# Introduction. Atmospheric Citizens: How to Make Breathable Worlds

Introduction

# ATMOSPHERIC CITIZENS

## *How to Make Breathable Worlds*

> I never want less citizenship, I always want more. More different ways of being in relation. And then we struggle it out, because we struggle with the ways in which they're incommensurate.
>
> Lauren Berlant, "On Citizenship and Optimism"

> How quick, how shallow, how deep, how possible is your breathing right now?
>
> Alexis Gumbs, "That Transformative Dark Thing"

An aerial shot of silty terrain fills the screen. The drone video documents a figure in military fatigues, backed by an armored police vehicle and pointing a weapon skyward. A blue projectile leaps into view, knocking the image from its stable frame. As the recording device steadies and pushes onward after the blow, it traces the long tail of a pipeline under construction. Upturned grasses and topsoil, along with trucks and heavy equipment, mark the landscape. The video documents the development of extractive fossil-fuel infrastructure, an event behind barricades that aerial observation brings into view.

The drone that records these images is sensing and monitoring environmental disruption and the destruction of Indigenous lands from the construction of the Dakota Access Pipeline. It gathers soundless video clips that circulate to online platforms and inform ongoing activism and resistance by drawing people to this site, Standing Rock, as part of the NoDAPL movement. Piloted by Water Protectors including Drone2bwild and Digital Smoke Signals, the pilots describe these drone-sensors as an important way to expose the "truth" of extraction and counter government and industry statements. The drones are being "pushed to their limits" in an attempt to develop alternative practices that can contend with—and overturn—extractive technologies that are part of ongoing processes of colonization and environmental destruction.[1] The pilots describe their drones as airborne "protectors" that provide additional power to expose and

protest the pipeline construction. Their videos show the growing movement of people who assemble to protect the land, water, and air. They provide a sense of possibility for different and less destructive engagements with environments and technology.[2] Their practices point toward ways of making more breathable worlds, where subjects and environments—people and land—are involved in more reciprocal exchanges and practices of computing otherwise.[3]

From drone monitoring of pipeline construction at Standing Rock in the Sioux (Dahcotah) Nation, to water testing in Flint, Michigan, radiation testing in Fukushima, Japan, deforestation monitoring in Brazil, and air-pollution monitoring in London, a diverse set of DIY, grassroots, and citizen-led practices is materializing to monitor environments. These sensing practices document pollution of air, soil, water, and ecosystems, and they challenge the destruction of environments. Whether monitoring public infrastructure and utilities, contesting extractive industries, or documenting environmental pollutants and biodiversity loss, such practices seek to generate alternative forms of evidence in place of government or industry data. At the same time, these practices express different worlds of experience along with the multiple political subjects and relations that constitute them.

At Standing Rock, protectors, pilots, residents, and activists flew their drones over the pipeline construction to show that unauthorized development in support of extractive industries was occurring. Even as they documented illegal and destructive activity on their lands, drone pilots were told their flights were prohibited.[4] In Flint, residents observed and lived with the effects of polluted water in their homes. They documented and tested their water and worked with university scientists to analyze samples and communicate findings to policy makers, regulators, and the media. While the evidence of severe pollution has drawn international attention, Flint residents continue to have unsafe drinking water.[5] During the 2011 earthquake and tsunami in Japan that destroyed the Fukushima Daiichi Nuclear Power Plant, Geiger counters sold out as residents attempted to obtain information about radiation levels in the area. The group Safecast developed sensors so that participants could monitor environments and exposure, since they did not have access to or did not trust government data and advice about radiation levels.[6] In forests from the Amazon in Brazil to the Carpathian Mountains in Romania, illegal and rampant logging activity continues apace. Networks of remote-sensing technologies and digital reporting systems track deforestation and send text alerts that attempt to halt illegal logging.[7] And in cities around the world, people are using a battery of equipment, including digital sensors, to monitor and mitigate air pollution while managing their exposure to harmful pollution levels.

Citizen-led digital monitoring now extends to a vast array of different environmental concerns. *Citizens of Worlds* investigates how digital sensing technologies transform environmental engagements. This book primarily focuses on how citizens use sensors and DIY electronics to gauge air pollution. From environmental justice groups monitoring petrochemicals in the Imperial Valley of California, to urban residents tracking exposure to air pollution in India and China,[8] there has been a proliferation of citizen-sensing projects focused on air quality. As one of the deadliest forms of environmental pollution, air pollution is a problem primarily caused by fossil-fuel extraction and use, including for transport, construction, buildings, and industry.[9] Air pollution also now occurs at significant levels due to the atmospheric accumulation of fossil fuels leading to climate change, which can contribute to wildfires, particle formation, haze, and smog.[10]

Citizen sensing is a practice formed through struggles to contend with these changing environments. Here, I consider how environmental monitoring technologies that involve low-cost and accessible digital sensors to monitor environments and collect data attempt to challenge and upend existing forms of expertise and ways of addressing environmental problems. These technoscientific engagements remake the usual approaches to environmental action and demand that other experiences—and worlds—be taken into account. In the process, such practices can also undo the designation of the citizen as a normative nation-bound political subject while recasting the affiliations and possibilities of political life.

However, as I will also discuss here, the promissory aspects of these technologies might equally be analyzed as part of a neoliberal sales pitch, where digital technologies are packaged in a glossy veneer of democratic action that does little to shift the entrenched conditions of environmental pollution or social injustice. While citizen-oriented technologies might promise a straightforward realization of positive political change, they rarely yield such effortless or liberatory outcomes when put into practice. On the contrary, citizen-sensing practices produce data sets that governments and experts often view with suspicion. At the same time, digital participation can lead to the proliferation of more (environmentally destructive) digital devices while the conditions of democratic involvement continue to be eroded and social and environmental injustices are amplified.

To account for these variable sensing practices, I engage with citizens neither as universal human actors nor as icons of technological liberation. Instead, I suggest that the "citizens" in "citizen sensing" are politically activated entities that form through worlds of struggle. People monitor environments to address and reduce pollution and related concerns. In this way, sensing citizens become *citizens of worlds*. With this concept, I offer an approach to citizens where different

ways of sensing and being affected by environments can activate, reinforce, or transform political subjects and collectives. Citizens require distinct worlds to come into being and to express political affiliations. Worlds are not containers or discrete spheres but rather are constitutive conditions of exchange. Worlds also form as conditions of proliferating citizenships and struggle, as Lauren Berlant notes in the first epigraph to this Introduction. Yet these collective conditions are not only a matter of human affairs but also involve relations that take hold across more-than-humans, technologies, and milieus. To be citizens in the making requires worlds in the making.[11]

This mutual constitution of citizens and worlds unfolds with and through exchanges that I describe as the *breathability of worlds*. "Breathability" indicates not just the ongoing access to actual air to breathe but also how and whether environments, subjects, and relations can be in constructive exchange. Such exchanges involve reciprocity and mutual benefit as part of forming political subjects and worlds. Breathability articulates possibilities for participatory democratic interaction. As Alexis Gumbs notes in the second epigraph, conditions of breathability align with political potential. Rather than indicating an essential biological state, breathability signals situations of differential confinement or flourishing, restriction or expansion that occur in exchange with other entities and milieus.

To be and become citizens of worlds signals the ability to be in constructive exchange with milieus: to observe and contribute, to listen and be heard. Such exchanges allow for the realization of political and environmental relations that extend into the open air of lived experience rather than close in on the airless confines of the universal citizen. With "open air," I refer to the pragmatist proposal to put ideas to the test through practice and to engage with worlds in process.[12] In the open air, the citizen is not an unchangeable entity. Instead, "the subject emerges from the world" and is contingent upon actual occasions and experience.[13] This text delves into the multiple subjects and practices that materialize when sensing air pollution and struggling toward more livable and just environments. Sensing and breathing are ways of constituting these relations. They are practices that indicate how subjects form through exchanges with environments and struggles for breathability.

*Citizens of Worlds* examines how sensing technologies are deployed, installed, operationalized, and put to work to support concrete struggles over air pollution and related environmental conditions. It analyzes how these practices become legible as citizenly engagements. This book asks: Who or what constitutes a citizen in citizen-sensing practices, and how do sensors activate different citizens in the making? How are possibilities of citizenship formed within and through world-making exchanges? And what are the worlds that citizens would sense, be

constituted by, fight for, and struggle to make more breathable? Rather than adopt an approach that univocally argues for the liberatory or condemnatory aspects of citizen-sensing technologies and practices, I instead consider how sensing technologies become caught up in struggles for breathability.

Questions of who or what is a citizen, as well as what is to be sensed and the worlds that are made and sustained through these practices, arise as key problems that unfold in the course of researching, building, installing, and scrutinizing sensing technologies. These questions ask what contributions citizens can make with environmental sensing technologies as well as how these citizens and practices are constituted or disregarded. While citizen sensing can enable specific actions for addressing environmental problems, it can also give rise to further complications for environmental engagement. Not everyone may have the time or resources to undertake environmental monitoring, and different contributions will register more or less forcefully when making claims about environmental pollution. Poor and racialized communities often have less traction when undertaking political advocacy, since environmental claims can be enabled or dismissed based on social, political, and economic privilege. Environmental monitoring can also be a very particular way of configuring environmental problems through data-driven technical practices, which, taken alone, can overlook multiple other experiences. I consider the demonstrations, rejections, and reworkings of citizenship that materialize through citizen-sensing technologies and practices.

In this Introduction, I initially propose *atmospheric citizens* as figures who monitor air pollution as a practice of building more breathable worlds.[14] Yet throughout this study, I also offer multiple other modalities of citizens and citizenship for consideration in the form of instrumental citizens, speculative citizens, data citizens, multiple citizens, and sensing citizens. These are figures constituted through engagement with instruments and toolkits, pollution and harm, evidence and rights, more-than-humans and ecological relations, collective experience and sensation. And yet this is far from a definitive list, since the "citizen" in "citizen sensing" is a shape-shifting entity. In the process of sketching these different yet intersecting citizens of worlds, I consider how subjects embody and express experiences of environmental pollution and destruction. These are citizens in the making, engaged in and constituted through exchanges with worlds. They are figures of breathability and struggle.

In questioning why "citizen" as a term is so frequently appended to digital technologies, this study investigates how such devices on the one hand offer up new participatory potential, and on the other hand create restrictions for democratic engagement.[15] "Citizen sensing" is a term that unevenly describes the use

of digital sensors to monitor environments. Indeed, even when working with sensing devices through practices that bear some resemblance to other citizen-sensing projects, Standing Rock drone operators and activists refer to themselves as "protectors," a designation distinct from the language of citizen sensing that expresses ways of watching over and fighting for land. From protectors to community science, to environmental witnessing and citizen science, a diverse array of environmental monitoring practices is now underway.[16] I begin with these examples across multiple sites of environmental struggle because they throw into question how or whether digital sensing technologies and practices might variously be described as "citizen" sensing.

Rather than working with a fixed definition of citizen sensing, I instead consider how environmental monitoring practices and technologies facilitate or hinder more democratic forms of environmental participation.[17] In this sense, I open another line of inquiry distinct from earlier uses of the phrase "citizens as sensors," which described the activities of the "general public" in contributing crowdsourced observations to open-mapping activities.[18] By contrast, I specifically investigate how digital sensing technologies activate more pluralistic practices of environmental citizenship. In other words, I unsettle the figure of the citizen rather than engage with it as a predesignated political actor that might scale into the "general public." At the same time, the technologies and data under investigation here do not assemble into crowdsourced mapping practices. Instead, such an approach considers how the citizenly aspects of sensing do not fully settle in advance of environmental encounters. Sensing, citizens, and worlds differently materialize in ways that can actively constitute or discourage political subjects and relations.

By investigating the problem of the citizen in citizen sensing, this research engages with social, political, environmental, and technological struggles that unfold through diverse monitoring projects and locations. But it primarily focuses on three intensive practice-based and participatory studies undertaken through the Citizen Sense project that I have led since 2013.[19] Our research collective has worked with communities to monitor environmental problems, with an emphasis on air pollution. Drawing on nine years of research, *Citizens of Worlds* documents and analyzes work that has involved developing and testing citizen-sensing technologies, installing sensing kits in collaboration with communities concerned about environmental problems, and analyzing citizen data to generate evidence for action. These three case studies focus on digitally informed ways of sensing air pollution, whether in the gas fields of northeastern Pennsylvania, the congested streets of South East London, or air-pollution gardens in the financial center of London.

Through describing practice-based research developed by the Citizen Sense project working in collaboration with citizens and communities as co-researchers, I investigate how environmental sensing technologies and toolkits take shape in polluted conditions and how struggles arise to fight for more just environments. This practice-based research asks "how to" put sensors to work by undertaking collective research to address environmental problems. In testing these technologies in lived situations, this study documents how these devices work (and fail to function) and engages with the citizen–subjects and worlds within which they become operational. In this way, I engage with citizen sensing less as a topic focused on discrete devices, whether as prototypes or off-the-shelf technologies, and more as formations of political subjects, environmental problems, affected communities, technoscientific practices, political strategies, and worlds struggling to become breathable.

## CITIZENS OF WORLDS

In a time when politicians pronounce that "If you believe you are a citizen of the world, you are a citizen of nowhere,"[20] it would seem more important than ever to account for the complex affiliations, attachments, and obligations that form political subjects. Such a declaration seems to announce that citizenship must be singularly designated and tied to a distinct national territory to be rendered meaningful. In its apparent condemnation of elites and jetsetters, this remark entrenches a fixed mode of citizenship with an essential form of belonging. This type of "citizen of the world" has also come under attack by purveyors of nationalism, who insist on discriminatory and racist renderings of the nation-state as a composition of citizens who are seen to "rightfully" belong to its territory.

A citizen of the world might in one way seem to be an elite figure, characterized as much by proselytizing prime ministers as in-flight magazines that promote the benefits of securing multiple national citizenships for weathering global uncertainty. A citizen of the world is critiqued for assuming the privilege of free movement and interchangeable affiliations, along with an uncomplicated appeal to fluid cosmopolitanism. "The world" of which this citizen is a member is a particular designation that can signal privilege undergirded by entrenched inequalities. A citizen of the world might also be diasporic or a subject without a fixed affiliation—yet many migrants find themselves in this situation and are rarely graced with the designation of "citizen of the world." This label is not available to all, however expansive it might seem.

In another way, a citizen of the world might indicate how the "rational demos" is being reconfigured through global interconnection and communications.

This particular articulation of cosmopolitanism designates a world membership that, in its deterritorialization, can be seemingly expansive.[21] A citizen of the world could be someone for whom "local" issues do not define the entirety of their political attentions and engagements, since they are concerned with planetary affairs.[22] Such tendencies become evident within planetary governance, planetary health, and planetary urbanism initiatives. However, the concept of a "world citizen" could also undo the plurality that constitutes the condition of politics by assuming a unitary world as the site of political concern.[23]

Despite these various compositions, the citizen of *the* world would still belong to a "one-world world," as John Law has termed it.[24] The constitution of the citizen and the world—as a citizen of one world—is situated within a universal and undifferentiated rendering of political subjects and the world to which they would belong. The world, in this sense, might even stand in for the singular designation of the nation. Indeed, the citizen of *the* world initially emerged through the transnational flows of colonial trade and conquest.[25] A one-world world can materialize as a figure of domination and extraction, as well as exclusion and marginalization, even as it promises universality.

By recasting the citizen of the world as *citizens of worlds*, this book seeks to study how political affiliations and encounters are multiple and do not necessarily or exclusively parse as nation-state territories or singular forms of belonging.[26] While this is by no means to suggest that struggles for national citizenship are not significant and formidable obstacles for many people, it is also to indicate how citizenships involve multiple exchanges and attachments, in declensions and grammars that differently constitute breathable worlds. There are many other collective entities and identities to which citizens—as variously and unequally constituted political subjects—attach. These are more pluralistic formations of political subjects, which include the nation as just one way of parsing the demos. With this mutual constitution of citizens and worlds, a potential proliferation of citizenships unfolds, forming sites of possibility and struggle because of their plurality and incommensurability.[27]

And yet, "citizen" is likely not even a proper designation of a political subject for all worlds. With this caveat, the term is used here in the plural to signal a differential array of political subjects and environmental relations, as well as a specific entry point for considering how political capacities materialize through digital technologies and practices. The drone pilots and protectors, community scientists, and environmental activists mentioned earlier are political subjects who occupy different configurations of land, collectivity, and more-than-human relations. Rather than innocuously providing data that might facilitate but not challenge standard operating procedures, drone pilots and protectors propel

technologies into other encounters that deliberately protest and unearth the violence of a one-world world. Their documentation and witnessing of environmental destruction and extraction might be described as citizen-sensing practices, yet in another way they unsettle the assumed contours of such techno-political undertakings.

The reworkings of citizens and worlds are made through the clashes of settler-colonial states with Indigenous inhabitations, through the protracted battles of residents suffering from environmental racism when living in fence-line communities next to petrochemical industries, by inhabitants dispossessed from their lands due to ongoing and accelerating extractive operations, and by less economically privileged urbanites pushed out of their homes and to the outer edges of cities through forces of development and gentrification. These citizens and these worlds are not the model figures typically imagined when technology companies market drones and sensors and data platforms. Instead, such citizens, formed through struggle, unsettle the seamless narratives of digital participation. In doing so, they demonstrate the limits of these technologies and scripts while forcing different engagements that work toward more breathable worlds.

### *Proliferating Citizenships*

*Citizen* is a term easily attached to any number of digital technologies. From citizen sensing to digital citizens and internet citizens, numerous digital technologies promise to make us all more informed and active participants. Citizen sensing could suggest the accessibility of these devices to everyday users, or it could signal a frivolous use of the term *citizen* to impart a democratic allure to these technologies. Indeed, at the very moment when digital technology companies are seen to be exercising antidemocratic influences, this packaging of democratic engagement is increasingly used as a strategy, and even smokescreen, to promote an increasing array of supposedly participatory digital products. The "digital citizen" can signal a transformation of political engagement through digital technologies, as well as a possible narrowing of democratic processes through increasing control over data and modes of participation.[28]

Any attempt to locate such a digital citizen within a genealogy inevitably forms a shaky project. The usual designation of the citizen as an ancient Greek conception bound to a city-state, which is now read through the nation, is a way of designating what Engin Isin refers to as an Occidental approach to citizenship. Such an approach to citizenship simultaneously generates specific alterities of citizenship.[29] While it could be possible to analyze the exclusions of citizenship, or who might be designated as noncitizens, Isin's provocation that citizenship is not only Occidental suggests that it might be more productive to consider the

alterities that are constituted along with different citizenships, since such alterities do not precede the constitution of specific forms of citizenship. Co-constituted modes of citizenship and noncitizenship are also productive of inequality and struggles for recognition.[30] Such an approach further orients attention to the possible alterities of digital citizenship, where technically oriented forms of political engagement begin to form non- or counter-citizenships to digital citizenships.

Moreover, abstract designations of citizenship manifest differently in everyday practice, and the rights that citizenship would guarantee do not equally extend to all of its members.[31] Writing about the Black Panther Party in the context of the United States in the 1960s and 1970s, Alondra Nelson has discussed how multiple forms of citizenship—across biological, economic, social, political, and other modes of engagement—have not been equally accessible to all people notionally designated as citizens.[32] Referring to this as a "citizenship contradiction," Nelson demonstrates how, enduring the deprivations of these forms of citizenship, Black people sought to expand and claim the full designations of citizenship through political action. They countered these dispossessions through community support programs, health screenings, educational initiatives, and political rallies.[33] Within the context of the civil rights movement, "health rights activism" and radical DIY health initiatives and institutions became a way to "push for equal liberties" and "bridge the stubborn gap that separated civic and social citizenship."[34] As Nelson's work demonstrates, the category of the citizen can be productive of gradated and restricted access to social and political institutions and practices. Struggles for fuller expressions of citizenship often emerge at these junctures, along with attendant anxieties about not being able to inhabit or exercise the modes of citizenship to which one is meant to have access. Yet these struggles can also form other modalities of citizenship that exceed the problem of inclusion in a one-world world to generate other worlds of political possibility.

The practices and proliferations of citizenship, then, destabilize the figure of the universal citizen, demonstrating how it can be discriminatory and exclude other possibilities for political engagement. In this sense, and drawing on Sylvia Wynter's critique of the universal human as an excluding and racializing figure, it might be possible to engage with other and multiple designations of citizenship, especially as projects of citizens and worlds in the making.[35] These subjects further exceed the human in its different declensions to include more-than-human exposures and contributions to the breathability of worlds. Such a move, I suggest, generates citizens of worlds that indicate how other political subjects and exchanges might become possible, especially as they contend with environmental pollution and destruction.

Citizens of worlds is a concept and practice that engages with more than recognition and inclusion within a one-world world. As a concept, it searches for how different ways of being political subjects and making and inhabiting worlds might constitute practices of citizenship. The proliferation of modes of citizenship suggests that there are many ways in which subjects become political. Marisol de la Cadena refers to the multiplications of worlds and ways of being in worlds as the "uncommons," where different worlds exist and come into contact but also diverge and are not always reconcilable.[36] Plurality generates conditions of possibility, yet it is not merely a celebration of the additional. Instead, it can form conditions of struggle within and across multiple worlds that might be incommensurable but can spark encounters and negotiations.[37] Practices that investigate the co-constitutive aspects of citizens and worlds offer a way to recast the hardened origin story of citizenship. They attend to the multiple worldings that generate diverse political subjects and engagements.

The "citizen" as it is operationalized through *citizen*-sensing technologies could at first be a seemingly universal subject and condition. But the expressive political capacities that such technologies are meant to enable do not so easily or evenly confer citizen-like status on everyone, where people with less economic and cultural capital, racialized communities, women, and many others outside the arenas of power and expertise will find that their contributions are less audible or delegitimated within arenas of evidence-making. Instead, questions arise about the proliferating political subjects and relations that take shape along with these practices and technologies. Citizen sensing can be a practice to mobilize findings from citizen data, appeal to policy makers, hold polluters to account, address environmental problems, and make breathable worlds by computing otherwise. Yet these practices do not follow effortless or straightforward trajectories. Regulators often ignore citizen data collected with sensors. "Facts" about environmental pollution can be dismissed if they do not align with sedimented relations of power and privilege. Moreover, the uptake and use of sensors might not always follow the same protocols or patterns of use and observation—not because these are erroneous practices but because they might tune in to different registers of experience and account for other worlds in the making.[38]

*Citizens of Worlds* examines how such modes of citizenship are constituted along with or even against citizen-sensing technologies as they are used in practice. This approach puts the citizenly aspects of these technologies to work to query the concrete political engagements that occur. Digital devices, in this sense, do not merely enable alternative forms of political engagement, where the citizen and the collective to which it belongs are wired up but remain relatively unchanged. Instead, the conditions for being and becoming citizens, for sensing

environments and making evidence claims, can transform and generate altered possibilities for breathability through these technoscientific reconfigurations.

Through grappling with the formation and activation of the "citizen," this research commits to an investigation of the political subjects, relations, and worlds that these technologies generate. Rather than dismissing or discarding the term "citizen" as overly contentious or loaded, and opting for a term such as "community," "civic," "participatory," or another seemingly less charged phrase,[39] I work with this complicated term exactly because it raises questions about the democratic dilemmas and potential of digital participation and environmental action. Once deployed, the term "citizen" opens up many unforeseen detours, obstacles, opportunities, and necessary reworkings in the course of its implementation. Part of the impetus for attending to the "citizen" is to demonstrate how this figure is not, as is customarily assumed in the context of citizen sensing, one that simply expresses the "general public" or an amateur participant who is meant to operate in contrast or in complement to expert science. Instead, the "citizen" in citizen sensing can become an indeterminate entity that forms through struggles toward more breathable worlds.

Although this study undertakes an intensive discussion of citizen-sensing practices and technologies, it also queries and reworks the designations of citizenship and approaches to political engagement that might be mobilized through these practices. Rather than signal toward more abstract designations of citizenship, whether in relation to cities, nations, globes, or planetary governance, *Citizens of Worlds* works through the practices by which world-making and world-binding activities such as environmental sensing also become citizen-making and citizen-binding practices.[40] The conditions of stressed environments, of having to breathe polluted air, and of not being able to alter states of uninhabitability can feel more constricting than expansive, where political subjects are bound to problems with which they are forced to grapple because they affect the very conditions of their breathability. Distinct citizenships materialize through struggles that unfold within these stifling atmospheres.

## ATMOSPHERIC CITIZENS: SENSING AIR POLLUTION

The World Health Organization (WHO) has deemed air pollution "the largest environmental risk factor" on the planet.[41] As many as 8.8 million people worldwide die each year from the effects of indoor and outdoor air pollution, with 4.2 million of these deaths attributable to outdoor air pollution.[42] On an annual basis, as many as 800,000 people in Europe and 40,000 people in the UK experience premature death from air-pollution-related causes, with over 9,000 UK

deaths located in London.[43] Overall, air pollution causes one in nine of total global deaths. Nitrogen oxides, ozone, volatile organic compounds, particulate matter, sulfur dioxide, and many other pollutants circulate through environments and bodies, contributing to disease and death. Cities from Beijing to Tehran and from London to Los Angeles are blighted by poor air quality. Yet as a global problem, air pollution is differently experienced, monitored, evidenced, and acted upon across the diverse locations that it affects.

The differential conditions of air quality and pollution across disparate locations can indicate the many and intersecting environmental problems, from resource extraction to extensive construction and development, traffic congestion, and petrochemical industries. Among the numerous articulations and proliferations of citizens and citizenship that I develop in this study, *atmospheric citizens* is a specific configuration that signals how air pollution and struggles for breathability affect people. Atmospheric citizenship materializes through the ongoing and worsening problem of air pollution. It designates political subjects and environmental actions that might reconfigure and transform atmospheres.

While this study engages with a limited cross section of practice-based citizen-sensing projects undertaken in the UK and United States that I describe in the chapters that follow, such projects are underway in numerous places worldwide. The Citizen Sense project has discussed monitoring practices with researchers, regulators, and community groups in locations from Vietnam and India to Kazakhstan and Montenegro, and from Chile to France and California. Although similar technologies might be used in many of these sites, very different considerations about atmospheric forms of citizenship are often at play. Issues arise related to the legality of collecting data, the availability or absence of state funding and support, the air-quality indices used, the local weather conditions, the receptivity of regulators to citizen data, and the communities of support both in environmental and technical contexts, which might also be able to act on findings from citizen monitoring.

Citizen-sensing practices and technologies could seem to outline a straightforward way to document, communicate, and act on the problem of environmental pollution and destruction and for individuals to avoid exposure to pollution by monitoring their everyday air space. Yet practices for monitoring air pollution also show how atmospheres are unevenly experienced, sensed, and acted upon through bodies, sensors, and environments. The atmospheric exchanges that sensors and sensing practices mobilize then inform the conditions and possibilities of citizenship. These are, in other words, atmospheric modes of citizenship.

When developing a concept of atmospheric citizenship in the context of air pollution, I draw in part on Berlant's notion of "ambient citizenship," where, as

they suggest, political world-building projects first become perceptible as atmospheres.[44] It is "the ordinary affective or interactive aspects of social exchange" that make up the "scenes of *substantive* citizenship," even though rational, communicative, and legal registers of citizenship are often (over-)emphasized as the key registers of citizenship.[45] Questions of who takes up space, of whose voice dominates, and how and why, are atmospheric (or in other words, affective) matters in Berlant's rendering of ambient citizenship.

I engage with multiple works that signal the affective and political registers of atmospheres and how they are constitutive and expressive of citizenship, along with research that emphasizes the unevenness and disparity of the atmospheres in and through which citizenship forms, especially in relation to air pollution. These works draw attention to the plurality of atmospheres and exposure to air pollution by capturing different struggles to breathe, which are as much sociopolitical and environmental as they are bodily. The "fact" of needing to breathe cannot be described simply as a universal condition when lived atmospheric conditions vary so significantly. Instead, such atmospheric conditions require grappling with the everyday and infrastructural conditions of environmental violence that constrain the ability to breathe.[46] Atmospheric citizens form as subjects and environments, or in other words, as citizens of worlds informed by the constitutive aspects of breathing.

### *Combat Breathing*

Atmospheres are expressive of the inhalations and exhalations of everyday life. Frantz Fanon elaborated on this condition of atmospheres through his investigations into colonial violence. Writing in the context of colonial occupation in Algeria, he argues that colonialism is not only an "occupation of territory." Instead, colonial occupation extends to a country's "daily pulsation." Within this pulsation, individuals undertake "occupied breathing" that Fanon suggests can become a form of "combat breathing," as it simultaneously endures yet works against the occupation of daily pulsations.[47] Combat breathing is a mode of respiration that contests its own occupation and suffocation.[48] Fighting for breath could on one level be a practice of fighting for survival. Yet on another level it could also involve fighting for different relations and inhabitations that are not bound to colonial power dynamics infusing everyday life. Fighting for breath consists in fighting for worlds.[49] Rather than referring to a more universal or biological rendering of breath, combat breathing marks out a struggle to transform the specific occupied atmospheres of everyday life and, in so doing, to cultivate more breathable worlds. Less an absolute envelope or sphere that conditions and terminates breathing,[50] such an approach draws attention to modes of exchange

as well as possibilities for breathing otherwise. Within this context, atmospheric citizens materialize as political subjects who come into being as they struggle toward the decolonization not only of land but also of everyday pulsations and exchanges.

Combat breathing is a practice and analytic that connects struggles across bodies, politics, histories, and environments.[51] Writers and theorists from Christina Sharpe to Alexis Gumbs have taken up Fanon's discussion of combat breathing to discuss on the one hand how toxic atmospheres become a sort of "weather" in which Black people struggle to breathe, and on the other hand to convey the violence of being robbed of breath within actual conditions of pollution, assault, and deprivation. In explicating Fanon, Sharpe suggests that it is necessary to turn to "the totality of the environments in which we struggle; the machines in which we live" to grapple with the "weather" of un/breathability.[52] Indeed, Sharpe proposes strategies for cultivating breathability—or breathing otherwise—by "refusing nation, country, citizenship" as anti-Black formations that contribute to unbreathability.[53]

In their discussions of breathability, both Gumbs and Sharpe refer to the well-known words of Eric Garner, who, when being assaulted in 2014 by NYPD police officers, repeated eleven times, "I can't breathe." His words, and his death from this restraint of breath, have become a central reference point within the Black Lives Matter movement. The repeated enunciation of "I can't breathe" by activists struggling for social justice recalls the violent death of Garner and many others. It also calls out the confined, airless, and toxic atmospheres within which Black people find themselves struggling to breathe due to systemic racism. This phrase gained renewed relevance in 2020 after the murder of George Floyd, whom a Minneapolis police officer suffocated with a knee on his neck as Floyd repeated, "I can't breathe." This call to breathability has resounded throughout protests in the United States and cities worldwide, as struggles for racial, social, and environmental justice amplify and gather force.

Writing in an earlier context, Fanon noted that revolutions emerge—here describing Indo-Chinese people rising up against French colonialism—"because 'quite simply' it was, in more than one way, becoming impossible for [them] to breathe."[54] Pheng Cheah refers to Fanon's discussion of revolution and struggles to breathe to show how decolonial efforts can lead to the formation of new subjects, along with new worlds in which they can breathe.[55] Struggles to breathe are articulations of other ways to move and respire that demand an expansion of sociopolitical possibilities. These are struggles with and against power, inequality, and the diminishment of worlds that people inhabit, require, and seek to build. Such an approach diverges from understanding atmospheres and breathing as

universal components of life to demonstrate how atmospheres and breathing are formative and transformative in addressing sociopolitical, epistemic, and ontological injustices.[56]

The relationship between air pollution and violence, particulates and power, as Lindsey Dillon and Julie Sze point out, leads to conditions of "embodied insecurity through the everyday act of breathing," especially for racialized and low-income communities. Not only does the phrase "I can't breathe" signal this insecurity, but it also indicates the "racial health disparities" and environmental injustices that lead to higher rates of asthma for Black people in the United States and elsewhere.[57] Environmental injustice in the form of air pollution occupies and constricts breathing. Such inequalities sediment in environments, bodies, and relations, which people struggle to transform by making more breathable worlds.

The phrase "I can't breathe" is a call to breathability, which, as Gumbs writes, is "designed to help us remember how to breathe and how to invite our revolutionary ancestors into our bodies and our movement."[58] From these "how-to" practices for breathing, Gumbs outlines "a cosmology" that forms to connect multiple struggles for justice.[59] The respiratory and inspiratory exchanges taking place here are a generative and revolutionary mixing of earthly relations and struggles, inheritances and embodiments, which work against conditions of unbreathability. Gumbs develops combat breathing toward "Black feminist breathing," as a practice that attends to "a lineage of Black revolutionaries whose faith in freedom continues to inspire."[60] Inspire and respire are exchanges informed by combat breathing, where to carry on breathing is to find ways to make that breathing less onerous and more expansive. Combat breathing troubles the divide between respiration and inspiration, not as a blindly hopeful project but as one that reckons with injustices while refusing to be bowed down, drowned out, or suffocated by them.[61]

### *Breathing Collectives, Breathing Otherwise*

Breath is a topic that has received attention from multiple fields. From environmental justice scholars and practitioners outlining long-standing work on the impairments to breathing in the form of asthma, heart, and pulmonary conditions for racialized communities and those who are less economically privileged, through social studies of science and technology that investigate the expert devices and practices that test and regulate the conditions of breath, to Black studies scholars who scrutinize the colonial legacies of breathing to work toward less suffocating sociopolitical conditions, there is a rich if at times diverging set of analyses on this topic. I especially engage with literature that attends to how

atmospheres and subjects, citizens and worlds, are mutually constituted through struggles for justice. I build on and extend this work to consider how citizens are not simply in worlds but rather how they are constituted through exchanges with worlds that express and materialize differential sociopolitical conditions of breathability.

As a process of daily pulsations, breathing is a mode of subjectification that is informed by environments and possibilities for collective engagement across registers of atmospheric exchange. In a similar way, Indigenous literature discusses how citizenship and breath are coextensive, where breath is an articulation of what connects people, land, and organizations in mutual exchange.[62] To be without breath is also to be without freedom, liberty, sovereignty, or citizenship. Breath in this way is not just an exchange; it is also a form of mutual benefit and governance. Writing about Canada's First Nations, Leanne Betasamosake Simpson describes Nishnaabeg "governance as breathing—a rhythm of contraction and release."[63] Such approaches to atmospheric governance are inclined toward reciprocity and flourishing that form through a mutual politics of breath. The daily pulsations identified by Fanon take on another register here, where governance requires sustaining and cultivating collective breathing by passing through combat into worlds of exchange.

Breathing involves more than one person inhaling and exhaling. It involves environments and other entities as they respire and exchange atmospheric gases and pollutants, along with circulations of air and weather. Breathing is transformative, remaking bodies and environments through continual exchanges of substances that accumulate and sediment into new ecologies. Étienne Balibar has suggested that a citizen is necessarily constituted as a member of a political community along with "fellow" citizens and is not a solitary entity.[64] A citizen always belongs to a collective that is the site and process of the political. But "fellow" citizens in the context of breathing, and sensing, extend not just to other humans but also to other entities, environments, and atmospheres that are in process, informing the possibilities for citizens and collectives to take hold as a democratic project. Indeed, breathability undertaken by humans depends upon multiple entities as they constitute and collectively create breathable worlds.

I have previously written about the co-constitution of subjects and worlds in *Program Earth*, which looked more broadly at the proliferation of environmental sensing technologies. I fold in this earlier work here to investigate how breathability is a process that forms subjects and environments through distinct conditions of exchange.[65] Breathing, like sensing, is an exchange that constitutes subjects and milieus, that establishes the ongoing relations that continue to sediment into worlds of experience. I return to these world- and subject-forming

conditions to consider in more detail how breathing and breathability are not universal properties of bodies but rather practices with differential possibilities and effects that inform the ability to be and become citizens of worlds. *Citizens of Worlds* expands on this earlier research by investigating how citizens, as political subjects, materialize across human and more-than-human relations and worlds of experience. Breathability signals exchanges with environments and other entities. It is an expression of collective and changing experiences. Incorporating more-than-humans into registers of citizenship necessarily expands the breathability of those worlds while also informing the conditions for being and becoming citizens of worlds.[66]

As citizens of worlds, atmospheric citizens are therefore constituted through distributed and social conditions that make breathing possible. The sociality of breathing and air, as Ashon T. Crawley notes, can generate different currents of air that involve mixing and exchanging as well as openness. Through these dynamics he refers to "otherwise air," which searches toward other possibilities for breathing.[67] Such characterizations of air, atmospheres, and breathing engage with currents and worlds of exchange, transformation, and struggle.

I consider how struggles for breathability surface through environmental sensing practices for monitoring air quality. This research analyzes how such practices could transform, reinscribe, or fail to address the daily pulsations of environmental pollution, injustice, constriction, and violence. Through these practices, I suggest that atmospheric citizens and citizenships materialize that are differently shaped by struggles to build more breathable worlds. To experience the constriction of breath and the pollution of air is to experience the world-binding conditions of everyday life. But citizens and worlds in the making also materialize through struggling against these conditions of unbreathability.

## HOW TO MAKE BREATHABLE WORLDS

This investigation into atmospheric citizens, along with the plural figures of citizens discussed in the pages that follow, unfolds through a practice-based and collaborative investigation into how people put sensing technologies to work to make more breathable worlds. At stake here are not just questions of what counts as a breathable world and for whom, but also how these worlds and practices of citizenship can be mobilized. The project and question of "how to" is central to this study, since it allows for an exploration of the practices that guide citizen-sensing efforts. Sounding a pragmatist note, Law suggests that practices are central to how different worlds are made and sustained and that they inform how "different realities are enacted."[68] Even more than *enacting* realities, however, this

study investigates how sense-making practices constitute ways of *struggling* for realities that could constitute breathable worlds.

This engagement with practice is at least twofold. It involves not only studying how citizen-sensing practices and technologies address environmental problems but also working with communities to develop practices and toolkits that respond to their struggles for breathable worlds. A study that is both *of and through* practices, this approach turns toward concrete effects to understand how citizen-sensing practices for monitoring air pollution materialize. Practice is a way to undertake research in the making, rather than work from a predetermined position. Practice as research is not, however, "applied" in the sense of a functional exhibition of theory. Instead, it is a way to mobilize and test propositions through actions within distinct conditions and communities of inquiry.[69] The modalities of practice developed here are more resonant with the notion of praxis than making for making's sake, since they also activate and connect with the ongoing formation of political concepts and actions.[70]

As a practice-based study on the plurality of world-making and citizen-sensing practices, this text spans multiple fields, including digital social research and science and technology studies, pragmatism and social theory, Black studies and Indigenous studies, political ecology and environmental justice. Through this approach, and in conversation with these fields, the notion that a device might embody and enable particular forms of citizenship can be tested, challenged, and rerouted. By working with citizen-sensing technologies to question how they allow—or do not allow—for different expressions of citizenship, participants could challenge the claims made about devices while also orienting citizen sensing practices toward more livable and breathable worlds. Practices of citizenship potentially materialize here less as a scripted technological program or sales pitch and more as a contingent and inventive set of collective engagements in the open air. Such engagements are as likely to arrive at impasses and confrontations as they are to realize improved air quality. I highlight the unevenness of these engagements as an indication of how atmospheric and multiple other citizens form and operate.

For each of the three case studies that inform this research, a survey of existing citizen-sensing practices underway in distinct locations became the initial spark for forming collaborations with community groups, individuals, and organizations already involved with monitoring environments. Through fieldwork, interviews, and ongoing documentation, the Citizen Sense research group learned about a wide range of ongoing sensing practices, which became the basis for making new sensing kits with communities. We also continued ongoing conversations with residents and communities, held workshops and hosted monitoring

walks, undertook site visits and installed sensors, diagnosed and repaired devices as they misfired and broke down, liaised with regulators and policy makers about environmental monitoring, joined teleconferences and meetings to discuss citizen data, retrieved devices at the end of monitoring tests, analyzed data and built data-analysis infrastructure, wrote and co-wrote data stories, and communicated and circulated findings from citizen data to a wide range of groups, including governmental agencies, the media, and scientists.

While one way to describe this research might be through the lens of participation, I deliberately work with the terms "collaboration" and "struggle," since these concepts emphasize how these projects took shape, often with considerable collective effort.[71] Citizens struggle to make their voices heard when ways of life are at stake due to environmental destruction. Collaborative and community-oriented research can be a site of struggle, as Linda Tuhiwai Smith has suggested. By working through more accountable methods, it might be possible to shift the gaze of research and contribute to the self-determination of communities involved in research.[72] Our collective practices of sensing air pollution were neither a straightforward project of user testing focused on the technical capacities of devices nor a tick-box exercise of gathering public opinion or input. Instead, the citizen-sensing investigations we developed were engaged with ongoing social, political, and environmental problems that closely informed our attempts to research sensors in practice.

As collaborative undertakings, these projects frequently involved longer time frames of becoming familiar with communities' existing monitoring practices and environmental concerns, finding workable practices for coming together to create a monitoring kit, and having multiple meetings and discussions to understand how best to analyze and communicate findings from citizen data. While our research group assembles monitoring toolkits for adaptation and use, the process of building a monitoring infrastructure takes place with communities and in response to their specific concerns. The material gathered here describes and analyzes the complexities of undertaking this practice-based work while continuing to address the key questions of who or what is a citizen and how worlds are formed or sustained through these sensing practices. In focusing on the air and air pollution as a growing area of concern for many urban dwellers, the text examines how the experience and evidence of air pollution contribute to particular ways of organizing environmental struggle and environmental citizenship through lived experiences of breathing polluted air, contending with urban traffic, and enduring ongoing construction and development.

The citizen-sensing practices and technologies discussed throughout this study take the form of open-air toolkits, since on the one hand they deal with matters

of sensing air and air pollution, and on the other hand—drawing on and creatively extending William James—they are formed through concrete experience and putting ideas and things to work in worlds. These toolkits are in process, gathering force, or dissipating as they are set into practice in the open air to form worlds in a "multiverse."[73] Such an approach allows for an understanding of how open-ended practices settle into recognizable forms as well as how the open, indeterminate, experimental, and speculative aspects of technologies unfold. The openness of technology might be pursued less as a question of open hardware or software and more as an investigation into how open technological engagements might be rerouted to be more democratic and inventive. These lines of inquiry require attention to and engagement with digital technologies as they are taken up, used, and reworked through practice.[74] Openness operates here in a pragmatist register, where how instruments are put to work in the open air informs the subjects and milieus that take hold.

Practice-based research demonstrates how open-ended and inventive encounters with digital technologies might be one way of more fully researching and addressing the qualities of technological engagements. They might also be ways to work toward more equitable and less extractive technologies and technological practices, when discrimination and inequality can unfurl through the very "code" of these devices.[75] With these points in mind, citizen-sensing research and practice might expand from the usual framing as sensing technologies enabling the collection of monitoring data toward political action to encompass a more inventive and open set of engagements. Digital technologies could be encountered as always in the making, changing through practice, and also open to disruption through sites of active engagement.

### *How to Use This Book: A Chapter Guide*

*Citizens of Worlds* takes the form of a how-to guide of sorts that presents the practice-based research of making toolkits and working with communities to sense air pollution. Each chapter examines a mode or practice of citizens and citizenship. Each chapter also explores different modalities of the "how-to" to analyze how practices, citizens, and worlds materialize. How-to guides are now proliferating along with any number of DIY engagements, from kits for building sensors, guides for launching satellites, instructions for managing urban infrastructure, and campaigns for achieving political change. This study takes seriously the upsurge of the how-to guide as a literary genre and social movement that attempts to give voice and direction to political and environmental struggles. At the same time, the research works through the opportunities and limitations of the how-to guide in providing apparently clear instructions on how

to address a world—or worlds—gone wrong. This investigation into how to make breathable worlds involves attending to citizens and worlds in the making. "How-to" involves putting technologies and practices to work, understanding their effects, and transforming conditions toward more breathable worlds.

The citizens, worlds, and how-to practices in the making that these chapters describe are far from definitive and could proliferate as an endless list. Chapter 1, "Instrumental Citizens: How to Retool Action," is an unconventional methods chapter that examines more fully the format and orientation of the how-to guide and the complex engagements with digital technology and politics that unfold through seemingly practical courses of action. This chapter introduces the how-to "cosmology" that informs this study's approach to practice-based research. It is written as an extended deliberation on instruments and instrumentality, interrogating how citizen-sensing practices and technologies are meant to operate and how they actually perform when put to work in the open air, thereby generating what I call *open-air instrumentalisms*.

Chapters 2, 3, and 4 narrate the fieldwork, installations, and collaborations undertaken with communities working with citizen-sensing technologies to monitor air pollution. Chapter 2, "Speculative Citizens: How to Evidence Harm," focuses on Citizen Sense's first project for sensing air pollution from the hydraulic fracturing (fracking) industry in northeastern Pennsylvania. This chapter describes attempts by residents to document effects from pollution in response to corporate and state neglect. I situate this work within citizen-sensing practices that grapple with how to generate forms of evidence while also building different infrastructures that could create more breathable worlds.

Chapter 3, "Data Citizens: How to Reinvent Rights," details residents' and workers' use of air-pollution sensing technologies in the context of rapid urban development in South East London. Citizen data become enrolled in ongoing projects that attempt to reshape and preserve the urban realm by articulating the right to breathe. Here, the right-to becomes aligned with the how-to through the collection and mobilization of citizen data. However, as this chapter suggests, data could even supplant a struggle for rights when citizens feel that rights do not provide an actionable or equitable basis for addressing environmental pollution.

Chapter 4, "Multiple Citizens: How to Cultivate Relations," documents the construction of air-pollution gardens in the financial center of London. This chapter works through the conjugations of sensing subjects that occur across humans and more-than-humans in the development of gardens that include sensors and vegetation responsive to air pollution. Sensing organisms such as vegetation can offer a way to observe and mitigate problems of air pollution. Chapter 4 describes

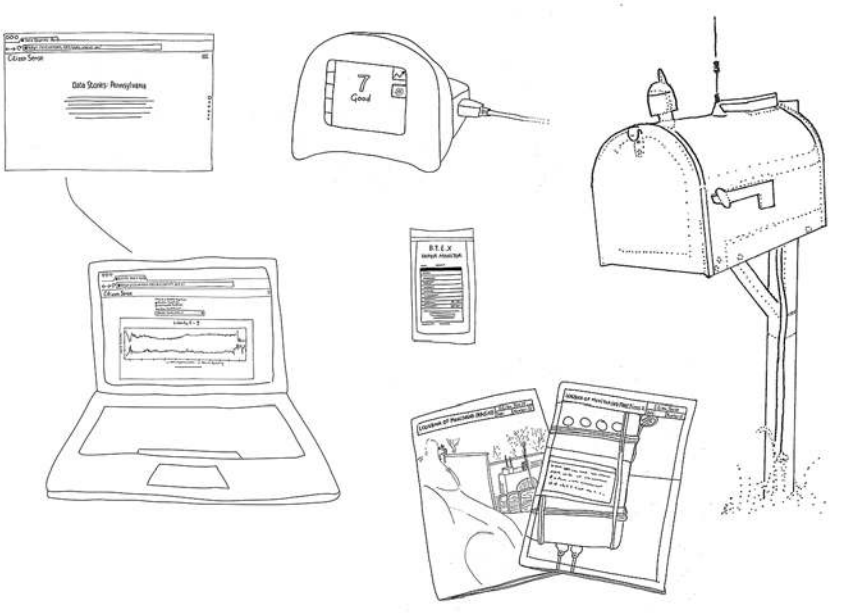
efforts to sense and rework air pollution by transforming urban infrastructures and incorporating multiple other entities into the project of making breathable worlds.

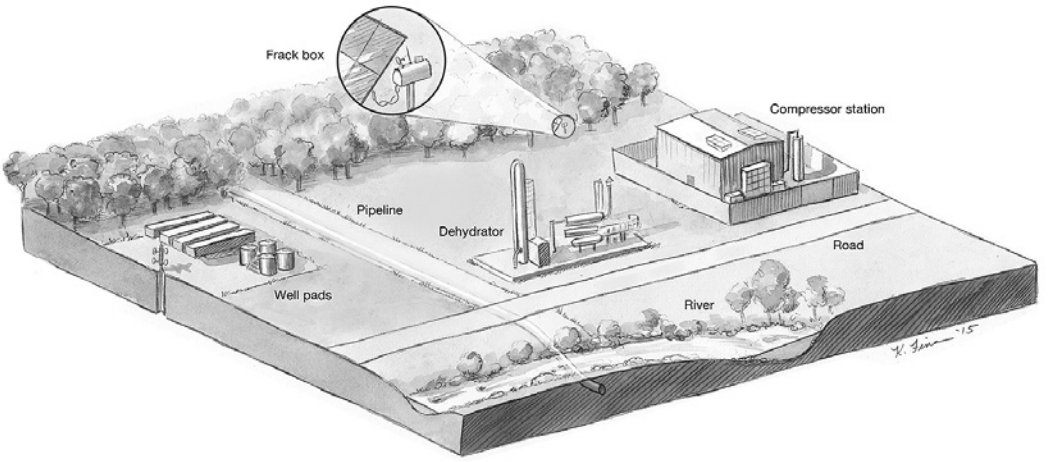
I close *Citizens of Worlds* by considering the citizenships worked through in this book. Atmospheric, instrumental, speculative, data-oriented, multiple, and many other citizens surface here. The conclusion, "Sensing Citizens: How to Collectivize Experience," reconsiders how environmental collectives form and are engaged in ongoing if differing struggles to make breathable worlds. Before and after the four chapters, citizen-sensing toolkits present different sensor configurations that the Citizen Sense research project has studied, tested, and installed. The adjacent chapters document and analyze these toolkits as attempts to develop practices of computing otherwise.

*Citizens of Worlds* is a proposal to move into the open air when studying how citizens and worlds, technologies and practices, materialize through concrete environmental struggles. A turn toward the open air involves a turn toward concrete effects and practices—it is an orientation and an undertaking that might involve combat breathing as well as many other struggles for reworking the pulsations of daily life. Air is more than a volumetric container, element, or essential unit of analysis. Instead, it is a differential process, material, exchange, and condition for being and becoming citizens of worlds. Such an approach considers how political subjects form with and through exchanges that sense and build more breathable worlds. The atmospheric citizen discussed here is an initial figure that signals how citizens and citizenships form through atmospheres and injustice, air pollution and air-quality monitoring. Many more citizens and worlds materialize in the chapters that follow. This text is written toward pluralistic practices and modes of citizenship—atmospheric and otherwise—that materialize through struggles to sense and act on air pollution as a way to realize more breathable worlds.

# TOOLKIT 1

## CITIZEN SENSE TOOLKIT




Citizen Sense Kit developed for monitoring air quality in relation to fracking infrastructure, northeastern Pennsylvania. Illustration above by Sarah Garcin, illustration below by Kelly Finan; courtesy of Citizen Sense. This toolkit can be found in a more extensive form online at https://manifold.umn.edu/projects/citizens-of-worlds/resource-collection/citizens-of-worlds-toolkits/resource/citizensense-kit.