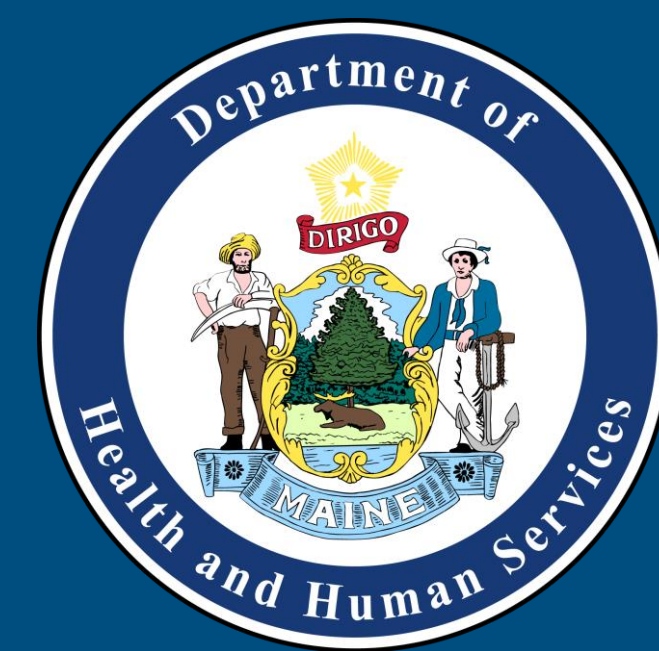


Summary findings of a multiyear study on PFAS uptake into grasses and corn plants on biosolid amended fields in Maine



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Background

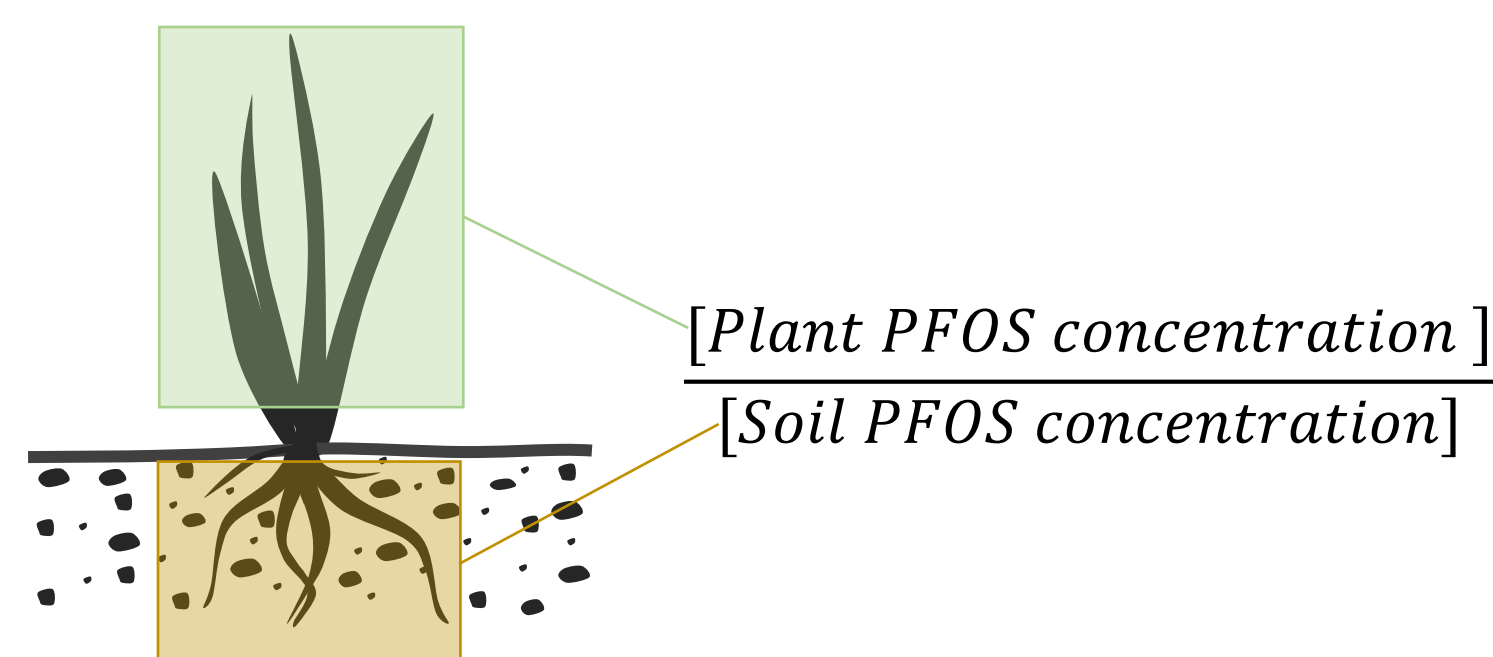
Several dairy and beef farms in Maine ceased sales of their products temporarily, or permanently, or depopulated their herds, due to elevated PFOS in their milk or beef products. The impacted farms all have a history of application of biosolids resulting in PFOS and other PFAS soil contamination. This led to the investigation of a soil to forage to cow's milk or beef tissue exposure pathway.



A key but understudied part of this PFOS exposure pathway is the transfer of PFOS from soil directly into the forage crops used for livestock feed.

Objective

- ❖ Conduct field studies to measure PFOS in soil, grasses/legumes, and corn plants to obtain a more robust plant-specific transfer factor estimate for PFOS.



Methods

- ❖ Perennial forage (grass/legume) farm plot and farm field studies

- Four study plots were established on a dairy farm with elevated PFOS soil levels with co-located soil and pasture sward sampling in 2021, 2022, and 2023. At four other farms co-located samples were collected in multiple fields in a single year as part of a multi-farm survey.
- The co-located samples were collected in a 1x1' section of pasture sward. Plant material was cut 2-3" above the ground and all plant material bagged. Within the 1x1' area three soil cores of 2" diameter and 6-8" depth were collected and hand homogenized.
- Co-located soil and pasture sward samples were collected in triplicate in the plot study and in most of the fields at other farms.
- Plant samples were cryoground at Battelle, or FDA laboratories, and analyzed for targeted PFAS using isotope dilution LC-MS/MS. Soil samples were sent to Battelle or Alpha Analytical for targeted PFAS analysis also using isotope dilution LC-MS/MS.



- ❖ Corn silage and snaplage farm field study

- At several fields co-located soil and corn silage and soil and corn snaplage samples were collected.
- Three to five replicate co-located soil/silage and soil/snaplage samples were collected at each field location:
 - Soil samples were collected at the base of each stalk with three 6-8" deep cores combined and hand homogenized.
 - Corn silage samples were entire plants cut 8" above ground, cut into 1' sections and bagged.
 - Snaplage samples consisted of ears, inclusive of husks, broken off the stalk and bagged.
- Silage and snaplage samples were cryoground at Battelle and analyzed for targeted PFAS. Plant sample homogenate was sent to the FDA laboratory for confirmatory analysis. All PFAS analyses were run using isotope dilution LC-MS/MS.



Results

- ❖ Perennial forage (grass/legume) farm plot and farm field studies

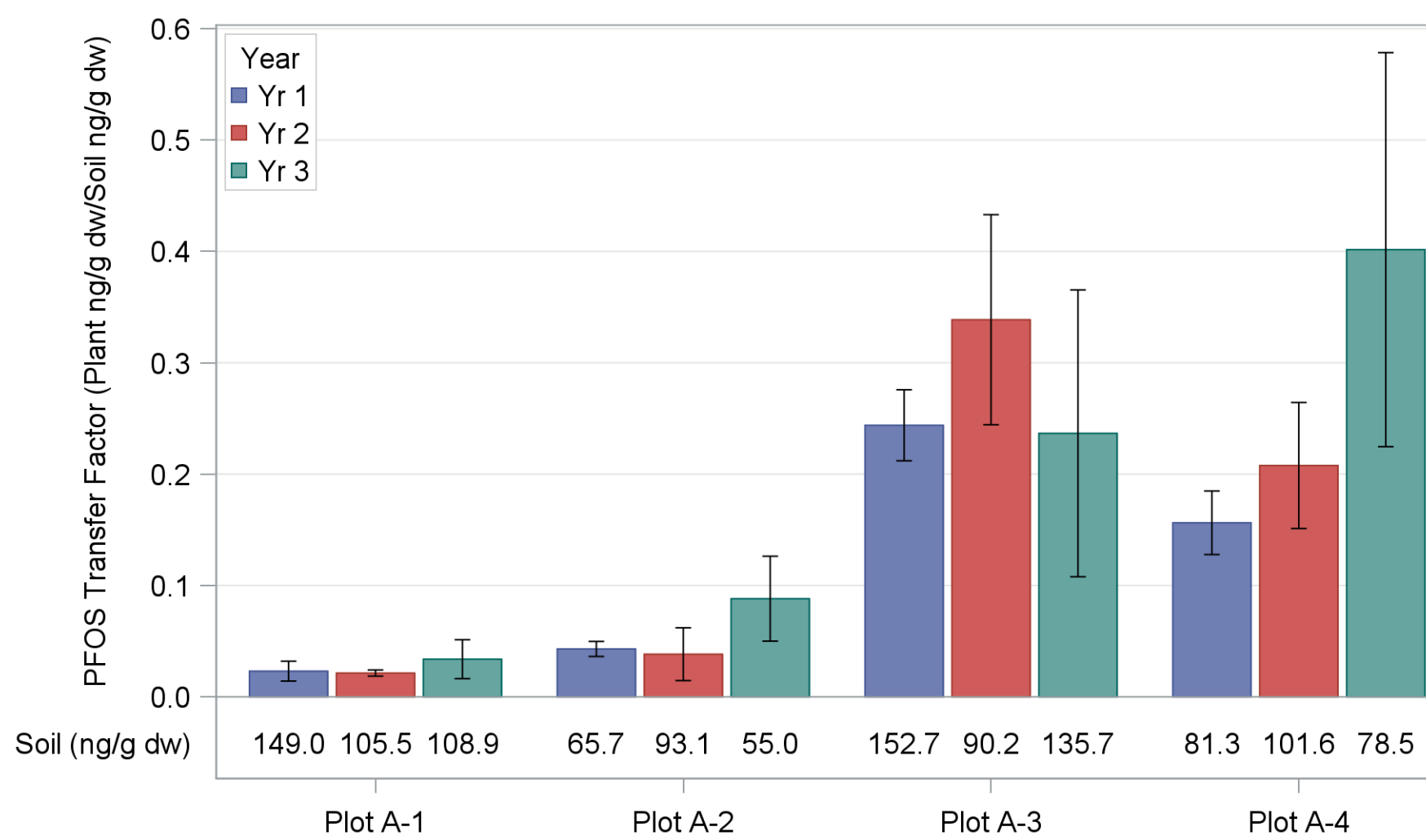


Fig 1. Pasture sward PFOS transfer factor in triplicate sampling of study plots over three years. Means and standard deviations. dw = dry weight.

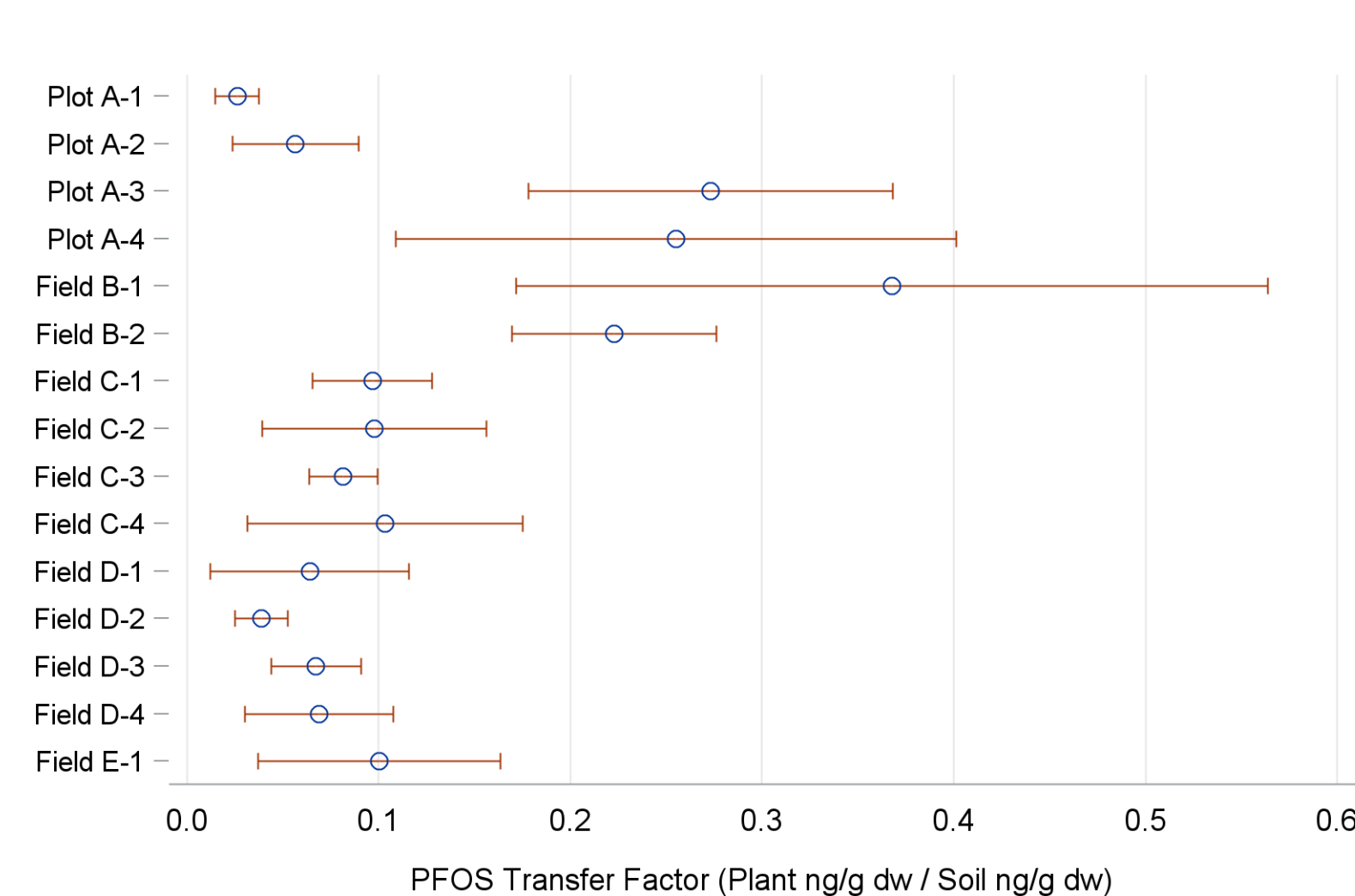


Fig 3. PFOS transfer factors across study plots and farm fields. Mean and standard deviation.

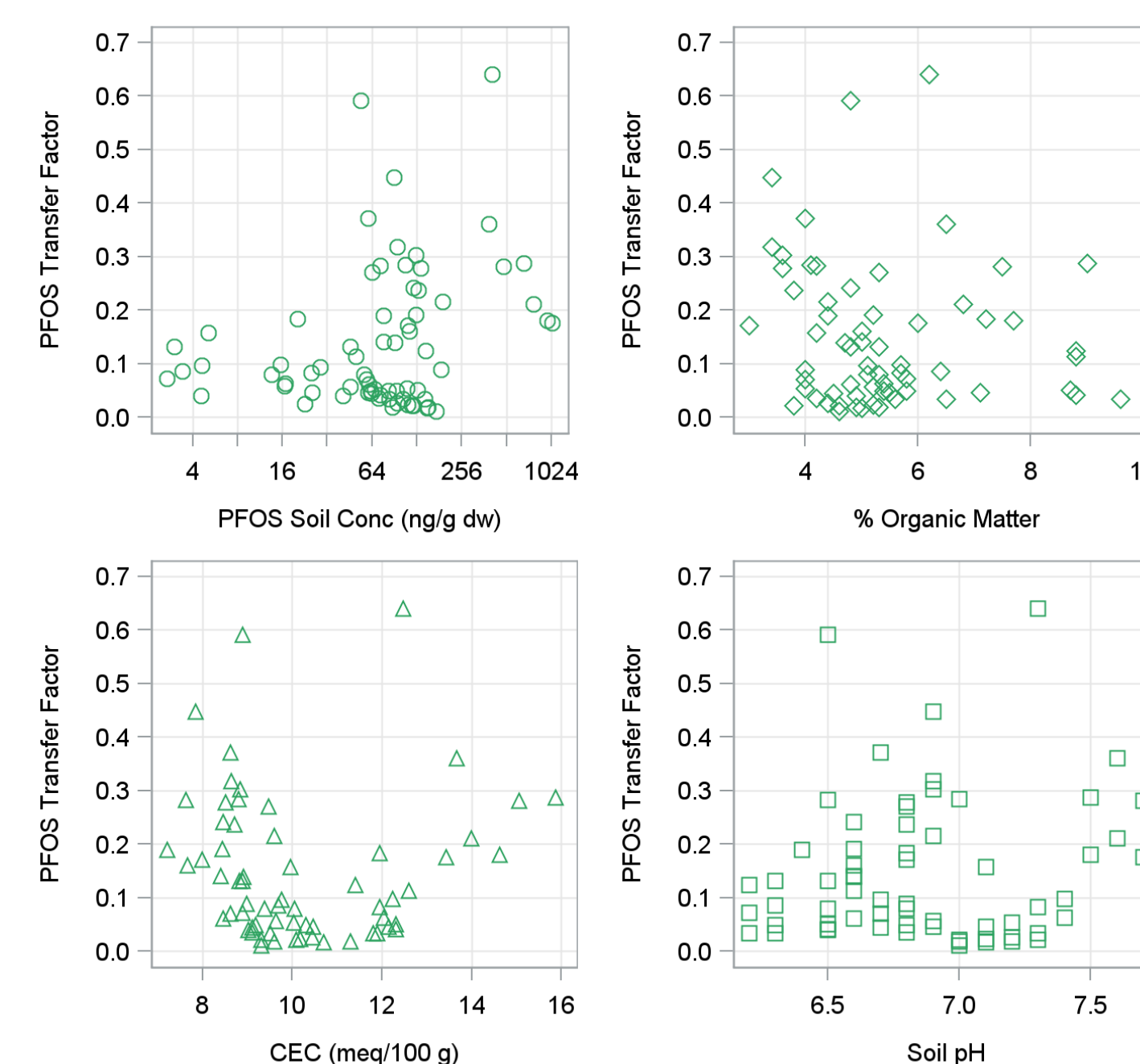


Fig 5. PFOS transfer factor and PFOS soil concentration, % organic matter, soil pH, or cation exchange capacity for all individual farm plot and farm field samples.

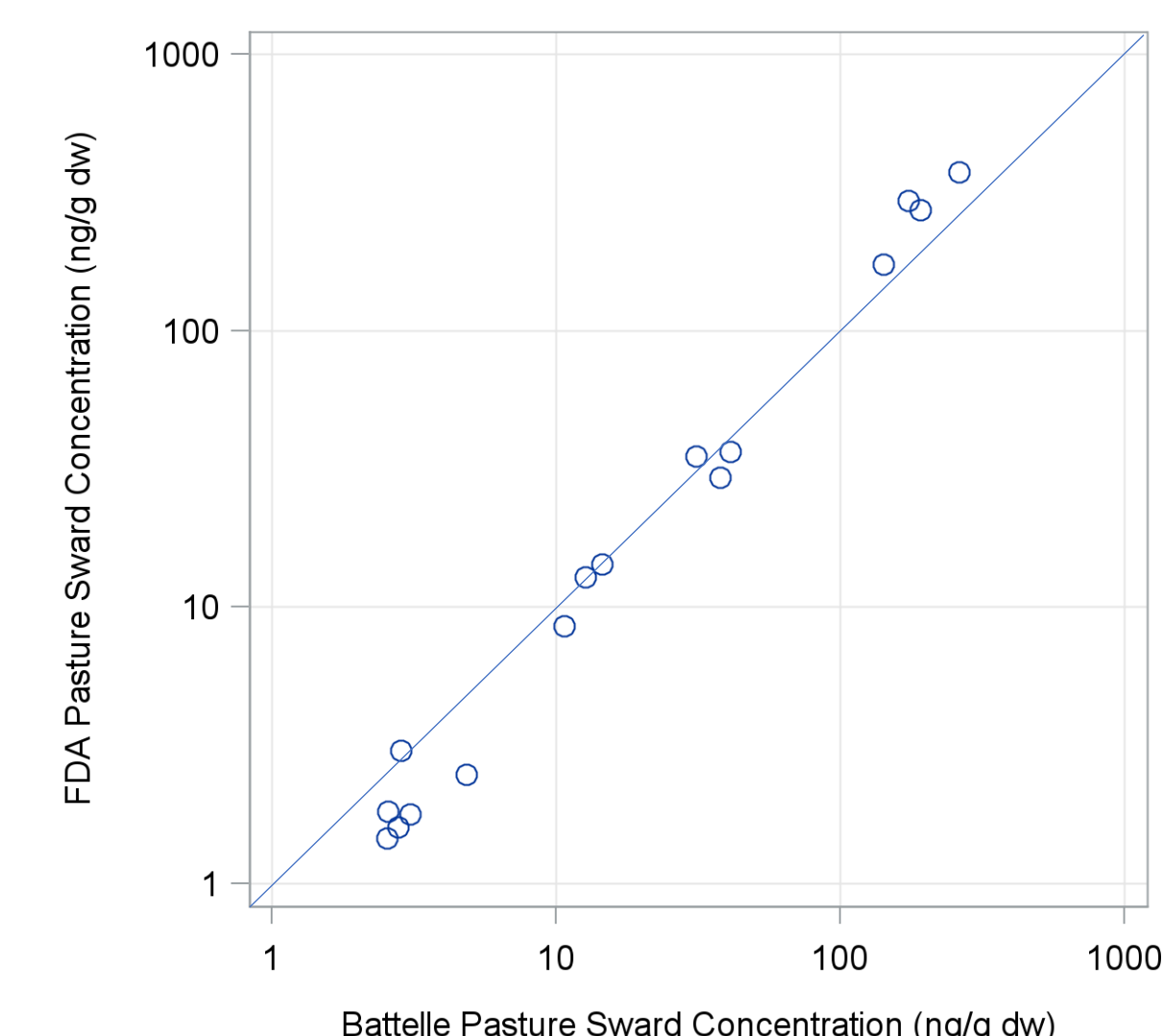


Fig 2. PFOS pasture sward levels in split samples analyzed by Battelle and FDA.

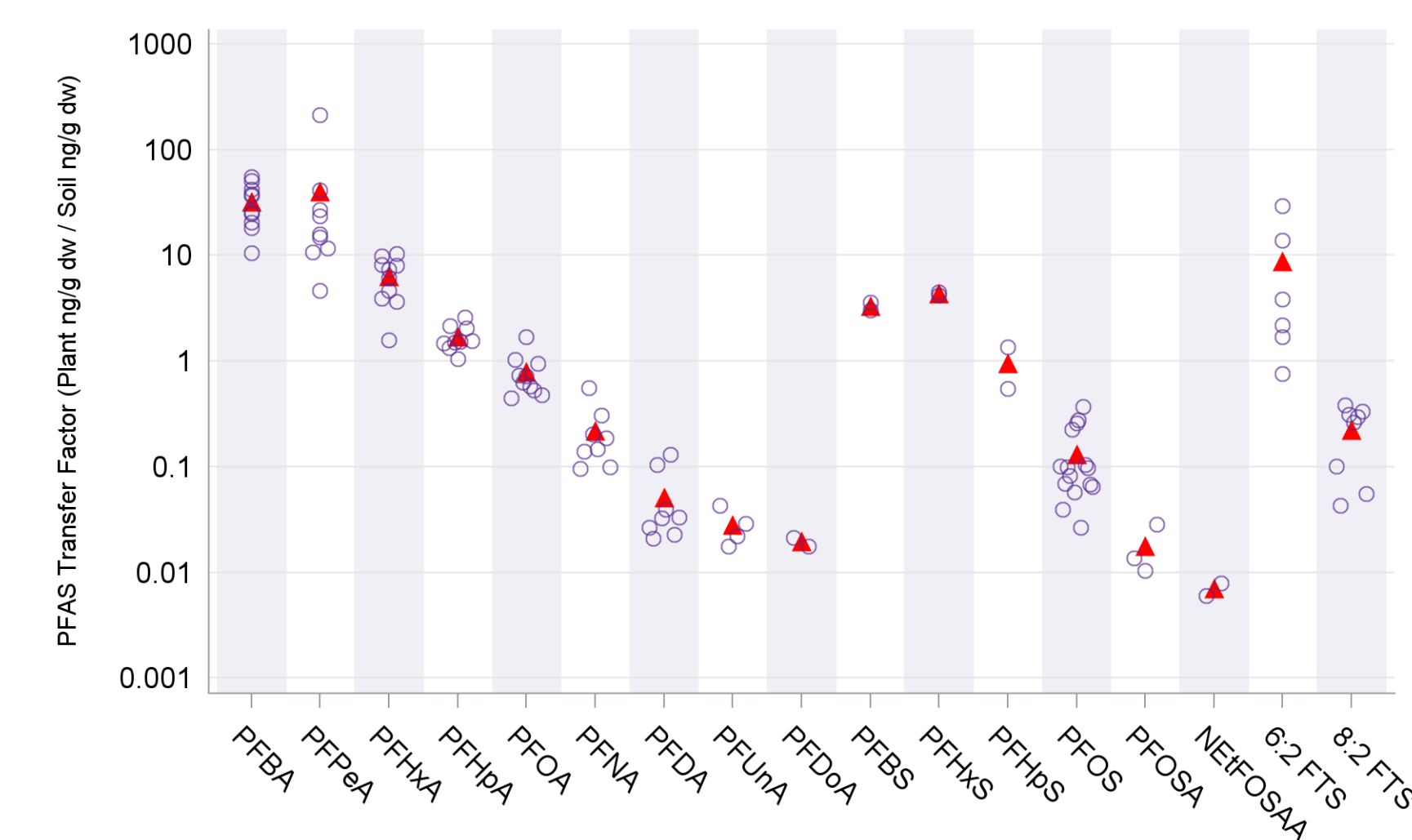


Fig 4. PFAS transfer factors from the study plots and farm fields. Circles are the means by plot or field and the triangles are the overall mean across plots and fields.

- ❖ Corn silage and snaplage farm field study

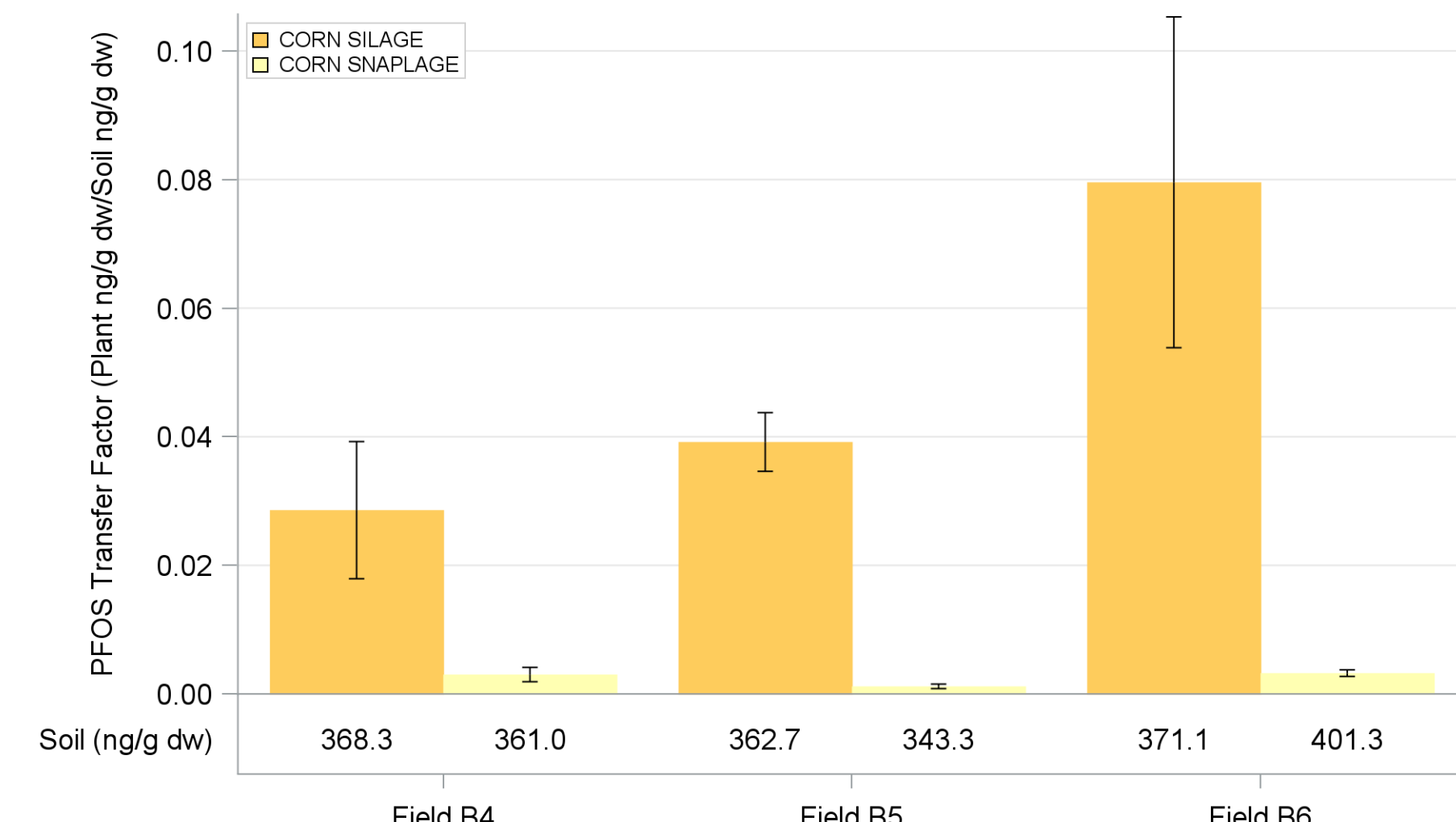


Fig 6. PFOS transfer factor in corn silage and snaplage on selected fields. Means and standard deviations

Conclusions

- ❖ PFOS transfer factors in pasture sward can vary nearly 10 fold. The overall average PFOS transfer factor across the 4 study plots and 11 farms fields tested is 0.1.
- ❖ Based on initial modeling soil PFOS concentration, % organic matter, soil pH, or cation exchange capacity do not appear to be robust explanatory variables for the observed variation in the PFOS transfer factor in pasture sward.
- ❖ There is substantially more PFOS uptake into corn silage than into corn snaplage.
- ❖ These plant-specific transfer factor data can be used in risk assessment models to develop soil screening levels for agronomic exposure pathways and to provide information to help with farm management practices to reduce PFOS levels in cow's milk or beef tissue ([Maine CDC Agronomic Soil Screening Level 2021](https://maine.cdc.gov/Screening-Level-2021), <https://tinyurl.com/4pvk232f>).

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Susan Genualdi at U.S. Food and Drug Administration, Center for Food Safety and Applied Nutrition for confirmatory analysis of PFAS levels in plant tissue. Funding provided by Maine Dept of Environmental Protection, Maine Dept of Agriculture, Conservation, and Forestry, and the Broadreach Foundation.