

The Impact of PFAS Contamination on Small-Scale Farms in Maine: Risks, Gaps, and Uncertainties

Michael Haedicke

University of Maine

Abstract: Per- and polyfluoroalkyl substances (PFAS) are a class of several thousand toxic industrial chemicals that persist indefinitely in the environment. PFAS contamination of soil and water in the United States is potentially widespread, although the process of documenting the extent of contamination is in early stages. In particular, the once-widespread practice of using municipal wastewater biosolids to fertilize agricultural land has resulted in PFAS deposits in the soils of farms. This paper explores the impact of PFAS contamination on small-scale agriculture in Maine, a state that has established a leading position in policy related to PFAS research and remediation. After describing the role of small-scale agriculture in Maine's culture and economy and reviewing the current state of knowledge about PFAS soil contamination, the paper takes up three broad questions: (1) to what extent do PFAS pose unique reputational, economic, and personal health risks to the owners-operators of small-scale farms, (2) how do gaps in state-level policies shift the burden of risk management to individual farmers, and (3) how do scientific and policy uncertainties related to PFAS affect small-scale farmers' efforts to adapt to actual or presumed contamination. Data come from secondary literature and targeted interviews with policymakers and NGO leaders who are active on agricultural and environmental issues. While not intended to be comprehensive, this paper draws attention to the distinctive ways that small-scale farmers have experienced this emerging environmental threat.

Keywords: PFAS, small-scale agriculture, local foods systems, public health, policy

Widespread environmental contamination with per- and polyfluoroalkyl substances (PFAS) represents a significant and complex social and public policy challenge. This paper reports on preliminary results from ongoing research about the impacts of PFAS contamination on the owner-operators of small-scale farms in Maine and about strengths of and gaps in Maine's policy response to PFAS. The first section summarizes information about PFAS risks, federal and state PFAS-related policies, and the intersection of PFAS contamination with farms in Maine. I then sketch a framework for understanding the impact of PFAS contamination in terms of multidimensional risks and for identifying gaps in PFAS-related policies. The remainder of the paper presents emerging themes from research interviews. I describe how farmers experience PFAS risks in the areas of health, economic sustainability, social relationships, and business reputation. I then describe two policy gaps identified by interview respondents: (1) partial devolution of economic risks associated with the identification of PFAS contamination on individual farmers and (2) inadequate resources to support short- and long-term health monitoring and potential treatment as a result of exposure to PFAS.

Background

Health Risks and Environmental Contamination

Per- and polyfluoroalkyl substances (PFAS) are a category of several thousand chemicals that have been widely used in industrial processes, firefighting applications, and consumer products for over half a century (Panieri et al. 2022). The chemical structure of PFAS is distinguished by the presence of bonds between carbon and fluorine atoms, which are extremely strong and result in a number of properties that range from useful to problematic (Buck et al. 2011). The ability of PFAS to repel water and oil has led to their widespread use in nonstick cookware, water- and stain-resistant clothing, and grease-proof food wrappers, as well as their addition as skin conditioners to lotions, makeup, and other personal care products. Furthermore, PFAS are used as surfactants in manufacturing settings and in the aqueous film-forming foams (AFFFs) used to extinguish gasoline and other flammable liquid fires. The stability of the carbon-fluorine bond causes PFAS to persist for an extended period in the environment and in the human body, with half-lives in the range of 41 years and 4-5 years, respectively (Li et al. 2020). This property has earned them the nickname “forever chemicals”.

PFAS toxicity and implication in a range of adverse health impacts is widely acknowledged at present, although for much of their history evidence of PFAS toxicity was obscured and these substances were generally assumed by the public and many regulators to be benign (Richter, Cordner and Brown 2021). Exposure to PFOA and PFOS, which are two of the most studied PFAS compounds, has been linked to increased cholesterol, hormonal alterations, increased cancer risk, and other health problems in animal studies and epidemiological research on human communities (National Academies of Sciences 2022). However, the number of substances in this category and the complexity of exposure pathways and dose-response timescales means that scientific understanding of the risks of PFAS contamination are still evolving (Abunada, Alazaiza and Bashir 2020). Adding to this uncertainty is a shift in the manufacture and use of PFAS away from “legacy” compounds like PFOA and PFOS and toward less-studied “short chain” PFAS, which may be less acutely toxic but which have displayed greater mobility and persistence in the environment and greater propensity to bioaccumulate.

The extent of PFAS contamination in the environment is only partly understood, although the research that exists indicates that it is widespread. Studies have documented the near-ubiquitous presence of trace amounts of PFAS in the blood of humans worldwide, as well as in blood of Arctic animal species living far from sites of manufacturing and mass consumption (Lindstrom, Strynar and Libelo 2011). Rainwater testing at sites around the globe has revealed that PFAS contamination levels in precipitation frequently exceed public health limitations on PFAS in drinking water, while soil and surface water contamination around manufacturing sites, military installations, and major airports may be presumed to be extensive (Cousins et al. 2022, Salvatore et al. 2022). The presence of PFAS in crops, seafood, and livestock products has also been documented (Ghisi, Vamerali and Manzetti 2019, Jha et al. 2021). For individuals who do not encounter PFAS directly through occupational exposures, diet and drinking water are understood to be the most significant exposure pathways (Evich et al. 2022).

Policy and Regulatory Responses

In the United States, policy and regulatory responses to PFAS are rapidly changing. Currently, no federal standards for PFAS in drinking water exist as they do for other well-known toxins, meaning that public water utilities are not required ensure that PFAS contamination falls below a certain threshold (Cordner et al. 2019). In 2016, the U.S. EPA published a non-

enforceable health advisory recommending a limit of 70 parts per trillion (ppt) of PFOS and PFOA (individually or combined) in drinking water. This was updated in 2022 to a new recommended limit of 0.004 ppt of PFOA and 0.02 ppt of PFOS, with recommended limits also set on two additional PFAS substances. The EPA has also included a certain number PFAS substances in its Unregulated Contaminant Monitoring Rule since 2012, meaning that mid- and large-sized public water utilities are required to report data about PFAS contamination that exceeds a minimum reporting level (not identical to the health advisory limit) to the EPA. Finally, in 2023, the EPA proposed enforceable regulations that would set a maximum contaminant level of 4 ppt of PFOS and PFOA in drinking water, with non-enforceable maximum contaminant level goals of 0 ppt. The EPA's proposal also included enforceable limits on four additional PFAS. As of this writing, these regulations are in the public comment stage and are expected to be finalized by the end of 2023.

In the absence of federal regulations, a number of states have issued guidelines or enforceable standards for concentrations of PFOS, PFOA, and related chemicals in drinking water, although the recommended or required limits vary from state to state. A handful of states have also adopted a more comprehensive approach to limit public health impacts related to PFAS exposure and to remediate sites with documented PFAS contamination, which includes PFAS-related legislation and litigation against PFAS producers (particularly the chemical company 3M). In terms of legislation, Maine holds a leading position, considering both the number of laws enacted and the bipartisan support that these laws have received (see Table 1). Maine's policy approach has emphasized three broad goals. First, laws have directed resources towards detection and monitoring of existing soil and water contamination, while also preventing further contamination through known pathways. Second, laws have worked to advance the remediation of contaminated sites, both by supporting the development of technologies to treat and destroy PFAS and by extending financial support and litigation opportunities to individuals affected by PFAS contamination. Finally, Maine has sought to limit PFAS exposure through restrictions on the presence of PFAS in products used or sold within the state.

Intersections of PFAS and small-scale agriculture in Maine

Like other New England states, Maine has a robust and diversified small-scale farming sector. According to the Maine Department of Agriculture, Conservation, and Forestry,

approximately 95% of Maine's 7,600 farms reported annual gross sales of less than \$250,000 in 2017, while nearly 50% of Maine farms operated on less than 50 acres of land. While the production of potatoes, Maine's highest-value crop, occurs mostly on larger farms in the northern portion of the state, dairying and blueberry cultivation (ranked second and fifth in terms of total crop value, respectively) include small-scale operations (Beck et al. 2011). During the 1970s, Maine was also a key destination for "back-to-the-land" homesteaders who were influenced by the countercultural and environmentalist movements of the era. This legacy appears today in the commitments that many small-scale Maine farmers have to sustainable and organic growing practices. Maine farmers, such as Eliot Coleman and Arthur Harvey, have played a prominent role in the organic farming community, and the Maine Organic Farmers and Gardeners Association (MOFGA), founded in 1971, is one of the country's oldest organic farming support and advocacy organizations. Finally, the number of local and regional marketing initiatives in the state, including farmers markets, CSAs, and food hubs, has trended upward in recent years.

The environmental and public health hazards of PFAS are closely connected with small-scale agriculture in public discourse about the PFAS problem in Maine. The first case of PFAS contamination to receive statewide attention occurred in 2016 on a dairy farm in Arundel, Maine. In subsequent years, Fred Stone, the farm's co-owner, faced the cancellation of purchasing contracts, the denial of federal aid, the expenditure of thousands of dollars to purchase water filtration equipment and to implement a milk testing regimen, and the eventual destruction of his herd and cessation of the farm's business activities (Perkins 2022). Stone and other residents on the farm also experienced elevated PFAS blood levels, which have a possible connection with chronic health conditions that affect members of Stone's family. PFAS contamination has also been documented on farms in Unity, Albion, and Fairfield, Maine, with contamination presumed likely at other sites around the state. Much of this contamination resulted from the practice of amending agricultural soils with municipal sewage sludge, also known as biosolids, which consists of organic material removed during wastewater treatment. Sewage sludge offers an inexpensive and plentiful source of nitrogen and phosphorus and its use as an agricultural fertilizer was common during the 1980s and 1990s. However, since PFAS present in wastewater tends to accumulate in organic material, sludge spreading also introduced these contaminants to farmlands where the sludge was applied (Schauffler 2022). Because of the persistent and

bioaccumulative nature of PFAS, farmland contamination is difficult and costly to remediate. Contamination also threatens public health through the potential of PFAS in soils to migrate into the food supply.

This information suggests that small-scale farmers in Maine are uniquely exposed to PFAS contamination and particularly vulnerable to personal, economic, and social disruptions that might result from contamination. To fully understand this situation and to consider the relationship between Maine's policy response and the needs of small-scale farmers, though, we must develop frameworks for thinking about the multidimensionality of PFAS risks and the role of policy in shaping the way people experience these risks.

Conceptual Framework

Risks as multidimensional

Broadly understood, “risk” refers to the “potential for loss” (Tierney 2014:6), or the likelihood that “unwanted, negative consequences” (Tierney 1999:217) will result from a triggering event. These losses and negative consequences may take a variety of forms; thus, risk is an inherently multidimensional concept. Environmental sociologists and other researchers have illustrated the multidimensionality of risk as it pertains to exposure to industrially-produced toxicants (Liboiron, Tironi and Cavillo 2018). For example, studies of industrial contamination in residential communities, such well-known cases in Love Canal, New York and Woburn, Massachusetts, demonstrate that residents typically experience personal health risks in the form of exposure-related medical conditions as well as economic risks associated with the loss of property values and the costs of medical care (Brown and Mikkelsen 1997, Levine 1982). Research has also documented psychological burdens, such as anxiety and depression, and social tensions that are associated with exposure to toxicants (Hart 2022). Lifestyle changes intended to reduce the extent of individuals' exposure may also bring risks of their own, including the possibility of separation from valued collective activities and cultural traditions (Hoover 2017).

The multidimensionality of risk poses significant policy challenges. In the first place, interventions that aim to mitigate one type of risk may amplify risks of other sorts. Stay-at-home orders issued during early months of the Covid-19 pandemic illustrate this problem: while they reduced individuals' likelihood of exposure to the virus, they also disrupted income streams,

social relationships, and educational activities, increasing the likelihood of other sorts of negative consequences (Stewart 2021). Additional complexity is added when considering that different types of risks tend to affect population subgroups in different ways. Thus, risk mitigation interventions may also have the unintended consequence of transferring risks from one population subgroup to another, along with shifting the balance between different types of risk. The experiences of Fred Stone, the Maine dairy farmer mentioned above, provides an example of this dynamic. In order to protect public health, milk from Stone's cows was removed from the market once it was determined to contain elevated levels of PFAS. This measure heightened the economic risks that Stone faced, as the farm was left without a revenue stream.

Policy Gaps and Uncertainties

Public policy can be a powerful tool both for mitigating risks and for moving towards a fairer or more egalitarian distribution of risks within society (Elliott 2017). In this context, conceptualizing risks as multidimensional can be a helpful way to identify gaps in risk mitigation and redistribution policies. In this paper, the term "policy gaps" applies to several different types of situations. First, a policy gap can be said to exist when risk mitigation policies fail to recognize and address certain dimensions of risk. Such a gap would exist, for example, in the case of policy interventions that aimed to reduce individuals' likelihood of exposure to a toxin while failing to consider the economic impacts of toxic contamination on livelihoods, business activities, and property values. A second form of policy gap might occur in a situation where policy interventions have the unintended consequence of actually increasing certain dimensions of risk, as in the case of the Covid-19 emergency measures mentioned above. Finally, policy gaps exist when an intervention unintentionally transfers risks from one group to another group within a risk-exposed population.

Arguably, policy gaps are more likely to emerge when risk-producing events or conditions are novel, complex, and partially understood. In such situations, the extent of risks may be unknown, the consequences of policies may be difficult to predict, and policies themselves may be unsettled, creating uncertainty about whether approaches that prevail at one moment will remain consistent over time. These characteristics certainly apply to the problem of PFAS contamination. In particular, policy development and implementation at the state level may be made more challenging by uncertainties that characterize the federal response to PFAS.

The Research Project

In the remainder of this paper, I report initial findings from research into the multidimensional risks that PFAS contamination creates for small-scale farmers in Maine and into the nature of gaps that exist in Maine’s policy response to the PFAS crisis. Data for the research come from two sources: (1) public reports, legislative documents, and news reporting related to PFAS contamination in Maine and (2) interviews with farmer advocates and members of Maine’s small-scale farming community. The interview portion of the research received approval from the University of Maine Institutional Review Board in February 2023 and contact with potential interviewees was initiated in April 2023. To date, interviews have been completed with three respondents (see Table 2). As part of the research protocol, respondents were given the option of being identified by name or by a generic description in reports based on the research. I have followed respondents’ preferences in this paper.

[TABLE 2 ABOUT HERE]

Dimensions of PFAS Risk

Geographies of contamination and health risks

The scale and other characteristics of agricultural operations in Maine tend to vary according to their location within the state. The state’s largest farms are generally located in Aroostook County, in the northern portion of the state. The bulk of Maine’s potato crop, which comprises the largest portion of total cash receipts for agricultural commodities within the state, is grown on these farms (Beck et al. 2011). Aroostook County farms also produce vegetable crops, particularly broccoli, and grain crops. The production of wild blueberries, another iconic Maine crop, tends to be concentrated in the Downeast region of the state’s coastline. Most of Maine’s potatoes and blueberries are sold to processors and the restaurant industry. Much dairying, which has experienced declines in recent years but remains an important part of Maine’s agricultural economy, occurs in the central and southern parts of the state. Maine’s conventional dairy farmers commonly sell milk to regional distributors in the Northeastern

states, while organic dairies contract with national organic milk brands, like Organic Valley. For historical reasons and because of proximity to urban markets, small-scale and diversified farming operations are also more common in these central and southern regions.

As discussed above, Maine's state-administered program to facilitate the agricultural use of biosolids, or sewage sludge, represents perhaps the most significant mechanism of PFAS contamination on farms. During the operation of this program, owners of agricultural land applied to the Maine Department of Environmental Protection for license to use sewage sludge as a nutrient source for crops on particular tracts. Once the license was granted, third-party contractors were employed to transport the sludge from municipal and industrial wastewater treatment sides and to spread it on the licensed tracts. In cases where the sludge contained PFAS, the contamination would be transferred to the treated soil. While land application of sludge occurred in all of Maine's agricultural regions, the majority of licensed sites are within central and southern Maine (see Figure 1). Interviewees noted that this pattern may exist for several reasons. For instance, Nordell pointed out that because population centers and industrial installations are concentrated in the southern part of the state, farms in Downeast and Aroostook County would likely have experienced higher costs to transport sludge to their properties. Megquier commented that sludge was generally not applied to perennial crops, like blueberries, and that hay fields were frequent candidates for sludge fertilization. Hay was often grown as part of dairy operations, and the tendency of dairies to be located in the southern part of the state contributed to the geographic pattern in sludge spreading licenses.

[FIGURE 1 ABOUT HERE]

The parts of the state where the majority of sludge spreading licenses were granted are, today, the places where small-scale, diversified, and locally-oriented farms are commonly located. This suggests the *possibility* (this word is emphasized because Maine's work to test for and document contamination on licensed sites is in early stages, and because not every site for which a license was granted necessarily received sludge application) that PFAS contamination is more likely to impact small-scale farms, as well as dairy operations, than other portions of Maine's agricultural industry. Nordell further explained that the recent economic history of the

dairy industry, involving the subdivision of older, larger farms and the sale of plots of land to new farmers, may contribute to this potentially heightened exposure.

When DEP licensed the sludge spreading program ... [dairy] farmers would have prioritized their hardest to get to fields to take advantage of the program since they had a fertility source right around the farmstead that was coming from the cows' [manure]. So the farmstead itself on a lot of older farms didn't get impacted by sludge spreading, this is my impression ... The satellite fields, some of which have 30 years later been sold off, and maybe those were some of the marginal portions of the farm, that as farms underwent economic stress over time, they were, they probably held onto their most valuable productive land, and then were able to let go or forced to let go of some portions of their property. And as a younger generation of farmers has entered the agricultural community and purchased our farms, those are often the parcels that we've purchased and thought to build our businesses on ... The small scale, locally oriented vegetable producers, those are the farms that we're buying, the smaller pieces or the farms that were, in this period, the late eighties and nineties, might have been managed as a satellite portion of a larger farm and not benefitting from a hyper-local cow manure fertility source.

Personal health risks

Agricultural land contamination poses personal health risks to individuals who work the land, both owner-operators and hired workers, and to farm-adjacent residents. PFAS may migrate through food and water into the bodies of individuals, increasing both their overall body burden and the likelihood of developing PFAS-related health conditions. These risks exist regardless of farm size, but to the extent that contamination is more widespread on small-scale farms, the owner-operators of these farms may be disproportionately impacted. The “homestead” character of many small farms, in which owner-operators live in close proximity to and eat directly from farm fields, may also add to these risks. Describing his family’s experience, Nordell commented:

You step out the door and you're on a heavily impacted piece of ground. Right in the door yard ... To me, that matters because when you think about occupational exposure, there's just so much traffic and so much land work that happens close to the farmstead. And if you're

compounding a drinking water exposure with a dust exposure, with exposure to food produced on the farm, that exposure in the primary production ground and close to the farmstead, that really matters, I think.

As is well-documented in the literature, becoming aware of an unexpected exposure to environmental toxins may also contribute to negative psychological and emotional outcomes that are similar to those that may result from an unexpected medical diagnosis, including anxiety or depression. These mental health risks may be increased by economic disruptions to farm operations and household finances related to the discovery of PFAS contamination.

Economic risks

In addition to personal health risks, PFAS contamination creates the potential for economic strain and disruption associated with the cost of installing risk mitigation infrastructure (such as water filtration systems), the loss of revenue from products that must be withdrawn from the market, and the need to change cropping and farm management strategies. Economic risks exist regardless of farm scale and interviewees pointed out that many factors that might increase or decrease a farm's vulnerability to PFAS-related economic risks, such as debt load, savings on hand, and the availability of alternative income streams, are not directly associated with farm size.

However, the effect of contamination on the market value of farmland represents one significant way in which economic risks may increase inversely with farm size. Documented contamination clearly has the potential to negatively affect the value of land, especially if the contamination is extensive enough to limit or prevent the future use of the land for agricultural purposes. Megquier explained, "For all farmers, their land is one of their greatest assets, if not their greatest asset, so to be a farmer and to have your land suddenly without value because by no fault of your own it was contaminated [is devastating]." The impact of the devaluation of contaminated land may be greater on small-scale farmers, simply because they tend to own and operate smaller and often contiguous acreages and thus may have a greater potential for whole-of-farm contamination. Conversely, the owner-operators of larger farms may cultivate more extensive tracts or multiple tracts. This may provide a source of resilience, if, for example, the

loss of use or value of a contaminated tract can be offset by improving and shifting cultivation to a different tract.

Social and reputational risks

Because small-scale farmers often sell directly to consumers in local foods systems, contamination may affect their social standing and their relationships with others, including consumers, in ways that are different from farmers that sell commodities to national markets. Megquier explained the nature of these reputational and social risks as follows:

I think there's something to be expressed around relationship with the consumer. For smaller farms that are doing direct market gardening, where they're selling out of farmer's markets or they have CSAs or they have a farm stand, or whatever variety of strategies they're taking to reach market with their crops. I think it's a lot different if that farm discovers that there's PFAS either in their land or water or both, and they are public about that and then are working to shift strategy or working to grow on different land, do a water filtration system, whatever it is they are doing if they're able to stay in operation. It's also like there's that amount of public perception where, a lot of Maine is small towns, if word gets out, then they may be in a place where even in a year or two if they're like, yep, we're still testing and now our products are clear, they have to overcome that perception or that stamp of like, no, that farm was impacted by PFAS. So I do think that relationship is different between smaller farms and larger commodity farms because for commodity crop farms, they're selling to a distributor, they're selling in mass and it's just a very different, several layers removed relationship with the consumer as compared to smaller farms. So I think that does really matter when it comes to PFAS contamination.

Nordell emphasized a similar point, speaking from personal experience:

By tying ourselves to the local agricultural community, by eating locally, we're really affirming that we're throwing out lot in with where we live and with the people who produce food where we live. So obviously when there's an issue of contamination on farms that are marketing that way, it rocks the boat and makes people really nervous. Both makes consumers nervous and makes farmers really nervous, farmers who've experienced contamination. That was a terrifying

thing to navigate for my wife and me, and for PFAS impacted friends. My impression from the broader farming community that I'm part of was that it was pretty challenging for people who were not impacted but were answering questions at the farmer's market.

It is easy to understand how the challenges that PFAS contamination poses to social relationships and a farm's overall reputation may mesh with economic risks. If consumers become skeptical of the safety of food produced on a particular farm, they may shift their business away from the farm, even if the farm is able to successfully mitigate the risk of PFAS migration into products. However, it is important to note that embeddedness in local food systems does not necessarily jeopardize the sales of PFAS-impacted small farms. In fact, Nordell described how farmer-consumer relationships in local food systems provided a source of resilience for some impacted small farms.

This was like a stress test of the local food economy ... The fear, I think broadly in the farming community, was that people are going to stop shopping at the farmer's market. They're only going to go to the grocery store and buy anonymous food now, because there's an identified risk here. But the fact that the impacted farms that spoke up publicly and those who are still in business continue to be so transparent about what they're doing to protect customers, they've amazingly reinforced the customers' loyalty and their sales are up in the same year ... So I think that's point proof that it's worth having hard conversations. Our customers are smart people who can understand complex situations. They're empathetic people and our customers want farmers to succeed and obviously they want their families to be safe ... So in the end, I think the trend is greater consumer confidence in local food.

In addition to the faced by small-scale farmers, interviewees also noted that the PFAS crisis had the potential to negatively impact perceptions of Maine's agricultural products as a whole. They pointed out that this risk was ironic, since PFAS contamination exists throughout the country. Farms in Maine is not necessarily more contaminated than other states, although the state is taking the potential food safety risks of farmland contamination more seriously than much of the rest of the country. As one farming and environmental advocate put it:

You have farmers being put in the same basket, in terms of perhaps the public view of all these farms. I think that's put a pall on agriculture as a whole, where you have people in Maine saying, you know, people in other states are looking at our produce suspiciously because it's from Maine, whereas the produce in Massachusetts is probably identically contaminated, except that they're not spending a lot of money to find out.

Strengths and gaps in Maine's policy response to PFAS

Maine's ongoing response to PFAS includes several laws and administrative actions that are specifically targeted to the agricultural community (see table 2). One of the most significant has been the allocation of \$60 million to the state's Fund to Address PFAS Contamination. The fund's authorizing statute indicates that the Fund may be used for investments to adapt farm operations or infrastructure, for health testing and monitoring, and for research into PFAS adaptation and remediation approaches. As of this writing, development of an implementation plan for the Fund is ongoing, and disbursements are expected to begin later this year. In the interim, impacted farmers are eligible to receive assistance from the Maine Department of Agriculture, Conservation, and Fisheries, including financial assistance with testing, the installation of adaptation infrastructure, and income replacement.

Several other important actions aim to detect the extent of farmland contamination and to reduce the likelihood that uncontaminated sites will be exposed to PFAS. These measures focus on sludge spreading, which has been the most prominent vector of exposure for farmland. Currently, the Maine Department of Environmental Protection (DEP) is testing soil and water at sites where sludge spreading was licensed to occur during the duration of the sludge spreading program. The program is no longer in existence, and the land application or composting of sewage sludge is now prohibited in Maine.

Interviewees highlighted these elements of the state's policy response as particularly important for farmers seeking to navigate the risks and uncertainties posed by PFAS. As Nordell put it, "I've had the opportunity to talk to impacted farmers in other states, in Michigan and Colorado and New Mexico, and their state governments have not been a quarter as responsive as Maine has. So while there are times that I will criticize our policy response and the implementation of our policies, I think we're incredibly lucky and I'm incredibly grateful for the

work that's being done at Maine DEP and DACF and at the Legislature." At the same time, identified gaps in Maine's existing policy response.

The first gap is perhaps most closely related to the multidimensional nature of the risks posed by PFAS. The physical health risks posed by exposure to PFAS contamination may be reduced through detection and mitigation practices (e.g. by installing water filters, changing cropping approaches, withdrawing land from production). This is the goal of the Maine DEP's testing program for licensed sludge spreading sites, as well as the financial and technical assistance provided by the Maine Department of Agriculture, Conservation, and Forestry (DACF) to farmers who choose to voluntarily test sites on their property. However, interviewees noted that PFAS detection may increase farmers' exposure to economic, social, and reputational risks resulting from the loss of revenue and property value, the cost of mitigation measures, and damage to public image. As one advocate put it, "There's no right of, at least right now, the state to go in and test unless someone will invite you in. And if inviting you in means that your farm is going to be blacklisted and you can't sell anything and you might, you know, end up moving, there's a disincentive there." Similarly, Megquier noted that "testing is voluntary and so there's sort of a certain level of farms and impacted farms that we're hearing about, but there may be many more, that are saying, no, I don't want that testing, or maybe the test results are not being fully disclosed publicly because it can destroy business." These concerns are supported by a status report about the sludge site testing program that the Maine DEP prepared for the state legislature in 2023, which noted that 12% of farm landowners who had been contacted about participating in the Tier 1 (highest priority) testing cycle had denied testing teams access to their properties (Maine Department of Environmental Protection 2023).

Both the state and the nonprofit sector have worked to fill this gap by making funds available to farmers for income replacement and to offset the costs of installing mitigation infrastructure. In the nonprofit sector, these efforts include an emergency relief fund created by the Maine Organic Farmers and Gardeners Association and Maine Farmland Trust. In terms of state action, they include assistance provided through the Maine DACF and the Maine Fund to Address PFAS Contamination described above. Interviewees emphasized the value of these efforts, while also pointing out that the requirements and timeline of these programs, particularly those administered by the state, did not always meet the needs of farmers. For instance, speaking of the DACF's PFAS relief efforts, Nordell commented:

I would like to see the [DACF] let farmers take the lead with defining their needs, vis-à-vis how the program is currently being run. I think impacted farms have to significantly struggle to get investments in PFAS responsible infrastructure funded through those programs. And to me, that's an untenable position for the [DACF] to be taking. These farms are literally struggling for their financial lives and the delay of a month, or three months or six months, makes an enormous difference given our short growing season, given how competitive some sectors of the farming economy are. If you lose your market position for a month, you might have lost it for the season. So as farmers identify their needs and present them to the [DACF] my hope is that the department will be a lot faster and a lot more willing to help farmers make those investments.

Speaking of the Maine Fund to Address PFAS Contamination, Megquier praised the decision to appoint impacted farmers to the state planning board charged with implementing the program but also noted the urgency of making funds available, including for state buybacks of impacted lands, to farmers as soon as possible. She explained:

For some impacted farmers, the wait has been long in terms of waiting for relief from the state. And the gap that I can see is just that for farmers that have been sort of at the forefront of this, there's just a huge need to prioritize financial support from the state for those impacted farmers. So we really want to see impacted farmers made whole, but we also want to see the state prioritize those farmers that at huge personal risk really helped to bring this issue to greater public awareness ... And that includes things like land buyback from the state, so the state actually purchasing severely contaminated land from farmers.

The second gap has to do with the need for both short- and long-term resources to offset the health risks of PFAS exposure. Interviewees noted that at present, blood tests to assess PFAS exposure are cost-prohibitive for many people and are generally not covered by private insurance. Nordell noted that this individualization of responsibility for personal testing has the potential to prevent many people from understanding and acting on the health risks that they may face. Moreover, the fact that PFAS-related medical conditions may take years or decades to

manifest creates a need for long-term monitoring and, possibly, eventual treatment. Costs related to these needs remain an individual responsibility. Nordell explained:

OK, I have my blood serum results ... what happens next? Whose responsibility is it to pay for the cost of any treatment for illnesses that are linked to that exposure at this point? The state hasn't touched that and I think that if we're going to offer anything that looks like justice for impacted communities, farmers, farm workers, farm-adjacent communities, we have to think about that and we have to try to meet that need.

One possible strategy for filling this gap is litigation brought either by the state or on the behalf of individuals who are impacted by PFAS contamination. To support this strategy, Maine recently extended the statute of limitations for damages related to PFAS exposure. However, interviewees pointed to the novelty and complexity of PFAS litigation and to the inaccessibility of this strategy for some PFAS-impacted individuals. As one advocate put it:

This is a challenge with litigation: If you know you were exposed in 2020 but you don't get cancer or whatever it is until 2030, if you file that lawsuit then, is it barred? [That's] A, and then B, you know, can you prove that? ... A lot of the litigation out there has been the situation where you had direct contamination arising from a manufacturing plant that's located in your city, let's say, as opposed to, you know, a manufacturing plant that produces PFAS that is then put into paper, that then ends up in the waste, then on the field, and it then contaminates somebody or something ... Maybe someday that liability will be proved. In the meantime, people need their health concerns addressed. They need to have their farms fixed up. They need to deal with the economic harm that they face in the short term and potentially longer term. And none of those things will be addressed in the near future by any of these lawsuits.

Uncertainties in federal policy

The challenges of developing an adequate and just policy response to PFAS contamination in Maine are also linked to uncertainties in the development of PFAS-related policies at the federal level. Perhaps the greatest uncertainty concerns the extent to which funds

will be allocated to meet the needs of PFAS-impacted farmers in the forthcoming Farm Bill. Maine's Congressional delegation has proposed legislation, the Relief for Farmers Hit by PFAS Act, that would establish a block grant program to support state-level provision of PFAS assistance to impacted farmers. If passed, this legislation would provide a revenue stream to expand the support and services that are currently being made available through state funds.

Beyond the overall availability of federal funds, interviewees noted other sources of uncertainty. For instance, one advocate pointed out the historical tendency for the majority of federal funding to support larger, commodity-focused farms, as opposed to small-scale agriculture. Another highlighted a potential for farmers in early-mover states, such as Maine, to become ineligible for certain federal programs as a result of the discovery of PFAS contamination on their properties. Interviewees acknowledged that these concerns were speculative, given the nascent state of PFAS policy development at the federal level.

Discussion

PFAS contamination represents a complex, serious, and long-term environmental and public health crisis. The risks posed by PFAS contamination are multidimensional and risk configurations differ across population subgroups. Policies related to PFAS are, at present, uneven and fragmented. Maine has staked a position on the leading edge of this crisis by developing progressive and well-considered policies in an effort to mitigate and redistribute PFAS-related risks. While there is much to admire about Maine's willingness to confront the PFAS crisis, it is also important to take account of gaps in policy that might limit the state's ability to address PFAS in an effective and equitable way.

This preliminary research has investigated the ways that PFAS contamination has impacted the experiences of people in Maine's small-scale, locally-focused agricultural sector. There are reasons to suspect that the way Maine's program to apply sewage sludge to farmland was implemented has led to greater likelihood of soil contamination in geographical areas with higher concentrations of small-scale farms. For farm owner-operators, PFAS contamination poses a range of risks to physical health, mental health, economic sustainability, social relationships, and reputation. The limited number of interviews conducted so far in this research point to two broad gaps in state policies that intersect with the experiences of small-scale

farmers: (1) the economic risks created by soil and water testing on farms and (2) the lack of policies to offset the cost of short- and long-term health monitoring and treatment. While the developing character of state and federal PFAS policies creates opportunities to address these gaps, it also interjects uncertainty into the planning process.

As knowledge about the extent of PFAS contamination and the health impacts of PFAS exposure continues to improve, attention to gaps and unintended consequences of policy responses will remain important. Future research within this project will continue to collect information in order to deepen understanding about the two gaps identified thus far and to potentially reveal other places where policies are poorly matched to the needs of Maine's small-scale farmers. This knowledge is essential for both policymakers and impacted farmers as they work to navigate the PFAS crisis.

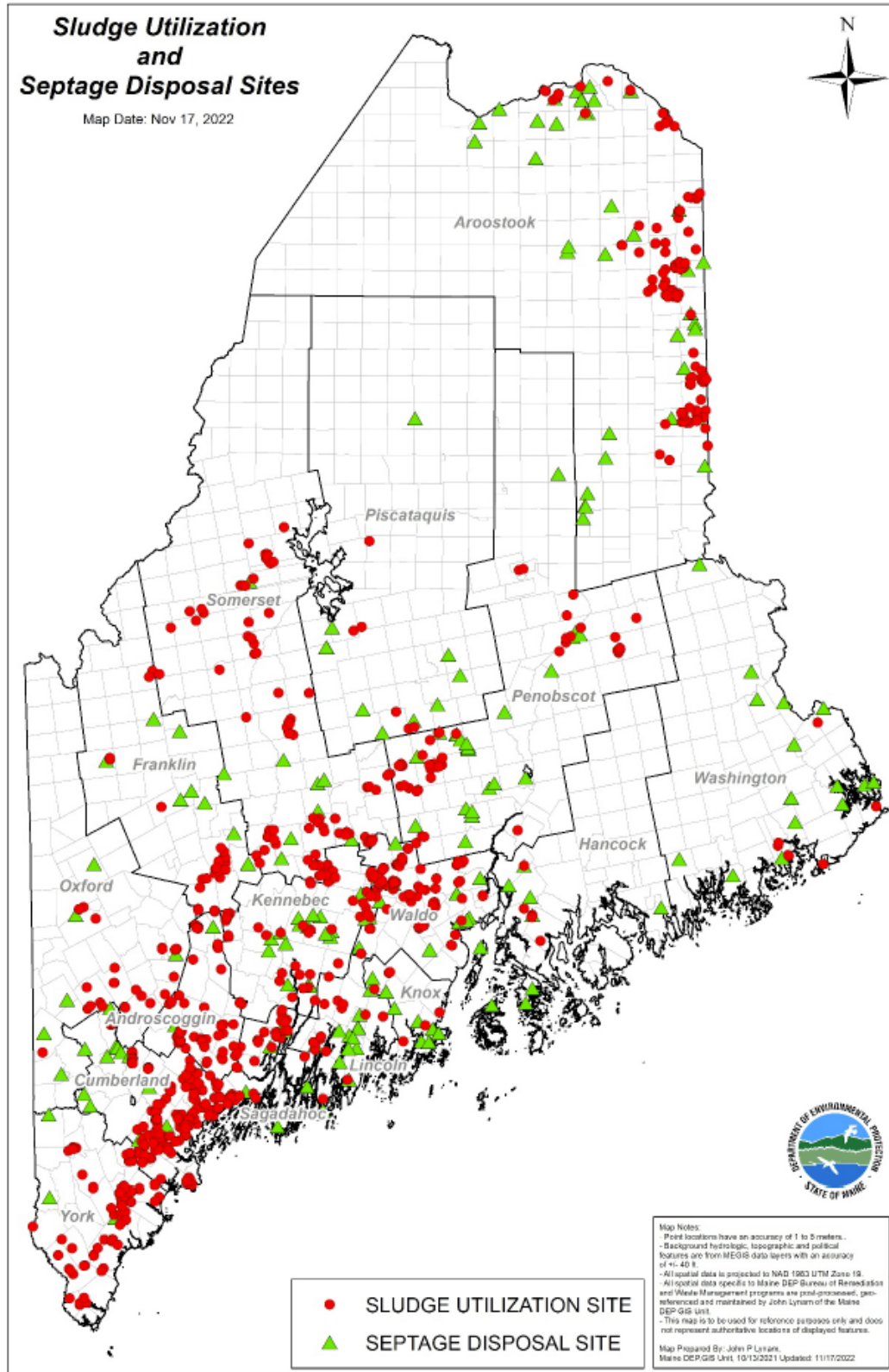
Table 1: Selected PFAS-Related Laws Enacted in Maine

Year	Bill Number	Title
2019	LD 1433	An Act to Protect the Environment and Public Health by Further Reducing Toxic Chemicals in Packaging
2021	LD 129	Resolve to Protect Consumers of Public Drinking Water by Establishing Maximum Contaminant Levels for Certain Substances and Contaminants
2021	LD 1503	An Act to Stop Perfluoroalkyl and Polyfluoroalkyl Substances Pollution
2021	LD 1600	An Act to Investigate Perfluoroalkyl and Polyfluoroalkyl Contamination of Land and Groundwater
2021	LD 2147	An Act to Require Reporting of Perfluoroalkyl and Polyfluoroalkyl Substances, PFAS, in Products and of Discharges of Firefighting Foam Containing PFAS
2021	LD 2160	An Act Relating to the Statute of Limitations for Injury or Harm Resulting from Perfluoroalkyl and Polyfluoroalkyl Substances
2022	LD 1505	An Act to Restrict the Use of Perfluoroalkyl and Polyfluoroalkyl Substances in Firefighting Foam
2022	LD 1875	Resolve to Address Perfluoroalkyl and Polyfluoroalkyl Substances Pollution at State-Owned Landfills
2022	LD 1911	An Act to Prevent the Further Contamination of the Soils and Waters of the State with So-Called Forever Chemicals
2022	LD 1995	An Act to Make Supplemental Appropriations and Allocations for the Expenditures of State Government, General Fund and Other Funds and to Change Certain Provisions of the Law Necessary to the Proper Operations of State Government for the Fiscal Years Ending June 30, 2022 and June 30, 2023
2022	LD 2019	An Act to Require the Registration of Adjuvants in the State and to Regulate the Distribution of Pesticides with Perfluoroalkyl and Polyfluoroalkyl Substances

Table 2: Interview Respondents

Interview number	Name	Organization	Position
1	Withheld	Withheld	Advocate for agricultural and environmental organizations
2	Adam Nordell	Songbird Farm/Defend Our Health	PFAS-impacted farmer/environmental health advocate
3	Shelley Megquier	Maine Farmland Trust	Advocate for agricultural organization

Figure 1: Maine Department of Environmental Protection Map of Sites Licensed for Sludge and Septage Application



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