Glacial Deaths, Geologic Extinction

JEREMY J. SCHMIDT
Department of Geography, Durham University, UK

Abstract In 2019 several funerals were held for glaciers. If enough glaciers die, could they go extinct? Is there geologic extinction? Yes. This article develops three arguments to support this claim. The first revisits Georges Cuvier's original argument for extinction and its reliance on geology, especially glaciers. Retracing connections to glaciers and the narrowing of extinction to biological species in the nineteenth century, the author argues that anthropogenic forcing on how the Earth system functions—the Anthropocene—warrants rethinking extinction geologically. The second argument examines the specificity of ice loss and multiple practices responding to this loss: from art exhibits at United Nations climate change meetings to anticolonial claims for the right to be cold. The third argument consolidates a theme built across the article regarding how Isabelle Stengers's notion of ecologies of practices provides an approach to geologic extinction that recognizes both relational and nonrelational loss.

Keywords extinction, glacier, geology, Anthropocene, ice, loss, Stengers

On a gray August day in 2019 approximately one hundred people held a funeral for a glacier in Iceland. Reverent mourners, including the country's prime minister, walked to where Okjökull Glacier once flowed and fixed a copper plaque to a nearby boulder. On the plaque for Ok Glacier (as it is locally known) was a Letter to the Future written by Icelandic author Andri Magnason. It reads: "Ok is the first Icelandic glacier to lose its status as a glacier. In the next 200 years all our glaciers are expected to follow the same path. This monument is to acknowledge that we know what is happening and what needs to be done. Only you know if we did it." The event was international news. Famed author Amitav Ghosh tweeted that he was "glad the loss of this glacier is being marked with a funeral. Such rituals are necessary also for [mountains] & rivers. They might help oil & mining companies (also scientists) understand why landscapes are sacred for many indigenous people (as in Mauna Kea)."[1] The celebrated Cree poet, Billy-Ray Belcourt, was struck by the obituary: "That shift from a present 'we' to a future 'you' is laden with anguish and hope. To speak to those who aren't yet alive! To speak in a

1. Ghosh, "I'm glad the loss of this glacier is being marked with a funeral."

Environmental Humanities 13:2 (November 2021)
DOI 10.1215/22011919-9320156

register of hundreds and hundreds of years!"[2] Marked by the shift from present to future, the plaque was not a headstone. It did not index Ok Glacier's past life, nor hazard a guess at its birth in time immemorial. Instead, time was marked by the concentration of atmospheric carbon dioxide. The geological time of death: "August 2019, 415ppm CO_2."

Not long after the ceremony in Iceland a memorial service was held for Pizol Glacier in Switzerland. It is conceivable that many more will take place. If enough glaciers die, could they go extinct? Is there geologic extinction? Yes: extinction is not reserved to species. Other uses of extinction already exist. In physics, radiation is extinct when the intensity of light reduces to zero, usually after passing through a medium that absorbs, reflects, or scatters it. In biology, if enough species are eliminated in short order, extinction may qualify as a geological event—there are five confirmed, and a sixth is widely considered to now be underway.[3] So, examining extinction beyond individual species is not a category mistake, but is this just nominalist sleight of hand? No. Geologic extinction is real, as irreversible as its biological kin.

Reckoning geologic extinction, however, requires revisiting concerns similar to those that occupied Georges Cuvier when he first proposed his ideas on species extinction while working at the National Museum of Natural History in Paris. For Cuvier explaining extinction required relating it to a "theory of the Earth." Today that phrase is longhand for geology, a field that is both "(1) a body of knowledge about Earth, and (2) a way of thinking about Earth."[4] Similarly geologic extinction requires attention to how what is known is related to ways of thinking. Isabelle Stengers described this relationship as an ecology of practices that connects knowledge to the ethos in which it is produced, a relationship wherein how a "matter-of-fact environment" is known defines "relations with other practices and the opportunities of the environment."[5]

Following Stengers this article makes three arguments for geologic extinction. The first revisits species extinction. As powerful as that idea is, it took shape in social and political contexts that obscured its connections to geology. In Cuvier's account of extinction, glaciers were key. Then, and since, glaciers have functioned as epistemic objects: constituent elements of reality that carry their own historicity and over which changing ideas about them afford new ways of knowing.[6] Instead of revisiting ideas of extinction as nineteenth-century geology developed, however, assumptions of race and empire fused extinction to biological loss, often fossilizing other races as remnants of lost worlds in the process. Scholars frequently critique the unethical and ecologically misguided aspects of this history, especially the dispossession of Indigenous peoples in the name of species protection.[7] Less obvious are the implications when theories of

2. Belcourt, "Ok is the first Icelandic glacier to lose its status as a glacier."

3. Ceballos et al., "Biological Annihilation."

4. Baker, "Geosemiosis," 633.

5. Stengers, "Including Nonhumans," 25.

6. Chang, "Persistence of Epistemic Objects."

7. Heise, *Imagining Extinction*; Rose, van Dooren, and Chrulew, *Extinction Studies*; Mitchell, "Beyond Biodiversity."

the Earth change. This is now the case as the body of knowledge regarding human impacts on the Earth system alters ways of thinking about Earth. In this context—the Anthropocene—geologic extinction requires tools alert to unjust histories and environments. Stengers's ecology of practices here provides a "tool for thinking through what is happening" in recognition that "a tool is never neutral."[8]

The second argument thinks through geologic extinction to consider glaciers that are contingent, unique, and irrecoverable once lost. Concern over glacial loss is not new, and analogies treating glaciers as endangered species have historically reinforced imperial, racialized notions of loss.[9] Yet they have not prompted reflection on extinction itself. For Stengers, however, a corollary to no ecology of practices being neutral is that each starts out by hesitating over, and paying attention to, matters of concern to which it is constitutively attached.[10] Such attachments can be straightforward: glaciology requires glaciers past or present. Attachments are also complex and interdependent in cases where glaciers are constitutive for alternate ways of knowing. In view of this complexity Stengers's aim of thinking about relations of knowledge and ethos points to an account that does not aim to "describe practices 'as they are.'"[11] Rather, the aim is speculative, to see what practices "may become in different surroundings."[12] In this article I hesitate over practices mourning glacial death. There are scientific and social reasons to do so. But it is easy to imagine a sceptic asking: "So what? Glaciers may return in scenarios where humans do not (as they have now done) push the next ice age back 50 millennia."[13] The counterfactual complaint, I show, is a non sequitur: what is at stake is geologic specificity, not physical laws. But other difficulties arise when multiple ecologies of practices among Indigenous peoples, social scientists, and glaciologists interact with, and elude, one another. These situations raise concerns of epistemic injustice regarding bodies of knowledge and ways of knowing. Following Black feminist and Indigenous scholarship, I argue these injustices command attention owing to both knowable and unknowable loss.[14]

The third argument is that geologic extinction is relational in ways that matter on human scales of space, time, and meaning, but that there are also nonrelational aspects of geologic extinction. I investigate how these nonrelational practices may be understood through Stengers's notion of divergence.[15] Divergence is not synonymous with difference, nor cover for detached assessments that compare other practices against those taken as given. Rather, it is a treatment of each ecology of practices that demands

8. Stengers, "Ecology of Practices," 185.
9. Carey, "Living and Dying with Glaciers."
10. Stengers, "Including Nonhumans."
11. Stengers, "Ecology of Practices," 186.
12. Stengers, "Including Nonhumans," 26.
13. See Ganopolski et al. "Critical Insolation-CO_2."
14. Dotson and Whyte, "Environmental Justice."
15. Stengers, "Including Nonhumans"; "Comparison."

none of them "be defined as 'like any other,' just as no living species is like any other."[16] Divergence points to how saying something is like another evokes practices that make comparison possible. This comparison is a matter of concern, since each ecology of practices is positioned toward loss from its own standpoint (in a manner analogous, for Stengers, to how each species has a unique standpoint toward its environment).[17] How funerals for glaciers matter to anthropologists, glaciologists, politicians, and authors may diverge.[18] The goal of geologic extinction is not to render divergent losses in comparable terms—to one way of relating bodies of knowledge to a way of thinking—but to attend to how multiple ecologies of practices may mark loss in incomparable ways.

Together these arguments warrant an approach to geologic extinction that facilitates respect for ways of knowing previously excluded by accounts of extinction, such as those of Indigenous peoples, and which also does not seek to commensurate loss. The argument also shows how, like other epistemic objects, glaciers carry weight for scientific ecologies of practices. Through Lavoisier's lab, for instance, a chemical account of water was adopted over the phlogiston theory even though water persisted as what it had always been.[19] Glaciers and their histories, of course, are weighed up not only in labs but also by Earth sciences now reckoning with how not only their persistence matters but also their disappearance. The histories glaciers carry, and the practices constitutively attached to them, point to how incomparable losses demand a new repertoire for loss itself.

Extinction and Earth Theory

In February 2019 Stephen Colbert memorialized the first mammal extinction caused by climate change on the television program *The Late Show*. An Australian rat, the Bramble Cay melomys, was not an especially magnetic animal to lose. It had nothing of the nonhuman charisma of rhinos or right whales[20] and certainly nothing like the spectacle of mastodon fossils that Georges Cuvier used to establish the idea of extinction in 1796.[21] But the rat carries an analogous implication. Its loss created a moment for hesitation, in science and in public, that requires reckoning with a shift in the theory of Earth's history. Cuvier's account was similarly entangled with a theory of the Earth, a phrase that waned as the discipline of geology consolidated in the nineteenth century.[22] Cuvier's social context helped make extinction a powerful concept, but it also foreshortened some

16. Stengers, "Introductory Notes," 184.

17. Stengers, "Comparison."

18. See Johnson, "How to Mourn a Glacier," *New Yorker*, www.newyorker.com/news/dispatch/how-to-mourn-a-glacier (accessed November 28, 2020).

19. Phlogiston was the combustible part of bodies. In water the combustible air released in phase change from liquid to gas. Chang, *Is Water H_2O?*

20. Lorimer, "Nonhuman Charisma."

21. Kolbert, *The Sixth Extinction*.

22. Rudwick, *Bursting the Limits of Time*.

of its geological implications. Among these social factors race and empire stand out. These building blocks of capitalism affected how extinction was mustered from a wide geologic assemblage into a biological spectacle.

Cuvier's work establishing a lost species akin to elephants came with a bold gambit: that there was a lost, prehuman world to which the mastodon would have been well suited.[23] Extinction was difficult for many to accept, including Thomas Jefferson.[24] Part of the difficulty was that Cuvier's conjecture upended theories in which Earth was on a unidirectional trajectory from a warmer past to a cooler future. Mastodon fossils provided evidence of a species adapted to a past, cooler world—a world now lost, according to Cuvier, owing to revolutions in Earth's history. Rudwick's masterful presentation of Cuvier's writings show the stakes of relying on anatomy as geologic evidence to deviate from explanations derived from physical laws governing Earth's cooling.[25] As Cuvier stated,

> But there is [also] a science that does not appear at first sight to have such close affinities with anatomy; one that is concerned with the structure of the earth, that collects the monuments of the physical history of the globe, and tries with a bold hand to sketch a picture of the revolutions it has undergone: in a word, it is only with the help of anatomy that geology can establish in a sure manner several of the facts that serve as its foundations.[26]

Cuvier's explanation of extinction through the relationship of anatomy to geology sharpened his position in early nineteenth-century debates over causality. During those decades the extension of Christian hermeneutics to geology facilitated a temporal revolution in understanding Earth's history.[27] As the new science secularized, however, Cuvier and others sought to reformulate causal explanations on scales exceeding the prevailing Christian imagination. There were many such theories, enough that Cuvier complained the proliferation of geologic "systems" required a system of classification just to keep the alternatives straight.[28] Nevertheless, Cuvier staked extinction to a theory of catastrophism in which Earth had undergone a series of prehuman revolutions.[29] Yet while Cuvier's concept of extinction stuck, his theory of the Earth did not. Instead James Hutton's *Theory of the Earth* took hold along with the idea of uniformitarianism: that present processes are the same as those of the distant past.[30] Uniformitarianism demanded an expansion of the geological imagination to scales of deep time that could

23. Cuvier, *Essay on the Theory of the Earth*.
24. Barrow, *Nature's Ghosts*.
25. Rudwick, *Georges Cuvier*.
26. Rudwick, *Georges Cuvier*, 21.
27. Rudwick, *Bursting the Limits of Time*.
28. Rudwick, *Georges Cuvier*.
29. Cuvier, *Essay on the Theory of the Earth*.
30. Hutton, *Theory of the Earth*.

accommodate significant change without catastrophe. One of Hutton's champions, Charles Lyell, anchored his magnum opus, *Principles of Geology*, in uniformitarianism to forge a new kind of causal explanation conditioned "to a great degree on what we commonly call chance . . . [and] . . . the casual discovery of some new localities rich in peculiar fossils [that] may modify or entirely overthrow all our previous generalizations."[31] In accounts of the "taming of chance," however, geology is a minor science: background to changes in social or political governance.[32] But there is more at stake. As geology developed, it was often in friction with causal explanations derived from mathematics and physics.[33] Furthermore, the epistemic objects that caused the stir around extinction (fossils) were mobilized in projects of empire.

In the nineteenth and early twentieth centuries fossils were used to naturalize projects of empire. This also obscured the link of extinction to geology owing, in part, to Lyell's influence on how geology approached time. Lyell's notion of deep time was derived through analogies with political economy, in which explanations of geologic processes that required vast expanses of time functioned like an inexhaustible line of credit on which to make withdrawals.[34] Although this is helpful for elucidating the temporal imagination relating the political economy of empire to geology, it does not explain how fossils were brought into the nineteenth century present. Two significant works, Brian Noble's *Articulating Dinosaurs* and Lukas Rieppel's *Assembling the Dinosaur*, show how imaginaries linking anatomy to geology also rendered fossils a public, marketable spectacle. Noble argues that through museum arrangements dinosaurs were constituted as specimens that were, "in turn, reconstituted in public form as spectacle" in what he terms a "specimen-spectacle complex."[35] This complex was part of an ecology of practices in which dinosaurs were constitutive of Cuvier's lost, prehuman world. Furthermore, explaining that world through public displays in museums (later, novels and movies) publicly reconstituted lost species as epistemic objects concordant with a temporal, evolutionary direction in which white, European races were ascendant.[36]

Making a spectacle of dinosaur fossils served the political economy of empire by supporting explanations of social differences based on racial comparison. Rieppel shows how gaps in fossil records were filled by colonial imaginations (scientific and social) outfit for capital accumulation.[37] These gaps existed within specimens owing to incomplete fossils, and also among specimens and the lost environmental worlds imagined for them to inhabit in public exhibitions.[38] Using colonial assumptions to fill gaps

31. Lyell, *Principles of Geology*, 146.
32. Hacking, *The Taming of Chance*.
33. Rudwick, *Earth's Deep History*.
34. Rudwick, "Poulett Scrope."
35. Noble, *Articulating Dinosaurs*, 15–16.
36. Noble, *Articulating Dinosaurs*.
37. Reippel, *Assembling the Dinosaur*.
38. Noble, *Articulating Dinosaurs*; Reippel, *Assembling the Dinosaur*.

in the fossil record rendered the movement from the past into the present as a natural temporal sequence and created racial anxieties peculiar to empire. For instance, after kill policies exterminated bison across North America to dispossess Indigenous peoples of their lands and relations, white settlers became concerned with conserving species to ward off their own racial peril.[39] The temporal sequence linking species loss and racial violence turned on a common environment that rendered losses comparable.

Glaciers were part of these racial formations. In 1840, after studying fossils with Cuvier, Louis Agassiz proposed that a previous ice age had covered much of Europe. His work in *Études sur les Glaciers* was rebuffed by geologists committed to uniformitarianism, which kept ice ages from gaining acceptance for decades.[40] Charles Darwin, however, almost immediately found use for Agassiz's ideas to explain glacial erratics—large boulders misfit with local geology—that he had encountered in Tierra del Fuego during his voyage on *H.M.S. Beagle*.[41] In 1946 Agassiz arrived in the United States and seized on anthropological notions of race.[42] While a professor at Harvard Agassiz used geology to backstop racist claims based on anatomical differences. Although Agassiz did not think species could evolve, Darwin selectively aligned parts of Agassiz's account with Lyell's view of time to show the opposite.[43]

By the end of the nineteenth century settler-colonial states in Australia, Canada, and the United States deployed evolution to compare societies through what Patrick Wolfe terms a "temporal syntax" that rendered cultural differences in terms of a natural racial hierarchy.[44] For many the extinction of "darker" races was inevitable, while anatomy and geology were employed to establish an ethos of racial superiority in efforts of ethnographic salvage.[45] Among the most influential was John Wesley Powell, a geologist who became a dominant ethnologist in late nineteenth-century America. Powell even designed thirty-three granite heads for the Library of Congress in a "social-spectacle complex" linking anatomy to cultural difference. Visitors can still look at the Jefferson building and see white Americans atop evolution.[46] Salvage ethnography reinforced racial difference even as it reckoned with industrial impacts on cultures and environments. These accounts also buttressed empire. For instance, racist treatments of Gonds in India described them as geologic remnants of a lost world, though a race uniquely suited to coal mining for the British.[47] The corollary to Indigenous peoples being consigned to lost worlds were programs of conservation that dispossessed Indigenous

39. Powell, *Vanishing America*.
40. Imbrie and Imbrie, *Ice Ages*.
41. Darwin, "On the Distribution of the Erratic Boulders."
42. Menand, "Morton, Agassiz."
43. Irmscher, "Louis Agassiz."
44. Wolfe, *Settler Colonialism*, 45.
45. Brantlinger, *Dark Vanishings*.
46. King, *The Reinvention of Humanity*.
47. Chakrabarti, *Inscriptions of Nature*.

peoples in the name of species protection.[48] As extinction was reserved to biology, only the products of geology (i.e., species or races) were candidates for extinction. Geologic processes themselves were not. Part of this may be explained by other factors of political economy, such as Herbert Spencer's influential rendering of evolution as the "survival of the fittest," which relied on isolating organisms from a more permanent "environment" in which comparisons of fitness took place.[49]

It is ironic that, as extinction was reserved to biology, water and ice became more prominent in nineteenth-century geologic debates. Recall that, for Cuvier, mastodon fossils furnished evidence for a previously cooler planet. But thinking with glaciers did not rest there. The geologic action of Agassiz's ice age was key to unlocking nineteenth-century concerns that Earth was in decay.[50] By 1874 James Geikie's *Great Ice Age* indexed the "lost world" that Cuvier imagined to glacial advance and retreat associated with cooling and rising temperatures.[51] American geologists, including Powell and his successor, William McGee, seized on glacial action to claim water's geologic agency provided grounds for national resource conservation in the United States.[52] In 1872 when John Tyndall published his classic work, *The Forms of Water*, understanding Earth's energy transfers was central to an emerging planetary imagination. As has been well documented Tyndall and others established geologic flow—ice advancing and retreating as part of a planetary energy system—in terms that anticipated explanations of anthropogenic forcing on Earth's climate.[53]

Glaciers figure significantly in explanations of extinction that rely on a theory of Earth in which ice indexes geologic history. Recovering this history (even in broad strokes) establishes one proposition in favor of geologic extinction. Namely, extinction does not operate apart from a theory of the Earth even if it is not always explicitly referenced to the geological commitments that provide the basis against which "background rates" of extinction are calculated.[54] When geologic knowledge changes significantly it warrants new ways of thinking, including about extinction. The Anthropocene is such a change; it is geology without analogue.[55] Anthropogenic forces may cross critical tipping points that set Earth on a trajectory in which positive feedback loops raise average temperatures above any of the last 1.2 million years (Steffen et al. 2018). Theorizing the Anthropocene is not the preserve of geologists. It is an interdisciplinary task of relating bodies of knowledge regarding anthropogenic forcing on the Earth system to ways of thinking that confront intersecting inequalities of race, gender, class, and species. As

48. Adams, *Against Extinction*; Barrow, *Nature's Ghosts*; Powell, *Vanishing America*.
49. Pearce, *Pragmatism's Evolution*.
50. Davies, *The Earth in Decay*.
51. Hamlin, "James Geikie."
52. Schmidt, *Water*.
53. Edwards, *A Vast Machine*.
54. See De Vos et al. "Estimating."
55. Steffen et al., *Global Change and the Earth System*.

Amitav Ghosh has argued, for instance, responses to the destabilizing force of climate change often betray a loss of bourgeois forms of stability that was itself built and sustained by empire.[56] My argument is similar: glacial demise destabilizes geological loss in ways that make questions of loss, *for whom* and *how*, central.

Elegies for Ice

In the Himalayas glacial ice loss is proceeding at twice the rate of the twentieth century.[57] Locally ice loss generates different responses. In Ladakh snow is piled to make artificial glaciers, or ice stupas, to increase summer water flows.[58] Artificial glaciers sit astride efforts to care for disappearing glaciers. As Karine Gagné compellingly shows, this is a multifaceted challenge in Ladakh. Members of aging communities can no longer make the trips to glaciers to perform ritual practices of care while young people have left to find work. Meanwhile younger monks cannot perform traditional rituals because their training has exchanged textual knowledge for that of local practices.[59] The specificity of these physical and social losses drive this section. Physically, water's nonessential nature and the constitution of ice make glaciers particular. Socially, the specificity of losing *this* glacier generates concerns specific to different practices. In some cases geographic specificity extends to *these* glaciers: the Himalayas, Alps, Andes, or Rockies. Funerals are one response to loss. There are other practices that are important in themselves, and also as alerts to plural concordances of time, meaning, and loss. Geologic extinction, in this sense, shares Thom van Dooren's "conviction that there is no single 'extinction' event. Rather in each case there is a *distinct* unravelling of ways of life, a distinctive loss and set of changes and challenges that require situated and case-specific attention."[60]

In July 2019, a month before Iceland's funeral for the Ok Glacier, the BBC aired a three-part podcast titled *The Dying of the Ice*. The first episode featured the artist Olafur Eliasson and his geologist collaborator Minik Rosing regarding their installation "Ice Watch."[61] The exhibit hauled blocks of ice from a fjord near Greenland to the bank of the River Thames in front of the Tate Modern in London. There ice that was fifteen thousand years old melted. Eliasson described the installation as prompting reflections on different ways of knowing climate. Rosing remarked that the goal was to bring knowledge out of science and politics and into the public sphere. These aims had also contextualized earlier installations of "Ice Watch" at the negotiations over the UN Framework Convention on Climate Change in Copenhagen (2014) and Paris (2015). Eliasson and Rosing described the experience of Ice Watch as powerful and plural. Not only did

56. Ghosh, *The Great Derangement*.

57. Maurer et al. "Acceleration of Ice Loss."

58. Sharma, "Giving Water Its Place."

59. Gagné, *Caring for Glaciers*.

60. Van Dooren, *Flight Ways*, 7 (original emphasis).

61. BBC Radio 4, *The Dying of the Ice*, "Olafur Eliasson." www.bbc.co.uk/programmes/m0006mqw (accessed November 28, 2020).

people watch ice, they also listened to air bubbles from atmospheres of lost worlds pop and fizzle into the present. They smelled air made under conditions different from those they lived in. People hugged and kissed the ice. They spied varying colors of ice blocks and talked about what ice melt meant. They licked and tasted ice as they learned that what they were witnessing was roughly 1/100th of a second of ice loss in the Arctic. Ice Watch was, in short, a climate-spectacle complex that used the environment as exhibit space for dying ice.[62]

The podcast series coincided with a retrospective on Eliasson's work at Tate Modern from July 2019 to January 2020. I took in the exhibit three times over two months. I gawked at, then reflected on, a poster display of source material some ten meters long at the end. Among news clippings, poems, and Google Earth images were works from Donna Haraway, Elizabeth Povinelli, Rebecca Solnit, and numerous scientists, theorists, and artists.[63] These formed a bibliographic bookend to an exhibit in which loss featured prominently. *The Glacier Melt Series 1999/2019* is a set of thirty paired images documenting disappeared ice. It hung opposite photos of *Melting ice on Gunnar's land*. Perhaps the most poignant, however, was *The Presence of Absence Pavilion*, in which a plaster cast was made from a block of northern ice before it melted. By using a rubber cast to produce a negative and then casting that in bronze, Eliasson's art lets people step into the void of absent ice (fig. 1). Experiencing ice loss this way is different for different people. It depends on the relative presence of bodies to absent ice. The space left by ancient ice was not incommensurate with experience, which pushed against ideas that human and geological scales are incommensurable. Such ideas were present in works referenced by Eliasson's poster board, such as Morton's idea that some objects are so vastly distributed in time and space that they exceed human experience of them as "things."[64] Such claims of incommensurability are a near axiom of the Anthropocene, yet they reify the human scale to compare it against the geological.[65] Standing inside absent ice, by contrast, provided space for an embodied process of scaling the geological to experience. Like other technologies that mediate space and scale, peering in and out of the glacial negative and watching others enter and exit was a reminder of geologist Marcia Bjornerud's remark that different ways of knowing the Earth now mean "that the planet's natural pace is not so far outside our own experience."[66]

A month after Eliasson's exhibit opened the funeral for Ok Glacier took place. It prompted further reflections on how ice loss is entangled with cultural loss. For instance, reflecting on his elegy for Ok Glacier, Andri Magnason described mourning in unfamiliar terms, stating he would "mourn it like a thermostat . . . it's telling me something is going

62. *Ice Watch* critiqued by Hornby, "Appropriating the Weather."

63. Eliasson, Olafur. "In Real Life Resources."olafureliasson.net/inrealliferesources/ (accessed November 28, 2020).

64. Morton, *Hyperobjects*.

65. Coen, "Big Is a Thing of the Past"; Schmidt, "The Moral Geography of the Earth System."

66. Bjornerud, *Timefulness*, 52.

Figure 1. Olafur Eliasson, *The Presence of Absence Pavilion,* 2019. Bronze, 200 × 100 × 100 cm, installation view: Tate Modern, London, 2019. Photo: Anders Sune Berg. Courtesy the artist; Neugerriemschneider, Berlin; Tanya Bonakdar Gallery, New York/Los Angeles. © 2019 Olafur Eliasson.

very wrong."[67] Elsewhere responding to the intersection of ice loss and cultural loss proceeds differently. For instance, among Indigenous peoples in Northern Canada, ice loss is constitutive of the struggle over what Sheila Watt-Cloutier termed "the right to be cold" in her petition to the Inter-American Commission on Human Rights.[68] Losing ways of knowing icy environments are not histories long forgotten. Neither is rapid global warming incommensurate with social experience or memory. Permafrost melting, coastal erosion, and sea ice loss are experiences of just a few human generations subject to industrialization and settler colonialism.[69] It is well established that the rate of Arctic warming exceeds the global average owing to a convergence of air temperature increase, ocean dynamics, and lowered albedo (the ratio of solar radiation reflected by Earth's surface). This acceleration of geologic time is constitutive for how loss is experienced in many Arctic communities and forces attention to different ecologies of practices.

There are several legitimate ways to relate the body of knowledge regarding how humans are altering the planet to a way of thinking consistent with Earth system science. These characterize debates about the Anthropocene. There is a narrower subset also consonant with how Indigenous scholars relate the Anthropocene to continued forms of colonial violence.[70] Histories of Indigenous fishing and trade across the Bering Sea have been bent into extractive regimes for oils both alive (whales) and fossilized (petroleum).[71] Indigenous ways of knowing ice were forcefully curtailed in the process: ways of seeing ice, of moving on it, of judging when to get off it and when not to venture out.[72] These losses were, and remain, specific to ecologies of practices in particular environments. As Julie Cruikshank's powerful engagement with Indigenous peoples and sciences in Canada's Yukon makes clear, watching ice was a practice long before London existed. So too was listening to it, making memories with it, and storying its movements and sentience.[73] When Sheila Watt-Cloutier submitted her petition for the "right to be cold" she drew on these relations of knowledge and ethos, describing the petition as "a gift from Inuit hunters and elders to the world and to those most negatively affected by climate change."[74] Despite Indigenous knowledge of ice, attitudes of "science for the West, myth for the rest" frequently treat Indigenous knowledge and practices as local or anecdotal.[75] Indigenous loss is in this way subject to the same double standard for ice as in other domains: Indigenous loss is relegated beyond the ken of Western science and

67. BBC Radio 4, *Beyond Today,* "Why Did Iceland Hold a Funeral for a Glacier?" www.bbc.co.uk/programmes/p07l7b2j (accessed November 28, 2020).

68. Watt-Cloutier, *The Right to Be Cold*.

69. Wright, *Our Ice Is Vanishing/Sikuvut Nunguliqtuq*.

70. Lewis and Maslin, "Defining the Anthropocene"; Whyte, "Indigenous Climate Change"; Davis and Todd, "On the Importance of a Date."

71. Demuth, *Floating Coast*.

72. Routledge, *Do You See Ice?*

73. Cruikshank, *Do Glaciers Listen?*

74. Watt-Cloutier, *The Right to Be Cold*, 241.

75. Scott, "Science for the West"; cf. Orlove et al., *Darkening Peaks*.

environmental concern even though Western practices draw on long histories of attachments to glaciers as menacing, sublime, and more recently through analogical treatments of glaciers as endangered species.[76]

Changes to the Earth system also alter affective attachments to ice in Italy, Nepal, and along the spine of South America.[77] Each summer palliative care for Presena Glacier (Italy) includes six weeks of painstaking work to roll out reflective bandages to stem melt.[78] Unease also takes other forms, such as Sami poets and knowledge keepers questioning traditional knowledge owing to how different colors of ice are no longer guides to stability.[79] Artists have set up hydrophones to listen to ice loss in Antarctica and made possibly the oldest musical instruments ever played using millennia-old ice from Svalbard.[80] On the border of Chile and Argentina opposition to direct threats to ice are more targeted as communities have mobilized to stop Barrick Gold's plan to "move" three glaciers for a new mine.[81] In short, there are many ways to be attached to ice, from reverence to resignation, and from care to contesting the hazards glacial loss poses scientifically, socially, and politically.[82] But it is not hard to anticipate a critic who might argue that if conditions changed, glaciers could return and attachments reform. So, proposals to move glaciers excluded, glacial loss is not so final because glaciers are not going extinct. They are coming and going in geologic time. To respond, I return to glaciers as epistemic objects.

Water is a marvelous phenomenon about which it has not always been easy to establish even basic facts, such as its boiling point.[83] Furthermore, despite its common notation as H_2O water includes OH- and H_3O and is characterized by atomic exchanges that last a millisecond on average, which is much longer than hydrogen bonding and other exchanges so rapid that it is erroneous to treat water "as a permanent structure."[84] Among these combinations no single arrangement of water's microstructure is the correct one.[85] Water is always and everywhere contingent. Glaciers too. They carry the geologic signature of atmospheric ratios of oxygen isotopes captured in their formation and they are historical repositories for pollen, dust, and volcanic ash. This is what makes ice cores so important to climate science. As epistemic objects, glaciers carry histories of Earth's contingent dynamics, not simply evidence that water has been freezing

76. Carey, "The History of Ice."

77. Brugger et al., "Climates of Anxiety"; cf. Jørgensen, "After None."

78. "Italian Team."

79. BBC Radio 4, *The Dying of the Ice*, "Reindeer Poets." www.bbc.co.uk/programmes/m0006mqw (accessed November 28, 2020).

80. BBC Radio 4, *The Dying of the Ice*, "Frozen Music." www.bbc.co.uk/programmes/m0006mqw (accessed November 28, 2020).

81. Li, "Moving Glaciers."

82. Carey, "Living and Dying with Glaciers."

83. Chang, *Inventing Temperature*.

84. Chaplin, "Structure and Properties of Water," 9; VandeWall, "Why Water is Not H_2O."

85. Chang, *Is Water H_2O?*

for a long time. To lose *this* glacier, then, is to lose a particular history of Earth in that place. Should conditions change, *that* glacier will not return. Any future glacier will carry its own unique history. A similar message on Olafur Eliasson's poster display stood out on a fluorescent orange Post-It™ note: "data will always bear the marks of its history."

Glaciers carry their own historicity. They also function as epistemic objects that help stabilize the search for other phenomena.[86] For Cuvier past glaciers stabilized species extinction. Since Cuvier's declaration geology has changed substantially: new dating techniques, geochemistry, isotope dating, and molecular phylogenies of species are situated amid new networks of expertise and new appraisals of anthropogenic intersections with Earth history. Epistemic objects, like glaciers, continue to provide "matter-of-fact environments" through which to extend knowledge within this scientific ethos. Yet this is not the only way epistemic objects can function. They can also be destabilizing forces.[87] They can generate worry and direct attention to new matters of concern. Glaciers hastening toward oblivion have this effect. When glaciers die, the response demands more than an affirmation of affective attachments. As Kristie Dotson and Kyle Whyte show in their intersectional work on Black feminist and Indigenous scholarship, developing attachments are not always sufficient owing to unknowable forms of epistemic injustice that arise from losing interdependent ways of knowing.[88]

Glacial Extinction, Epistemic Injustice

In 2016, floating on a fake iceberg near Svalbard, Ludovico Einaudi performed his haunting piece *Elegy for the Arctic*. Watching it on YouTube, as I often do to begin classes on climate justice, the music seems to echo off of ice walls plunging into Arctic seas. The listener has no way of knowing how it actually sounded. It seems likely the piano was drowned out by oceanic churn, especially when ice calved mid-melody. The conundrum points to broader issues of epistemic justice and the knowability of loss. Some aspects of loss can be related to by cultivating ways of detecting moral harms. By cultivating scientific attachments, for instance, we can learn why glaciologists are so concerned about how glacial loss has now permanently pushed the Greenland ice sheet into a state of mass loss.[89] Other losses are unknowable. Dotson and Whyte identify these as forms of abjection in which communities directly affected by injustice are "placed on the border of collective consideration."[90] They term such injustices "present absences" because they marginalize and oppress the interdependent relations through which entire communities relate knowledge and ethos.[91] Stepping into the void Eliasson creates in *The Presence of Absence Pavilion*, whatever attachment that might bring, is incomparable to

86. Chang, "The Persistence of Epistemic Objects."
87. Rheinberger, *Toward a History of Epistemic Things*.
88. Dotson and Whyte, "Environmental Justice."
89. King et al., "Dynamic Ice Loss from Greenland Ice Sheet."
90. Dotson and Whyte, "Environmental Justice." 61.
91. See also Karera, "Blackness and the Pitfalls of Anthropocene Ethics."

losing interdependent relations. This is especially so for Indigenous peoples now recovering the plurality of practices that place extinction within the ethos of their lands and relations.[92] These are not exercises in salvage but of political self-determination. They also point to how losses of interdependent relations are nonrelational in the sense of being incomparable. The aim of considering relational and nonrelational concerns is not to develop a common currency for loss. It is to show—to make perceptible, not to prove—how incomparable glacial loss demands a new moral repertoire for loss.[93]

Within scientific communities, different practices may diverge in ways open to comparison.[94] This makes for rigorous debate about how to best explain deglaciation when relations among methods, analysis, interpretation, and so on are compared. But for geologic extinction there are multiple ecologies of practices in play. In 2016, for instance, bloggers and several scientists criticized an article that proposed the idea of feminist glaciology.[95] Critics argued it reignited the "science wars" and was bent on attacking objectivity. For many others the article made a point comfortably accepted beyond the geography journal in which it was published; namely, knowledge is produced in social contexts. The "brouhaha" over the article was sufficient for the journal *Science* to seek clarifications from the lead author, Mark Carey, who argued that appraising the epistemic disposition of one field through the criteria of another inevitably leaves one or both parties unsatisfied.[96] That is, Carey appealed to the lack of neutral ground on which to compare diverging practices for linking bodies of knowledge to ways of thinking.

In the case of feminist glaciology divergent ways of relating bodies of knowledge to ways of thinking were contested for how they compare with other practices of glaciology. Comparison can also lead to collaboration, such as when artists partner with geologists. For Stengers such alignments take the form of an event over common concerns that "does not have the power to define its eventual practical consequences."[97] That is, collaboration or contest is not predictive. Artists or scientists may go their own ways after events end. A rapprochement may be reached regarding feminist glaciology. These possibilities present unique matters of concern owing to how glaciers compel concern regarding divergent attachments and relations. Geologic extinction can be an event that stabilizes practices marking loss, such as in a funeral attended by glaciologists, anthropologists, politicians, and artists. There is no prediction of how convergence on that event will translate going forward, however. Speculatively geologic extinction may become a way to hesitate over glacial death in new, Anthropocene surroundings. It may not; glacial funerals may become rituals attended by many for whom deaths augur different meanings.

92. Hernández et al., "The Creatures Collective"; Theriault et al., "Living Protocols."
93. Distinction to "showing" from Stengers, *Cosmopolitics I*.
94. Chang, *Is Water H_2O?* describes these as "systems of practices."
95. Carey et al., "Glaciers, Gender, and Science."
96. Gramling, "Q&A: Author of 'Feminist Glaciology.'"
97. Stengers, "Including Nonhumans," 27.

Glacial death, and geologic extinction, may also be destabilizing in ways that require a new repertoire for loss. Recall from Dotson and Whyte that some losses are unknowable owing to particular forms of interdependence between knowledge and ways of knowing. In the case of glaciers, for instance, it is not only concern about whether glaciers are either contingently here or not; rather, for the Indigenous interlocutors that Cruikshank engages, glaciers have interdependent relations with humans that also explain the contingent behavior of glaciers.[98] The loss of these interdependent relations are incomparable; these are nonrelational losses that not every group is equipped to know. Furthermore, to put these losses into comparable terms is to perpetuate epistemic injustices by only admitting loss on terms legible to the dominant group.[99] Mick Smith raises an adjacent issue: that a nonanthropocentric account of extinction requires apprehending and appropriately responding to the particular worlds of species.[100] My argument is proximate: rather than seek terms for making unknowable losses of extinction knowable, the violence of comparison can be avoided by reckoning geologic extinction—like its biological kin—as destabilizing for loss itself.

The account of geologic extinction provided here is speculative. It cannot be settled in advance owing to geological losses being as contingent for different worlds as glaciers are constitutive of them. Stengers work, especially her recovery of cosmopolitics as the affordances available for treating a plurality of worlds without presuming on Western ones, provides another recommendation.[101] When there are many worlds at stake, or intersecting, cosmopolitics oblige adherents to hesitate over matters of concern.[102] These obligations do not reduce to rules. They are socially constituted in ways that require maintenance and renewal. Furthermore, hesitation can be compelled by nonhumans owing to their constitutive places in respective worlds.[103] Glacial loss is not the only case; mountains disemboweled by mining, despoiled waters, and unearthed ancestors all compel concern for losses of incomparable, interdependent relations.[104]

The constitutive power of glaciers makes them "good to think with" across multiple ecologies of practices, from warnings by glaciologists to art installations at conferences of the United Nations Framework Convention on Climate Change, and through to anticolonial claims for the right to be cold.[105] Not all of these are at ease with one another. For instance, when Magnason reflected on the Letter to the Future he penned for Ok Glacier, he wondered who he was writing to, dismissed ideas that Earth is sentient,

98. Cruikshank, "'Are Glaciers Good to Think With?'" 248.

99. Mitchell, "Beyond Biodiversity"; Rose et al., *Extinction Studies*.

100. Smith, "Ecological Community."

101. Stengers, *Cosmopolitics I*; "Including Nonhumans."

102. de la Cadena et al., *A World of Many Worlds*.

103. Stengers, "Including Nonhumans."

104. Padel and Das, *Out of This Earth*; de la Cadena, *Earth Beings*; Povinelli, *Geontologies*; Li, *Unearthing Conflict*; Teaiwa, *Consuming Ocean Island*.

105. Cruikshank, "'Are Glaciers "Good to Think With'?"

and worried about how to catch up to the speed of geology.[106] There is no a priori rule identifying which nonhuman attachments or detachments may be constitutive for an ecology of practices. Nor is there an obligation to force incomparable losses into relation. Rather, glacial loss obliges divergent responses. Geologic extinction provides a tool to think through how Earth's contingent relations are constitutive for a plurality of worlds and ways of thinking in an epoch of severe, unequal anthropogenic forcing on the planet. Geologic extinction obliges a disposition to losses that are as irreducible to one another as glacial death is irreversible.

JEREMY SCHMIDT is an associate professor of geography at Durham University. He is the author of *Water: Abundance, Scarcity, and Security in the Age of Humanity* (2017).

Acknowledgments

I thank Olafur Eliasson for permission to use an image of *The Presence of Absence Pavilion* installation. Sohini Kar, Willis Jenkins, and anonymous reviewers sharpened my argument. The Impact Award from the Social Sciences and Humanities Research Council of Canada provided support.

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106. Magnason, *On Time and Water*.

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