



Socio-Economic Impacts of PFAS on Farming Communities

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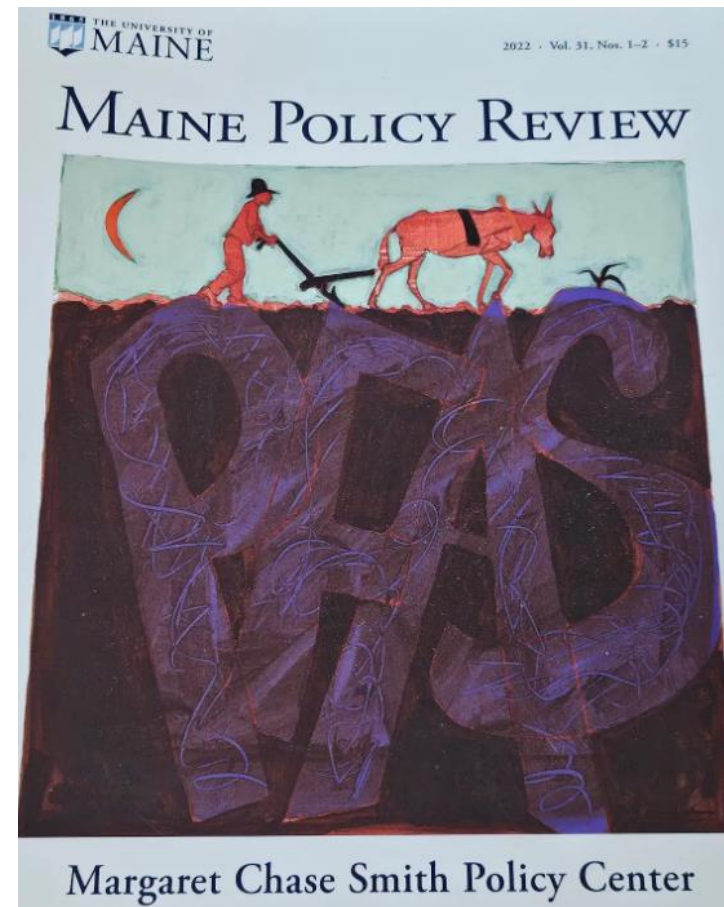
With multiple amazing co-authors and
collaborators!
I'll share with each study

PFAS Shut Maine Farms Down.

Civil Eats October 2, 2023

A moment on how your economist & social science colleagues are (maybe) thinking about PFAS

- (1) We'd probably call PFAS a **stock pollutant**
- Pollutant that accumulates in the environment over time
 - ... lasting damage even after emissions stop
 -didn't realize generating externalities for our communities



A moment on how your economist & social science colleagues are (maybe) thinking about PFAS

(2) We'd turn to the **Polluter Pay Principle** - reduce use of the 'pollutant' AND pay for clean up

- Often sales taxes on products, set high to pay for remediation
- but... what if who we should blame becomes tricky?
- ...urgency, need the \$ now?

Maine farmers push for tens of millions to address PFAS

—
"That land is never going to produce food for humans."

News Center Maine March 15, 2022



Maine may have to spend \$20M annually to fight 'forever chemicals' in land and water

Bangor Daily News January 31, 2022

A moment on how your economist & social science colleagues are (maybe) thinking about PFAS

(3) Like all of you – we’d look to see what people are thinking about.....

PFAS exposure leaves Maine people wondering: What is it doing to us?

As more than 500 private wells exceed state standards for **safe drinking water**, residents who have been consuming it for years want answers about the chemicals' effects.

Portland Press Herald, May 14, 2023

Costs of investigating PFAS contamination are rising ‘exponentially’ in Maine

Maine Public, January 2022

spend annually on testing, remediation and installation of water treatment systems. The Legislature **earmarked \$30 million** in the current budget to cover those costs



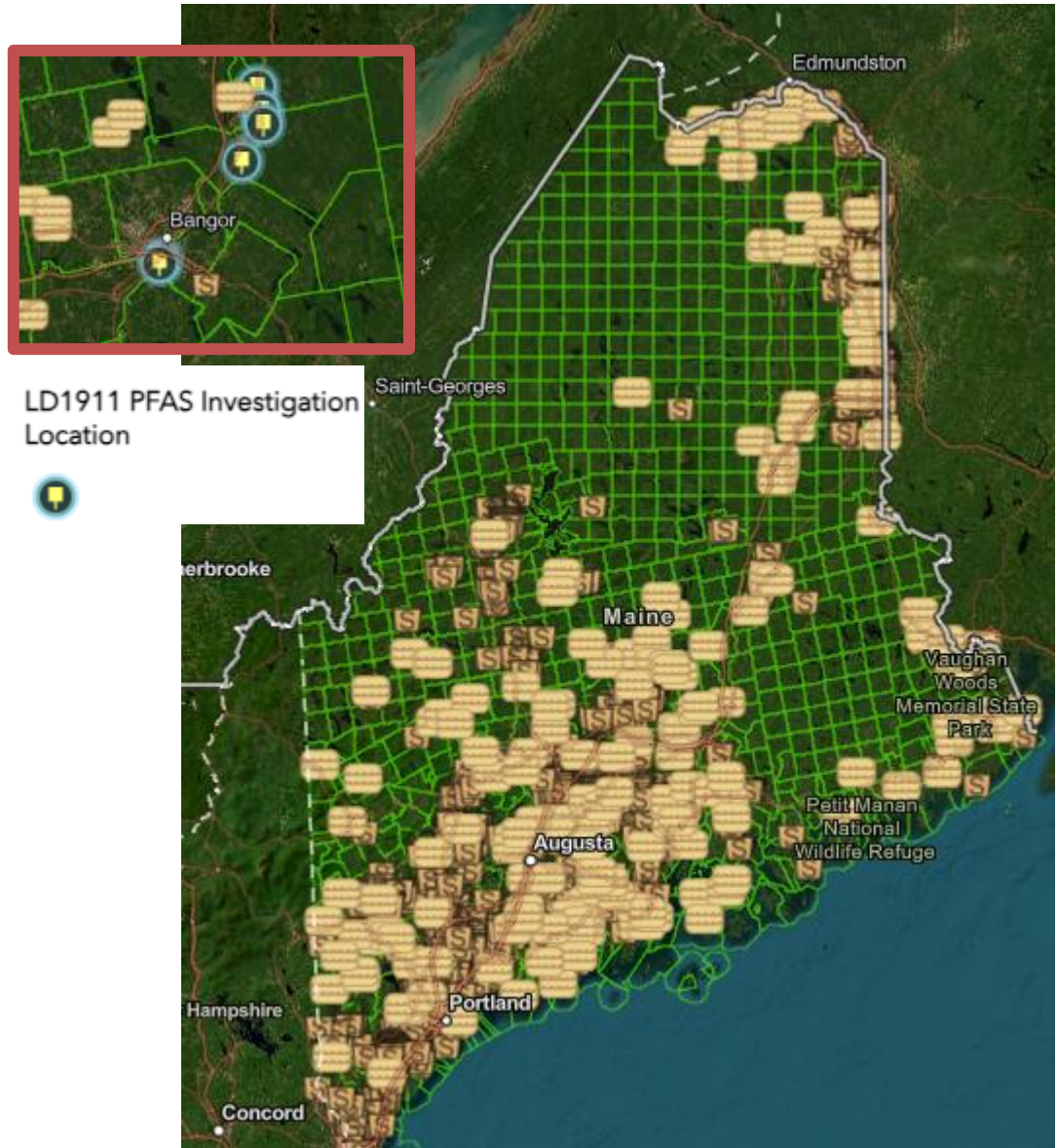
Willingness to contribute towards PFAS cleanup: *Contaminated drinking water*

With:

Dr. Keith Evans

Charity Zimmerman

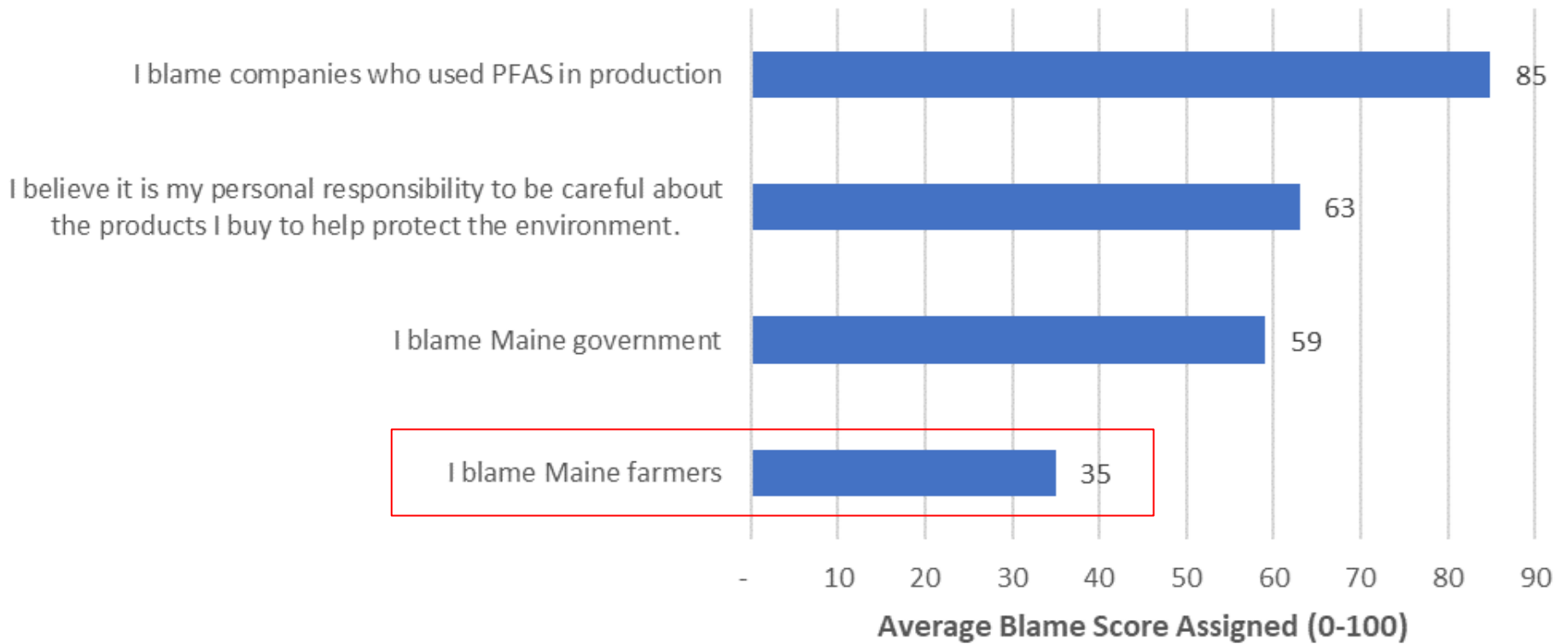
Molly Shea



Maine Citizen Surveys

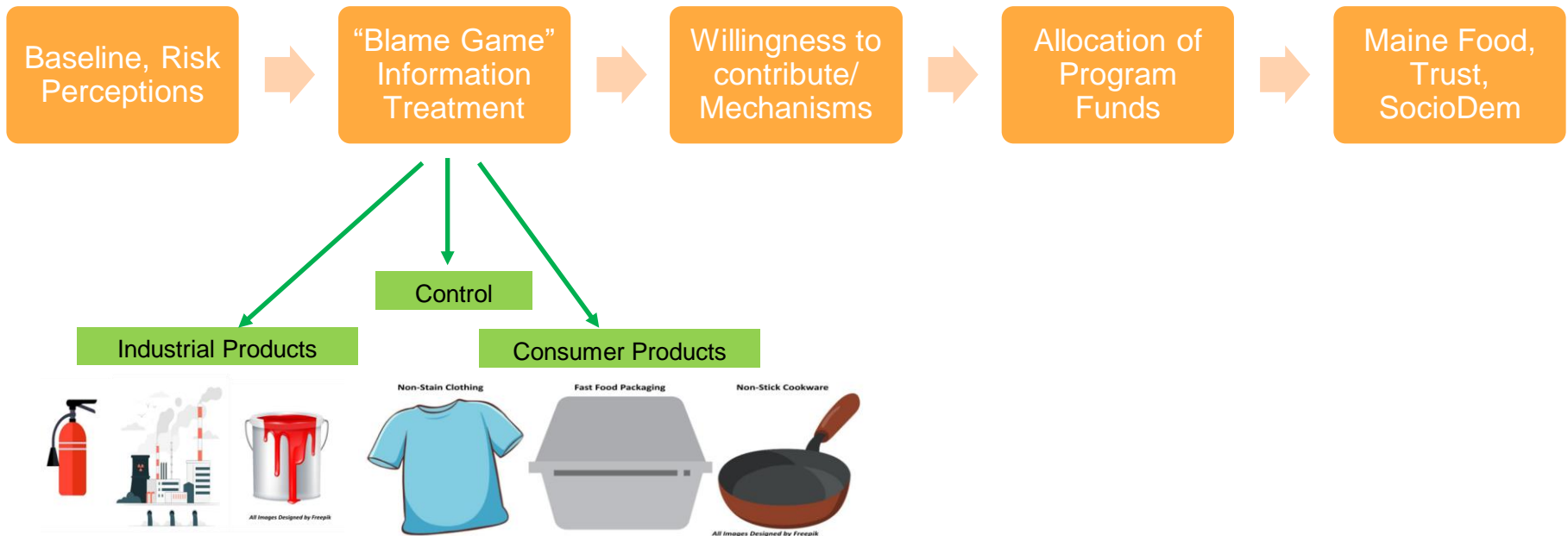
- Focus on willingness to contribute to, and allocate, state-wide Maine PFAS funds
- Conducted in March 2022 and November 2022
- N= 450

Who are people blaming for PFAS contamination?

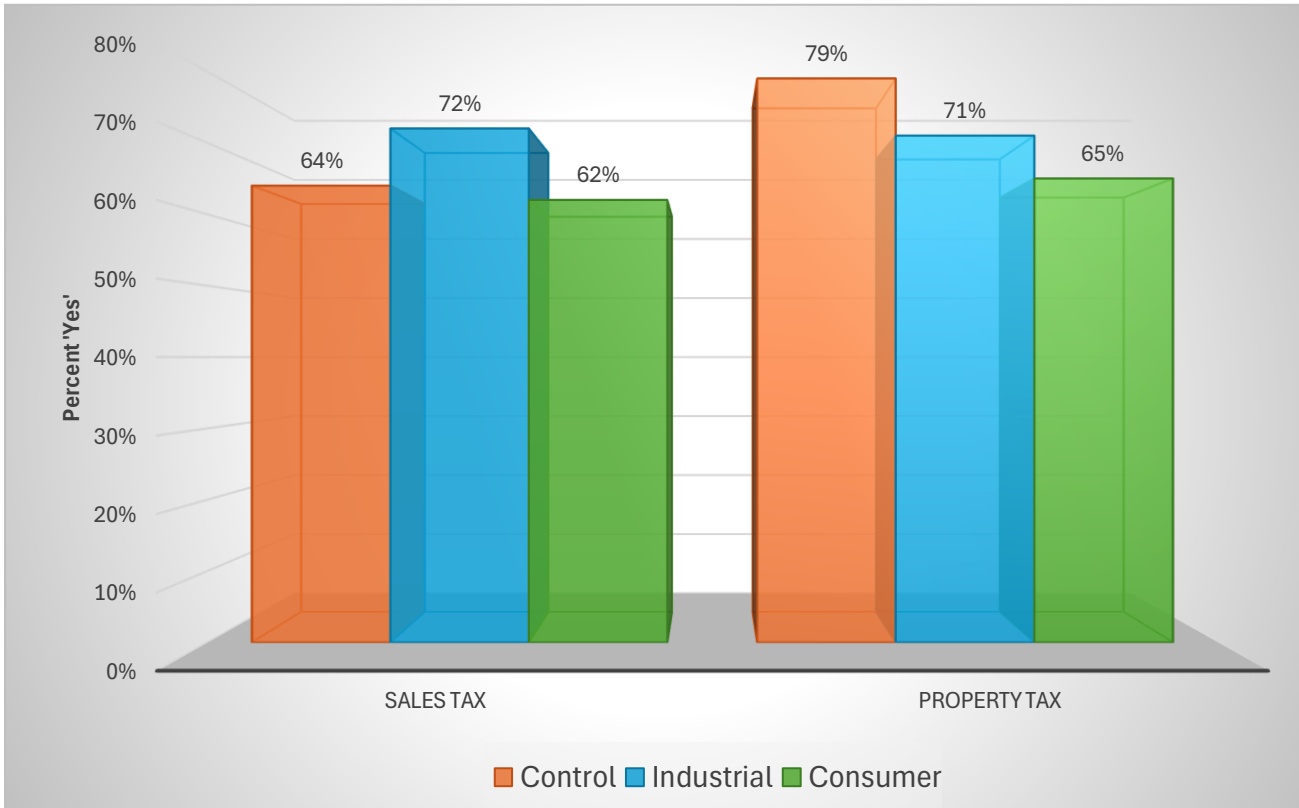


What are we looking to understand?

- (1) Does providing information about ‘who to blame’ impact willingness to contribute towards clean up?
- (2) Do people have preferences about mechanisms to contribute (sales tax, property tax)



What did we find? How does this help?

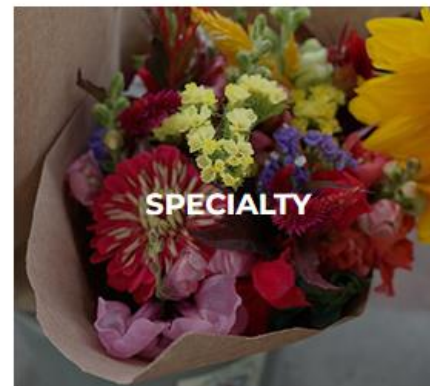
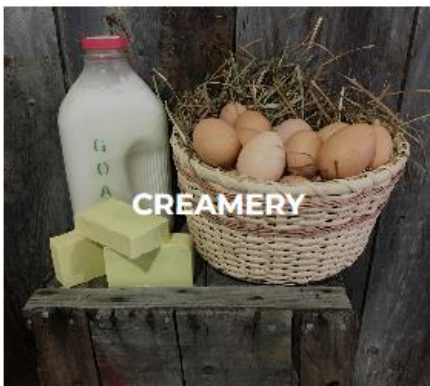


How we communicate about, and collect, PFAS cleanup funds may impact citizen willingness to contribute

Another moment on how your economist & social science colleagues are (maybe) thinking about PFAS

(4) We'd think about how markets (and the people in them!) are being impacted

Photos and layout from
<https://www.realmaine.com>



Media coverage of PFAS impact on consumer confidence in Maine food

With:

Dr. Erin Percival Carter

Dr. Angie Zheng

Charity Zimmerman

Molly Shea

Mel Godin



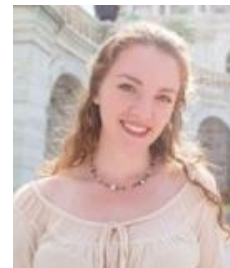
Dr. Angie Zheng
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Dr. Erin Percival Carter
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Charity Zimmerman
M.S. Economics. '24



Molly Shea
M.S. Economics. '25



Mel Godin
M.S. Economics. '26

Maine farmers worked hard to create a
trusted brand

A photograph of various fresh vegetables, including green bell peppers, purple carrots, a blue crate of cherry tomatoes, white onions, and green zucchini, arranged on a dark surface.

Experience Real Maine

The Washington Post
Democracy Dies in Darkness

'Forever chemicals' upended **Maine farm** — and point to larger problem

By Keith O'Brien
April 11, 2022 at 8:00 a.m. EDT

NEWS | ENVIRONMENT, HEALTH

Toxic PFAS Chemicals Found in **Maine** Farms Fertilized with Sewage Sludge



Adam Nordell and Johanna Davis leased this land across the street from
(Washington Post)

**'I don't know how we'll survive': the
farmers facing ruin in **Maine's** 'forever
chemicals' crisis**

Maine faces a crisis from PFAS-contaminated produce, which is causing farms to
close and farmers to face the loss of their livelihoods

patagonia50▶

The Forever Chemicals

Beth Schiller / May 13, 2022 / 5 Min Read / Workwear

The story was supposed to be about a thriving, women-led organic farm
in Maine. Then came news of the "forever chemicals."



How does all this negative press impact consumer confidence in our food system?

Can we do something to get confidence back?

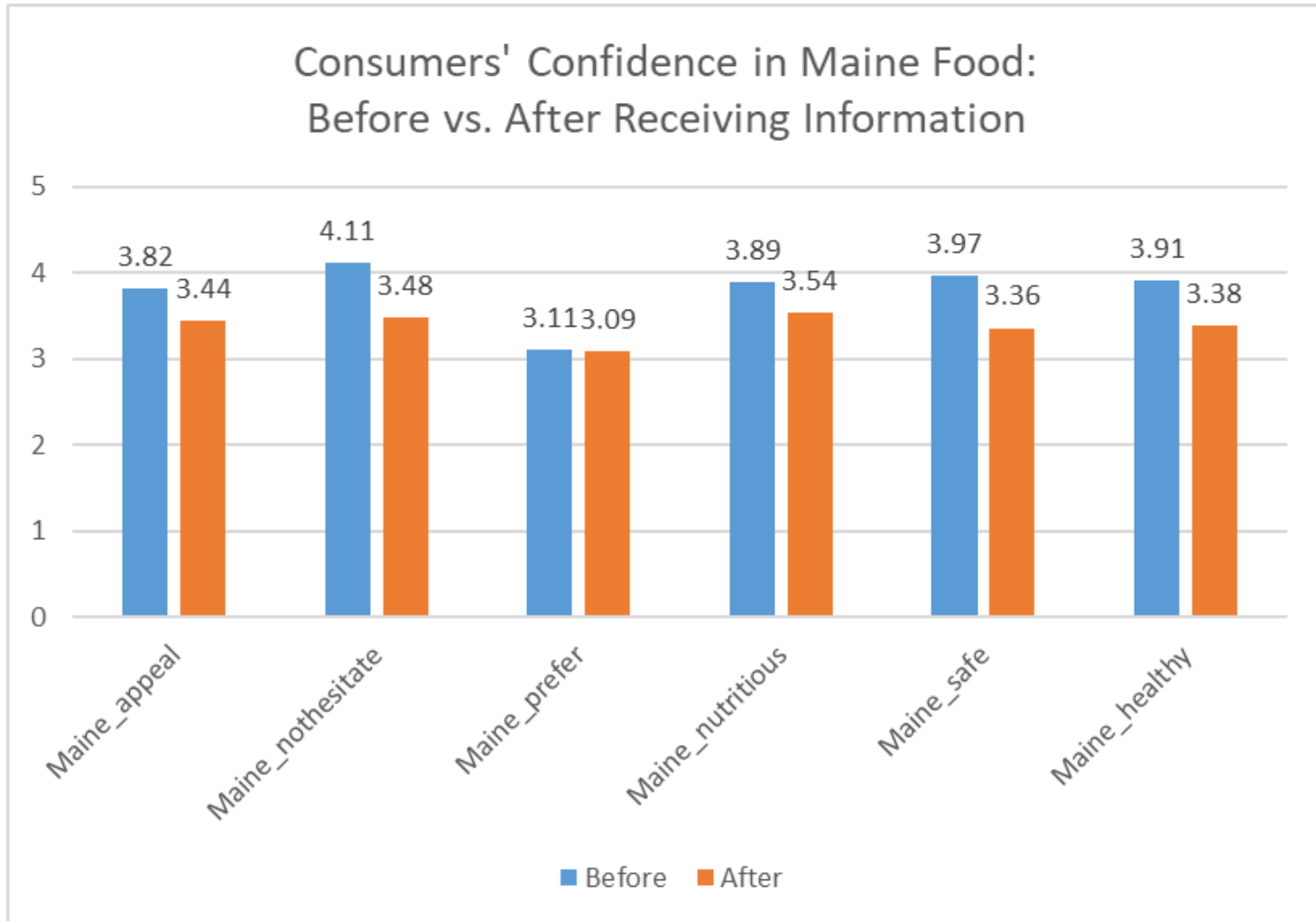
Northeast Consumer Surveys

- Focus on improving/restoring Consumer Confidence in Maine's food system through messaging
- N=607
- Northeast consumers (CT, MA, ME, NH, NJ, NY, PA, RI, VT)

	Strongly disagree (1)	(2)	(3)	(4)	Strongly agree (5)
Food grown and produced in Maine is appealing to me (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would not hesitate to purchase food grown or produced in Maine (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would prefer to purchase food grown and produced in Maine (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Food grown and produced in Maine is nutritious (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Food grown and produced in Maine is safe (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Food grown and produced in Maine is healthy (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Scale administered before and after message conditions

The Real Maine brand exists, and it is hurt by talking about PFAS



How we tested messages with consumers

0	Baseline	Information on what PFAS is, human health implications
T_1	Maine Licensed	Baseline + Maine <i>licensed</i> biosolids as fertilizer on farms
T_2	Maine Encouraged	Baseline + Maine <i>encouraged</i> use of biosolids on farms
T_3	Lots of states licensed	Baseline + <i>Many states licensed</i> biosolids as farm fertilizer
T_4	Maine and Michigan are testing & acting	Baseline + Many states licensed; <i>Maine and Michigan are testing</i> ; Maine outlawed spread in 2022
T_5	Maine Two Sided	Baseline + Many states licensed biosolids + <i>Maine Two-sided</i>
T_6	Maine Taking Steps	Baseline + Many states licensed biosolids + <i>Maine Taking Steps</i>
T_7	Maine Two Sided and Taking Steps	Baseline + Maine Two-sided + Maine Taking Steps

How we tested messages with consumers

(3) Lots of states licensed

- **Many states licensed the use of municipal wastewater**, also known as biosolids or sludge, as a fertilizer on farm fields starting in the 1970's. This activity was licensed because at the time little was known about PFAS. The legacy of this application of biosolids is that farms across the U.S. test at higher than recommended levels of PFAS.

(4) Maine and Michigan are on the ball!

- **Many states licensed the use of municipal wastewater**, also known as biosolids or sludge, as a fertilizer on farm fields starting in the 1970's. This activity was licensed because at the time little was known about PFAS. The legacy of this application of biosolids is that farms across the U.S. test at higher than recommended levels of PFAS.

Currently, only two states – Maine and Michigan – routinely test sludge and soil and water at farms for PFAS. Both states routinely find contamination. **Maine became the only state to outlaw the spreading of sludge as fertilizer in 2022.**

How we tested messages with consumers

(5) Two-Sided

- Many states, including Maine, licensed the use of municipal wastewater, also known as biosolids sludge, as a fertilizer on farm fields starting in the 1970's. This activity was licensed because at the time little was known about PFAS. The legacy of this application of biosolids is that farms across the U.S. test at higher than recommended levels of PFAS. Maine became the only state to outlaw the spreading of sludge as fertilizer in 2022.

The bad news is, there is PFAS in Maine. The good news is, Maine is taking steps to address contamination. Maine is one of the first states to invest in testing for contamination and educating the public about the dangers of PFAs in food production. Many people are learning about the dangers of PFAS in the food system as they learn about steps that Maine is taking to address the problem. This has the potential to inadvertently harm Maine's food sector by making it seem disproportionately contaminated, when it is actually one of very few states looking for contamination. Maine's willingness to lead on educating the public, even when the news is negative, is unique in the nation.

(6) Taking Steps

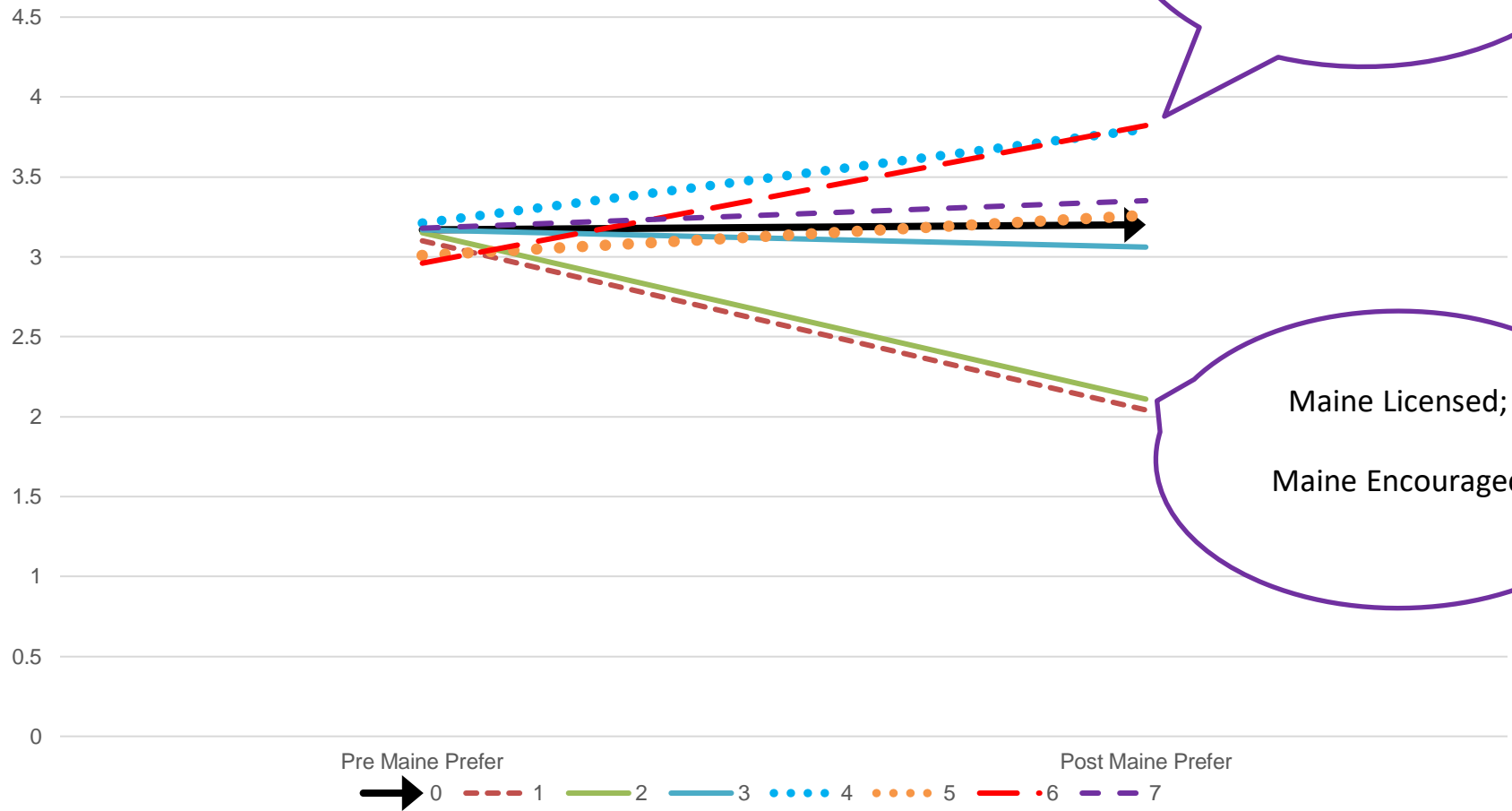
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Maine is proactively addressing PFAS contamination by passing laws that require the testing of soil and groundwater for PFAS at locations licensed for biosolid application and near landfills. In fact, Maine's PFAS standards were stricter than EPA standards until 2022. Many farmers in Maine are voluntarily pulling their crops when their water and food test "high". Maine is one of two states routinely testing sludge and farms for PFAS and is the only state to have outlawed the spreading of sludge as fertilizer.

What messages work?

Variable	Model (1)		Model (2)	
	Coef.	Std. Err.	Coef.	Std. Err.
<i>T1_maine</i>	-1.330***	0.140	-1.346***	0.141
<i>T2_maine_encourage</i>	-1.194***	0.137	-1.204***	0.138
<i>T3_many_states</i>	-0.212	0.134	-0.224*	0.135
<i>T4_many_mm_test</i>	0.286**	0.138	0.273**	0.138
<i>T5_2sided</i>	-0.060	0.136	-0.073	0.137
<i>T6_steps</i>	0.511***	0.136	0.496***	0.137
<i>T7_2sided_steps</i>	0.014	0.136	0.008	0.136
<i>aware/concern</i>			-0.141*	0.082
<i>T1_maine*aware/concern</i>			0.088	0.121
<i>T2_maine_encourage*aware/concern</i>			0.151	0.112
<i>T3_many_states*aware/concern</i>			0.124	0.113
<i>T4_many_mm_test*aware/concern</i>			0.148	0.117
<i>T5_2sided*aware/concern</i>			0.142	0.117
<i>T6_steps*aware/concern</i>			0.229**	0.115
<i>T7_2sided_steps*aware/concern</i>			0.038	0.117
constant	-0.187*	0.097	-0.174*	0.097
Number of obs.	592		592	
Adj R-Squared	0.346		0.344	

Different messages yield different responses:
"I would prefer to purchase food grown and produced in Maine"

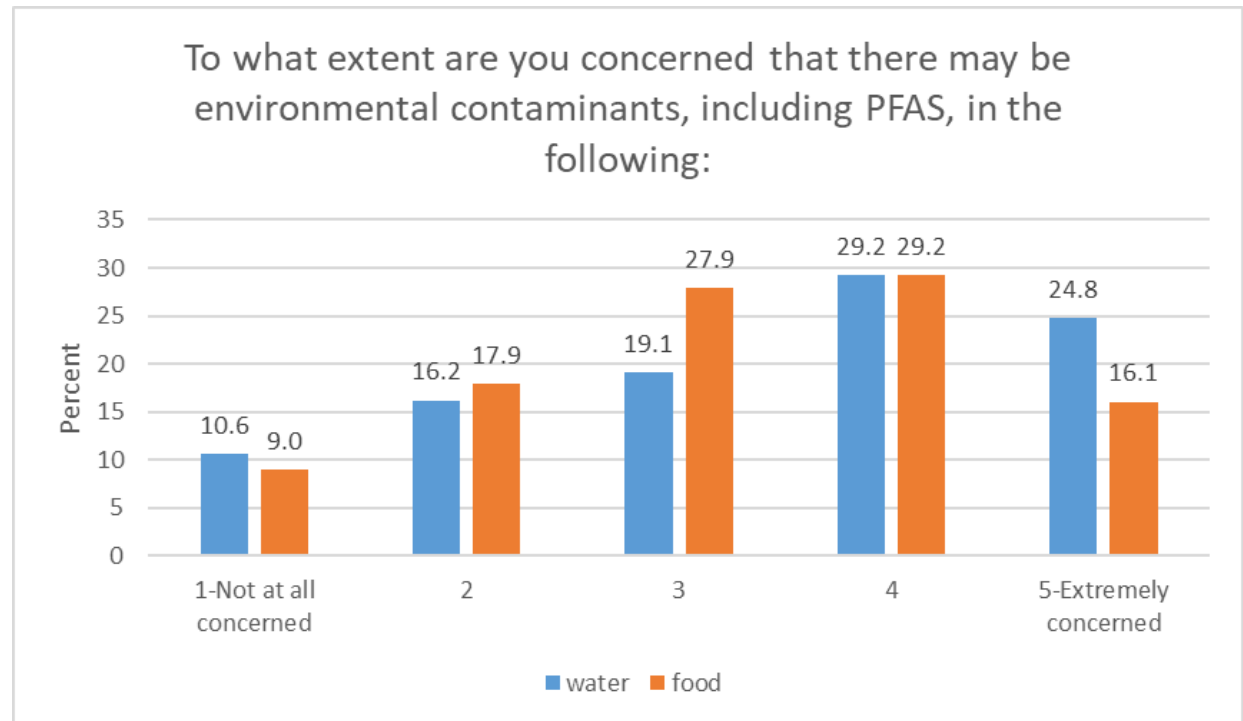
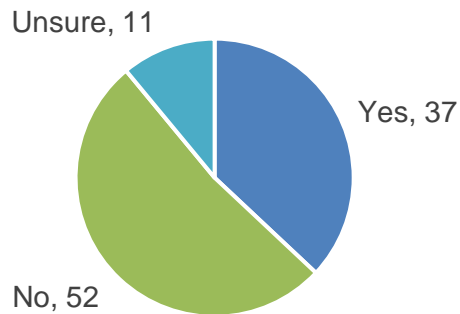


Maine and Michigan are testing
 Maine Taking Steps

Maine Licensed;
 Maine Encouraged

We all think about PFAS a lot, but not everyone has the same priors.....

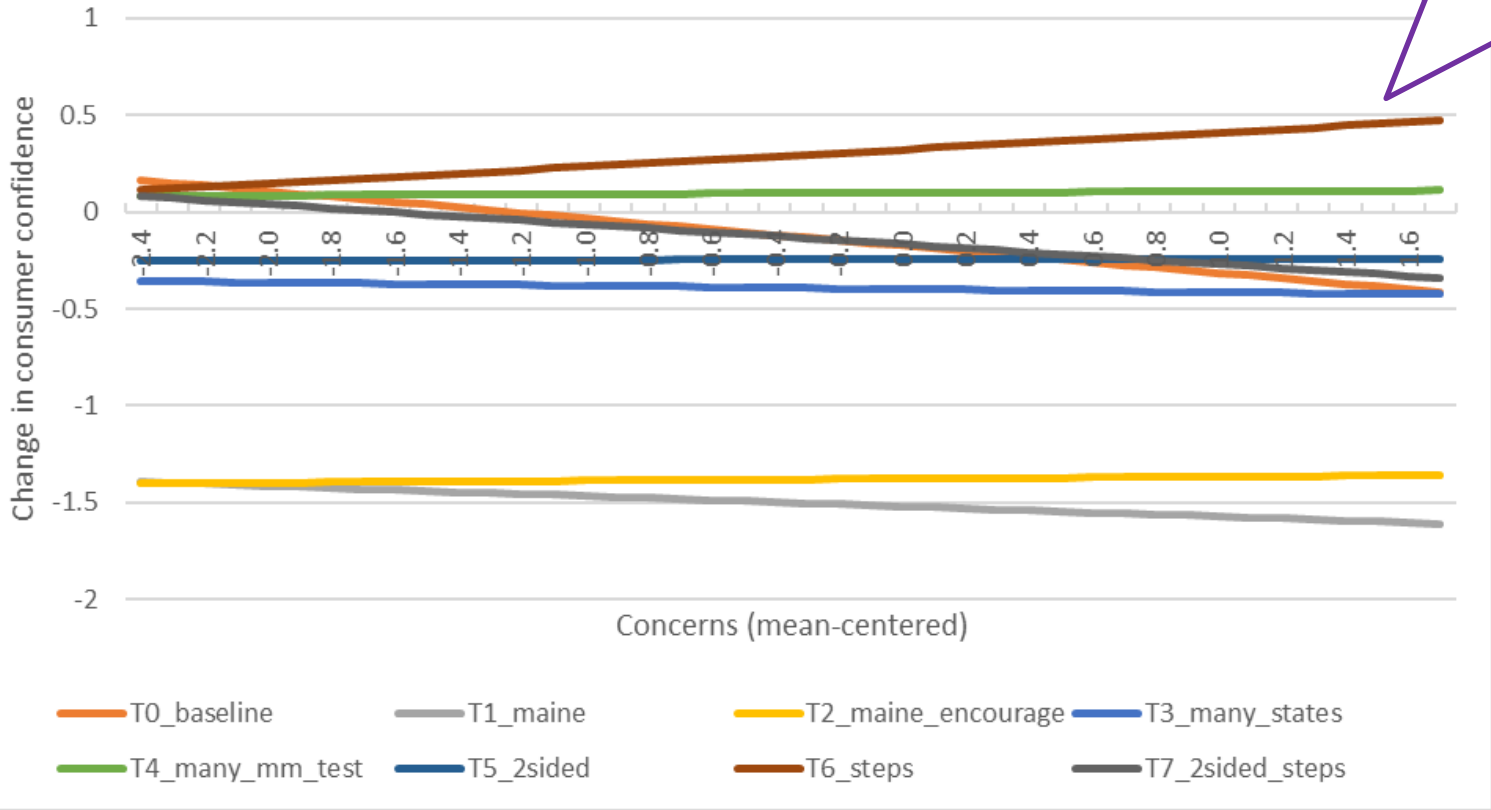
Have you heard of PFAS in food or drinking water? (%)



What about people with different levels of awareness/concern?

Variable	Model (1)		Model (2)	
	Coef.	Std. Err.	Coef.	Std. Err.
<i>T1_maine</i>	-1.330***	0.140	-1.346***	0.141
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Number of obs.	592		592	
Adj R-Squared	0.346		0.344	

Do messages work differently, on people with different levels of awareness/concern?



How can our Case Study help?

(1) Consumers who hear about PFAS in food systems are concerned

- But respond *very positively* to messages about states acting (testing, banning biosolids, etc.) to protect food systems

(2) People have different levels of awareness/concern – but the messages can still work

The next Socio-Economic Questions (?)

(1) Impacts on Farm Families

- Physical and Mental Health Impacts
- Variety of voices (size of farm, products, locations, etc.)
- Financing for Farming (loan requirements, etc.)
- Non-farm Employment (opportunities, training, etc.)

(2) Impacts on Farm Communities and beyond: Property Values

- if some farms can no longer be farms, what happens to the price of other farmlands? (scare resource prices....) Tax implications of removing land from farms (easements, etc.)
- What happens to property values with PFAS findings in the town?
- What can be done with properties that are no longer farms?

The next Socio-Economic Questions (?)

(3) **Impacts on Farm Communities and beyond: Communication**

- Appropriate testing and labeling of food (and are consumers/citizens willing to pay because this isn't costless for farmers or government....)
- What actions are people taking to lessen their exposure? Are they the 'right' actions? (ex: filters for waters; avoiding certain types of foods)

(4) **Impacts on Farm Communities and beyond: Large Scale**

- Environmental Justice (rural communities, Tribal Nations, other)
- Changes to our waster management systems - if we don't spread biosolids, now go to landfills – are our landfills ready? Price of garbage disposal?

“Wicked” Problems Need Wicked Teams And funding!!

- USGS: 104b (G21AP10591); 104g (G22AP00014)
- National Science Foundation: National Research Training Program, One Health and the Environment (Grant No. 1922560).
- Maine Agricultural and Forest Experiment Station: (5501285, 5501417)
- George J. Mitchell Center for Sustainability Solutions, University of Maine



Dr. David Hart
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Molly Shea
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Charity Zimmerman
M.S. Economics
Student
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Mel Godin
M.S. Economics
Student
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Thank you!

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Aroostook Farm

Witter Farm



High Moor Farm

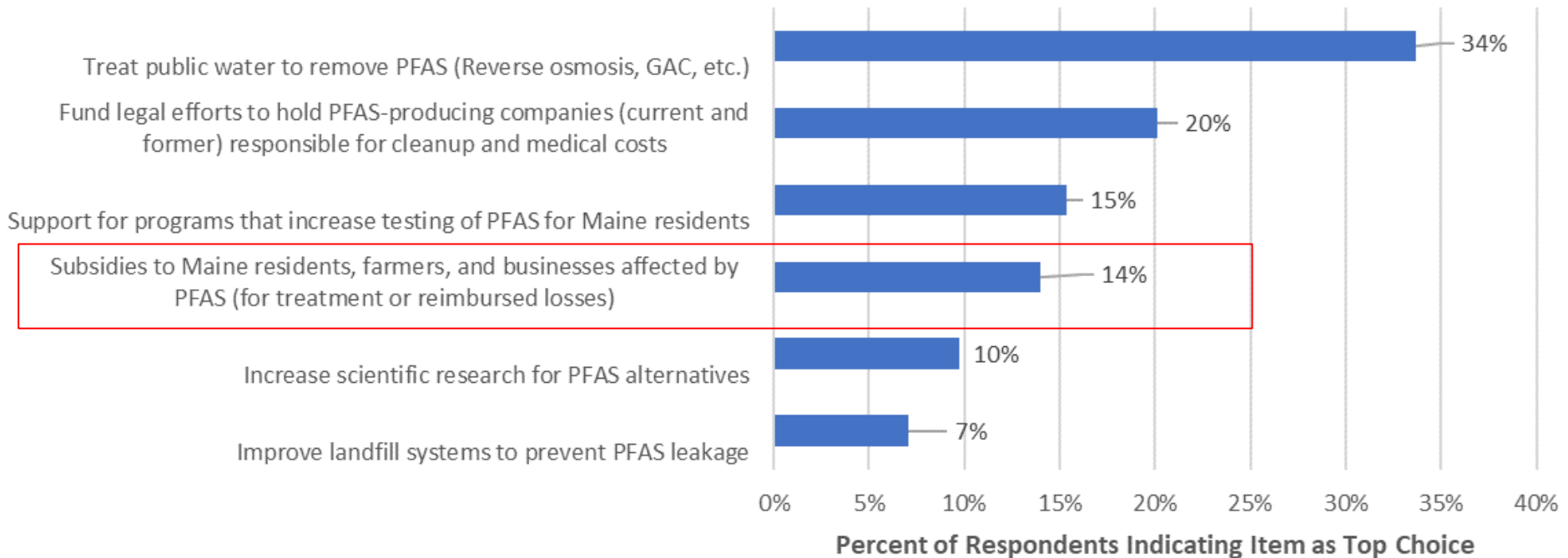


Welcome to Maine's center for fruit and vegetable research.



APPENDIX SLIDES

Citizen Preferences for PFAS Management Alternatives



- **48%** of respondents selected allocating funds toward subsidies for Maine residents, farmers, and businesses affected by PFAS in their **top 3 allocation choices**
- Respondents who **live near a farm** were more likely to rank subsidizing farms **higher** in their allocation preferences ($t = 1.52, P = 0.06$);
- Respondents who **had not heard of PFAS** were more likely to rank subsidies to farmers **lower** ($t = -1.59, P = 0.06$)

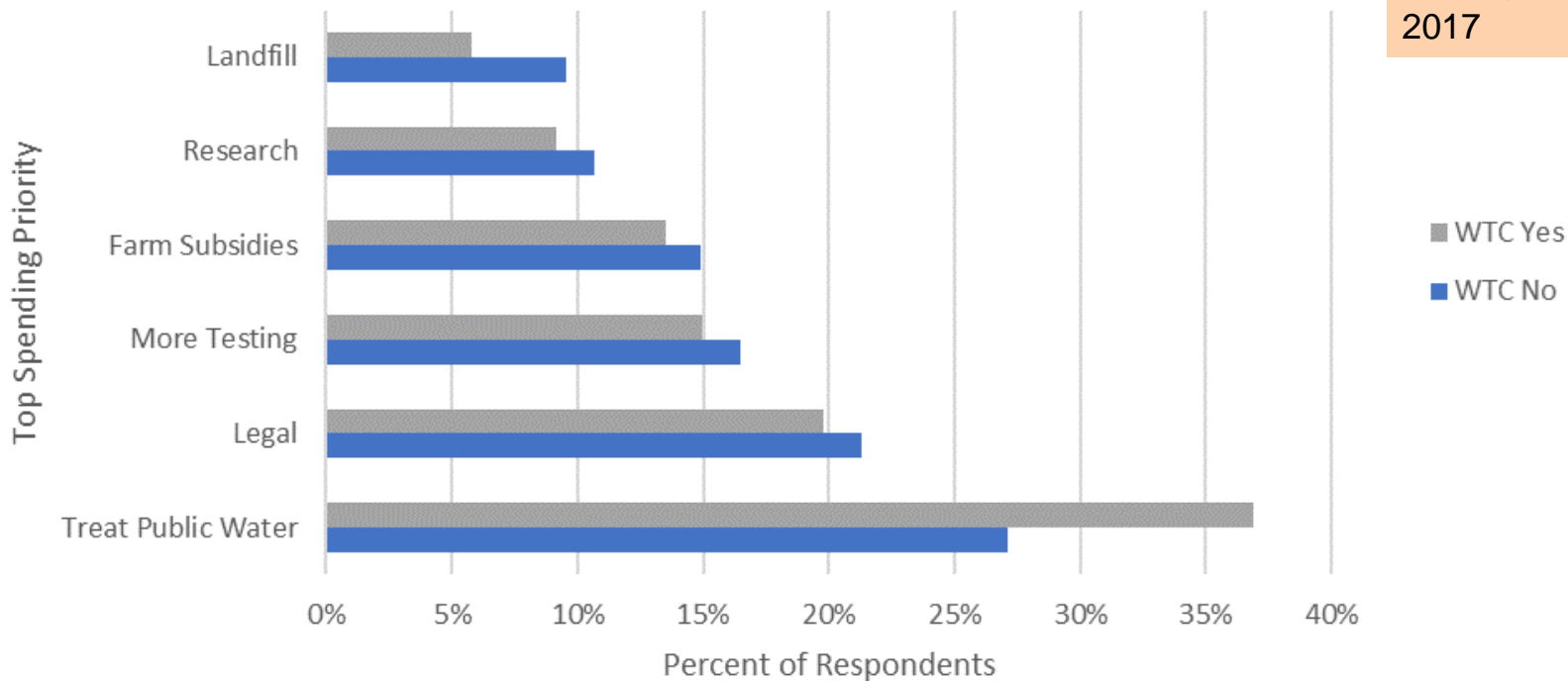
Do citizens have unrevealed preferences for PFAS management alternatives?

Relationship to WTP?

What about 'No' under WTP?

Jones et al, JBEE 2008
Noblet, Evans et al, ARER 2017

Allocation Choice and Willingness to Contribute



How we tested messages with consumers

Baseline

- There is a family of chemicals known as per- and polyfluoroalkyl substances (this family of chemicals is often called PFAS). PFAS have been used for a long time in many household and industrial products. These chemicals are used to make products able to repel water and resist stains and grease. Some of these chemicals persist for a very long time once released into the environment, leading to the nickname ‘forever chemicals’ (they may also be called PFC, PFOA, PFOS or Chemical GenX). In this survey, we will continue to use the term PFAS to refer to this group of chemicals.

Because PFAS are present in so many products and manufacturing processes, we increasingly find evidence of PFAS contamination in wastewater and sludge or biosolids that result from wastewater treatment processes.

A growing body of scientific evidence shows that exposure to PFAS can negatively impact human health through a variety of mechanisms, including increasing cholesterol, decreasing vaccine response, and increased risk of certain kinds of cancer. PFAS can remain in our bodies long after our exposure has stopped.

How we tested messages with consumers

Maine licensed

- The state of Maine **licensed the use of municipal wastewater**, also known as biosolids or sludge, as a fertilizer on farm fields from the 1970's to 2022. This **activity was licensed** because at the time little was known about PFAS. The legacy of this application of biosolids is that farms across Maine test at higher than recommended levels of PFAS.

Maine encouraged

- The state of Maine **encouraged the use of municipal wastewater**, also known as biosolids or sludge, as a fertilizer on farm fields from the 1970's to 2022. This **activity was encouraged as beneficial reuse** because it simultaneously saved towns money on their wastewater bills and provided farmers with nutrient rich material and because at the time little was known about PFAS. The legacy of this application of biosolids is that farms across Maine test at higher than recommended levels of PFAS.

How we tested messages with consumers

Two-Sided and Taking Steps

- Many states, including Maine, licensed the use of municipal wastewater, also known as biosolids sludge, as a fertilizer on farm fields starting in the 1970's. This activity was licensed because at the time little was known about PFAS. The legacy of this application of biosolids is that farms across the U.S. test at higher than recommended levels of PFAS. Maine became the only state to outlaw the spreading of sludge as fertilizer in 2022.

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