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ARTICLE



Environmental chemicals and public sociology: engaged scholarship on highly fluorinated compounds

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ABSTRACT

We report here on a multifaceted body of research on per- and polyfluoroalkyl substances (PFAS), chemicals that have become a well-known group of 'emerging contaminants' in recent years. Our PFAS Project team of over 10 researchers – faculty, postdocs, graduate students, and undergraduates – has been working since 2015 to study the extent and health effects of PFAS contamination through a broad model of engaged public sociology. Our model of research combines organic public sociology with elements of community-based participatory research, a related but distinct research form most widely used in the environmental health sciences. Based on long-term, place-based relationships, our engaged public sociology has led to numerous academic, regulatory, and social movement effects. We argue that this form of engaged, intervention-oriented public sociology is appropriate and beneficial for research in many areas of environmental sociology given the social and ecological stakes in the current moment. Engaged public sociology involves collaborative, reflexive research with broadly-conceived communities or publics. It facilitates the creation of previously undone science by addressing research topics of interest to community members, and allows researchers to directly contribute to environmental and social justice movements by acting as reflexive, observant participants.

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Introduction

We report here on a multifaceted body of research on per- and polyfluoroalkyl substances (PFAS, also called perfluorinated compounds or PFCs), previously little known to the public but that have become a well-known group of 'emerging contaminants' in recent years. Our model of research combines organic public sociology, research which involves dialogue and engagement with a broad range of relevant and non-academic publics (Burawoy 2004), with community-based participatory research (CBPR), a related but distinct research model most widely used in the environmental health sciences (O'Fallon and Dearry 2002). Our PFAS Project (pfasproject.com) team of over 10 researchers – faculty, postdocs, graduate students, and undergraduates – is part of Phil Brown's Social Science Environmental Health Research Institute (SSEHRI) at Northeastern University. We have been working since 2015 to make known the extent and health effects of PFAS contamination by publicly tracking new cases of discovery in real-time; aiding community groups and local and state governments in remediation, research, and regulatory action; engaging with journalists to publicize the issue; giving conference and webinar presentations to diverse audiences; organizing national conferences; and acting as bridge-builders

between activists, social movement organizations (SMOs), scientists, and regulators.

We argue that through engaged public sociology, our research has contributed to numerous social movement and interdisciplinary events, activities, and collaborations. Our engagement has directly contributed to the formation of a national coalition of community groups, spurred collaborations among concerned residents and scientists, provided assistance to community groups, and produced interdisciplinary scholarship for multiple social and natural sciences. We view this range of activities and relationships as examples of a broad form of engaged environmental sociology. In this paper, we describe the range of projects that are both possible and necessary to effectively carry out such work, arguing that this form of engaged, intervention-oriented public sociology is appropriate and beneficial for community-based research given the social and ecological stakes in the current moment. It also provides a model for how environmental sociologists can interact and collaborate with natural and biomedical scientists, a central feature of environmental sociology (York 2014), to advance both science and policy.

We begin by describing the engaged public sociology framework guiding our research, with a focus on

alignments between public sociology and CBPR. We next discuss our engaged scholarship on the social and scientific discovery of PFAS, focusing on four areas of our work: 1) mobilizing academic, advocacy, and media attention on PFAS, 2) engaging with government officials and scientists, 3) a national conference as catalyst for additional impacts and activities, and 4) maximizing and leveraging resources for collective goals. We argue that engaged public sociology makes possible significant policy successes and research advances because it combines practices from CBPR, including collaboration and reflexivity, with a public sociology orientation.

Engaged public sociology

Our approach combines public sociology and CPBR into a form of community-engaged public sociology that supports the environmental and public health goals of the movements with which we work. Environmental sociology is particularly well-suited to this combination because it grew up as a sub-discipline contemporaneously with the modern environmental, antitoxic, and environmental justice movements (Cable and Cable 1995; Dunlap and Catton 1979). Similarly, the environmental justice focus within environmental sociology that emerged in the 1980s integrated directly with social movements working on issues of community contamination and remediation (Bullard 1990; Mohai et al. 2009). Two contemporary academic trends make this a particularly relevant moment for engaged research: a focus on issues of inequality and participation related to knowledge production (e.g., Frickel et al. 2010; Gross and McGoe 2015), and widespread concern for attacks on science and vulnerable populations by the Trump Administration and as part of the broader ‘post-truth’ era (Lockie 2017; Shostak 2018, and other articles in this special issue). These two trends make clear the stakes involved in how environmental sociologists conduct research on topics with significant environmental health and justice implications.

Public sociology

Burawoy writes that ‘public sociology brings sociology into a conversation with publics, understood as people who are themselves involved in conversation’ (7). He distinguishes between *traditional* and *organic* public sociology. Traditional public sociology involves work by sociologists or journalists that moves sociological research from the academy into the public sphere, a form he describes as generally ‘thin’ and ‘passive’ (Burawoy 2004, 7). Others have called it ‘the sociology of op-ed pages’ (Zussman and Misra 2007, p. 5). In contrast, organic public sociology relies on a deeper level of engagement: ‘the sociologist works in close connection with a visible, thick, active, local

and often counter-public’ (Burawoy 2004, 7), and involves significant dialogue and interaction, ‘a process of mutual education’ (8).

Burawoy is deliberately agnostic about whether public sociology has any normative or political bent, privileging dialogue and broad civic engagement rather than any particular political or policy orientation (2004, 8). Some observers have expressed concern over the potential for politicization of public sociology in a way that detracts from the detached search for greater knowledge about social systems (Smith-Lovin 2007). Offering a different perspective on engaged scholarship, Feagin writes in favor of an explicitly social justice-oriented sociology: ‘it is time for the discipline to fully recover and celebrate its historical roots in a sociology committed to social justice in ideals and practice’ (Feagin 2001, 10). This approach argues that *all* public sociology should be concerned with social justice (Feagin, Elias, and Mueller 2009, 72). For environmental sociology, we would extend this focus on *social* justice to *environmental* justice, as Malin and Ryder (2018) suggest in their recent call for intersectional research on the unequal exposures to environmental hazards experienced by low income communities and communities of color.

Community-based participatory research

CBPR is a related but distinct form of engaged research that involves close, collaborative planning, conduct, and translation of research between participants and researchers. Research participants – often residents of impacted communities or community groups – are involved in the research at every step, and this public involvement ensures that research questions are relevant and useful; increases the quality, quantity, and utility of collected data; and increases the potential for dissemination of research findings and their translation into policy interventions (Israel et al. 1998; O’Fallon and Dearth 2002; Wallerstein et al. 2017). CBPR projects are typically local in scale and focused on identifiable geographic and/or cultural communities, such as residents in a contaminated community or members of a Native American tribe (Hoover 2016). Unlike public sociology, which is often normatively agnostic, CBPR typically has the express goal of providing research to improve public and environmental health, often with an explicit focus on environmental justice issues (Hoover 2016; O’Fallon and Dearth 2002, 158). Although CBPR can be challenging in terms of divergent goals, timelines, control over data, and communication (Minkler 2005), its benefits for communities include information sharing, training and research experience, monetary benefits from research expenditures and employment, empowerment, and an understanding

of environmental health issues that facilitates greater engagement in future policy and scientific processes. CBPR also has significant benefits for researchers, including potential partnerships with restricted or reluctant communities, improved recruitment of research participants, improved quality of data collected, and increased research capacity for future projects (Cordner et al. 2012; Hoover 2016; Morello-Frosch et al. 2011).

Sociologists and other social scientists are increasingly involved in transdisciplinary CBPR collaborations in environmental health fields (Finn and Collman 2016; Hoover et al. 2015; Matz, Brown, and Brody 2016). With a strong focus on environmental inequalities, research has moved away from isolated disciplinary silos toward engaged, transdisciplinary work in partnership with impacted communities to investigate exposures and health effects, influence environmental policy, and prevent new exposures. Though these topics might seem purely technical on the surface, sociology has much to offer to a transdisciplinary research enterprise: as examples, sociologists can give voice to previously undiscussed sites or routes of exposure through interviews or community mapping projects, they can evaluate the impacts and reception of report-back or policy proposals, and they can improve recruitment and trust by facilitating communication between the research team and communities. In such research partnerships, sociologists become active members of environmental health research teams rather than just observers or consultants.

The engaged public sociologist

While public sociology focuses on how sociologists can create *dialogue* with multiple publics, including impacted communities, we believe that this is too narrow an approach for some research topics and collaborations. Instead, we advocate for deliberate *engagement* with impacted communities at all steps of the research process, not only sharing and discussing results but privileging community-focused research questions and research designs. The community or public in engaged public sociology can be a specific geographic community, but need not be limited to a specific place: relevant communities and publics could include international networks of organizations working on a particular topic, or activists from sites across a country dealing with the same environmental issue.

This approach brings into public sociology the central elements of CBPR, particularly *reflexivity*. Elsewhere we have written about CBPR as an inherently reflexive form of research, requiring continual reflexivity regarding ethical guidelines, decision-making principles, and relationships between

researchers and participants (Cordner et al. 2012). Reflexivity is particularly important in areas of research marked by a high degree of uncertainty, since all research decisions and ethical consequences cannot be known at the outset but instead must be identified and negotiated throughout the research process. This type of reflexivity and communication is also an essential component of engaged public sociology, given its emphasis on dialogue between researchers and participants. Reflexivity is an essential component of ethnographic and qualitative research for many sociologists (Atkinson et al. 2014), though discussions tend to focus either on how the researcher's identity influenced their research or on a desire for reciprocity regarding how the researcher can 'give back' to their field sites (Coffey 2011; Maiter et al. 2008; Shostak 2018). In contrast, a continually reflexive approach demands constant dialogue and interrogation of researcher and participant goals, expectations, and experiences (Cordner et al. 2012).

Furthermore, we follow Hale (2008), Lipsitz and Rios (2018), and Vargas (2008) in valuing the role of the *observant participant* rather than (only) the detached participant observer. This involves switching our primary identity from observer to participant – from someone studying an issue through the act of participation, to someone contributing to a social movement or policy issue using our training as observant scientists. Certainly there are many times in our research when we embody the participant observer role: for example, when conducting in-depth interviews, or analyzing interview transcripts or databases. However, as described below, we also spend a significant amount of time in the observant participant role, contributing to fields of science, advocacy, and policy. Such an interventionist approach is more common in the environmental health sciences than in sociology, but we see this model as a bridge from the scholar-advocate role in environmental health science to the engaged public sociologist role in environmental sociology. It is a way of researching with solidarity or acting as an ally (Lockie 2015; Shostak 2018).

Our proposed model of engaged public sociology sees the researcher as a reflexive and observant participant in the environmental and social justice movements they study or the environmental topics they investigate. This approach deliberately focuses knowledge production on issues and inequalities of concern to impacted and marginalized communities. If all knowledge is produced for some end or some audience, whether that end be the theoretical advance of the discipline or the politicized advance of a particular policy goal, the engaged public sociologist is explicit in producing knowledge *for impacted publics*. Thus this model of research may be a way to get undone science done (Frickel et al. 2010; Hess 2009), by targeting questions and topics of interest that are

underfunded and understudied because they are of interest to community members rather than corporations or government funders. Our model of research responds to Lockie's (2017) query, 'who is knowledge to be produced for' (4), with a firm commitment to both our disciplinary communities and our research participant communities.

Case study: PFAS as a class of emerging contaminants

Our research examines the social and scientific discovery of PFAS compounds, a class of an estimated 4,730 human-made chemicals containing chains of carbon and fluorine atoms widely used in industrial processes and consumer goods (OECD 2018). Two PFAS compounds are most widely known: perfluorooctanoic acid (PFOA), which was used to manufacture nonstick coatings such as Teflon™ and is a byproduct of many other chemical processes, and perfluorooctane sulfonate (PFOS), used in fabric protectors such as Scotchguard™, firefighting foam, and semiconductor devices. While PFOA was scientifically discovered by DuPont chemists in 1938, first used in commercial products in 1949, and studied by DuPont for toxicological and exposure concerns starting in the 1960s (Lyons 2007), significant awareness of PFAS within the regulatory and academic science community did not occur until decades later.

Though the chemicals are used in countless industrial and consumer applications, there is no available data about total PFAS production, in part because no regulatory agency systematically keeps track of these chemicals as a class (U.S. EPA 2009). The general public's exposure to multiple PFAS compounds is ubiquitous: research by the Centers for Disease Control and Prevention's national biomonitoring program tested a representative sample of 2,500 U.S. residents for 12 PFAS compounds, and found four PFAS in the serum of over 98% the people tested (Calafat et al. 2007; Centers for Disease Control and Prevention 2009). Academic, advocate, and regulatory studies documenting widespread exposure have brought PFAS to the attention of a new audience of environmental health scientists and involved laypeople, especially the estimated 110 million U.S. residents whose drinking water is contaminated with PFAS (Andrews 2018; U.S. EPA 2017b).

Beyond the ubiquity of their exposure, this class of chemicals is particularly concerning because they demonstrate the potential for low-dose or hormone disrupting effects, and they do not naturally degrade in the environment (Post, Cohn, and Cooper 2012). A large epidemiological study of communities in Ohio and West Virginia whose drinking water was contaminated with PFOA found that exposure is linked to high cholesterol, ulcerative colitis, thyroid disease,

testicular and kidney cancers, and pregnancy-induced hypertension (C8 Science Panel 2017). Other suspected health impacts of exposure to certain PFAS include endocrine disruption, obesity, reproductive problems, birth defects, other types of cancer, stroke, and developmental problems in children (Lau 2015). While PFOA and PFOS are no longer produced in the United States, replacement compounds called PFAS are widely used in spite of growing concerns about widespread exposures and toxicity (Danish Ministry of the Environment 2015; Wang et al. 2015).

The field of stakeholders working on PFAS is broad and includes scientists at regulatory, academic, and independent institutions; industry advocates and scientists along the supply chain from chemical production to retail; regulators at the local, municipal, state, and federal levels, in a variety of agencies; military scientists and policy makers; legislators at the state and federal levels; journalists; lawyers and other legal experts; residents of impacted communities; firefighters and fire safety organizations; and community and social movement groups at the local, state, regional, national, and international levels. Within this broad field of stakeholders, we focus here on a loosely defined PFAS social movement, using the tool of *field analysis* to situate PFAS activists and organizers within a larger movement field (Brown, Morello-Frosch, and Zavestoski 2011). This method allows us to map the dynamic relationships between social movement actors and closely connected stakeholders in other fields and other social movements.

Figure 1 describes the PFAS social movement field, identifying players in the PFAS movement, related social movement influences, and important factors from other social systems. Notably, the PFAS social movement extends from the local level, with individual activists and concerned residents advocating for clean-up of spill sites or delivery of uncontaminated water, to national nonprofits that work on PFAS issues along with other environmental and health related issues. Scientific research is central to this field of action, allowing activists to learn about relevant areas of science, to collaborate in academic-community partnerships, and to cite scientific findings to government, media, and industry. Our research has engaged with participants at each of these levels.

We use a mixed methods approach including multi-sited participant observation, in-depth interviews, and archival research. We have completed 84 in-depth, semi-structured interviews with regulatory scientists, industry spokespeople, academic researchers, affected community members, SMO representatives, and journalists. We have also conducted multi-sited participant and non-participant observations at numerous sites related to PFAS, including two EPA offices, several contaminated communities, and numerous public and regulatory meetings. We also

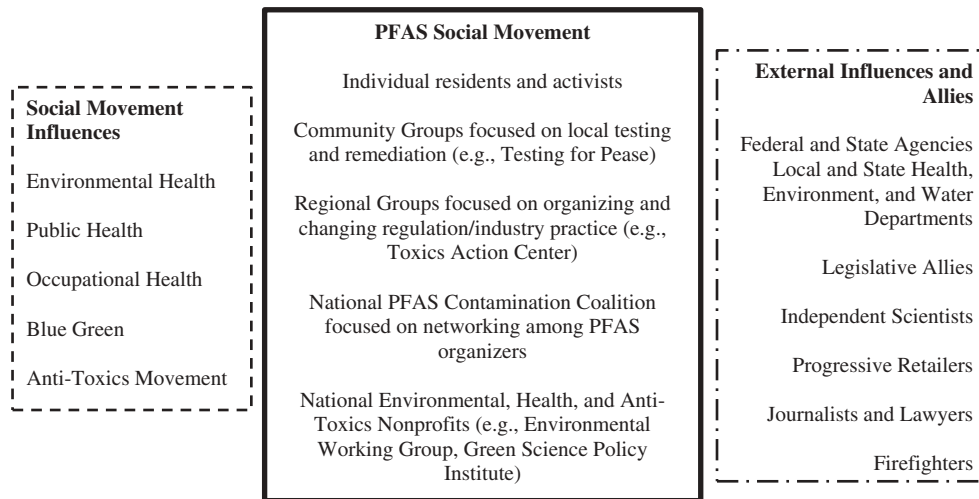


Figure 1. PFAS field analysis.

draw on historical documents from industry archives, legal discovery files, and state and federal regulatory dockets. As we describe below, we developed and maintain the Contamination Site Database of all identified sites of PFAS contamination.

In the following sections, we describe our engaged public sociological research on PFAS science, regulation, and advocacy. Our project involves not only our interviews and observations – the ‘participant observation’ component of our research – but also deliberate work as ‘observant participants’ with activists, regulators, and scientists. The forms of engagement we describe here are examples of engaged public sociology, not prescriptions. More generally, we view our approach as a new form of research engagement and reflexivity that is applicable to many subjects.

Mobilizing academic, advocacy, and media attention

A centerpiece of our engaged public sociology has been working with regional and national environmental groups to build awareness of and engagement in PFAS-related activism and science. When we began our PFAS work in 2015, most SMOs were unaware of or unengaged with these chemicals, and most existing advocacy involved professional, scientific organizations such as the Environmental Working Group (EWG) and Green Science Policy Institute (GSPI). Indeed, our interest in PFAS grew out of a prior collaboration with GSPI, who had identified PFAS as needing class-based regulation (GSPI 2018). We were surprised at the lack of organized, grassroots opposition to PFAS drinking water contamination (Judge et al. 2016), especially given the outcomes of class-action lawsuit against DuPont in the Mid-Ohio Valley: a court-ordered 69,000-person epidemiological study that found connections between PFOA and six

diseases and conditions, and leading to 38 scientific publications (C8 Science Panel 2017).

Building on long-standing research partnerships

Our experiences highlight the benefits of existing collaborations, along with an eagerness to develop new partnerships. Longstanding place-based relationships with SMOs have facilitated our rapid response to emerging PFAS issues. One of the authors (Brown) has been working for 25 years with Toxics Action Center (TAC), a New England regional anti-toxics organization that supports community groups, runs some of its own campaigns, and hosts the largest annual conference of environmental activists in New England. Starting in 2015, as communities around New England learned that their drinking water was contaminated with PFAS from industrial and military sites, TAC put much energy into community groups coalescing around PFAS contamination, and our team organized PFAS-related panels at their 2016 and 2017 conferences. Local PFAS activists made public presentations, and other affected residents in the audience took back lessons and collegial support for their organizing efforts.

Developing new collaborations

We have also developed new research partnerships through this project. In 2015, we were connected with activists from Testing for Pease (TFP), a small community group formed after residents learned that the drinking water supplying the Pease Tradeport, an industrial park on the site of the former Pease Air Force Base, was contaminated with high levels of aqueous film-forming foam (AFFF), a firefighting foam containing PFAS. TFP is highly organized and uses local and online tactics to advance local

interventions, while additionally aiding other communities throughout the Northeast. We have collaborated extensively with TFP: Brown has written several grant proposals and supported scientific presentations and community events, and undergraduate and graduate students have attended community meetings and interviewed community members. We continue to work with them to pursue funding and regulatory support for additional blood testing, immune function testing of exposed children, and interpretation of testing results, focusing on communities impacted by PFAS contamination on the Pease Tradeport in New Hampshire. For the latter, our team has been expressly focused on getting state officials to report-back to individuals the levels of their exposures and the potential health effects.

Sharing research with broad audiences

We have worked extensively with EWG, a national environmental nonprofit that was one of the first organizations to look at PFAS contamination. In 2016, Lauren Richter connected with one of their senior staff while she was conducting research for her dissertation with the EPA in Washington DC. EWG expressed interest in collaborating to develop an interactive map displaying information from our Contamination Site Database, the only systematic tracking of known sites of PFAS contamination (<https://pfasproject.com/pfas-contamination-site-tracker/>). EWG was interested in this information because it complemented their analysis of PFAS contamination results from EPA's Unregulated Contaminant Monitoring Rule (UCMR) water testing program. We worked closely with EWG editors and website developers to design and implement the map, which was first publicly released in June 2017. We have worked with EWG on two updates to the map, in 2018 with an additional 78 contamination sites, and in 2019 with 610 PFAS contamination detections, including sites from our Database and sites from the federal Safe Drinking Water Information System (EWG 2019).

The map has received extensive media and public attention, with stories in such prominent outlets as *Time*, *Huffington Post*, and *USA Today*. We also received numerous queries from residents in communities who previously were unaware of local PFAS contamination, and from other researchers (including professors, graduate students, regulators, and consultants) interested in using the database in their own work. For example, a regulatory scientist with the Washington State Department of Ecology shared that the Database was 'very helpful' in developing and contextualizing questions for the state's PFAS Chemical Action Plan, and a group of environmental science PhD students at the University of Michigan used the database to analyze PFAS contamination in

their state and develop policy recommendations (Personal communications). The Database is an example of *basic social science*, research that involves gathering previously unavailable descriptive information to potentially inform future research.

We have also discussed our work on webinars for environmental advocates. In 2017, Alaska Community Action on Toxics (ACAT), a group that Brown and Alissa Cordner had worked with previously, asked us to present a webinar on the science, regulation, and activism around PFAS, with a focus on the national conference we had just organized (see below). We invited Andrea Amico, a leader of TFP, to also participate in the webinar to represent the community organizing perspective. Approximately 200 people registered for the webinar, more than their typical attendance. We also received several follow-up queries from impacted residents after the webinar.

Partnerships to develop new research projects

Our PFAS engagement has allowed us to deepen our team's long-term collaboration with Silent Spring Institute (SSI) that began in 2004 with CBPR biomonitoring and household chemical exposure studies on Cape Cod, where SSI has been studying breast cancer excesses and other health concerns for over 25 years (Brody et al. 2007). By 2015, SSI was already studying PFAS, especially on Cape Cod where they measured PFAS levels in household wastewater and septic systems (Schneider et al. 2014). Dr. Laurel Schneider at SSI had conducted water testing for PFAS in a municipal well in Hyannis, a town on Cape Cod with PFAS contaminated water, and we participated in a community meeting. That meeting included presentations by Brown, SSI, TAC, TFP, and local government officials, as part of the effort to more fully engage Cape Cod residents for a proposed study on PFAS immunotoxicity. Our work also allowed us to connect SSI, a longtime collaborative partner, with TFP, a new collaborator. TFP participated in the Community Advisory Panel (CAP) for the Agency for Toxic Substances and Disease Registry (ATSDR) study of Pease Tradeport. ATSDR asked us for help in finding a scientist with special expertise in measuring PFAS in water, and we connected them with Schneider, who was later added to the CAP.

This collaboration generated funding for SSI to hire additional staff positions. The research team wrote a successful proposal to the Switzer Foundation to support a community engagement leadership grant for author Richter to work with SSI to continue her PFAS work and expand it to the University of Rhode Island, Harvard University, and the Silent Spring Institute's Superfund Research Program. This funding supports the overall work of SSI, and enabled Richter

to engage with affected citizens and environmental organizations on Cape Cod.

Engagement with government and government science

While our engagement with community groups and SMOs has been an intentional and important part of our research program, we also engage with regulatory processes and with government science to influence problem definition and policy development.

Advising and contributing to regulatory processes

Our observant participant (Hale 2008) role in PFAS governance has largely taken an official advisory component, providing feedback to ongoing government assessments and advocating in favor of greater research on the health effects of PFAS exposure. For example, we have offered critical feedback on state government evaluations of PFAS. Because of our engagement with activists in Hoosick Falls, NY and our larger visibility on PFAS issues, the New York State Department of Health (NYSDOH) asked Brown to write a response to NYSDOH's report on contamination at Hoosick Falls. Brown's response pointed out that the report downplayed and misrepresented the extent to which researchers have found health effects, and overemphasized the role of personal lifestyle behaviors as sources of exposure. The response letter also called for reporting back data to participants whose blood had been tested. Brown also responded to TFP's request that he write a letter to the New Hampshire Department of Environmental Services supporting the adoption of an Ambient Groundwater Quality Standard for PFOS and PFOA. These mechanisms allow researchers to insert sociological thinking into government assessments.

Researchers can also participate directly in regulatory processes, another dimension of observant participation. Cordner is on the Advisory Committee for the Washington State Department of Ecology's PFAS Chemical Action Plan, a collaborative stakeholder process to assist the state in 'identifying sources and recommending actions to reduce [PFAS] use, release, and exposure' (Department of Ecology 2018). The Steering Committee meets with state officials and scientists, and provides feedback on the development of a report and recommendations. As part of this Steering Committee, she has attended meetings and provided written feedback on draft documents. As a final example, in March 2019 Brown was invited to give a presentation about our research to the Interstate Technology Regulatory Council, a body of state officials and scientists who provide guidance on advisory and regulatory levels for many chemicals.

We have found additional ways to use social science expertise to directly improve community- and state-based responses to PFAS contamination. In 2018, Brown was asked to assist the Connecticut Academy of Science and Engineering (modeled after the National Academies) to advise the Connecticut Department of Energy and Environment (DEEP) on how to approach state investigations of PFAS, especially in light of other New England states' recent activities. The Connecticut Academy sought help in defining the problem and developing a job description for a scientist to lead the project. Later that year, Brown was also asked to assist the research team assembled by a \$5 million North Carolina state legislature program to examine water exposure throughout the state, by reviewing their approach to community engagement. In both cases, our sociological expertise *and* our knowledge of the technical details of the PFAS case were indispensable.

Advocating for research directions

Our team has also advocated in favor of more research on the health effects of PFAS exposure. Upon request from GSPI, a California-based environmental health nonprofit that has led science-based activism on chemicals and one of our research partners, Brown was a signatory to GSPI's commentary calling for strong national health studies of PFAS published in the influential journal *Environmental Health* (Bruton and Blum 2017). GSPI asked us to take the lead on press outreach for this commentary, which involved using our Contamination Site Database to locate and contact 124 publications in locations with PFAS contamination and obtaining quotes from 24 local activists to tailor those press releases. In addition, we sent press releases to members of Congress in the districts where contamination sites existed. These activities led to broad coverage of the commentary, including articles in five regional papers and a feature in *The Hill*, distributed to all federal legislators.

Direct engagement with government scientists

We engage with government researchers at the EPA in a range of offices responding to PFAS. Richter conducted six months of participant observation at EPA offices as part of her dissertation research, interviewing federal EPA stakeholders involved in tracking and responding to PFAS contamination. The national conference, described in the next section, facilitated new collaborative research opportunities between communities and government scientists. We seek input on our current and future research from agency staff, as we do with our SMO and community collaborators. Richter and SSI scientists submitted public

comments to the EPA with suggestions on how to improve the federal response to the PFAS contamination crisis and community concerns. At the state level, Richter has provided expert testimony in legislative hearings on PFAS bans in food packaging in the State of Rhode Island.

Leveraging publications for policy

Finally, several of our academic publications have direct policy and regulatory relevance. Our 2018 publication in *Social Studies of Science* on chemical regulation and industry secrecy (Richter, Cordner, and Brown 2018) was quoted at a Senate Hearing on 'The Local, State, and Federal Response to the PFAS Crisis in Michigan' (U.S. Senate Committee on Homeland Security & Governmental Affairs 2018). A 2019 paper published in the *Journal of Exposure Science and Environmental Epidemiology* (Cordner et al. 2019) described the scientific decisions and social and political influences over the risk assessment process used to develop state and federal drinking water guideline levels for PFOA and PFOS. We received numerous requests for the paper from regulators and academics, and presented our findings on two webinars: one with a primary audience of academic and clinical researchers, and the other with a primary audience of environmental and health advocates. This demonstrates our commitment to sharing results broadly with multiple publics.

Supporting movement building through multi-stakeholder conferences

We now describe a 2017 conference organized to highlight our roles as participant observers and observant participants in engaged public sociological work. The 1st National PFAS Conference was a two-day conference bringing together scientists, community advocates, government officials, state legislators, journalists and filmmakers, environmental advocates, lawyers, industry representatives, and students in Boston, MA to share their experiences addressing PFAS contamination throughout the country. The Steering Committee (SSEHRI, SSI, TFP, and TAC) worked for a year and a half to connect with a wide range of people and organizations to develop this unique conference. The conference as funded by an NIEHS conference grant written by Brown and Cordner with feedback from the Steering Committee, along with financial contributions from SSEHRI, Northeastern University's Humanities Center, Northeastern University's Superfund Research Program, and in-kind contributions from SSI, TAC, and TFP. The 140 attendees represented groups and organizations such as the U.S. EPA, ATSDR, NIEHS, New Hampshire Public Radio, The Intelligencer, Keep Your Promises DuPont, GSPI, and EWG.

Throughout the planning process, in keeping with CBPR principles, activists led in shaping the conference. We prioritized attendance by community members and activists, and provided travel support to residents of ten PFAS-contaminated communities. In addition to doing several presentations, activist groups had separate lunch and dinner strategy sessions, and several workshops on the second day focused on issues of concern for impacted communities.

This conference was especially useful from an engaged scholarship perspective because it raised the visibility of the scale of PFAS contamination nationally. The invisibility of PFAS arises from many different factors tied to what we have called *unseen science*, research that is produced but never shared outside of institutional boundaries (Richter, Cordner, and Brown 2018). Breaking those institutional boundaries and making PFAS research highly visible, the conference exposed areas of unseen science, and directly contributed to research in areas of undone science by connecting researchers and community members. Scientists shared data with colleagues and community representatives, journalists heard numerous stories of contamination and discovery, and attendees participated in coalition building and strategizing. The conference also spurred our social science research: conversations with diverse stakeholders at this conference directly shaped new research articles by our research team on PFAS and the systemic production of environmental health ignorance.

This conference resulted in collaborations between stakeholders from different parts of the country that would not otherwise exist. Most significantly, the National PFAS Contamination Coalition, a network of dozens of social movement and community group working on local PFAS contamination, developed out of the conference (www.pfasproject.net). The Coalition now holds monthly activist-only meetings to provide support to the PFAS movement. Regulators and resource specialists working in state government connected with their counterparts from other states and heard talks about effective regulatory and policy activities around the country. Scientists shared cutting edge data and unpublished findings, and some of these results were picked up by the media. Notably, journalists covered a new study on GenX (a widely-used short-chain PFAS of emerging concern) contamination in North Carolina, and this contributed to new awareness in that state of water contamination and subsequent regulatory action (NC Department of Environmental Quality 2017).

Putting on such a conference is a major task, and SSEHRI was able to utilize its grants administrator and several undergraduate students supported on university internship positions. Hosting the meeting on the Northeastern campus allowed us to use free meeting

spaces and obtain university discounts on housing. The 2nd National PFAS Conference in June 2019 was even more collaborative, with additional Steering Committee members from U.S. EPA, other academic institutions, and other SMOs.

Maximizing resources

One of the most significant things that academics can do in engaged public sociology partnerships with communities is to leverage resources such as personnel, expertise, and grant-writing capacity. The National PFAS Conferences described above are prime examples; resource leveraging included writing and executing NIEHS conference grants, direct financial support from Northeastern University and SSEHRI, and reduced cost access to university facilities. We have also sought additional grant funding to support our engaged public sociology and the work of our partners, directed at research questions that came directly from impacted communities. We submitted two proposals co-written by our TFP and TAC activist partners, both of which were successful. A first project on PFAS immunotoxicity, PFAS REACH, addresses a health effect prioritized by community members, and will also involve a broad web portal for reporting back results and sharing PFAS information generally.

The second funded project will enable us to use our constantly expanding Contamination Site Database to examine how activism develops or fails to develop, and how local social movement organizing is affected by local conditions and exposures, as well as race, class, gender, education, and type of site (military/airbase or industrial). Based on a request from TFP, this grant will also involve water testing in Portsmouth, NH, and will validate a new water analysis method against a well-established but more expensive method, potentially decreasing costs associated with water testing in the future.

The utility of our public sociology approach

The form of engaged public sociology that we practice is broadly valuable for researchers working with communities on issues of social and environmental justice. Here we delineate elements that are generalizable to other public sociology efforts.

Serve the needs of SMOs

Engaged public sociology allows researchers to better identify the concerns and needs of people who are affected by environmental problems. This allows researchers to more efficiently and successfully leverage scientific knowledge, cultural capital, institutional resources, and grant-writing expertise.

Improve access through reciprocity

Engaged research provides better access to research material by being of service to affected communities and SMOs, and also by being familiar with technical and policy issues. In a trust-based and collaborative working relationship, community partners and organizations can co-produce richer and more accurate datasets with researchers. This reciprocity is particularly important when working with marginalized or under-resourced communities or organizations (Cordner et al. 2012; Hale 2008).

Develop innovative data-sharing platforms

Partnerships with non-academics may lead researchers to develop innovative tools and platforms to share their data. For example, graphic artists and data scientists at large SMOs can translate research findings into visually appealing and easy-to-navigate data platforms, such as the PFAS contamination map hosted by EWG. While these forms of data representation are rarely taught in graduate schools and may be less valued by traditional metrics of academic evaluation, they are incredibly valuable in reaching broad audiences.

Learn technical, scientific material

Sociologists who study scientific issues need to gain basic knowledge of the field (Cordner 2016; Shostak 2013). Sometimes they can do this on their own, but collaborating with scientists, government officials, and technically-savvy activists provides a more comprehensive and useful approach that enables them to better select new research methods and sites, and allows them to stay up to date on the latest developments.

Develop 'basic social science'

Sociological research is often constrained by data availability. Engaged public sociologists can identify datasets that would be useful for their own research and for a broad range of publics, and create and maintain these datasets in collaboration with impacted communities who may be well-suited to refine data collection processes or add data points. This process produces basic social science of broad scientific and public utility. This echoes Theo Colborne's assembly of data on endocrine disrupting chemicals through the Endocrine Disruption Exchange, which enabled her to formulate the endocrine disrupter hypothesis (Krimsky 2000). As another example, Matthew Desmond's recently developed Eviction Lab has brought together academics, students, and 'citizen researchers' to develop a publicly available database of eviction information deliberately

designed to be of broad utility to ‘policymakers, community organizers, journalists, educators, non-profit organizations, students, and citizens’ (Eviction Lab 2019). Without making claims regarding the relative impact of different basic social science initiatives, we highlight the value in compiling information in publicly available databases, including qualitative data (Broom, Cheshire, and Emmison 2009).

Provide technical knowledge to publics

Engaged researchers often commit to broadly sharing data and communicating results to a broad range of publics. For example, our Contamination Site Database provides much data for public use by other academics, environmental NGOs, local activist organizations, and government agencies.

Link with data justice movement

Producing new, usable, publicly available data for social change aligns with the growing data justice and environmental data justice approach (Dencik, Hintz, and Cable 2016; Dillon et al. 2019; Taylor 2017). This movement makes data publicly accessible that might have otherwise been hidden, thus helping others to use the data for social justice.

Link with ‘engaged STS’

Engaged public sociology has connections with engaged science and technology studies (STS), which emphasizes practical applications of STS scholarship. The annual meeting of the Society for the Social Study of Science (4S) now has a ‘Making and Doing’ exhibit with dozens of people showing technical products and methods, such as air sensors and other forms of citizen science. Additionally, 4S recently added an online journal *Engaging STS* to promote such work. Application-driven research has yet to make significant theoretical inroads in environmental sociology, though there are notable exceptions including Wylie’s (2018) work on fracking and Harrison’s (2011) work on air monitors.

Discussion and conclusion

Our research on PFAS science, regulation, and activism has taken an engaged public sociology approach, working with a broad range of stakeholders and intentionally designing and implementing our research in ways that involve impacted communities and aim to improve public and environmental health through local activism, regulatory change, and cutting-edge environmental research. In this way, our model shares much with other longstanding community focused research collaborations: long-term study of the impacts of oil spills (Gill, Steven Picou, and

Ritchie 2011; Mayer, Running, and Bergstrand 2015), a decade-long study of children’s trajectories after Hurricane Katrina (Fothergill and Peek 2015), or innovative monitoring of community exposures to fracking pollution (Willow and Wylie 2014). Yet unlike these stand-alone projects, our research on PFAS cannot be described as a single collaboration or single project, but rather is an ongoing process that continually leads to new projects and in new directions. Engaged public sociology incorporates the reflexivity, collaboration, and communication of CBPR into a public sociology practice that takes an expansive view of what counts as ‘public’ and ‘community.’

We argue that the addition of deliberate, community-focused engagement offers significant improvements to public sociology. Though our project does not strictly conform to the principles of CBPR in that we are not solely working with specific communities and community members are not always involved in all stages of our research process, we view our research as always community-engaged and oriented towards reflexive interaction with impacted publics. This focus on engagement brings sociology into conversation with STS’s focus on engaged research. Our model of engaged public sociology brings constant reflexivity and an emphasis on acting – at least at times – as an observant participant, designing and implementing research projects of value to those impacted by the topics we study. This allows us to identify areas of undone science and contribute to closing those research gaps. By leveraging material resources, we can also destabilize the asymmetrical power relationships between researchers and participants.

The broad range of activities in which we engage points to some of the difficulties but also the benefits of this type of deeply engaged scholarship. Some components of our overall research agenda on PFAS – for example, the National PFAS Conferences – are unlikely to directly lead to peer-reviewed publications, despite requiring significant investments of time and resources. Additionally, questions and topics that are deeply interesting to us as sociologists – for example, the theoretical relationship between social and scientific discovery of emerging contaminants (Richter, Cordner, and Brown 2018) – are of only marginal interest to many other stakeholders.

However, we believe that these drawbacks are absolutely worth the potential benefits of engaged scholarship and advocacy. In particular, throughout this paper we have identified numerous interdisciplinary and movement effects of our engaged public sociology. Our sociological research has directly contributed to our own research partnerships with toxicologists, epidemiologists, exposure scientists, and environmental engineers; to interdisciplinary work on PFAS by other scholars; and to newly formed research partnerships between researchers at EPA, state health and environmental agencies, and

community groups. Additionally, the social movement impacts of our work have been substantial, and include the formation of a national coalition of PFAS community groups, new collaborations among concerned residents and scientists, and providing assistance to community groups.

We encourage other environmental sociologists to practice engaged public sociology in a way that involves a broad range of actions and deeply and reflexively engages with a variety of publics. Truly partnering with non-academic publics to work toward improved environmental and health conditions will involve a range of methodological and practical approaches, including but not limited to the practices we have describe. Engaged public sociology helps meets the needs of this current political moment by generating high quality research through engagement with communities and attention to the concerns of marginalized communities.

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