

PFAS in Agricultural Systems

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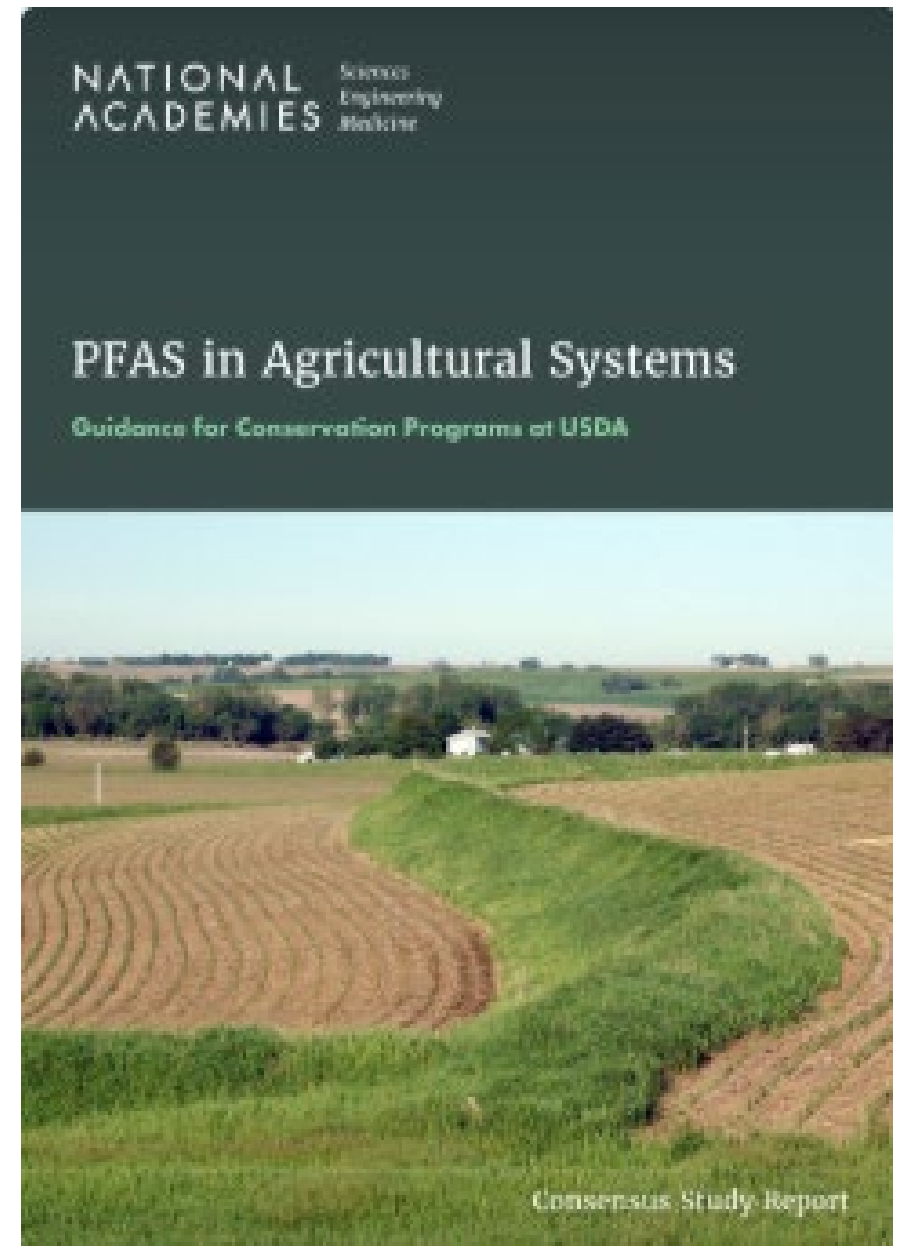
THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,
AND ENVIRONMENTAL SCIENCES

Assistance to the U.S. Department of Agriculture in Building a Framework for Addressing PFAS on Agricultural Land

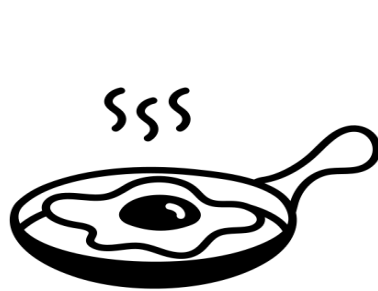
Free download, but you do need to provide an email account:

<https://www.nationalacademies.org/projects/DELS-BANR-24-03/publication/29272>



What are Per- and polyfluoroalkyl substances (PFAS)?

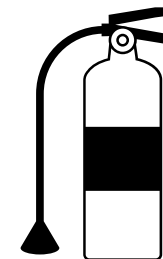
- > 20,000 PFAS compounds
 - “Persistent Chemicals” known for resisting heat, oil, stains, and water
 - Strong C-F bond; this bond is not naturally found in nature
 - Short vs. Long Chain PFAS
- They're everywhere!



Non-stick
cookware (Teflon)



Water-repellent
clothing

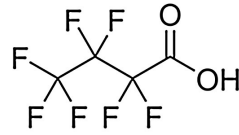


Fire-fighting
foams

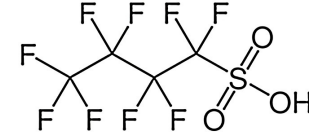


Food
packaging

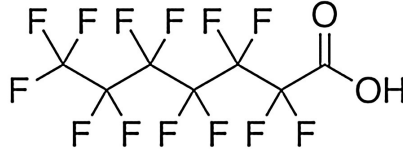
What do they look like?



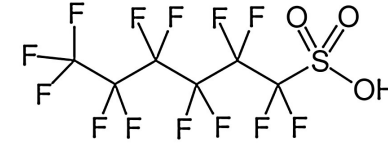
Perfluorobutanoic acid (PFBA)



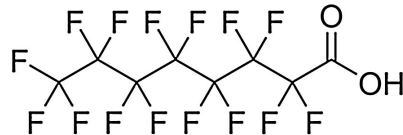
Perfluorobutane sulfonic acid (PFBS)



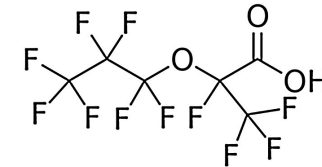
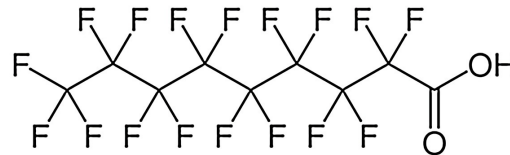
Perfluoroheptanoic acid (PFHpA)



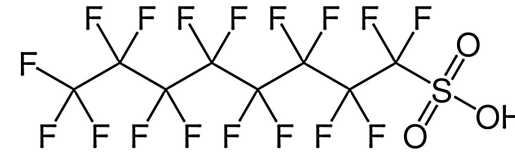
Perfluorohexane sulfonic acid (PFHxS)



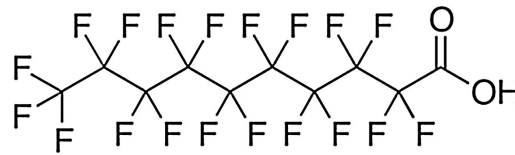
Perfluorooctanoic acid (PFOA)

Hexafluoropropylene oxide dimer acid
(HFPO-DA or GenX)

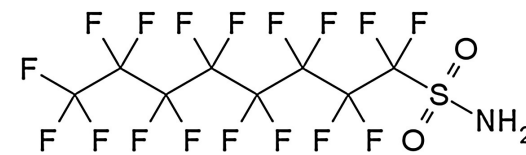
Perfluorononanoic acid (PFNA)



Perfluorooctane sulfonic acid (PFOS)



Perfluorodecanoic acid (PFDA)



Perfluorooctanesulfonamide (PFOSA)

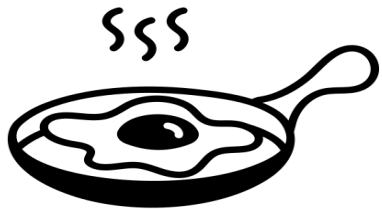
— Pathway of PFAS of concern?

What most people think:



— But.....again:

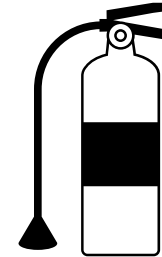
What most people should be thinking



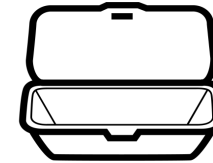
Non-stick
cookware (Teflon)



Water-repellent
clothing

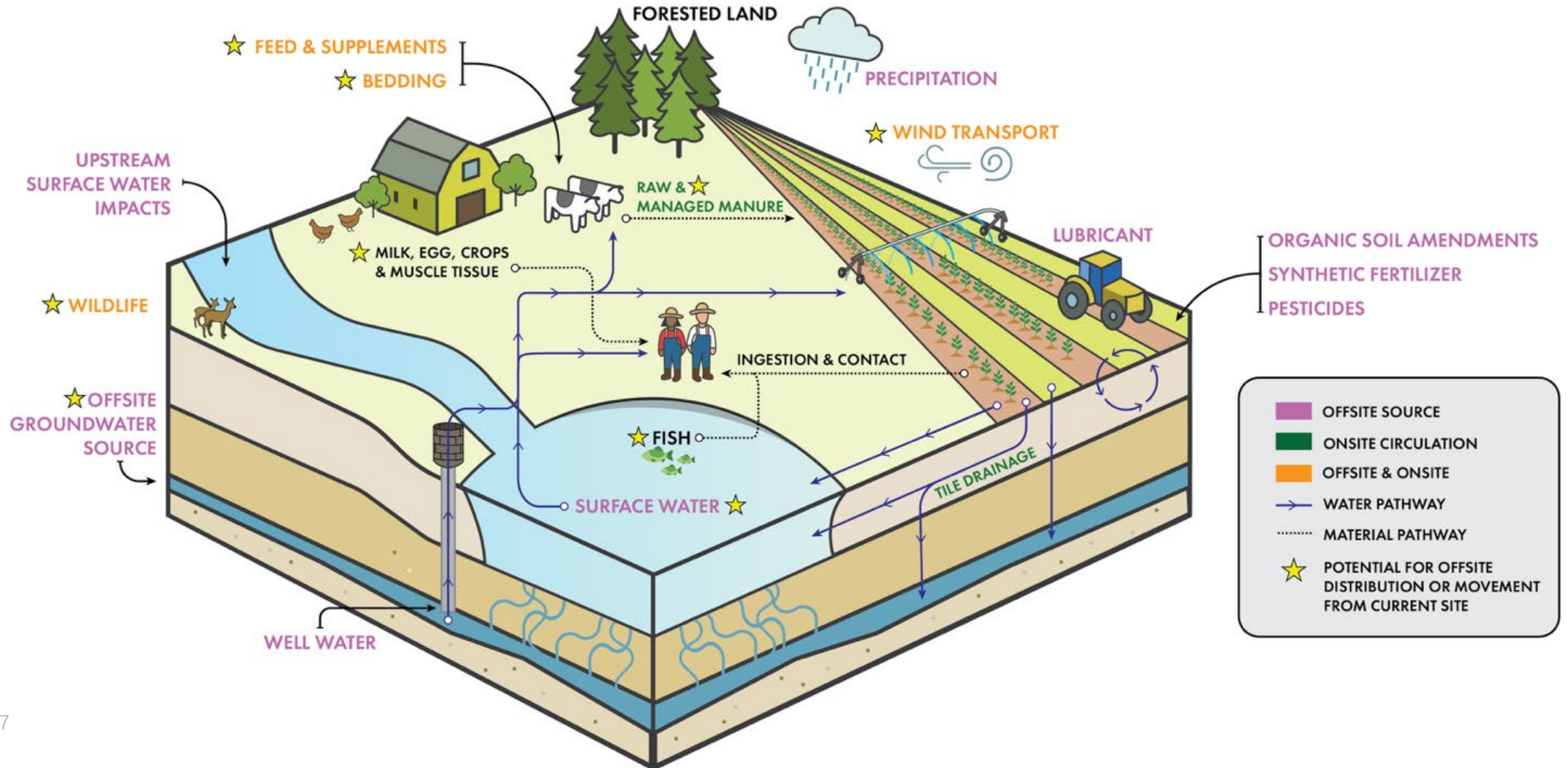


Fire-fighting
foams



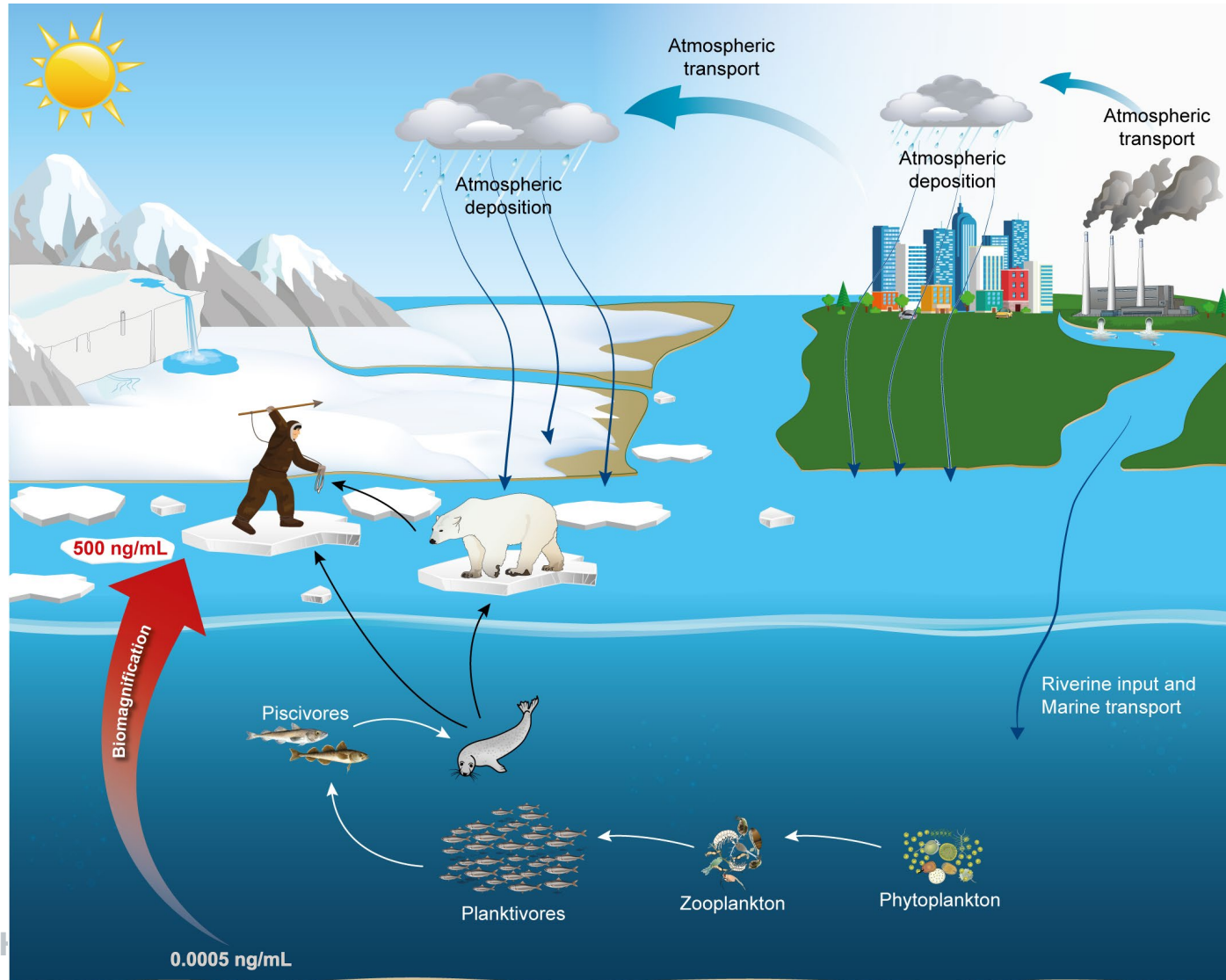
Food
packaging

Why are PFAS of concern?



Why are PFAS of concern?

Even more complicated:

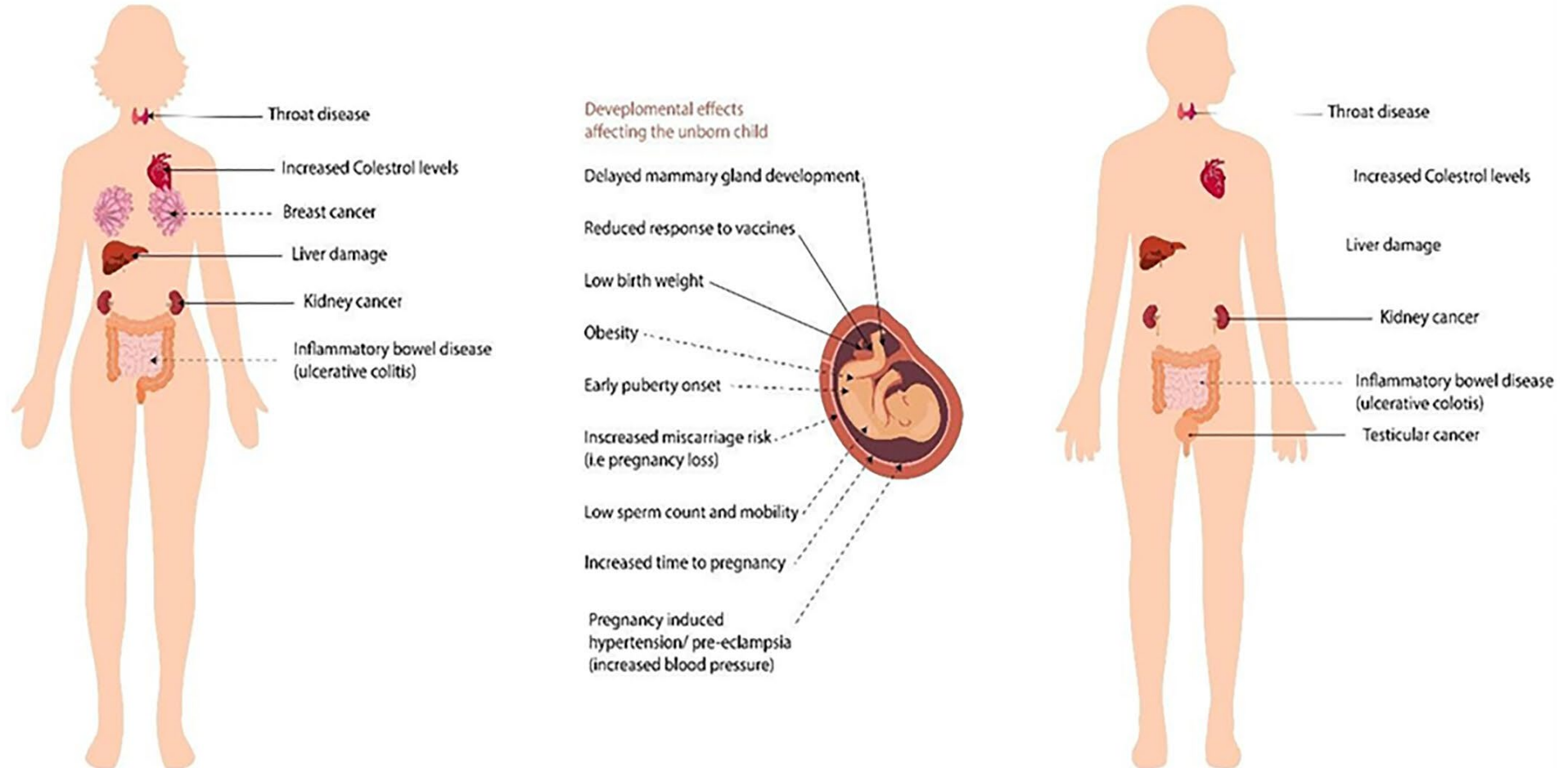


Aarhus University, Dep. Biology, 2026

ENVIRONMENTAL SCIENCES

Why are PFAS of concern?

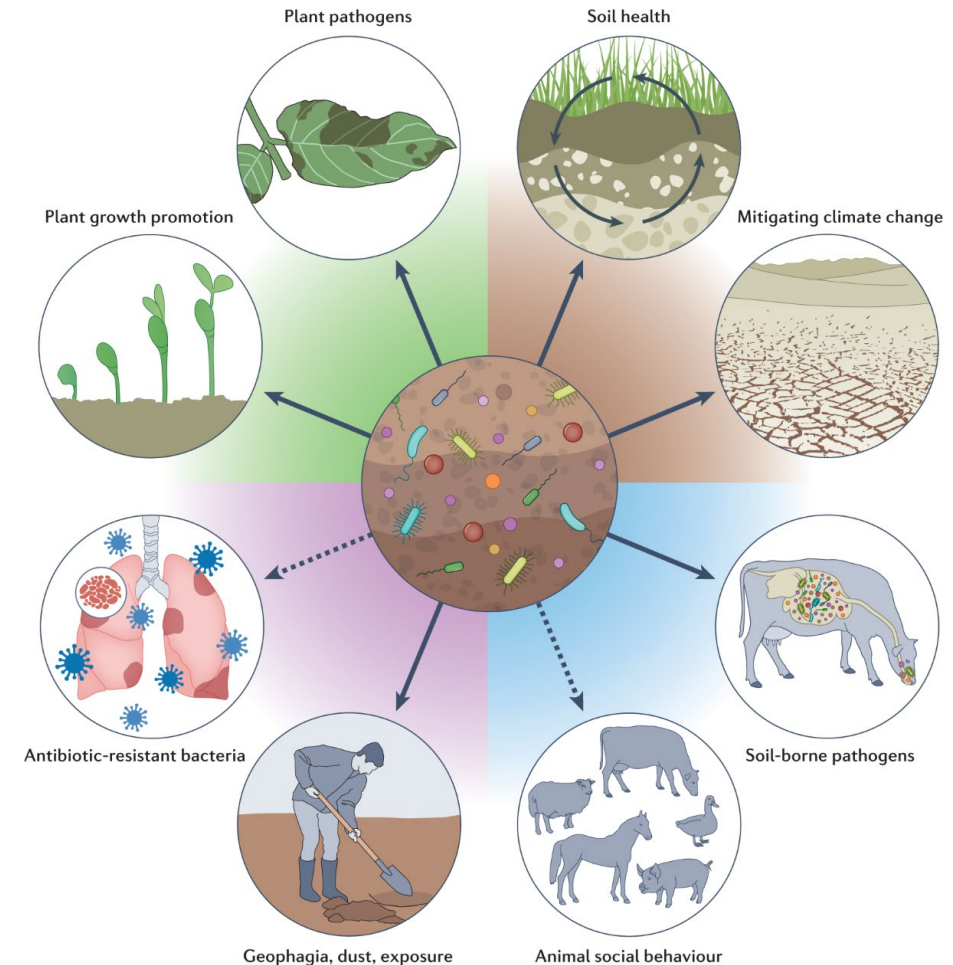
———— High certainty
----- Low certainty



Why are PFAS of concern?

Once present in soils, it has been either shown or thought that:

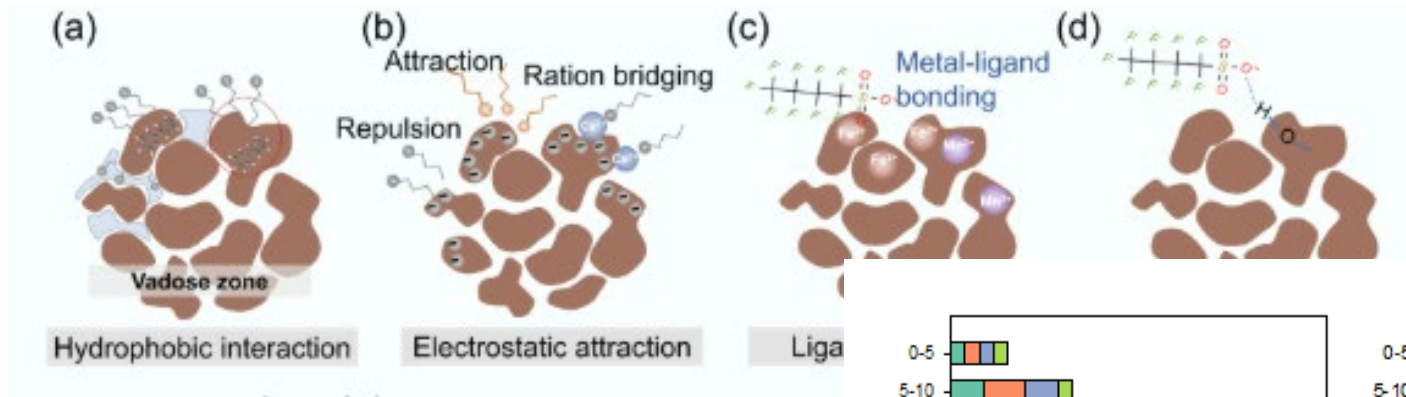
- Microbial communities can be altered.
 - Actinobacteria communities decrease, shifting microbial population towards PFAS tolerant species
 - These species decompose tough organic materials like lignin, they help cycle nutrients, and produce antibiotics that help plants fight pathogens and other stressors
- Long-chain PFAS (like PFOS) can suppress microbial enzymes that are vital for C and N cycling.
 - E.g., sucrase, urease
- PFAS may suppress aggregate formation.



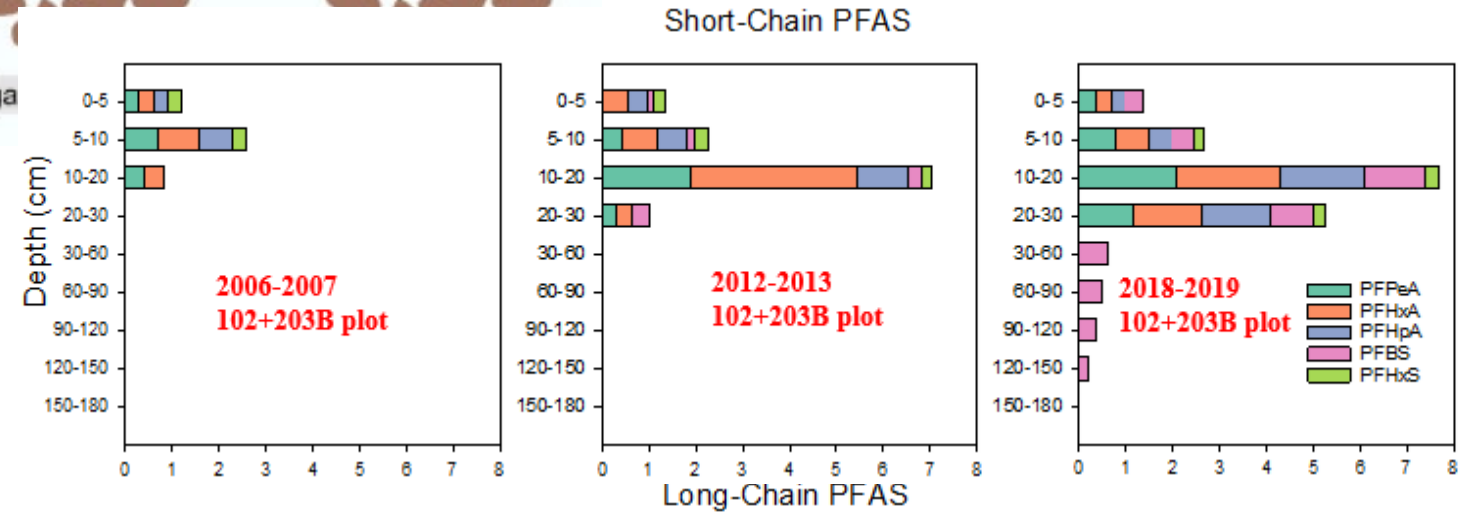
Banerjee and van der Heijden; Nature Reviews Microbiology (2023)

Why are PFAS of concern?

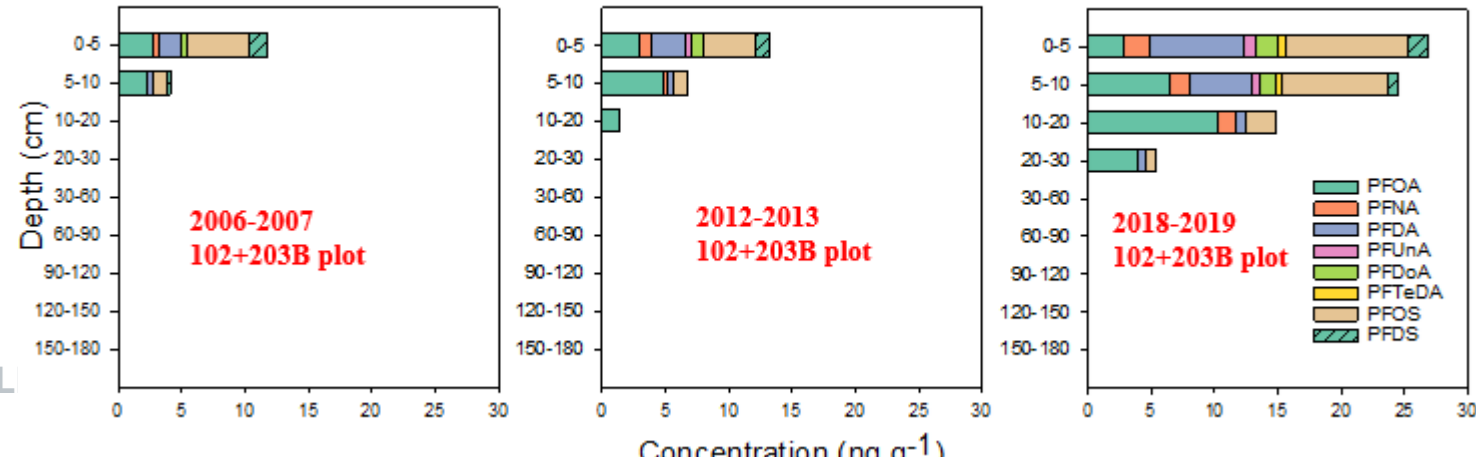
Soils:



Han et al., (2025) New Contam.



Hui, Ippolito, et al. (to be published)



Why are PFAS of concern?

Soils:

	Background Sites	Primary-Source Contaminated Sites	Secondary-Source Contaminated Sites
	----- ug kg ⁻¹ -----		
Global:			
Total PFAS	<0.001-237	ND [†]	ND
Min. PFOA	0.01	2	0.8
Max. PFOA	123.6	50,000	2,531
Median PFOA	2.7	83	38
Min. PFOS	0.003	0.4	0.4
Max. PFOS	162	460,000	5,500
Median PFOS	2.7	8,722	680.5
U.S.:			
Total PFAS	<0.2-135	ND	ND
Min. PFOA	0.5	58	23.6
Max. PFOA	33	50,000	2,531
Min. PFOS	3.1	9,700	483
Max. PFOS	126	373,000	1,409

Why are PFAS of concern?

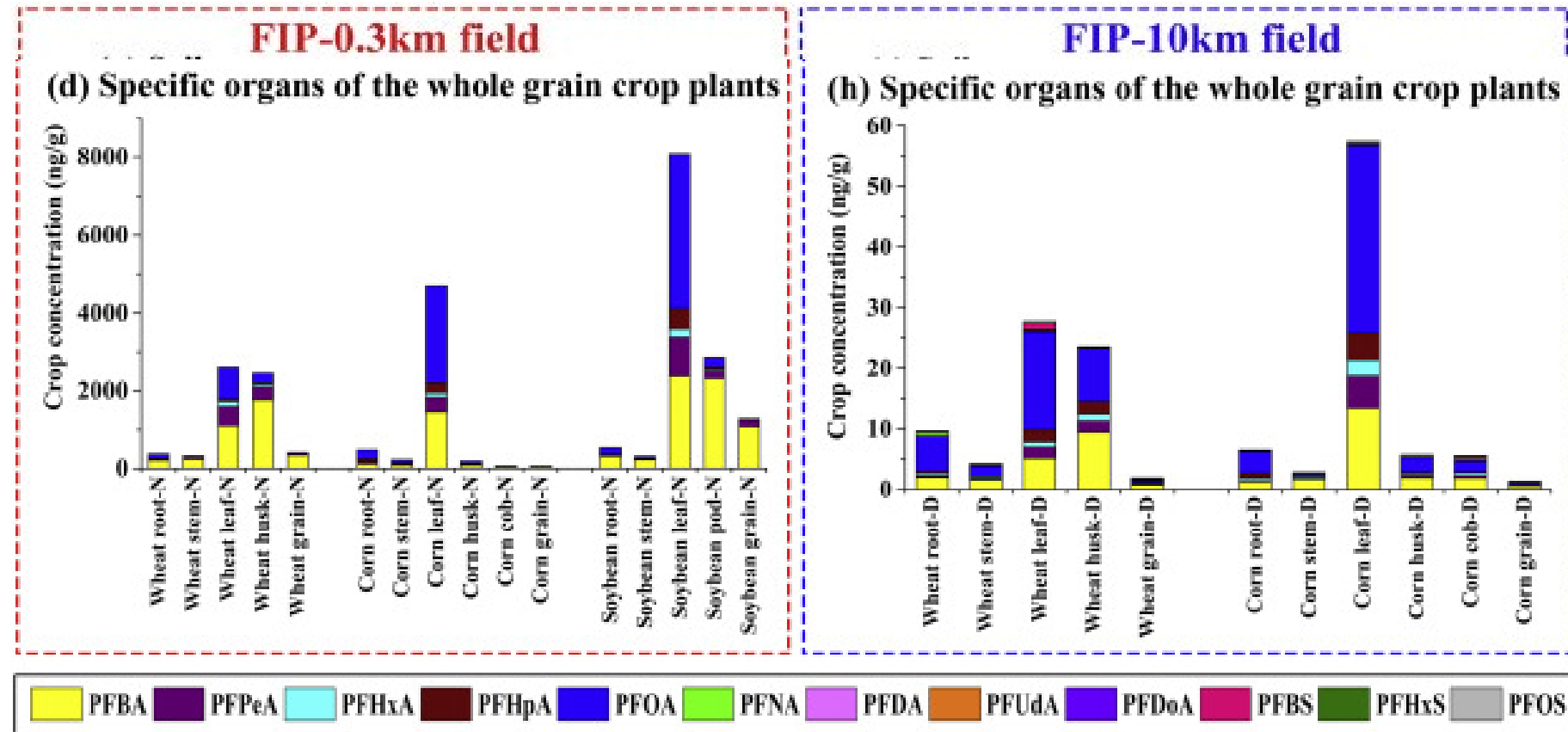
Crop Uptake:

- Often observed:

Grain < Stem < Leaves

Take home message:

Bioaccumulation is often greatest in leaf-raised crops (e.g., leafy vegetables, hay)



Liu et al., 2019 (Environ. Intern.)

Regulation Examples

Based on US EPA National Primary Drinking Water Regulations (revised 2025)

Ohio's PFAS 2024 Action Levels						
PFAS Chemicals* Parts per trillion (ppt)	PFOA	PFOS	GenX	PFBS	PFHxS	PFNA
New 2024 Action Levels	4.0	4.0	10	2,000**	10	10
Previous 2020 Ohio Action Levels	>70 single or combined with PFOS	>70 single or combined with PFOA	>700	>140,000	>140	>21
*PFOA (Perfluorooctanoic Acid), PFOS (perfluorooctane Sulfonate), GenX (HFPO dimer acid), PFBS (perfluorobutanesulfonic acid), PFHxS (perfluorohexane sulfonic acid), and PFNA (perfluorononanoic acid). **Health Based Water Reference Concentration (U.S. EPA 2023)						

Michigan Biosolids for PFOA or PFOS:

<20 ppb: landowner notification required; sampling within 30 days

20-100 ppb: Reduced application rate (max 1.5 dry tons/ac); implementation of a source reduction plan

>100 ppb: Land application prohibited

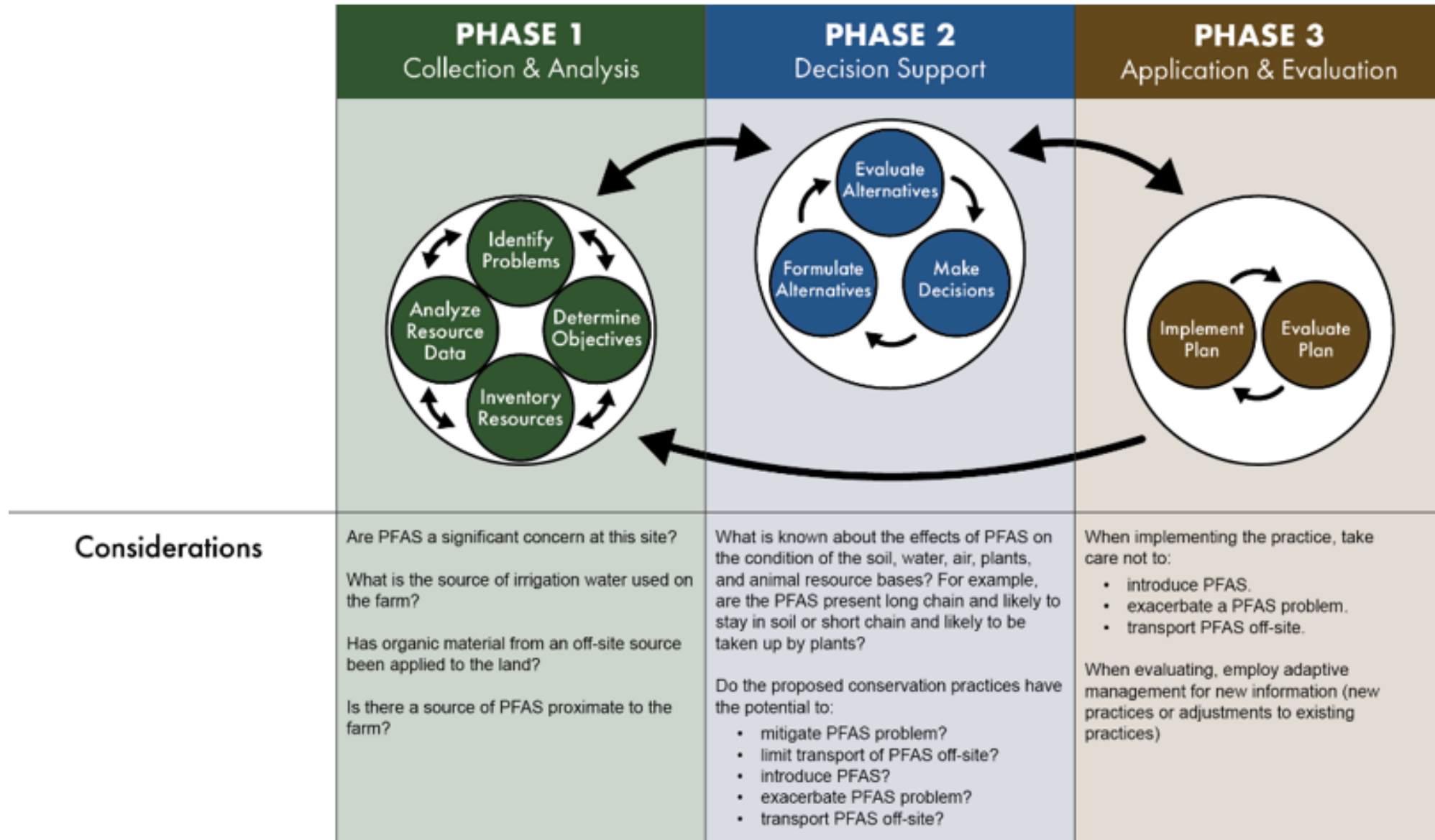
— How to manage on-farm PFAS?

Some initial thoughts:

- Understand what type of PFAS are present.
 - Short vs Long Chain
- Crop changes?
- Land retirement?
- Identify other actions, such as conservation practices, that could help avoid further PFAS accumulation



How to manage on-farm PFAS?



How to manage on-farm PFAS?

EX:

PFAS could be addressed in a conservation plan through existing resource concerns and conservation practice standards (~170ish), such as those pertaining to the transport of pathogens and chemicals to water, or through the creation of a standalone resource concern, much as nutrient transport to surface water and groundwater are standalone resource concerns.

There are pros and cons to either approach which would have to be considered by the USDA-NRCS.

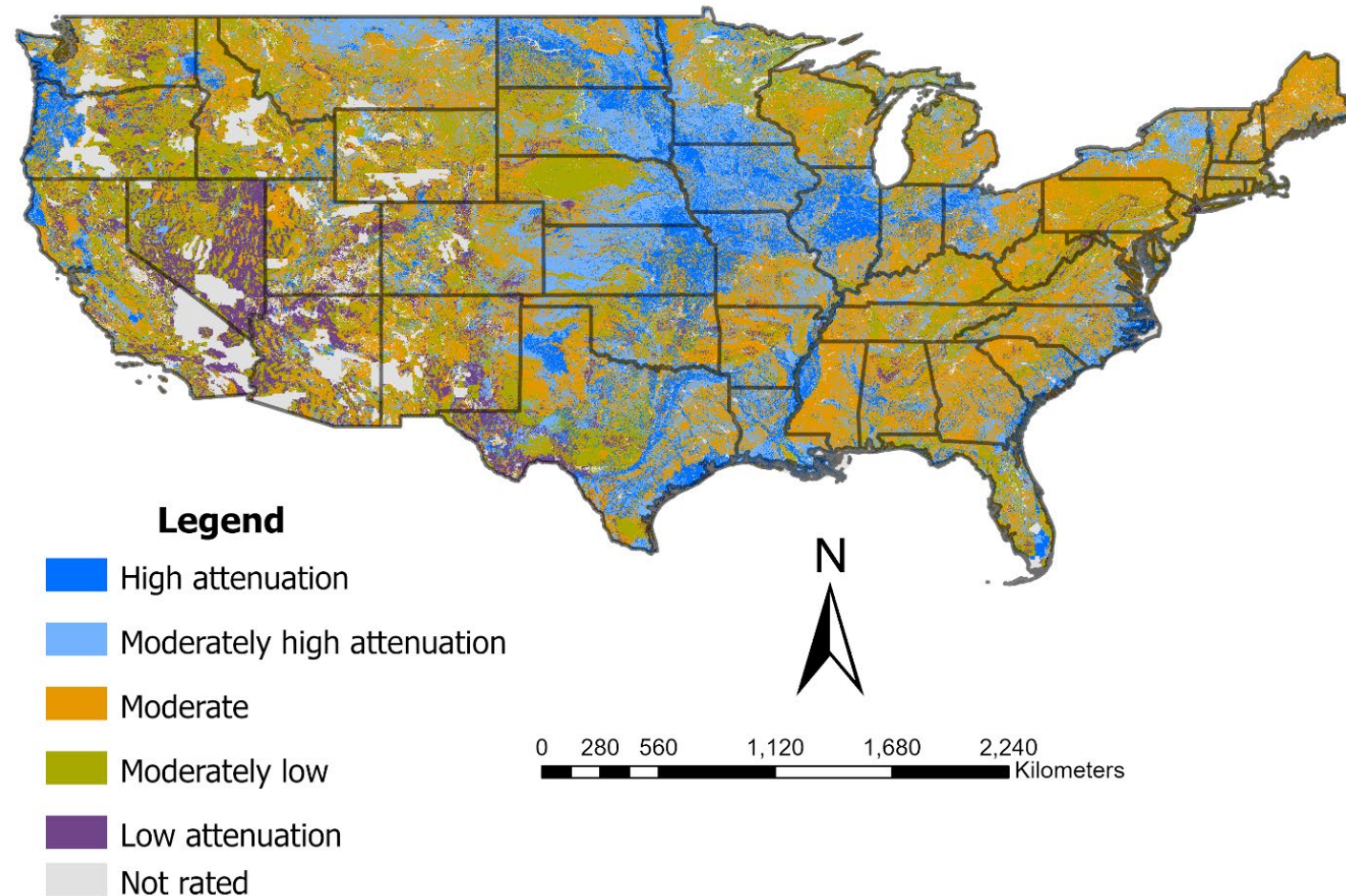
Snippet:

Purpose of practices and enhancements	Could have these positive impacts related to PFAS	Could have these negative impacts related to PFAS	Example practices with NRCS code
Increase soil carbon	Reduce plant uptake by immobilizing PFAS in soil*	<u>Introduce</u> PFAS onto the farm by importing contaminated materials	Soil Carbon Amendment (Code 336) <u>Nutrient</u> Management (Code 590)
Improve nutrient management	Reduce surface loss of PFAS if a nutrient source with unknown contamination is applied via subsurface injection	<u>Introduce</u> PFAS onto the farm by importing contaminated materials	Nutrient Management (Code 590)

How to manage on-farm PFAS?

Gather basic information as to whether a farm might have an issue: Web Soil Survey

- Might help further identify the presence/absence, or transport of PFAS to ground or surface waters, all based on soil properties



How to manage on-farm PFAS?

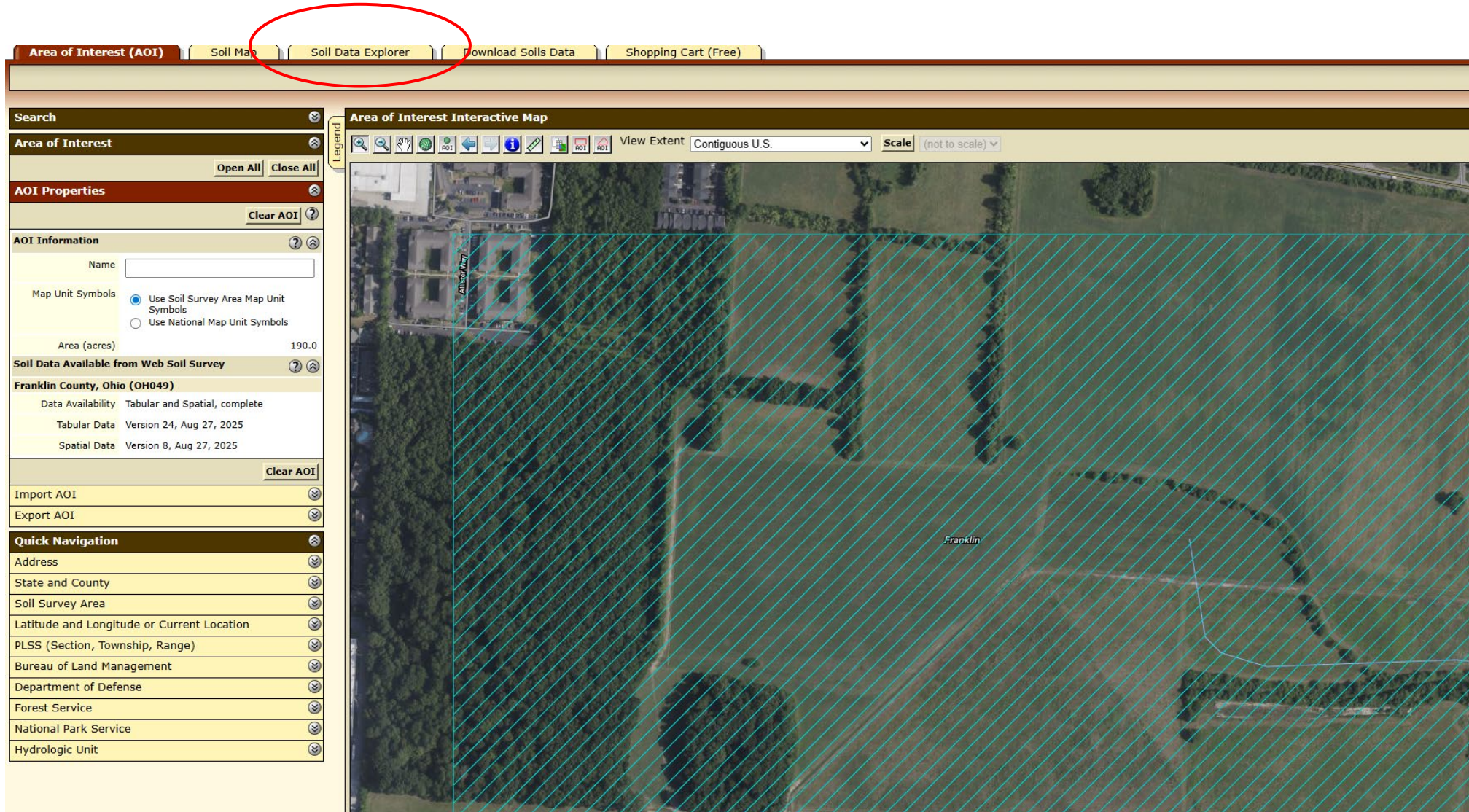
How to find this information in the web Soil

1. Go to the Web Soil Survey:
<https://websoilsurvey.nrcs.usda.gov/app/>



How to manage on-farm PFAS?

2. Zoom in and select your area of interest (AOI), then
3. Click on the “Soils Data Explorer” tab on the top



How to manage on-farm PFAS?

4. Next, choose the “Suitabilities and Limitations for Use” tab, and then choose
5. The “Land Classifications” line

The screenshot displays the 'Soil Data Explorer' web application. At the top, there are tabs for 'Area of Interest (AOI)', 'Soil Map', 'Soil Data Explorer' (which is active), 'Download Soils Data', and 'Shopping Cart (Free)'. Below these, a dropdown menu shows 'View Soil Information By Use: All Uses'. A secondary row of tabs includes 'Intro to Soils', 'Suitabilities and Limitations for Use' (circled in red), 'Soil Properties and Qualities', 'Ecological Sites', and 'Soil Reports'. On the left side, there is a 'Search' section with 'Basic Search' and 'Advanced Search' fields. Below that is a 'Suitabilities and Limitations Ratings' section with a list of categories. 'Land Classifications' is circled in red in this list. The main area of the application is a map titled 'Soil Map' showing an aerial view of a landscape with orange contour lines and labels such as 'CrA' and 'CrB'. A legend is visible on the left side of the map area.

How to manage on-farm PFAS?

9. This box should pop open:

I choose Attenuation in Soils



Land Classifications	
Conservation Tree and Shrub Group	⌵
Conservation Tree and Shrub Group OLD	⌵
Ecological Classification ID	⌵
Ecological Classification Name	⌵
Farmland Classification	⌵
Hydric Rating by Map Unit	⌵
Irrigated Capability Class	⌵
Irrigated Capability Subclass	⌵
National Commodity Crop Productivity Index	⌵
NCCPI Corn Productivity	⌵
NCCPI Small Grains Productivity	⌵
NCCPI Soybeans Productivity	⌵
NH Forest Soil Group	⌵
Nonirrigated Capability Class	⌵
Nonirrigated Capability Subclass	⌵
NRCS Ecological Site ID	⌵
NRCS Ecological Site Name	⌵
Order of Soil Survey	⌵
Pasture and Hayland Suitability Group 2 (OH)	⌵
PFAS Attenuation in Soils	⌵
PFAS Movement Classes	⌵
Soil Moisture Class	⌵
Soil Moisture Subclass	⌵
Soil Taxonomy Classification	⌵
Soil Taxonomy Great Group	⌵

How to manage on-farm PFAS?

6. This box opens up below the “PFAS attenuation in soils” line that you just clicked on:
7. Choosing “view description” will provide you a lengthy text box focused on how attenuation was determined.
8. Choosing “view rating” and making sure the map “box” is checked will give you a map.

I choose “view rating”.

PFAS Attenuation in Soils

View Description **View Rating**

View Options

Map ☒

Table ☒

☐ Component Breakdown and Rating Reasons

☐ Numeric Values

Description of Rating ☒

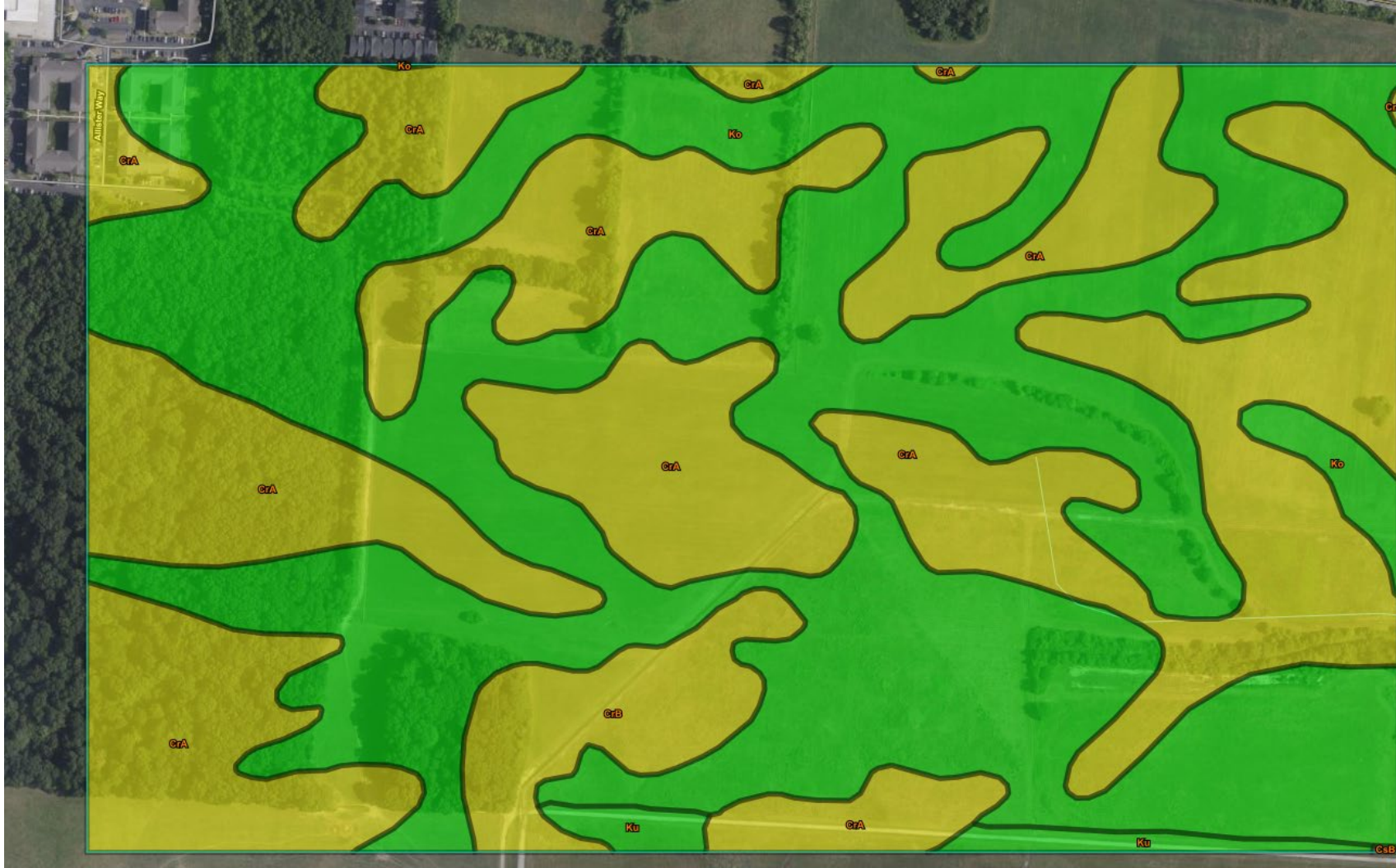
Rating Options ☒

☐ Detailed Description

Advanced Options

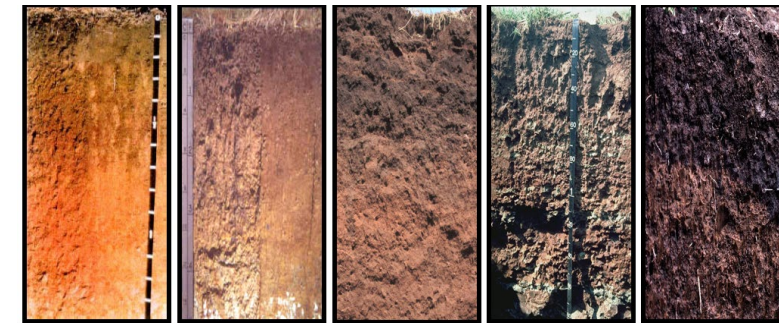
— How to manage on-farm PFAS?

10. A color-coded map appears that mimics a traffic light.



Missing from the Web Soil Survey is any actual data associated with any of these soil series.

This could be a next step for the NRCS to tackle via partnerships with OSU, others.



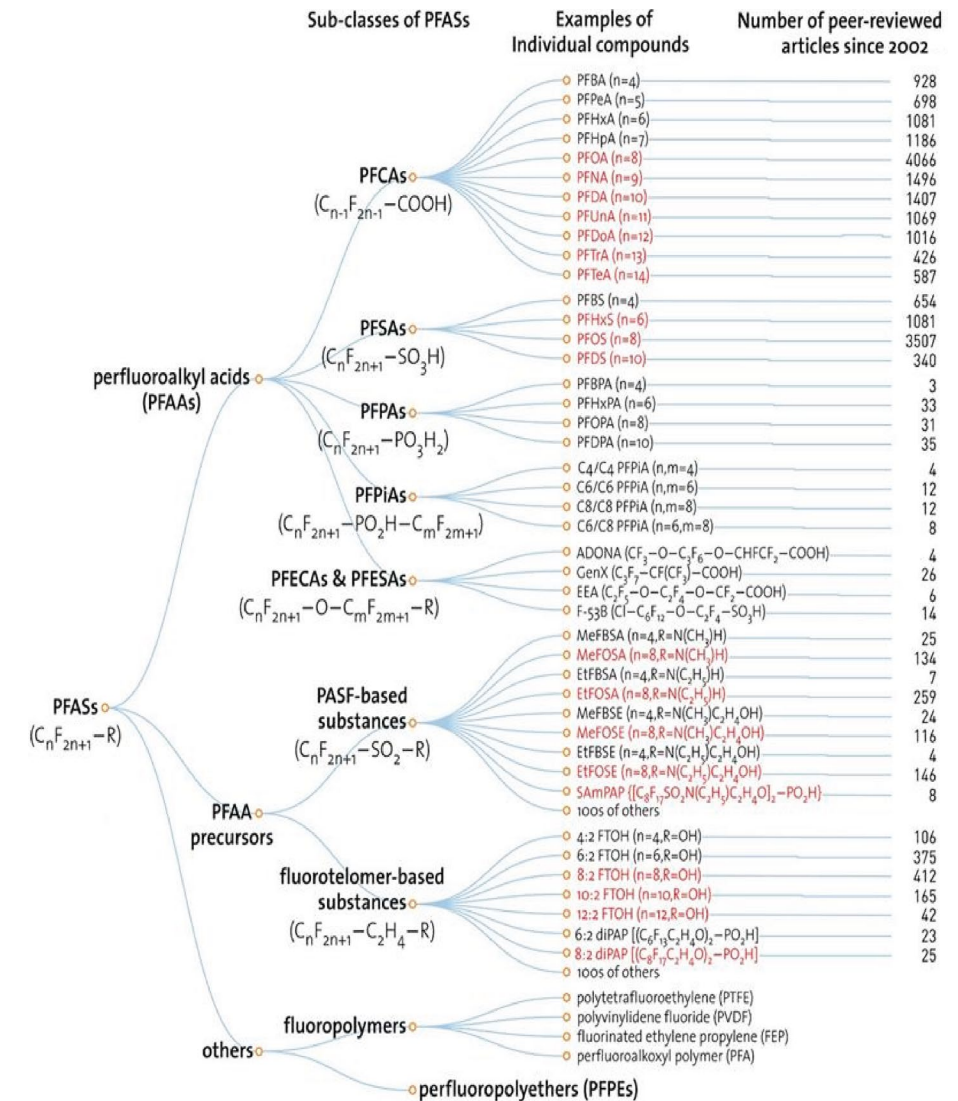
Conclusions? More questions than answers

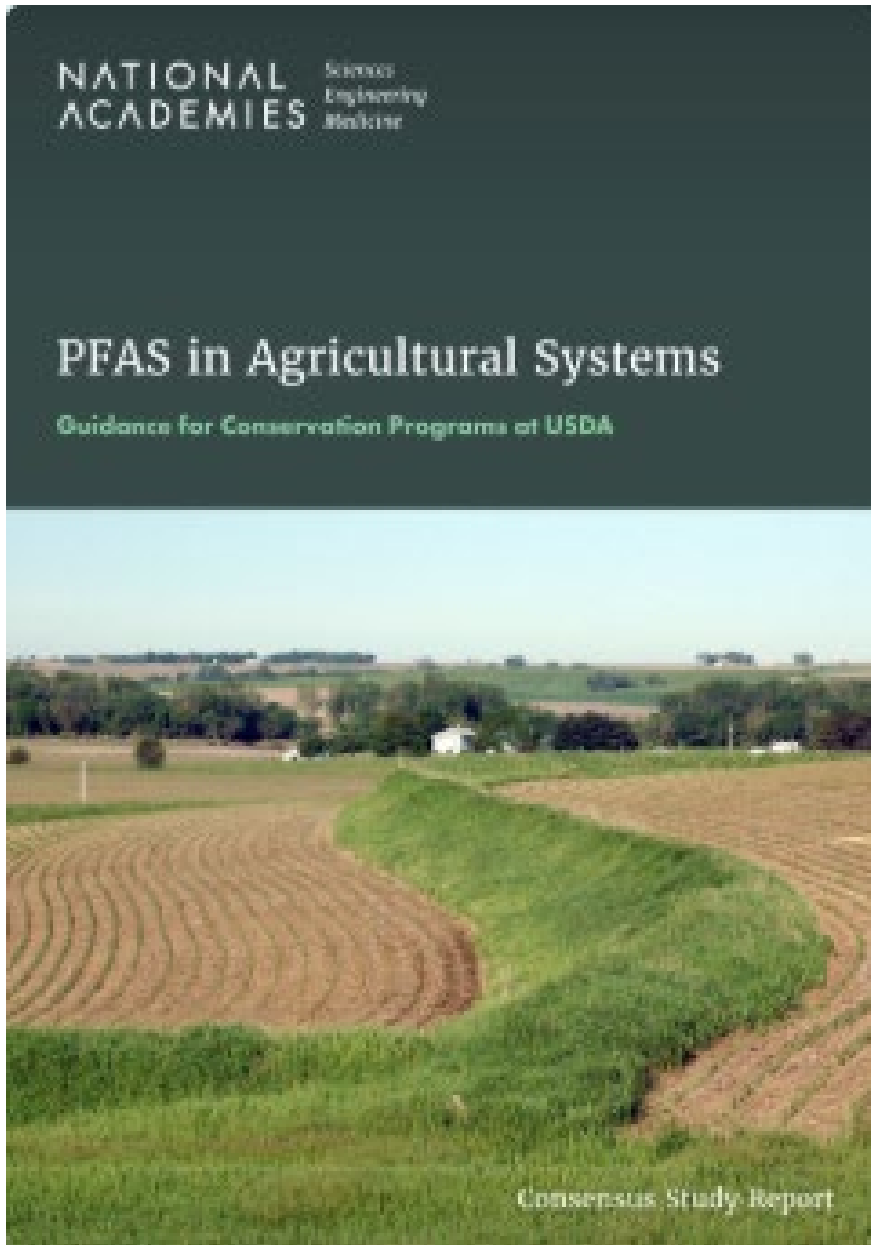
PFAS are complicated

- They can be positively or negatively charged
- They can be hydrophilic or hydrophobic
- They can act like micelles
- There are likely >20,000 PFAS

Once in soils, there is no easy solution for removing

- Not natural, so microorganisms haven't developed a means for degradation (impossible?)
- Some move, some don't – what do you focus on (better be both)
- Can we utilize conservation practices, crop alterations, etc. to minimize risk?
- Can we sequester PFAS in place, reducing their bioavailability?





PFAS: Lots of Questions

Dr. Jim Ippolito

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