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Infrastructure and Catastrophe in Histories of Envirotech

Jamie Pietruska

Hello everyone. Thank you to Roe for convening this wonderful event, and for kindly including me. And thanks to Judy Spitzer for her heroic labors in organizing all of us. I'm delighted to be back at MIT and in conversation with you all. Since I received Roe's invitation to participate, I've been reflecting on how my own engagement with the field of the history of technology has changed since my days here as a graduate student at MIT in the Program in History, Anthropology and STS, where I was extremely fortunate to have Roe Smith as my advisor, Deborah Fitzgerald as a committee member, along with Chris Capozzola and Meg Jacobs, and Roz Williams and Leo Marx as teachers. I mean, this was a dream team in the history of technology if ever there was one.

Now I teach in a large history department where history of technology is a relatively small part of the program. And so I've occasionally had to explain to colleagues how and why history of technology matters to scholarly work in general, to other historical subfields, and to the world we live in today amid a climate emergency, pandemic, and ongoing cascade of geopolitical and economic crises. And the way I've done that in my research and my teaching is through the lens of envirotech, which as you know, emerged as a field of inquiry in the 1990s and then as a SHOT special interest group in the year 2000.

And since then, envirotech scholarship has produced some analytical frameworks and insights thanks to some of the people in this room like Deborah Fitzgerald and Ed Russell and others that I think are especially important to the present and the future of the history of technology. And so today I'll offer some reflections on thinking and teaching with envirotech

and try to connect the dots in a way between the themes of infrastructure and catastrophe and how they invite us to think about different temporalities in the history of technology.

And so I should say I took Roe's call quite literally to just reflect on where I see the most exciting scholarship in the field today and what I hope for in the future. And I just want to acknowledge how much I have learned from the scholars and the works that I'll reference today. And one of the things I've always appreciated about SHOT is how welcoming its environment, its intellectual and personal environment, has always been. But also its generous and generative politics of citation, that everyone is always learning from each other and really building on the work that has come before.

So the major innovation in envirotech has been to establish hybrid or envirotechnical landscapes as an analytical point of departure, not the sort of grand conclusion that emerged in the 1990s. And the thematic binary of technology and nature that Leo Marx famously traced in his *Machine in the Garden: Technology and the Pastoral Ideal in America* in 1964 was then reconceptualized in Richard White's *Organic Machine* in 1995, which demonstrated the historical entanglement of the natural and the human-built worlds as they've been shaped, particularly through energy and labor.[1]

Then in 2010 an important volume edited by Martin Reuss and Stephen Cutcliffe demonstrated the illusory boundary between technology and nature. And Sara Pritchard subsequently introduced the categories of envirotechnical systems, regimes, and landscapes in her book *Confluence* in 2011.[2] Others, of course, contributed monographs and edited volumes to this kind of trajectory as well.

And so this hybridity framework is a central analytic category for envirotech as I think socio-technical systems are for the history of technology more broadly. And these scholarly analyses of hybrid or envirotechnical landscapes make clear that as Sara Pritchard and Carl Zimring noted in 2020, "The boundaries of social technological environmental things and processes are often unclear and porous."[3] And this hybridity framework emphasizes, again in Pritchard and Zimring's words, "Interconnections and entanglements, multiplicity and

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[1] Leo Marx, *The Machine in the Garden: Technology and the Pastoral Ideal in America* (Oxford University Press, 1964); Richard White, *The Organic Machine: The Remaking of the Columbia River* (Hill and Wang, 1996).

[2] Martin E. Reuss and Stephen H. Cutcliffe, *The Illusory Boundary: Environment and Technology in History* (University of Virginia Press, 2010: Sara B. Pritchard, *Confluence: The Nature of Technology and the Remaking of the Rhone* (Harvard University Press, 2011).

[3] Sara B. Pritchard and Carl A. Zimring, *Technology and the Environment in History* (Johns Hopkins University Press, 2020), 8.

simultaneity urging scholars and citizens to consider interdependency, unintended consequences, and shared fates rather than strict divisions between things often held apart."[4]

And one promising avenue, as I see it, for future research in this vein, might be to foreground even further the historical relationship between envirotechnical landscapes and global capitalism, as Gabrielle Hecht, Gabriela Soto Laveaga, and Courtney Fullilove, among others, have done so brilliantly in their work on African uranium and the waste of South African uranium and gold mining, Mexican barbasco (wild yam) in pharmaceutical production, and the global circulation of seeds as deep time agricultural technologies.[5]

These works really, I think, reveal an important contrast between the short-term temporalities of capitalism and the long-term temporalities of ecological change. And one example that's of particular interest to me is the production of global commodities in the mining, pharmaceutical, and agricultural industries typically involves a future-oriented calculating. The future-oriented calculating technology of discounting, which is a method for estimating the time value of money or how much future cash flows are worth in the present. In simplest terms, it's cost benefit analysis projected into the future.

Discounting is an extraordinarily powerful yet often invisible tool that has been critiqued for its short-termism, its stifling of innovation, and its moral inadequacy in contexts like our climate emergency. I've learned a great deal about discounting from Liliana Doganova's new book and also from Will Deringer, who's here at MIT STS.[6]

And I think future work in envirotech might consider more fully the role of calculating technologies like discounting, other market devices, and finance capitalism more broadly in shaping envirotechnical landscapes.

In a related methodological innovation from envirotech is its analysis of infrastructure as inseparable from its ecological and social costs. Infrastructure has become a central frame of analysis within the history of technology. And it includes, as you know, histories of transportation, communication, information, computing, and energy, among other topics.[7] And

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[4] Pritchard and Zimring, *Technology and the Environment*, 20.

[5] Gabrielle Hecht, *Being Nuclear: Africans and the Global Uranium Trade* (MIT Press, 2014); Gabrielle Hecht, *Residual Governance: How South Africa Foretells Planetary Futures* (Duke University Press, 2023); Gabriela Soto Laveaga, *Jungle Laboratories: Mexican Peasants, National Projects, and the Making of the Pill* (Duke University Press, 2009); Courtney Fullilove, *The Profit of the Earth: The Global Seeds of American Agriculture* (University of Chicago Press, 2017).

[6] Liliana Doganova, *Discounting the Future: The Ascendancy of a Political Technology* (Princeton University Press, 2024); William Deringer, "Mr. Aecroid's Tables: Economic Calculations and Social Customs in the Early-Modern Countryside," Journal of Modern History 96, no. 1 (2024): 1-46.

[7] For a recent appraisal of the "infrastructural turn" in history, see Mary Bridges, "The Infrastructural Turn in Historical Scholarship," *Modern American History* 6, no. 1 (2023): 103-20. See, for example, Ashley Carse, *Beyond Big Ditch: Politics, Ecology, and Infrastructure at the Panama Canal* (MIT Press, 2014);

the MIT Press publishes an important series on infrastructure and its material informational and structural aspects.

The short-term and the long-term economic and environmental impacts of these infrastructures are increasingly visible in their histories and in the present day as historians and STS scholars have shown in context from civil engineering projects like the Panama Canal to energy delivery systems to electrical grids to irrigated landscapes, and the list goes on.

To take one example that's a data infrastructure, I just want to mention for a minute the environmental impacts of cloud computing, cryptocurrency mining, and AI, which consume mind-boggling amounts of energy and water. And this has recently come into view in histories of technology, environmental histories of computing, STS scholarship, and tech journalism. The cloud, as Nathan Ensmenger has pointed out, is a factory, not an abstract or ethereal entity.[8]

Cloud computing is powered by data centers requiring industrial scale energy consumption for data processing and cooling, which has the potential to significantly increase carbon emissions and contribute to water scarcity. And as the anthropologist Steven Gonzalez Monserrate explains in his work, was done here at the MIT program and HASTS, as of a couple of years ago, the cloud "has a greater carbon footprint than the airline industry. And data centers use more energy than some small countries."[9]

Recent scrutiny of these kinds of environmental consequences of data infrastructures has pushed the giant cloud service providers Google, Microsoft, Amazon, etc., to begin to articulate some kind of focus on decarbonization and renewable energy. How much of that is just rhetoric remains to be seen. And I think future historians of computing might use an envirotech lens to consider more fully the ecological dimensions of their topics.

And although infrastructural technologies are sometimes used as a kind of convenient chronological shorthand like "The Railroad Age" or "The Automobile Age," historians of technology remind us of the overlapping histories of infrastructures – transportation, communication, information infrastructures, for example. And also postal, telegraph, and

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Christopher F. Jones, *Routes of Power: Energy and Modern America* (Harvard University Press, 2014); Andrew Needham, *Power Lines: Phoenix and the Making of the Modern Southwest* (Princeton University Press, 2014); Mark Fiege, *Irrigated Eden: The Making of an Agricultural Landscape in the American West* (University of Washington Press, 1999).

[8] Nathan Ensmenger, "The Environmental History of Computing," *Technology and Culture* 59, no. 4S (2018): S19.

[9] Steven Gonzalez Monserrate, "The Cloud Is Material: On the Environmental Impacts of Computation and Data Storage," *MIT Case Studies in Social and Ethical Responsibilities of Computing* (January 2022), https://doi.org/10.21428/2c646de5.031d4553.

telephone networks, for example, existed on top of each other in layers in the nineteenth century, not in these neat, indiscrete temporal stages.[10]

Historians of technology since Thomas Hughes have relied on systems, networks, and infrastructures as analytic frameworks for explaining historical change over time.[11] And I think it's important and really interesting to note that infrastructure also has a future-oriented temporality. And anthropologists of infrastructure have begun to work on this topic.

In a recent theorization of infrastructural time, the anthropologist Akhil Gupta has emphasized the future orientation of infrastructure. It's capital intensive and resource intensive in its initial investment. And that investment is calculated to pay off in the long term in the form of economic growth, social progress, other imagined social and economic benefits. And according to Gupta, infrastructures reflect particular social imaginaries of the future, so how a particular society could be, how it should be, and thus are what he calls "concrete instantiations of visions of the future."[12]

And the material forms, of course, of these infrastructures, imagined infrastructural futures, produce envirotechnical change over time, which leads Gupta to "conceptualize infrastructure as a process, not a thing, a thing in motion, ephemeral, shifting, elusive, decaying, degrading, becoming a ruin but for the routines of repair, replacement and restoration, or in spite of them."[13] And I read this and think, what better description of envirotech?

This is the scary part. Don't get nervous. Histories of infrastructure and maintenance too often deferred also direct our attention to risk, accidents, and disasters, all things that have drawn much recent attention in the history of technology and other fields and disciplines all concerned with risk.

Large technical systems, as we know, do not always work as intended. Neither do networks or infrastructures. And technological failure is one framework for that phenomenon. Although, as the sociologist Charles Perrow famously observed in his classic book *Normal Accidents*, in large, complex, tightly-coupled systems -- his examples are nuclear reactors,

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[10] See, for example, Richard R. John, *Spreading the News: The American Postal System from Franklin to Morse* (Harvard University Press, 1998); Richard R. John, *Network Nation: Inventing American Telecommunications* (Harvard University Press, 2010); Robert MacDougall, *The People's Network: The Political Economy of the Telephone in the Gilded Age* (University of Pennsylvania Press, 2014).
[11] Thomas Parke Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Johns Hopkins University Press, 1983).
[12] Akhil Gupta, "The Future in Ruins: Thoughts on the Temporality of Infrastructure," in *The Promise of Infrastructure*, ed. Nikhil Anand, Akhil Gupta, and Hannah Appel (Duke University Press, 2018)," 63.
[13] Gupta, "Future in Ruins," 62.

petrochemical plants, commercial aviation, space flight -- accidents are inevitable and cannot be engineered out of the system.[14]

So accidents in these systems are rare but normal. My students always panic at this part, so don't panic, even if you flew here on a Boeing aircraft. You're fine. You're fine. You're fine. I always ask my students what's the most dangerous part of flying? And they say, "Sometimes it's the takeoff, and sometimes it's the landing." And I say, "No, it's driving to the airport." Once you're on board the airplane, statistically you're fine.

As work by Arwen Mohun and Andrew Russell and Lee Vinsel has emphasized, the role of risk experts and also maintainers is critical to histories of infrastructure and how well or not infrastructure functions in the present. Here, too, the work of safety professionals and maintainers, which is mostly invisible until an accident happens, unfolds on a long-term time frame in contrast to the short-termism of innovation or the shorter time frame in which a system is built and is up and running.[15]

Okay, this is the scary part to me. I'm just going to admit that at the outset. In the twenty-first century -- well, let me back up and say yes, as others have pointed out in their talks, we have had previous episodes of historical crisis and crises unfolding over different time scales. Historians of disaster have written brilliantly on different cultures of calamity that have emerged in different periods, in different times and places. And all that is quite true.

It's also true that in the twenty-first century weather and climate-related disasters have become more frequent. They've become more intense due to rising global temperature, rainfall and sea levels, more rapid intensification of tropical storms, higher winds, and slower moving storms. And this is a data visualization from the NOAA National Centers for Environmental Information of the number of billion-dollar disasters in 2023, which was the highest number ever in the United States: twenty-eight billion-dollar weather and climate-related disasters during its fifth warmest year on record (see Figure 1).

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[14] Charles Perrow, *Normal Accidents: Living with High-Risk Technologies* (Basic Books, 1984).
[15] Arwen Mohun, *Risk: Negotiating Safety in American Society* (Johns Hopkins University Press, 2013); Andrew Russell and Lee Vinsel, "Hail the Maintainers," aeon.com, April 7, 2016, https://aeon.co/essays/innovation-is-overvalued-maintenance-often-matters-more.

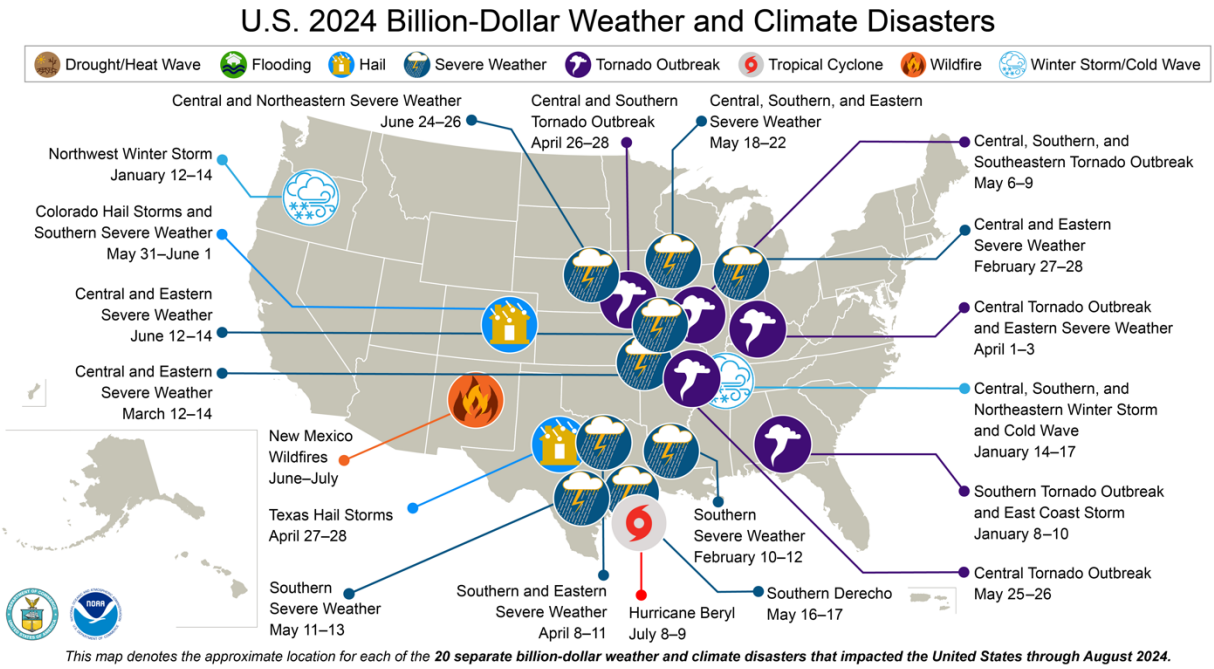

Figure 1: Map of U.S. 2024 Billion-Dollar Weather and Climate Disasters
NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2024). https://www.ncei.noaa.gov/access/billions/, DOI: 10.25921/stkw-7w73

And these records were first kept going back to 1980. So by simply counting the number of billion-dollar weather and climate-related disasters in the United States, we are in a new era of disaster preparedness and emergency management.

So hurricane forecasters are beginning to consider, is it time for Category 6 for hurricanes? As they have that debate, scholars have also begun to reconsider and redefine catastrophe itself. And here I just want to offer two examples that I find especially compelling from literary history and cultural history. Eva Horn has identified in modern fiction and film what she calls a "catastrophic imaginary" in which catastrophe became in the twentieth century more of a process than an event, as she writes, "a keyword for the modern historical sense of the present, the looming sense of danger." And Rosalind Williams has identified in a 2021 essay in *Technology and Culture*, "our current historical consciousness [as] the perception of living in a rolling apocalypse."[16] And I think both Horn and Williams point to a shifting temporality for

[16] Eva Horn, *The Future as Catastrophe: Imagining Disaster in the Modern Age* (Columbia University Press, 2018), 23, 7; Rosalind Williams, "*Crisis*: The Emergence of Another Hazardous Concept,"

catastrophe away from a singular spectacular event to a long-term gradual, often invisible process or less visible process that mirrors the shift in scholarly frameworks for disaster that have emerged in envirotech in disaster-related fields.

As disaster scholars and social historians have demonstrated, the effects of disasters, both rapid-onset fast disasters and slow infrastructural disasters, are disproportionately borne by communities of color and economically disadvantaged communities that have less ability to live outside of disaster-prone regions and less ability to evacuate in the face of life-threatening hazards.

The examples are too numerous to list at length, but some of the most obvious include Hurricane Katrina (2005), Fukushima (2011), the Flint water crisis (2014-), and the ongoing Covid-19 pandemic. And the inability of many black residents of New Orleans to evacuate by car ahead of Hurricane Katrina is now well known. And it really has to be understood in the longer historical trajectory of restricted black mobility and segregated travel as the historian Mia Bay makes clear in her Bancroft prize-winning book *Traveling Black: A Story of Race and Resistance.*[17]

And I think this echoes Ed Russell's earlier observation today about the relationship between the history of technology and social histories of racial injustice.

Also recently, disaster researchers and emergency management professionals have started to emphasize the importance of disaster justice as a guiding principle in approaches to recovery. You can see an example of this thinking from Alessandra Jerolleman, *Disaster Justice for All: The Need for a More Equitable and Just Recovery Lens*, who writes,

> As disasters become more frequent and severe, it is more important than ever to determine what can be done to promote more just and equitable disaster recovery. The outcomes of major disasters are nearly always inequitable, which increases the vulnerability of those who struggled before the disaster and often displaces large portions of communities. The tremendous burdens that disaster recovery imposes result in some

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Technology and Culture 62, no. 2 (2021): 532. See also Theo Reeves-Evison, "The Art of Disciplined Imagination: Prediction, Scenarios, and Other Speculative Infrastructures," *Critical Inquiry* 47, no. 4 (2021): 719-48; Rosalind Williams, *The Triumph of Human Empire: Verne, Morris, and Stevenson at the End of the World* (University of Chicago Press, 2013); Amanda Rees and Iwan Rhys Morus, eds., *Presenting Futures Past: Science Fiction and the History of Science*," *Osiris* 34, no. 1 (2019): 1-15.

[17] Mia Bay, *Traveling Black: A Story of Race and Resistance* (Harvard University Press, 2021).

> individuals—such as renters, those working in low-paying jobs, and undocumented people—finding it nearly impossible to recover after disaster.[18]

I think future scholarly works on history of infrastructure might aspire to a fuller engagement with disaster justice, with infrastructural justice in the present day. And I think this again echoes Ed Russell's suggestion earlier today of process-oriented interest groups in the history of technology. With respect to justice, for example, technology and various forms of justice, whether disaster related or infrastructural, etcetera.

And so as I continued connecting the dots through all of these different frameworks and concepts, these structural racial inequities in experience of disaster and calls for justice-oriented framework remind me of this article from *Technology and Culture* in October of 2022 when leading historians of technology Chandra Bhimull, Gabrielle Hecht, Edward Jones-Imhotep, Chakanetsa Mavhunga, Lisa Nakamura, and Asif Siddiqi identified a systemic and epistemic racism in the history of technology in this roundtable.

And as they note at the outset of the roundtable, "Systemic racism is first and foremost an infrastructural phenomenon. Systemic racism is a deeply techno-political matter, one that deserves serious and sustained attention from historians of technology and their intellectual allies. This is and should be a central topic for our field."[19]

And in my view, confronting and substantively addressing this problem in the field remains the biggest challenge for historians of technology. There are no easy answers to the hard questions and critiques that they lay out, but my hope for our field is that more scholars will follow the lead of these scholars and others who are reckoning more fully with the social harms of infrastructure in their work, including its historical relationship to systems of white supremacy.

And I'll end on this note, that thinking envirotechnically may be one way that allows us to do that. As Sara Pritchard and Carl Zimring note, again from their 2020 volume,

> within the global south and indigenous spaces across the planet, stories of how people navigate the porous boundaries of technology and environment and how in fact diverse communities defy and understand them will give us better understandings of what we

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[18] Alessandra Jerolleman, "Disaster Justice for All: The Need for a More Equitable and Just Recovery Lens," Research Counts online essay for Natural Hazards Center, December 10, 2019, https://hazards.colorado.edu/news/research-counts/disaster-justice-for-all-the-need-for-a-more-equitable-and-just-recovery-lens.

[19] Chandra Bhimull, Gabrielle Hecht, Edward Jones-Imhotep, Chakanetsa Mavhunga, Lisa Nakamura, and Asif Siddiqi, "Systemic and Epistemic Racism in the History of Technology," *Technology and Culture* 63, no. 4 (2022): 935.

have built, what we have altered, how we have shaped the past, and how we might shape the future. We hope that by thinking envirotechnically, we can engage with the surrounding world and with one another in ways that are more sustainable and just.[20]

[20] Pritchard and Zimring, *Technology and the Environment*, 167-68.