PFAS: Chemistry, Sources & Policy

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Green Science Policy Institute

July 19, 2019

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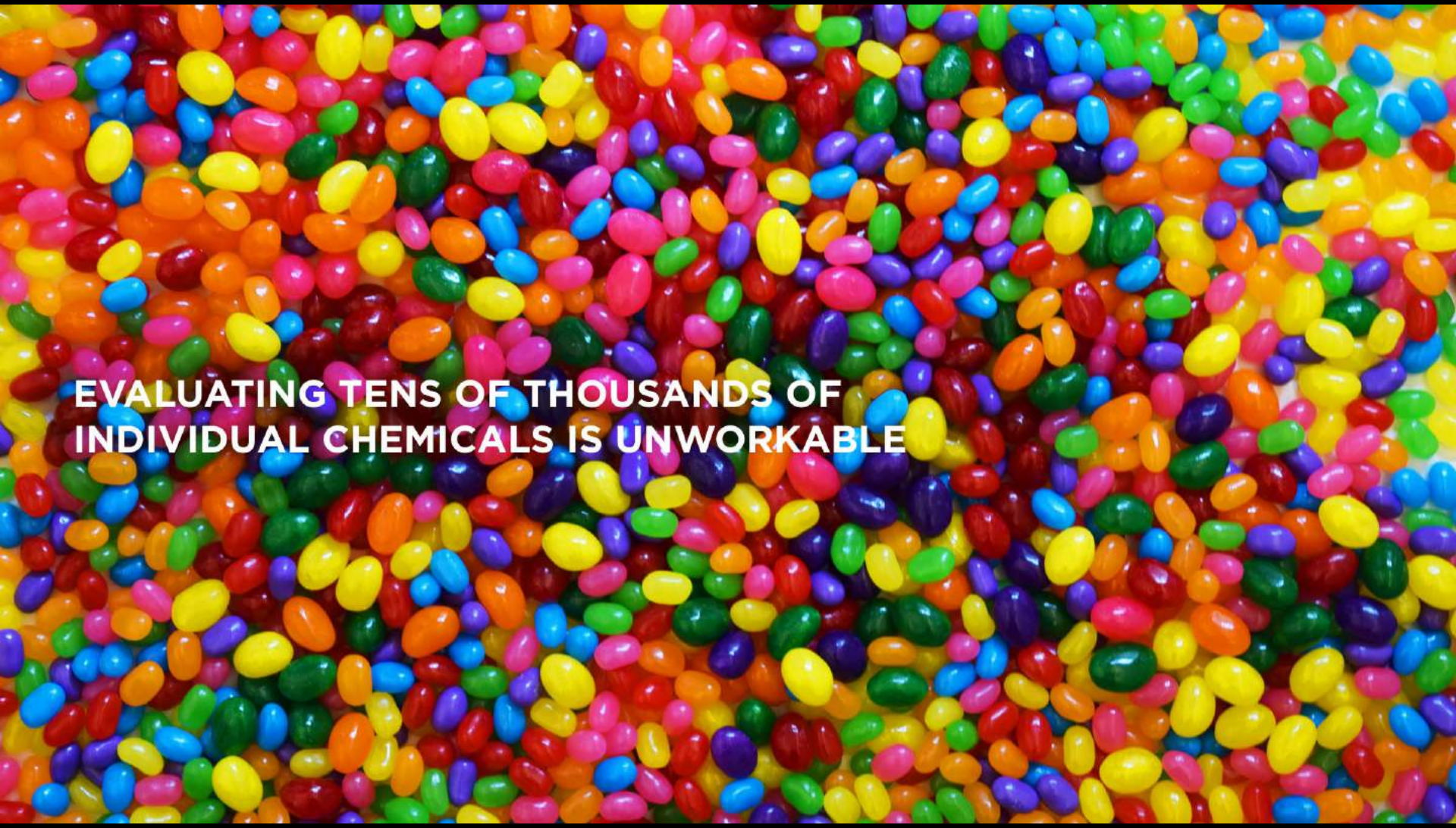
Research

Education

Retreats

Policy & Purchasing Change


EVALUATING TENS OF THOUSANDS OF
INDIVIDUAL CHEMICALS IS UNWORKABLE


BUT ADDRESSING SIX GROUPS OF
CHEMICALS OF CONCERN IS MANAGEABLE

1	2	3	4	5	6
Highly Fluorinated	Antimicrobials	Flame Retardants	Bisphenols + Phthalates	Some Solvents	Certain Metals



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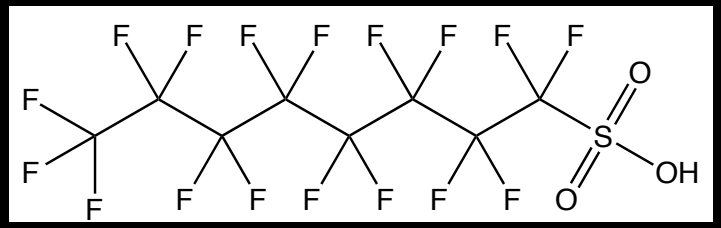
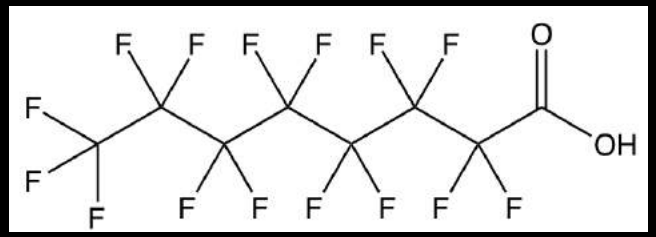
PFAS

PFOS



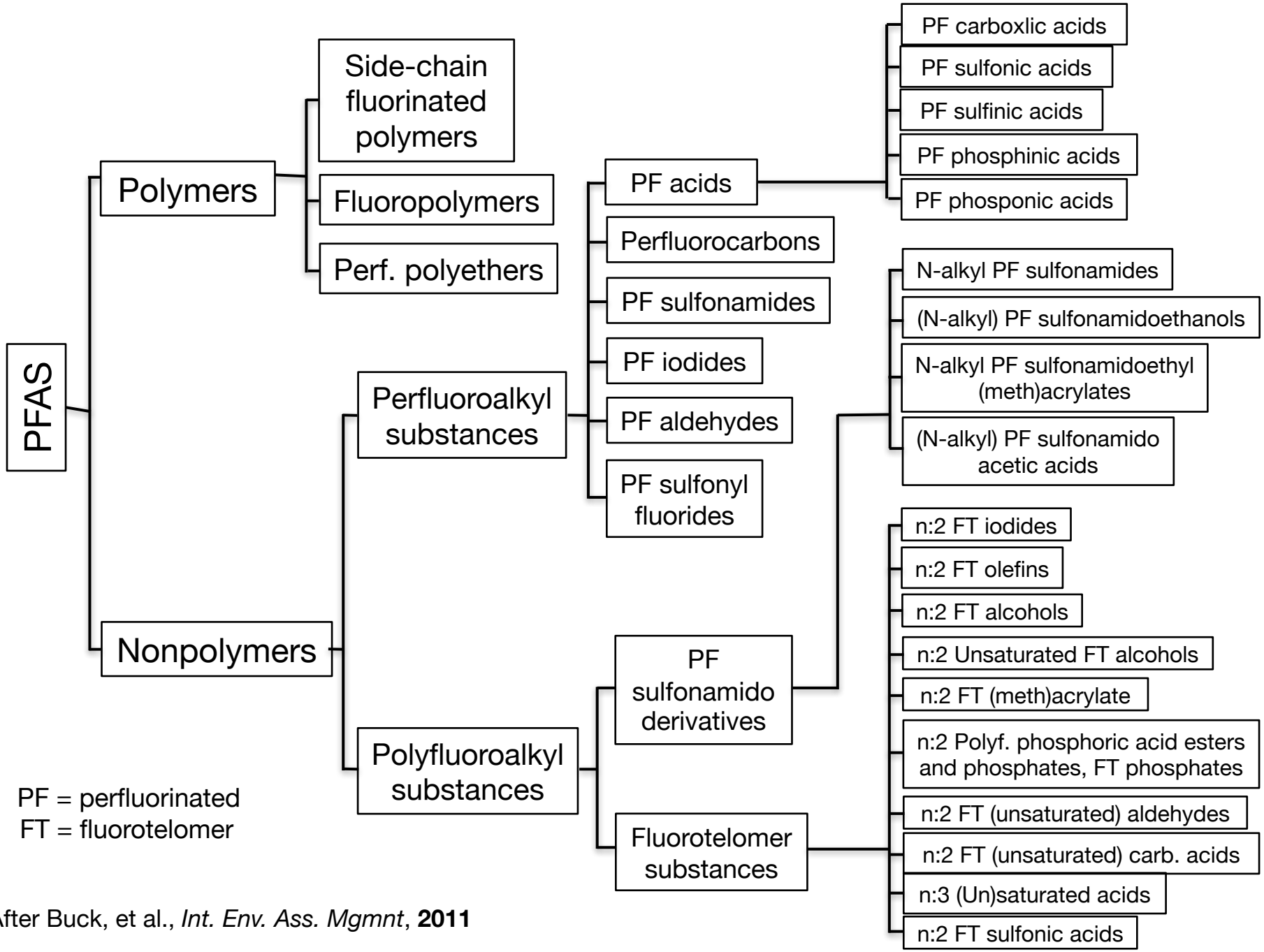
PFOA



Carbon-Fluorine bond strength:

- Leads to oil and water repellency
- "Forever chemicals" -- last for geologic time!

Courtesy: Dr. Jennifer Field



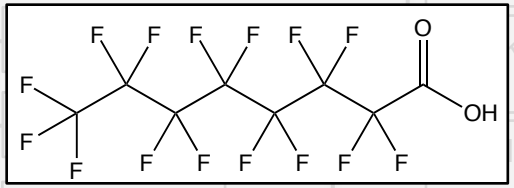
After Buck, et al., *Int. Env. Ass. Mgmnt*, **2011**

PFASs

Polymers
- Side-chain fluorinated polymers
- Fluoropolymers
- Perf. polyethers

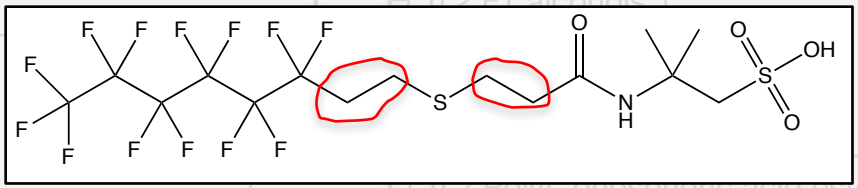
Nonpolymers

Perfluoroalkyl substances
- PF acids
  - PF carboxlic acids
  - PF sulfonic acids
  - PF sulfinic acids
  - PF phosphic acids
  - PF phosponic acids
- Perfluorocarbons
- PF sulfonamides
  - N-alkyl PF sulfonamides
  - (N-alkyl) PF sulfonamidoethanols
  - kyl PF sulfonamidoethyl (meth)acrylates
  - kyl) PF sulfonamido acetic acids

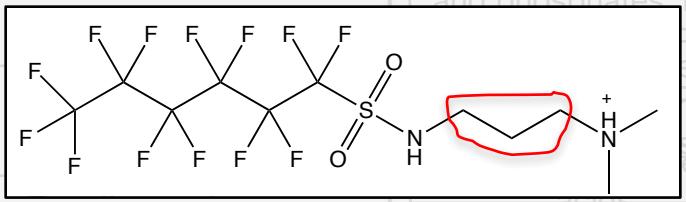


- PF sulfonyl fluorides

Polyfluoroalkyl substances
- n:2 FT iodides
- n:2 FT olefins
- n:2 FT alcohols

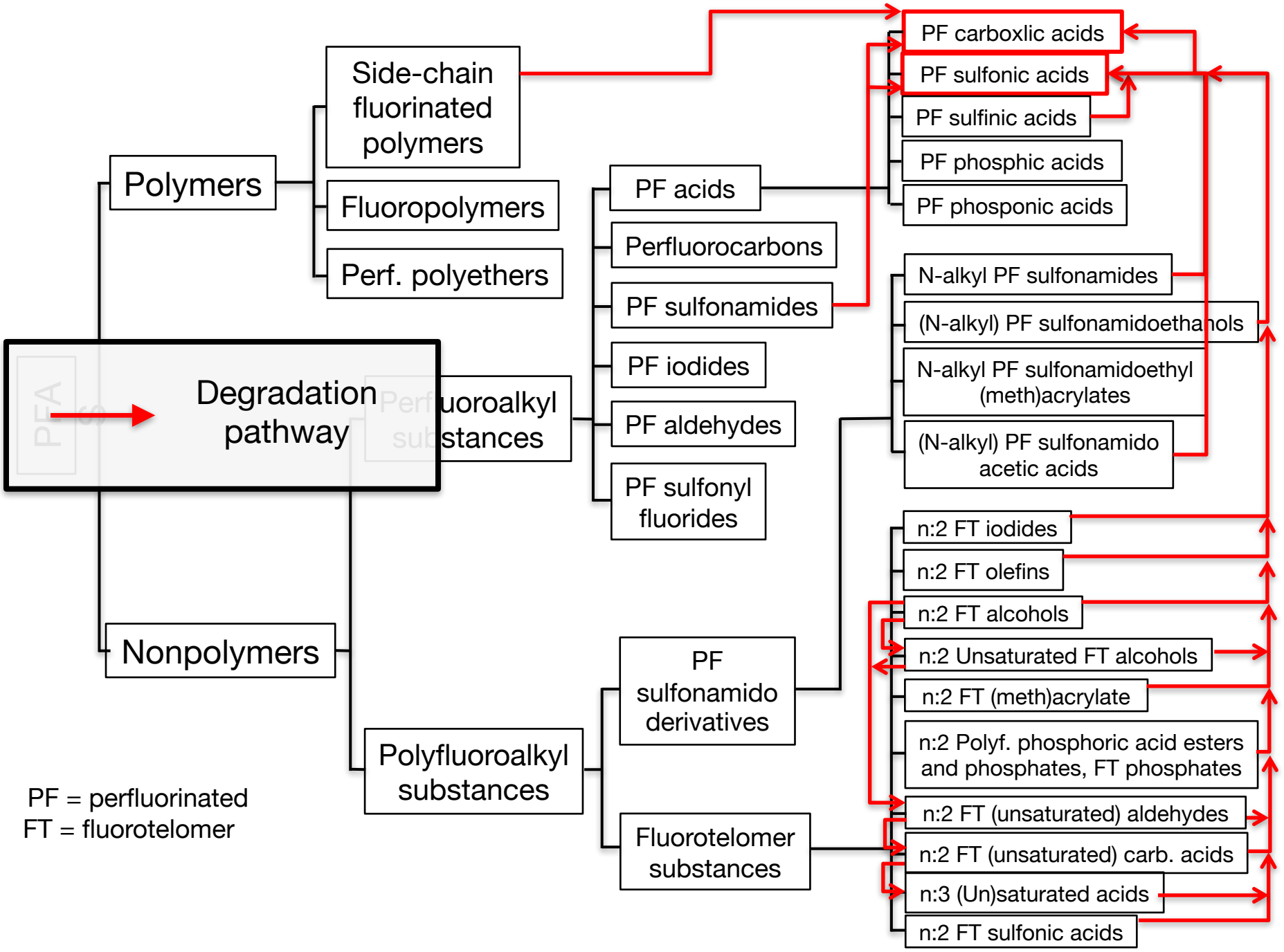


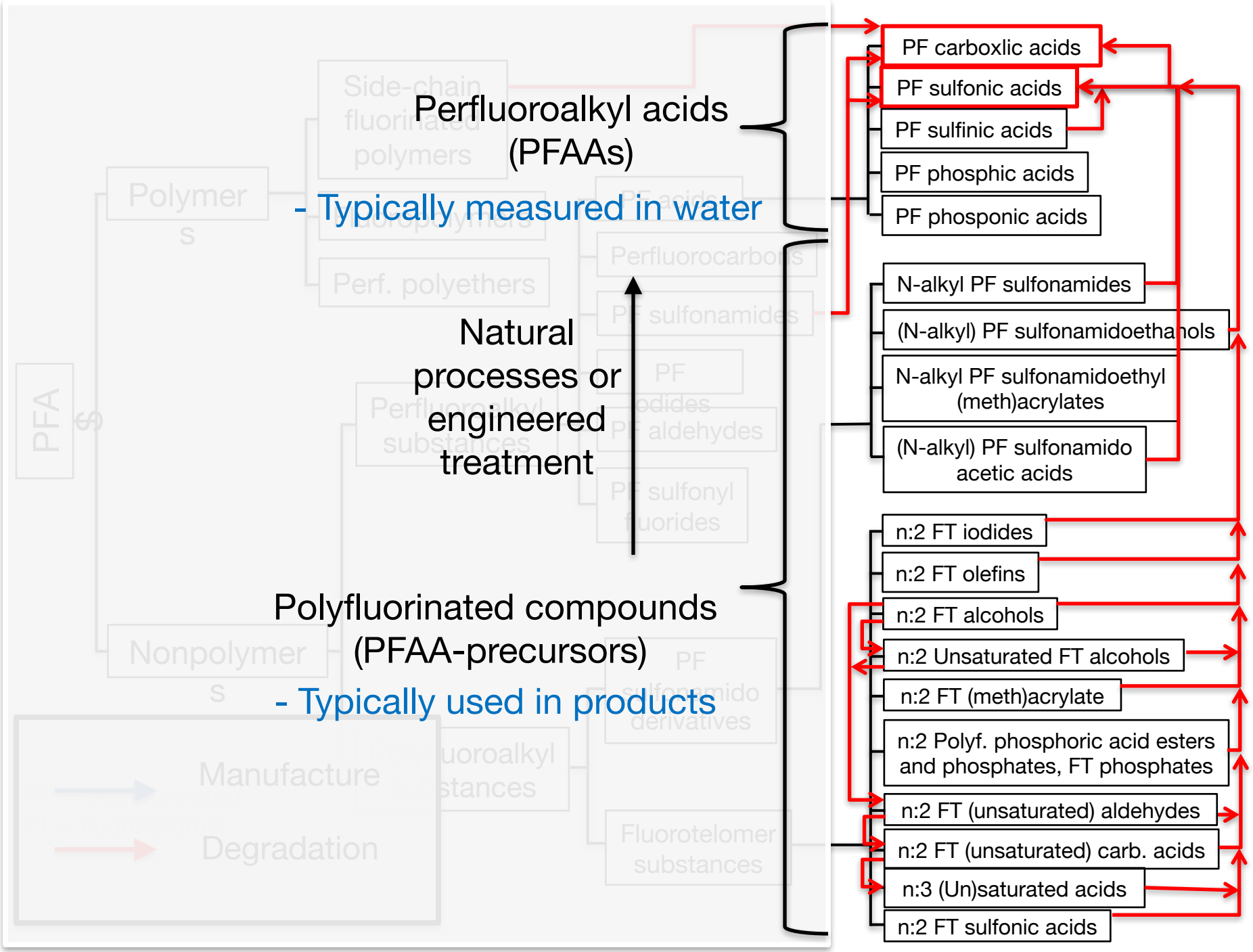
- n:2 Polyf. phosphonic acid esters and phosphates, FT phosphates
- ed) aldehydes
- ated) carb.
- ed
- acids
- n:2 FT sulfonic acids



PF = perfluorinated
FT = fluorotelomer

After Buck, et al., *Int. Env. Ass. Mgmnt*, **2011**


Polymers
Side-chain fluorinated polymers
Fluoropolymers
Perf. polyethers
Degradation pathway
Nonpolymers
uoroalkyl stances
PF acids
Perfluorocarbons
PF sulfonamides
PF iodides
PF aldehydes
PF sulfonyl fluorides
Polyfluoroalkyl substances
PF sulfonamido derivatives
Fluorotelomer substances
PF carboxlic acids
PF sulfonic acids
PF sulfinic acids
PF phosphic acids
PF phosponic acids
N-alkyl PF sulfonamides
(N-alkyl) PF sulfonamidoethanols
N-alkyl PF sulfonamidoethyl (meth)acrylates
(N-alkyl) PF sulfonamido acetic acids
n:2 FT iodides
n:2 FT olefins
n:2 FT alcohols
n:2 Unsaturated FT alcohols
n:2 FT (meth)acrylate
n:2 Polyf. phosphoric acid esters and phosphates, FT phosphates
n:2 FT (unsaturated) aldehydes
n:2 FT (unsaturated) carb. acids
n:3 (Un)saturated acids
n:2 FT sulfonic acids
PF = perfluorinated
FT = fluorotelomer


Perfluoroalkyl acids (PFAAs)
- Typically measured in water
Natural processes or engineered treatment
Polyfluorinated compounds (PFAA-precursors)
- Typically used in products
PF carboxlic acids
PF sulfonic acids
PF sulfinic acids
PF phosphic acids
PF phosponic acids
N-alkyl PF sulfonamides
(N-alkyl) PF sulfonamidoethanols
N-alkyl PF sulfonamidoethyl (meth)acrylates
(N-alkyl) PF sulfonamido acetic acids
n:2 FT iodides
n:2 FT olefins
n:2 FT alcohols
n:2 Unsaturated FT alcohols
n:2 FT (meth)acrylate
n:2 Polyf. phosphoric acid esters and phosphates, FT phosphates
n:2 FT (unsaturated) aldehydes
n:2 FT (unsaturated) carb. acids
n:3 (Un)saturated acids
n:2 FT sulfonic acids

Common Uses


CARPETS


CARPET CLEANING PRODUCTS


FOOD PACKAGING


FURNISHINGS


COSMETICS


OUTDOOR GEAR


CLOTHING


ADHESIVES AND SEALANTS

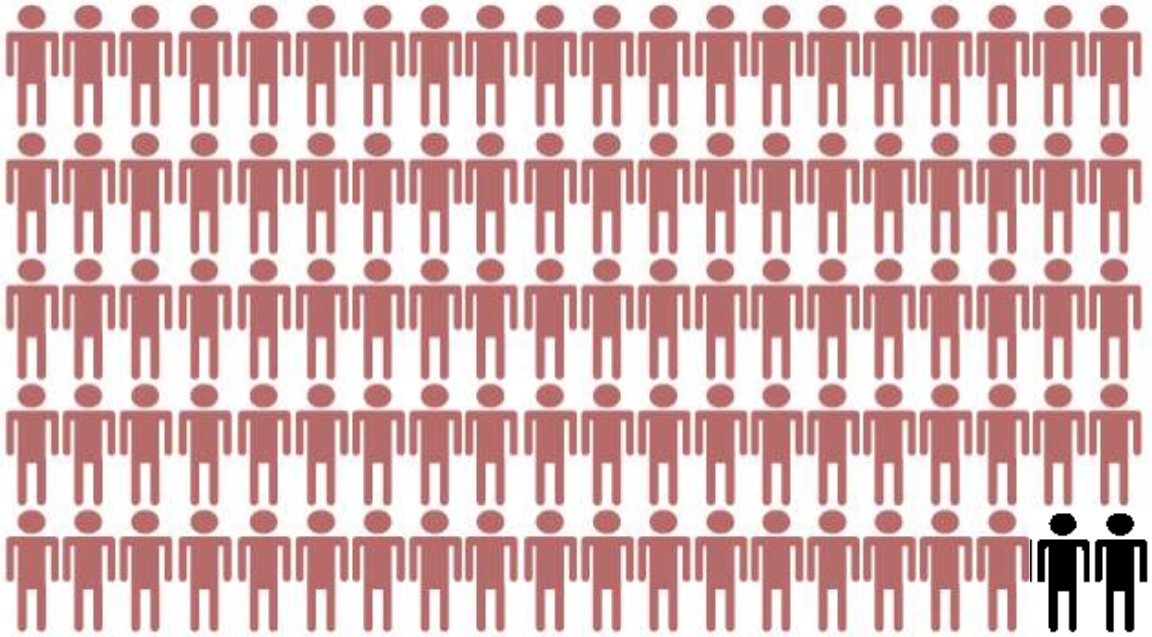

PROTECTIVE COATINGS


NON-STICK COOKWARE


CARSEATS


FIREFIGHTING FOAM

PFASs exposure is a health concern



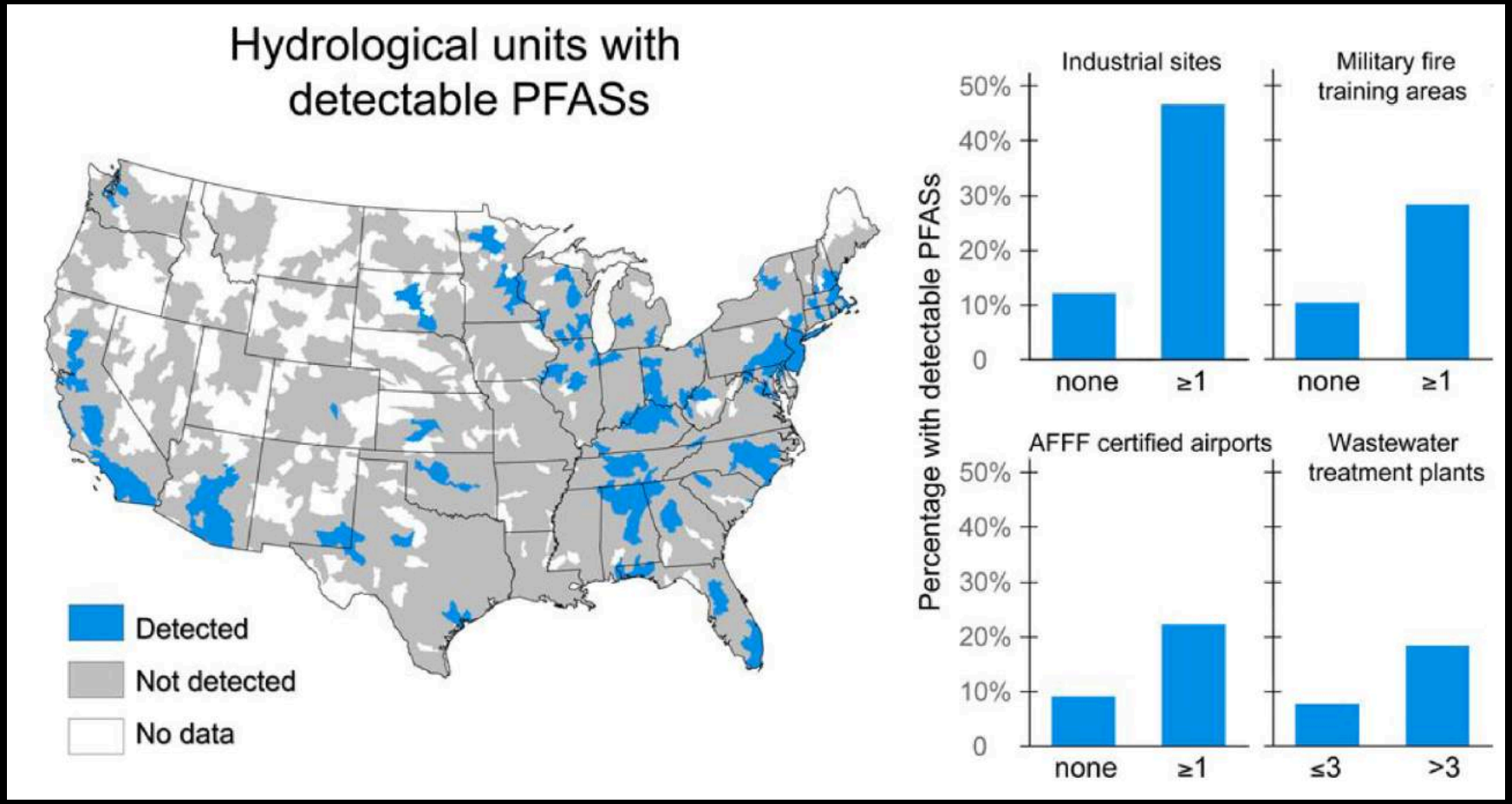
Exposure linked to health risks:

Cancer, elevated cholesterol, obesity, immune suppression, and endocrine disruption

Courtesy, Cindy Hu, Harvard University

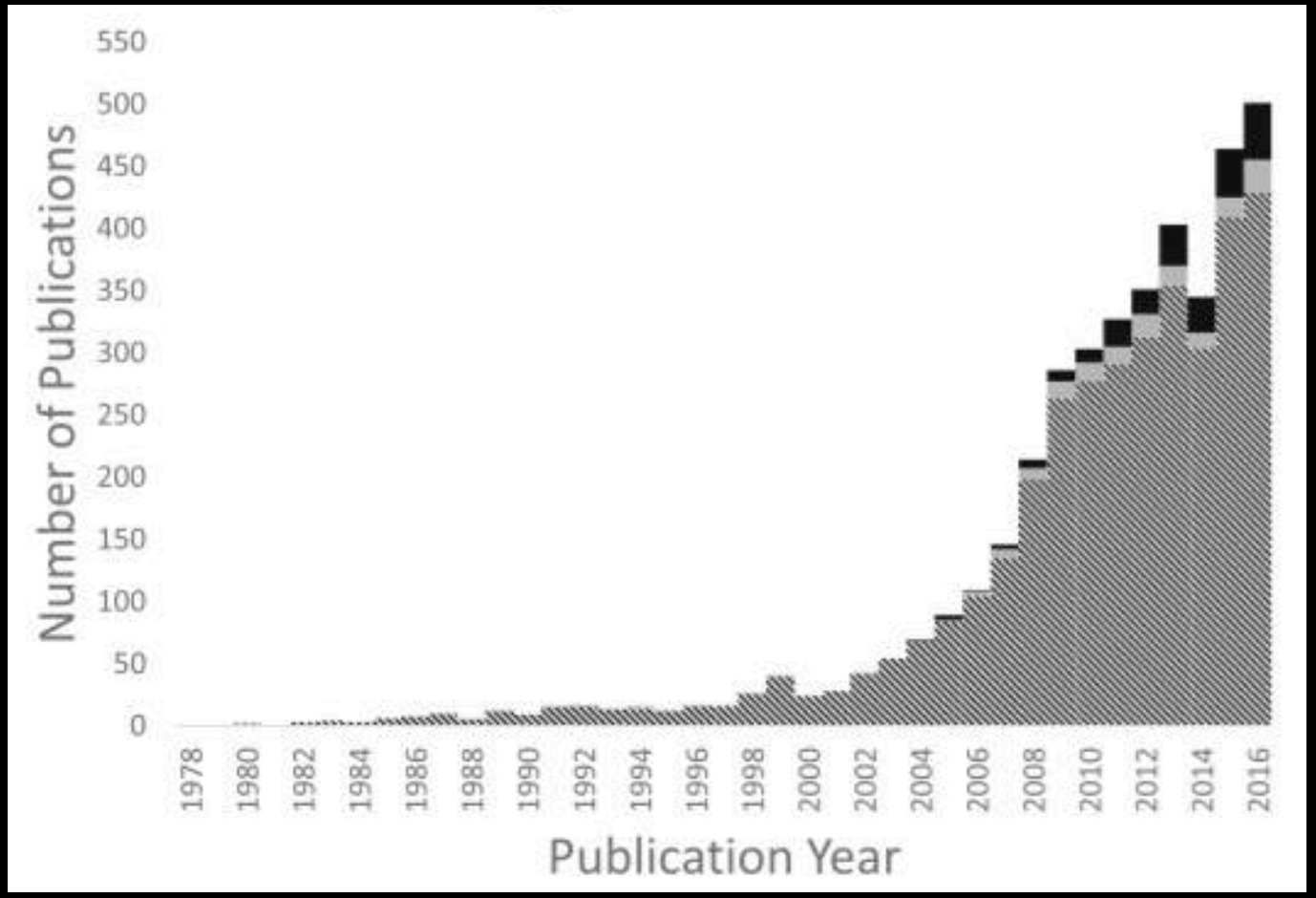
(Ref: Lewis et al., 2015; Grandjean et al., 2012; Braun et al., 2016; Barry et al., 2013)

EPA Lifetime Health Advisory Level of 70 ng/L PFOA + PFOS



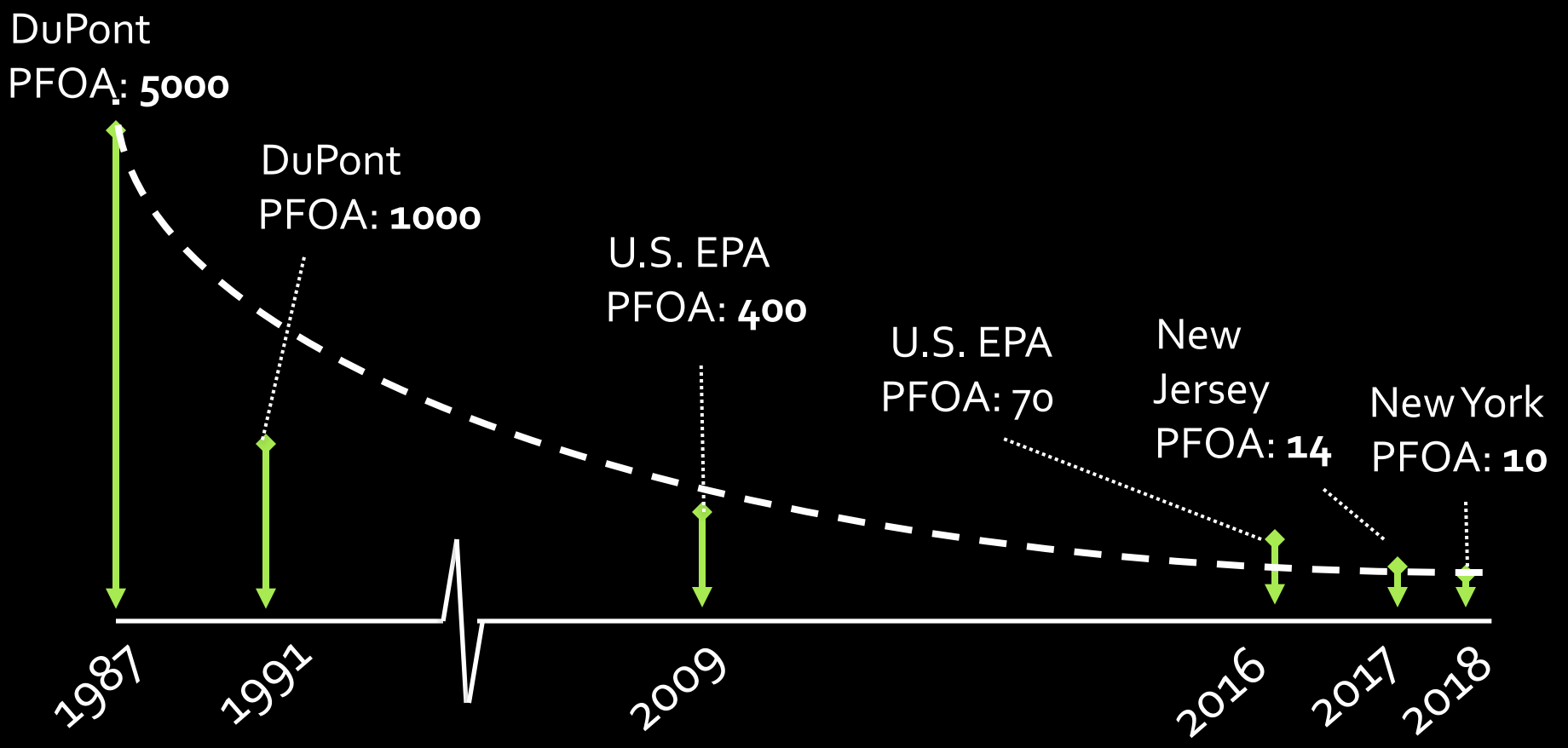
Hu et al., Environ. Sci. Technol. Lett. 2016

Scientific publications on PFAS

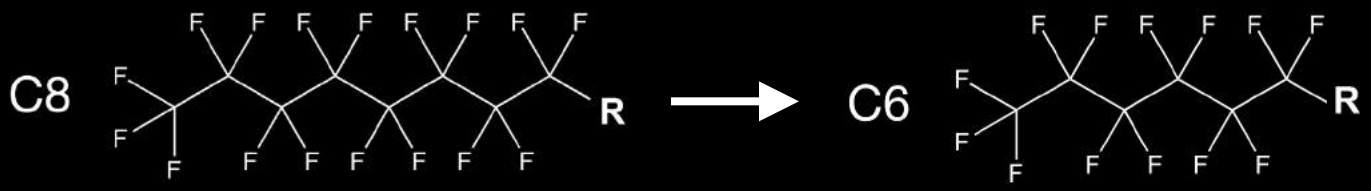


Grandjean, Environ. Health. 2018

Drinking Water Health Guidelines



Industrial Transition



Long-chain PFAS

Concerns:

- Extreme persistence
- **Bioaccumulation**
- Toxicity

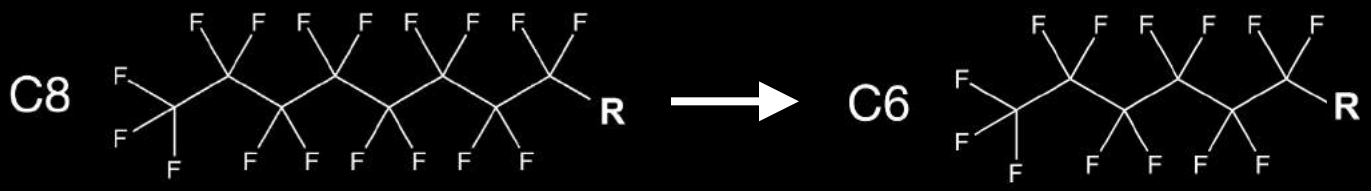
Short-chain PFAS

- "Favorable toxicological profile"[1]
- "Safe for intended use"[2]

1._https://www.chemours.com/Industrial_Bakery_Solutions/en_GB/sustainability/dibs_genx.html

2._https://fluorocouncil.com/fluorotechnology/terminology/

Is C6 a safer substitute for C8?



Long-chain PFAS

Concerns:

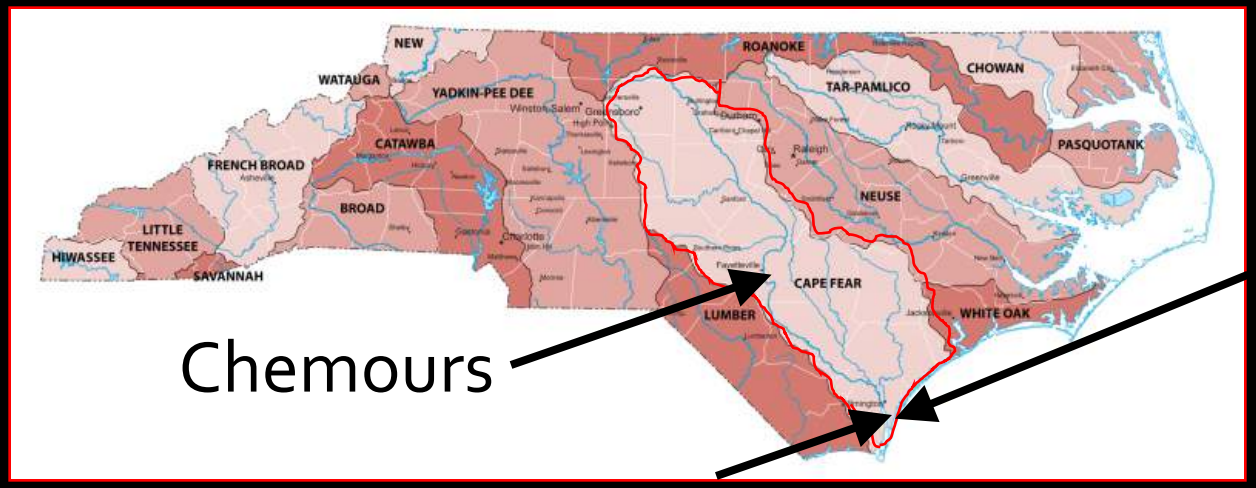
- Extreme persistence
- **Bioaccumulation**
- Toxicity

Short-chain PFAS

Concerns:

- Extreme persistence
- Build up in plants
- Suspected toxicity
- More mobile
- Remediation more difficult

Water Treatment Costs: North Carolina



Brunswick County: reverse osmosis filtration:

- $99M to build
- $2.9M to operate

Cape Fear Public Utility Authority activated carbon filtration:

- $46M to build
- $2.7M to operate each year

Wilmington Star News, May 9th and 10th, 2018

Recent comments from CDC

Patrick Breysse, Director of the CDC's National Center for Environmental Health:

The presence of perfluorinated chemicals in U.S. drinking water is "one of the most seminal public health challenges for the next decades."

"...it won't be too long before we think hundreds of millions of Americans will be drinking water with levels of these chemicals above levels of concern."

- BNA News, Oct. 17, 2017

Congressional PFAS Task Force

- Launched 1/24/19
- Goals
  - Educate
  - Legislate
  - Elevate
  - Appropriate

- Members:

Lujan (NM-03)
King (NY-03)
McGovern (MA-02)
Upton (MI-06)
Huizenga (MI-02)

Dingell (MI-12)
Turner (OH-10)
Boyle (PA-02)
Walberg (MI-07)
Lawrence (MI-14)

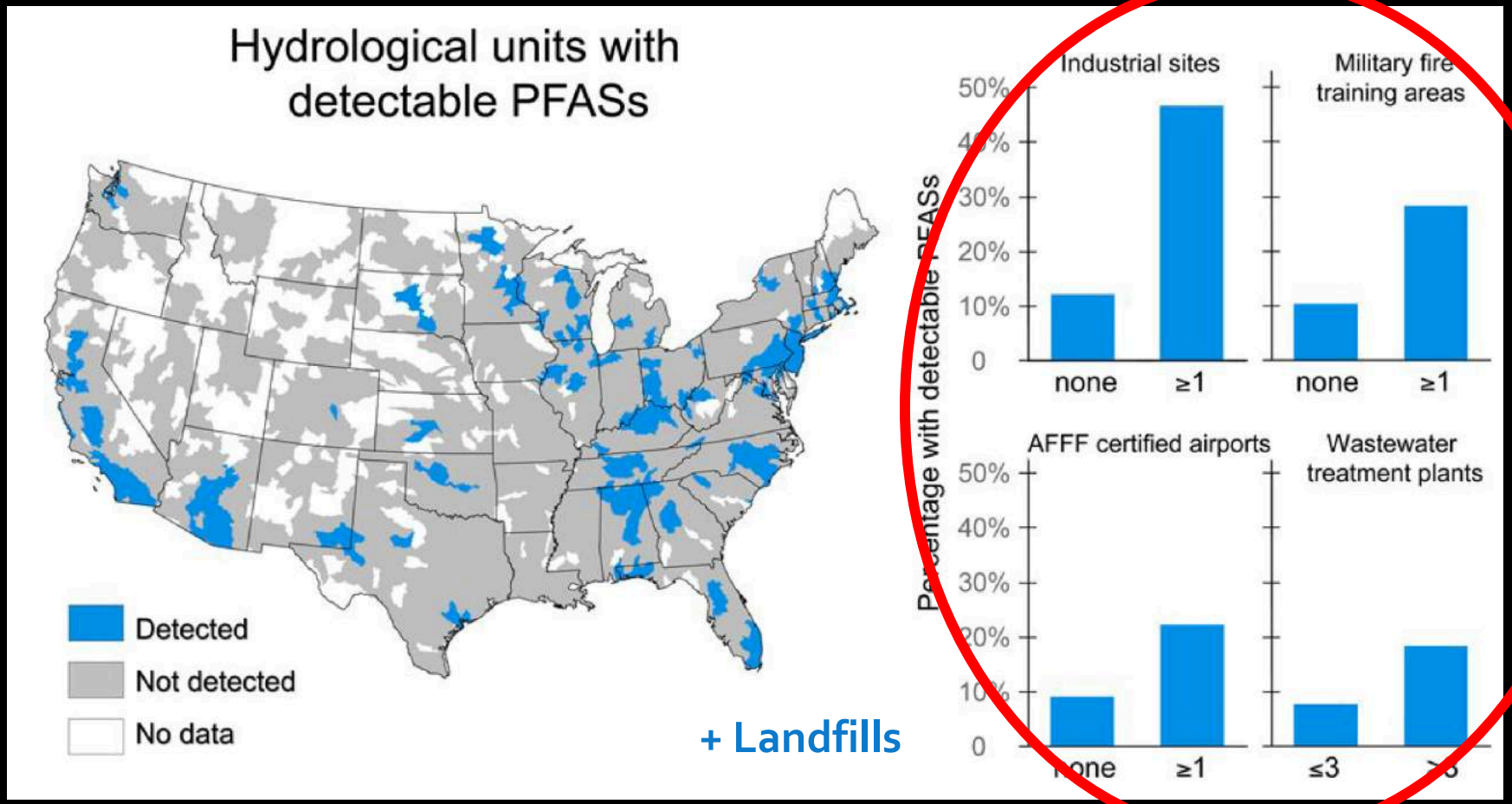
Bergman (MI-01)
Dean (PA-04)
Delgado (NY-19)
Levin (MI-09)
Stevens (MI-11)

Slotkin (MI-08)
Tlaib (MI-13)
Maloney (NY-18)
Pappas (NH-04)

PFAS are Problematic & Difficult to Clean Up

Prevention is Preferable!

EPA Lifetime Health Advisory Level of 70 ng/L PFOA + PFOS



Hu et al., Environ. Sci. Technol. Lett. 2016

Industrial facilities

- Primary manufacturing
  - Where PFAS are made
  - Relatively few
  - Responsible for massive amounts of emissions
- Secondary manufacturing
  - Where PFAS are used
  - More common

Primary Manufacturing:
West Virginia fluorochemical plant

- PFOA used to manufacture fluoropolymers
- Releases to air, groundwater, surface water
- 70,000 + residents with contaminated drinking water
- C8 Health Study + class action suit

Secondary Manufacturing: Michigan leather tannery

- Wolverine treated leather with Scotchguard (PFOS)
  - Leather scrap dumped
  - Sludge applied to fields

- PFOA + PFOS level up to 58,000 ppt

  842 times EPA health advisory level!

Secondary Manufacturing: other examples

- Hoosick Falls, NY
- Bennington, VT
- Merrimack, NH

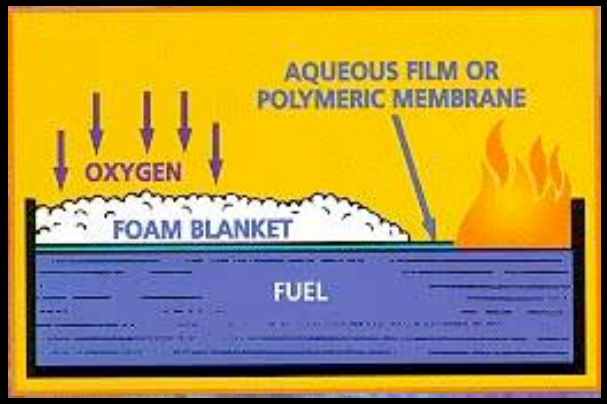
} PFAS-coated fabrics/plastics

- Parchment, MI — Paper mill
- Wixom, MI — Chrome plater

- Likely other industries

Firefighting foam

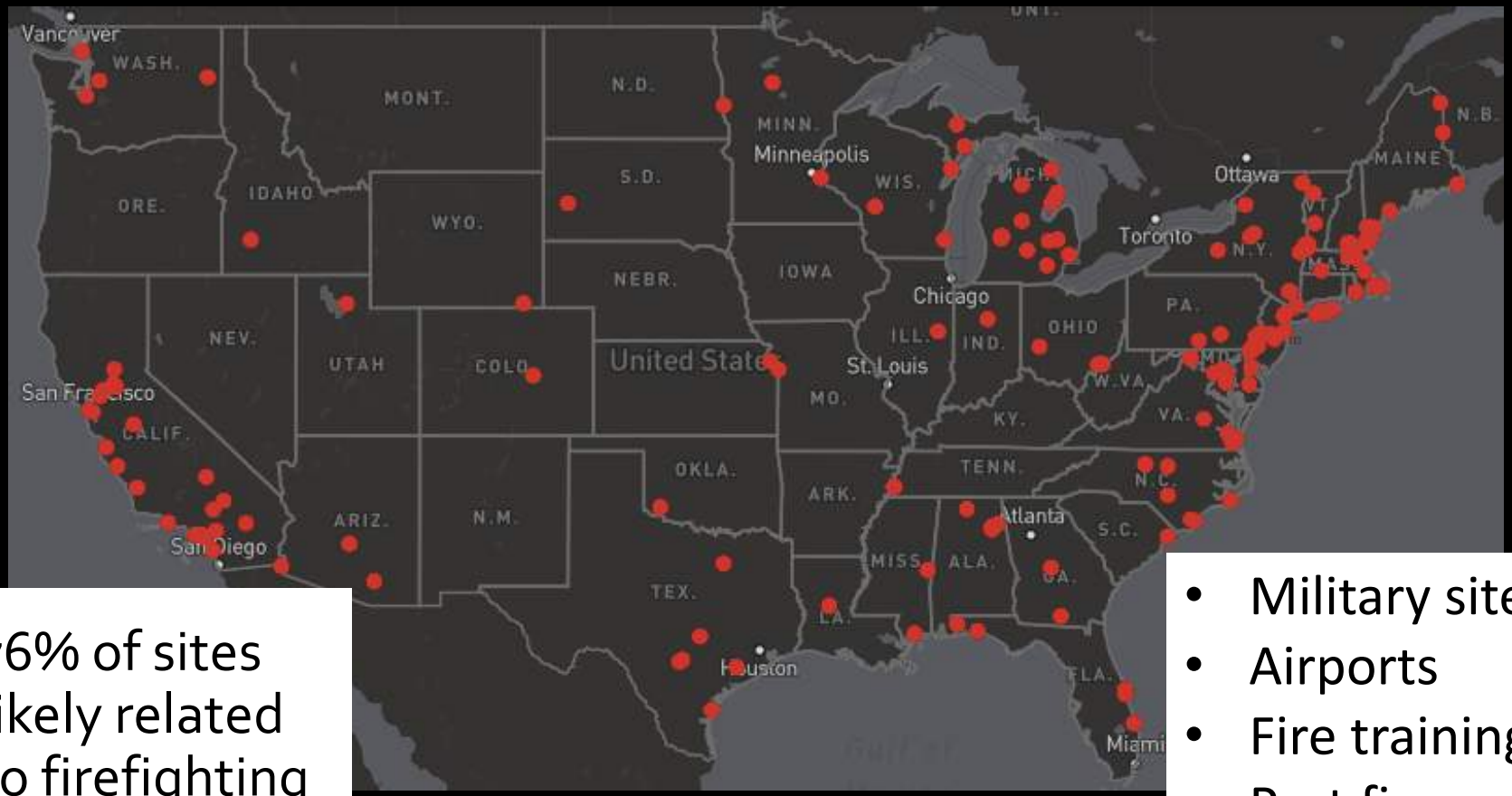
Aqueous Film-Forming Foams (AFFF)



- For fighting Class B (petroleum) fires
- Contains PFAS
- Used by military, airports, municipal firefighters, oil & gas industry
- High concentrations of PFAS now found in soil and groundwater at training sites

Foam as a Source of Water Contamination

Northeastern U. and EWG Site Tracker, 10/4/18



76% of sites likely related to firefighting foam use

- Military sites
- Airports
- Fire training
- Past fires

SE Pennsylvania

- 3 military installations:
  - Horsham
  - Warminster
  - Willow Grove
- 230-340k gallons foam used over 46 years

- PFAS leached to groundwater
- Water systems serving > 85k people impacted
  - PFOS+PFOA level up to 329,500 ppt

>4000 times EPA health advisory level!

New Mexico

- Cannon Air Force Base
  - Firefighting foam entered groundwater
  - PFAS migrated from base to dairy wells to cows to milk
  - Farmer: "I can't sell the milk. I can't sell beef. I can't sell the cows. I can't sell crops on my property."
    - PFOS level up to 12,000 ppt

      171 times EPA health advisory level!

Government policy is a major driver of AFFF use

- Class B firefighting foams used by the U.S. military are required to contain PFAS.
  - MILSpec: "Concentrates shall consist of fluorinated surfactants…"
- U.S. civilian airports are also required to use PFAS-containing foam
  - FAA policy refers to MILSpec

Fluorine-Free Foams

"Current fluorine-free … firefighting foams are now viable operational alternatives to fluorinated AFFF."

"Unlike fluorinated AFFFs, fluorine-free foams do not give rise to environmentally persistent, toxic, or bio-accumulative chemically stable end-products."

https://ipen.org/documents/fluorine-free-firefighting-foams

Washington State's Ban on PFAS in Firefighting Foam

(HB 2793/SB 6413)

- Signed into law on March 27, 2018
- Bans sale of firefighting foam containing any PFAS beginning July 1,2020

- **The states of CT, GA, KY, MA, MN, NY have similar bills this year**

More info https://toxicfreefuture.org/key-issues/legislative-priorities-2018/

TOXIC-FREE FUTURE

SCIENCE • ADVOCACY • RESULTS

Congress to FAA: allow the use of fluorine-free foams

2018 FAA Reauthorization

- Directs FAA to allow airports to use PFAS-free Class B firefighting foams (within 3 years)
- Signed into law Oct. 5
- Response from FAA?

Congress to DoD: allow the use of fluorine-free foams

2020 defense bill:

- Senate: Bans most use of PFAS-containing foam after 2023
- House: Phase-out of PFAS foam 2027-2029


THE HILL

Trump threatens veto on defense bill that targets 'forever chemicals'

BY REBECCA BEITSCH AND MIRANDA GREEN - 07/10/19 05:40 PM EDT

158 COMMENTS

3,278 SHARES

SHARE TWEET

WWTPs

WWTPs

- Sources of PFAS loading
  - Industrial – electroplating, firefighting foam, other?
  - Landfill leachate
  - Consumer – carpets, apparel, food packaging, cosmetics, other
- Conventional treatment trains not effective for PFAS removal
  - Effluent > influent
- Partitioning to biosolids
  - Long-chains > short-chains
- Air emissions?

Maine

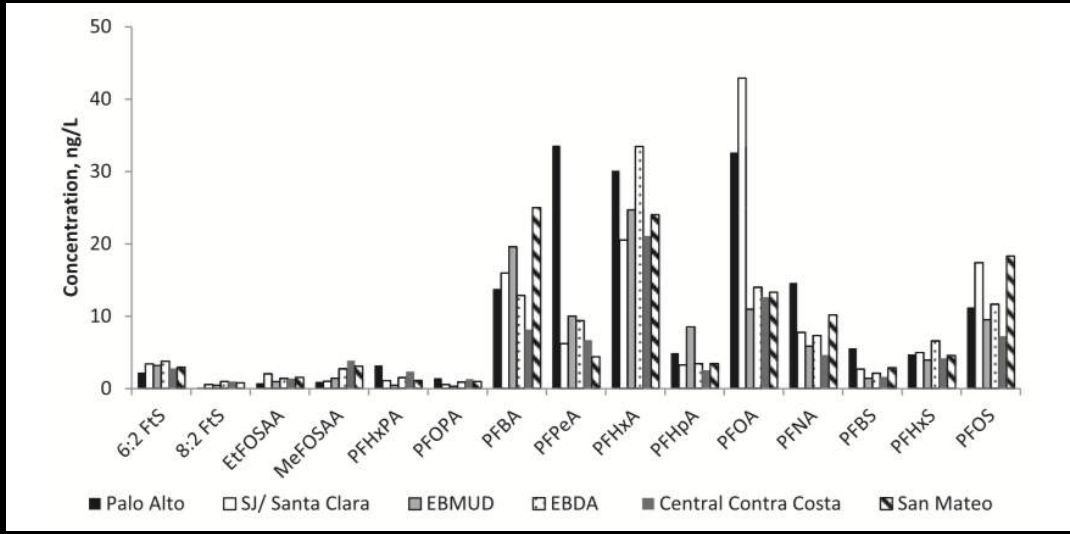
- Biosolids spreading led to contamination of
  - Local municipal supply well
  - Milk at dairy

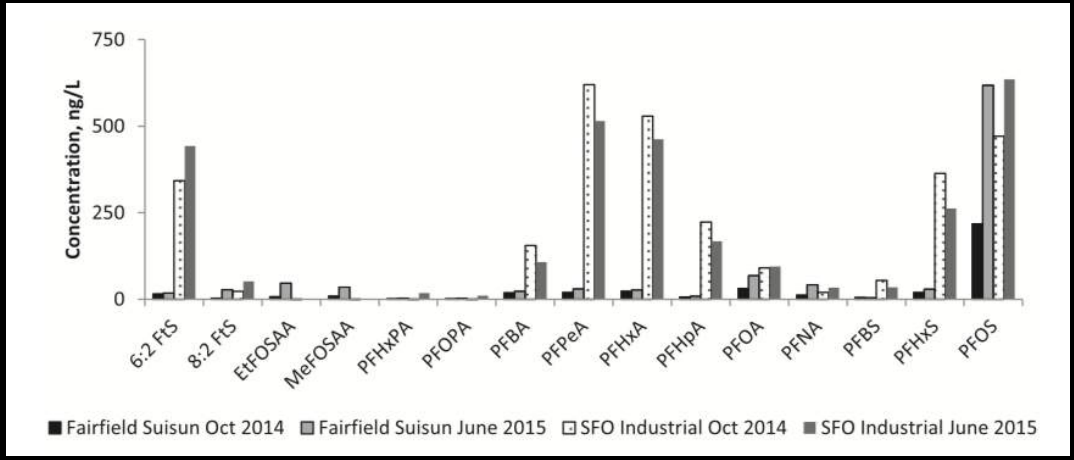
- Maine DEP:
  - All biosolids must now be tested for PFAS prior to use
  - Initial testing: nearly all biosolids exceed state screening levels for PFOS and/or PFOA (5.2 and 2.5 ng/g)

https://theintercept.com/2019/06/07/pfas-chemicals-maine-sludge/

See also: Venkatesan and Halden, J. Hazard Mater., 2013

WWTPs - the impact of firefighting foam





See: Houtz, et. al, Water Research, 2016

Landfills

Landfills – C6 PFAS dominate

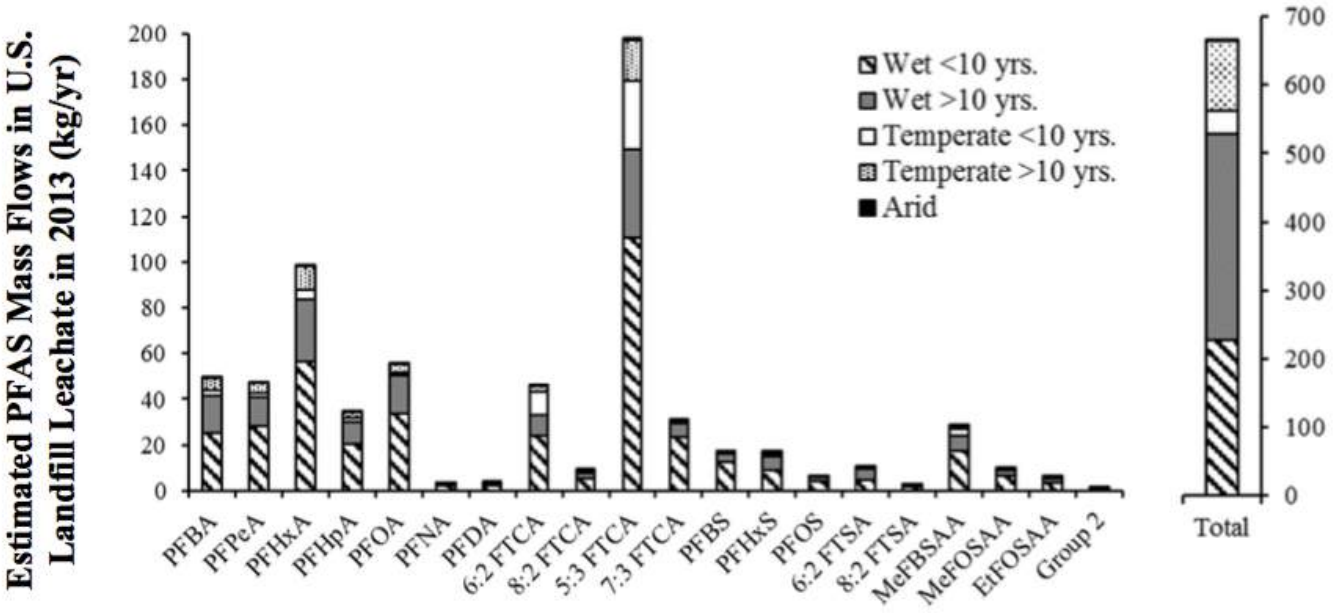
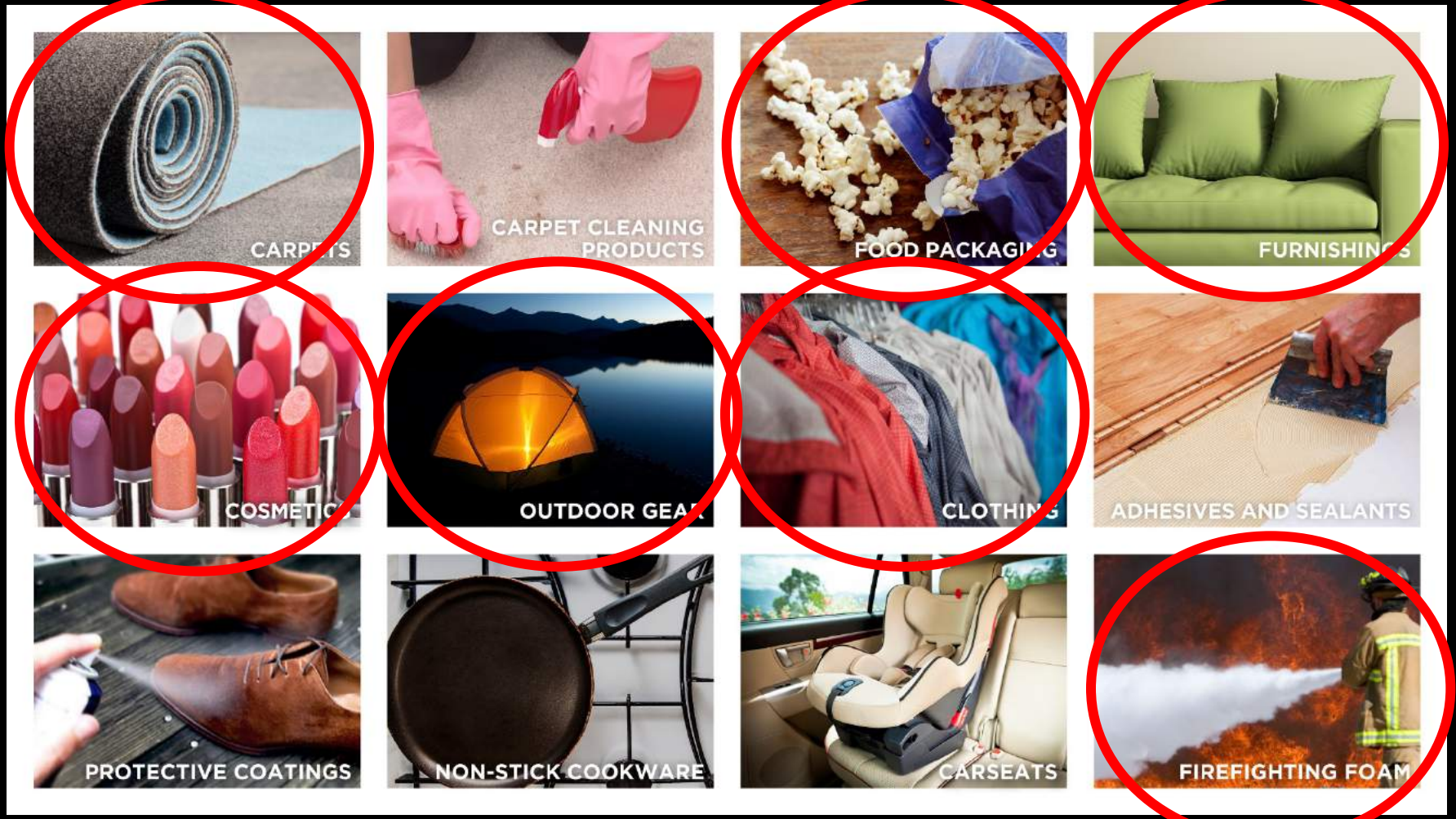


Figure 1. Group 1 PFAS release in U.S landfill leachate for 2013 demonstrating a dominance of compounds with five fluorinated carbons (PFHxA and 5:3 FTCA). Releases were calculated from mean concentrations in each climate and age category (Table 3). The individual columns are based on eq. 1 while the total is based on eq. 2

See: J. Lang, et. al, ES&T, 2017

Moving away from PFAS



2020 Defense Bill (NDAA)

House

- DoD foam phaseout
- $ for USGS monitoring
- $5M for ATSDR health study
- Clean Water Act
- Superfund
- More…

Senate

- DoD foam phaseout
- $ for USGS monitoring
- $10M for ATSDR health study
- Drinking water standard for PFOA + PFOS in 2 y
- Toxics Release Inventory
- Firefighter blood testing

By reducing use of Six Classes

We can have a healthier world.

For more information
Green Science Policy Institute
www.greensciencepolicy.org