragon*, a Japanese fishing boat, near the March 1954 Bikini hydrogen bomb test), and from observations that strontium-90 from nuclear tests had circled the globe.[25] In 1953, the US Atomic Energy Commission (AEC) launched "Operation Sunshine," a secret effort to track the global distribution of strontium-90. This included the Arctic, where it was found that fallout could descend to earth within a few months, long before decay would have rendered it less radioactive.[26] This and other studies exemplified the expansion of the physical environmental sciences in response to Cold War imperatives, particularly in the strategically crucial Arctic region.[27]

Fallout data, once declassified, indicated that the north received less than did temperate regions. But evidence also accumulated that fallout was not only a global phenomenon; local ecological conditions also determined its consequences. The surprising discovery was made—first, apparently, in Norway—that concentrations in caribou and reindeer of Strontium-90 were higher than in grazing animals elsewhere, even those closer to the sources of these radionuclides. In addition, Eville Gorham, a British botanist, noted the peculiar capacity of lichen—a favoured food of caribou—to accumulate fallout. As he explained, "the chief practical conclusion to be drawn from this work is that animals feeding on mosses and lichens may well exhibit high intakes of radioactive fall-out on this account. In this connection a few reindeer bones from Norway have been shown to contain markedly greater concentrations of radioactive strontium-90 than sheep bones from the same country."[28] By the early 1960s, these observations were indicating the distinctive vulnerability of northern ecosystems and people to radioactive fallout: lichen accumulate fallout, caribou eat lichen, and many northerners eat caribou. Bill Pruitt, a wildlife biologist working on environmental studies associated with Project Chariot, the AEC plan to test the feasibility of excavating a new harbour in Alaska using "peaceful" nuclear explosions, helped publicize these conclusions, and elevated levels of cesium-137 were detected in numerous northern peoples, in Sweden, Finland, and Alaska.[29] Concerns regarding fallout were sharpened in September 1961, when the Soviet Union (followed by the United States) ended a three-year moratorium on atmospheric nuclear testing. In 1963 a study of the presence of cesium-137 in Canadian Inuit was initiated by the Radiation Protection Division of the Department of National Health and Welfare, to determine where Canada sat in relation to studies of other peoples in the circumpolar region.[30] This research concluded that it was below the maximum permissible body burden, and that there was no need to restrict consumption of caribou.

In 1963, with the signing of the Limited Test Ban Treaty, nuclear fallout concerns began to diminish (except for briefly renewed concern in the aftermath of the Chernobyl accident in 1986).[31] What remained was the awareness that contaminants could travel long distances—a lesson that echoed powerfully in Rachel Carson's *Silent Spring*.[32] By analogy with nuclear fallout, it was thought that organic contaminants (such as pesticides) could also be distributed as "fallout," and prominent scientists like

George Woodwell made explicit the parallel between radioactive material and pesticides such as DDT.[33] This perspective provoked global studies of the movement and distribution of pesticides. Among those pursuing this research, Alan Holden, a British scientist, was apparently the first to note the presence of PCBs and DDT in seals in arctic Canada, in the course of a study in Britain, Norway, and northern and southern Canada.[34] He and other scientists considered seals and other marine mammals of particular interest, because they accumulated contaminants in their fat, thereby serving as indicators of environmental contamination. The Canadian Wildlife Service (CWS) also began research: in 1967 biologists working under contract for the CWS in northern Quebec and the Northwest Territories measured DDE (a derivative of DDT) in the fat and eggs of peregrines and thinning of their egg shells, demonstrating that even in the north, this species was affected by pesticides.[35] Fisheries Research Board scientists also became involved, measuring DDT residues in beluga whales from the Mackenzie Delta.[36] Both studies reflected these agencies' interest in expanding their research beyond their traditional focus on resource management, thereby demonstrating their relevance to the federal government's new environmental responsibilities.[37] Canada's role in international arctic science was also a consideration. Gerald Bowes and Charles Jonkel of the CWS measured PCBs in arctic char, seals, and polar bears, confirming that they were found throughout the north, and in increasing concentrations as one ascends the food chain.[38] Their research was a contribution to the Polar Bear Specialist Group of the International Union for the Conservation of Nature—an early effort in circumpolar science and conservation.[39]

In summary, between the 1950s and the early 1970s several northern contaminants issues had attracted attention, including exposure to radioactive fallout and the presence of contaminants in peregrines and polar bears. Changes in how the north was known and experienced also influenced perceptions: the presence of aviators rendered arctic haze visible, fallout studies were provoked by global Cold War concerns, and research by the CWS and other agencies on contaminants signalled the extension of federal authority into arctic environmental affairs. The Arctic also gained a new status: while no longer pristine, it, like a few other remote places, could now indicate the global background level of contamination. The Arctic became a "baseline reference area"—as clean a place as one could find on a now-polluted planet, and a necessary station in international monitoring networks.[40]

Each of these phenomena: haze, fallout (especially its concentration in caribou and reindeer), and DDT, surprised those who had assumed the Arctic was pristine. But eventually, the concerns provoked by each dispersed. Haze seemingly had no implications for the environment or human health, and so remained only a scientific curiosity. The Limited Test Ban Treaty and restrictions on DDT eliminated any sense of urgency regarding fallout and pesticides. While contaminants in the Arctic (and in the Antarctic, and other remote places) remained, they were present in lower concentrations than elsewhere. Environmentalists and other observers turned their attention to more immediate northern issues, including resource development and proposals for pipelines and oil tankers. A new generation of Aboriginal leaders focused on land claims and authority over wildlife and renewable resources. Research and regulation shifted accordingly.

The Atmospheric Arctic

In 1972, Glenn Shaw, a scientist at the University of Alaska, was surprised to observe that the supposedly pristine air above Barrow was less clear than expected; in the language of atmospheric physics, he recorded high "atmospheric turbidity." Subsequent observations during flights over the pack ice north of Barrow confirmed that it took the form of distinct layers of brownish-yellow haze—just as, Shaw noted, Mitchell had recorded nearly two decades before.[41]

Shaw reinterpreted Mitchell's observations in terms of his own discipline. To an atmospheric physicist, turbidity didn't mean impaired flying conditions, but the presence of aerosols—tiny suspended particles. Scientists had been studying these for a long time, even before the era of environmentalism: tracking dust swept aloft from deserts, ejected from volcanoes (like Krakatoa in 1883), and blown away in the American Dust Bowl of the 1930s.[42] During the early Cold War, these studies were sometimes linked to strategic concerns: for example, Harry Wexler of the United States Weather Bureau published his studies of volcanic dust even while pursuing classified research on the dust swept aloft by nuclear explosions.[43]

Wexler's research exemplifies how atmospheric research done for strategic purposes, including meteorological studies of particle transport and distribution, would eventually have implications for understanding northern contaminants. However, much of the study of the movement of material in the atmosphere remained focused on "natural" sources—as reflected, for example, in the discovery in the 1960s that desert dust from Africa could cross the Atlantic.[44]

Shaw accordingly evaluated arctic haze in the context of studies of the intercontinental movement of dust, applying techniques to determine its origins that were similar to those of his colleagues elsewhere. These included meteorological maps of the movements of continental air masses, and chemical analysis of the material itself. A particle has a chemical "signature" (a distinctive elemental composition) that can indicate whether it is, say, desert dust, or the product of combustion—that is, pollution. At first, he and his collaborator, Kenneth Rahn of the University of Rhode Island, interpreted arctic haze as a natural phenomenon—it was dust from Asian deserts. But then it turned out that this conclusion was the product of a chance occurrence: they had collected samples after a storm in Asia had blown unusual quantities of dust into the atmosphere.[45] In 1977, new samples indicated vanadium, manganese, aluminum, and sulfates, suggesting industrial sources.

Shaw and Rahn also realized that what they were describing was not simply a northern instance of a global phenomenon. Arctic haze had properties distinct from those of haze elsewhere; to scientists, it seemed to "break all the rules."[46] For one thing, it was a complex mixture, formed predominantly from sulfates, as well as graphitic carbon, organic compounds, several metals, and carbon dioxide, methane, and carbon monoxide.[47] It also had a distinctive seasonal pattern, occurring only in winter and spring, not summer. And finally, arctic haze particles were transported at lower elevations than was typical in the south.[48]

This material distinctiveness found a parallel in a distinctive research community that emerged during the 1970s and 1980s. Besides Shaw and Rahn, an early member was Len Barrie of the Atmospheric Environment Service at Environment Canada. An informal Arctic Chemical Network formed, which, like arctic haze itself, covered most of the circumpolar region, including the United States, Canada, and Scandinavia (but not the Soviet Union). They organized a series of conferences on arctic air chemistry, as well as cooperative research, including three Arctic Gas and Aerosol Sampling Programs (in 1983, 1986, and 1989), which tracked the movement of the aerosols that constituted haze from Eurasia across the Arctic to Canada and Alaska.[49] While this was an interdisciplinary community—mainly meteorologists, atmospheric chemists, and physicists—they focused almost entirely on the atmosphere. And while they often noted that the ecological consequences of arctic haze were worthy of study, in practice these received very little attention.[50] This reflected the power of disciplinary boundaries: these consequences only became evident when contaminants left the atmosphere—at which point they were of less interest to atmospheric scientists.

With its focus on the atmosphere, the arctic haze research community eventually moved out of step with developments elsewhere. By the late 1970s, atmospheric contaminants, reconceived as Long-Range Transboundary Air Pollution (LRTAP), had emerged as a major international concern thanks to the newly acquired notoriety of acid rain, as well as an emerging awareness that the atmosphere was a source of contaminants affecting the Great Lakes and other ecosystems. Arctic researchers shared in the resources that now became available for atmospheric science: they tied their studies to work in the Great Lakes (the most active region for Canadian contaminants research), and the Canadian Network for Sampling Precipitation collected samples of snow and surface water on Ellesmere Island. But acid rain was not really an issue in the north, and neither were other prominent sources of pollution: metal smelters, coal plants, the Alberta tar sands, or motor vehicles. For arctic researchers, particulates remained a scientific matter—intriguing, and a way of understanding the movement of continental air masses, but remote from the environmental and health issues motivating scientists elsewhere. As scientists later recalled, in the 1970s the detection of contaminants in the north "was generally regarded as little more than a curiosity."[51] This was also reflected in the focus on elements like vanadium—not significant in terms of toxicity, but relevant to scientific questions, such as the origins of contaminants and the mechanisms by which they travel to the Arctic. It is not surprising, then, that arctic haze research did not lead to significant political initiatives, such as an international agreement; this was consistent with the nature of the phenomenon and of the scientific effort devoted to it.[52]

Persistent Pollutants

In the late 1980s a new phase in arctic contaminants research began. Instead of examining the stew of disparate substances that together formed arctic haze, research focused on a single category of synthetic chemicals: persistent organic pollutants (POPs, also referred to as organochlorines). This research was tied to developments elsewhere: the global political economy of chemicals, and environmental and health concerns in affected regions, such as the Great Lakes. Their presence in both the environment and in political affairs testified to the status of POPs as a category defined in terms of both science and policy.[53]

The environmental history of POPs is the product of both their intended characteristics (including their persistence) and their unintended behaviour once released. They can be classified in terms of purpose into three main categories (see Table 12.1). PCBs were among the first, introduced in 1929, and used in electrical equipment virtually everywhere. They were followed by thousands of other synthetic chemicals. Many were pesticides, with DDT only the most notorious. Other substances, including dioxins and furans, are waste products of combustion and industrial processes. Given enough time, POPs can travel everywhere, and do not depend on the meteorological processes that had been of interest to those studying arctic haze. By the mid-1960s, they were found everywhere on the planet. Eventually some became subject to bans or stringent regulation: the insecticide hexachlorobenzene in 1965, DDT in numerous countries in the early 1970s, aldrin in the United States in 1975, PCBs in Europe and the United States in 1976 (1977 in Canada), and dieldrin, another pesticide, in the United States in 1984. POPs continue to be used in many countries; some pesticides still evaporate from the soil in areas where they were once, but are no longer, used; and novel chemicals continue to be invented and released (deliberately or accidentally) into the environment.

By the mid-1980s, these substances had become a focus of concern regarding their often-insidious consequences for health, even in minute concentrations. Graphic images—deformed fish in the Great Lakes, and abnormal sexual development in amphibians, for example—captured attention, as did the arguments of those who urged action, including Theo Colborn, co-author of *Our Stolen Future*.[54] These concerns were reinforced by the emerging view, expressed in Carson's *Silent Spring*, that the health

Table 12.1: Categories of Persistent Organic Pollutants (POPs).

Category of Use	Examples
Compounds for industrial applications	PBBs (polybrominated diphenylethers), PCBs (polychlorinated biphenyls), PCP (pentachlorophenol)
Compounds for agricultural applications (e.g. pesticides)	Aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, HCB (hexachlorobenzene)
Unwanted by-products of chemical production processes (e.g. incineration)	Polychlorinated dioxins, polychlorinated furans, PAHs (polycyclic aromatic hydrocarbons)

Source: R. Kallenborn, "Persistent Organic Pollutants (POPs)" in: *Encyclopedia of the Arctic*, ed. M. Nuttall, (New York: Routledge, 2005), Vol. 3, 1622-1624.

of bodies is tied to the health of their surrounding environments, undermining the modernist view of health as strictly a matter of protecting individual bodies from external pathogens.[55]

Concerns about chemicals in the industrial heartland eventually reached the Arctic. Evidence of their presence was, in part, the product of sampling networks mainly based in the south, but some studies also addressed specific northern concerns. Surveys of their distribution across the north helped demonstrate, in combination with other evidence, that they did not come from local sources.[56] By the late 1980s, there had been extensive surveys of contaminants across the arctic environment: in the atmosphere, snow, plants, and animals. Favoured species received particular attention: in particular, scientists examined polar bears (killed by Inuit hunters) throughout the Northwest Territories in an effort to identify effects on their health.[57]

But these surveys did not explain the larger puzzle: these chemicals seemed to be everywhere in the Arctic, in quantities that suggested there was some sort of mechanism—almost a conveyor belt, it seemed—facilitating their movement north from industrial centres. This notion had, in fact, been mentioned before. In 1973, Max Dunbar, the McGill University oceanographer, had noted the "rule of the cold wall"—that volatile substances such as pesticides evaporate, and then condense and concentrate in cold places. And in 1975, E. D. Goldberg coined the term "global distillation" to describe this process of evaporation and condensation, re-conceiving the global atmosphere as a laboratory experiment.[58] The result, as the Norwegian scientist Brynjulf Ottar noted in 1981, was a "systematic transfer of the more persistent compounds from warmer to colder regions," so that "the Arctic is a region where a general accumulation of partly volatile pollutants may be expected."[59]

In the late 1980s, a few scientists, including Don Mackay of the University of Toronto, applied these ideas to the presence of chemicals in the Arctic. Since their movement in the atmosphere could not be observed directly, Mackay and his colleagues constructed models of how they expected them to behave. These models were simplified descriptions of nature: they represented the atmosphere as a few compartments, each described in terms of a few characteristics, such as temperature. By combining these models with knowledge of the chemicals' properties (such as their tendency to evaporate at various temperatures), scientists could predict how and where they should move. These predictions could then be compared with their actual distribution. When predictions and data matched, scientists could be confident that the models were describing the chemicals' actual behaviour.

These models exemplified how contaminants research was changing; they were a way of bringing together previously distinct forms of knowledge—about global air movements, and the behaviour and distribution of chemical molecules—to form a synthetic explanation of their presence in the Arctic. Thus, by combining in a novel way what was already known about these substances, new knowledge was created. New disciplines also now became defined as relevant to understanding contaminants: meteorologists and atmospheric chemists were joined by modellers, toxicologists, marine ecologists, and wildlife biologists, while new techniques—and knowledge of additional aspects of the Arctic environment, such as marine ecology and caribou biology—were called upon to help make sense of their presence, movement, and ecological consequences.[60] In all these ways: techniques, disciplines, and the phenomena themselves, the study of POPs broke from studies of arctic haze. These substances also displaced arctic haze as the focus of arctic contaminants research.

As these models demonstrated, POPs demonstrate a distinctive behaviour in the atmosphere, reflecting characteristics of the substances themselves. They evaporate when it is warm, and condense on surfaces when it is cold. They may repeat this cycle several times, as winds carry them toward the north, finally being deposited where it is too cold to evaporate again—in the Arctic. The more volatile a substance, the more readily it travels north. Scientists referred to these cycles of evaporation and deposition as the "grasshopper effect," and deduced that they could account for both the observed delay between the release of chemicals in the south and their appearance in the north, and their substantial presence in the region.[61]

The grasshopper effect meant that the north was peculiarly vulnerable to these chemicals. While they could travel anywhere, they tended to condense and concentrate in the north. The region was now a "sink," actively attracting contaminants. Once there, the cold, diminished biological activity, and lack of winter sunlight allowed them to persist longer without breaking down. Arctic animals were also distinctively vulnerable: large marine mammals, near or at the tops of food chains, with ample body fat, readily accumulated these contaminants. (And, looking to the future, climate change may, for a variety of reasons, magnify these impacts.)[62] In effect, therefore, the Arctic became not just a passive receptacle for contaminants but an active agent in their environmental history, adding thereby a regional complication to their global distribution. However, they would only become a political priority to the extent that they had implications for humans.

The Unhealthy Arctic

A striking feature of this research was its inattention to humans. In hindsight, this is puzzling—as scientists themselves later noted. Contaminants were known to concentrate as they moved up the food chain. Inuit were involved in the research; they often provided the wildlife samples used for analysis; and their position at the top of the food chain as hunters was obvious. Given the history of synthetic contaminants production, it can be assumed that northern people have been exposed to them since at least the 1960s. However, only in the 1980s were these connections made. Why was there such a delay? Evidently, the scientific disciplines and policy agencies involved in contaminants research shaped a particular regime of perceptibility that drew attention away from risks to humans—in effect rendering invisible some of the implications of the use of country foods.

A new regime of perceptibility began to emerge once official agencies and their scientific experts began to consider Aboriginal use of country foods on its own terms, and not simply as a vestige of a disappearing traditional lifestyle. As Liza Piper discusses in her chapter in this volume, federal and territorial governments have long included food and nutrition as part of their responsibility for Aboriginal health and wellbeing; from this stemmed their initial actions regarding food and contaminants. Extensive nutrition surveys in the 1960s and 1970s provided the foundation for harvest surveys in the 1980s, which showed that Aboriginal communities still relied on wildlife for food. Information about the contaminant content of northern food species had also been assembled. There was clearly a potential risk. But to fulfill their administrative responsibility, a formal risk assessment had to be done. This required specific information: how much contaminants were being consumed, in what foods, and with what consequences in terms of the presence of contaminants in human bodies. With this information, officials and health scientists could compare exposures to generally accepted allowable limits, and advise people accordingly.

Because this was novel territory for northern medical experts, a pilot study was deemed necessary. In 1985, the community of Broughton Island was chosen, as harvest data had indicated that it had the highest per-capita consumption of country foods in the Baffin Island region. After conducting dietary surveys and analyzing samples of the food types reported in these surveys, as well as samples of blood and breast milk, David Kinloch, the regional medical officer, and Harriet Kuhnlein, an experienced scholar of Aboriginal food and nutrition, were surprised to find that a significant fraction of the population consumed more than the acceptable daily intake of PCBs, or had levels in their blood above "tolerable levels."[63] These PCBs came mainly from eating narwhal.

In 1985, meanwhile, a province-wide survey of PCBs and other contaminants in breast milk was getting under way in Quebec. It was a response to concerns in industrial centres, not the north; in fact, no northern communities were included, as it was assumed that they were not affected. However, Eric Dewailly, a health scientist based in Quebec City, was given an opportunity to include samples from a community in Nunavik. He thought they would serve as useful "blank" controls—that is, samples without contaminants—but to his surprise they indicated levels of PCBs five times those recorded in southern Canada. At first, he suspected the samples had been contaminated in the lab.[64] This reaction stemmed from distance—both geographic (the community was far from obvious sources of contaminants), and intellectual (he was unaware that scientists were already studying contaminants in the Arctic). To make sense of this discovery, he would need to shorten this intellectual distance by reaching beyond his medical training and studying the ecological literature.

As I noted at the start of this paper, these surprises attracted a great deal of attention. Kinloch and Kuhnlein's study received front-page coverage in the national media.[65] Several factors—some specific to the north, others of more general significance—had converted a scientific result into a public health crisis. Inuit themselves felt shock (as Watt-Cloutier emphasized), and because of anxiety, some reduced their consumption of country foods, with unfortunate consequences.[66] The special vulnerability of women and infants made it an issue of gender and environmental justice. Contamination of northern wildlife also contradicted the federal government's legal obligations to Aboriginal peoples, including their rights to hunt and to consume country foods.[67] The then-recent Krever Inquiry, instigated in response to a scandal regarding contaminated blood, had sensitized the public to federal responsibilities regarding the protection of the purity of the nation's blood supply; it was noted that the federal government had an analogous responsibility to Aboriginal people to ensure their safe access to uncontaminated country foods, with failure to do so implying potential legal liability and a requirement for compensation.[68]

Beyond the north, contaminants had, of course, become a matter of general concern, and news of their presence in the Arctic—still widely considered to be pristine—accentuated perceptions that no place was immune. The Canadian Arctic Resources Committee, together with environmental organizations active in the Great Lakes and other contaminant-rich regions, helped focus attention on the issue.[69] Acid rain and ozone-layer depletion made tangible the idea that pollution was a long-distance and not simply a local issue (just as nuclear fallout had at the time of *Silent Spring*). And finally, the public and governments were receptive to an issue that involved the environment and Aboriginal people. The Brundtland Commission in 1987 and the run-up to the 1992 Earth Summit made the environment a political priority; for various reasons, Aboriginal issues had also become prominent in Canada. Thus, through scientific and political developments, in both the north and elsewhere, northern contaminants were "discovered"—that is, they became not just a northern, but a national issue.[70] Knowledge previously held within the north, and within a limited professional community, now flowed beyond the region.

The federal government responded by redefining the contaminants issue in terms of its administrative structures. This had begun even before it became an issue in the media. In 1985, a Technical Committee on Contaminants in Ecosystems and Native Diets was assembled, composed of federal scientists and science managers from four federal departments and the Northwest Territories government. This committee was eventually expanded to include representatives from five northern Aboriginal groups. Much of its attention focused on Kinloch and Kuhnlein's results from Broughton Island.

More research was also underway—reflecting, as did the formation of the technical committee, an effort to define the issue as a scientific matter. Studies sought a link between country foods and exposure to contaminants, as evaluated by comparing an individual's diet with his or her contaminant burden. During the late 1980s, surveys in Inuit communities across much of the north accumulated evidence of high levels of contaminants.[71] Scientists also found contaminants throughout the northern environment—in the atmosphere, surface water, and living organisms, evidence that the atmosphere was a pathway by which these substances entered northern food chains.[72] Aboriginal peoples initiated research: reflecting a broadening of concern beyond Inuit, Dene and Métis communities requested studies of contaminants in their food, including fish from the Mackenzie River downstream of Norman Wells.[73]

By 1990, research on contaminants had shifted from studies of their presence in various arctic species to a focus on how people encountered them, particularly through food—their most immediate link with their environment. The meaning of northern contaminants was shifting from being a chemical and ecological, to a human health and cultural issue. A view of the north as a region distinctively vulnerable to contaminants was also emerging. However, this view was not uniform across the north. Marine mammals—specifically, narwhal, beluga, and walrus—emerged as the main sources of contaminants. These are a more important part of the diet in the eastern than the western Arctic. This implied a new geography of exposure, introducing a human dimension to the mapping of northern contaminants.

By 1989, preparations were underway to build on this emerging view of northern contaminants. The Department of Indian and Northern Affairs organized two workshops to synthesize information and plan a more integrated research strategy; this would eventually become the basis for the Northern Contaminants Program (NCP).[74] Funding became available through the Green Plan (an initiative intended to demonstrate the federal government's environmental commitment). The Arctic Environmental Strategy was one component of the Green Plan, and it, in turn, provided funding for the NCP. It ran from 1991 to 1997, with funding of $5 million per year. Renewed in 1997, its second phase continued until 2003.[75] The program then began a third phase, at a lower level of support.

The NCP represented an effort to redefine a politically difficult issue in terms of both administrative and scientific priorities. It would do so by replacing individual research efforts with a more systematic approach that could provide an overview of contaminant movements from the atmosphere, through ecosystems, to people, as well as specific advice regarding food and health. This involved several challenges, some of which were inherent in interdisciplinary research, or in community-based research, or stemmed from diverse views of food, hazards, and knowledge. To understand how the NCP developed, we can begin by examining these challenges.

Studies involving humans required a combination of toxicological, medical, and social expertise and sensitivity entirely unlike that required by studies of contaminants in wildlife. It required novel areas of research, including the social, cultural, and nutritional importance of country foods. There were also challenges encountered in communicating between scientists and non-scientists, including translating technical terms and working out protocols and expectations for community-based research.

Other challenges were more specific to the north, its history, environment, and communities. Scientists and northerners had distinctly different ideas regarding nature, health, and knowledge. The scientific understanding of the effects of contaminants—as subtle, long-term, and invisible—challenged Aboriginal perspectives on food safety, which did not involve these characteristics. Other differences were apparent in views of how knowledge of contaminants should be applied to decisions regarding food and health. Scientists trained in the south were guided by ideas about risks, which, it became evident, were not appropriate in northern communities. Conventional risk analysis (as was employed on Broughton Island in the 1980s) involves several steps: determining the toxicity of the contaminant and possible pathways of exposure, evaluating potential risks, and then managing these risks through consumption advisories (advice on what foods should or should not be eaten, by whom, and in what quantities). This process defines contaminants as a biophysical phenomenon, to be understood in terms of scientific descriptions of substances and hazards, with advice formulated by experts and based on rational analysis of risks and benefits. It relies on several assumptions: that the boundary between bodies and the environment is clearly defined, that individuals can act autonomously in response to advice, and that knowledge of health consequences will be the determining factor in individual actions.

None of these assumptions were valid in the north, given the importance of country foods, the lack of alternatives, and controversies over risk communication. Individual and community health are considered inseparable from country foods—encouraging a reluctance to believe they could be unhealthy; as one Inuk explained, "Country food is preventing you from diseases. Therefore it is a medicine. When you are sick and you are trying to gain back your strength, you eat country food. It's your medicine."[76] The importance of country foods—nutritionally, economically (given the expense of imported foods), and socially (through their contribution to community relationships), as well as the ethical ties between people and wildlife—contradicts the view of health as a characteristic of individual bodies. Disruption of traditional community lifestyles has its own consequences, illustrating how the effects of contaminants are not limited to direct toxicity. And although Aboriginal people had no experience with substances such as PCBs or DDT, hunters able to draw on their own experiences and their community's traditional knowledge are intimately aware of where their food comes from, and pay close attention to its quality. As one hunter explained, "When you've been working with caribou all of your life you just know when it is healthy."[77] They rely on concrete, visual forms of evidence, such as spoiled food, garbage, or parasites.[78] This reflects a particular view of what counts as reliable knowledge; protection against unhealthy meat requires careful observation and checking (for example, for parasites), while monitoring the overall health of wildlife. This knowledge has several dimensions: cultural (ideas about health and how it relates to the environment), social (the importance of hunting and sharing food), political (defining who has authority to make decisions about food and animals), and epistemological (the reliability of sensory evidence).[79]

It is helpful to place in historical context this distinction between scientific and Aboriginal perspectives. As Linda Nash and other scholars have argued, roughly a century ago a shift occurred in ideas about the relationship between health, landscapes, and bodies. Health had been seen as a characteristic shared by a landscape and the people living in it.[80] A healthy place could ensure healthy people; accordingly, as Gregg Mitman has described, certain places—mountains or deserts, for example—became noted as health resorts.[81] Conversely, illness was linked to an unhealthy environment. But this view was eventually displaced by a modernist perspective that discounted local environments, focusing instead on individuals. Guided by germ theory, health became defined as the absence of disease, landscapes served only as neutral spaces occupied by harmful agents (germs, poisons, contaminated food), and the function of medicine was to protect bodies from these agents. Health expertise no longer implied an understanding of local landscapes, but a mastery of lab-based, universally applicable knowledge.

This modernist perspective on health was applied widely in the postwar north: through efforts to reduce Aboriginal peoples' reliance on country foods in favour of vegetables and other "southern" food, to apply the advice of nutritional science (as Piper discusses in her chapter in this volume), and to extend modern medical expertise into northern communities, backed up by transfers to southern hospitals. This represents, as Nash has noted, the project of modernity: erasure of local environments and their recreation as homogenous, controlled space.[82]

Given these contrasting views, a research program on contaminants satisfactory to all parties would require considerable negotiation. The challenge was exacerbated by a history of difficult relations between government officials, scientists, and northerners—the product of a colonial relationship and of scientists' failures to consult while attempting to manage Aboriginal relationships with northern wildlife.[83] One result of this history has been Inuit skepticism toward scientists' claims about contaminants—perhaps, some thought, this was merely another strategy to discourage hunting.[84] Distrust was further exacerbated when the

Department of Indian and Northern Affairs initially excluded Aboriginal leaders (as well as the media) from meetings about the Broughton Island situation.[85] Yet these difficult circumstances also made a socially responsible research program all the more essential; only then would those affected by contaminants accept advice from experts or government officials.

The Northern Contaminants Program

The NCP thus took form amidst distrust and uncertainty. Planning research that addressed both scientific and community priorities required extensive consultations and workshops. Researchers and communities gained considerable experience in collaborating. There were ample precedents to draw upon, including the work of the territorial science institutes, which licensed researchers and administered ethical guidelines for the conduct of research, including requirements relating to conduct, participation, and communication. In 1994, a new concept of practice was implemented known as "responsible research."[86] Responsible research became one aspect of the distinctive nature of northern contaminants research, exemplifying its new social relations.[87]

The NCP involved a wide range of research activities on a range of topics corresponding to the ecological and human systems relevant to the movement and effects of contaminants. However, the NCP also had objectives beyond research. These included building the capacity of Aboriginal organizations and communities to evaluate evidence and to make decisions about contaminants and other environmental factors. In addition, because it presents its own challenges in northern communities, communication became a discrete research area, with a focus on strategies to communicate effectively to various audiences. This work was guided by the view that scientific and Indigenous knowledge, applied through community-based research and consultation that considers local customs, cultures, and ways of life, could together provide the basis for advice regarding food consumption. As one research group explained, "it has been most effective for local public health authorities working in concert with the community at risk and experts from a variety of disciplines to develop risk reduction strategies that address the risks and benefits components of each specific concern."[88] This included study of the ways and means of dietary advice, such as the value of positive options: instead of banning consumption of one species, consumption of an alternative food could be encouraged. When exposure to contaminants is greater than recommended, people are not immediately advised to alter their diets, but instead are provided with the information required so that they themselves might evaluate the risks in relation to benefits of traditional foods.[89]

In the second phase of the program, beginning in 1997, research emphasized the human dimensions of contaminants, with substantial community involvement in setting priorities, conducting research, communicating, interpreting, and applying results. Northern contaminants research gained a distinctive regional character by acknowledging its social and cultural dimensions. This included enabling Aboriginal people to help determine research priorities and allocation of research funding—a feature that likely makes the NCP unique among federal research programs.[90] The political significance of these dimensions became evident in the fact that this research was the only part of the Arctic Environmental Strategy to continue after 1997, with human dimensions remaining central to the program throughout its third phase (2002–08).[91]

The NCP was also an effort of synthesis. In 1997, both the NCP and the Arctic Monitoring and Assessment Programme (to which the NCP contributed) published extensive assessments combining knowledge from within and outside the region, and linking the scientific and social dimensions of contaminants. But the NCP's synthesis function extended beyond assessment reports. Synthesis—bringing together knowledge of disparate parts of nature and society—was also evident in the program's organization. A complex management structure was constructed, far more elaborate than the model of the individual researcher, which brought together scientists of various disciplines, managers, and Aboriginal organizations.[92] Synthesis was also evident in the formation of institutions that enabled new combinations of expertise. The Centre for Indigenous Peoples' Nutrition and the Environment, established in 1992 with funding from the Arctic Environmental Strategy and the NCP, focused on diet-related research conducted through collaboration with Aboriginal peoples. This centre represented a novel approach to the organization of northern research—independent of government, and with leadership provided by Aboriginal people. During the 1990s, it conducted three large, participatory studies of the risks and benefits of contaminants and country foods in more than forty northern communities.[93] Another institution combining disciplines in a novel way was (and still is) the environmental health research group at Université Laval's Public Health Research Unit, which includes researchers in community medicine, epidemiology, toxicology, nutrition, psychology, and anthropology.[94]

However, synthesis and new ways of studying and acting on contaminants were most evident in the formation of new objects of research and practice. Periodically in the history of science a new object is constructed, which becomes a template for the organization of nature, research, and practice.[95] One such object in northern contaminants research was the pathways by which contaminants travel to humans. This included the mechanisms by which contaminants move from their origins, through the atmosphere and ecosystems into country food species, reaching humans through the harvesting, sharing, and consuming of food. This object implied a shift in research effort: less emphasis on ecology, and more on medical and toxicological science, and the community dimensions of food. This object also underlined the specifically northern character of NCP research: for example, it encompassed the specific mixtures of contaminants that enter these pathways in the north; and it also corresponded to the focus of the Centre for Indigenous Peoples' Nutrition and the Environment.

A second research object related even more directly to the dual biophysical and social dimensions of northern risk assessment. This object, the "Arctic Dilemma," emerged in the late 1990s as a way of referring to the fact that while country foods provide essential benefits, they are also the primary conduit of exposure to contaminants.[96] It thus expressed a regionally specific version of the challenge of risk assessment: determining the appropriate balance between benefits and hazards. When contaminants were seen as a strictly biophysical phenomenon, they could be understood in terms of global mechanisms of atmospheric transport and ecosystem behaviour. Once, however, attention focused on how humans exposed to contaminants actually think about them, they became a dilemma—a local issue, situated within Aboriginal communities and the spaces in which food is hunted and consumed. As such, the Arctic Dilemma is a hybrid concept: it combines environmental and social dimensions, scientific and Indigenous perspectives, and general and local knowledge. It is also an administrative concept, framed in terms of northern government jurisdiction. Resolving the Arctic Dilemma requires consideration not only of the type, amount, and nutritional value of foods, but of their social, cultural, economic, and spiritual benefits, and appropriate ways of communicating and developing options for communities.[97]

Shaping the NCP

The NCP was framed in terms of science and Aboriginal perspectives, and the specific character of each in the northern context. It was also a federal administrative initiative. To understand how and why the NCP took the form it did, we need to examine the influence of all three factors.

Consistent with its position in northern environmental affairs, science has been central to the NCP. One major role of scientists has been as a conduit for knowledge and experience from outside the region. By the late 1980s, health scientists elsewhere had accepted that effective research required that communities gain a sense of ownership over it, by participating at all stages, and with the research considering not just the biophysical, but all dimensions of the environment and health, including well-being and not merely absence of disease. This view developed through experience: a study in the late 1970s and early 1980s of mercury exposure in Canadian Aboriginal communities, as well as the Effects on Aboriginals from the Great Lakes Environment (EAGLE) project, had demonstrated the importance of the indirect health effects of contaminants, such as reluctance to consume traditional foods.[98] Thus, the NCP's distinctive northern approach to contaminant research can also be traced back to national studies.

Scientists also brought to the NCP ideas about how to combine knowledge from the north and elsewhere, and from diverse disciplines. Perspectives on health in northern communities have been based not only on observations in the north, but on information obtained elsewhere, such as from laboratory studies and accidental exposures.[99] However, this information was not necessarily directly applicable to specific northern conditions, thus necessitating studies in the region itself.[100] In several ways, the Arctic presents unique circumstances: a distinctive mixture of contaminants, chronic exposure to relatively low levels of contaminants, nutrients in arctic seafood that may affect its toxicity, human genetic variability, and diverse socioeconomic and lifestyle factors, such as seasonal patterns of food consumption specific to the Arctic. As Dewailly and Furgal noted, the "specificity of the Arctic situation raises the question: to what extent can results and conclusions from epidemiological studies conducted outside the Arctic apply to this region."[101] Knowledge of arctic contaminants therefore had to combine knowledge from elsewhere with knowledge from within the region, with scientists working out this combination. Evaluating the risks and benefits of country foods also means bringing together previously separate research communities: atmospheric chemists and ecologists studying the long-range movement of contaminants and their distribution in the environment; health scientists and toxicologists examining the implications of contaminants for humans; and social scientists involved in research in northern communities. This presented challenges, such as how to balance the uncertain risks described by toxicology against the certain benefits outlined by nutritional science.[102]

But beyond its scientific dimensions, the NCP was above all a federal administrative initiative—part of the long history of such initiatives in the north. It was also the federal government's chief political response to the northern contaminants controversy. It was designed in relation to federal jurisdictional mandates over the environment and human communities in the two northern territories (three after 1999, with the creation of Nunavut). It also defined "contaminants" quite specifically: as substances that had been transported long distances to the north. These were distinct from "waste": namely, unwanted substances originating from within the north itself. The NCP thus excluded local issues such as drinking water quality and cleanup of DEW Line sites.[103] Overall, as an effort to relate scientific activity to federal jurisdiction in the region, the NCP exemplified the co-production of the scientific and political dimensions of a research area.[104]

The NCP's status as a federal program was also apparent in its international role. Federal jurisdiction included all foreign, including circumpolar, affairs. By the late 1980s, contaminants were becoming a circumpolar issue thanks both to new scientific information and to improved prospects for arctic cooperation with the thawing of the Cold War and dissolution of the Soviet Union.[105] Circumpolar initiatives were reinforced by the view of the Arctic as a distinct place facing a distinctive challenge from contaminants.[106] Arctic Monitoring and Assessment Programme studies showed that Indigenous people, and particularly those who consume marine mammals, were among the most exposed to POPs of any people on earth. Other organizations, such as the Northern Aboriginal Peoples' Coordinating Committee on POPs, also urged recognition of the Arctic, and arctic people, as distinctively vulnerable to POPs.[107] Through such initiatives, POPs gained an identity not only as scientific entities, defined in terms of chemical characteristics and environmental behaviour, but as a political concept—the end-products of activism and negotiation through which the "dirty dozen" POPs were identified as a collective priority.[108] Through the Stockholm Convention, POPs also became both a global issue and one situated in a specific region, with the Convention mentioning only one region—the Arctic—as facing specific risks. In effect, a regional perspective on contaminants became globalized.[109]

The Canadian government both responded to and led international actions on contaminants. Canada participated in negotiations that led to the Declaration on the Protection of the Arctic Environment (signed by eight arctic nations in June 1991) and the creation of the Arctic Environmental Protection Strategy, and co-chaired with Sweden the United Nations ECE Task Force on Persistent Organic Pollutants. The regional Protocol on Persistent Organic Pollutants (the "Arhus Protocol") was adopted in 1998, followed by the global Stockholm Convention, which was adopted on 22 May 2001, with Canada becoming the first nation to ratify it the following day. Canada's international leadership was largely facilitated by the NCP, which gave it the necessary scientific capacity. The NCP also provided Canada's chief contribution to the Arctic Monitoring and Assessment Programme, a component of the Arctic Environmental Protection Strategy.[110]

In addition to scientists and the federal government, Aboriginal communities and organizations helped shape the NCP. One way they did this was by asserting alternative perspectives on contaminants, and thus orienting the NCP toward human health.[111] Their coalition, Canadian Arctic Indigenous Peoples Against POPs, also asserted the definition of contaminants as both a northern and an Aboriginal issue. And, as I noted at the beginning of this chapter, Aboriginal representatives, led by Watt-Cloutier, became a powerful voice urging application of NCP results to the pursuit of environmental justice at the Stockholm negotiations—engaging, in effect, in "scale jumping" by transforming a local concern into a global challenge.[112] Community interests and concerns have also influenced the priorities and practices of science; for example, by ensuring that traditional harvest areas and populations are the focus of research. Aboriginal perceptions regarding the relative importance of contaminants have also had an influence. For example, endocrine disruptors have received less attention in the north because communities have not identified reproductive or fertility issues as significant concerns.[113]

We have seen how Aboriginal views of contaminants varied from those of scientists; but they also differed from how the federal government defined them. For example, communities expressed concerns regarding contaminants that were "of a local nature." While these were excluded from the federal definition, there was no other source of funding available to deal with them. Accordingly, the NCP made provision to respond to these "Local Contaminants Concerns," thereby improving its relations with northerners.[114] This arrangement represented a negotiation between divergent definitions—in terms of government jurisdiction, or local perceptions—of contaminants. Aboriginal concerns, and scientific information, also compelled the federal government to expand its program beyond its territorial jurisdiction. Although Nunavik and Labrador are within provinces, not territories, and thus are not under direct federal jurisdiction, after 1997 the NCP was enlarged to include them, because people there also consume marine mammals and are thus exposed to contaminants.[115] Social (food consumption) and ecological (presence of contaminants) dimensions thus trumped federal jurisdictional limits in defining the geography of northern contaminants.

The NCP and Northern Research

The NCP represented a distinctively northern form of the challenge, often encountered in environmental affairs, of bringing together different ways of perceiving, experiencing, and knowing the environment. Knowledge from elsewhere about contaminants and their impacts on humans and other species was relevant to understanding them in the north. This knowledge then had to be combined with knowledge that was distinctive to the region, such as the special sensitivity of some northern species, and the distinctive ways in which northern people value and consume country foods. By forming new knowledge and practices, as well as new institutions and working relationships, the NCP had a variety of consequences for northern science and environmental history.

By providing an arena for the influence of regional factors, the NCP reinforced the distinctive character of northern contaminants research. Its status as a separate institution contributed to this—likely more than would have been the case if funding for contaminants research had been the responsibility of a national granting agency. The result was juxtapositions of research fields, such as atmospheric chemistry alongside community-based food studies—highly unlikely anywhere else. Explicit attention to community and ethical issues was also central to this regional character. The attention devoted to community decision-making and involvement in research and communication represented a new social contract for northern research. This encompassed an evolving view of the citizenship of northern Aboriginal peoples—from seeing them as objects of expert guidance to playing an active role in shaping expert knowledge and advice.

This distinctive character was evident to scientists from elsewhere. As one report noted, from "the perspective of a scientist trained in the South, the conduct of research in the North presents its own unique and unfamiliar challenges."[116] Contaminants research thus became a pathway by which scientists were encouraged to adopt specifically northern approaches to doing science. One scientist commented that first-hand experience of Dene culture had "changed the way that I implement southern standards in the North"—acknowledging that scientific standards could be situated geographically.[117] In effect, contaminants researchers and their community partners constructed a distinctively northern definition of "good science."[118] Their research thus evolved differently than other projects in the history of northern science that aimed to construct the north (often without success) as a "placeless" laboratory, producing knowledge valid everywhere.[119] In contrast, the NCP aimed to formulate contaminants advice that eschewed universal standards of risk and tolerable limits in favour of community-specific perceptions and values.

Contaminants research reinforced two other ideas about the north. One was quite obvious—that the region is linked to the rest of the world: physically, politically, intellectually. But even while this research drew attention to these connections, it also reinforced the view of the north as a distinctive space, as defined in terms of both scientific and Aboriginal perspectives on health, community, and the land. Among its distinctive characteristics was the practice of research in an inhabited landscape, with people that have a distinctive relationship with the environment. In this way, the NCP exemplified the more general evolution of northern environmental research. Although its practice of Aboriginal involvement in priority-setting and funding allocation has not been emulated in other research programs, the underlying social principle has: by 2010, and via Canadian involvement in the International Polar Year, northern environmental research had gained a strong social dimension focused on the wellbeing of northern peoples, integrated with northern communities, acknowledging local cultural beliefs and knowledge, drawing on concepts of vulnerability, adaptation, and resilience, and organized in ways that parallel how people relate to the environment. In areas ranging from climate change to caribou, as well as contaminants, environmental change was reinterpreted not only in terms of scientists' perspectives, but the perspectives of people and communities.[120]

Conclusion

One could imagine a linear history of northern contaminants in which these substances are produced and then deposited in the north, scientists describe their properties, and generate knowledge that is translated into action. But the surprises punctuating the actual history hint at a more complex tale. Repeatedly, the north was found not to be the pristine environment it was assumed to be. Instead, contaminants were discovered in places—the atmosphere, animals, human bodies—that confounded expectations. Their presence recalled the classic definition of pollution as misplaced matter—with "misplaced" being a category constructed on the basis of knowledge, experience, and expectations of what belongs in a place.[121]

Contaminant surprises stemmed in part from the persistent assumption that the Arctic was a pristine space, remote from sources of pollution. In reality, features of atmospheric transport mechanisms and of certain contaminants made the Arctic more contaminated than elsewhere. The complex and unpredictable behaviour of contaminants also contributed: in the Arctic, contaminants have tended to "break the rules" that scientists had formulated through research in more temperate regions. The structure of knowledge was also a factor. Disciplines influenced scientists' choices of where and what to study, and these choices rendered certain phenomena and places for contaminants visible, while obscuring others. In the early years of contaminants research, scientists focused on species that were ecologically significant or useful as indicators of environmental contamination; in doing so, species important as food were neglected. Scientists also produced discipline-specific descriptions of contaminants in the atmosphere or in ecosystems, and thereby limited their knowledge to what could be understood within that discipline, excluding other ways of knowing, including local knowledge.[122] Thus, scientists constructed a geography of knowing and unknowing in which partial knowledges of various kinds were distributed across disciplines and institutions.[123] Surprises resulted when observations failed to match the expectations formed by the regimes of perceptibility that these partial knowledges engendered.

These surprises had consequences. Scientists interpreted them as hints about how contaminants move and behave, and about the structure of nature itself. To align their research with this structure, they linked previously distinct bodies of knowledge: atmospheric chemistry and ecology; ecology and toxicology; toxicology and community health.[124] Scientists of different disciplines worked together, and also with non-scientists, including people in communities affected by contaminants. Spurred on by surprises, contaminants science exhibited a dynamic, evolving structure, with shifting regimes of perceptibility—an interdisciplinary research community that supported a view of the north as a single system linked to the rest of the planet.

Even as knowledge about contaminants evolved, so did the objects themselves: both contaminants, and ecological and human systems. As scientists, policymakers, public health experts, and Aboriginal people became involved, the actual substances they were talking about changed. In the 1950s, arctic haze was a visual phenomenon that could be described through observation. In the 1970s, it became an aerosol—a physical phenomenon describable in terms of chemical composition. Until the mid-1980s, organic contaminants were described in the context of an arctic ecosystem that apparently lacked humans. By the early 1990s, the food chain linking country foods and humans had become the focus of attention. These diverse and partial identities testify to the instability of contaminants as a category; it shifted and reshaped as different communities became involved in contaminant affairs, provoking surprise whenever its behaviour contradicted its assigned identity.[125]

Arctic contaminants were thus not simply "discovered." Their contemporary identity—as substances that link industrial regions to the north, and that have consequences for northern ecosystems, wildlife, and people—was constructed over several decades, and out of various forms of evidence and reasoning. Several communities were involved in constructing contaminants: scientific disciplines (each concerned with an aspect of contaminants: sources, behaviour in the atmosphere or in ecosystems, implications for human communities or bodies), forums for policy-making and international negotiations, and northern communities.

These complexities, formed by the interaction between the processes by which knowledge is formed and the materiality of the north, underline how northern contaminants present opportunities to consider the relations between the history of science (the evolution of scientific practices and knowledge) and environmental history (the production, distribution, and consequences of contaminants). Each shapes the other; our awareness of the presence of contaminants has depended on production of scientific knowledge, and this production has been, in part, in response to their presence. For several decades, observers have tracked the movement and transformation of contaminants into and within the north, their motivations ranging from Cold War strategic priorities, to scientific curiosity, to concerns regarding the health of arctic people and wildlife. Similarly, this paper has tracked the movement (and sometimes non-movement) and transformation of knowledge about contaminants, seeking clues as to how knowledge about the north is constructed and shared, and by whom. The shifting regimes of perceptibility produced through these activities resulted, at different times, in certain contaminants becoming highly visible, even as others did not—an outcome that implies a need for caution in using scientific evidence to reconstruct the material history of northern contaminants. The environmental history of contaminants science also illuminates how the places where science is done shape knowledge, and conversely, how doing science changes a place—through research, through the activities that accompany scientific work, and through the knowledge that results. This history therefore illustrates how science constitutes part of living in a place, and so has been central to the environmental and political history of northern Canada.

The presence of contaminants, and knowledge about them, has also influenced ideas about the north: its identity, and those of its inhabitants. Their presence eroded the identity of the Arctic as remote and pristine (although it remains oft invoked, notably when presenting the region to tourists). Instead, this knowledge helped form a distinctive identity of northern Canada as a landscape of exposure, in which contaminants are everywhere (albeit usually at very low concentrations). This identity was, in part, about vulnerability. The links between the region and the rest of the planet encouraged this view; as did features of arctic ecosystems: cold that slows breakdown of contaminants, and the fat-based metabolism of mammals that encourages their accumulation. Reliance on country foods was another factor, as was the longstanding view of the Arctic as a fragile environment. This identity was shared with the rest of the circumpolar region, becoming the basis for circumpolar institutions such as the Arctic Council, and for the notion of arctic citizenship.[126] Finally, contaminants reinforced perceptions of the intimate ties between Aboriginal people and their environments: they belonged there, because their wellbeing was tied to the wellbeing of their homeland.

Notes

1 Sheila Watt-Cloutier, "The Inuit Journey towards a POPs-Free World," in: David L. Downie and Terry Fenge, eds., *Northern Lights against POPs: Combatting Toxic Threats in the Arctic* (Montreal: McGill-Queen's University Press, 2003), 257; on the surprise felt in Inuit communities, see also Heather Myers and Chris Furgal, "Long-Range Transport of Information: Are Arctic Residents Getting the Message about Contaminants?", *Arctic* 59, no. 1 (2006): 49.

2 Marla Cone, *Silent Snow: The Slow Poisoning of the Arctic* (New York: Grove Press, 2005), 31.

3 David Kinloch and Harriet Kuhnlein, "Assessment of PCBs in Arctic Foods and Diets: A Pilot Study in Broughton Island, Northwest Territories, Canada," *Arctic Medical Research* 47, supp. 1 (1988): 159–62; Matthew Fisher, "Soviet, European pollution threatens health in Arctic," *Globe and Mail*, December 15, 1988.

4 Cone, *Silent Snow*, 39.

5 Michelle Murphy, *Sick Building Syndrome and the Problem of Uncertainty: Environmental Politics, Technoscience, and Women Workers* (Durham: Duke University Press, 2006).

6 Angela Creager applied a similar historiographical approach in her study of knowledge and practice relating to radioisotopes. Creager, *Life Atomic: A History of Radioisotopes in Science and Medicine* (Chicago: University of Chicago Press, 2013).

7 On the implications of perceptions of the north as remote and unspoiled, see Ken Coates, "The Discovery of the North: Towards a Conceptual Framework for the Study of Northern/Remote Regions," *Northern Review* 12–13 (1993–94): 15–43; and Sherrill E. Grace, *Canada and the Idea of North* (Montreal: McGill-Queen's University Press, 2002).

8 Mats Olsson, "Ecological Effects of Airborne Contaminants in Arctic Aquatic Ecosystems: A Discussion on Methodological Approaches," *Science of the Total Environment* 160–61 (1995): 619; see also Shawn G. Donaldson, et al., "Environmental Contaminants and Human Health in the Canadian Arctic," *Science of the Total Environment* 408 (2010): 5167.

9 See, for example, Robie W. Macdonald, et al., "Contaminants in the Canadian Arctic: 5 Years of Progress in Understanding Sources, Occurrence and Pathways," *Science of the Total Environment* 254 (2000): 94.

10 Theo Colborn, Dianne Dumanoski, and John P. Myers, *Our Stolen Future* (New York: Plume Books, 1996), 109.

11 David L. Downie and Terry Fenge, eds. *Northern Lights Against POPs: Combatting Toxic Threats in the Arctic* (Montreal: McGill-Queen's University Press, 2003).

12 Derek C. G. Muir, Rudy Wagemann, Barry T. Hargrave, David J. Thomas, David B. Peakall, and Ross J. Norstrom, "Arctic Marine Ecosystem Contamination," *Science of the Total Environment* 122 (1992): 5–134; Eva C. Voldner and Yi-Fan Li, "Global Usage of Selected Persistent Organochlorines," *Science of the Total Environment* 160–61 (1995): 201–10. For an analysis of contaminants that, unlike those that are the focus of this chapter, originate in sites within the Arctic (and, for comparison, the Antarctic), see John S. Poland, Martin J. Riddle, and Barbara A. Zeeb, "Contaminants in the Arctic and in the Antarctic: A Comparison of Sources, Impacts, and Remediation Options," *Polar Record* 39, no. 211 (2003): 369–83. The ambiguities of classifying some contaminants as "natural" is illustrated by the case of arsenic: as Keeling and Sandlos explain in their chapter, while it is found naturally in gold ore, in the Yellowknife region it became a significant problem only because it was released when the ore was roasted to release the gold.

13 Gregg Mitman, Michelle Murphy, and Chris Sellers, eds., *Landscapes of Exposure: Knowledge and Illness in Modern Environments*, Osiris 19 (Chicago: University of Chicago Press, 2004).

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of Circumpolar Health 69, no. 4 (2010): 322–32; Henrik Selin, *Global Governance of Hazardous Chemicals: Challenges of Multilevel Management* (Cambridge, MA: MIT Press, 2010); Charles Thrift, Ken Wilkening, Heather Myers, and Renata Raina, "The Influence of Science on Canada's Foreign Policy on Persistent Organic Pollutants," *Environmental Science and Policy* 12 (2009): 981–93.

15 Robert E. Kohler, "History of Field Science: Trends and Prospects," in *Knowing Global Environments*, ed. J. Vetter (New Brunswick, NJ: Rutgers University Press, 2010), 212–40; Jeremy Vetter, "Introduction," in *Knowing Global Environments*, 1–16. And as Marionne Cronin explains in her chapter in this volume, aviators also contributed to defining the atmosphere as part of the northern environment.

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"The Cold War on Canadian Soil: Militarizing a Northern Environment," *Environmental History* 12, no. 4 (2007): 921–50; Stephen Bocking, "A Disciplined Geography: Aviation, Science, and the Cold War in Northern Canada, 1945–1960," *Technology and Culture* 50 (2009): 320–45.

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Harvey E. Palmer, Wayne C. Hanson, Bobby I. Griffin, and William C. Roesch, "Cesium-137 in Alaskan Eskimos," *Science* 142, no. 3588 (1963): 64–66; D. G. Watson, W. C. Hanson, and J. J. Davis, "Strontium-90 in Plants and Animals of Arctic Alaska, 1959–61," *Science* 144, no. 3621 (1964): 1005–9; Peter A. Coates, *The Trans-Alaska Pipeline Controversy: Technology, Conservation, and the Frontier* (University of Alaska Press, 1993): 111–33; and, especially, Dan O'Neill, *The Firecracker Boys* (New York: St. Martin's Griffin, 1994). Another link between radioactive materials and northern scientific and military affairs resulted from interest in human performance and adaptation to the arctic environment. Alaska and its Aboriginal inhabitants were together viewed as a "natural laboratory" for the study of these topics; accordingly, iodine-131 was administered to humans and used to trace physiological functions. By the 1990s, these and many other Cold War studies of humans that used radioactive materials had become highly controversial; Matthew Farish, "The Lab and the Land: Overcoming the Arctic in Cold War Alaska," *Isis* 104, no. 1 (2013): 1–29.

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113 Clive Tesar, "Confirming the Effects of Contaminants on Inuit Children: An Interview with Eric Dewailly," *Northern Perspectives* 26, no. 1 (2000): 18.

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118 On the construction of "good science" in another arena of toxicological research, see Kim Fortun and Mike Fortun, "Scientific Imaginaries and Ethical Plateaus in Contemporary U.S. Toxicology," *American Anthropologist* 107, no. 1 (2005): 43–54.

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122 O'Neil et al., "Poisoned Food."

123 On the disciplinary geography of scientific knowledge, see, for example, Scott Kirsch, "Harold Knapp and the Geography of Normal Controversy: Radioiodine in the Historical Environment," in *Landscapes of Exposure*, 167–81.

124 Len A. Barrie, Dennis Gregor, Barry Hargrave, R. Lake, Derek Muir, Russel Shearer, B. Tracey, and T. Bidleman, "Arctic Contaminants: Sources, Occurrence and Pathways," *Science of the Total Environment* 122 (1992): 1–74.

125 In this discussion, I am drawing on the notion of "historical ontology"—that things emerge and become stabilized in relation to knowledge about those things; see Mitman et al., "Introduction"; Sellers, "Artificial Nature."

126 Martello, "Global Change Science."