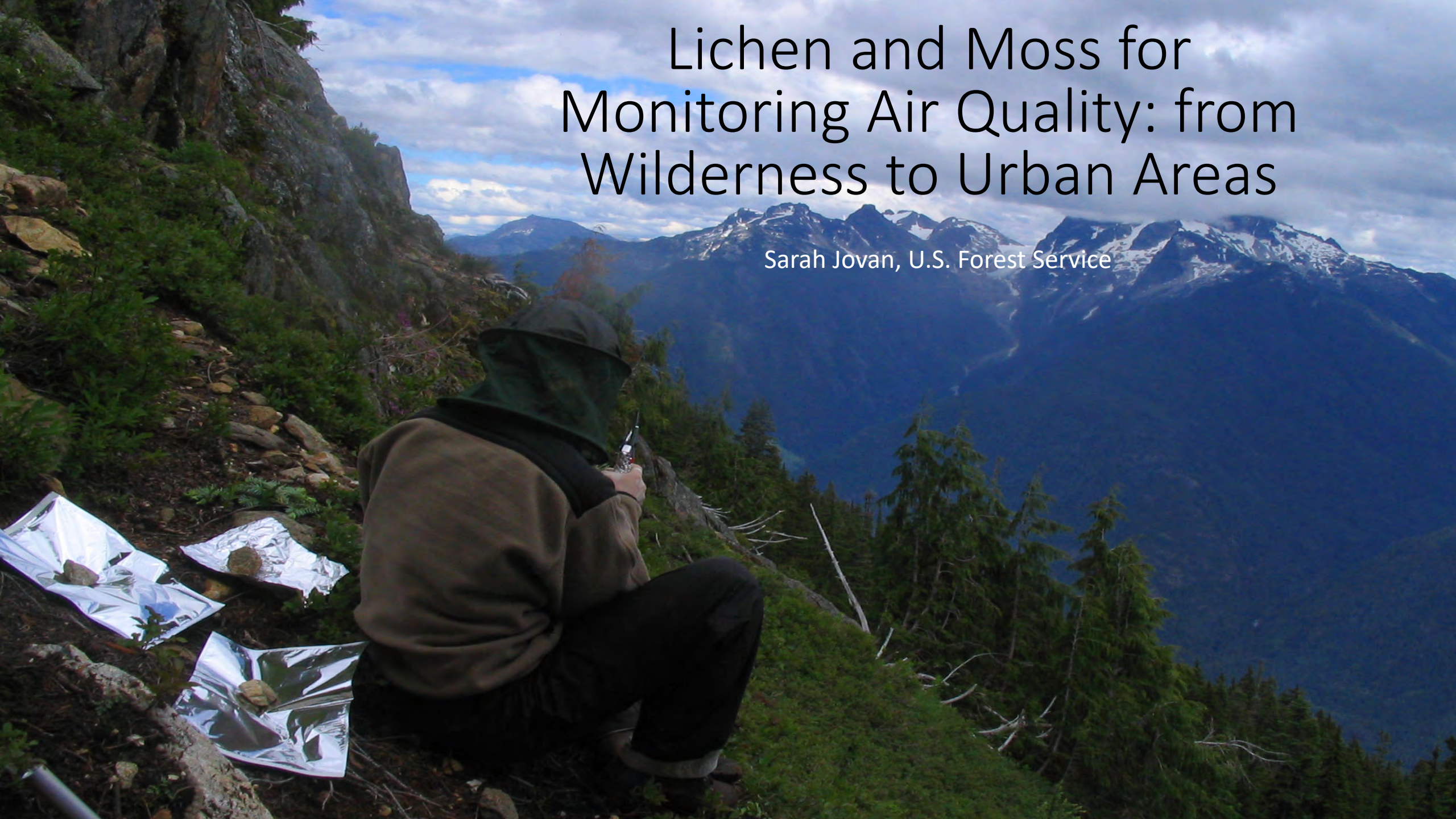


Lichen and Moss for Monitoring Air Quality: from Wilderness to Urban Areas

Sarah Jovan, U.S. Forest Service



Overview

- The insufficiency of air monitoring networks for describing pollution at spatial scales relevant to human or environmental health is a critical challenge for land managers, air managers and air regulators...

Bioindicators are a low cost as a screening tool...to prioritize management actions and placement of air monitoring instruments.

Air Q instruments: ~\$40K annually (heavy metals)

Moss: ~\$150





- High species diversity and biomass in the PNW and California

What is a lichen?

A symbiotic relationship between a fungus and one or more photosynthetic organisms
(usually a green algae)



Lobaria linita



Cladonia



Ramalina menziesii



What is a moss?

Taxonomic division *Bryopsida*

Small, non-vascular plants

The oldest plant lineage...

Non-vascular organisms



- Obtain all water and nutrients from the atmosphere (no roots)
- Air pollutants are also trapped

- Lack a protective outer layer (i.e. epidermis)
- Absorb like little sponges

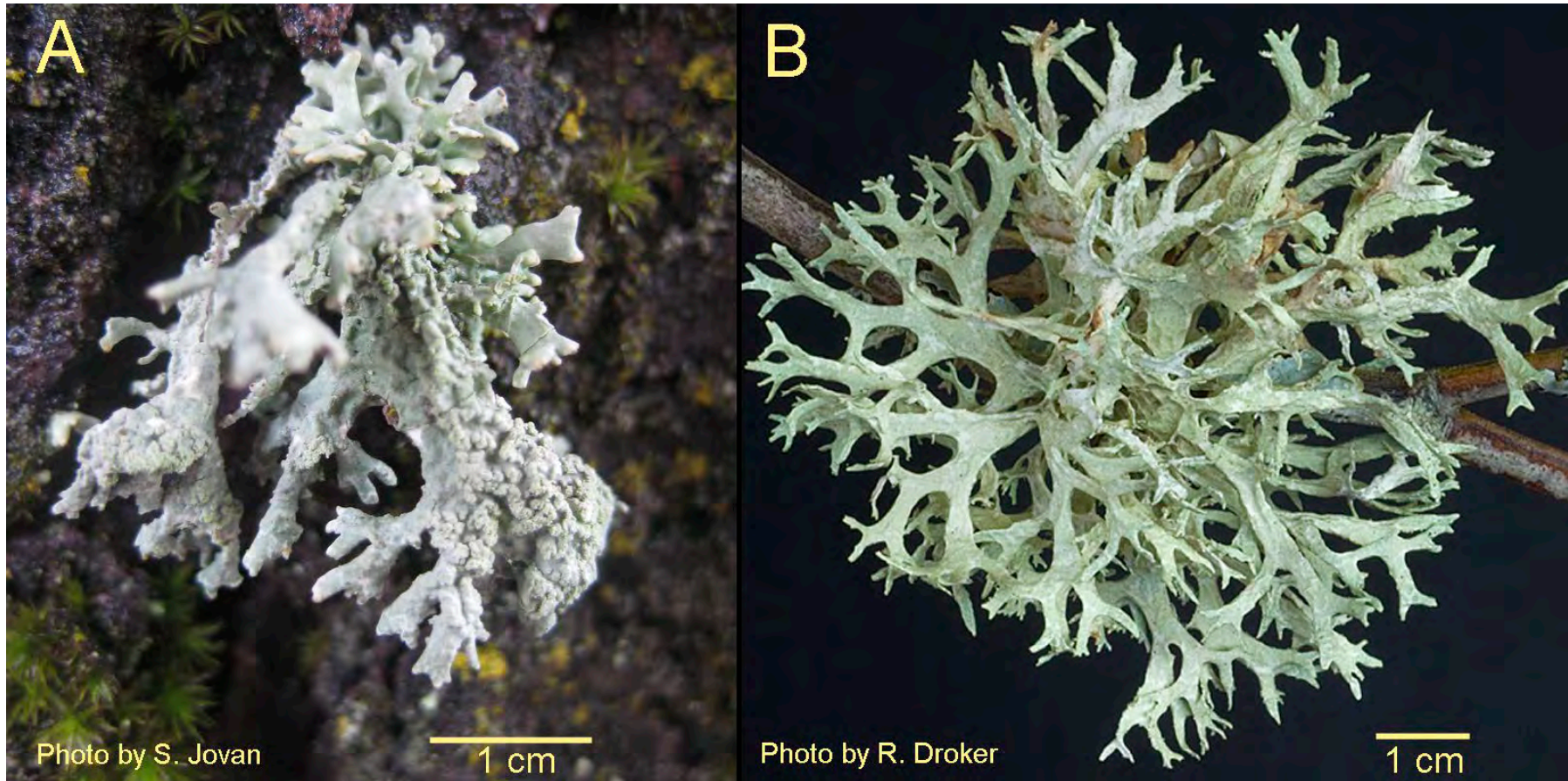


2 kinds of metrics

- Chemical – assays of pollutants accumulated in moss and lichen tissues
 - Can capture a broad array of pollutants
- Ecological – surveying the local community of moss or lichen
 - Primarily for assessing nitrogen and sulfur-based pollutants

Lichens are among the most pollution sensitive terrestrial organisms

health, survivorship are closely linked to atmospheric deposition of N, S



Pollution impacted (A) vs. healthy thallus (B) of *Evernia prunastri*

Our lichen “canaries in the coal mine”

N-Sensitive
Oligotrophs



Forage + nest species



N-fixers

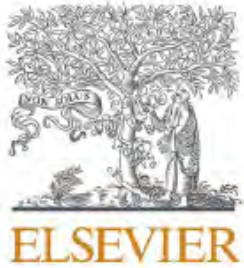


Lichen “weeds”



N-loving
Eutrophs

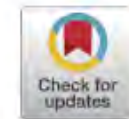
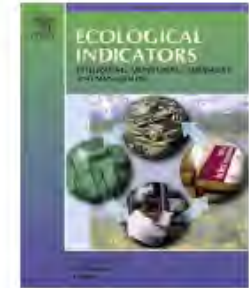




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Challenges characterizing N deposition to high elevation protected areas: A case study integrating instrument, simulated, and lichen inventory datasets for the Devils Postpile National Monument and surrounding region, USA

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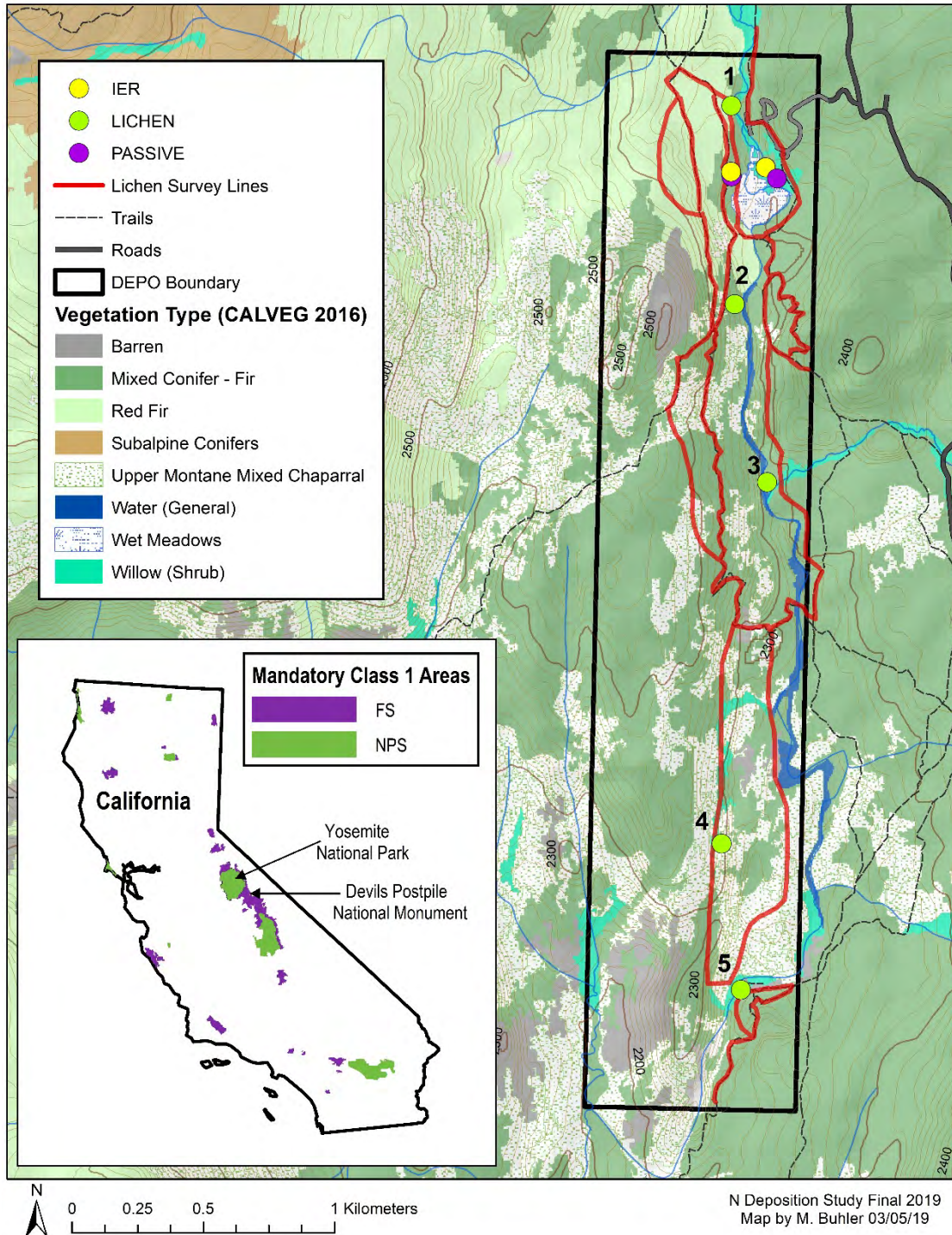
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^d Oregon State University, Department of Botany and Plant Pathology, 2082 Cordley Hall, Corvallis, OR 97331, USA

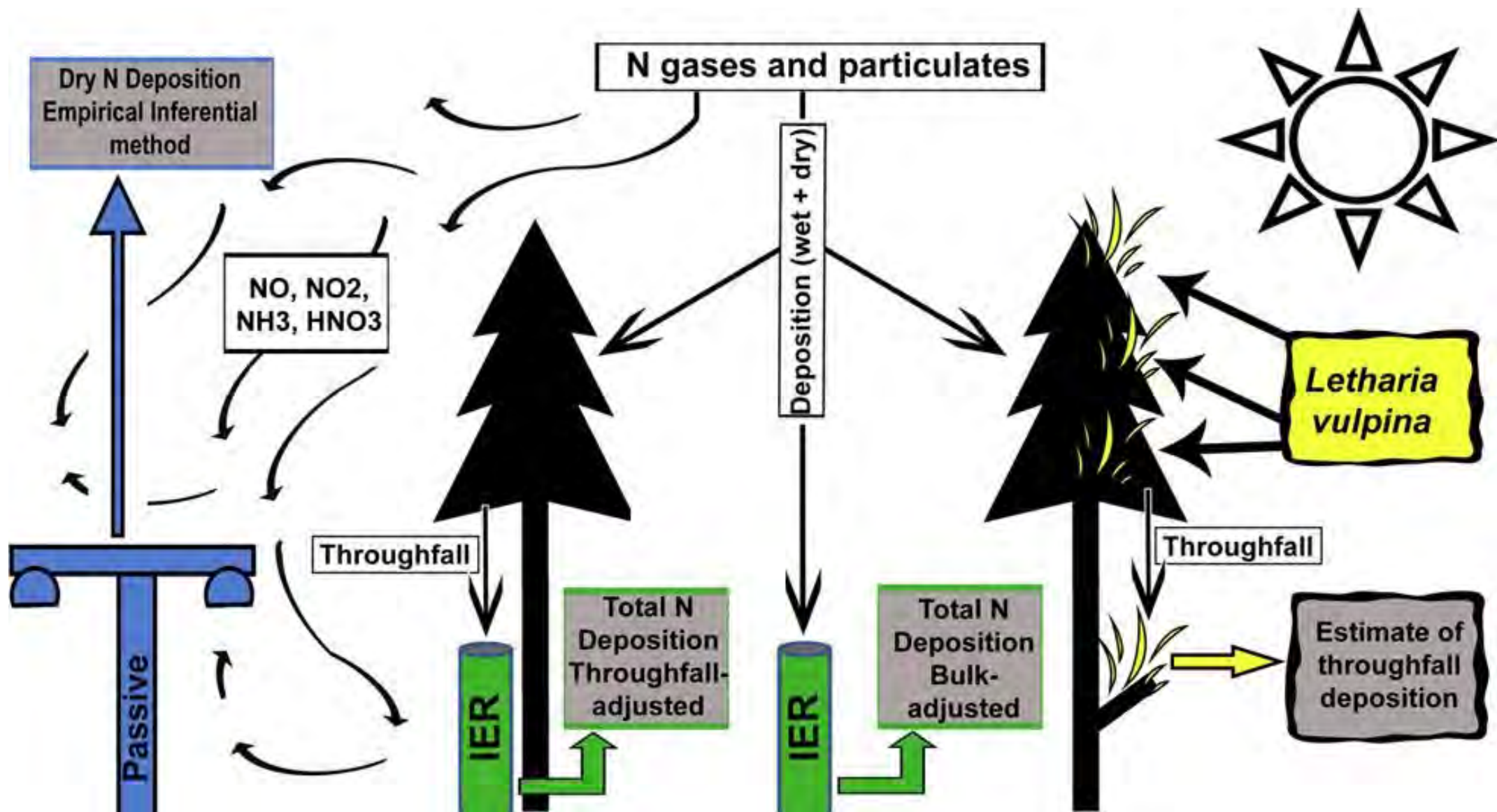
^e USDA Forest Service, Wrangell Ranger District, Wrangell, AK, USA

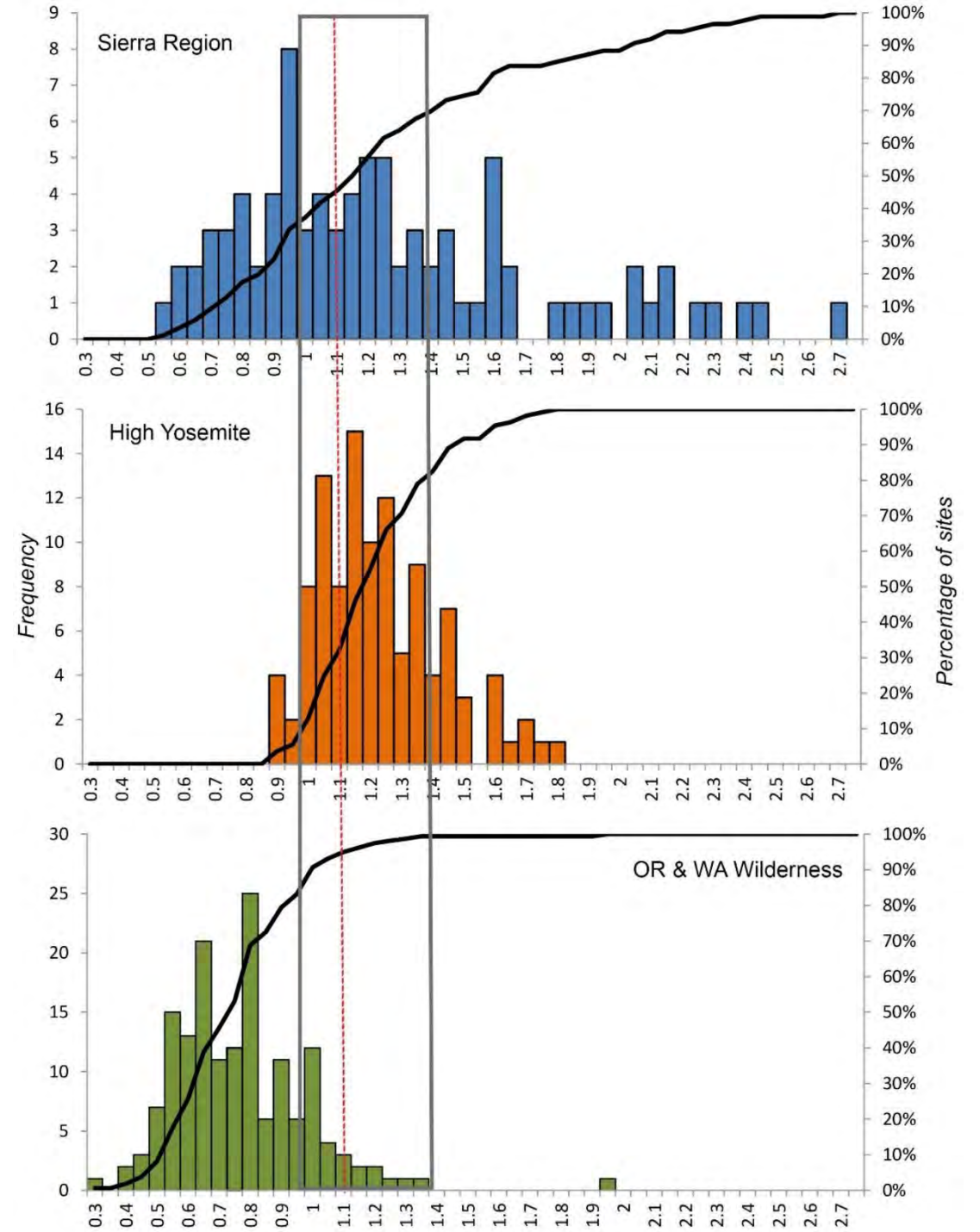
^f USDA Forest Service, Pacific Southwest Region, 351 Pacu Lane, Bishop, CA 93514, USA

^g Health Sciences Research Institute, University of California, Merced, 5200 N. Lake Road, Merced, CA 95343, USA



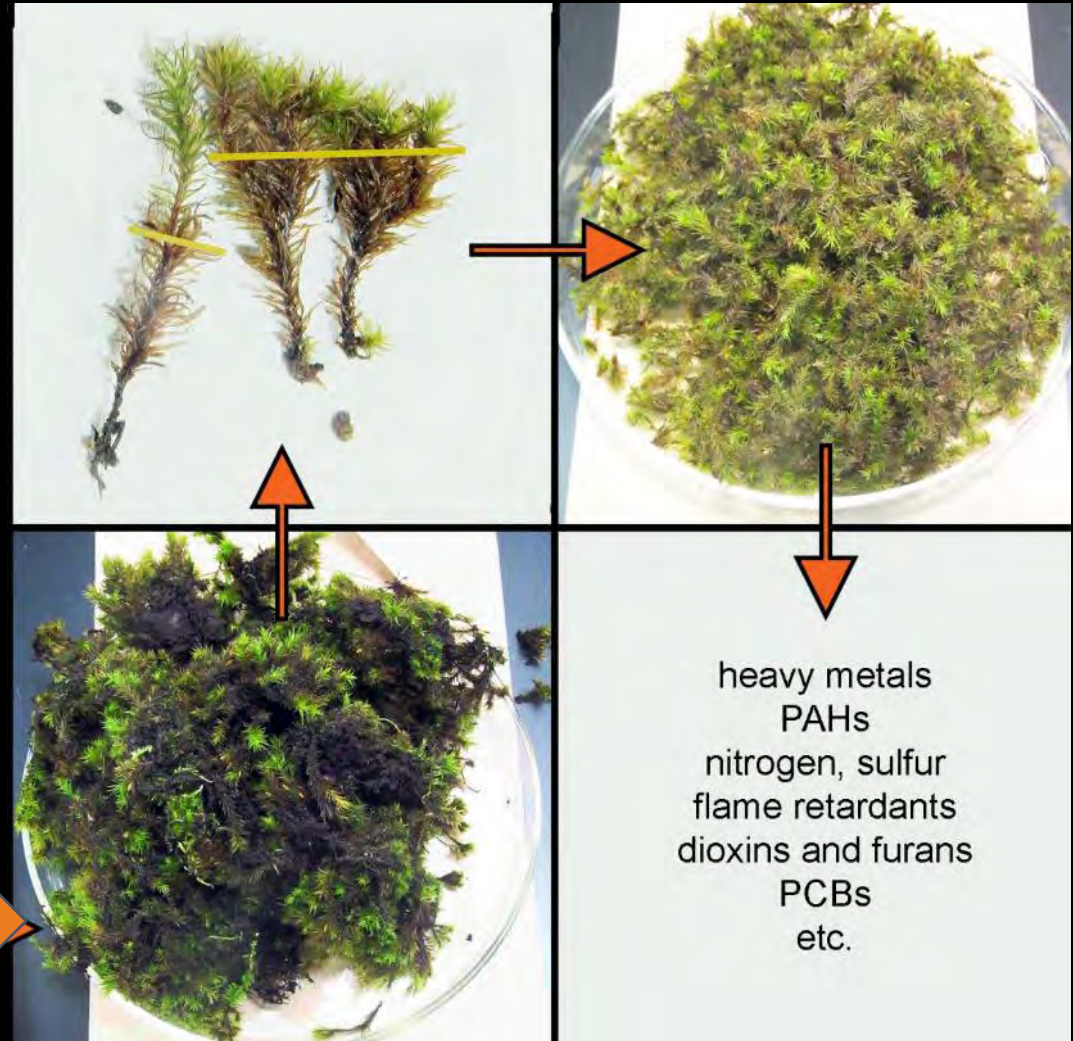
- DEPO is a very small (323ha) Federal Class 1 Area, which receives special protections under the Clean Air Act
- Established air monitoring networks are too sparse to really understand potential threats
- While being tiny and quite remote, DEPO's location along a deep river canyon, we suspected, made it especially vulnerable to nitrogen



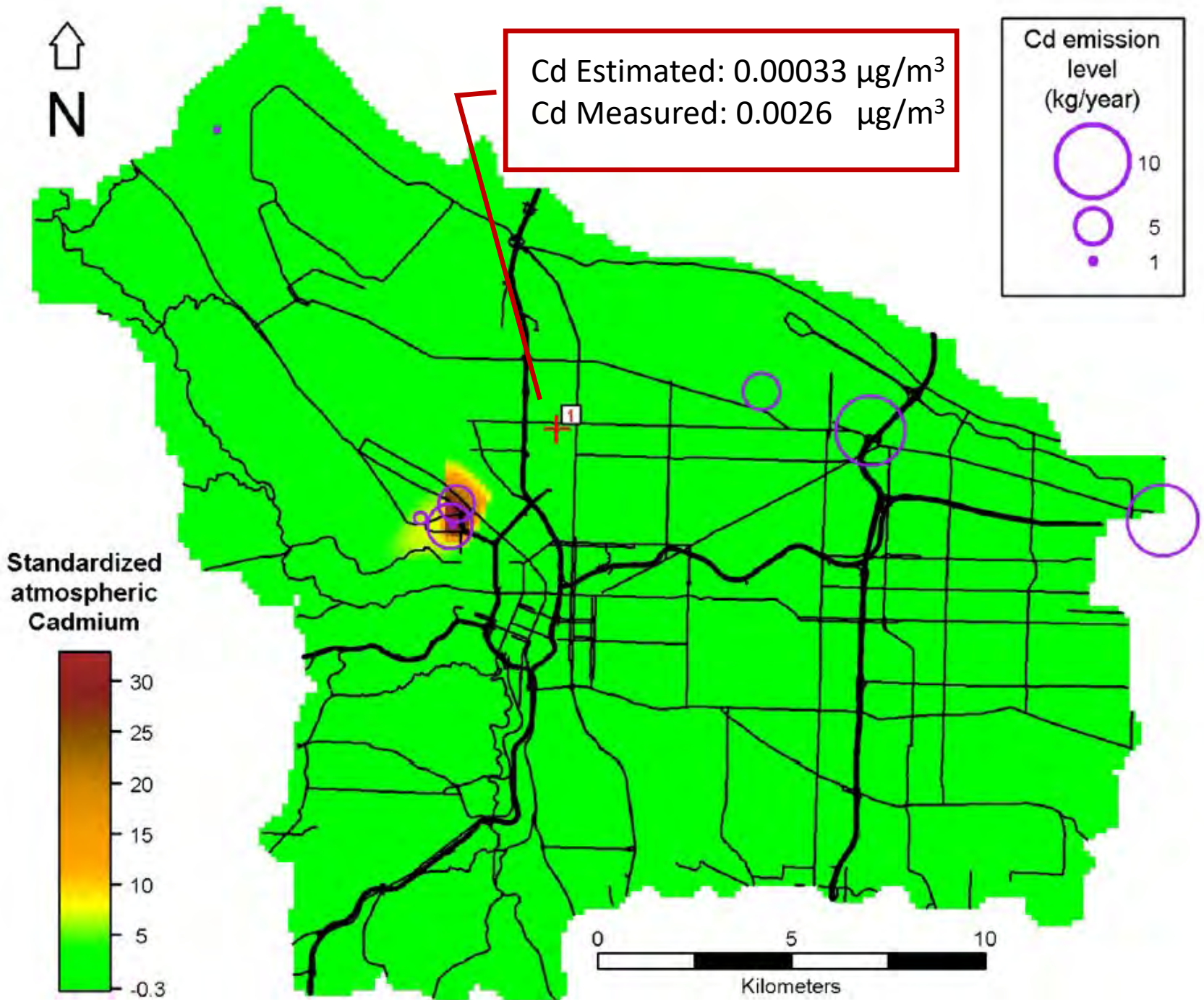


Orthotrichum lyellii

U.S. distribution: AK, CA, ID, OR, WA



- Why?: urban pollution is extremely heterogeneous. Direct measurements available only at a couple locations. Small-scale patterns based on simulations.

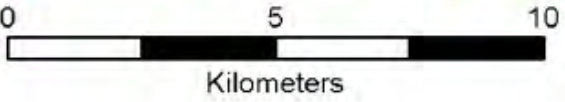
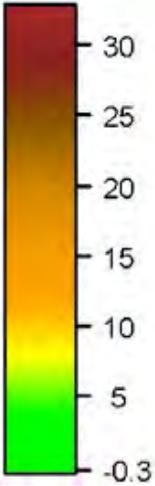


Cd Estimated: 0.00033 $\mu\text{g}/\text{m}^3$
Cd Measured: 0.0026 $\mu\text{g}/\text{m}^3$

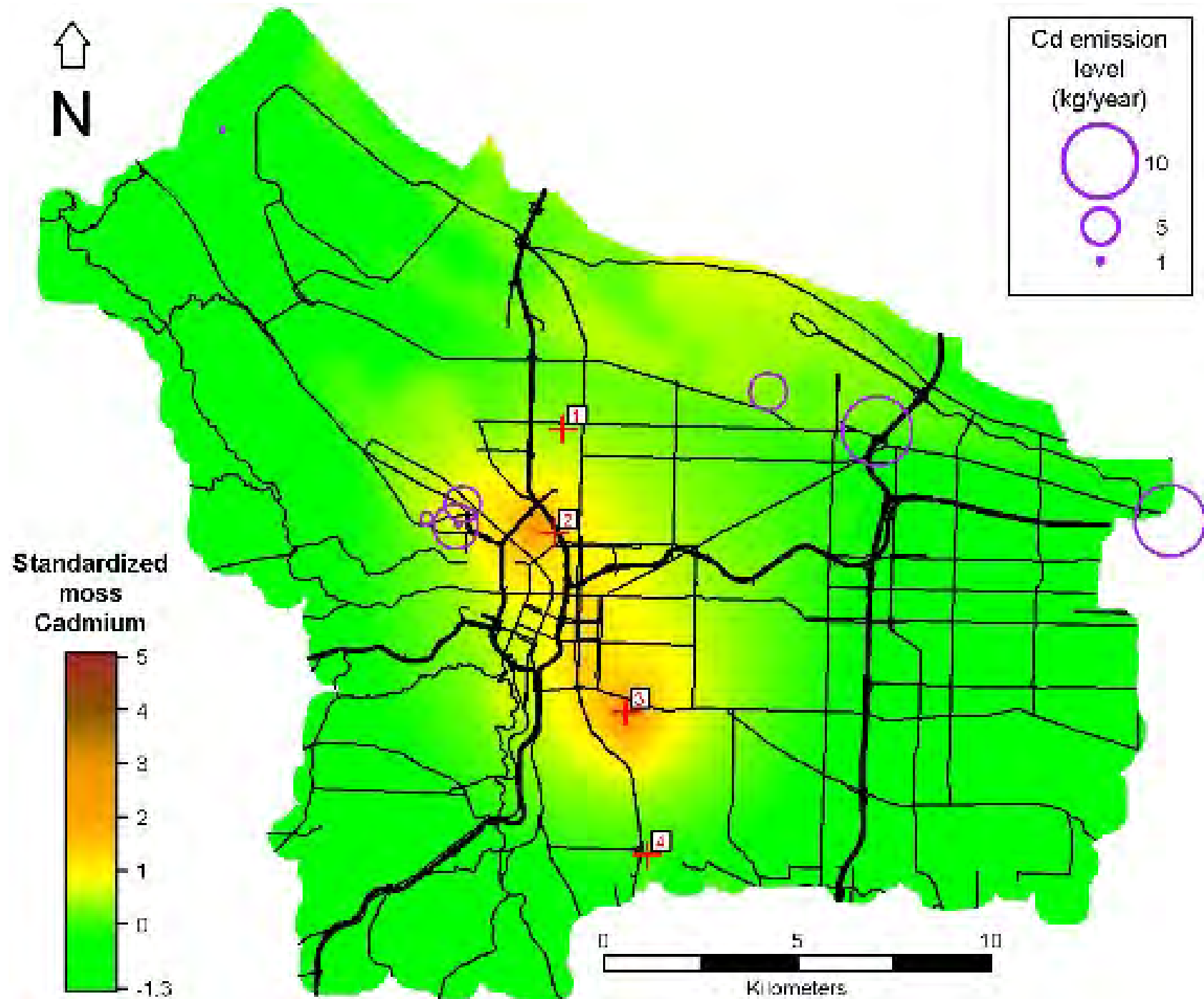
Cd emission level (kg/year)

- 10
- 5
- 1

Standardized atmospheric Cadmium



- 346 moss samples collected over 3 weeks
- Focused on residential areas
- Spatial regression to make prediction maps
- Units = standardized moss cadmium





Tree Moss Collected by Community Scientists: Moss as an Indicator of Air Pollution in Georgetown and South Park

Project Overview and Preliminary Data
May 1st 2020

DRCC - Clean Air Stakeholders Meeting



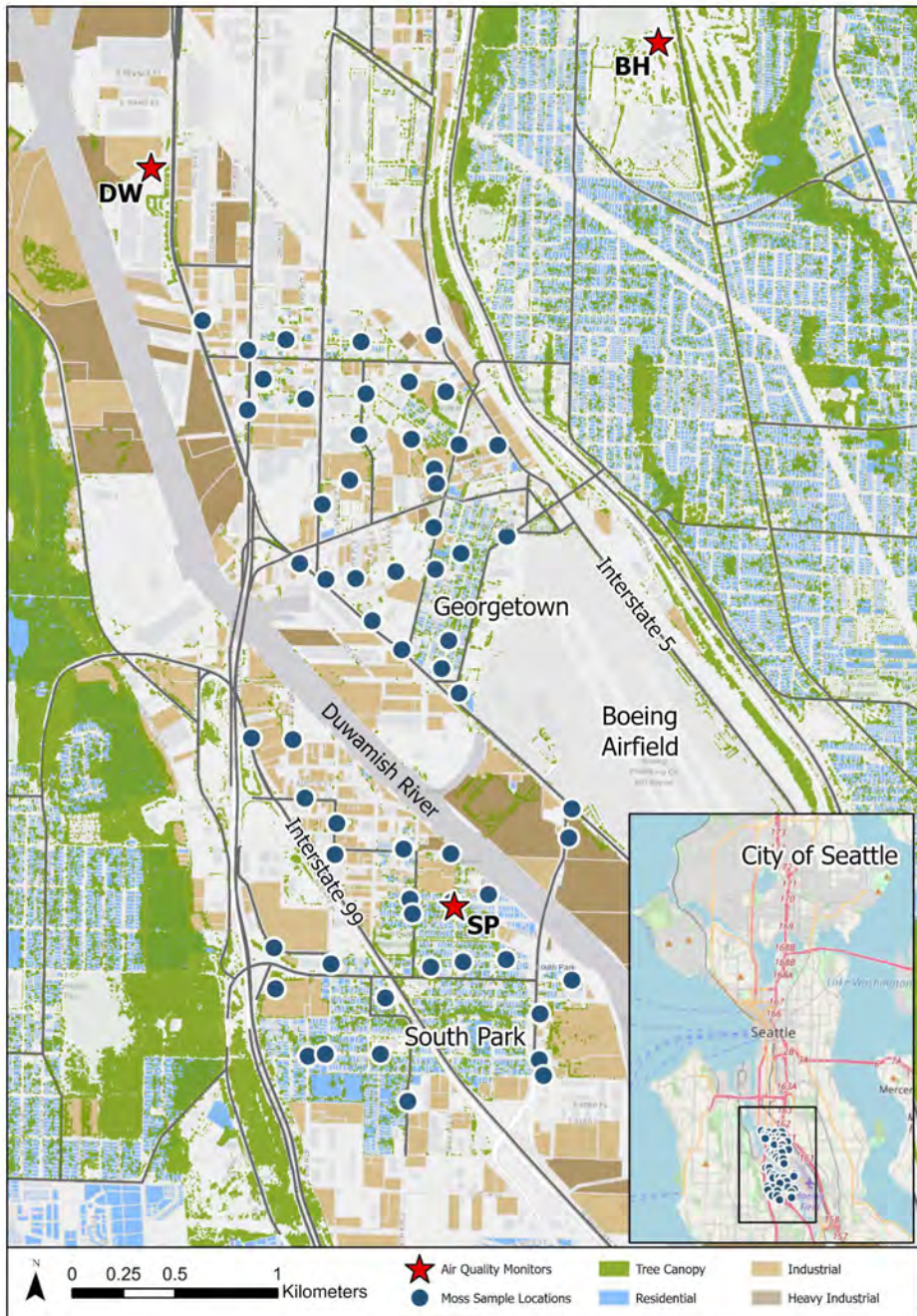
Funding provided by the U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, and State and Private Forestry Pacific Northwest Region. In accordance with Federal law and U.S. Department of Agriculture policy, this institution is prohibited from discriminating on the basis of race, color, national origin, sex, age, or disability.

Youth involvement - The key!



Photo credit: Just Health Action

Twenty-six youth participants of the Duwamish Valley Youth Corps (DVYC) supported by the DIRT Corps, the US Forest Service, City of Seattle, and others did trainings on moss, moss collection and sample preparation.

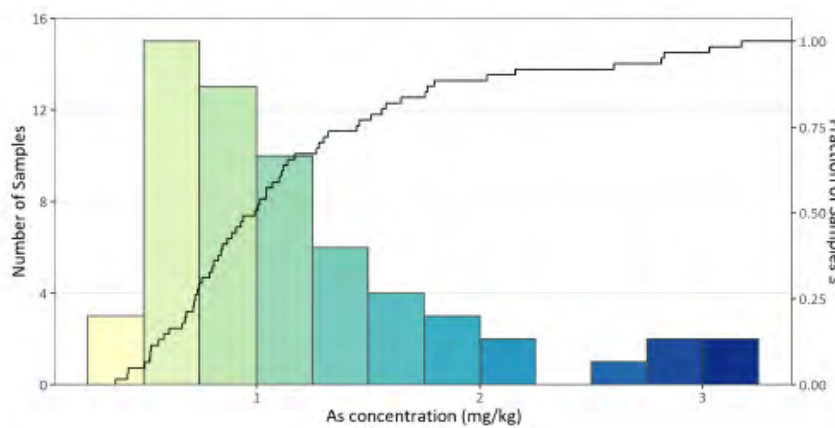
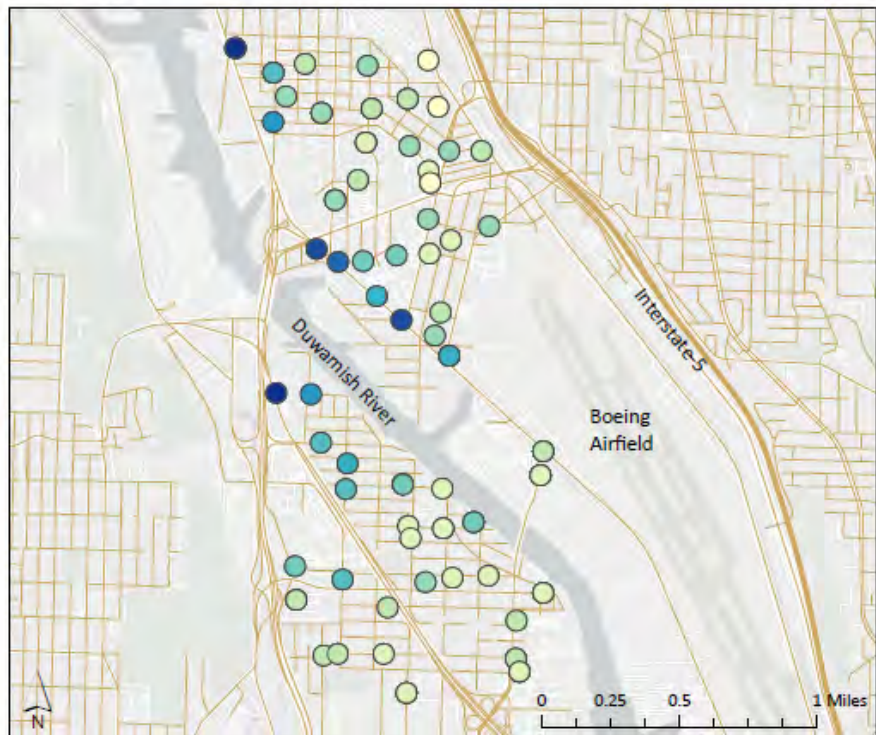


- Many studies show Georgetown and South Park are disproportionately burdened with poor air quality and health outcomes.
- These are also two of Seattle's most diverse neighborhoods, with a substantially higher percentages of non-white residents, non-English speakers, subsistence fishing and harvesting, and lower incomes, than the surrounding city (DVAP 2018).
- Several thousand residents live in single- and multi-family houses near or amongst the industrial blocks.

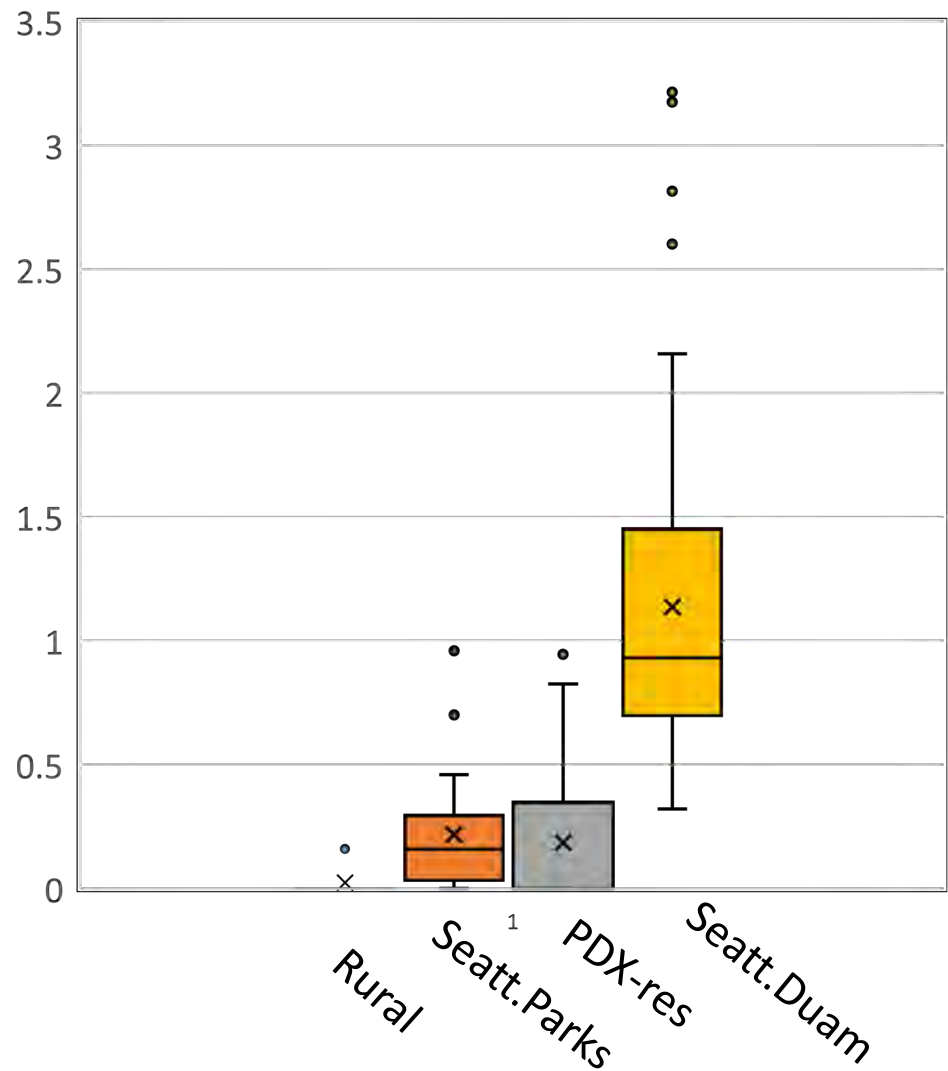
What are the pollution source(s)?

- There is additional research focusing on that question.
- Difficult because many potential pollution sources converge in the same area (i.e. industrial, highway, active harbor, Boeing airport, etc).
- For this first study, however, our main questions were:
 - Is there any moss-based evidence that heavy metals are locally high?
 - Using moss-based maps, where should instruments be placed to evaluate whether human health is at risk?

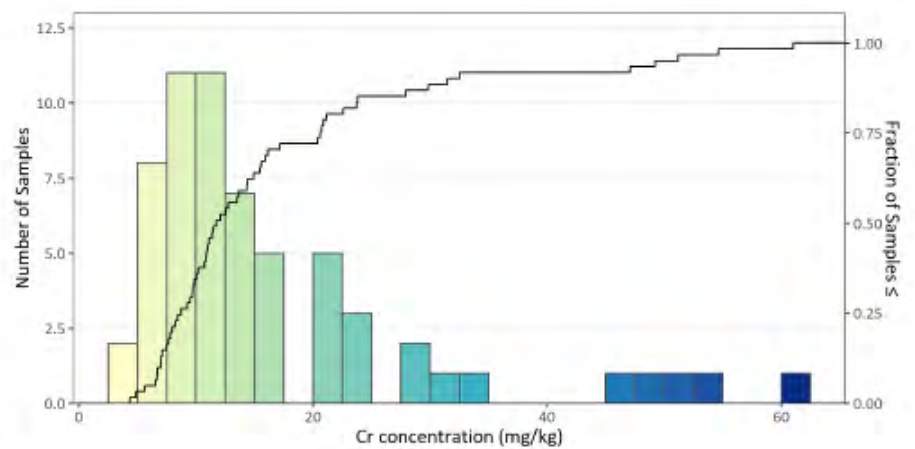
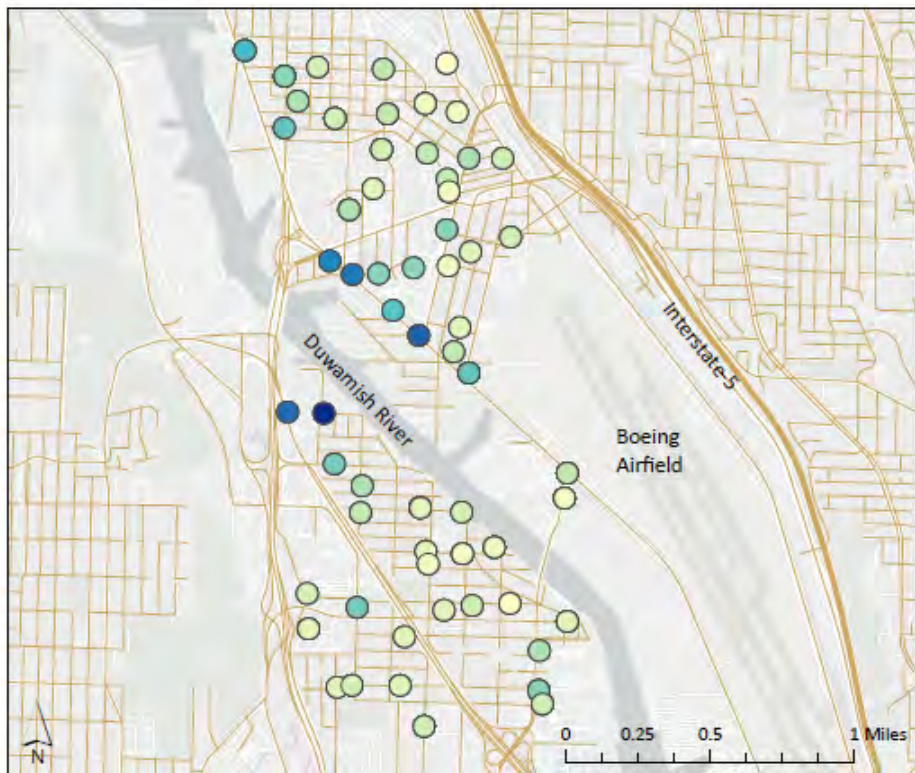
Green-Duwamish Moss Bioindicator Study
Sample Values: Arsenic (As)



Arsenic



Green-Duwamish Moss Bioindicator Study
Sample Values: Chromium (Cr)



Chromium

