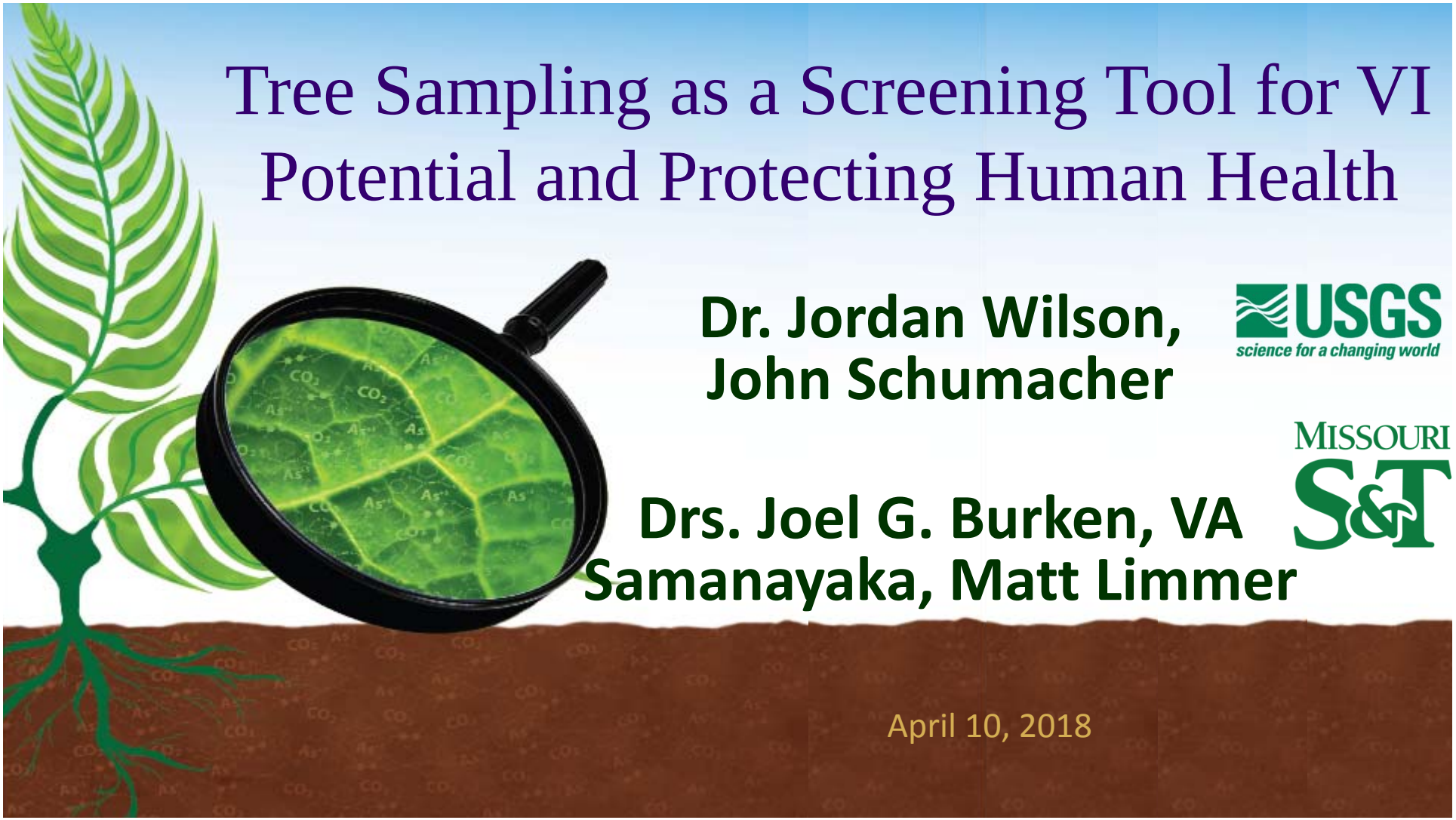
Tree Sampling as a Screening Tool for VI Potential and Protecting Human Health



Dr. Jordan Wilson,
John Schumacher

USGS science for a changing world

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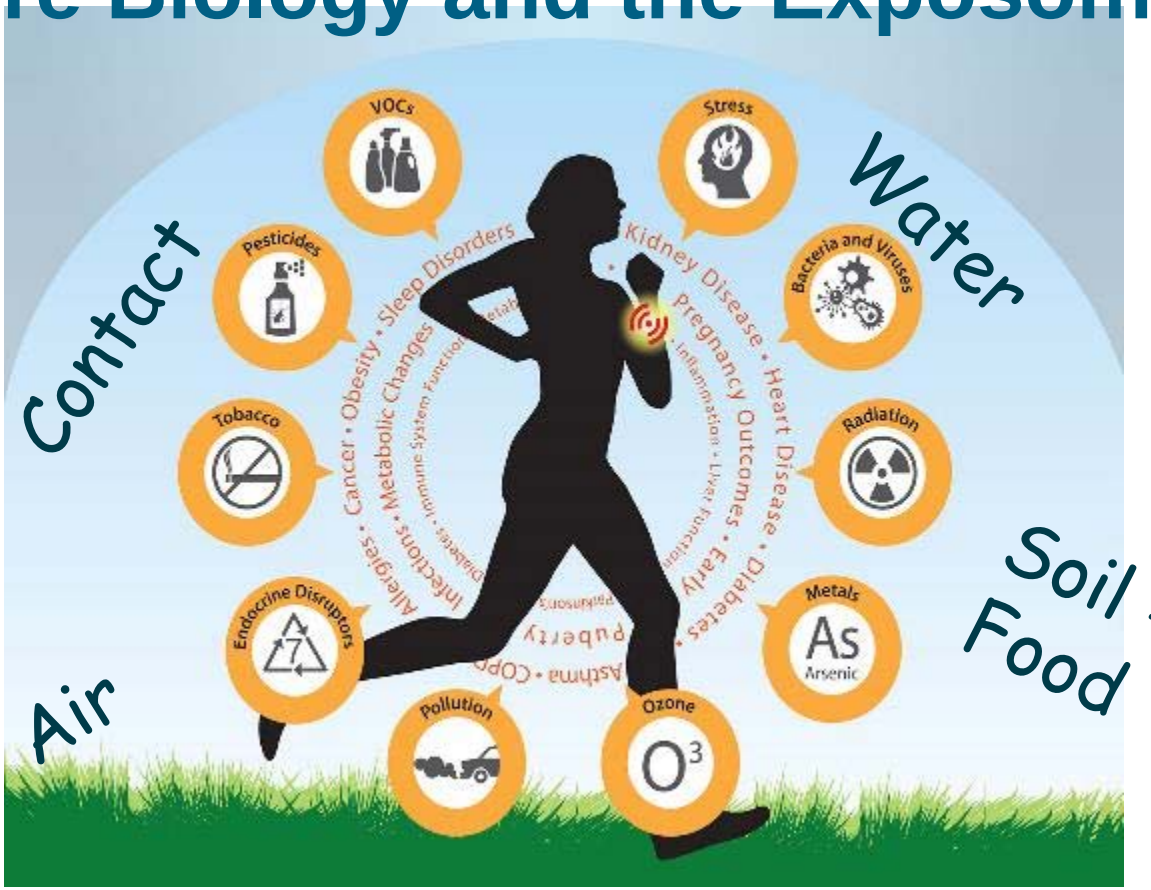
Drs. Joel G. Burken, VA Samanayaka, Matt Limmer

April 10, 2018

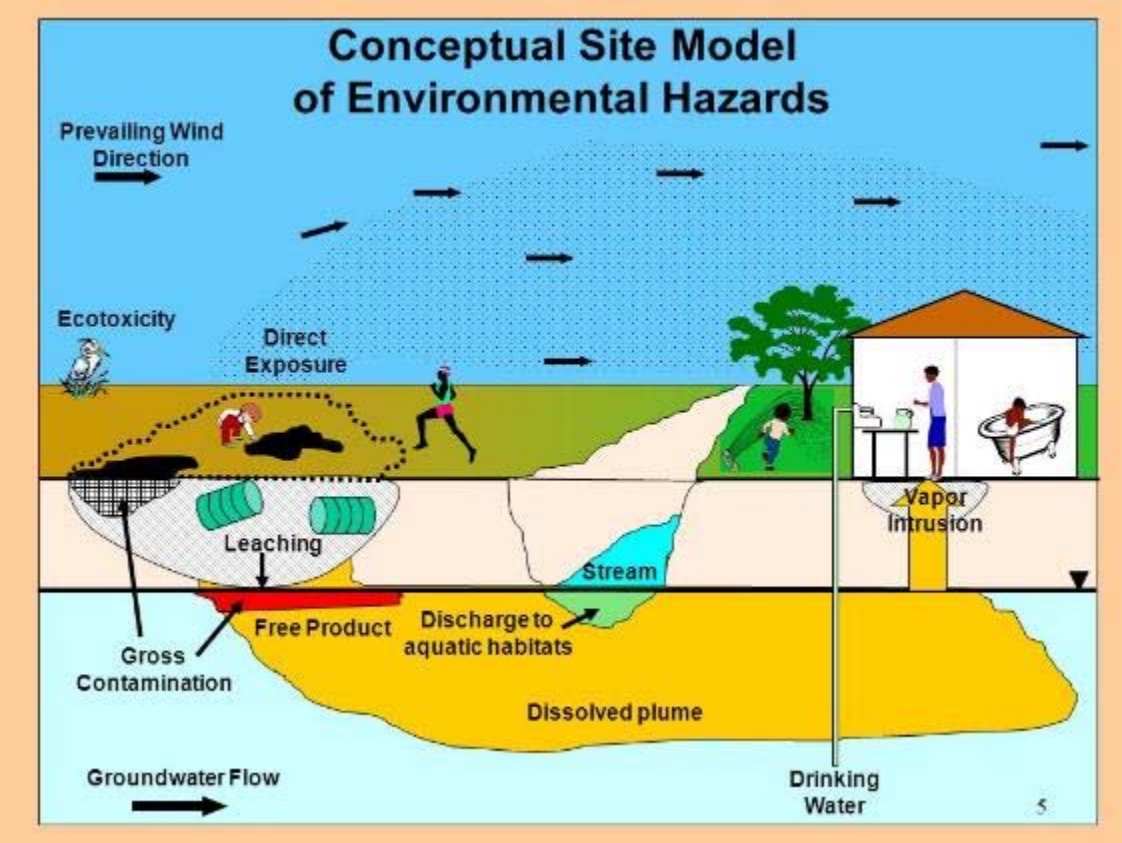
Exposure Biology and the Exposome



Health Impacts

+ Exposures

= Hard to evaluate



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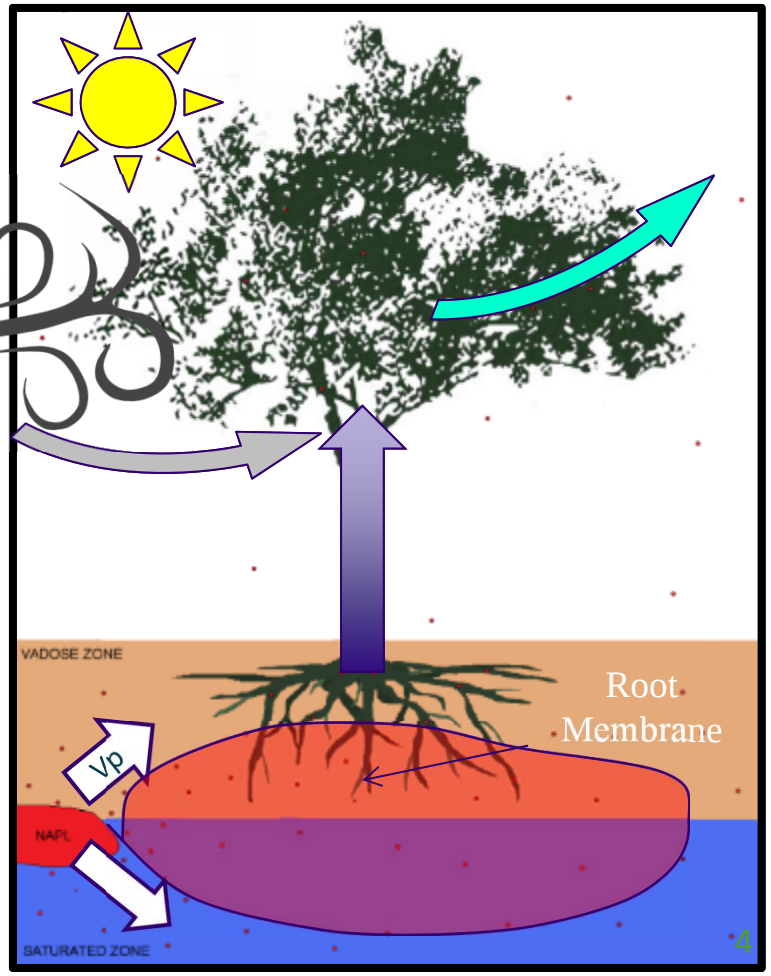
Phytoforensic Conceptual Model

Transport characterized by chemical properties



April 2018 Battelle ChlorCon

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Tree Coring

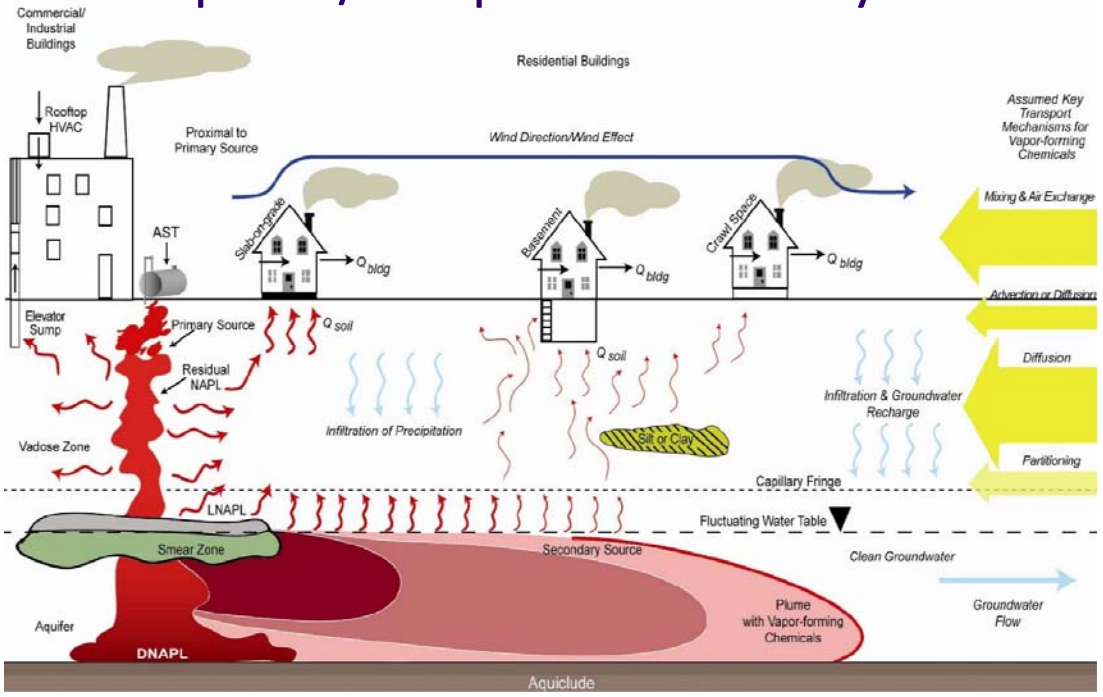
- Methods: D. Vroblesky - USGS
- Collect a core sample of the trunk/stem
- Core sample placed into vial
- After equilibration time headspace GC analysis
- Partition coefficients determine concentrations

Headspace Analysis

‘The’ Problem/Current Need

Health Impacts + Exposures = Hard to evaluate

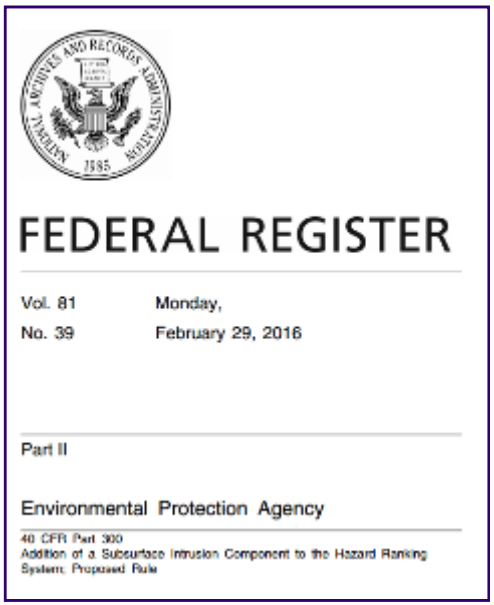
Spatial/Temporal Variability



U. S. Environmental Protection Agency, 2015

Hazard Ranking System

- Vapor intrusion potential may drive target groundwater concentrations below EPA maximum contaminant levels
- Vapor- or water-intrusion contamination may be the sole driver for placing a contaminated site on the Superfund National Priorities List


FEDERAL REGISTER

Vol. 81 Monday,
No. 39 February 29, 2016

Part II

Environmental Protection Agency

40 CFR Part 300
Addition of a Subsurface Intrusion Component to the Hazard Ranking System; Proposed Rule

Difficulties in Vapor Intrusion Sampling

- Results are variable
  - Temporal
  - Spatial
    - Inherent subsurface heterogeneity
    - Preferential pathways for vapor transport
- Invasive/Difficult in obtaining permissions
  - Property owners don't want people in their homes
  - Drilling near foundation of homes and utilities has safety concerns

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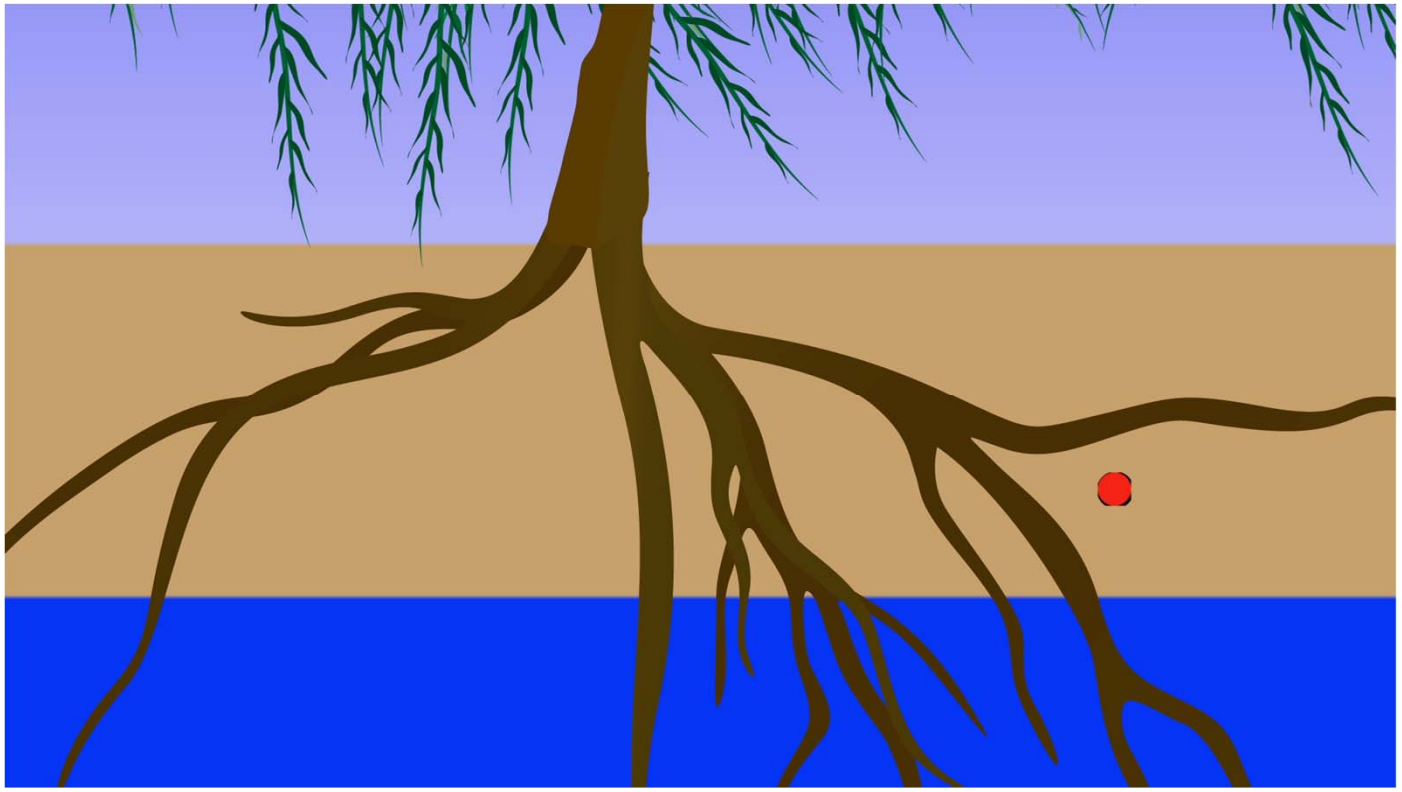
Plants are like our home?



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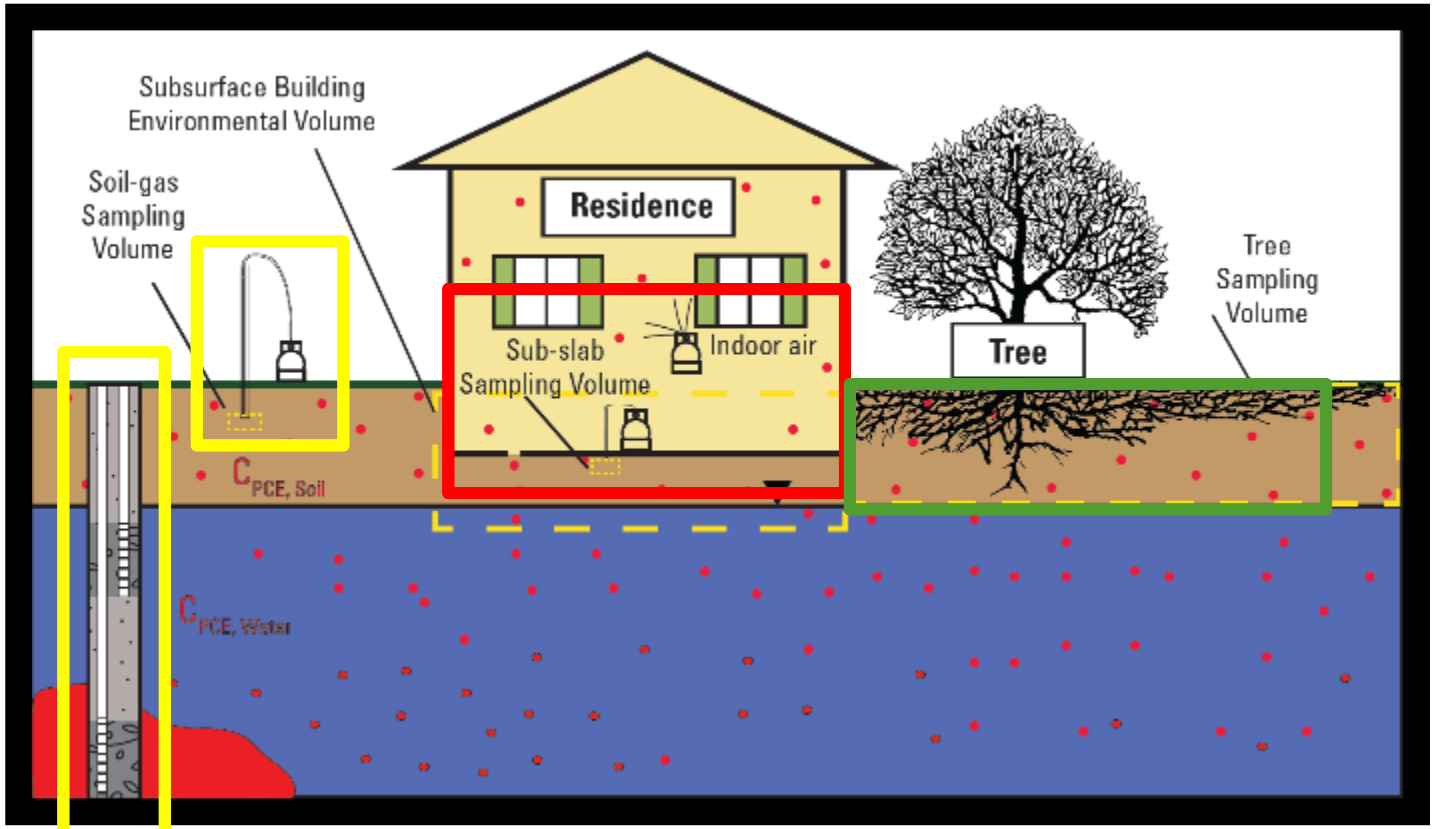
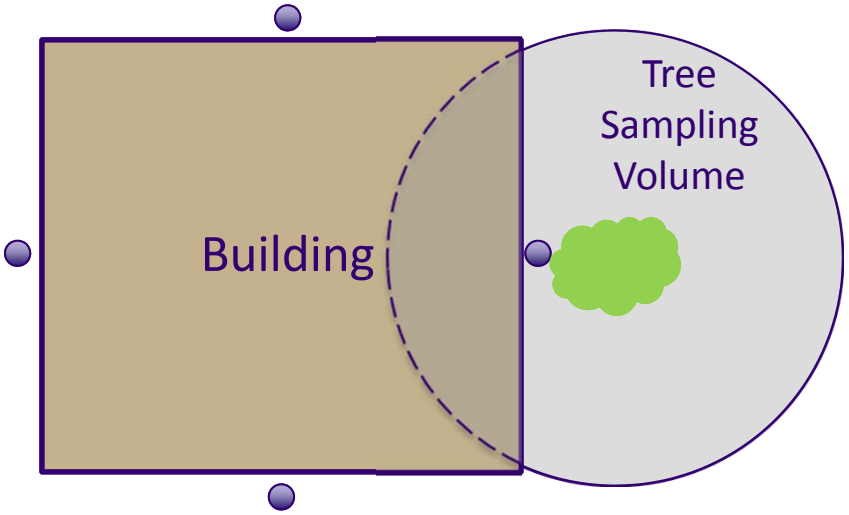
Sampling plants



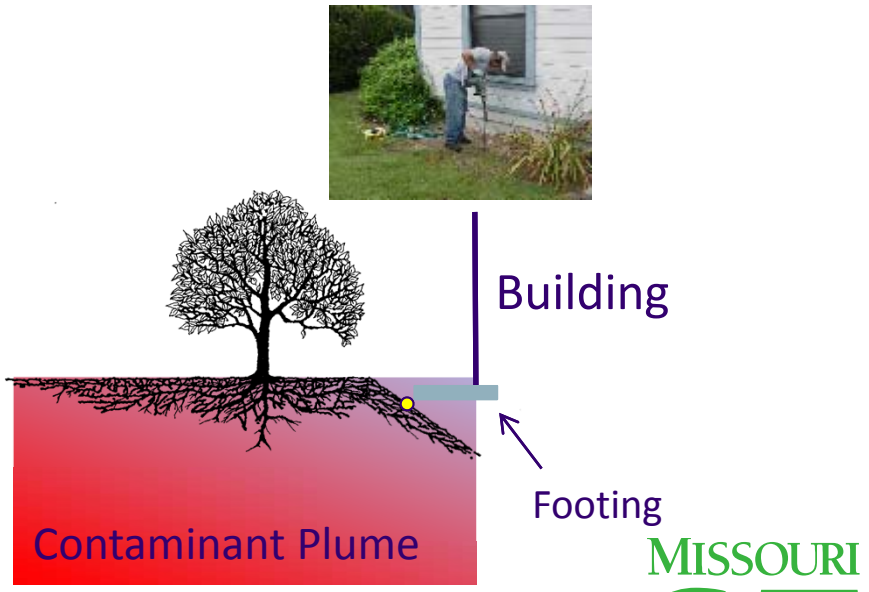
Fast
Cheap
Accurate
Noninvasive
Low impact

Soil Vapor Screening

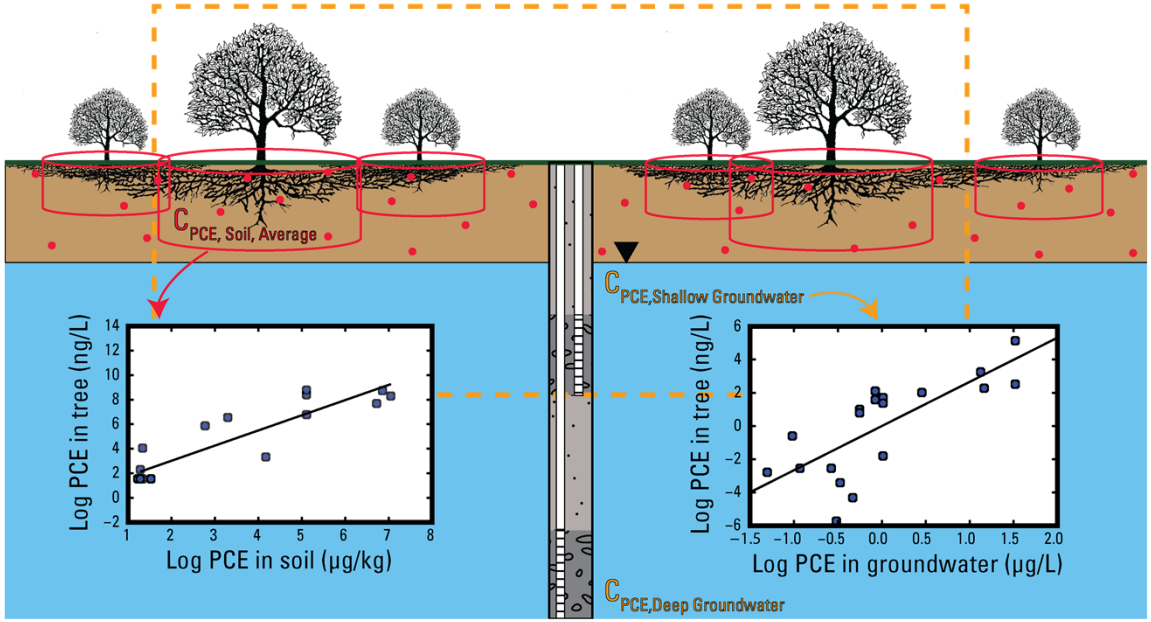
Areal View



Cross-sectional View

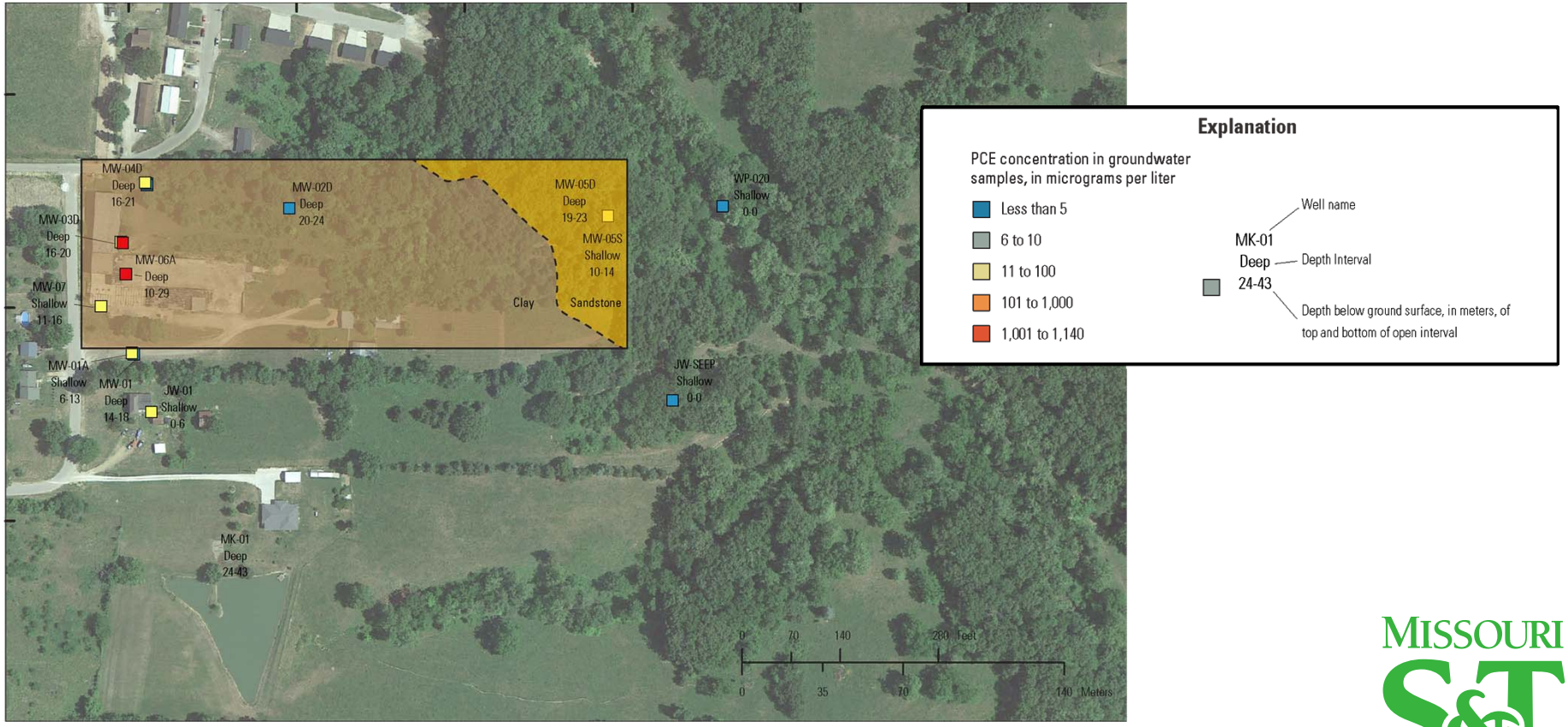


Tree Sampling as a Method to Assess Vapor Intrusion Potential at a Site Characterized by VOC-Contaminated Groundwater and Soil

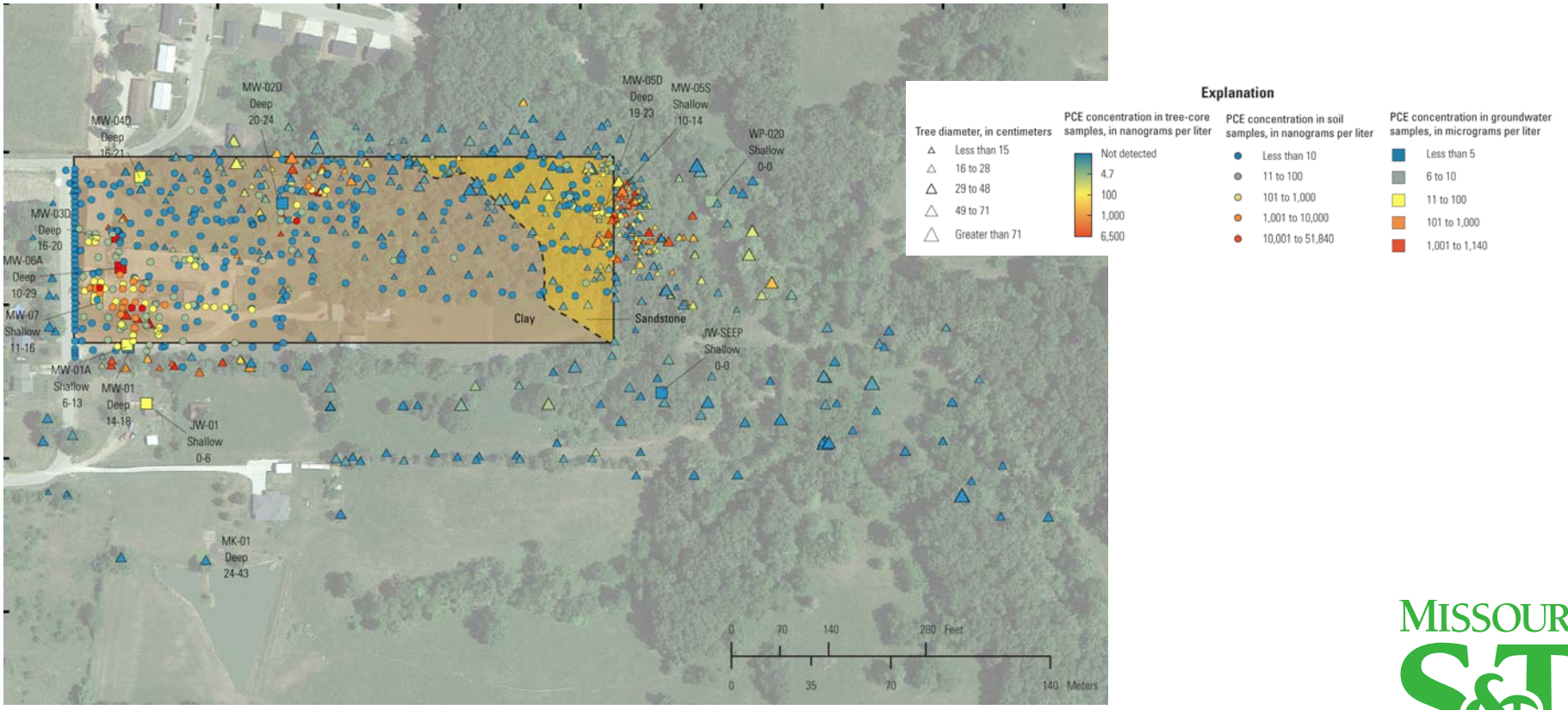


Wilson J.L., et al. (2017) Tree Sampling as a Method to Assess Vapor Intrusion Potential at a Site Characterized by VOC-Contaminated Groundwater and Soil, Environmental Science and Technology. 2017, 51 (18), 10369-10378.

Vienna Wells Superfund site



Over 900 soil samples with geoprobe measured with field GC
Over 450 tree-core samples



Wilson et al. *ES&T.* **2017a**

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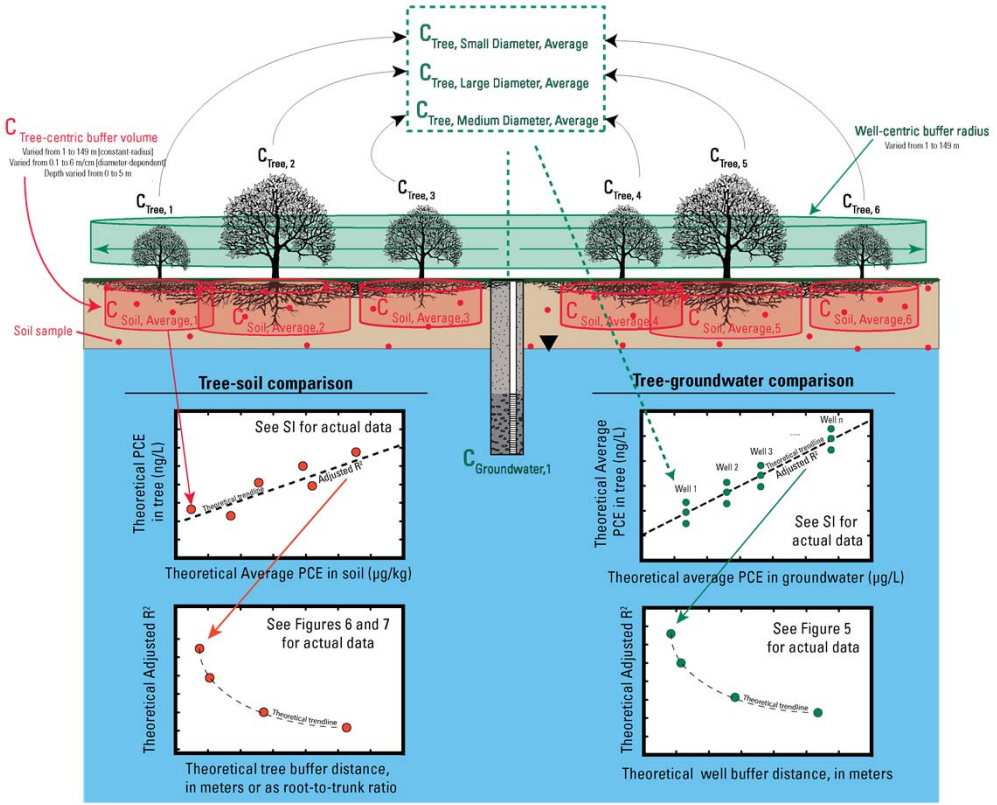
Subsurface Sampling Volume

What is the environmental volume sampled by a single tree?

If we detect or Do Not detect pollutants, what does that mean?

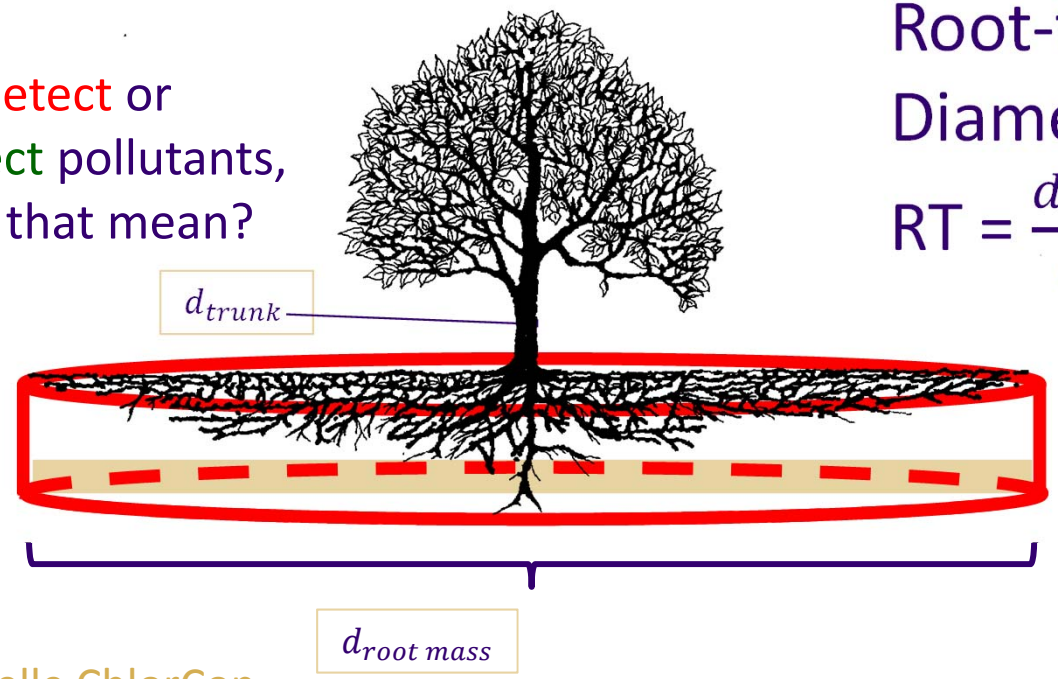


Wilson et al. *ES&T.* **2017a**

What does a plant actually sample?

What is the environmental volume sampled by a single tree?

If we Detect or Do Not Detect pollutants, what does that mean?



Root-to-Trunk Diameter Ratio

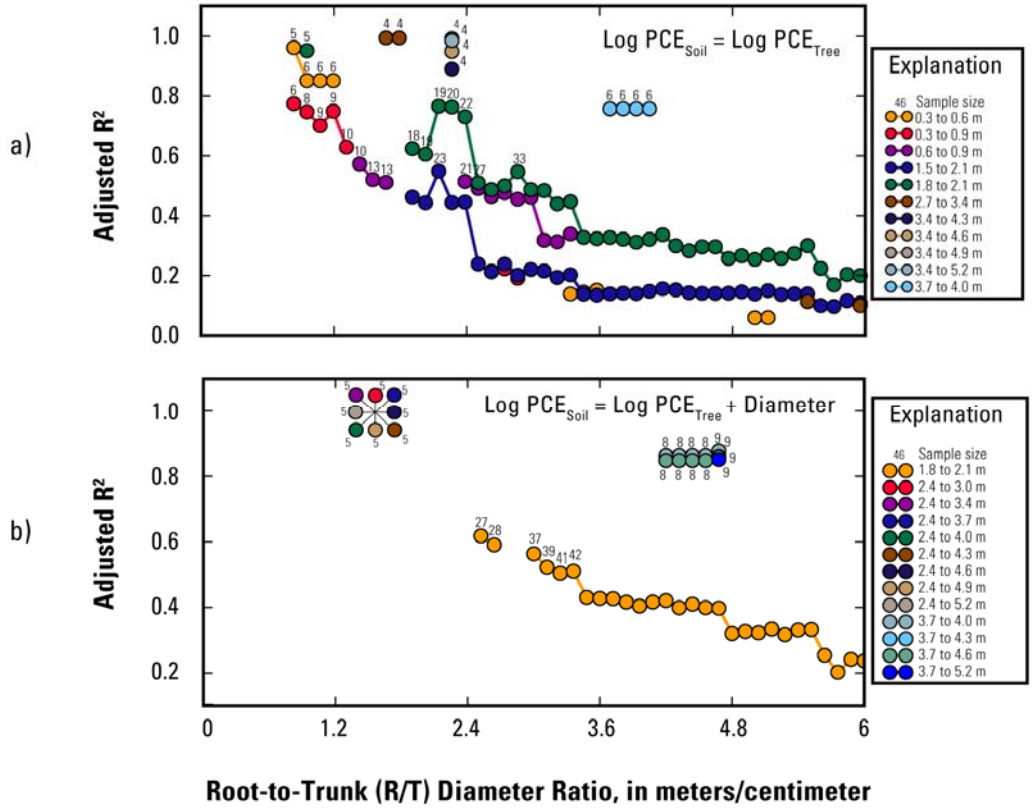
$$RT = \frac{d_{root\ mass}(m)}{d_{trunk}\ (\mathrm{cm})}$$

Diameter-Dependent Soil Response Curve

At a R/T ratio of 3, we have a > 0.5 R^2 to predict subsurface concentrations

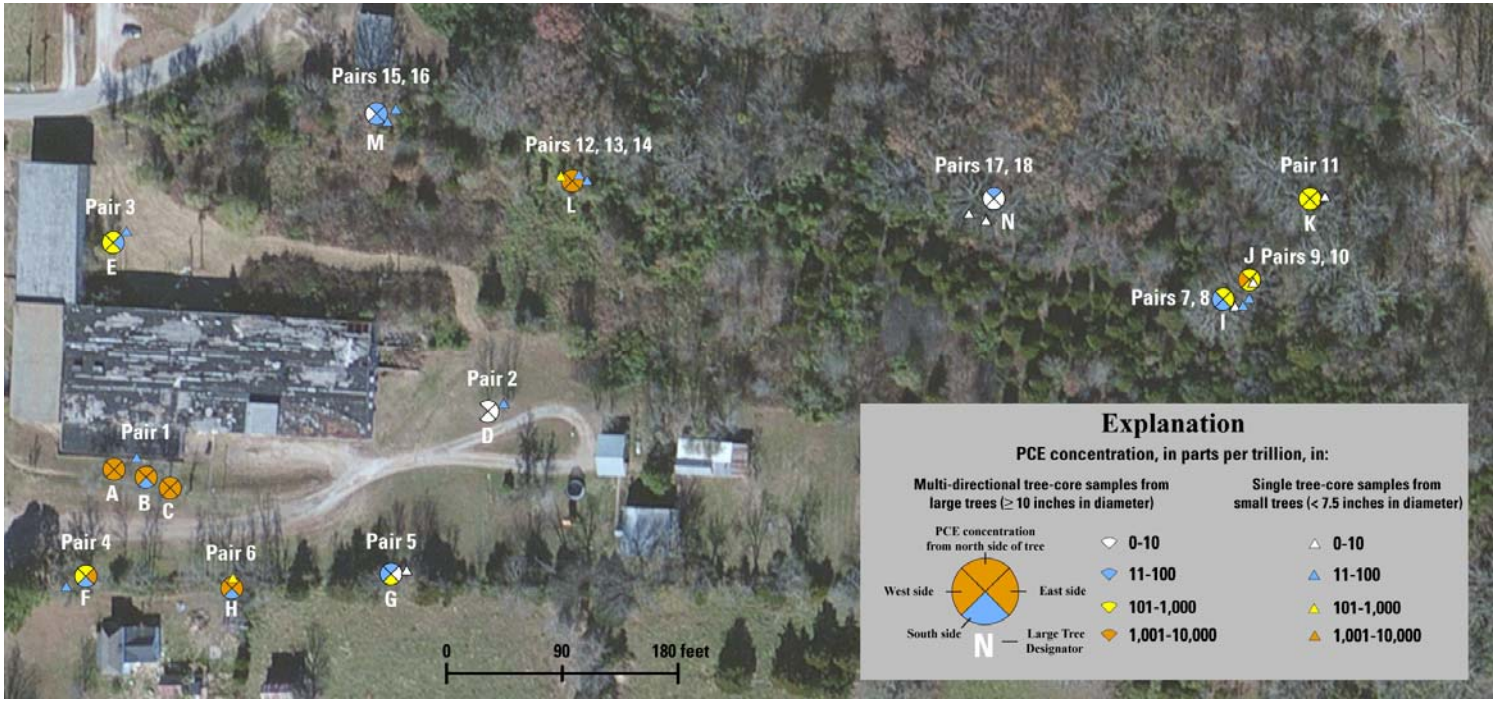
A 50 cm tree can predict concentrations in 150 meter diameter Area or 17,660 m^2

1 meter tree = 300 m Dia, 70,000 m^2



Wilson et al. *ES&T.* **2017a**

Soil and *in-planta* Concentration Gradients



Wilson J.L., et al. (2017) Contaminant Gradients in Trees: Directional Tree Coring Reveals Boundaries of Soil and Soil-Gas Contamination with Potential Applications in Vapor Intrusion Assessment" Environmental Science & Technology 51 (24), pp 14055–14064.

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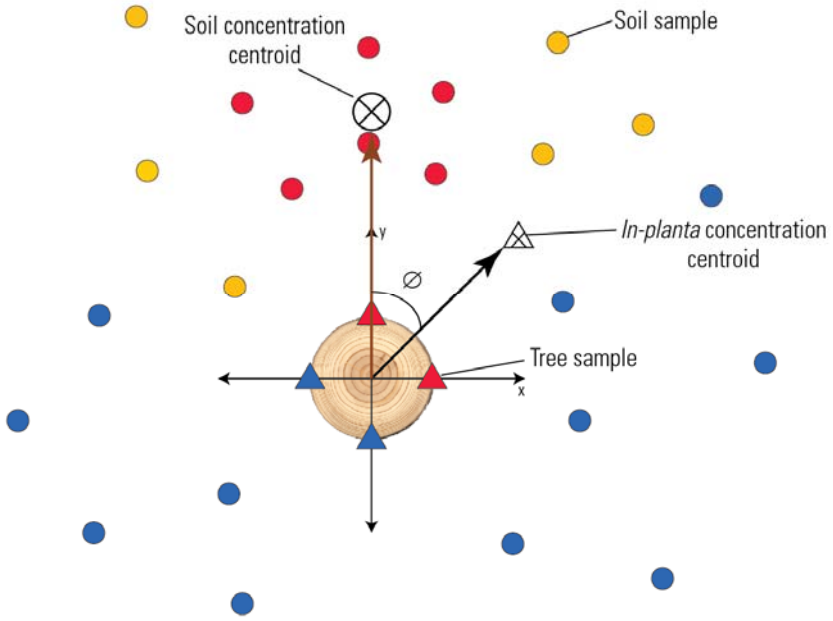
Concentration Centroids

- $(x_c, y_c) = \vec{u} = \left(\frac{\sum_i C_i x_i}{\sum_i C_i}, \frac{\sum_i C_i y_i}{\sum_i C_i}\right)$ $\quad \emptyset = \arccos\left[\frac{\vec{u}_{tree} \cdot \vec{u}_{soil}}{\|\vec{u}_{tree}\| \cdot \|\vec{u}_{soil}\|}\right]$



Wilson J.L., et al. *ES&T.* **2017b**

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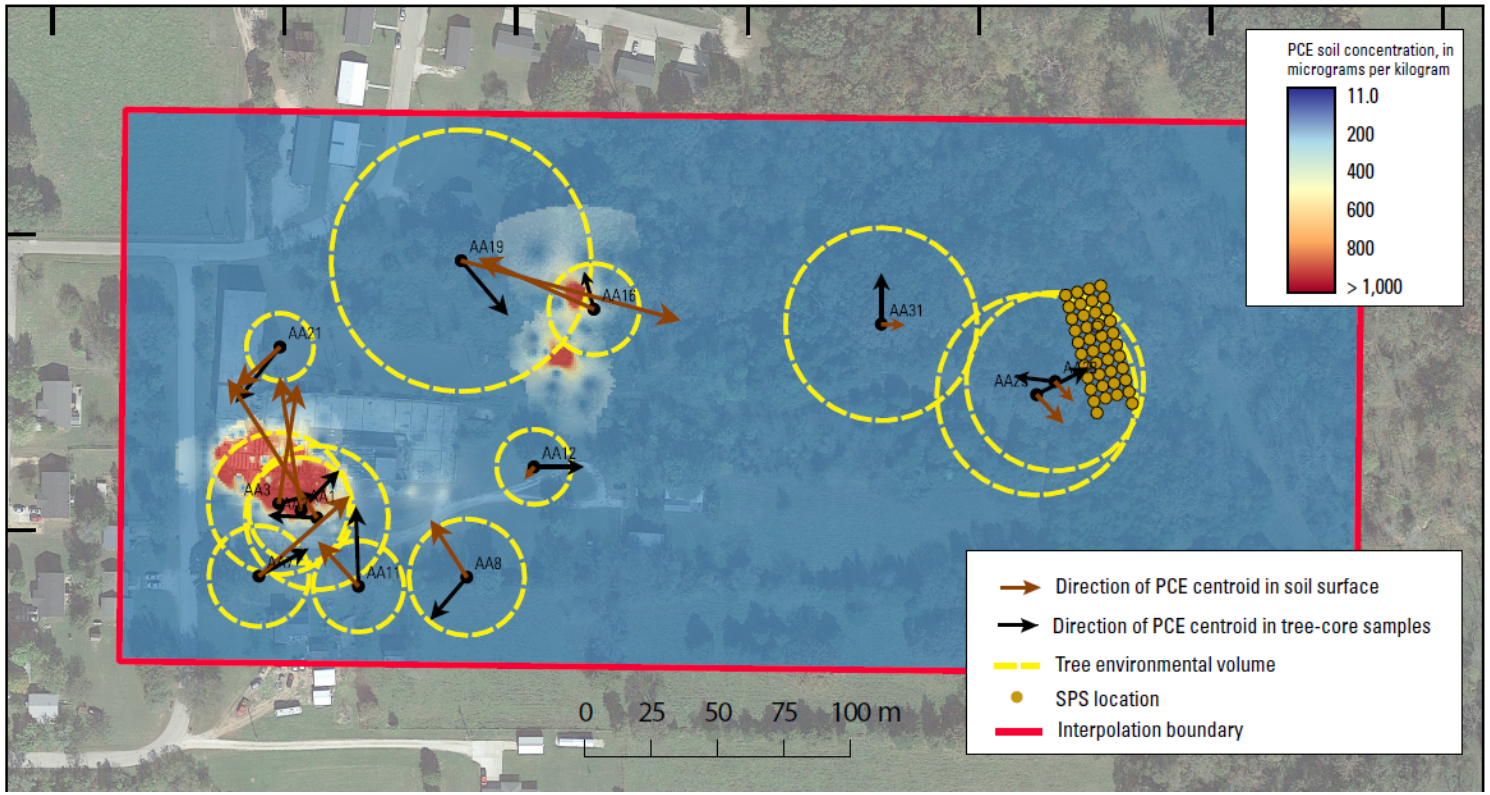
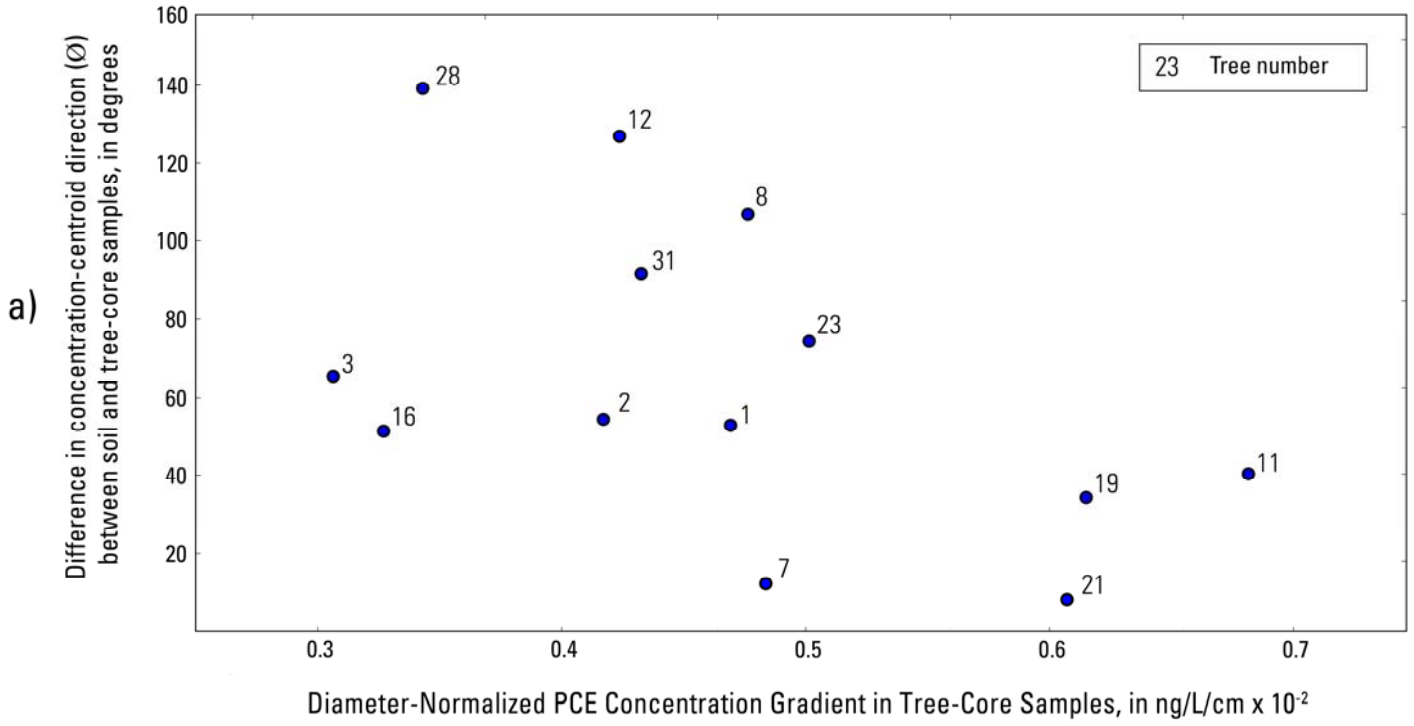
Soil and *in-planta* Concentration Gradients



Wilson J.L., et al. *ES&T.* **2017b**

In-planta Concentration Gradients



Wilson J.L., et al. *ES&T.* **2017b**

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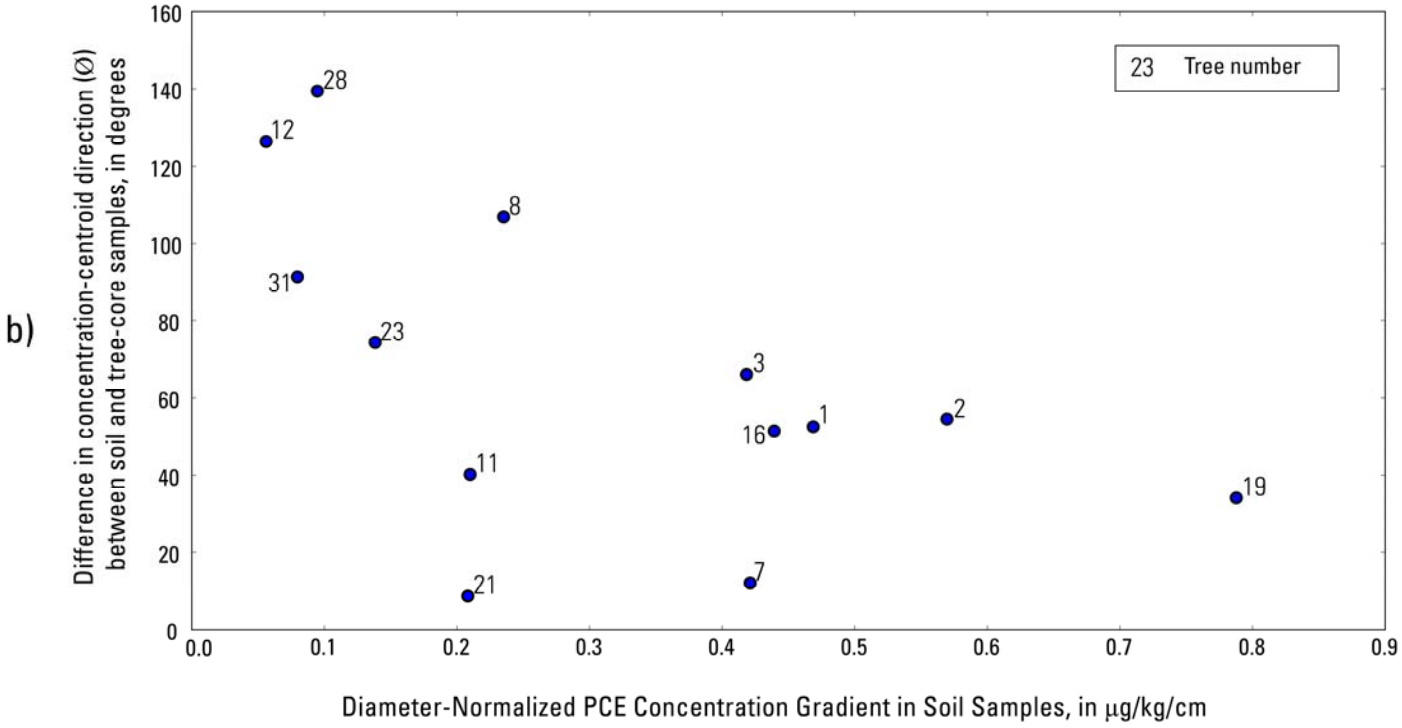
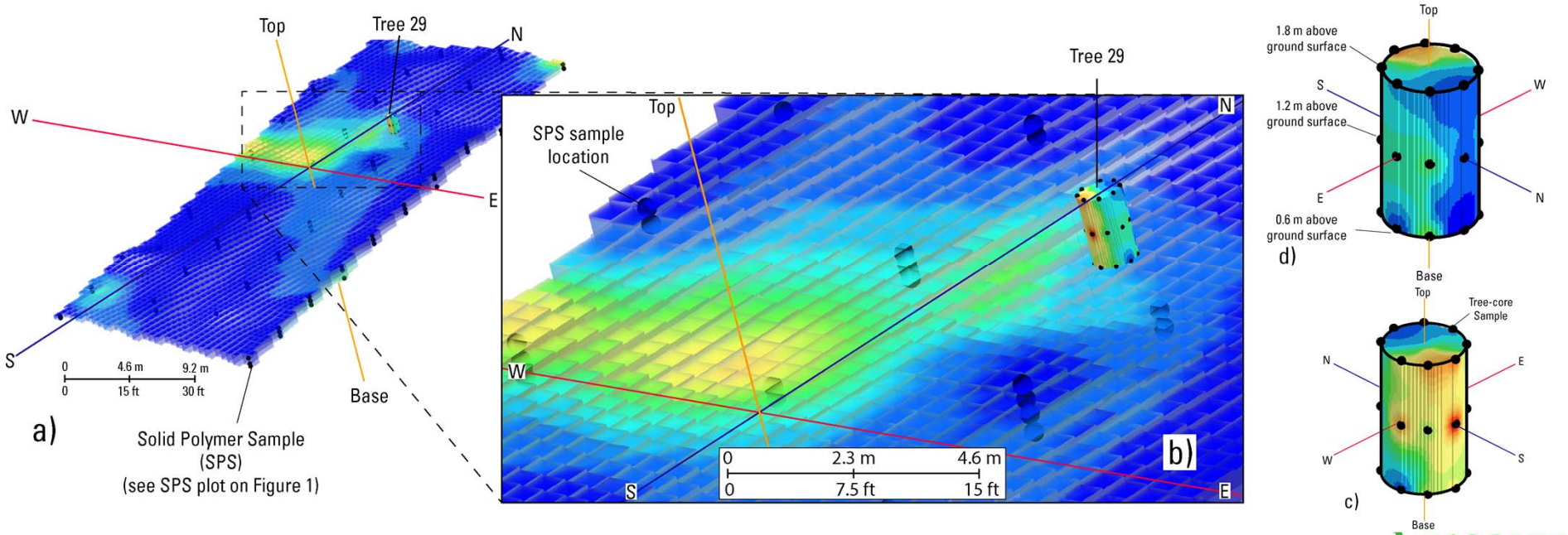
Soil Concentration Gradients



Wilson J.L., et al. *ES&T.* **2017b**

Directionality with Shallow Soil-Vapor Plume



Wilson J.L., et al. *ES&T.* **2017b**

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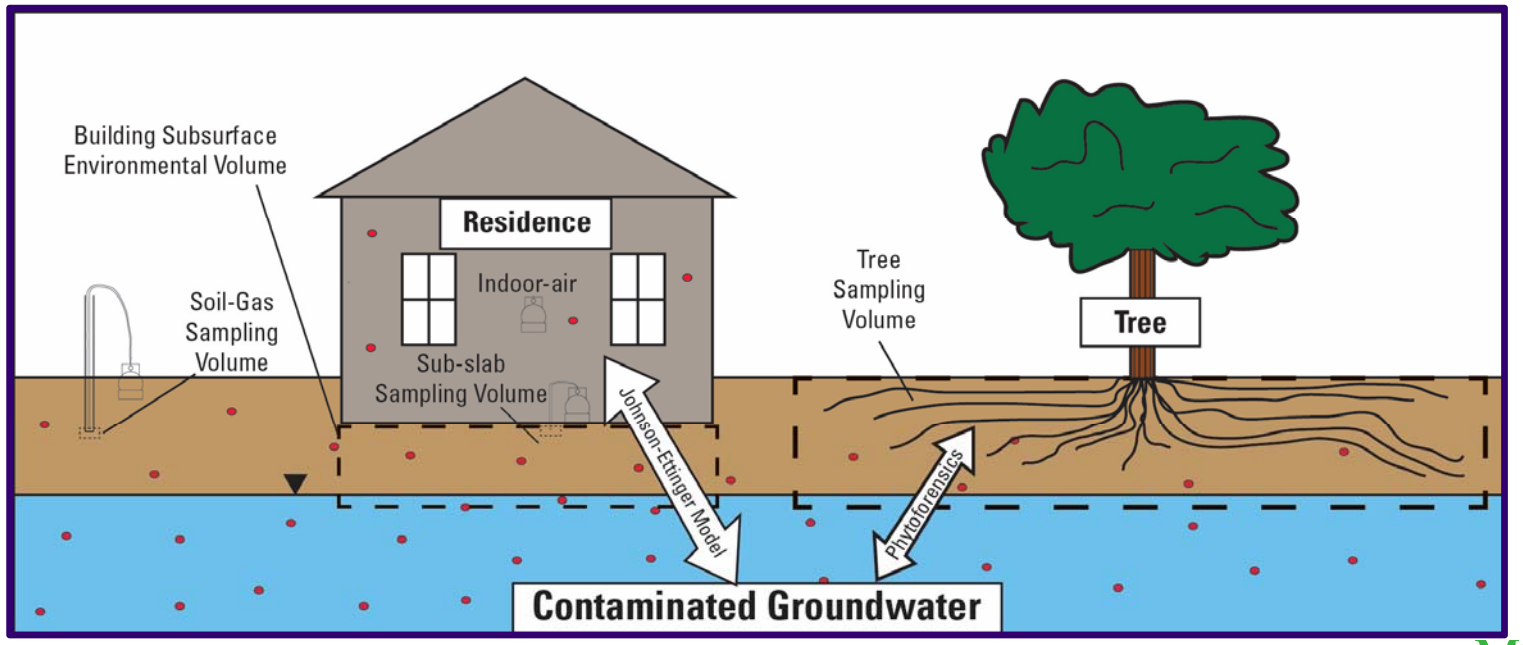
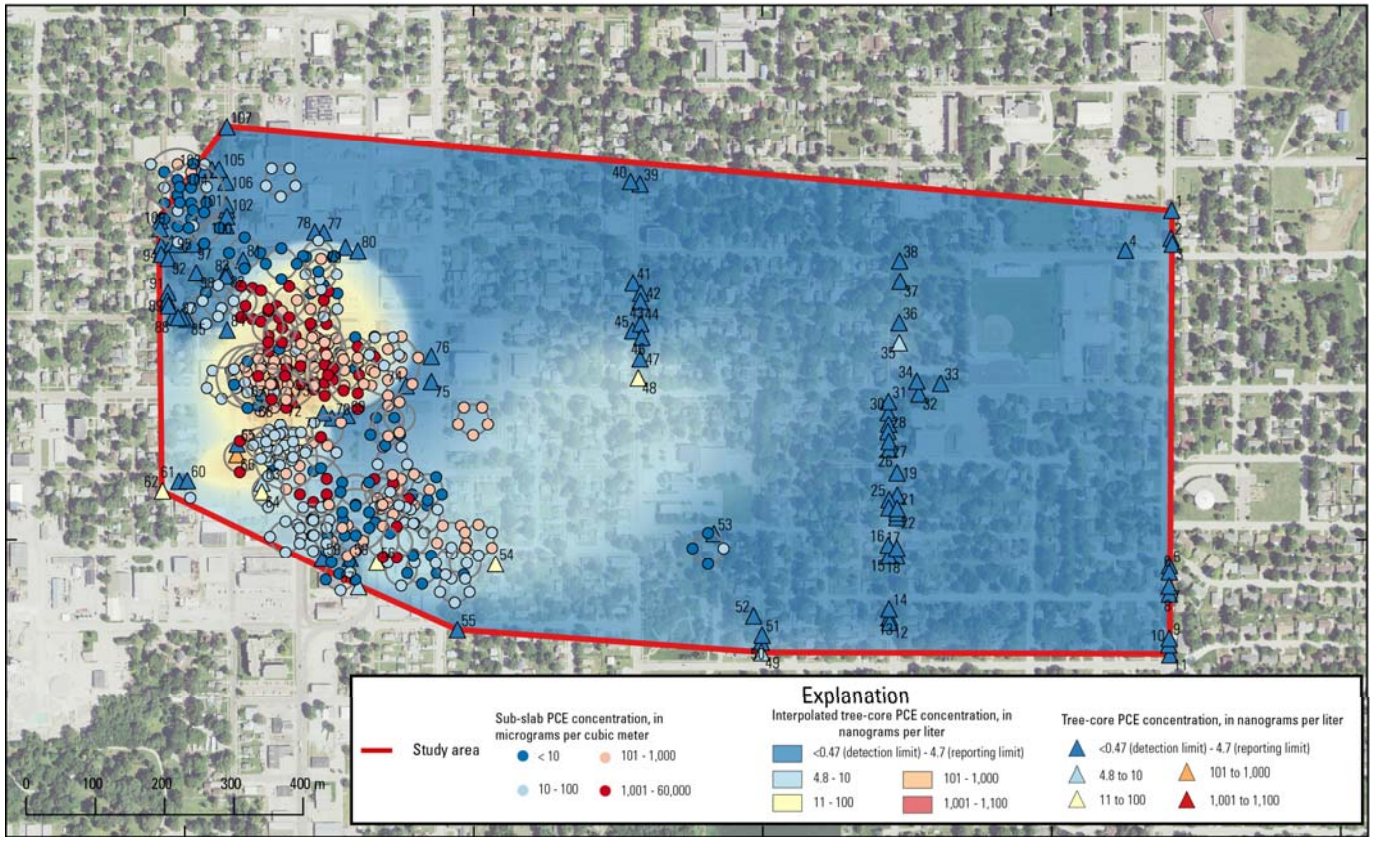
Phytoforensics: Trees As Bioindicators of Potential Indoor Exposure via Vapor Intrusion



Wilson JL, et al (2018) Phytoforensics: Trees as bioindicators of potential indoor exposure via vapor intrusion. PLoS ONE 13(2): e0193247. https://doi.org/10.1371/journal.pone.0193247

Sub Slab: Trees York, Nebraska



Wilson JL, et al (2018). PLoS

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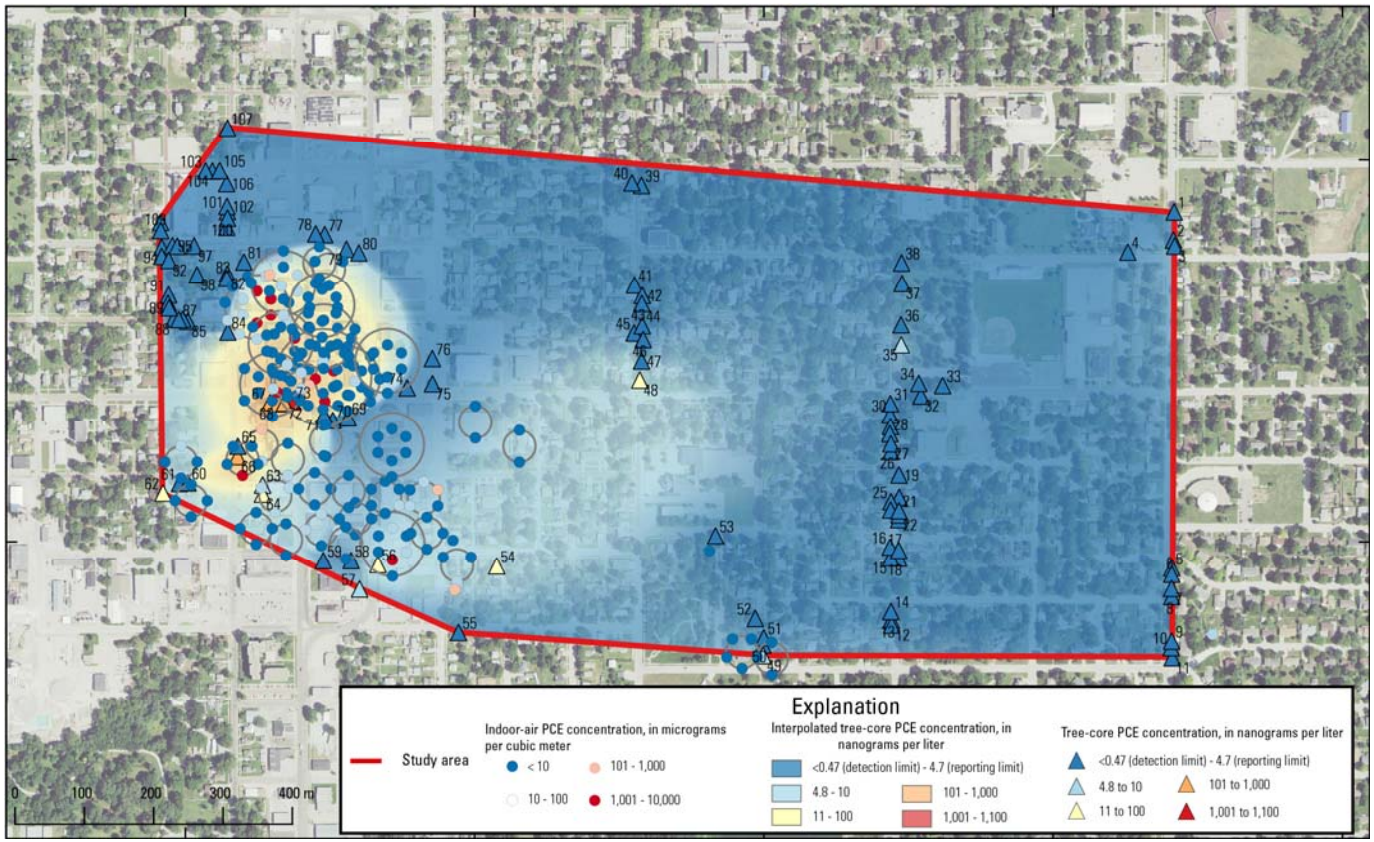
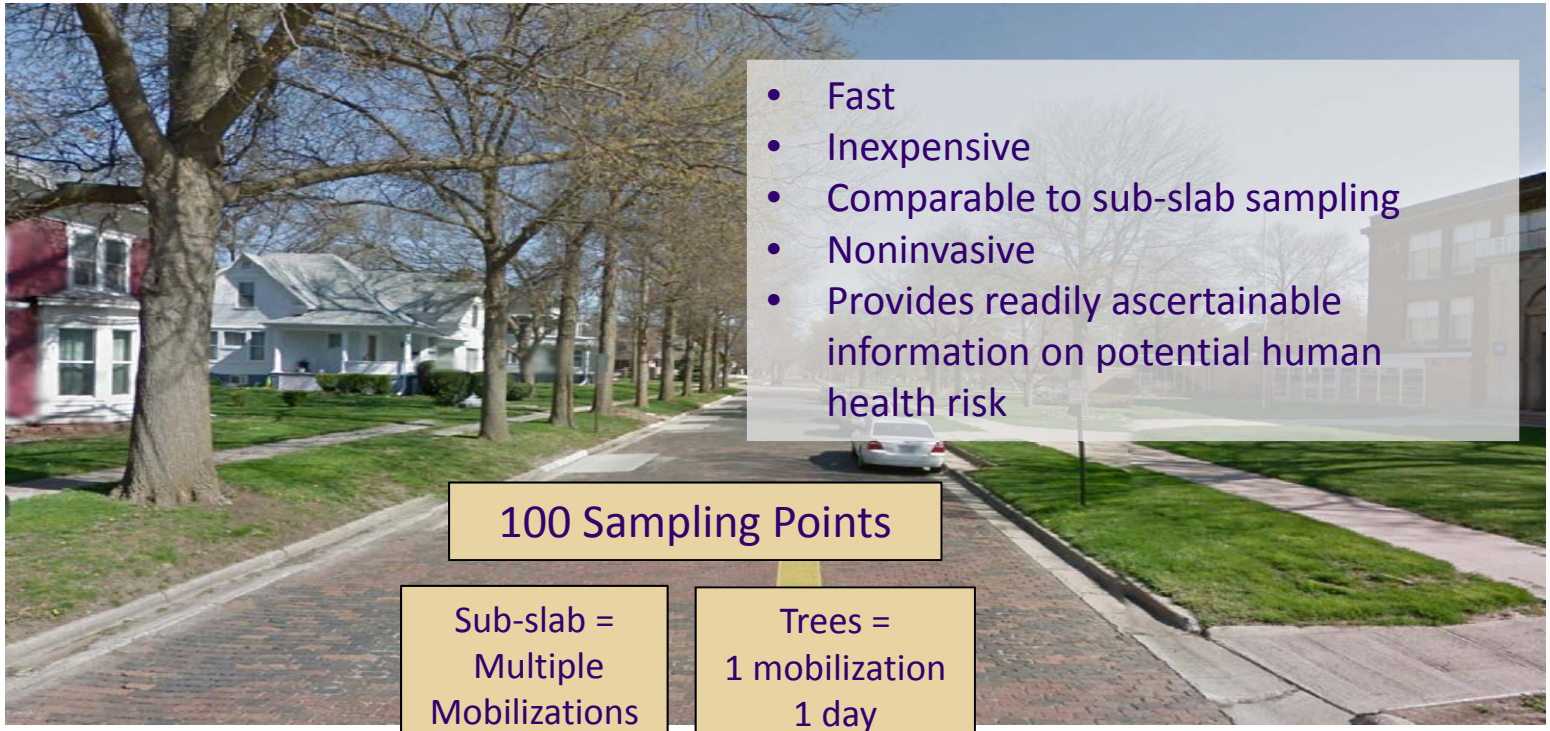
Indoor Air: Trees York, Nebraska



Wilson JL, et al (2018). PLoS

Ease of Tree Sampling



- Fast
- Inexpensive
- Comparable to sub-slab sampling
- Noninvasive
- Provides readily ascertainable information on potential human health risk

100 Sampling Points

Sub-slab = Multiple Mobilizations >1.5 months

Trees = 1 mobilization 1 day

Plants and our Planet

https://www.dreamstime.com

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