Notes

➡ For additional information about this book

Notes

1. Chariton, "Drone Pilots Exposing Oil Police Violence." For more extensive studies of Indigenous resistance and environmental (in)justice at Standing Rock, see Estes, *Our History Is the Future*; and Whyte, "The Dakota Access Pipeline."

2. See also Drone2bewild (interviewed by Paulette Moore), "Drone Footage of Dakota Access Pipeline"; Real News Network, "Police Are Shooting Down Aerial Drones." For more extensive analysis of protest as well as environmental monitoring with drones, see Kaplan, "Atmospheric Politics"; Elliott et al., "Drone Use for Environmental Research"; and Fish, "Crash Theory."

3. Duarte, *Network Sovereignty*. For a discussion of computing otherwise, see Pritchard, "The Animal Hacker"; Amrute and Murillo, "Introduction"; and Philip, Irani, and Dourish, "Postcolonial Computing."

4. Chariton, "Drone Pilots Exposing Oil Police Violence." For a more extensive discussion of Indigenous science and environmental change, see Whyte, "Indigenous Science (Fiction)."

5. See Clark, *The Poisoned City*; Hanna-Attisha, *What the Eyes Don't See*; Fennell, "Are We All Flint?"; and Pulido, "Flint, Environmental Racism, and Racial Capitalism."

6. For a more extensive discussion of these dynamics, see Hemmi and Graham, "Hacker Science versus Closed Science"; Kimura, "Citizen Science in Post-Fukushima Japan"; Kenens et al., "Science by, with and for Citizens"; and Plantin, "The Politics of Mapping Platforms."

7. See Global Forest Watch.

8. For a sense of the range of community and citizen science projects monitoring air quality, see the Air Sensors International Conference 2018 program archive, which includes slides and videos of project presentations. For a more extensive discussion of one of these projects, IVAN (Identifying Violations Affecting Neighborhoods), see English, Richardson, and Garzón-Galvis, "From Crowdsourcing to Extreme Citizen Science."

9. Gabrys, "Planetary Health in Practice."

10. For a discussion of the connection between wildfires, air pollution, and sensing, see Gabrys, "Sensing a Planet in Crisis."

11. This concept of world making travels across multiple texts that I engage with throughout this book. While numerous researchers take up this term in different and diverging ways, I especially situate this discussion in relation to William James's discussion of world making in *A Pluralistic Universe*.

12. James, *Pragmatism and Other Writings*, 27. While I draw on James's notion of the open air, the general sensibility to test and remake concepts in relation to lived experience runs through a number of pragmatist texts.

13. Alfred North Whitehead did not use the term "open air" as such. Still, James's writings influenced his commitment to pluralism, which Whitehead described in his own work as "pluralistic realism." In this way, his emphasis on contingency and experience resonates with James's focus on worlds in process. See Whitehead's *Process and Reality*, 78, 88.

14. I have previously briefly written about "atmospheric citizenship" in the context of climate change and managing the global commons of the atmosphere as articulated through creative-practice projects. In other writing I have explored how wireless and digital technologies operate through atmospheric modalities to form atmospheric media. This current work on citizen sensing more directly engages with the atmospheric registers of air pollution, breathing, and citizenship while also drawing on this earlier work. See Yusoff and Gabrys, "Climate Change and the Imagination"; and Gabrys, "Atmospheres of Communication." In addition, as I discuss throughout *Citizens of Worlds*, many more writings at the juncture of atmospheres and air pollution inform this study of atmospheric citizenship, including Alaimo, *Bodily Natures*; Choy, *Ecologies of Comparison*; Fortun, "From Latour to Late Industrialism"; Graham, "Life Support"; and Mark Whitehead, *State Science and the Skies*. Writing recently in a more biopolitical rather than pluralistic register, Asher Ghertner suggests how the "airpocalypses" in Delhi, India, generate atmospheric citizenships that require governing "the citizen body" as a distributed composition. See Ghertner, "Airpocalypse."

15. There is an extensive and expanding range of work on digital (and data) citizenships that this book does not have space to survey. While throughout I draw on my earlier analyses of citizens and digital technologies, especially as developed in Gabrys, "Programming Environments," I am also in conversation with ongoing research in this area, including Hintz, Dencik, and Wahl-Jorgensen, *Digital Citizenship in a Datafied Society*; Isin and Ruppert, *Being Digital Citizens*; and Powell, *Undoing Optimization*. Also in the background are studies on citizens and smart cities—see Shelton and Lodato, "Actually Existing Smart Citizens"; and Datta, "The Digital Turn in Postcolonial Urbanism."

16. Citizen science as a field and topic of research has been proliferating over many decades now, along with civic science, public engagement, participation, and many more related areas of theory and practice. While this study does not undertake a comprehensive survey of these literatures, several texts informing this research include Irwin, *Citizen Science*; Michael, "Publics Performing Publics"; Lave, "The Future of Environmental Expertise"; Chilvers and Kearnes, *Remaking Participation*; Felt and Fochler, "The Bottom-up Meanings"; Waterton and Tsouvalis, "An Experiment with Intensities"; and Jasanoff, "Technologies of Humility."

17. Gabrys, "Citizen Sensing, Environmental Monitoring."

18. Goodchild, "Citizens as Sensors." While this text is often referenced as a sort of originary use of "citizen sensing," Goodchild instead referred to "citizens as sensors"

who might crowdsource map data within the context of volunteered geographic information (VGI). There is actually very little by way of sensor technologies—or sensing as a practice—in Goodchild's text. However, this is an early and interesting example of participatory mapping, as developed by many researchers often working in geography. For parallel examples, see Elwood, "Volunteered Geographic Information"; and Zook et al., "Volunteered Geographic Information." Earlier uses of "citizen sensing" in reference to environmental sensing technology by potentially grassroots groups of participants seem to be within the HCI community and tech companies. For instance, the Center for Embedded Network Sensing (CENS) used the term "participatory sensing" in Burke et al., "Participatory Sensing." However, here I want to complicate this genealogy and usage further by attending to the fluidity of a practice that has not yet settled into form, and by engaging with how the scripts of technology companies do not lead to a direct unfolding of devices in the world toward certain outcomes. In this way, while this study also engages with citizen science and aligned practices, it does not adopt a taxonomic or classificatory approach to these practices, which are often further presented as a hierarchical ordering of modes of participation, perhaps under the influence of Arnstein's "ladder of participation." See Arnstein, "A Ladder of Citizen Participation."

19. More information on the Citizen Sense project is available at http://citizensense.net.

20. The statement attributed to Theresa May is: "Today, too many people in positions of power behave as though they have more in common with international elites than with the people down the road, the people they employ, the people they pass on the street. . . . But if you believe you are a citizen of the world, you are a citizen of nowhere. You don't understand what citizenship means." There was significant backlash after this statement, with many people adopting the label "citizen of nowhere" on social-media profiles and adding it as graffiti in London spaces. See Bearak, "Theresa May."

21. As Pheng Cheah suggests, "cosmopolitanism is about viewing oneself as part of a world, a circle of political belonging that transcends the limited ties of kinship and country to embrace the whole of deterritorialized humanity." Cheah, *What Is a World?*, 3.

22. See Kleingeld, *Kant and Cosmopolitanism*, for a discussion of these permutations of world citizenship and cosmopolitanism, especially in relation to Kant. As she suggests, in a Kantian reading, a citizen of the world is not necessarily someone who is unfixed and rudderless, but instead can be someone who is rooted in place and yet has a concern and consideration for world affairs, and is not limited by the nation. However, this project may involve caring for a very particular kind of world (formed through European colonialism), and by a particular kind of white male European citizen–subject.

23. In discussing the work of Karl Jaspers, Hannah Arendt suggests, "The establishment of one sovereign world state, far from being the prerequisite for world citizenship, would be the end of all citizenship. It would not be the climax of world politics, but quite literally its end." Arendt, "Karl Jaspers," 82. This particular configuration of politics as plurality can be found in the work of Carl Schmitt, who writes, "The political world is a pluriverse, not a universe." Schmitt, *The Concept of the Political*, quoted in de la Cadena, "Indigenous Cosmopolitics in the Andes," 341. De la Cadena queries this formation of politics by considering the other-than-humans that could also be constitutive of the political.

24. Law, "What's Wrong with a One-World World?" See also de la Cadena and Blaser, *A World of Many Worlds*. In a different but resonant register, Kathryn Yusoff refers to the "global-world-space" where the world is a singular entity available for conquest, which in turn informs relations across subjects and environments. See Yusoff, *A Billion Black Anthropocenes or None*.

25. For instance, Balibar notes that the emergence of the citizen of the world was in relation to a European colonial world that enabled specific transnational flows of commodities and people. See Balibar, *Citizenship*, 71. See also Lowe, *The Intimacies of Four Continents*.

26. These more-than-state formations of citizenship are a common refrain within citizenship studies, and can be found in work ranging from Balibar, *Citizenship*, to Braidotti, *Transpositions*. In a different way, Indigenous and Black studies literatures discuss refusing the nation—and its forms of citizenship—as units of belonging because of the exclusions, diminutions, violence, and dispossessions that have been and are undertaken under the label of the citizen. See A. Simpson, *Mohawk Interruptus*; and Sharpe, *In the Wake*.

27. It bears mentioning that "constitution" is a key way in which Balibar theorizes the formations of citizens and citizenship. Coincidentally, "co-constitution" has become a word commonly used to refer to the (participatory) formation of entities and practices, for instance, within collaborative research projects. These multiple versions of constitution are at play here. See Balibar, *Citizenship*.

28. In addition to digital citizenship literature noted earlier, there are now numerous works that challenge the easy or singular promises of greater participation (or even disconnection) that digital technologies and makerly activities would bestow. For example, see Irani, "Hackathons"; Kelty et al. "Seven Dimensions"; and Bucher, "Nothing to Disconnect From?"

29. As Isin further writes, citizenship is a conception of "dominant" groups that produce the alterities of citizenship. Isin, *Being Political*, 5.

30. Writing about the *noncitizen*, Haraway has similarly suggested, "the discursive tie between the colonized, the enslaved, the noncitizen, and the animal—all reduced to type, all Others to rational man, and all essential to his bright constitution—is at the heart of racism and flourishes, lethally, in the entrails of humanism." Haraway, *When Species Meet*, 18.

31. Berlant makes this point and further notes, "Citizenship is the practical site of a theoretical existence, in that it allows for the reproduction of a variety of kinds of law in everyday life." Berlant, "Citizenship," 38–40.

32. How citizenship can be restricted or limited, especially in relation to race (as well as class, gender, and other categories of the social), is discussed more extensively by Nelson in *Body and Soul* in reference to national as well as economic, biological, and medical forms of citizenship. Nelson's discussion of biological citizenship and health resonates with Petryna, *Life Exposed*.

33. Nelson, *Body and Soul*, 10 and passim.

34. Nelson, 22.

35. For example, see Wynter, "Unsettling the Coloniality"; and Wynter and McKittrick, "Unparalleled Catastrophe for Our Species?" In Wynter's framework and following on from Aimé Césaire, the human is "made to the measure of the world." See also Césaire,

Discourse on Colonialism; and Yusoff, *A Billion Black Anthropocenes or None*. In a resonant way, this work suggests that citizens are made to the measure of worlds.

36. While the term "uncommons" surfaces in a broad range of research, de la Cadena has established a particular approach to this concept through pluralistic ontologies. For instance, see de la Cadena and Blaser, *A World of Many Worlds*.

37. This is a recurring thread within pragmatist literature—that pluralism is not a condition of equally available or viable different possibilities, and for this reason it especially points to the power dynamics, modes of participation, and struggles that surface across multiple worlds and world making. For example, see Dewey, *The Quest for Certainty*; and Glaude, *In a Shade of Blue*.

38. The US Environmental Protection Agency has developed an "Air Sensor Toolbox" that includes instructions and protocols on how to collect citizen-sensing data. There are now multiple initiatives to provide more verifiable conditions for citizen data. However, as I discuss in chapter 3, different worlds of data can generate very different ways of working with and mobilizing data. See US Environmental Protection Agency, "Air Sensor Toolbox." For a related discussion of citizen data see Parasie and Dedieu, "What Is the Credibility of Citizen Data Based On?"

39. For instance, *civic* has variously been proposed as an alternative to *citizen*, despite their shared root, since these terms are seen to circulate differently, especially in different national contexts. See Fortun and Fortun, "Scientific Imaginaries and Ethical Plateaus." See also Backstrand, "Civic Science for Sustainability"; and Jasanoff, "Technologies of Humility." There are also now a number of studies on the conjugation of civic and tech, including Boehner and DiSalvo, "Data, Design, and Civics"; and Perng and Maalsen, "Civic Infrastructure."

40. Berlant outlines how worlds might be more binding than expansive: "Optimism is cruel when the object/scene that ignites a sense of possibility actually makes it impossible to attain the expansive transformation for which a person or a people risks striving; and, doubly, it is cruel insofar as the very pleasures of being inside a relation have become sustaining regardless of the content of the relation, such that a person or a world finds itself bound to a situation of profound threat that is, at the same time, profoundly confirming." World binding thus signals the possibility that world making is no guarantee that those worlds will be expansive or enabling. Berlant, *Cruel Optimism*, 2.

41. World Health Organization, "Ambient Air Pollution."

42. Das and Horton note that total deaths from all types of environmental pollution are estimated to be 9 million worldwide, while deaths specifically attributable to air pollution are estimated to be around 6.5 million worldwide. See Das and Horton, "Pollution, Health, and the Planet." They draw their numbers from the Global Disease Burden and the World Health Organization. However, the WHO now estimates that 7 million deaths are due to air pollution per year globally, with 4.2 million premature deaths attributable to ambient air pollution. See World Health Organization, "Air Pollution." Other studies suggest that the actual number of premature deaths due to air pollution could be as high as 8.8 million. See Lelieveld et al., "Cardiovascular Disease Burden."

43. The Royal College of Physicians has provided the estimate of 40,000 deaths attributable to air pollution per year in the UK. See Royal College of Physicians, "Every Breath We Take." The reference to over nine thousand deaths attributable to air pollution per year in London draws on the study from Walton et al., "Understanding the Health Impacts."

44. Berlant, *Cruel Optimism*, 230.

45. Berlant, "Citizenship," 37; see also *Cruel Optimism,* passim. In complement to the earlier-mentioned references on atmospheric citizenship that emphasized air pollution and atmospheres, here I would also add extensive writings on atmospheres as zones of affect. For example, see Choy and Zee, "Condition–Suspension"; Anderson, "Affective Atmospheres"; Adey, "Air/Atmospheres of the Megacity"; McCormack, *Atmospheric Things*; and Stewart, "Atmospheric Attunements." However, as noted elsewhere, I depart from the more Sloterdijkian (as well as Heideggerian) readings of atmospheres that surface in some of these texts.

46. The differential conditions of breathing due to air pollution are a long-standing and recurring topic that environmental justice researchers discuss. For this research I especially draw on Corburn, *Street Science*; Sze, *Noxious New York*; G. Walker, Booker, and Young; "Breathing in the Polyrhythmic City"; Ottinger, "Buckets of Resistance"; and Bullard, "Solid Waste Sites." In addition to the many texts on topics of breathing and atmospheres cited up to this point, a further reference on the making and remaking of bodies includes Górska, *Breathing Matters*. At the same time, Black studies scholars address struggles for breathability in response to structural inequality and racism as they materialize in bodies, relations, atmospheres, and environments. These works further inform this study of citizens of worlds and breathability. See Fanon, *A Dying Colonialism* and *Black Skin, White Masks*; Sharpe, *In the Wake* and "The Weather"; Gumbs, "That Transformative Dark Thing"; and Crawley, *Blackpentecostal Breath*.

47. As Fanon writes, "There is not occupation of territory, on the one hand, and independence of persons on the other. It is the country as a whole, its history, its daily pulsation that are contested, disfigured, in the hope of a final destruction. Under these conditions, the individual's breathing is an observed, an occupied breathing. It is a combat breathing." Fanon, *A Dying Colonialism*, 65.

48. Fanon, 65.

49. In a conversation on John Akomfrah's films, including *Handsworth Songs*, Tina Campt notes in the context of police violence and Covid-19 that "to have the breath be pressed out from you" is to feel the end of the world. See Campt, "John Akomfrah."

50. The notion of atmospheric citizens, as I develop it here, is also less aligned with atmospheric terror or control, which is a prevailing yet somewhat troubling point of reference for its essentialist and undifferentiated discussion that overlooks the actual lived sites of atmospheric violence and unbreathability. This atmospheric-engineering-meets-social-engineering perspective can especially be found within Sloterdijk's militaristic *Terror from the Air*, which is a recurring reference within many atmosphere-focused texts. I depart from this Sloterdijkian influence here to engage instead with research tuned to differential atmospheric inequalities and specific struggles for breathing otherwise. On an expanded discussion of the "otherwise" in relation to breathing, see Crawley, *Blackpentecostal Breath*.

51. See Gumbs, "That Transformative Dark Thing"; and Sharpe, "The Weather."

52. Sharpe, *In the Wake*, 111. For Sharpe, the weather is an atmosphere that is "anti-black" and carries with it the density and memory of slavery, which is pervasive and stifling.

53. Sharpe, 111. For a related discussion that draws on Sharpe, see Simmons, "Settler Atmospherics."

54. Fanon, *Black Skin, White Masks*, 201.

55. Cheah, *What Is a World?*, 199. Citing Fanon, Cheah describes the importance of decolonial struggles that make new subjects and new worlds in which they can flourish, where flourishing and breathing become interchangeable.

56. Somewhat like Cheah (and Fanon), Crawley proposes going beyond a "*merely biological*" approach to breathing, so as to more fully engage with the sociality—and potential openness—of breathing. See Crawley, *Blackpentecostal Breath*, 48.

57. See Dillon and Sze, "Police Power and Particulate Matters," 13.

58. Gumbs, "That Transformative Dark Thing."

59. Gumbs.

60. Gumbs.

61. Gumbs. For a discussion of breathing "after the end of the world," see also Gumbs, *M Archive*.

62. For example, see Kimmerer, *Braiding Sweetgrass*.

63. L. B. Simpson, *As We Have Always Done*, 3.

64. Balibar, *Citizenship*.

65. I especially discuss the co-constitution of bodies and environments in relation to breathing in chapter 6 of *Program Earth*, 162–63. This chapter focuses on sensing air pollution and engages with air and breath as exchanges that undo the hard edges of subjects and milieus. In this analysis, I draw on A. N. Whitehead, *Modes of Thought*, 114.

66. *Citizens of Worlds* is a companion volume to this previous study, since it carries over and extends a Whitehead-inspired approach to designating everything as a subject (including rocks and sensors) that forms as an experiencing entity through connections with environments. As I have previously argued, citizen sensing can mobilize distinct ways of being and becoming a political subject within environmental registers. In this sense, *Program Earth* expands possible designations of citizens across human and more-than-human entities and practices. This text lays the groundwork for developing this analysis into how pluralistic citizens and worlds form.

67. Crawley, *Blackpentecostal Breath*, 1.

68. Law, "What's Wrong with a One-World World?," 130. Law also draws on Annemarie Mol to discuss how multiple "realities are being done in practices." See Mol, *The Body Multiple*.

69. I develop a theory of practice that draws especially on pragmatism, which I discuss further in the following chapter. By way of comparison, there are a number of theories and investigations of practice that also proliferate within science and technology studies, among other fields. See Gad and Bruun Jensen, "The Promises of Practice"; Rosner, *Critical Fabulations*; and Fortun et al., "Pushback."

70. For an expanded discussion of the many definitions, histories, and uses of "praxis," see Balibar, Cassin, and Laugier, "Praxis."

71. For example, see Pritchard and Gabrys, "From Citizen Sensing to Collective Monitoring."

72. L. T. Smith, *Decolonizing Methodologies*.

73. James, *A Pluralistic Universe*, 68.

74. For a related discussion, see also Mackenzie, *Wirelessness*.

75. See Benjamin, *Race after Technology*.

1. INSTRUMENTAL CITIZENS

1. See Dhanjani, *Abusing the Internet of Things*.

2. A vast range of texts provide resources for social organizing and participation, from the straightforward handbook of Bolton, *How to Resist*, to detailed considerations of how participation is not evenly available, as in Keenaga-Yamahtta Taylor, *How We Get Free*, and how to change the conditions of political engagement through guides that take the form of the syllabus, as in Chrisler, Dhillon, and Simpson, "The Standing Rock Syllabus Project," and the follow-on collection, J. Dhillon and Estes, *Standing with Standing Rock*. For a related critique of discourses of participation, see J. Dhillon's *Prairie Rising*.

3. Ahmed outlines strategies for surviving in a world with which one is at odds, as well as ways to build other worlds, in *Living a Feminist Life*.

4. For just a few examples of these projects, see El Recetario; Makea Tu Vida; and "What You'll Need to Escape New York."

5. See Jencks and Silver, *Adhocism*; Daniek, *Do It Yourself 12 Volt Solar Power*.

6. *The Whole Earth Catalog* is the standard reference here, as discussed in Kirk, *Counterculture Green*; and Turner, *From Counterculture to Cyberculture*. During the early 1970s in Italy, a parallel and radical approach to technology developed with the Global Tools project, documented in Borgonuovo and Franceschini, *Global Tools*.

7. For an example of the serendipity that can emerge through toolkits in the form of Fluxus projects, see Higgins, *Fluxus Experience*.

8. Da Costa and Philip, *Tactical Biopolitics*; Nelson, *Body and Soul*.

9. The Feel Kit is a speculative project from Feel Tank Chicago, described at http://feelkit.feeltankchicago.net/. Ahmed describes the killjoy survival kit in *Living a Feminist Life*, 235–49. The art and research program How to Work Together is an example of a multiplatform collaborative project investigating alternative modes of community organization and collaboration, available at http://howtoworktogether.org/.

10. For instance, see the UK government's Open Policy Making Toolkit.

11. Simondon, *On the Mode of Existence*. Much more could be written about Simondon's specific discussion of instrumentality and the master–slave dynamic within technology, a topic that has also been discussed at length by scholars of race and technology, including Chude-Sokei, *The Sound of Culture* (thanks to Louis Henderson for this reference).

12. Gabrys, "Citizen Sensing: Recasting."

13. Dewey, "The Development of American Pragmatism."

14. James, *Pragmatism and Other Writings*, 27.

15. West, *The American Evasion of Philosophy*.

16. Simondon, *On the Mode of Existence*.

17. This discussion picks up where *Program Earth* left off in thinking about propositions for open technology (which are somewhat different expressions of "openness" from those that call for open hardware, software, and data—since this openness requires attention to the milieus that inform technology as an expanded field of relations).

18. For example, see Noble, *Algorithms of Oppression*.

19. For instance, see Ruha Benjamin's edited collection *Captivating Technology*, which captures the "carceral techniques" that have been implemented in policing, prisons, surveillance, and profiling and yet are also critically engaged with to forge potential sites of retooling and liberation.

20. For examples of these guides, see Tarantola, "How to Erase Yourself from the Internet"; LA Crypto Crew, "How to Become Anonymous Online"; Tactical Tech, "Data Detox Kit"; Zetter, "How to Make Your Own NSA Bulk Surveillance System." This is a short list that could be significantly expanded. For instance, see also Bellingcat's multiple how-to guides, including Ruser, "How to Scrape Interactive Geospatial Data."

21. For an expanded discussion and critique of these reductive and expedient sorts of instrumentalization, see Gabrys, "Programming Environments."

22. Create Lab, "CATTfish"; "Flood Network."

23. Radiation Watch, "Pocket Geiger."

24. Spence, "Earthquake/Vibration Sensor."

25. Seeed Studio, "Grove Smart Plant Care Kit for Arduino."

26. OSBeehives, "BuzzBox"; Veith, "AWS IoT and Beehives."

27. For an extensive example of how to build an air-quality sensor, see rawrdong, "How to Build a Portable, Accurate, Low Cost, Open Source Air Particle Counter."

28. For a commentary on how diverse forms of citizen science can align with different political (or apolitical) objectives, see Kuchinskaya, "Citizen Science."

29. For more on the Dustbox, see https://citizensense.net/kits/dustbox-hardware/. Citizen Sense developed a second version of the AirKit project, available at https://citizen sense.net/projects/airkit/.

30. For a more extensive discussion of electronics and obsolescence, see Gabrys, *Digital Rubbish*.

31. See A. N. Whitehead, *Process and Reality*.

32. See Whyte, "Indigenous Women." Within Indigenous cosmology, distributions of spirituality can inform not just what Whyte calls the "instrumental value" of entities like water but also the "intrinsic value" of these entities because of their connection and agency within cosmologies.

33. The difference, however, is that for Whitehead, cosmologies endure in the realm of abstraction and are drawn into the experiences of actual entities. See Whyte.

34. Stengers makes such a move in her multivolume text *Cosmopolitics*, where, through investigating the history and philosophy of science, she demonstrates how scientific and technical practices make particular worlds hold together, and to what effect. Cosmopolitics, then, describes how these systems of technoscientific relations have political effects, and how they come down to earth. Stengers, *Cosmopolitics I* and *II*.

35. The "tear down" is increasingly becoming a method for unpacking technologies to look at their material composition, infrastructural requirements, and extended operational logic. For example, see yang9741, "How to Tear Down a Digital Caliper."

36. In part, I draw here on an argument made by Dourish and Edwards, who discuss how "pre-packaged expectations of usage patterns" might characterize software components in toolkits, yet toolkits also need to be "designed to accommodate the wide range of potential applications and situations in use." See Dourish and Edwards, "A Tale of Two Toolkits," 34.

37. For example, see Southwest Pennsylvania Environmental Health Project, "Citizen Science Toolkit."

38. Simondon, *On the Mode of Existence*.

39. For an extended discussion on the topic of work-arounds, see L. Houston, Gabrys, and Pritchard, "Breakdown in the Smart City."

40. One very thorough and informative guidebook that does not gloss over the many points of consideration of air-quality monitoring is a citizen sensing guidebook published by the US Environmental Protection Agency. See Williams et al., *Air Sensor Guidebook*.

41. Cvetkovich, *Depression*. See also Pritchard, Gabrys, and Houston, "Re-calibrating DIY."

42. Povinelli, "The Toxic Earth."

43. See Ahmed, *Living a Feminist Life*; Berlant, *Cruel Optimism*; Pritchard, "The Animal Hacker."

44. Berlant, *Cruel Optimism*, 6.

45. See Stengers, *Thinking with Whitehead*.

46. Karvinen and Karvinen, *Getting Started with Sensors*, xi.

47. Karvinen and Karvinen, 2.

48. Karvinen and Karvinen, 9.

49. Karvinen and Karvinen, 4.

50. Ratto and Boler, *DIY Citizenship*, 5.

51. For a critique of the master–servant relationship in technology, see Simondon, *On the Mode of Existence*. For more on a discussion of decolonizing mastery, see Singh, *Unthinking Mastery*.

52. Austin, *How to Do Things with Words*.

53. Latour, "The Berlin Key."

54. Butler, *Bodies That Matter* and *Excitable Speech*.

55. Barad, *Meeting the Universe Halfway*.

56. Isin and Ruppert, *Being Digital Citizens*.

57. For example, see Haraway, *Modest_Witness@Second_Millennium*.

58. See Gabrys, "Sensing Air and Creaturing Data."

59. Wicked Device, "Air Quality Egg."

60. For a discussion of these inscrutable aspects of the Air Quality Egg, see Nold, "Device Studies of Participatory Sensing."

61. For an in-depth ethnography of the communities involved with making and testing the Air Quality Egg, see Zandbergen, "'We Are Sensemakers.'"

62. This process might align with what Suchman, Trigg, and Blomberg have discussed as co-constituted courses of "instructed action" in relation to the prototype. With the prototype, the "configuring" of devices and actions, working practices and sociomaterial relations, is one that relays "across sites of technology development and use." See Suchman, Trigg, and Blomberg, "Working Artefacts," 168.

63. Suchman, *Human–Machine Reconfigurations*, 8–9.

64. Suchman, 22.

65. Wicked Device, "Air Quality Egg."

66. Swart, "Egg Version One End of Life."

67. Latour demonstrates how the how-to, as a form of instruction, can proliferate through scientific infrastructures that travel along with artifacts to ensure that they are suitably encountered. For instance, in relation to a natural history museum collection, he writes, "Even those elements which can withstand the trip, like fossils, rocks or skeletons, may become meaningless once in the basement of the few museums that are being built in the centers, because not enough context is attached to them. Thus, many inventions have to be made to enhance the mobility, stability and combinability of collected items.

Many instructions are to be given to those sent around the world on how to stuff animals, how to dry up plants, how to label all specimens, how to name them, how to pin down butterflies, how to paint drawings of the animals and trees no one can yet bring back or domesticate." Latour, *Science in Action*, 225.

68. Gabrys, "Air Walk."

69. I discuss this project in more detail in the following chapter. For a related discussion, see also Pritchard and Gabrys, "From Citizen Sensing to Collective Monitoring."

70. Citizen Sense, "Citizen Sense Kit."

71. Dewey, *Logic,* 78.

72. A. N. Whitehead, *Process and Reality*, 11.

73. A. N. Whitehead, 11.

74. Benjamin, *People's Science*.

75. Shapin and Schaffer, *Leviathan and the Air-Pump*.

76. Haraway, *Modest_Witness@Second_Millennium*, 23–45.

77. Descartes, *Discourse on Method and Related Writings*.

78. Simondon, *On the Mode of Existence*.

79. Haraway, *Simians, Cyborgs, and Women*, 202–16.

80. For example, see Daston and Galison, *Objectivity*; Pickering, *The Mangle of Practice*; Mody, *Instrumental Community*; and Taub, "Introduction."

81. Latour, "Tarde's Idea of Quantification."

82. As I discuss in *Program Earth*, Simondon describes how information gives form across material, experiential, and epistemic registers through the term "in-form." For example, see Simondon, *Individuation*.

83. As scholars in science and technology studies have noted, many of these experimental engagements are already underway, remaking technologies in practice. For example, see de Laet and Mol, "The Zimbabwe Bush Pump"; and Helmreich, "Reading a Wave Buoy."

84. To this end, works that examine the inequalities that digital technologies operationalize often also propose "otherwise" engagements across subjects, devices, environments, and relations. For example, see Benjamin, *Race after Technology*; and Kukutai and Taylor, *Indigenous Data Sovereignty*.

85. Simondon, *On the Mode of Existence,* xii–xiii.

86. Simondon, 16.

87. A. N. Whitehead, *Process and Reality*, 11.

88. A. N. Whitehead, 11.

89. I discuss the environments needed to sustain facts in a related register in "Sensing Air and Creaturing Data."

90. This is what Whitehead refers to as the "impossibility of tearing a proposition from its systematic context in the actual world." See *Process and Reality*, 11.

91. Reardon et al., "Science and Justice," 13.

92. Reardon et al., 13.

93. Barad, *Meeting the Universe Halfway*, 170.

94. For a discussion of critiques of instrumental reason and instrumental control through the works of Heidegger and Habermas, see Feenberg, *Questioning Technology*. Also extending the Heideggerian consideration of technology and instrumentality, Arendt takes up this topic in relation to her conception of *Homo faber* in *The Human Condition*.

However, in this work I develop a different approach to the instrumental by revisiting and reworking instrumentalism as continuous with experimentalism, as discussed by pragmatist scholars.

95. Barad, *Meeting the Universe Halfway*.

96. As Dewey further writes, "Instrumentalism is an attempt to establish a precise logical theory of concepts, of judgments and inferences in their various forms, by considering primarily how thought functions in the experimental determinations of future consequences." Writing also about the work of James, Dewey suggests that the "reconstructive or mediative function ascribed to reason" becomes a way to develop "a theory of the general forms of conception and reasoning." This suggests that the experimental processes of instrumental concepts are the means by which theories cohere into general forms rather than instrumental approaches proving *a priori* truths. Instrumentalism in this rendering is necessarily experimental and contingent. See Dewey, "The Development of American Pragmatism," 14.

97. Glaude extends pragmatism's discussion of struggle by quoting James, who writes, "The actually possible in this world is vastly narrower than all that is demanded; and there is always the pinch between the ideal and the actual which can only be got through by leaving part of the ideal behind." As Glaude elaborates, this "pinch is a constitutive feature of the world of action," which consists of what James refers to as "'the struggle and the squeeze.'" Glaude, *In a Shade of Blue*, 20–21; James, "The Moral Philosopher," 202–3, 209. Struggles, as I further suggest here, involve tussling across not only ideas and action but also across multiple subjects, modes of political engagement, lived experiences, and worlds in the making.

98. See Dewey, *The Public and Its Problems*.

99. West, *The American Evasion of Philosophy*, 5.

100. James, *Pragmatism and Other Writings*, 27.

101. James, 27.

102. James, 28–30. See also West, *The American Evasion of Philosophy*.

103. This discussion connects to theories of breathing discussed in the Introduction, including combat breathing and breathing as sociality. See Fanon, *A Dying Colonialism*, 65; Gumbs, "That Transformative Dark Thing"; Sharpe, *In the Wake*; and Crawley, *Blackpentecostal Breath*.

104. Ian Hacking notes that instrumentalism came to suggest a certain "antirealism" within the philosophy of science. As West has pointed out, however, pragmatists such as a Dewey, James, and Peirce worked with realist ontologies while evading the fundamental epistemological concerns of philosophies pertaining to truth. In West's analysis, this sidestepping (or "evasion") of epistemologies of truth does not make pragmatism antirealist; rather, it contributes to the evasion of Cartesian framing and concerns with knowing how the real is really real through a preconceived division of subjects and objects. See Hacking, *Representing and Intervening*; and West, *The American Evasion of Philosophy*.

105. For a related discussion on the "work" of political, collective, and democratic life, see Pritchard and Gabrys, "From Citizen Sensing to Collective Monitoring."

106. For example, see Corburn, *Street Science*; and C. M. Dhillon, "Using Citizen Science in Environmental Justice."

107. See Plume Labs, "Clean Air, Together."

108. For analysis of these different ways of parsing the state, the community, and the citizen through or beyond the family, see Berlant, *The Queen of America*.

109. As I noted in the Introduction, a popular reference for discussing air pollution and air control, Sloterdijk's work nevertheless strikes an essentialist and deterministic note in its rendering of the air as a space of terror and control. This study deliberately sidesteps this more fixed reading of air as an "element" "essential" for life, not least because of the rigid political imaginaries that issue forth along with these atmospheric ontologies. See Sloterdijk, *Terror from the Air*; and Müller, "Behind the New German Right."

110. Simondon, *On the Mode of Existence,* 51.

111. Majaca and Parisi, "The Incomputable and Instrumental Possibility."

112. Majaca and Parisi, 1–3.

113. While Dewey opted to use the terms *instrumentalism* and *pragmatism* interchangeably, he also worked with *experimentalism* as a term and concept that attempted to explain the ideas he was developing. In science and technology studies, experiments and experimentality are frequently discussed to describe how these open-ended practices of inquiry and engagement take place. Drawing on Dewey, Ana Delgado and Blanca Callén investigate DIY biology and electronic waste hacking experiments to consider how "hacks" as an "experimental mode of inquiry" open up new approaches to problems. See Delgado and Callén, "Do-It-Yourself Biology." See also Lezaun, Marres, and Tironi, "Experiments in Participation."

114. James, *Pragmatism and Other Writings*, 28 (emphasis in original).

115. Dewey, "The Development of American Pragmatism," 20.

116. As West has pointed out, it is worth noting how experimentalism emerged in pragmatist thought, where the scientific method was seen to be a paragon of "critical intelligence," and experimentalism was very much a product of this practice—where the "social base" for such pragmatism required a more elite professional class to engage in such practices. Nevertheless, West suggests that a possibility for "creative democracy" might still persist in relation to experimentalism. See West, *The American Evasion of Philosophy*, 62, 90, 97, 103.

117. James quoted in Dewey, "The Development of American Pragmatism," 6.

118. James, *Essays in Radical Empiricism*.

119. Haraway, *Modest_Witness@Second_Millennium*, 37.

120. For a related discussion, see DiSalvo et al., "Toward a Public Rhetoric."

121. Peirce is generally credited with having developed the notion of community of inquiry. Peirce developed this idea in relation to the pursuit of logic and science, but pragmatists (especially Dewey) have adapted the concept in relation to democratic modes of inquiry. As Peirce writes, "Unless we make ourselves hermits, we shall necessarily influence each other's opinions; so that the problem becomes how to fix belief, not in the individual merely, but in the community." See Peirce, "The Fixation of Belief."

122. Dewey, *The Public and Its Problems*.

123. Working within a different context, Grant Wythoff describes how "communities of amateur tinkerers" experiment with technologies and gadgets to become the "engine of emerging media." Experimental inquiry in this more hands-on sense becomes part of the process whereby technologies further develop and concretize as media. See Wythoff, *The Perversity of Things*, 37.

124. Spivak, *Imperatives to Re-imagine the Planet*.

125. Simpson further writes, "engagement changes us because it constructs a different world within which we live." See L. B. Simpson, *As We Have Always Done*, 19–20.

126. These questions also introduce what science and technology studies scholars have referred to as the "politics of how." See Dányi, "The Politics of 'How'"; and Law and Joks, "Indigeneity, Science, and Difference."

127. These modes of collaboration could be described as "contingent collaborations" that work across different engagements, here with environmental conflict and social justice. See Tuck et al., "Geotheorizing Black/Land."

128. Irani, "Hackathons," 807.

129. L. B. Simpson, *As We Have Always Done*, 23.

130. Simpson, 20.

131. While James works with the notion of the "pluralistic universe," *pluriverse* is a term that other writers such as Latour have used in relation to James's work. Writers such as Walter Mignolo take up the pluriverse as a concept but do not cite James as part of its development, instead developing *pluriverse* as a term associated with postcolonial and decolonial theory. Marisol de la Cadena develops yet another reading of the pluriverse; initially through the conservative political writings of Carl Schmitt. This study recognizes these multiple formations of the pluriverse (and somehow it is fitting that this term has a plurality of uses and affiliations) but especially emphasizes James's discussion of the pluralistic universe. See James, *A Pluralistic Universe*; Latour, *Facing Gaia*, 36; Mignolo, "On Pluriversality"; and de la Cadena, "Indigenous Cosmopolitics in the Andes."

132. For a discussion of collective causation in relation to environmental protest, see Zitouni, "Planetary Destruction."

133. Haraway, *Modest_Witness@Second_Millennium*, 23–45.

134. Barad, *Meeting the Universe Halfway*, 170.

135. Dewey, "The Naturalization of Intelligence."

136. West, *The American Evasion of Philosophy*, 82.

137. For a discussion of how to decolonize methodologies, along with an extensive set of case studies and examples of community research, see L. T. Smith, *Decolonizing Methodologies*.

138. For a discussion of this question, see Gane and Haraway, "When We Have Never Been Human."

139. Berlant, *Cruel Optimism*, 3.

140. Stengers, "Including Nonhumans in Political Theory."

141. For instance, see Pollock and Subramaniam, "Resisting Power, Retooling Justice"; and Ahmed, *Living a Feminist Life*.

142. For a discussion of the limits of categories in relation to citizen science, see Irwin, "Citizen Science and Scientific Citizenship."

143. Center for Urban Pedagogy, "Making Policy Public."

144. Hickey, *A Guidebook of Alternative Nows*.

145. Blas, *Gay Bombs*.

146. Allahyari and Rourke, *The 3D Additivist Cookbook*.

147. Detroit Community Technology Project. See also Institute of Technology in the Public Interest.

148. There is insufficient space here to cover the proliferation of different forms of toolkits, handbooks, and guides. A notable example at the intersection of technology and

democracy is Soon and Cox, *Aesthetic Programming*. At the intersection of environmental justice and air-pollution monitoring, the West Oakland Environmental Indicators Project provides many excellent resources for monitoring and improving environments. See https://woeip.org.

149. Nelson, *Body and Soul*.

150. Dewey, "The Development of American Pragmatism," 12.

151. Berlant, *Cruel Optimism*, 21.

2. SPECULATIVE CITIZENS

1. Moore, "Air Impacts."

2. International Agency for Research on Cancer, World Health Organization, "IARC."

3. Climate and Clean Air Coalition, "Satellite Data"; and Zhang et al., "Quantifying Methane Emissions."

4. This particular video can be found at https://www.youtube.com/watch?v=OQmo K1DJIyE.

5. This FLIR technique has become much more pervasive across environmental NGOs and journalism. For instance, see Kessel and Tabuchi, "It's a Vast, Invisible Climate Menace"; and Environmental Defense Fund, "With This Technology." The latter refers to methane leaks as "oil spills in the sky."

6. Frank Finan's YouTube channel is https://www.youtube.com/channel/UC7Eph 33czawYR2ZKZrexS0Q. See also Vera Scroggins's YouTube channel, https://www.you tube.com/channel/UCfbfGPFJn5t3HvJcRNTvJxQ.

7. World Health Organization, "Ambient (Outdoor) Air Quality and Health."

8. For instance, see Bullard, "Solid Waste Sites"; Buzzelli et al., "Spatiotemporal Perspectives"; Corburn, *Street Science*; Dillon and Sze, "Police Power and Particulate Matters"; Mitchell and Dorling, "An Environmental Justice Analysis"; Morello-Frosch, Pastor, and Sadd, "Environmental Justice and Southern California's 'Riskscape'"; and Pearce, Kingham, and Zawar-Reza. "Every Breath You Take?" For an example of an especially pluralistic approach to spatial distribution and environmental injustice, see G. Walker, "Beyond Distribution and Proximity."

9. Sharpe, *In the Wake*, 109. "Breathtaking" is a term also used by Alison Kenner (although not in reference to Sharpe) in a study of asthma. See Kenner, *Breathtaking*.

10. More information on fracking exemptions from environmental safeguards can be found at National Resources Defense Council, "NRDC Policy Basics." A discussion of federal- and state-level oil and gas regulations is available at Phillips, "Burning Question." The US Energy Policy Act of 2005 can be found at https://www.gpo.gov/fdsys/pkg/ PLAW-109publ58/html/PLAW-109publ58.htm. Energy policies continue to vacillate in relation to different political agendas, with the forty-fifth US president significantly rolling back regulations on oil and gas. For example, see Geiling, "Trump Administration Officially Scraps Obama-Era Rules."

11. Ingraffea et al., "Assessment and Risk Analysis"; Osborn et al., "Methane Contamination of Drinking Water." For an example of a well organized citizen-based water-monitoring initiative in Pennsylvania, see the Alliance for Aquatic Resource Monitoring, along with their manual, "Shale Gas Extraction."

12. There is an extensive and varied array of academic research on fracking. For example, see Green, "Fracking the Karoo"; Kama, "Resource-Making Controversies"; Kinchy,

Jalbert, and Lyons, "What Is Volunteer Water Monitoring Good For?"; Lave and Lutz, "Hydraulic Fracturing"; Neville et al., "Debating Unconventional Energy"; Willow et al., "Contested Landscape"; and Wylie, *Fractivism*. While this chapter does not have space to survey this broad-ranging work, it does align with studies specifically oriented to how energy and extraction spark or constrain political possibilities. In this sense, this discussion resonates with broader developments and investigations into energy as a social, political, material, and cultural organizing force. For example, see Szeman and Boyer, *Energy Humanities*; and Barry, *Material Politics*.

13. For an example of other modes of science (fiction) within Indigenous practices of observation and narration, see Whyte, "Indigenous Science (Fiction)."

14. "Care about your air" is a strapline on the box of the Air Quality Egg product, a relatively well known DIY air-quality monitor available for purchase (discussed in more detail in chapter 1). "Care for Your Air" is also a motto for the EPA in its indoor air-quality initiative. See US Environmental Protection Agency, "Care for Your Air." It is also the name for an air-pollution initiative in India, Care for Air.

15. Berlant, *Cruel Optimism*.

16. Puig de la Bellacasa, "Matters of Care in Technoscience," 85. See also Mol, *The Logic of Care*; and Mol, Moser, and Pols, "Care."

17. I discuss this point further in *Program Earth*. This extended discussion also draws on Stengers, *Thinking with Whitehead*; and A. N. Whitehead, *Process and Reality*.

18. Stengers, *Thinking with Whitehead*, 267; and A. N. Whitehead, *Process and Reality*, 11.

19. Shaviro, *Without Criteria* and *The Universe of Things*.

20. See Gill, Singleton, and Waterton, "The Politics of Policy Practices."

21. In this way, Citizen Sense worked with communities to understand and develop ways of documenting pollution and proposing different modes of action together, based on preexisting community practices. This approach builds on attempts to decolonize research methodologies. See L. T. Smith, *Decolonizing Methodologies*.

22. State Impact, "The Marcellus Shale Explained"; and Soeder and Kappel, "Water Resources and Natural Gas Production."

23. Fractracker Alliance, "Pennsylvania Shale Viewer."

24. Griswold, "The Fracturing of Pennsylvania." For an extended investigation, see Griswold, *Amity and Prosperity*.

25. Griswold, "The Fracturing of Pennsylvania."

26. Llewellyn et al., "Evaluating a Groundwater Supply Contamination."

27. Some estimates indicate that up to 750 chemicals are used in the fracking process, many of which are also endocrine disrupters. For instance, see Kassotis et al., "Estrogen and Androgen Receptor Activities." However, not all chemicals are used at the same time or place. Other sources suggest that "50 known chemicals" "may be added to the water that is used for hydraulic fracturing." See http://exploreshale.org. These lists of chemicals are obtained from industry sources, which might not disclose (since they are not required to) all chemicals, particularly proprietary chemicals, used in the fracking process. For instance, see Department of Environmental Protection Bureau of Oil and Gas Management. "Chemicals Used by Hydraulic Fracturing Companies."

28. Howarth, Santoro, and Ingraffea, "Methane and the Greenhouse-Gas Footprint."

29. Gabrys and Yusoff, "Arts, Sciences, and Climate Change"; Latour, "Atmosphère, Atmosphère"; Briggle, *A Field Philosopher's Guide.*

30. There is extensive research on this problem. See especially Griffith Spears, *Baptized in PCBs.*

31. Chen, *Animacies*; Schrader, "Responding to *Pfiesteria piscicida.*"

32. Felt and Fochler, "Bottom-up Meanings."

33. Cohen, "Challenges and Benefits."

34. Edwards, "Pigeon Air Patrol."

35. Gabrys, Pritchard, and Barratt, "Just Good Enough Data"; US Environmental Protection Agency, "Draft Roadmap."

36. Stengers, *Thinking with Whitehead*, 518; Gabrys, *Program Earth.*

37. Griswold, "The Fracturing of Pennsylvania."

38. The "List of the Harmed" is an ongoing record last updated August 22, 2018, to which anyone can contribute by emailing the list moderator. It is available at http://pennsylvaniaallianceforcleanwaterandair.wordpress.com/the-list.

39. Olsen, "Natural Gas and Polluted Air." This journalist's reference to incomplete science in some ways resonates with "undone science" and knowledge struggles as discussed in Frickel et al., "Undone Science."

40. Earthworks, "Gas Patch Roulette."

41. Macey et al., "Air Concentrations of Volatile Compounds."

42. See Fractracker Alliance; and Marcellus Gas.

43. Roter, "Breathe Easy Susquehanna County."

44. For an overview of these different techniques, see Steinzor, "Community Air Monitoring."

45. Murphy, *Sick Building Syndrome.* As Corburn importantly points out, however, there are many possible ways of engaging with citizen data beyond the framings of epidemiology and risk. Such an expanded approach would work to ensure that citizen data could operate in more and other registers than those in direct comparison to expert methods. See Corburn, *Street Science*, 5–10.

46. Murphy, *Sick Building Syndrome,* 81–110. See also Irwin, "Citizen Science."

47. As Stengers notes in relation to Whitehead, practices of perceptibility and imperceptibility can indicate how "the future hesitates in the present." Stengers, *Thinking with Whitehead*, 191.

48. There are six criteria pollutants that the EPA monitors because they are especially hazardous to human health, environments, and organisms: carbon monoxide, lead, ground-level ozone, particulate matter, nitrogen dioxide, and sulfur dioxide. More information is available at https://www.epa.gov/sites/default/files/2015-10/documents/ace3_criteria_air_pollutants.pdf.

49. For more information on the Citizen Sense Toolkit, see https://citizensense.net/kits/citizensense-kit. Frackbox assembly instructions are also available at https://citizensense.net/kits/frackbox-hardware.

50. See Create Lab, "Speck." The Heinz Foundation supported the distribution of Specks in libraries. See Spice and Thinnes, "CMU, Airviz."

51. For related approaches to the problem of observation and action, see Dewey, "The Development of American Pragmatism"; and Haraway, *Modest_Witness@Second_Millennium.*

52. Citizen Sense, "Citizen Sense Monitoring Events."

53. For an extended discussion of these aspects of the participatory research process, see Pritchard and Gabrys, "From Citizen Sensing to Collective Monitoring."

54. On these possibilities for other sciences and knowledge practices, see Jasanoff, "Technologies of Humility"; Benjamin, *People's Science*; McKittrick, *Dear Science and Other Stories*; and Rusert, *Fugitive Science*.

55. For an expanded discussion of the Citizen Sense walking methodologies developed during the research (along with other approaches to walking-as-research that inspired this approach), see Gabrys, "Air Walk."

56. See Colaneri, "Gas Drilling Draws Citizen Scientists."

57. openair was developed by David Carslaw. More information is available at https://davidcarslaw.github.io/openair/.

58. To read the five data stories see Citizen Sense, "Pennsylvania Data Stories." For project films see Citizen Sense, "Pollution Sensing Videos."

59. Cox, "Citizens' Digital Monitoring Project."

60. Agency for Toxic Substances and Disease Registry, "Health Consultation."

61. Pennsylvania Department of Environmental Protection, "DEP Expands Particulate Matter Air Monitoring Network."

62. Hurdle, "PA Expands Particulate Monitoring."

63. Breathe Easy Susquehanna Co., "Citizen Science." After this study, citizens and community groups also purchased several Specks, which they made available in the public library for general use.

64. The full list of pollutants monitored at this site, including carbonyls and VOCs, can be found at: https://www.facebook.com/BreatheEasySusq/posts/citizen-science-spurred-real-air-quality-monitoring-in-the-pa-shalegas-fields-re/895271397320857/.

65. Davenport, "Trump Eliminates Major Methane Rule."

66. Hurdle, "PA Expands Particulate Monitoring."

67. See West, *The American Evasion of Philosophy*, 147–48. West writes about the development of W. E. B. Du Bois's pragmatism and his sense of the limitations of individual—in comparison to collective—pursuits within a creative democracy.

68. Writing about the uneven qualities of the empirical, Benjamin notes that "demanding empirical evidence of systematic wrongdoing can have a kind of perverse quality—as if subjugated people must petition again and again for admission into the category of 'human,' for which empathy is rationed and applications are routinely denied." Benjamin, "Racial Fictions, Biological Facts," 2.

69. Benjamin, 2.

70. See Lane et al., "Doing Flood Risk Science Differently;" Waterton and Tsouvalis, "'An Experiment with Intensities.'"

71. Dewey, "The Development of American Pragmatism."

72. West, *The American Evasion of Philosophy*, 91.

73. See Pritchard and Gabrys, "From Citizen Sensing to Collective Monitoring"; Combes, *Gilbert Simondon*, 34–35.

74. Or as Stengers writes, this would involve the "invention of the field in which the problem finds its solution." Stengers, *Thinking with Whitehead*, 17.

75. Stengers, 17.

76. Gabrys, "A Cosmopolitics of Energy" and "For the World." See also Gill, "Caring for Clean Streets."

77. Stengers, *Thinking with Whitehead*, 147; A. N. Whitehead, *Science and the Modern World*, 86.

3. DATA CITIZENS

1. The literature on the health effects from air pollution is vast. One current study estimates that as many as 8.8 million deaths worldwide are due to air pollution each year. See Lelieveld et al., "Cardiovascular Disease Burden"; and Gabrys, "Planetary Health in Practice."

2. In 2005 the WHO established guidelines for $PM_{2.5}$, including 25 µg/m³ for twenty-four-hour mean and 10 µg/m³ for the annual mean. The guidelines have since been updated in 2021 to 15 µg/m³ for twenty-four-hour mean and 5 µg/m³ annual mean. However, as health research on air pollution notes, there is no safe level of exposure to $PM_{2.5}$. See World Health Organization, *WHO Air Quality Guidelines;* World Health Organization, "Ambient (Outdoor) Air Pollution"; Dockery et al., "An Association between Air Pollution and Mortality"; Grigg, "Where Do Inhaled Fossil Fuel–Derived Particles Go?"; and Holgate, "Every Breath We Take."

3. Analyses of air-pollution events as they inform citizens' engagement with environments, especially through digital technologies, are now increasingly common. For instance, in the Chinese context see Kay, Zhao, and Sui, "Can Social Media Clear the Air?"; Li and Tilt, "Public Engagements with Smog"; and Aunan, Hansen, and Wang, "Introduction."

4. As reported in "India: Health Emergency Declared as Toxic Air Shrouds New Delhi." Based on this story, it is unclear which pollutants measured "999" on the Air Quality Index (AQI). The AQI is available at https://aqicn.org/city/delhi.

5. This work is situated within long-standing environmental justice research that studies these distributions of inequality and pollution. See Bullard, *Dumping in Dixie;* Sze, *Noxious New York*; and Corburn, *Street Science*.

6. For a related discussion that addresses this unequal distribution not just within cities but also across countries, see Hecht, "Air in a Time of Oil."

7. As UN Special Rapporteur David Boyd writes of the 2019 report on the right to breathe clean air, "The Special Rapporteur focuses on the right to breathe clean air as one of its components and describes the negative impact of air pollution on the enjoyment of many human rights, in particular the right to life and the right to health, in particular by vulnerable groups. He highlights the different state obligations in relation to the right to breathe clean air, which are both procedural and substantive, as well as the specific obligation to protect people and groups in vulnerable situations." See Boyd, "The Right to Breathe Clean Air." This report sits within a broader framework of more than one hundred countries agreeing to a right to a healthy environment. See United Nations Human Rights Council, "Human Rights and the Environment."

8. Guidelines that establish measures for what counts as clean air include the European Commission Directive 2008/50/EC; and World Health Organization, *WHO Air Quality Guidelines*.

9. For an example of one such challenge, see ClientEarth Communications, "Client Earth Launches."

10. Isin and Ruppert, *Being Digital Citizens*.

11. See Haraway, *Modest_Witness@Second_Millennium*; and Gabrys, Pritchard, and Barratt. "Just Good Enough Data."

12. Alan Irwin discusses how those affected by environmental matters should be involved in decision-making processes as a way to build trust and address ethical concerns. See Irwin, "Citizen Science and Scientific Citizenship."

13. John Law has referred to how people are formatted and enacted through surveys in "What's Wrong with a One-World World?" I have similarly discussed the programming of citizens and environments via sensor technologies in *Program Earth*.

14. Gregory and Bowker. "The Data Citizen," 220.

15. Benjamin, *Race after Technology*.

16. For a more extensive discussion of the pitfalls of the Citizen app, see Ashworth, "Inside Citizen." As the article notes, the Citizen app was originally launched in 2016 under the name Vigilante. As the podcast included as part of Ashworth's article notes, the app currently covers eighteen cities in the United States, but the makers hope to monetize and expand to 1.5 billion users worldwide.

17. The literature on wearables is vast, and I do not have space to discuss this here. However, several researchers address the formations of citizenship and political subjects through wearable sensors. See Lupton, *The Quantified Self*; and Boyle, "Pervasive Citizenship."

18. Literature on these topics is equally vast, and there is no space to engage with the many studies in this dynamic field. A representative range of research on data practices and politics that informs *Citizens of Worlds* includes Milan and Treré, "Big Data from the South(s)"; Couldry and Powell, "Big Data from the Bottom Up"; Loukissas, *All Data Are Local*; Kukutai and Taylor, *Indigenous Data Sovereignty*; and Meng and DiSalvo, "Grassroots Resource Mobilization."

19. For instance, see initiatives such as Data for Black Lives, also discussed elsewhere in this chapter (https://d4bl.org); as well as Currie et al., "The Conundrum"; Gutiérrez, *Data Activism and Social Change*; Bruno, Didier, and Vitale, "Statactivism"; and Renzi and Langlois, "Data Activism."

20. There has been a proliferation of studies that examine power and justice in relation to data. Another partial list of work in this area includes Dencik, Hintz, and Cable, "Towards Data Justice?"; L. Taylor, "What Is Data Justice?"; and D. Walker et al., "Practicing Environmental Data Justice." Working in a different but related register are projects including the Our Data Bodies Project; Onuoha and Mother Cyborg, "People's Guide to AI"; Mertia, *Lives of Data*; and Cifor et al., "Feminist Data Manifesto-No."

21. As Justin Pidot writes, "The new law is of breathtaking scope. It makes it a crime to 'collect resource data' from any 'open land,' meaning any land outside of a city or town, whether it's federal, state, or privately owned. The statute defines the word collect as any method to 'preserve information in any form,' including taking a 'photograph' so long as the person gathering that information intends to submit it to a federal or state agency. In other words, if you discover an environmental disaster in Wyoming, even one that poses an imminent threat to public health, you're obliged, according to this law, to keep it to yourself." Pidot, "Forbidden Data"; see also Kravets, "Law Making It Illegal to Collect Data."

22. US Court of Appeals, Tenth Circuit, "People for the Ethical Treatment of Animals."

23. Rights to participate can be variously recognized, with two notable examples: the 1998 Aarhus Convention (or the UNECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters) and the Protocol on Pollutant Release and Transfer Registers. These measures seek to protect the right to environment through the right to participate. See United Nations Economic Commission for Europe, "Public Participation."

24. See Berlant, *Cruel Optimism*, passim.

25. In this sense, this approach departs from the focus on rights as speech acts as discussed by Isin and Ruppert in *Digital Citizens*.

26. These differently constituted and emerging rights feature in Spivak's discussion of migration in *Imperatives to Re-imagine the Planet*.

27. Étienne Balibar configures citizenship along these lines in *Citizenship*.

28. I developed this concept by building on Foucault's notion of environmentality. See Gabrys, "Programming Environments."

29. Balibar, *Citizenship*, 18. Such continued invention of democracy resonates differently with Dewey's pragmatist articulation of political engagement, as well as Black pragmatist and Indigenous discussions of democratic politics as unfolding through struggle, praxis, mutual exchange, and reciprocity. See Dewey, The *Public and Its Problems*; Glaude, *In a Shade of Blue*; and Denzin, Lincoln, and Smith, *Handbook of Critical and Indigenous Methodologies*.

30. This approach resonates with pragmatism's general orientation toward prospective conditions. While Dewey engaged especially in the prospective conditions of democratic participation, James established how forms of knowing and things that are in the making characterize pragmatist methods. He writes: "What really *exists* is not things made but things in the making." James, *A Pluralistic Universe*, 263. Elsewhere, James contrasts rationalism and pragmatism to suggest that rather than being "ready-made," reality "is still in the making, and awaits part of its complexion from the future." David Lapoujade suggests that this approach characterizes pragmatism as a method (something that James also discussed). See Lapoujade, *William James*.

31. This approach to conditions in the making continues within pragmatist work from James to Dewey, who writes of the self and "worlds in the making" through different modes of conduct, deliberation, and conflict. See Dewey, *Human Nature and Conduct*, 150. Also quoted in Glaude, *In a Shade of Blue*, 30.

32. Rights, citizenship, and environmental participation could, by extension, materialize less as fully formed conditions and more as sought-after relations. In a different but resonant register, Henri Lefebvre discusses the right to make the city as a collective work, as the "right to the *ouevre*," which spans the right to public space, difference, housing, political engagement, social life, and even information technology. Such an articulation of the right to the city suggests possible ways to reinvent rights as open-ended and in the making. The pursuit and exercise of the right to the city could occur through attempts not only to make a claim to the city but also to actively shape it as a more breathable world. In this sense, rights could become another sort of instrument that materializes through practices of open-air instrumentalism. See Lefebvre, *Writings on Cities,* 145, 157, 174.

33. Berlant, "Citizenship."

34. Berlant, *Cruel Optimism*, 4. This focus on failure and impasse resonates in a different way with Glaude's conception of tragedy and the blues, which he suggests (drawing

on James) should more fully infuse and be acknowledged as a necessary condition of pragmatism, as unfolding through "the struggle and the squeeze of the world of action." See Glaude, *In a Shade of Blue*, 22.

35. Berlant, *Cruel Optimism*, 227.

36. See Seitz, interview with Berlant. This observation is also included in the introductory epigraph to *Citizens of Worlds*.

37. Writing in a similar way in relation to Black Americans, Alondra Nelson refers to the "citizenship contradiction" that occurs in the "gap between civil rights and social benefits." Nelson, *Body and Soul*, 10.

38. For example, see Kimura and Kinchy, "Citizen Science in Post-Fukushima Japan."

39. Data for Black Lives.

40. Cocco and Smith, "Race and America." This *Financial Times* article includes an interview with Milner, as well as reference to W. E. B. Du Bois's data visualizations, collected in Battle-Baptiste and Rusert, *W. E. B. Du Bois's Data Portraits*.

41. As the Data for Black Lives website notes, "We are a movement of scientists and activists. Data as protest. Data as accountability. Data as collective action."

42. Mayor of London, London Data Store, "2011 Census Ethnic Group Fact Sheets."

43. South East London Combined Heat and Power, "History." For a discussion of community resistance to the incinerator, see Parau and Wittmeier Bains, "Europeanisation as Empowerment."

44. Laville, "UK Waste Incinerators."

45. Evelyn, *Fumifugium*.

46. Steele, *Deptford Creek Surviving Regeneration*.

47. Steele, 2.

48. Steele, v.

49. "Deptford Is Changing" is a visual–social research project and website by Anita Strasser that documents these more current changes. See especially Strasser, "Tidemill Garden."

50. Don't Dump on Deptford's Heart, "Help Us Combat Thames Tunnel Pollution." See also Thames Tideway Tunnel, https://www.tideway.london/the-tunnel/.

51. The results from the diffusion-tube monitoring can be reviewed at the Don't Dump on Deptford's Heart project's Google Map.

52. An extensive background literature informs this discussion on infrastructure, especially in relation to how material and political relations and possibilities of action are distributed through infrastructures. See Berlant, "The Commons"; Bruun Jensen and Morita, "Introduction"; Larkin, "The Politics and Poetics of Infrastructure"; Hawkins, "Governing Litter"; and Maguire and Winthereik, "Digitalizing the State."

53. For a related discussion of this approach as researcher–participants, see Pritchard and Gabrys, "From Citizen Sensing to Collective Monitoring."

54. Loxham, Davies, and Holgate, "Health Effects."

55. Shinyei, Particle Sensor Unit PPD42NJ.

56. For the site data see Department for Environment, Food, and Rural Affairs, "Site Information for London Marylebone Road (UKA00315)."

57. For a more extensive discussion of our approach to calibrating the Dustbox, see Pritchard, Gabrys, and Houston, "Re-calibrating DIY."

58. A video of the workshop and walk is available at Citizen Sense, "Urban Sensing Using the Dustbox," and is also available at https://manifold.umn.edu/projects/citizens -of-worlds/resource-collection/citizens-of-worlds-videos/resource/sensing-dustbox.

59. Before the Citizen Sense monitoring commenced, a monitor sited on Mercury Way near the incinerator and waste-transfer yard was taken offline by Lewisham Council, with the intention of moving this site to the UK Environment Agency. However, Mercury Way does not appear on the Department for Environment, Food, and Rural Affairs' "Interactive Monitoring Networks Map." After the Citizen Sense monitoring had been completed, Lewisham Council brought two new urban-background air-quality monitoring stations online in Deptford, one near the Thames Tunnel Super Sewer construction site and the other at Honor Oak Park (an air-pollution research supersite). See London Air, "Lewisham."

60. For a more extensive discussion of these encounters with troubleshooting, see L. Houston, Gabrys, and Pritchard, "Breakdown in the Smart City."

61. It should be noted that there was no vandalism or theft of the Dustboxes, which remained in place without incident when installed outdoors for monitoring.

62. See also Gabrys, "Planetary Health in Practice."

63. As indicated in the introduction to this chapter, this discussion builds on concepts of figuring developed in Haraway's *Modest_Witness@Second_Millennium* and in Gabrys, Pritchard, and Barratt's "Just Good Enough Data." Figurations are ways of worlding, and they can take the form of stories and numbers. Indeed, numbering is a way of narrating. Sociological studies of quantification are extensive and it would not be possible to cover the richness of this area of analysis here. However, several aligned texts that inform this study include Verran, "The Changing Lives"; Asdal, "Enacting Things through Numbers"; and Lippert and Verran, "After Numbers?" Enumeration is a process and practice for making objects, infrastructures, and governance practices, but as these texts show, it is rarely if ever a simple process of counting or accounting and instead involves social-calculative relations and practices.

64. In an examination of sensing air quality in *Program Earth* I suggested that it could be possible to engage with data less as free-floating facts or as the monolithic products of expertise and more as *creatures* that are constituted with and through environments of relevance. Air pollution, in this way, is constituted through numbering practices that configure and creature air pollution as a specific object of relevance. Different modalities of data in turn can generate different figurations and creatures of air pollution. In developing this analysis, I draw on Alfred North Whitehead's discussion, in *Process and Reality*, of creatures as the actual entities and occasions that coalesce through processes and relations.

65. Different approaches to narratives, storying, and fictions surface through these practices, that could follow much different trajectories of "science," observation, and experience as indicated in work ranging from McKittrick's *Dear Science and Other Stories* to Nadim's "Blind Regards." Storytelling can also be a way to hold a plurality of experiences together without resolving them, as noted in D. Houston, "Environmental Justice Storytelling"; and Spencer, Dányi, and Hayashi, "Asymmetries and Climate Futures."

66. The *Deptford Data Stories* are available at https://citizensense.net/data-stories -deptford.

67. A resonant discussion of stories can be found in Petryna's *Life Exposed*, xxvi.

68. Morgan, "'It's Time to Act Now.'"
69. Foxcroft, "Business of the House."
70. Foxcroft.
71. The latest state of plans for this site can be found at Peabody, "Frankham Street Development." For an account of the site transformation and community protest at the development, see Worthington, "Deptford's Tidemill Campaign."
72. For an example of some of these initiatives, see Save Reginald! Save Tidemill!, "Help Us Save Reginald House and Tidemill Wildlife Garden."
73. Corporate Watch, "Tidemill."
74. Vickers, "The Battle for Deptford."
75. Cuffe, "Lewisham Paying Back Debt."
76. Save Reginald! Save Tidemill!, "Destruction of Deptford's Much Loved Community Garden."
77. Noor, "Housing Approved Despite Pollution Warning."
78. Crosswhatfields?, "No. 1 Creekside."
79. After extensive protest over development plans at the Old Tidemill site, Peabody incorporated a community-consultation process as part of the development. They write: "Our aim is for everyone to participate in the design of the open and public spaces that will be delivered within the new scheme. . . . We have consulted with the community on the designs for the green space and have been working with a small group of local people to shape the proposals." No indication is given as to how this small group was selected, whom it involves, or to what extent it is representative of local interests. See Peabody, "Frankham Street Development."
80. Virginia Eubanks suggests that these analyses of power must remain a critical component of participatory research. See Eubanks, "Double-Bound."
81. Rankine, *Citizen*. Balibar also notes how civility and political participation can be at odds when attempting to undertake democratic engagement and challenge existing power structures. See Balibar, *Citizenship*, 53 and passim.
82. Berlant, *Cruel Optimism*, 28.
83. Nelson, *Body and Soul*.
84. Thanks to Helen Pritchard for this discussion about countering the perennial promise of making and doing, which can often foreclose the necessity of unmaking and undoing. These practices are likely to occur in conditions of conflict and struggle, since they work against rather than reinforce established technoscientific practices. See also McGlotten, "Black Data."
85. Glaude discusses this point at length in relation to Dewey and pragmatism in *In a Shade of Blue*.
86. The Deptford Park area is located within Evelyn Ward, one of the most impoverished wards in the UK. See End Child Poverty.
87. Deptford Folk.
88. Royal College of Physicians, "Every Breath We Take."
89. Deptford Parks.
90. As Lewisham Council writes, "We have expanded our network of air quality monitoring. A new site has been set up in Deptford which increases the continuous monitoring sites to four. A new state of the art supersite has recently been set up at Honor Oak Park sportsground. This includes important research being carried out by Kings College

London." The council's efforts especially focused on engaging with atmospheric scientists who had a preestablished relationship with the council. See Lewisham Council, "What We Are Doing."

91. Hancock, "Khan Calls Lewisham Emissions 'Health Crisis.'"

92. Following on from James and Dewey, especially as read by Glaude, contingency and action here characterize open-air instrumentalisms through the maxim "Act, but at your peril." This statement from Dewey indicates how practical activity guided toward change can generate uncertain effects in the making and remaking of worlds. See Dewey, *The Quest for Certainty*, 6; and Glaude, *In a Shade of Blue*, 22.

93. The Ella Roberta Family Foundation.

94. The Ella Roberta Family Foundation, "About the Foundation."

95. PA Media, "Inquest"; and Laville, "Air Pollution a Cause." See also Blackstone Chambers, "Inquest into the Death of Ella Adoo-Kissi-Debrah"; and London Inner South Coroner's Court, "Inquest Touching the Death of Ella Roberta Adoo Kissi-Debrah."

96. The Ella Roberta Family Foundation's "Every Breath Matters" is a film that narrates the effects of air pollution on Ella and on 93 percent of children around the world. It ends with the appeal to rights, "Clean Air Is a Human Right," as well as the hashtag #EveryBreathMatters, a campaign to demonstrate how every breath has an accumulative and potentially lethal effect.

97. Tobin, "Extinction Rebellion Lewisham."

98. Carrington, "Covid-19 Impact on Ethnic Minorities."

99. As noted in the Introduction, Fanon wrote, "It is not because the Indo-Chinese has discovered a culture of his own that he is in revolt. It is because 'quite simply' it was, in more than one way, becoming impossible for him to breathe." Fanon, *Black Skin, White Masks*, 201. This quote, and paraphrases of it, have become a common refrain in Black Lives Matter, as well as environmental and social-justice movements and actions.

100. Mbembe, "The Universal Right to Breathe."

101. Hannah Arendt famously raised this line of critique in her discussion of the "right to have rights," which would require a (universal) governing body to ensure the realization of rights. See Arendt, *The Origins of Totalitarianism*; and DeGooyer et al., *The Right to Have Rights*. A different but resonant critique of universality vis-à-vis pragmatism can be found in Glaude's *In a Shade of Blue*, which calls attention to the specificity of justice and ethics. These works, however, do not create a simple binary between the universal and the situated, but rather emphasize the struggles to realize principles or rights that might be articulated in a more universal register. In so doing, they raise the challenge of how to realize justice through, and not despite, these struggles.

102. See also Gabrys, Pritchard, and Barratt, "Just Good Enough Data."

103. Benjamin, "Racial Fictions, Biological Facts," 2. As discussed in chapter 1 in a related register, Cornel West raises a critique of Deweyan pragmatism and its possible reliance on the scientific method as the basis for democracy. See West, *The American Evasion of Philosophy*. Writing along with these texts, I suggest here that pluralistic data practices can make multiple worlds and activate citizenships, where the right to data also forms the right to experience. In other words, many other data ontologies could surface through different formations of evidence and experience.

104. See also Stengers, *Thinking with Whitehead*, passim.

4. MULTIPLE CITIZENS

1. For example, see Howe, "Sensing Asymmetries"; and Gramaglia and Mélard, "Looking for the Cosmopolitical Fish."

2. I have previously written about this topic, which I continue to develop through this discussion of air-quality gardens. See Gabrys, "Becoming Urban."

3. For a related discussion on how to move beyond human-based understandings of sensing and embodiment, and what these transformations of sense can generate (especially in relation to aquifers and satellites), see Ballestero, "Touching with Light."

4. In chapter 4 of *Program Earth,* I outline how citizenship could be understood ecologically through relations and practices, and also something that activates more-than-human relations and entities. This work draws on Rosi Braidotti's concept of the ecological citizen. Here, I extend this discussion of multiple citizens into an engagement with William James's notion of the multiverse, as well as the broader array of science and technology studies literature that works through ontologies of the multiple. See Gabrys, *Program Earth*; Braidotti, *Transpositions*; James, *A Pluralistic Universe*; and Mol, *The Body Multiple*.

5. Crawley, *Blackpentecostal Breath*, 3.

6. Crawley, 5. As Cornel West proposes in his analysis of pragmatism (drawing on Emerson), citizens form through the interactions of social life, which also give rise to the conditions of common experience. As this chapter further suggests, these interactions also involve more-than-humans as contributors to social interactions.

7. Kimmerer, *Braiding Sweetgrass,* 58.

8. Kimmerer, 58.

9. However, there are now multiple projects that have developed real-time and hybrid sensing and signaling technologies that enhance and convert plants' distributed sensing capabilities to detect pollution, explosives, and more. For instance, see "Plants Employed as Sensing Devices"; and Trafton, "Nanobionic Spinach Plants." In many ways, these projects are continuous with attempts to understand how plants sense and communicate. For example, see Karban, *Plant Sensing and Communication*.

10. For expanded discussions of more-than-human modes of witnessing, see Sheikh, "The Future of the Witness"; and Schuppli, *Material Witness*.

11. Van Haluwyn and van Herk, "Bioindication," 44.

12. Ferretti and Erhardt, "Key Issues in Designing Biomonitoring Programmes," 112.

13. Van Haluwyn and van Herk, "Bioindication," 56–58.

14. Van Haluwyn and van Herk, 40.

15. Kimmerer extensively discusses this making and remaking of earth and atmospheres. She writes: "We are all bound by a covenant of reciprocity: plant breath for animal breath, winter and summer, predator and prey, grass and fire, night and day, living and dying. Water knows this, clouds know this. Soil and rocks know they are dancing in a continuous giveaway of making, unmaking, and making again the earth." *Braiding Sweetgrass*, 383. While this chapter specifically investigates the relationships across plants and air, there are many other connections across water, other organisms, and soil that could be drawn out here if space permitted. Soil is now an especially dynamic area of research that points to further exploration across organisms, politics, technoscience, and ecologies. For example, see Puig de la Bellacasa, "Making Time for Soil"; and Lyons, *Vital Decomposition*.

16. As discussed throughout this book, world making as a concept and related set of terms now traverses multiple texts. While I draw on William James's use of this term, as well as ongoing pragmatist uses of it, I also follow this rich vein of thought into feminist technoscience, Indigenous theory and practice, and parallel literature. For the purposes of this chapter, I especially engage with Tsing, *The Mushroom at the End of the World*; Haraway, *When Species Meet*; Stengers, *Thinking with Whitehead*; and Kimmerer, *Braiding Sweetgrass*. Elaine Gan has also developed a Multispecies Worldbuilding Lab, which includes podcasts on this topic; see http://multispeciesworldbuilding.com/.

17. Tsing, *The Mushroom at the End of the World*, 21. As science and technology studies research would note, "nonliving" things also remake the world. This analysis necessarily extends to digital sensors and networks, among many other more-than-human entities.

18. Tsing, 22.

19. Simondon, *L'individuation*; Combes, *Gilbert Simondon*. See also Simondon, *Individuation*.

20. While Simondon's work examines these formations of entities and milieus, a parallel but different investigation into the "human" can be found in Sylvia Wynter's analysis of raced, classed, and sexed humans as misaligning with the universal human of colonialism or the Anthropocene. See Wynter and McKittrick, "Unparalleled Catastrophe for Our Species?"

21. Gilbert, Sapp, and Tauber, "A Symbiotic View of Life," 336.

22. Haraway begins her chapter "Tentacular Thinking: Anthropocene, Capitalocene, Chthulucene" with the epigraph "We Are All Lichens Now."

23. Kimmerer, *Braiding Sweetgrass*, 275.

24. Tsing, *The Mushroom at the End of the World*, 180.

25. Van Haluwyn and van Herk, "Bioindication," 48.

26. Van Haluwyn and van Herk, 50.

27. Van Haluwyn and van Herk, 53.

28. Gramaglia and Sampaio da Silva, "Researching Water Quality."

29. Kohn, *How Forests Think*.

30. More-than-human sensing as expressed through these multiplying points of view also demonstrates how "nature" is not a stable referent but rather a realm where diversity multiplies toward a "multinaturalism," where, as Eduardo Viveiros de Castro suggests, organisms might also be approached as persons and as having perspectives as persons. See Viveiros de Castro, *Cannibal Metaphysics*.

31. Such encounters with multiple environmental subjects and their worlds have further consequences for how "the ends of the world" are identified, averted, or addressed. See Danowski and Viveiros de Castro, *The Ends of the World*.

32. Stengers, *Cosmopolitics I*, 55. Cosmopolitics as developed by Stengers is a concept that indicates or asks how it might be possible to work toward different collective arrangements and processes that engage with humans and multiple more-than-humans, and thereby to transform the political scenes and environments of relevance within which problems come to matter. Plants, soil organisms, and fungi are viable actors that force different approaches to politics through cosmopolitical relations.

33. Tsing, *The Mushroom at the End of the World*, 254.

34. Simondon, *L'individuation*; and Combes, *Gilbert Simondon*. See also Simondon, *Individuation*.

35. Berlant, *The Queen of America*, 20.

36. TallBear, "Why Interspecies Thinking Needs Indigenous Standpoints." In a related way, Kimmerer notes that Indigenous knowledges allow for integral and democratic environmental engagements, where scientific analysis can tend to atomize its objects of analysis. See Kimmerer, *Braiding Sweetgrass*, 345.

37. Wenzel, "Reading Fanon Reading Nature," 189.

38. Simpson writes that the nation is a "place where we all live and work together" and "a web of connections to each other, to the plant nations, the animal nations, the rivers and lakes, the cosmos, and our neighboring Indigenous nations." See L. B. Simpson, *As We Have Always Done*, 8.

39. Rather than anthropomorphizing plants, such a move would even vegetalize citizens to allow for other encounters with environments as the conditions for being and becoming political subjects.

40. Resonating with Whitehead's approach to encountering everything as a subject, Kimmerer notes that "thinking about plants as persons, indeed, thinking about rocks as persons, forces us to shed our idea of the only pace that we live in is the human pace." Kimmerer, "The Intelligence of Plants." See also A. N. Whitehead, *Process and Reality*.

41. See City of London, "Barbican Low Emission Neighbourhood."

42. The work that more-than-humans undertake in processing carbon and pollutants is an ongoing area of research that I am developing further here. See also, Gabrys, "Plastic."

43. City in Bloom, *The Clean Air Gardens*. See also City of London Gardens; and City in Bloom, "Air Quality Challenge."

44. See Clean Air Gardens; and Friends of City Gardens.

45. Mapping for Change, "Science in the City: Barbican Citizen Science Project" and "Science in the City: Barbican Report."

46. This was also in the context of the City of London's development of a CityAir app to lower exposure to air pollution by suggesting walking routes away from heavy traffic. See https://www.cityoflondon.gov.uk/services/environmental-health/air-quality/cityair-app/.

47. For a discussion of community gardens and their contradictions, see McClintock, "Radical, Reformist, and Garden-Variety Neoliberal."

48. Museum of London, "How to Grow Your Own." The Phyto-Sensor Toolkit is also available to view and download on the Citizen Sense website at https://phyto-sensor-tool kit.citizensense.net. In the vein of the "how-to" guide that informs this book, there are also popular guides to purifying indoor air, including Wolverton, *How to Grow Fresh Air*.

49. The plants installed across the two demonstrator gardens included *Taxus baccata, Sorbaria sorbifolia, Hedera helix, Achillea millefolium, Aster* spp., *Sambucus racemosa, Symphoricarpos albus, Osmanthus delavayi, Salvia nemerosa, Lavandula* 'Platinum Blond', *Heuchera* spp., and *Euphorbia characias*. However, the Phyto-Sensor Toolkit includes a much more extensive list of air-quality plants, even if many of these are specific to UK and similar temperate environments.

50. For a resonant discussion of this theory and practice within Nishnaabeg intelligence, see L. B. Simpson, "Land as Pedagogy."

51. I include the Latin names here as a way to identify the organisms planted in the garden, but I also follow Kimmerer's suggestion not to let the scientific naming of plants become a strategy for closing down inquiry into established objects of analysis, but rather

to attend to the relationships and processes that are always unfolding and making worlds. See Kimmerer, "The Intelligence of Plants." For another example of how plants, relations, naming systems, and practices are co-constituted, see Siisip Geniusz, *Plants Have So Much to Give Us.*

52. City of London Corporation, "Air Quality Monitoring." The Beech Street air-quality monitor is one of five continuous monitoring locations in the City of London, which also has over one hundred nitrogen dioxide diffusion tubes. The City of London Corporation also provides air pollution alerts via the CityAir app and through airTEXT. See https://www.cityoflondon.gov.uk/services/environmental-health/air-quality/cityair-app/ and https://www.airtext.info.

53. Examples of how these multiple more-than-human interactions could unfold are discussed in Clarke et al., "More-than-Human Participation."

54. For an extensive range of references on these different pollution-absorbing and pollution-responding characteristics of plants, see Citizen Sense, "Phyto-Sensor Toolkit."

55. There is an extensive range of research on planting and power. While there is no space here to engage fully with this material, references that inform this discussion include Gray and Sheikh, "The Wretched Earth"; Tsing, *The Mushroom at the End of the World*; Haraway, *Staying with the Trouble*; Allewaert, *Ariel's Ecology*; Davis et al., "Anthropocene, Capitalocene . . . Plantationocene?"; Wynter and McKittrick, "Unparalleled Catastrophe for Our Species?"

56. Tuck et al., "Geotheorizing Black/Land," 55.

57. Tuck et al., 68. See also M. Smith, "Wildness."

58. Kimmerer, *Braiding Sweetgrass.*

59. Community gardening can be a way to activate "otherwise infrastructures," as LaDuke and Cowen discuss in "Beyond Wiindigo Infrastructure." For a parallel discussion in relation to the planetary, plantations, and the Anthropocene, see Yusoff, *A Billion Black Anthropocenes or None.*

60. Plumer and Popovich, "Decades of Racist Housing Policy."

61. Groundwork USA, "Climate Safe Neighborhoods."

62. The Phyto-Sensor Toolkit is available at https://phyto-sensor-toolkit.citizensense .net/.

63. Crawley, *Blackpentecostal Breath*, 11.

64. Crawley, 24, 79.

65. Crawley, 41.

66. Botanist John Gerard (along with others) is generally credited with having authored the *Herball*, a text that outlines medicinal uses of plants. See Gerard, *The Herball.* There has been a garden on this spot since at least 1555, and the Worshipful Company of Barber Surgeons (of which Gerard was Master of Company in 1607) created a Physic Garden to demonstrate plants involved with healing.

67. Crawley, *Blackpentecostal Breath*, 85.

68. A. N. Whitehead, *Process and Reality*, 78.

69. De la Cadena and Blaser explore the incommensurability of worlds and pluralism in their discussion of the uncommons. See de la Cadena and Blaser, *A World of Many Worlds.* In a somewhat different register than the uncommons, however, James's notion of pluralism engages with difference as requiring ongoing encounters, negotiations, and

adjustments to contingent worlds that are, at the same time, in contact with many other worlds.

70. For discussions of these different epistemologies and ontologies of citizen science, see Irwin, "Constructing the Scientific Citizen"; and Ottinger, "Buckets of Resistance."

71. See James, *Pragmatism and Other Writings*, 20 and 35; and James, *A Pluralistic Universe*, passim.

72. James, *Essays in Radical Empiricism*, 148.

73. James, *A Pluralistic Universe*.

74. In this use of the term "vegetating," Allewaert draws on William Bartram's travels through the United States, where he refers to plants and swamps more specifically as "vegetating" to indicate "the process by which a sentient force acts in an ecology that acts on and through it." See Allewaert, *Ariel's Ecology*, 34.

75. Richard J. Bernstein uses the term "engaged pluralism" to propose that James's pluralism did not lead to mere relativism. When we encounter other experiences and worlds, he notes, "This does *not* mean that when we make a serious effort to understand other points of view we will simply accept them or suspend our critical judgment. James's pluralism is not flabby or sentimental. It calls for a critical engagement with other points of view and with other visions. It is an engaged pluralism. Contrary to the picture of relativism that speaks of incommensurable frameworks and paradigms, James's pluralism demands that we reach out to the points of contact where we can critically engage with each other." See Bernstein, *The Pragmatic Turn*, 62.

76. Kimmerer, *Braiding Sweetgrass*, 373. As Simpson writes in a similar vein, these are struggles for particular ways of living, which span thought systems, bodies, temporalities, and practices. See L. B. Simpson, *As We Have Always Done*, 21. See also Celermajer et al., "Justice through a Multispecies Lens."

CONCLUSION

1. A. N. Whitehead, *Process and Reality*, 88.

2. Fanon, *A Dying Colonialism*; Crawley, *Blackpentecostal Breath*.

3. Gabrys, *Program Earth*, 162–63.

4. See also Sharpe, "The Weather"; and Gumbs, "That Transformative Dark Thing." Here, breathing is an accretion and accumulation, an ongoing struggle, as well as an opening into other possibilities for social, political, and worldly engagement.

5. James, *Essays in Radical Empiricism*, 153; see also Barry, "What Is an Environmental Problem?"

6. Consider, moreover, the networks of citizenship and noncitizenship that support the design, manufacture, and use of digital technologies: if people become citizens through sensors, what becomes of those humans and more-than-humans who are involved with and affected by the hazardous extraction of minerals for digital technologies, as well as the often-toxic conditions for the manufacture of these devices? The conditions of citizenship can signal toward the erasures and exclusions required to support particular designations and groupings of technopolitical subjects.

7. Or as Leanne Betasamosake Simpson has written, in the North American context for Indigenous peoples, "In situations in which sovereignties are nested and embedded, one proliferates at the other's expense." See L. B. Simpson, *As We Have Always Done*, 12.

8. While this resonates with pragmatist conceptions of democratic worlds and subjects, especially as articulated by Dewey, Glaude, and others, I am especially referring to Berlant's notion of "the affect of feeling political together," where "the attainment of that attunement produces a sense of shared worldness, apart from whatever aim or claim the listening public might later bring to a particular political world because of what they have heard." See Berlant, *Cruel Optimism*, 224. This also resonates with James's discussion of the formation of worlds and subjects, where the conditions of mutual experience involve meeting in common worlds (and perhaps, following de la Cadena, across uncommon worlds). As James suggests, mutuality and worlds are formed through meeting and experience. They are ongoing negotiations rather than absolute conditions. See James, *Essays in Radical Empiricism*, 79.