PFAS and Agriculture: Research by the Food Resources Lifecycle Integrated Science Team

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Northwest Water Planning Alliance

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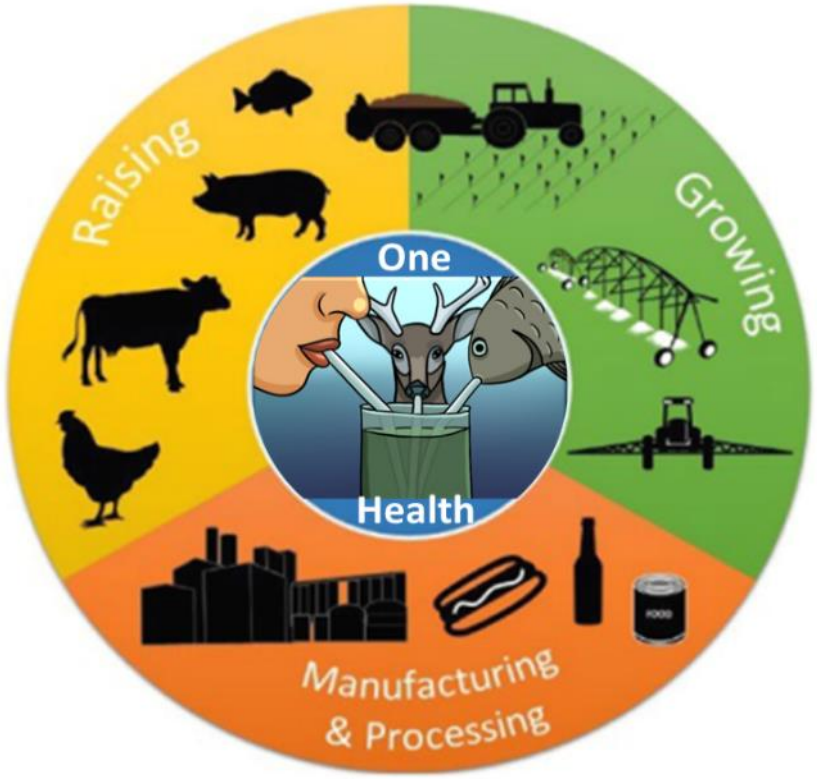
U.S. Department of the Interior
U.S. Geological Survey

This information is preliminary and is subject to revision. It is being provided to meet the need for timely best science. The information is provided on the condition that neither the U.S. Geological Survey nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the information."

Agriculture is vital to our economy, supplying food, fibers, fuels, and jobs. Ensuring the quality of our natural resources is essential for keeping our food and other agricultural products safe and secure.

Food Resources Life Cycle IST

Multi-disciplinary nationwide team



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Drupal Story

Geonarrative

Per- and polyfluoroalkyl substances (PFAS)

- Synthetic organofluorine compounds
  - 5000+ PFAS
- C-F bonds extremely strong
  - "**forever chemicals**"
- In use since the 1930s
- Properties → many uses
  - persistent, bioaccumulative
- Found in drinking water
- Nearly ubiquitous in humans
- **Mounting evidence of effects**

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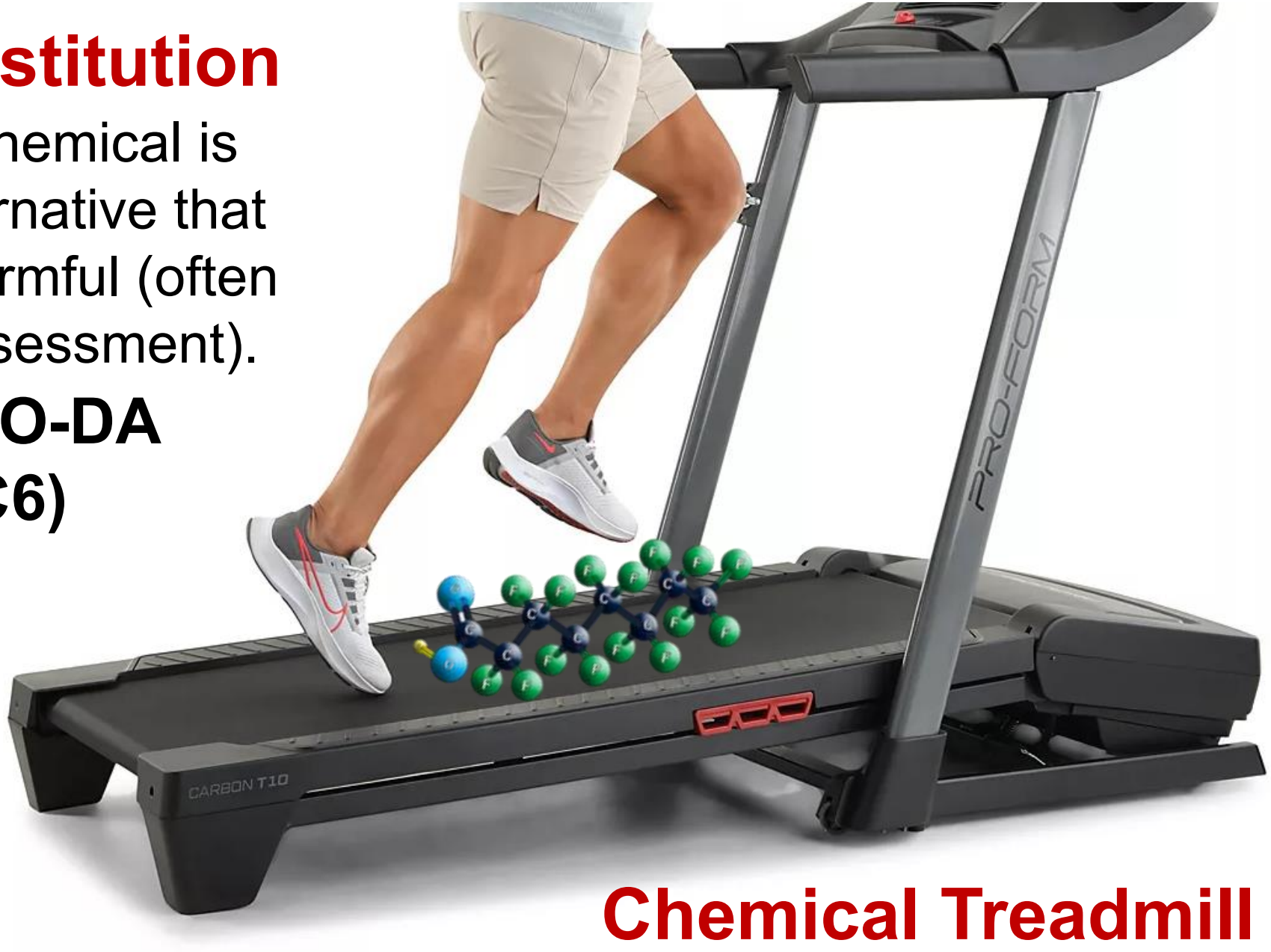
tampabaywater.org

Regrettable Substitution

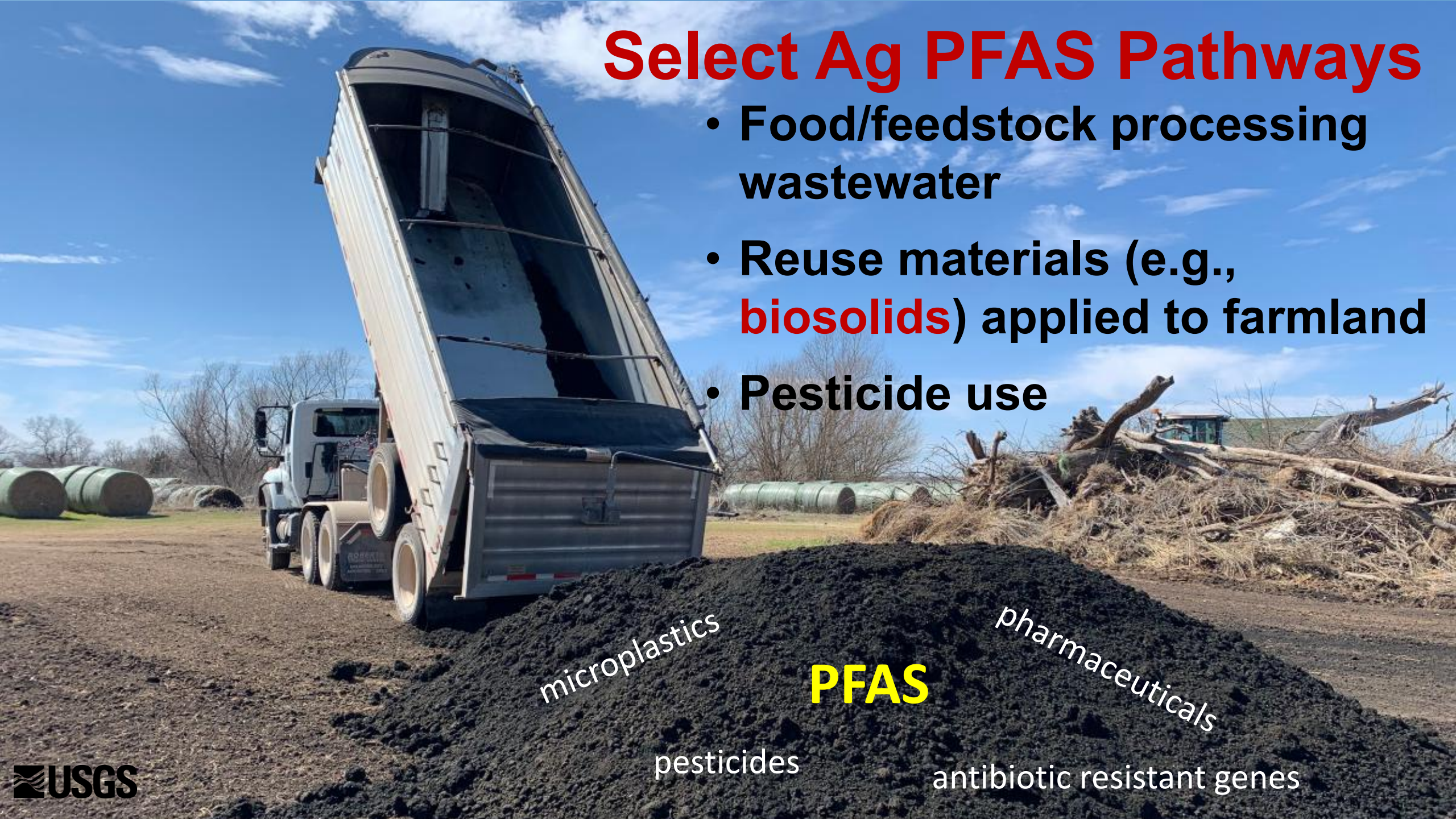
When a hazardous chemical is replaced with an alternative that is equally or more harmful (often due to insufficient assessment).

PFOA → HFPO-DA

(C8) (C6)



Chemical Treadmill


Select Ag PFAS Pathways
• Food/feedstock processing wastewater
• Reuse materials (e.g., biosolids) applied to farmland
• Pesticide use
microplastics
PFAS
pharmaceuticals
pesticides
antibiotic resistant genes
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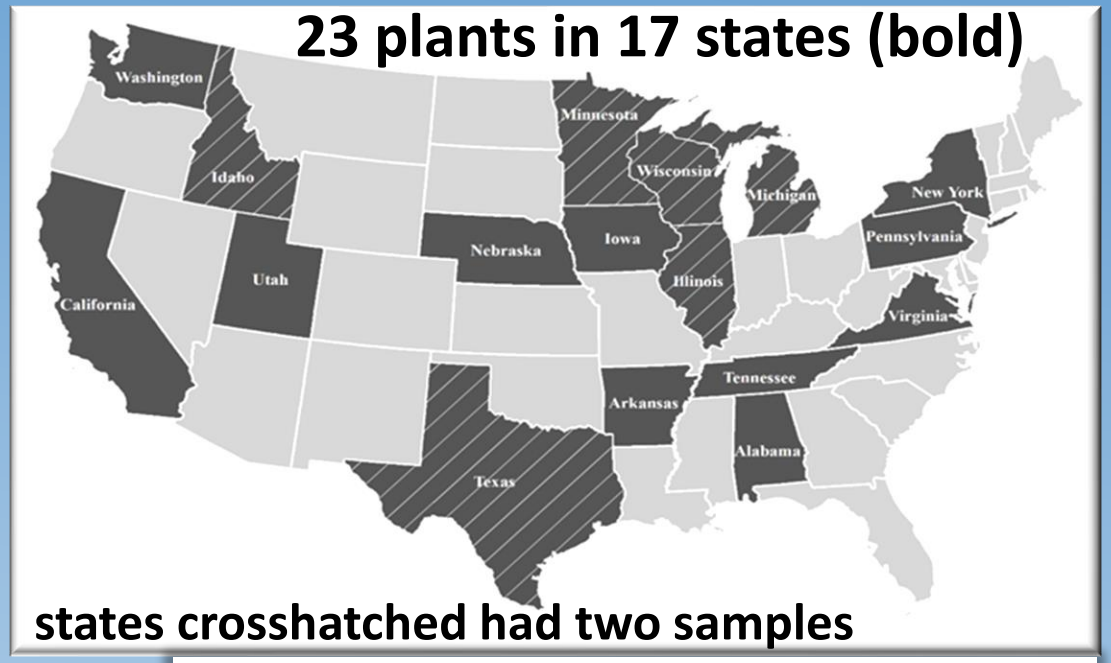
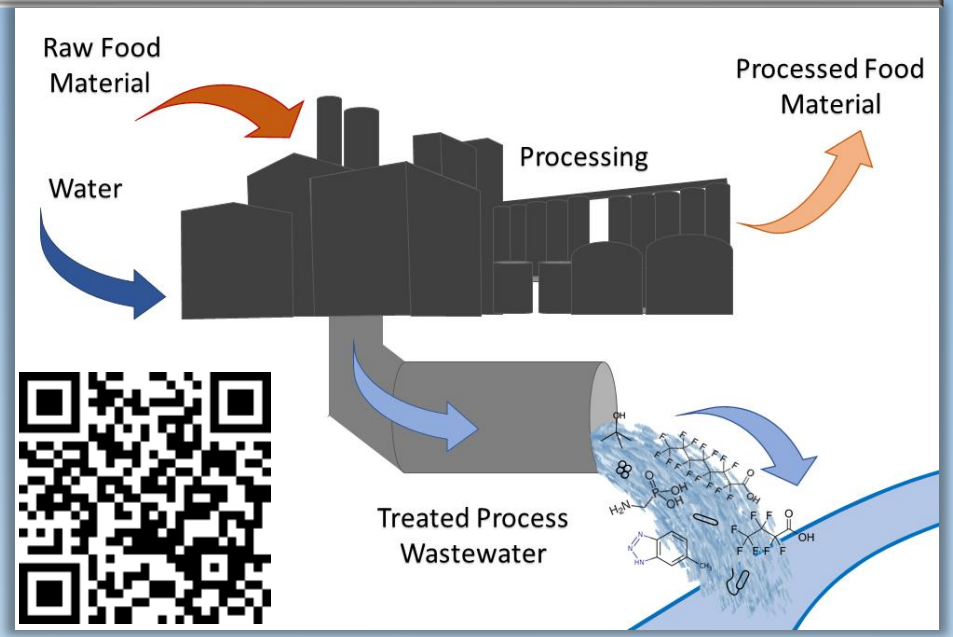
National Assessment of FPWW

First national study of food production wastewater (FPWW) discharged to environment.



- **Meat** (7), **Fruit/Veg** (6), **Beverage** (3), **Seafood** (2), **Dairy** (3), **Soy** (1), **Ethanol** (1)
- **Complex mixture of organic chemicals**
  - **PFAS**, Pharms, Pesticides,….
- **Ubiquitous bacterial growth**
- **Biologically active**
  - estrogenicity (100%); androgenicity (39%)
- **Environmental source of PFAS**
  - Detected at 65% of facilities (1 to 15 PFAS)
  - Max Σ_{34}PFAS = 185,000 nanogram per liter (ng/L)



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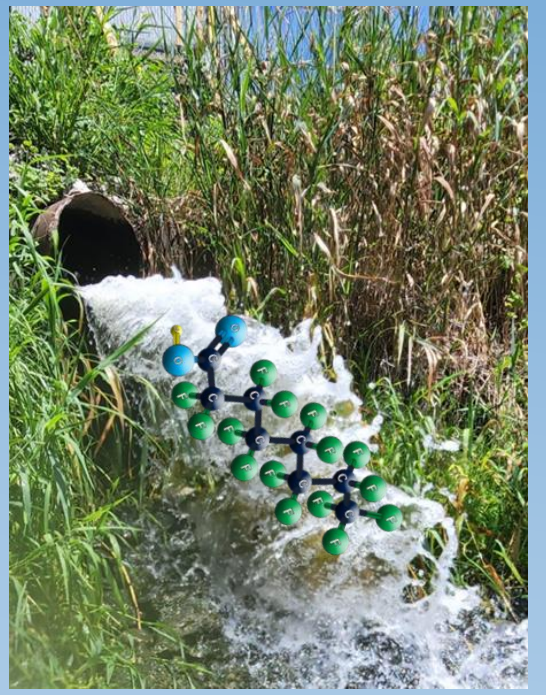
SoyOil Food Web PFAS Study

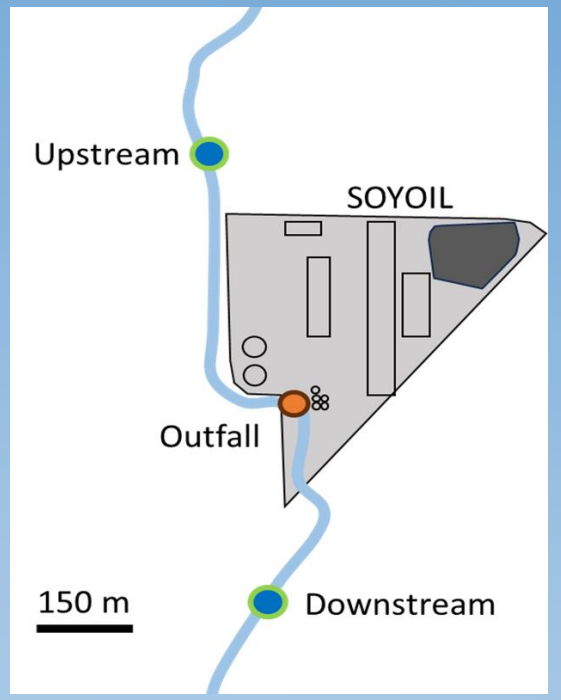
Understanding trophic transfer

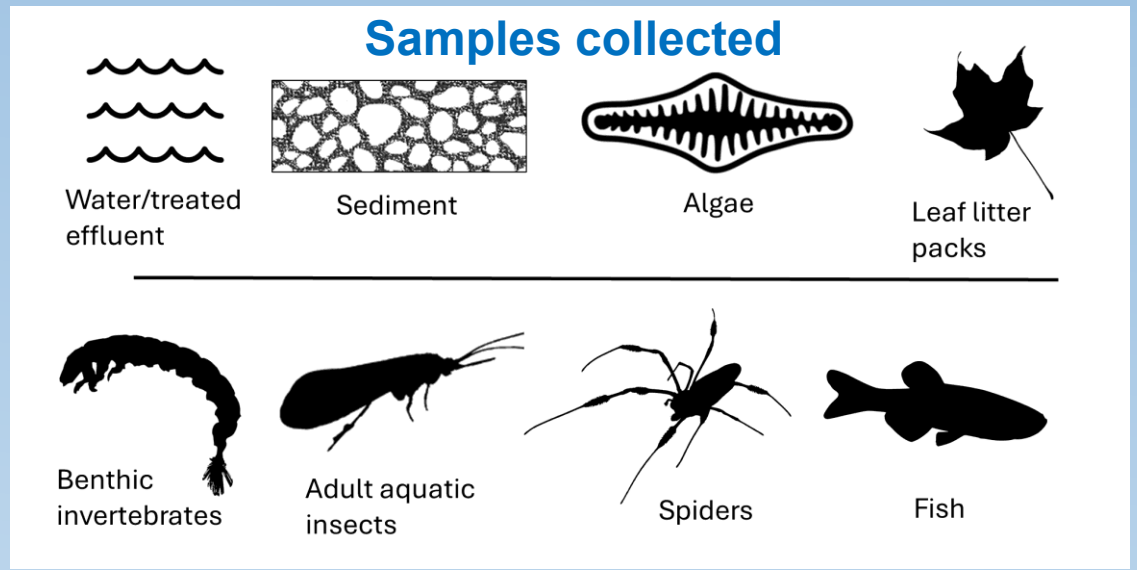
- During insect metamorphosis
- Uptake into algae & detritus
- Uptake into riparian food web
- Effects on microbial communities & microbiomes

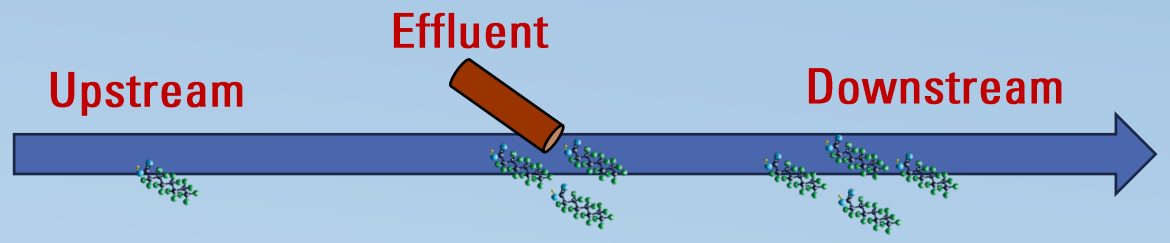
Collaborative science

- USGS UMidWSC + CMWSC
- USGS CERC
- USGS Pathways + PFAS ISTs
- University of Notre Dame
- Duke University
- McMaster University







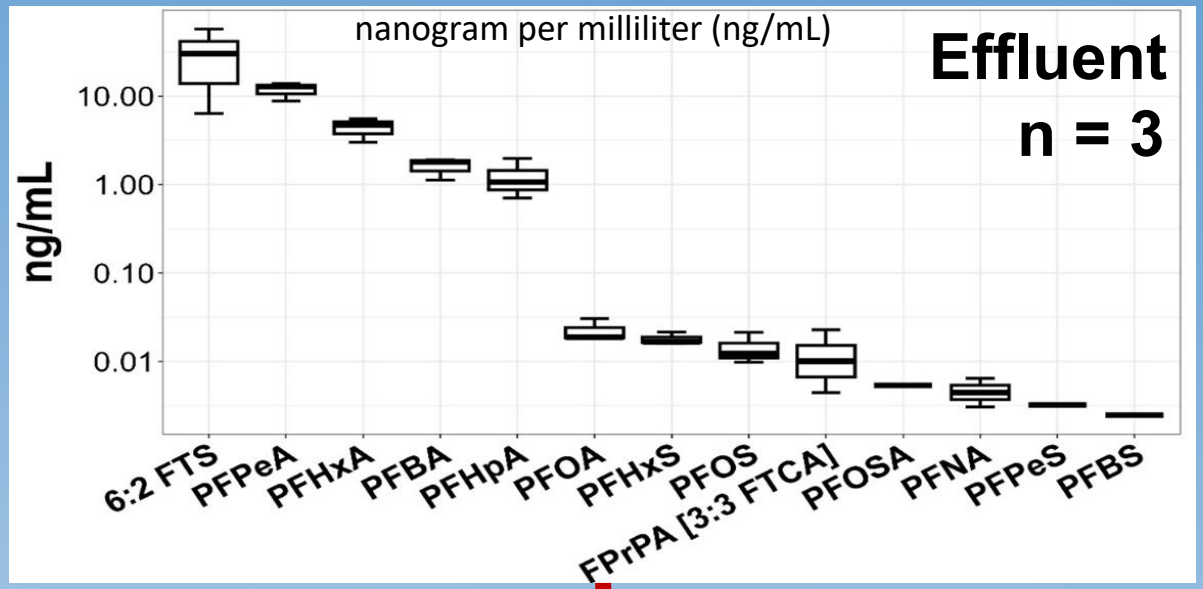


USGS

Kotalik et al., 2025: https://doi.org/10.1021/acs.est.5c04867

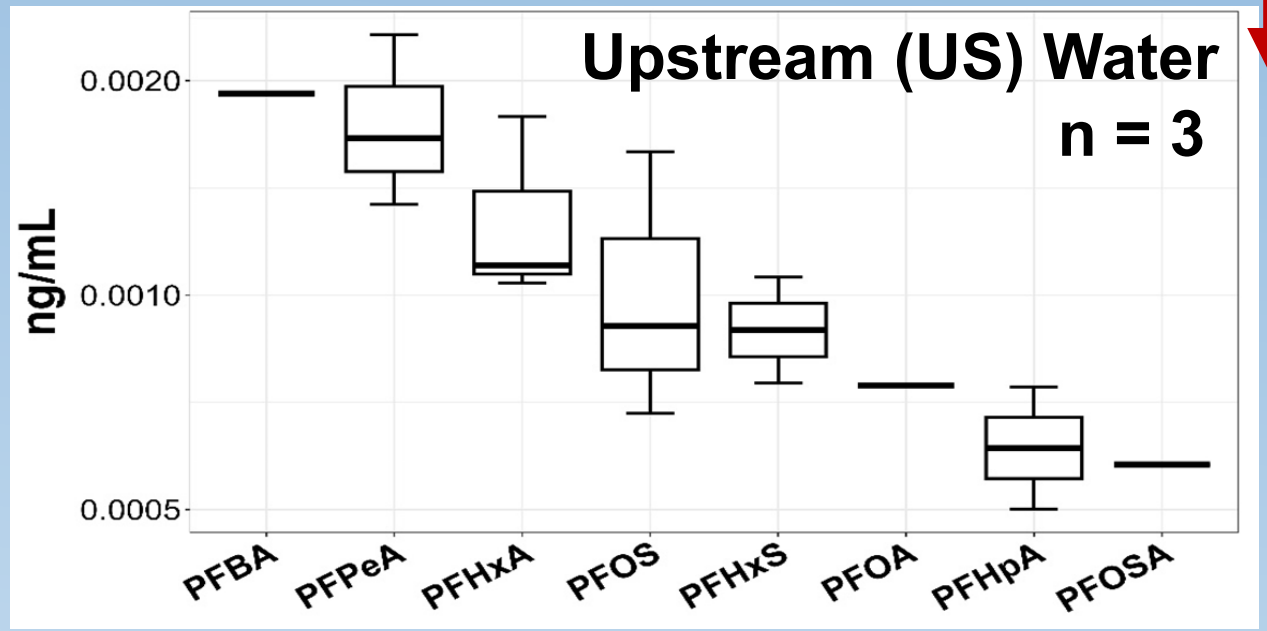
US PFAS << DS PFAS

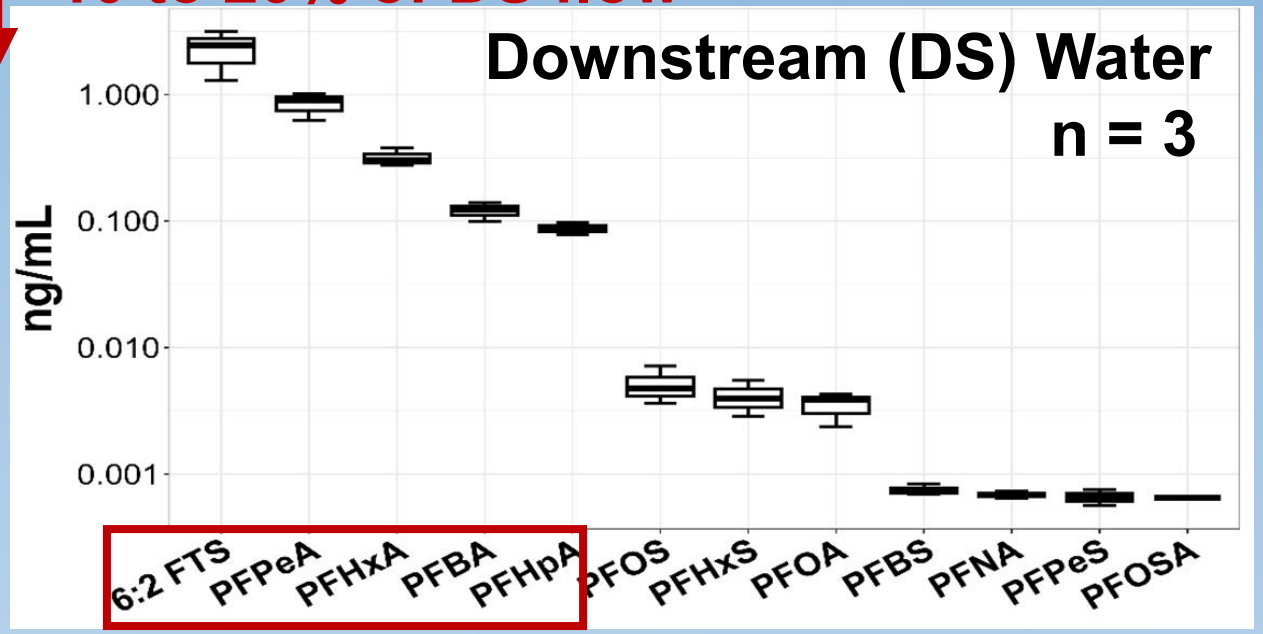
- Effluent input



DS Water: mainly 6:2 FTS and its transformation products.

~10 to 20% of DS flow





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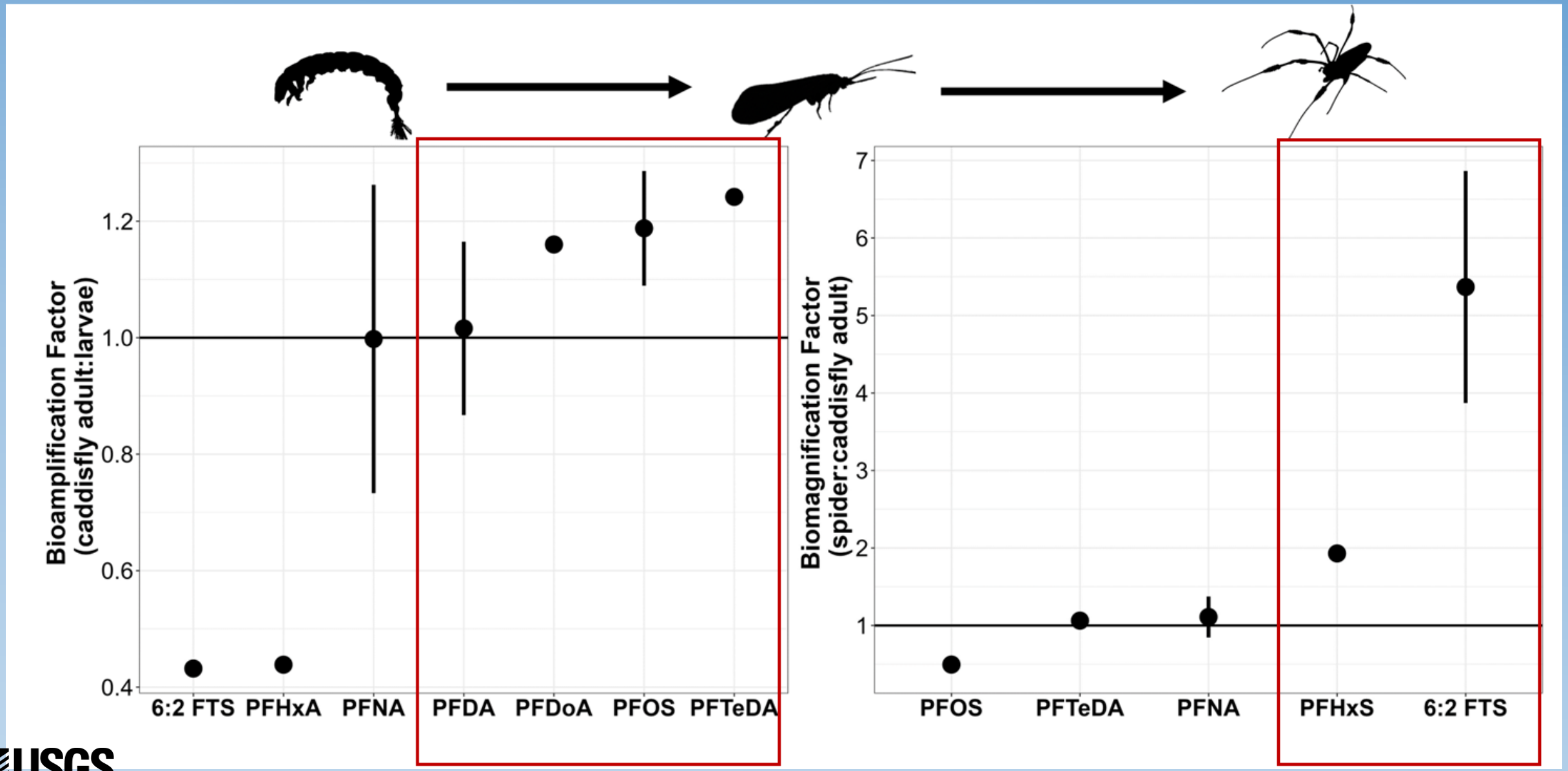
PFAS Profiles at SoyOil Facility

Kotalik et al., 2025

Metamorphic retention and transfer to terrestrial consumers



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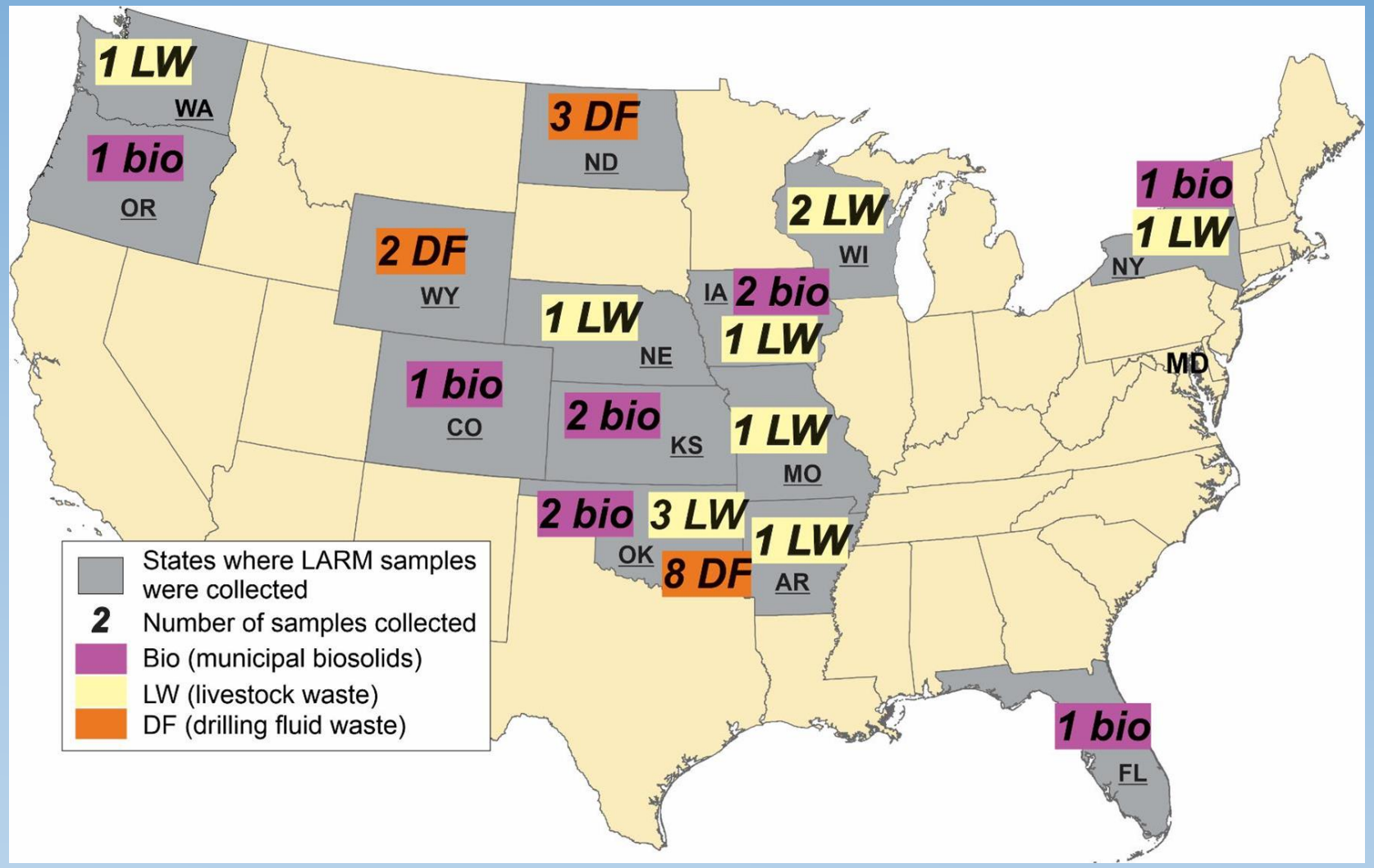
Kotalik et al., 2025

Characterizing Land Applied Reuse Materials (LARMs)



Municipal Biosolids

(53%: 12.4 billion kg)

- 9 Class – B
- 1 Class – A

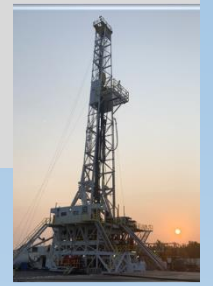
Livestock Manure

(100%: 1,270 billion kg)

- 5 bovine
- 4 poultry
- 2 swine

Oil/Gas Drill Fluids

(??: 1.3 billion kg in OK)



- 7 water-based
- 6 oil-based

kilogram (kg)

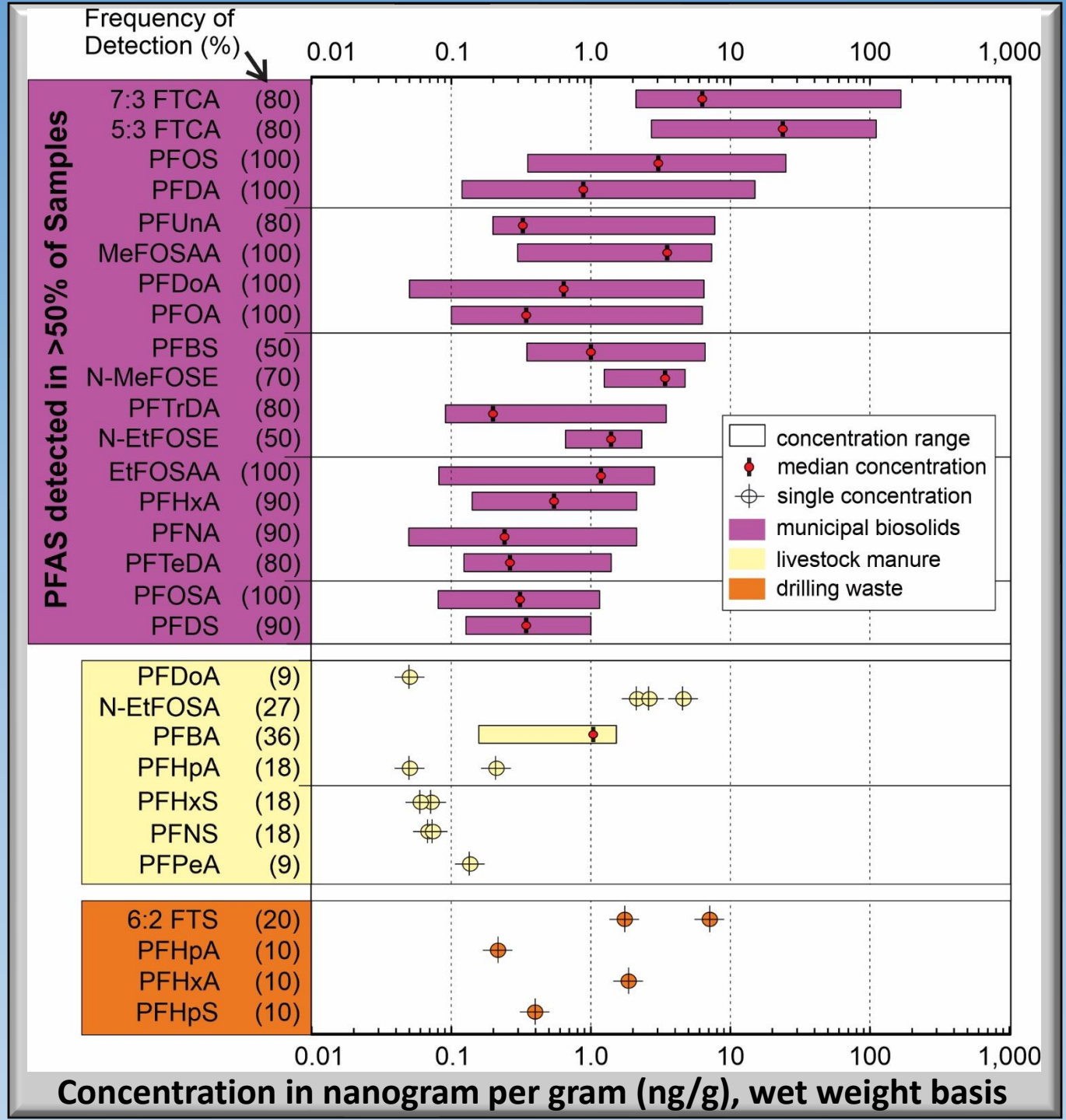
PFAS, pesticides, pharms, microplastics,…….

USGS

Masoner et al., 2025: https://doi.org/10.1039/D5EM00312A

Biosolids: PFAS

- 90% ∑detections
- 97% ∑concentration
- 7 PFAS found in every sample
  - **PFOS** max = 26.1 ng/g
  - **PFOA** max = 6.3 ng/g
- Precursors indicate potential for in-field transformation to final terminal PFAS (e.g., PFOS, PFOA).
- **Land application could result in PFAS accumulation in soils with uptake to crops.**



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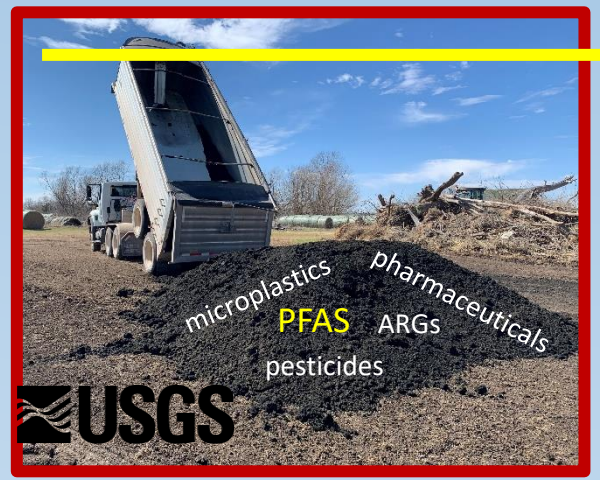
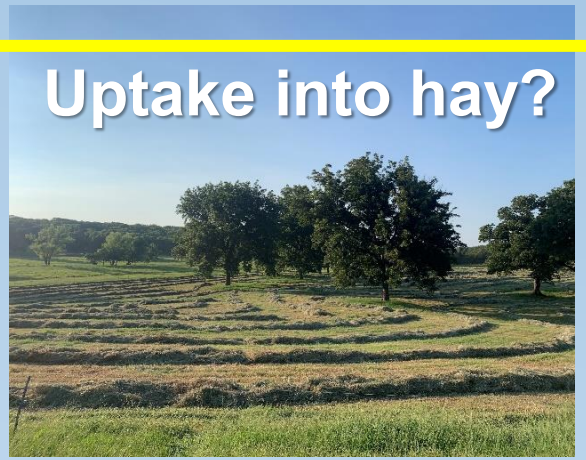
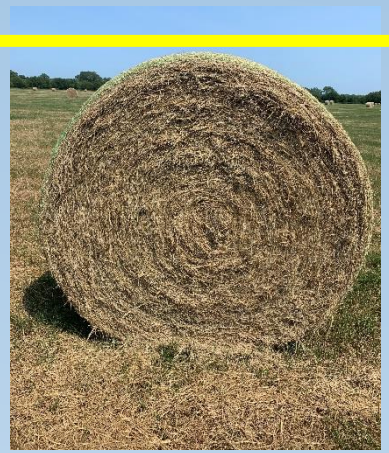
Masoner et al., 2025

Examining PFAS uptake in hay fields with differing biosolid histories

1. **Recent hay field (REC)**
   - Long history of biosolids (**1 year rest**)
2. **Intermediate hay field (INT)**
   - Long history of biosolids (**10 years rest**)
3. **Control hay field**
   - No history of biosolid application





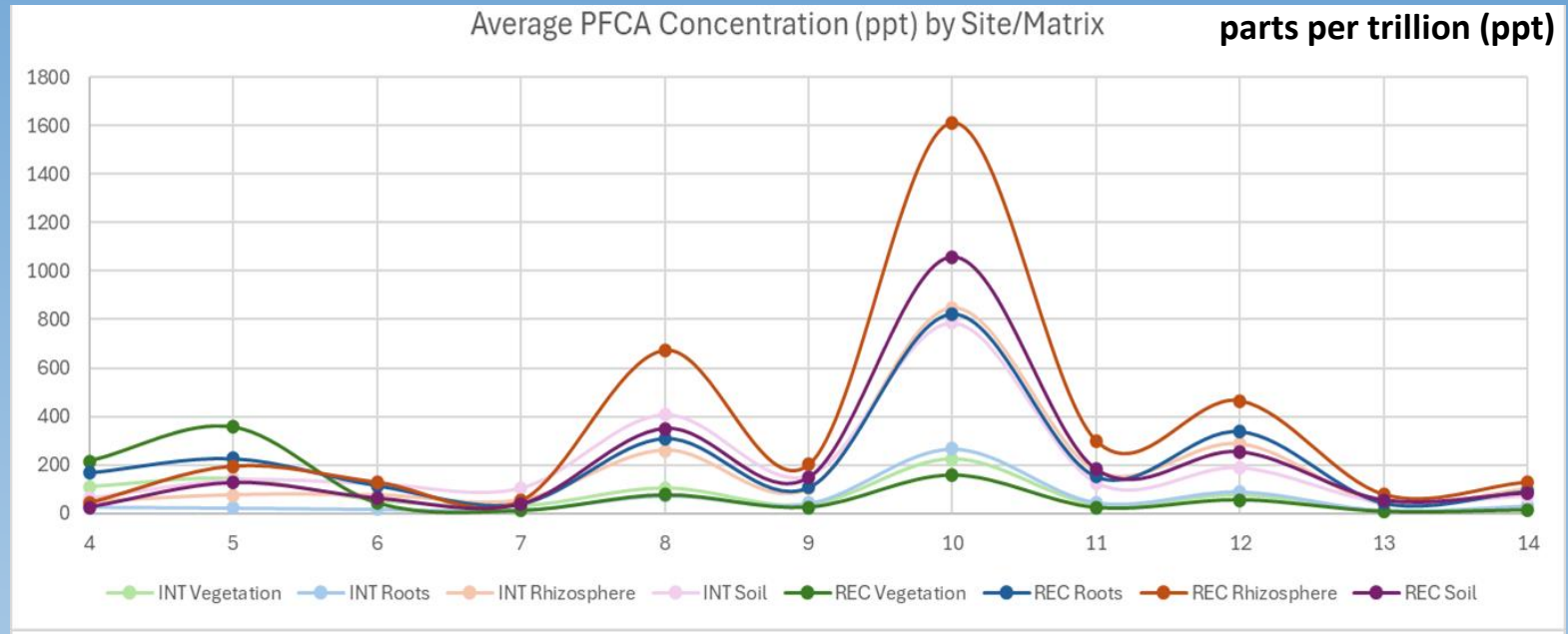


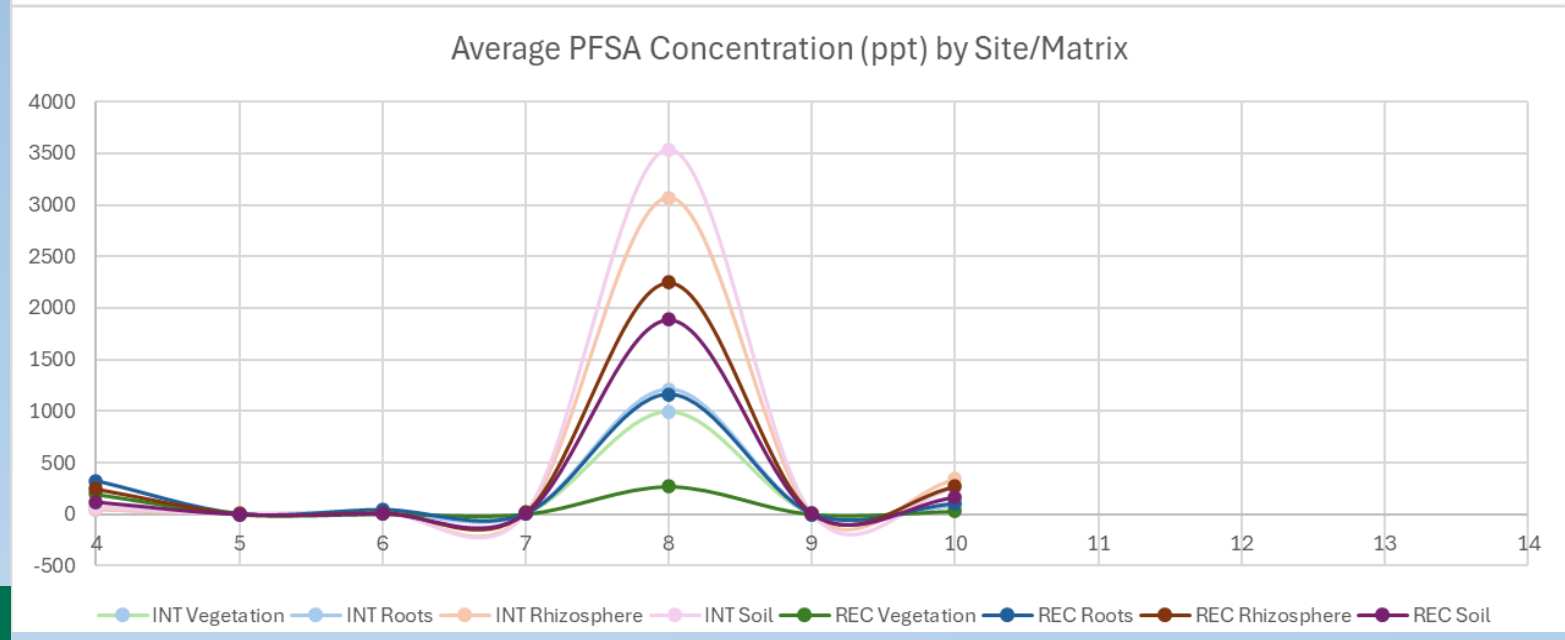
PFAS Uptake by Matrix

PFAS prevalent in biosolids-applied soils.

Precursor compounds primarily in Recent field.

PFAS in both roots (below ground) and hay (above ground).





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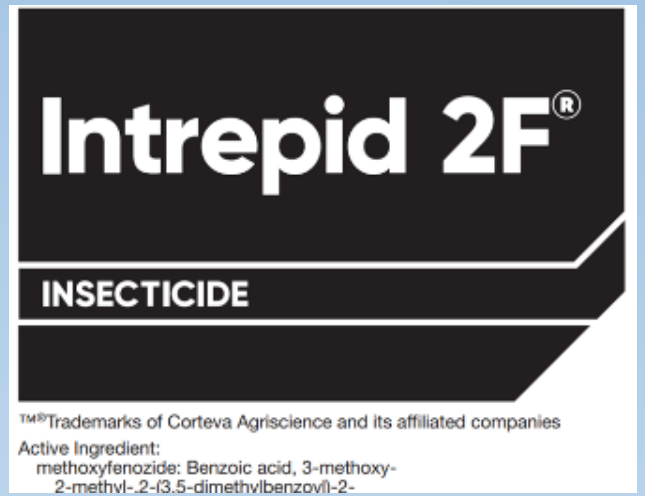
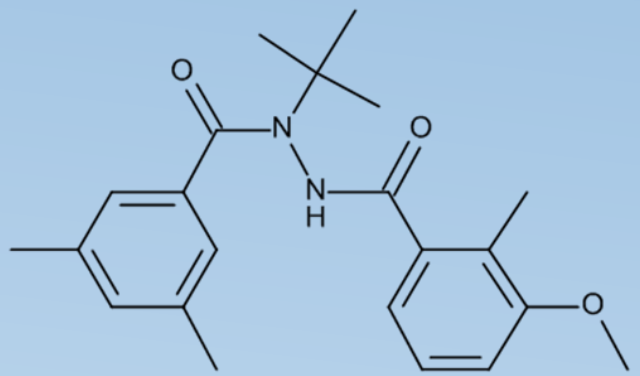
Examining PFAS uptake in cattle fed hay with differing biosolid history

- **Hamburger & liver**
  - Fed hay grown on field with **1 year of biosolids**
  - Fed hay grown on field with **3 years of biosolids**
  - Rinse water from meat processor
  - Meat packaging material
- **Drinking water source**
- **Finishing grain**

PFAS in pesticide applications? Yes!

- e.g., Intrepid 2F® (methoxyfenozide) documented as having PFAS
  - Second only to glyphosate as most widely used pesticide in California





US food pesticides contaminated with toxic 'forever chemicals' testing finds

PFAS are present at 'potentially dangerous' levels in widely used chemicals sprayed on food crops destined for Americans' plates

Spraying pesticide at grape vineyard in the San Joaquin Valley, California. Photograph: Education Images/UIG/Getty Images

Some of the United States' most widely used food pesticides are contaminated with "potentially dangerous" levels of toxic PFAS "forever chemicals", new testing of the products finds.

https://pfasproject.com/2023/05/11/us-food-pesticides-contaminated-with-toxic-forever-chemicals-testing-finds/.pdf

https://www.biologicaldiversity.org/campaigns/pesticides_reduction/pdfs/J113812-1-UDS-Level-2-Report-Final-Report.pdf

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Commentary

A Section 508–conformant HTML version of this article is available at https://doi.org/10.1289/EHP13954.

Forever Pesticides: A Growing Source of PFAS Contamination in the Environment

Nathan Donley,[1] Caroline Cox,[2] Kyla Bennett,[3] Alexis M. Temkin,[4] David Q. Andrews,[4] and Olga V. Naidenko[4]

Potential pesticide sources of PFAS

- **Known PFAS sources: active ingredients, inert ingredients, fluorinated containers**
  - Intrepid 2F®, Anvil 10+10®, Oberon 2 SC®, Permanone 30-30®, Malathion 5EC®
- **Suspected PFAS sources: adjuvants, solvents, manufacturing by-products**
  - PFAS precursors in pesticide products

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Analysis of Pesticide Coated Seeds

Seeds analyzed

- 3 wheat
- 2 soybeans
- 2 corn (maize)
- 1 canola
- untreated seeds

Analysis by LC-HRMS for 52 PFAS
(**includes ultrashort-chain PFAS**)

No PFAS detected above current MDLs

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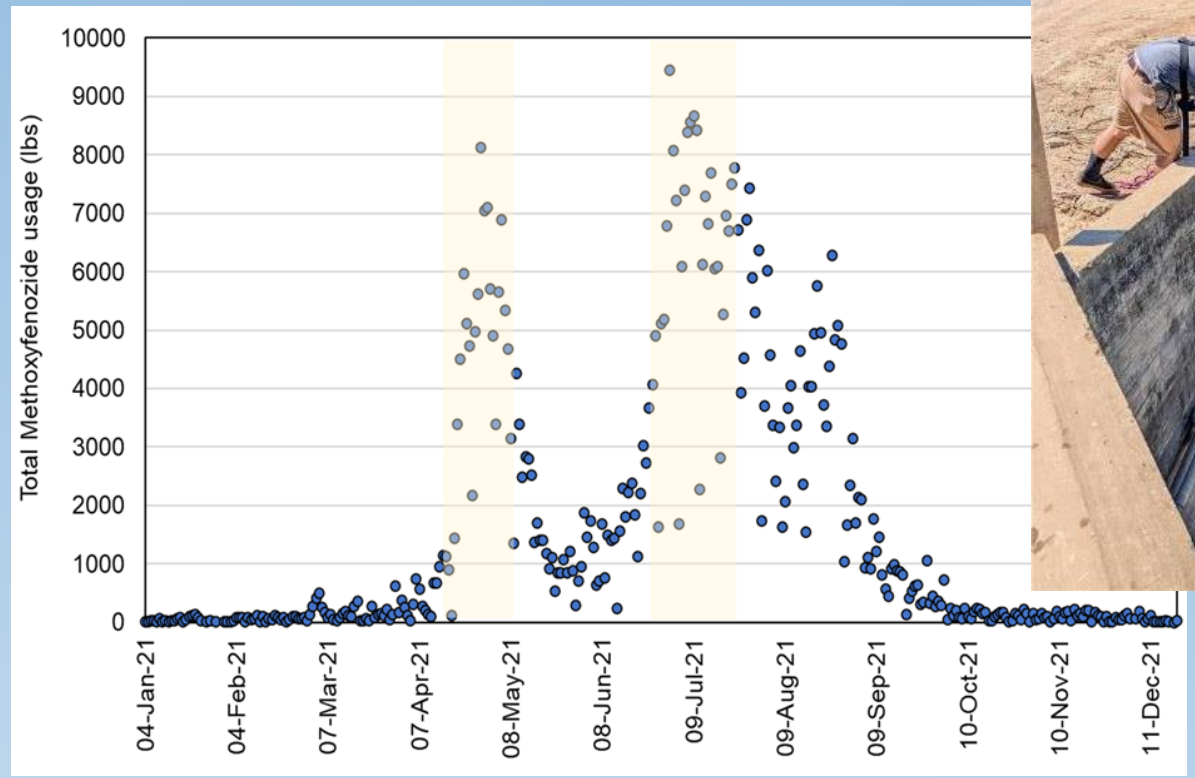
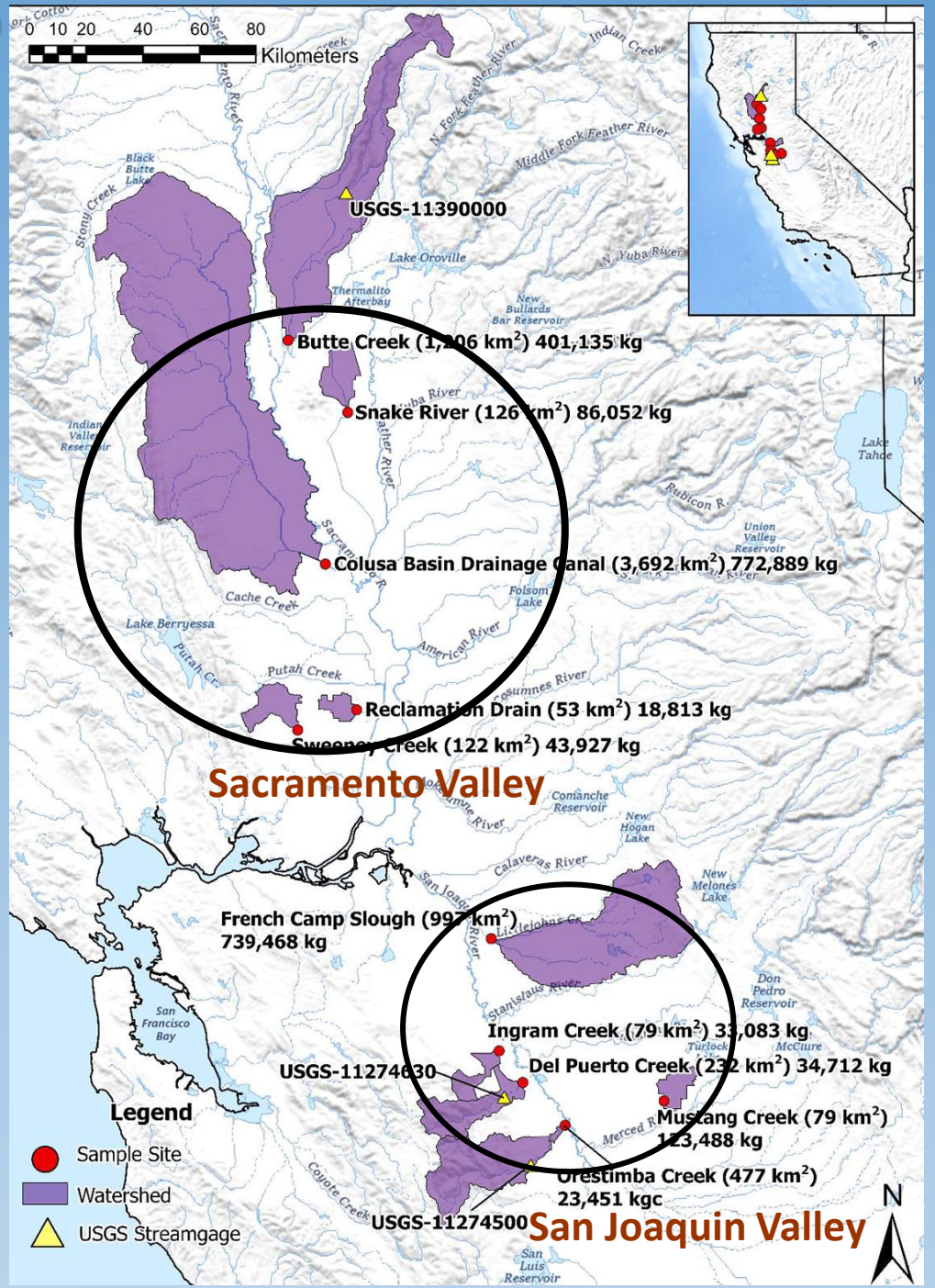
Preliminary Information – Subject to Revision. Not for Citation of Distribution.

Pesticides → Stream PFAS?

- **Stream sampling: May & July 2024**
  - 183 pesticides
  - 57 PFAS
- Timing targeted for methoxyfenozide applications





pounds (lbs)
kilograms (kg)
square kilometers (km²)

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Results

60 pesticides

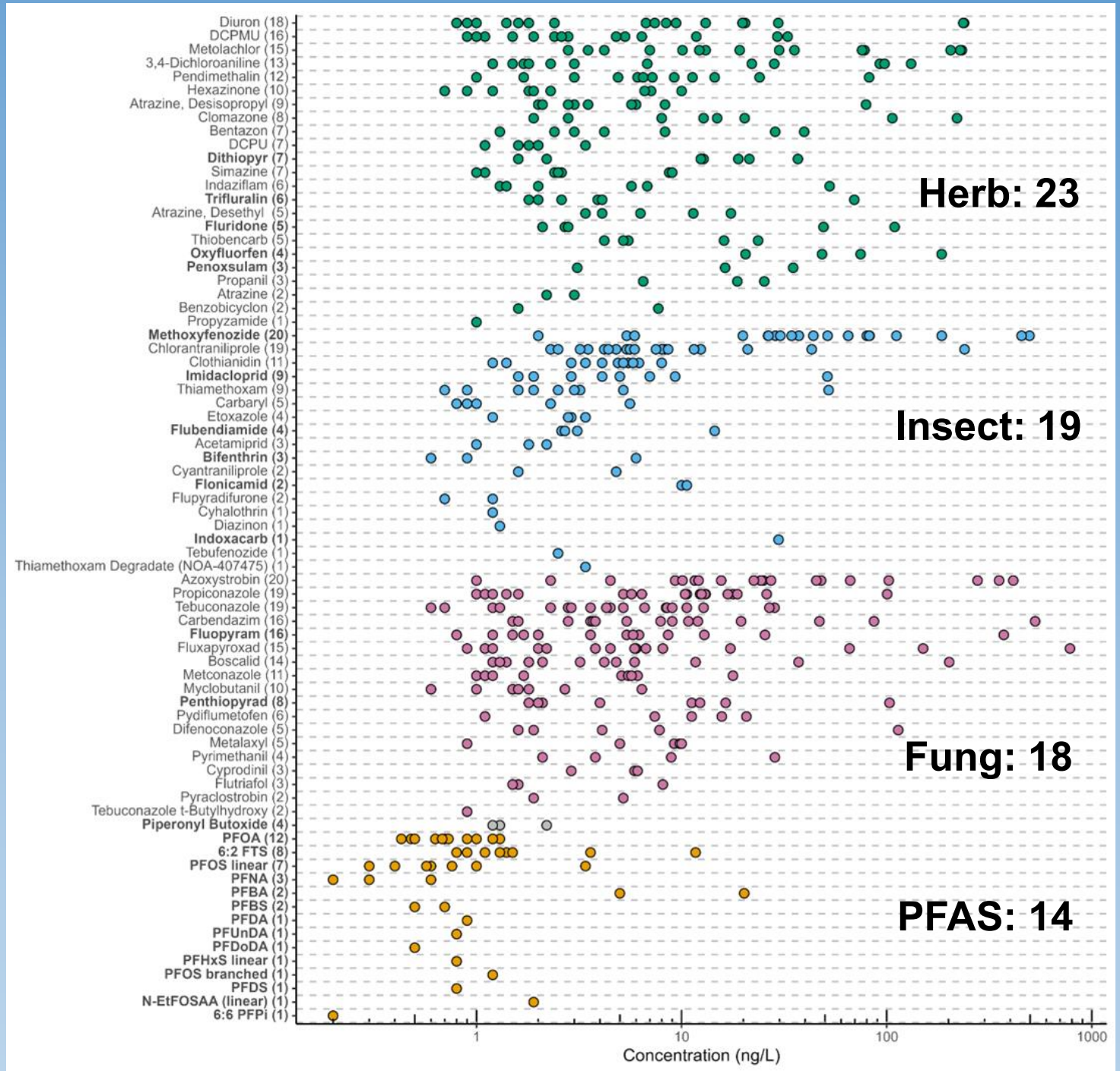
- Azoxystrobin (F) (100%)
- Methoxyfenozide (I) (100%)
- Max: 783 ng/L (fluxapyroxad)

14 PFAS

- Short to long chains detected
- PFOA: 60%, 6:2 FTS: (40%)
- Max: 20.2 ng/L (PFBA)
- Trifluoroacetic acid (TFA) not measured

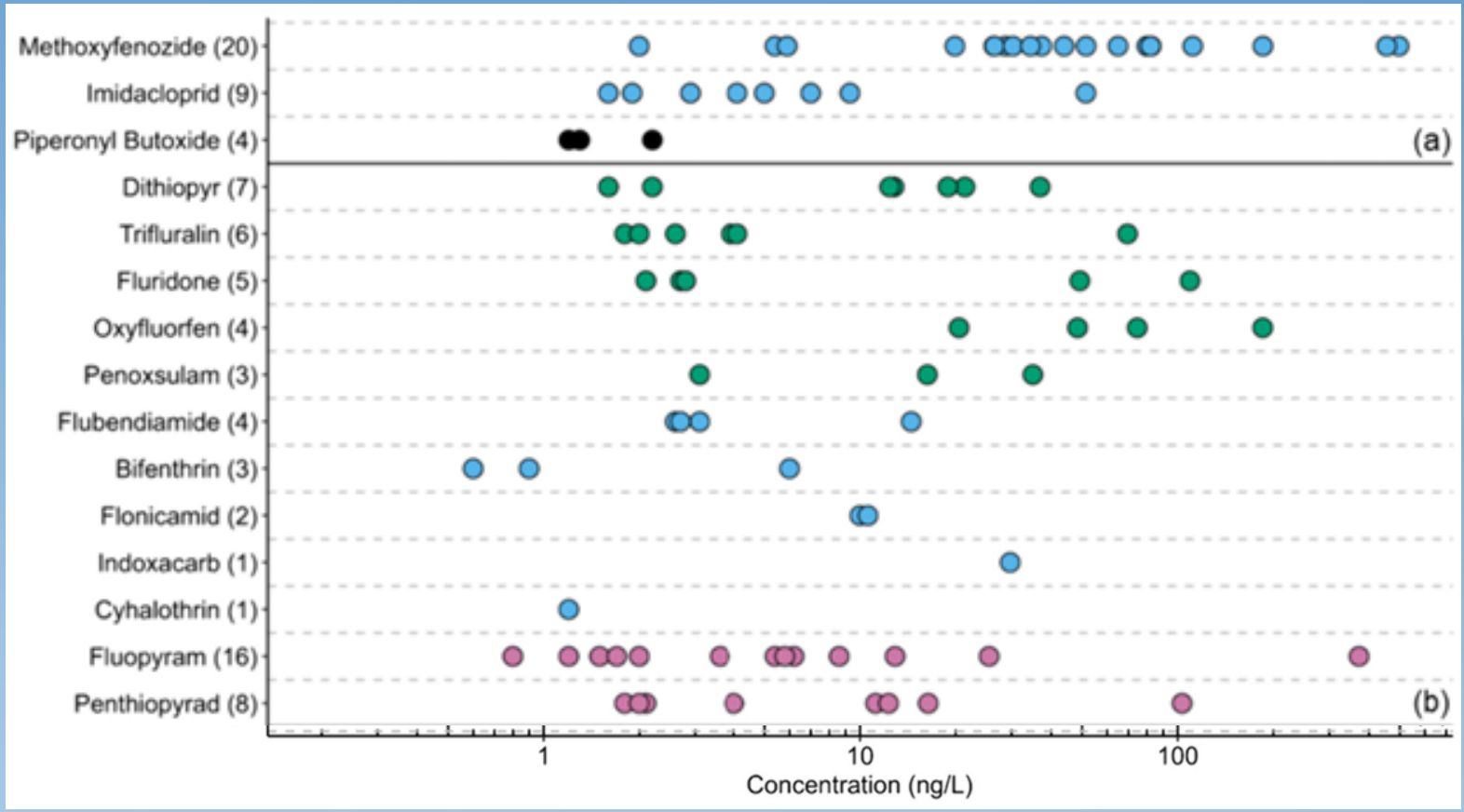
Pesticides + PFAS

- 80% of samples



Pesticide formulations linked to PFAS (3) →

Fluorinated pesticides by OECD definition (12) →



(∑PFAS-linked / ∑pest) x 100

% total pesticide concentration potentially linked to PFAS ranged from 0.7 to 76.7% (average = 34.6%)

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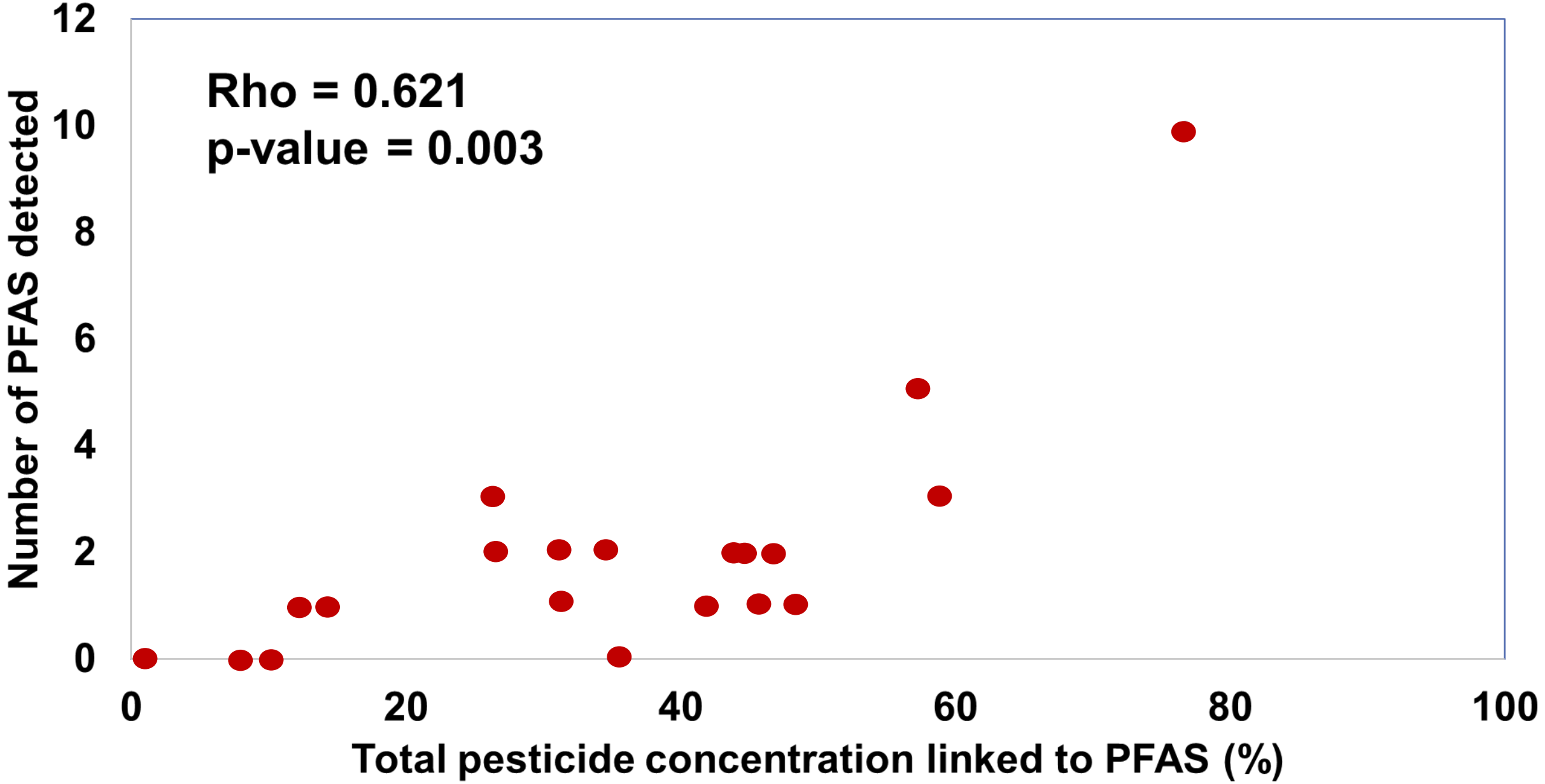
Woodward et al., 2026



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Preliminary Information – Subject to Revision. Not for Citation of Distribution.

Conclusions

Evidence suggests pesticides may be contributing to stream PFAS.

- **Pesticides and PFAS commonly co-occurred (80% of samples).**
- **Positive relation between ∑pesticides linked to PFAS and number of PFAS detected in streams.**

TFA should be included in future research (transformation to TFA has been documented for select fluorinated pesticides).

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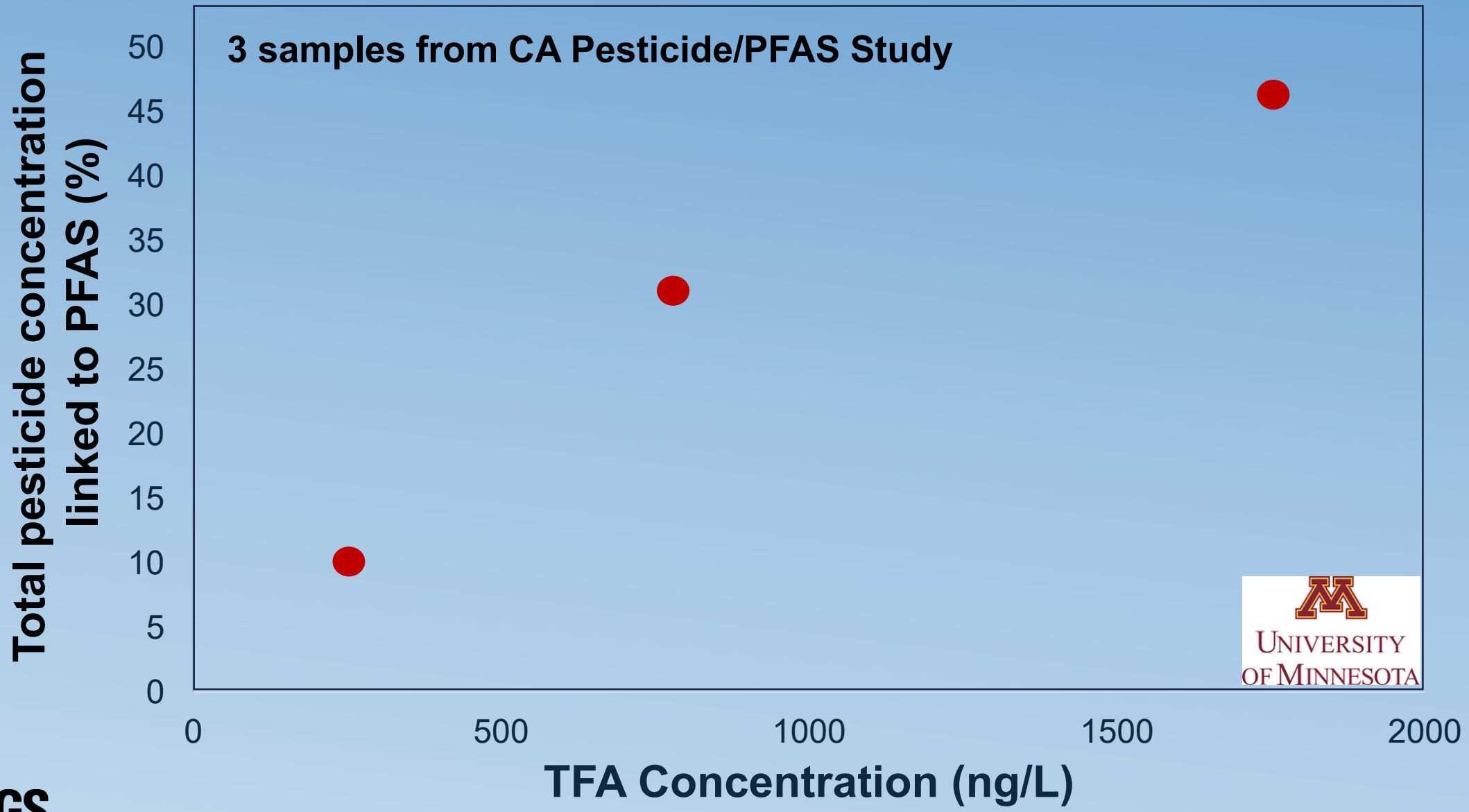
USGS science for a changing world

Preliminary TFA Results



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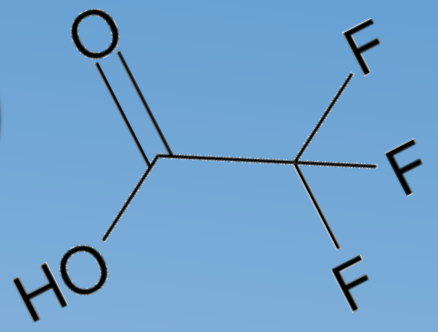
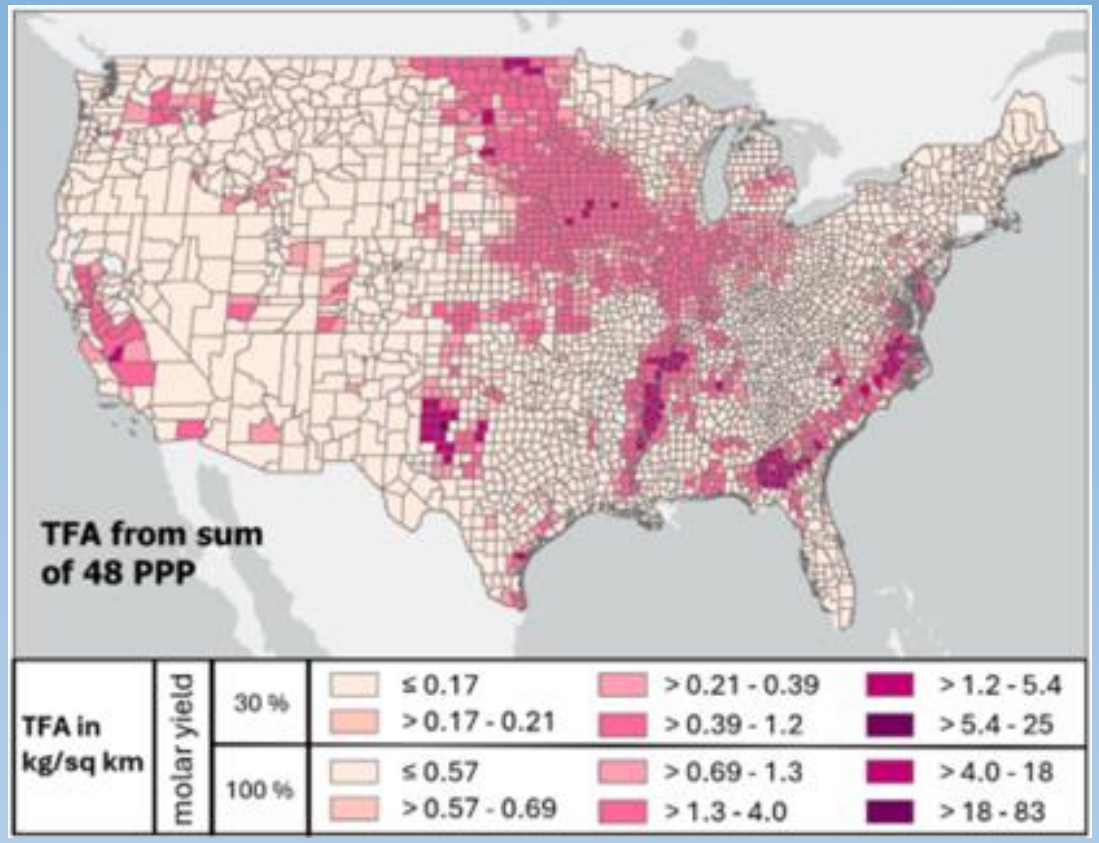
Trifluoroacetic Acid (TFA)



- Ultrashort-chain PFAS
- Most abundant and prevalent PFAS
  - **global distribution**
- Numerous sources
  - **select fluorinated pesticides**
- Entering food chain
- Risks to human/ecological health
- **Limited data on stream exposures**



TFA formation potential from pesticides (Joerss et al., 2024)

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TFA Study

- 142 streams
  - 43 states
- 58 PFAS
- 183 Pesticides
- Apr-Aug 2026

Kolpin, Gray, Hladik, Hubbard, Meppelink, Arnold, Faber, Woodward

USGS

University of Minnesota

Drainage areas: 0.2 to 2,938,531 mi²

EXPLANATION

TFA Sampling Sites

- Agricultural (105)
- Mixed (17)
- Reference (8)
- Urban (12)

NHDPlusV2 Streams

N

0 475 950 Miles

0 800 1,600 km

N

0 50 100 Miles

0 120 240 km

N

0 180 360 Miles

0 350 700 km

Questions?

Dana Kolpin

dwkolpin@usgs.gov

Drupal Story

Geonarrative