FIELD TRIALS:

Maine farmers and scientists research how PFAS contamination affects soils, plants and our food

BY MARINA SCHAUFFLER | PHOTOGRAPHS BY BRENDAN BULLOCK

Farmers routinely adapt to changing weather and markets, but PFAS contamination (from per-and polyfluorinated compounds) is forcing abrupt shifts in some operations and prompting wide-ranging research into how these persistent chemicals affect food systems. “PFAS is not really of agriculture’s making but agriculture is certainly going to have to deal with it,” observes Marlen Eve, deputy administrator of the U.S. Department of Agriculture’s Agricultural Research Service (USDA ARS).

When PFAS were discovered on an Arundel, Maine dairy farm in 2016, those tasked with responding found scant guidance. Lack of understanding about this vast class of ‘forever chemicals’ exacerbated challenges for affected farmers, and no federal authorities could tell Maine State Toxicologist Andrew Smith “how much is too much in food,” he recalls.

State and university researchers, farmers and independent consultants scrambled to gather and share information. “It’s been really collaborative; we’re all starting from scratch,” observes soil scientist Andrew Carpenter of the firm Northern Tilth.

Maine has identified 78 farms to date contaminated by PFAS from past applications of wastewater sludge. To meet the needs of farmers and consumers, Maine’s “research community has really moved by leaps and bounds,” notes Adam Nordell, a PFAS-affected farmer and a campaign manager with the nonprofit Defend Our Health.

Maine’s research on PFAS could expand markedly in coming years, with the prospect of up to $20 million in federal support for a new PFAS research center housed at the University of Maine in Orono, established in partnership with USDA ARS. Work undertaken by Maine scientists may generate far-reaching benefits, given the international scope of PFAS agricultural contamination. In the U.S. alone, roughly one-quarter of all wastewater sludge generated is still spread on agricultural land.

A UMaine test plot on Sue Hunter’s farm in Unity, Maine. Side by side ‘companion’ plantings, as well as solitary control plantings measure uptake levels of PFAS into various crops.

Left *Sue Hunter in the farm store at her property in Unity, Maine.* ***Right*** *Control planting of tomatoes alone in the UMaine test plot on Sue Hunter's farm, testing PFAS uptake levels.*

A Hard Pivot

For Sue Hunter, a Unity resident who has farmed for nearly 50 years, the discovery of PFAS contamination on her land followed repeated losses. Her husband's death to cancer in 2015 necessitated selling their dairy herd. She leased some fields for several seasons while selling hay and establishing a small market for farm-grown vegetables. Then in 2022, PFAS testing revealed what she terms "crazy numbers."

"It was devastating," Hunter recalls, to see the land's productive potential evaporate after "I've worked all these years and this hard. And I still have to pay my taxes and insurance." With help from the PFAS Emergency Relief Fund established by Maine Farmland Trust and the Maine Organic Farmers and Gardeners Association, she installed raised beds in her greenhouse to safely grow vegetables for her farm market.

PFAS levels vary considerably over the property, Hunter says, because "we farm this place differently in sections of land." Testing occurred by section so she could compare the PFAS results with management records; "I've always been intrigued by science," she reflects. Hunter wondered whether researchers could use the data and conduct field experiments on-site, while she helped supply equipment and irrigation.

Taking Research into the Field

At the University of Maine, Diane Rowland, dean of the College of Natural Sciences, Forestry, and Agriculture, and Rachel Schattman, an assistant professor of sustainable agriculture, shared Hunter's enthusiasm about that prospect. The University will not knowingly introduce PFAS to existing Experiment Station farms so "we can't set up experimental conditions that farmers have on their farms now," Rowland explains.

Greenhouse testing can reveal important insights about how plants take up chemicals—such as PFAS tending to concentrate in leafy greens and not in reproductive plant parts like grains, fruits and seeds. However, lab findings "have to be taken out into the field to have confidence in the results," says Ellen Mallory, a University of Maine agronomist, a process that "just takes time, [often] several field seasons. The biggest challenge continues to be that very few experiments have been conducted in the field."

Field work is also needed to find means of remediating contaminated soils. Since 2019, the nonprofit Upland Grassroots and the Mi'kmaq Nation have been testing the efficacy of hemp (Cannibas sativa) to draw PFAS from the soil and have learned that it's a powerful accumulator. Now several teams of university scientists (outside Maine) are experimenting with ways to rid the harvested hemp plants of PFAS.

A Living Laboratory

Only small-scale, experimental means currently exist to break PFAS into harmless elements so researchers are investigating what materials could bind the compounds, making them inaccessible to food crops or to absorption in livestock's digestive tracts. Two University of Maine faculty members in dairy cattle nutrition and forage science, Juan Romero and Glenda Pereira, are studying potential binders that—when added to dairy feed—could help cows flush out a common PFAS compound, PFOS (the only one Maine now regulates for milk and beef), without affecting their nutritional intake or milk production. To date, Romero says, "we have screened six types of binders and found one that can bind PFOS under conditions similar to those in the digestive tract of cattle. It's the same one identified in published research going back to 1984 as helping rats and humans eliminate accumulated PFOS."

One material being assessed as a potential PFAS binder in soil is biochar, a byproduct of wood broken down with heat in the absence of oxygen. It acts similarly to the granular activated carbon (GAC) often used in water filters to remove PFAS and other contaminants, explains Ling Li, assistant professor of sustainable bioenergy systems at the University of Maine. GAC is expensive and often sourced from coal or materials such as coconut shell fiber, but biochar can be supplied from Maine forests, making it potentially an affordable and relatively sustainable soil supplement. Another biochar study launched this fall by

Sue Hunter's greenhouse on her farm in Unity. The raised beds were built with funding from Maine Farmland Trust after it was discovered that her farm fields were contaminated with PFAS.

Above *Ling Li, Assistant Professor of Sustainable Bioenergy Systems at the University of Maine, advises her students as they lay out a test plot grid at Sue Hunter's farm to study the effect of biochar as a PFAS remediation technique.* ***Below*** *UMaine students add biochar to soil in their test plot grid.*

Northern Tilth and Purdue University, using Hunter Farm soils, will test whether introducing biochar to fairly contaminated soils helps limit its uptake into pasture grasses.

Alongside Li's biochar research plot at Hunter Farm is an established plot where Schattman and student assistants grew combinations of lettuce, fescue and tomatoes this past season. She had tissue samples from those plants tested for 36 PFAS compounds, hoping to determine whether intercropping with plants that readily accumulate PFAS—like fescue—can lower levels of the chemicals in neighboring food crops.

A team of Maine scientists led by Alexandra Scearce, a graduate student working with Schattman, recently published a review in the journal Biointerphases summarizing the variables affecting plant uptake of PFAS—including chemical factors like soil type and pH, plant characteristics like root structure and leaf area, and the structure of the PFAS compounds present. This understanding builds on work by the Maine Centers for Disease Control and Prevention (Maine CDC) and Maine Department of Agriculture, Conservation and Forestry (DACF), which have spent years doing opportunistic sampling on contaminated farms to learn how much of the PFAS in soil ends up in the edible portions of vegetable and forage plants.

Field experiments will help researchers refine predictive models, Schattman says, so that farmers can find the safest crop options and combinations in mildly contaminated soils. "Rachel's project is very dear to my heart," Hunter observes, "because I want to be able to do vegetables."

Figuring Out What Works

Better predictive models can't come fast enough for farmers contending with PFAS. For New Beat Farm owners Adrienne Lee and Ken Lamson, who grow organic vegetables in Knox, the discovery of PFAS from sludge applications decades earlier came as "a slap in the face when you're trying to be so careful about what you put in the soil," Lee reflects. "We need to feel extra confident that we're selling a product that we can stand behind," she adds, and that's hard when "no one knows specifically much of anything right now."

Nearly all of Maine's PFAS research has been guided by farmers' needs, but critical information required for their daily decisions is still missing. Lee wants to know, for example, how best to manage spent plant matter containing PFAS. Approaches to remediation require the sort of systemic view farmers have, she says, so that contamination is not simply shifted around.

Adrienne Lee and Ken Lamson on their farm in Knox, Maine, which was among many farms found to have significant PFAS contamination from sludge spreading. The plot behind them was one of the only areas on the farm to never have sludge applied, and it is therefore safe for growing food crops.

Reliant now on trucked-in water for irrigation, Lee and Lamson have gone from growing leafy greens in field rows to using smaller beds in an unaffected area where added compost and no-till methods reduce the water required. To help compensate for selling fewer greens, they've expanded their cut-flower beds and tomato production (since PFAS concentrates in the leaves not the fruits). Farmers need latitude to determine which adaptations for safe food production will fit their farming vision and crop preferences, Lee says; "The solution has to be helping farms find their path."

The state is bearing the high cost for plant tissue sampling on affected farms, typically upward of $250 per sample, but turnaround times of up to eight weeks render results of limited use for that growing season. Beyond data from their own land, Lee says, farmers need access to datasets that are as comprehensive and accessible as possible.

Adrienne Lee in a cut flower greenhouse at her farm in Knox. After discovering that the farm had significant levels of PFAS contamination, cut flowers provided Lee an alternative option to growing food crops.

Researchers are working to standardize sampling protocol toward that end, Mallory says, so that everyone sampling "collects a full suite of parameters. We want to develop really good datasets that people will be using for years and years," she adds. "We don't want [future researchers] saying 'they didn't record that.'"

Funding Ongoing PFAS Research

A PFAS Fund Advisory Committee established by the Maine Legislature, on which Lee, Nordell and other farmers served, recently approved a plan allocating $70 million in state funds to meet a broad spectrum of farmer needs related to PFAS impacts—including $11 million for applied agricultural research.

Augmenting those state resources is funding proposed in the 2024 federal budget to create a USDA ARS research center at the University of Maine. If funded, it would help the agency mitigate PFAS threats to agriculture, health and ecosystems. Eve of the USDA anticipates that half the initial funds allocated would help renovate and expand the New England Plant, Soil and Water Research Laboratory in Orono to house the new center. The balance would support up to four new scientific positions through USDA and a comparable number through the University, as well as supporting staff and student researchers.

Expanded research efforts could help fill remaining gaps in scientific understanding, such as how soil microbial communities affect PFAS (and vice versa) and how "precursor" PFAS chemicals may transform within ecosystems, elements and organisms into more enduring compounds. Another pressing research gap, both Nordell and Lee underscore, is the occupational exposure farmers face breathing in windblown farm soils and handling contaminated soil.

'Willingness To Collaborate'

Despite moments of "friction and frustration" in Maine's quest to understand how PFAS affects agricultural systems, Nordell credits state and university representatives with "a deep commitment to listening to research questions coming from farmers, and a frequent willingness to collaborate."

Working closely with those on affected farms, staff members at the Maine CDC have undertaken field studies, compiled and analyzed data and developed models that DACF can use to guide farmers' use of contaminated land. Maine CDC has also worked to develop "food action levels" for PFAS in livestock forage and in milk, beef and an array of vegetable, enabling DACF to set regulatory standards.

While "talking to the public about chemical exposure is the mainstay of what we do," Smith, of the Maine CDC, acknowledges, PFAS has placed unusual demands on researchers. Interacting with farmers who have their economic viability and health on the line "has been humbling and personally challenging," he reflects. "It's a real tragedy." Yet through it all, farmers have demonstrated "this amazing can-do attitude," sharing access to land, equipment, samples, and support and "being patient as we learn their language and farming practices," he adds. "They're wonderful collaborators; We wouldn't have this data without [them]."

University researchers share similar admiration and appreciation for the farmers struggling to adapt their management and to research new approaches atop the countless demands they already juggle. Speaking of the partnership evolving at Hunter Farm, Schattman says "As a team, I think we've worked well together. And that's the key. We're a team."

Maine Farmland Trust is contributing to that collective effort through two grants from a new PFAS Research Fund, which provides supplemental resources for researchers working on affected farms, helping with expenses not covered by other funding sources. The first two grants are for research at Hunter Farm, helping support farmer compensation and biochar purchase and transport.

The spirit of collaboration that marks ongoing PFAS research stems from a shared commitment to sustain Maine's farmland and its thriving local food economy; "There's so much on the line," Schattman observes. "We owe it to our state to do the science and do it right to grow food that is safe."

MARINA SCHAUFFLER, *an independent environmental writer, wrote a fellowship-funded article series on PFAS in 2022, "Invisible and Indestructible." Read more at marinaschauffler.com.*

CROSS-STATE COLLABORATION ON RESEARCH

Leading PFAS researchers and representatives from Maine and Michigan—states at the forefront of PFAS agricultural research—exchanged insights this fall at two conferences collaboratively organized by Maine Farmland Trust, University of Maine, Michigan State University (MSU) and USDA ARS. USDA and private funders helped more than 30 Maine representatives (including several affected farmers) attend a three-day symposium at MSU in October. Participants at a subsequent workshop hosted by Colby College heard from symposium representatives and other regional speakers and discussed actions for the Northeast. "These gatherings allowed us to brainstorm potential solutions and identify research needs and resources that are directly responsive to our farming communities," observed Cheryl Murphy PhD, Director of the Center for PFAS Research at MSU's Department of Fisheries and Wildlife.

AN OPPORTUNITY TO ADVANCE RESEARCH AT SONGBIRD FARM

In fall 2023, almost two years after Adam Nordell and Johanna Davis of Songbird Farm learned that the soils on their farm were highly contaminated with PFAS chemicals, Maine Farmland Trust purchased the farm property. With the purchase of the Unity property, MFT is seeking agricultural research partners to explore long-term solutions for impacted farmers and farmland. "When PFAS contamination was discovered at Songbird Farm, we knew that Maine farmers needed urgent solutions to the PFAS crisis—and we also knew that Maine was at the forefront of a national problem that demands investment in long-term research," says MFT President and CEO Amy Fisher.