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

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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.

Moss: ~$150

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

- Lack a protective outer layer (i.e. epidermis)
- Absorb like little sponges
- Obtain all water and nutrients from the atmosphere (no roots)
- Air pollutants are also trapped
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.
Our lichen “canaries in the coal mine”

N-Sensitive Oligotrophs

Forage + nest species

N-fixers
Lichen “weeds”
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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• 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 µg/m³
Cd Measured: 0.0026 µg/m³
• 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!

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.

Photo credit: Just Health Action
• 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)

[Map of sample locations with box plots showing arsenic concentration]

- Arsenic values are presented for different areas: Rural, Seatt.Parks, PDX-res, Seatt.Duam.
- The box plots show the distribution of arsenic concentrations with outliers indicated.

[Graph showing distribution of arsenic concentrations with a histogram and box plot]