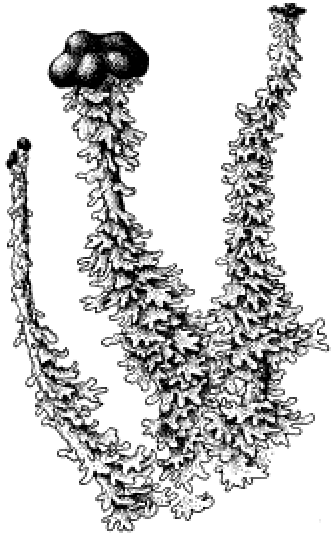
Lichen Biomonitoring in the USFS



2024

Amanda Hardman National FS Lichen Biomonitoring Coordinator
Linda Geiser National Air Resource Program Lead

Air Quality Monitoring and more

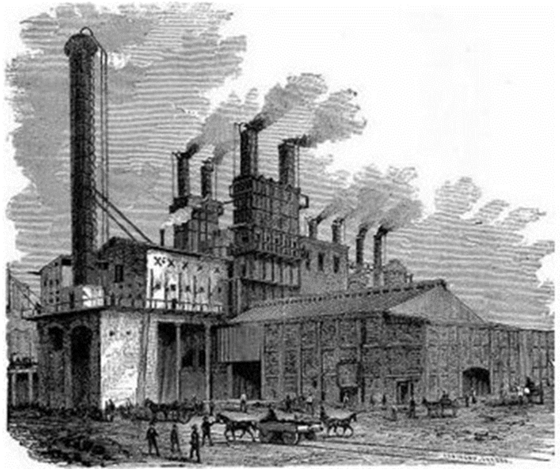
1970 Clean Air Act &1977 amended
"**prevent significant deterioration**" of air quality in class 1wilderness

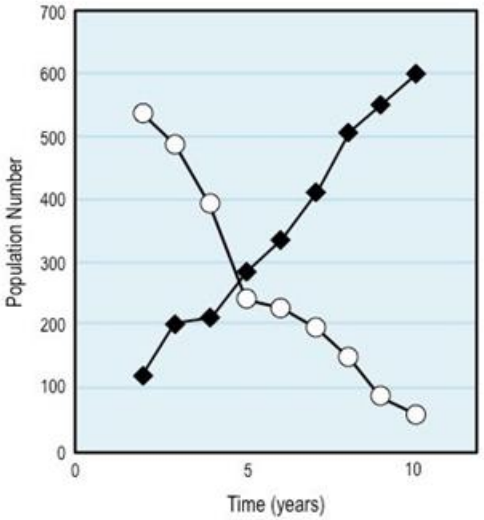
1974 National Forest Management Act &
1976 Federal Land Management Policy Act

*Chief's 10year Wilderness Stewardship Challenge
*Wilderness Character Monitoring

Agency Mission = sustain biodiversity
Forest and Project planning under NEPA (critical load exceedances)
Climate Change

Early observations





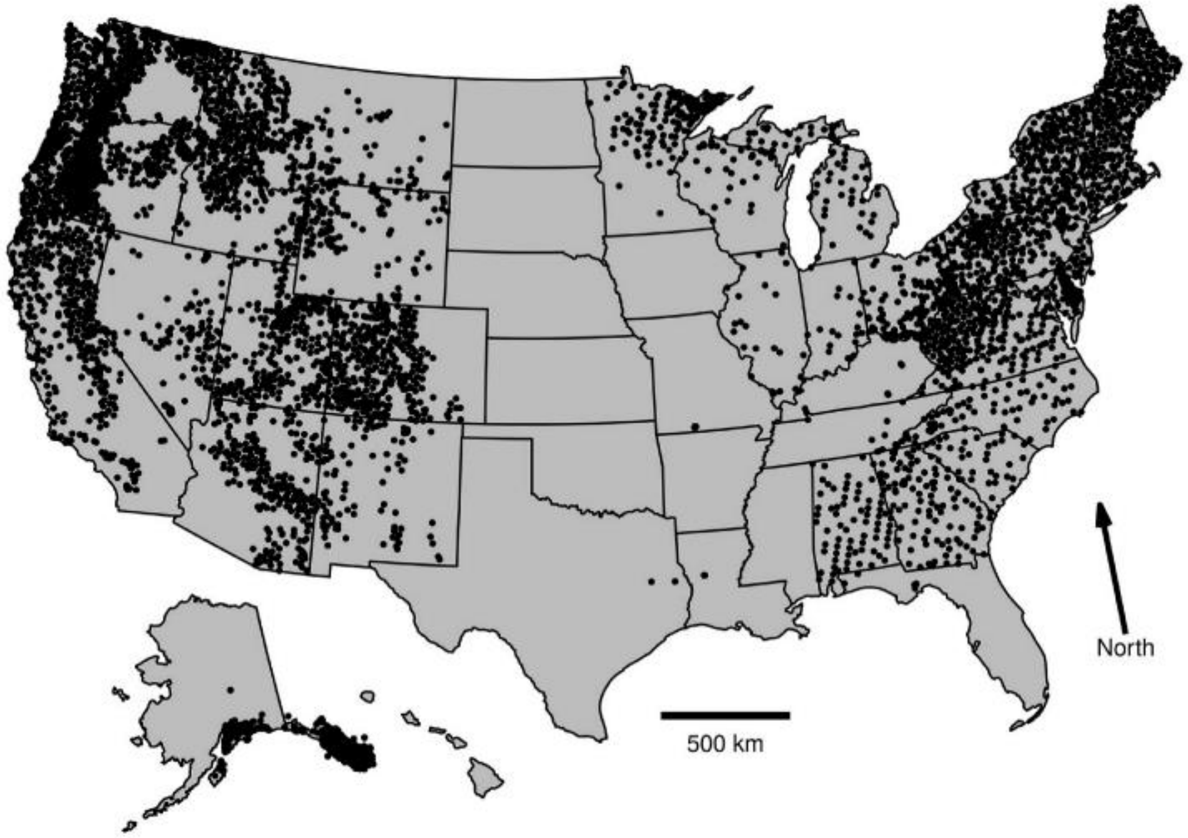
William Nylander
Early Lichenologist

Lichen Surveys Federal Land Nationwide

1973- 2023

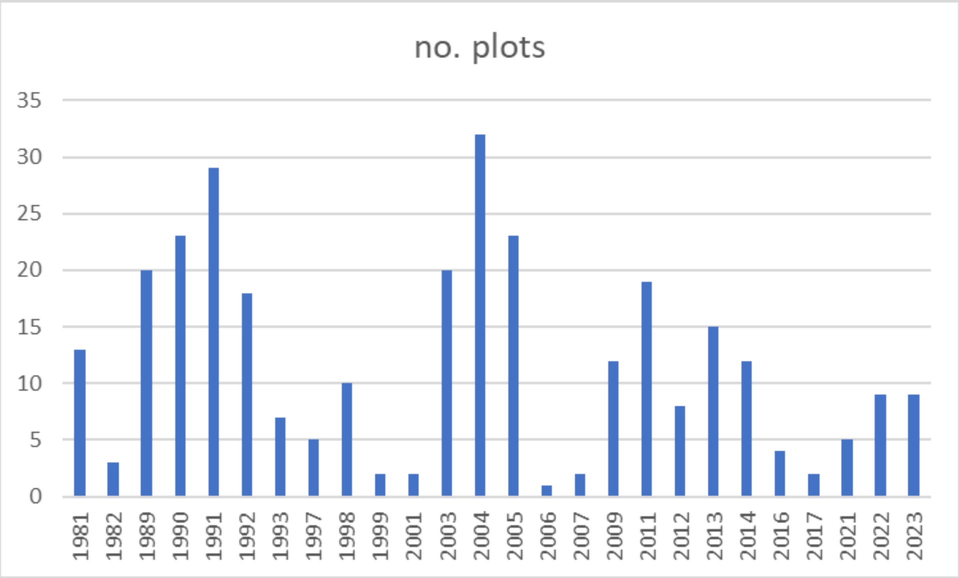
- 42 states
- **127 National Forests**
- **277 FS Wilderness areas**
- 9,000 baseline surveys, 4,000 with trends
  - NPS = 45
  - USFWS = 21
  - BLM = 327
- 200,000 species records
- 18,000 elemental analysis records

Efforts most notably accomplished by the Air Resource Management and FIA programs.

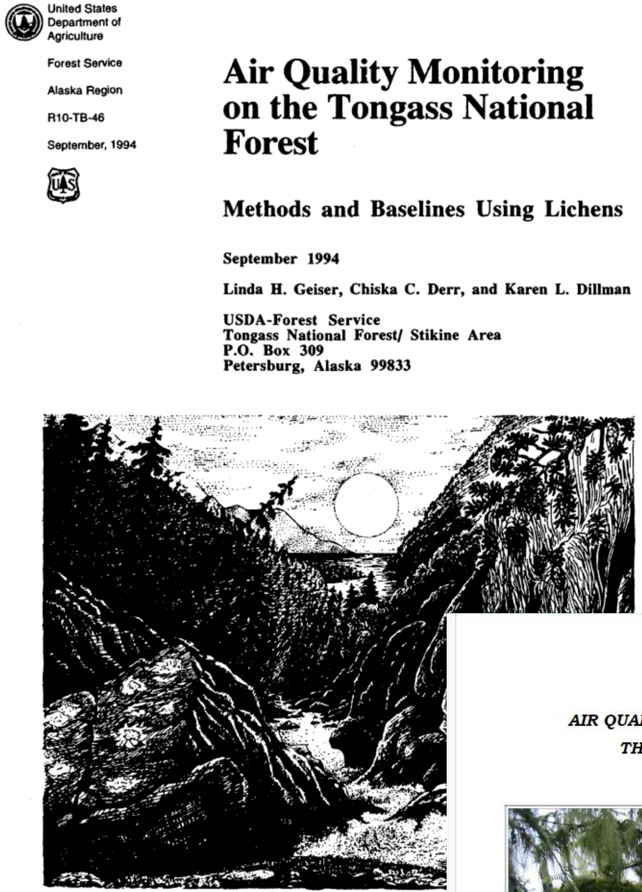


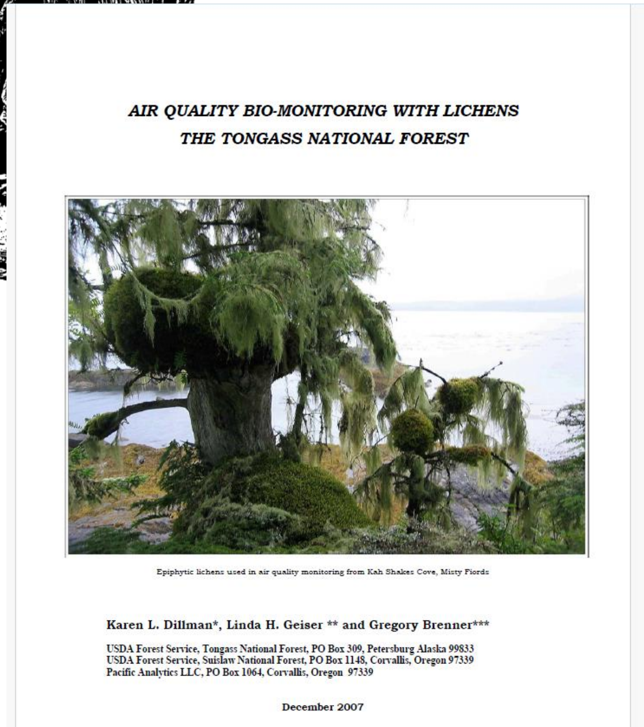
Alaska Biomonitoring

- **1989** First lichen biomonitoring installed Tongass
- **1993-1994** Chugach plots installed
- **2004** Chief's 10-year Wilderness Challenge



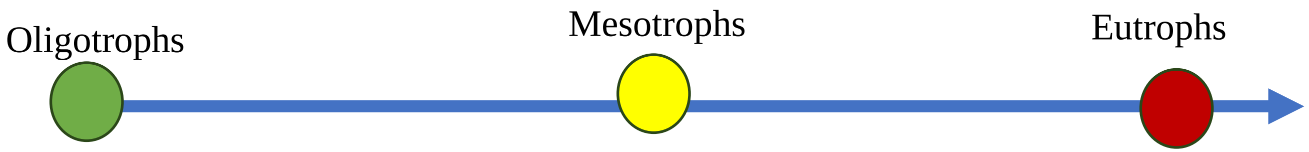
Plots		Chugach	Tongass
Baseline	815	109	706
Trends	63	13	50
Wilderness	215	8	203





Why Lichens?

- Sensitive absorb chemicals at proportions that reflect composition in the air through wet and dry deposition



Nitrogen Deposition Gradient

- Inexpensive
- Common and diverse in most forested ecosystems
- Infrastructure, protocols, and baseline plots ~30 years

What else do lichens tell us:

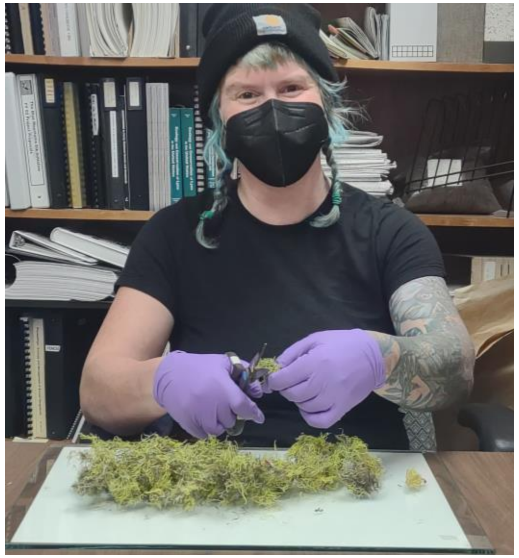
- biodiversity
- Climate shifts

Sample Method 1: Elemental analysis

Measure pollution content in lichen tissues

1. Collect

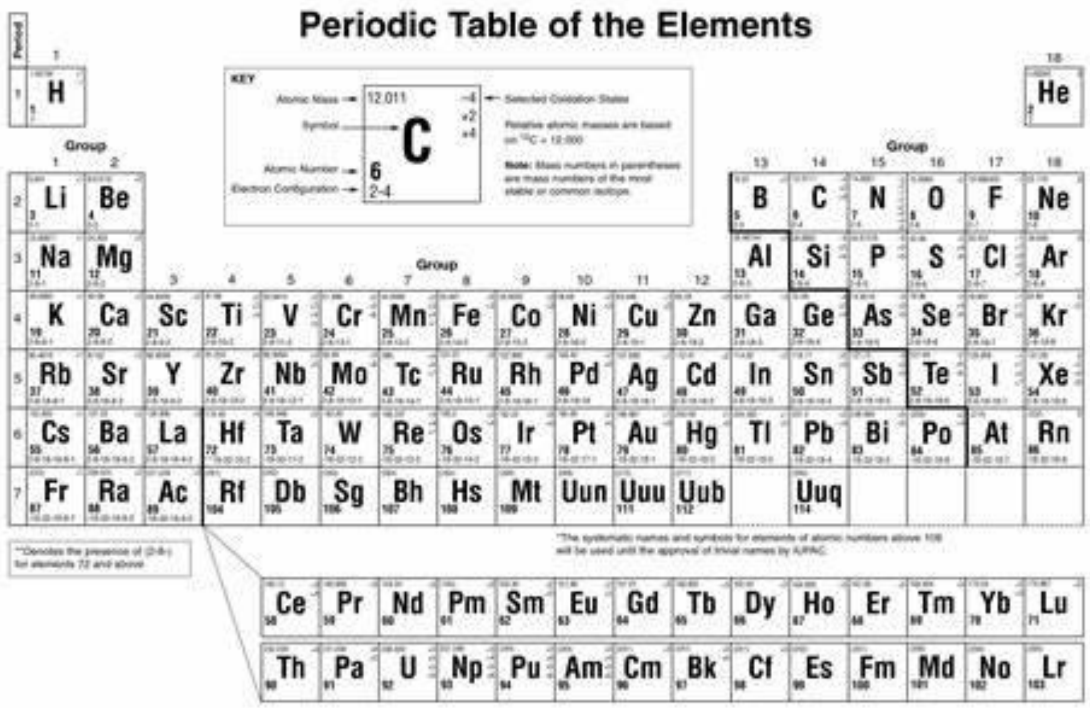
2. Clean



3. Analyze

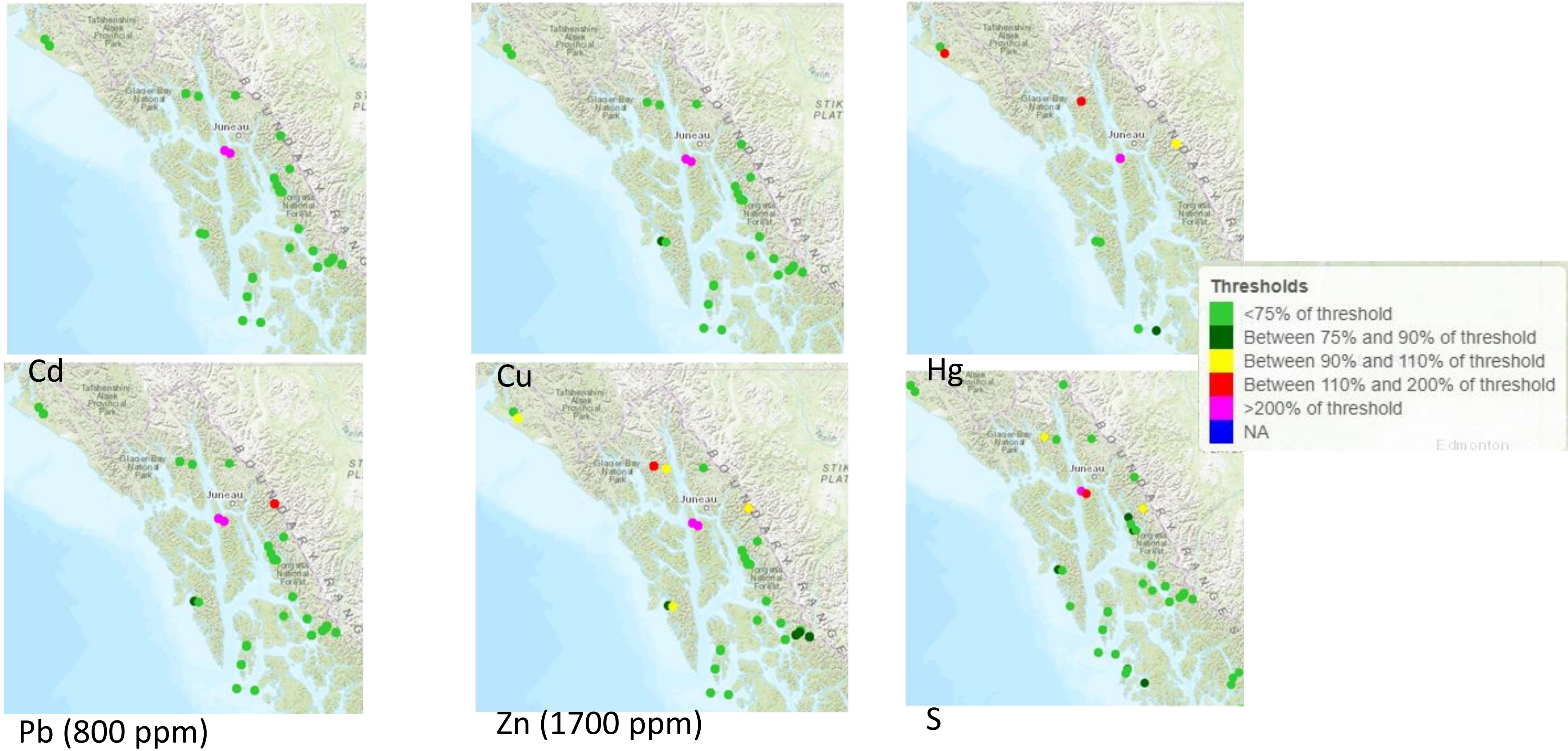
Sample Method 1: Elemental analysis

- Potential to measure SVOC, and persistent air pollutants (PFAS), and microplastics
- We track 27 elements: sulfur, nitrogen, lead, cadmium, chromium, lead, zinc and mercury



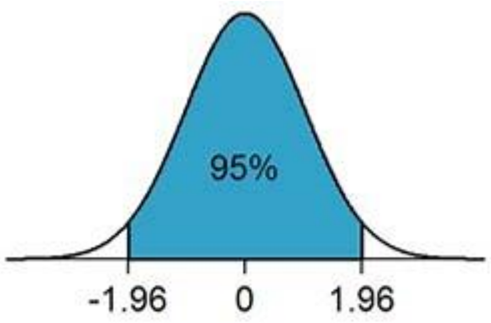
Green's Ck Mine The Tailings Disposal Facility Fugitive Dust Mitigation and Monitoring Plan

Metal and sulfur levels in the lichen Platismatia glauca sampled near the tailings were more ***than 200% above national thresholds****, and in some cases, orders of magnitude higher than thresholds (Cd 30x, Pb 100x, Zn 37x), warranting additional monitoring and monitoring sites to demonstrate effectiveness of best practices to be implemented*.



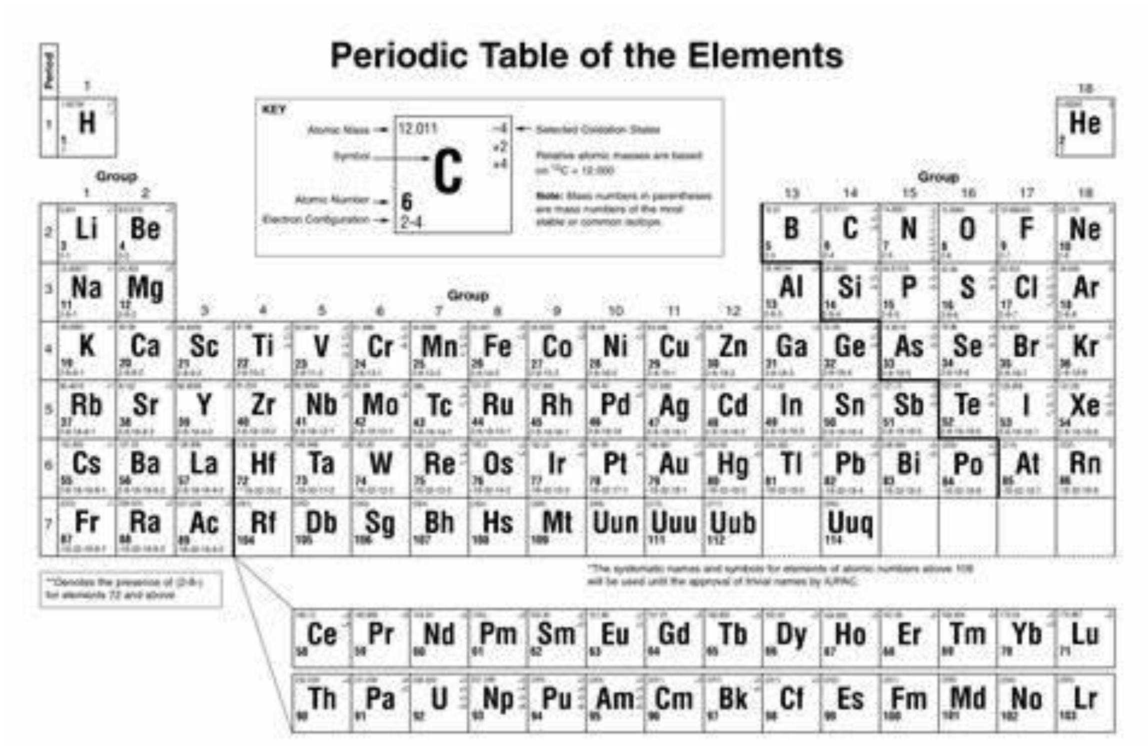
Sample Method 1: Elemental analysis
Determining National Thresholds

	Cd ppm	Cr ppm	Cu ppm	Hg ppb	N %	Ni ppm	Pb ppm	S %	Zn ppm
Platismatia glauca									
Regional Threshold	0.5	3	27.8	n/a	0.79	4.4	10	0.115	49.6
Mean									
Round 1 (n= 14)	0.2	1.3	8.6	n/a	0.61	1.8	5.6	0.072	32.6
Round 2 (n= 4)	0.2	1.4	3.6	144	**0.84**	1.3	3.8	0.074	31.9
Standard deviation									
Round 1 (n= 14)	0.1	0.4	5.8		0.21	0.6	1.9	0.01	6
Round 2 (n= 4)		0.6	1.3		0.54	0.6	0.5	0.045	2.2
Minimum									
Round 1 (n= 14)	0.1	0.9	3.6		0.25	0.9	3.6	0.06	26.7
Round 2 (n= 4)	0.2	0.6	2.9	144	0.5	0.6	3.5	0.037	29.6
Maximum									
Round 1 (n= 14)	0.6	1.9	19.8		0.97	3.3	9.6	0.09	47.2
Round 2 (n= 4)	0.2	2.1	5.5	144	1.64	2.1	4.6	0.14	33.7



Sample Method 1: Elemental analysis

- Benefit: least amount of training
- Challenges: no climate change, high humidity, low biomass, can take up to a year for results



Sample Method 2: Community analysis

- Can also detect climate change
- Relative proportion of sensitive vs. tolerant species indicates air quality
- Assessing community composition as a whole produces a robust Air Score

Oligotrophic (sensitive) species


Eutrophic (N tolerant) species


Acid rain

Sample Method 2 Community analysis

FIA "Lichen Indicator"

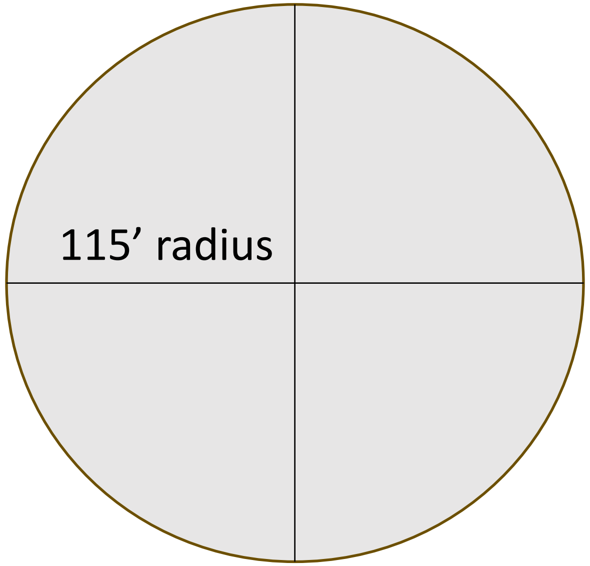
- ✓ 0.4 ha circular plots
- ✓ Time limited survey
- ✓ Epiphytic macrolichens
- ✓ Collect sample of each species
- ✓ Ocular estimates of abundance
- ✓ Quality assurance met through certification
- ✓ Revisits made every 10 years

1 = **Infrequent**

2 = **Uncommon**

3 = **Common**

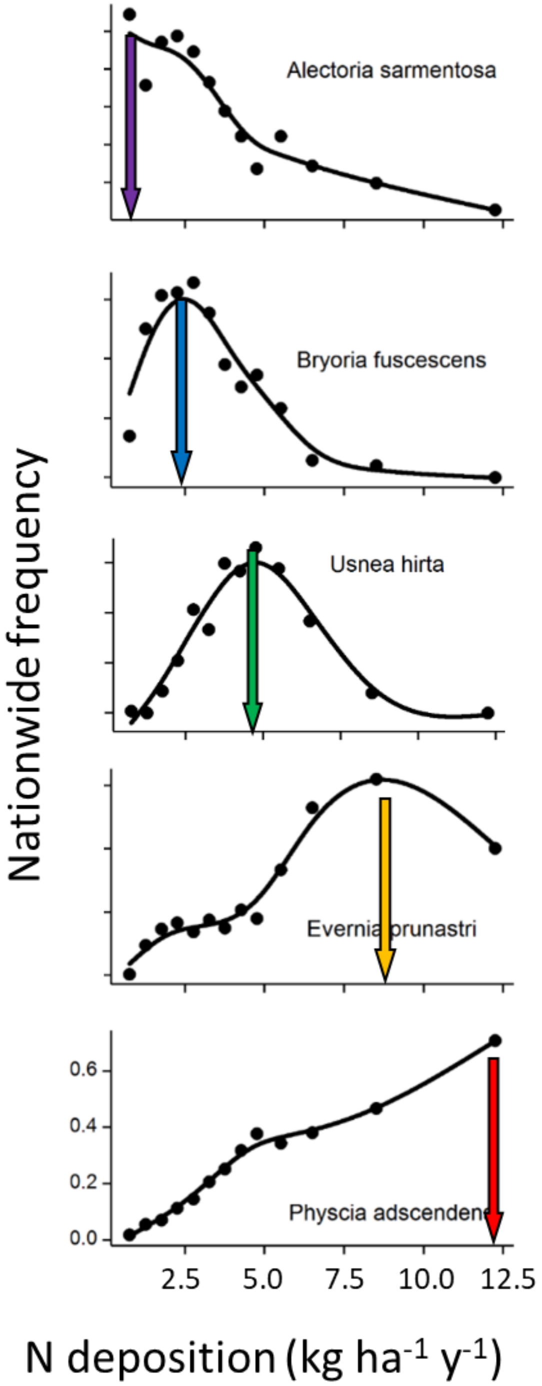
4 = **Abundant**



- ✓ Method requires some skill and training
- ✓ An understanding of where species grow
- ✓ Ability to see and collect the full diversity of lichen species
- ✓ Physical fitness-endurance, backpacking
- ✓ Navigation off
- ✓ Tolerance for challenges of field work

Relating peak frequency of species to deposition

the deposition value at which each species reached its peak detection frequency



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Environmental Pollution

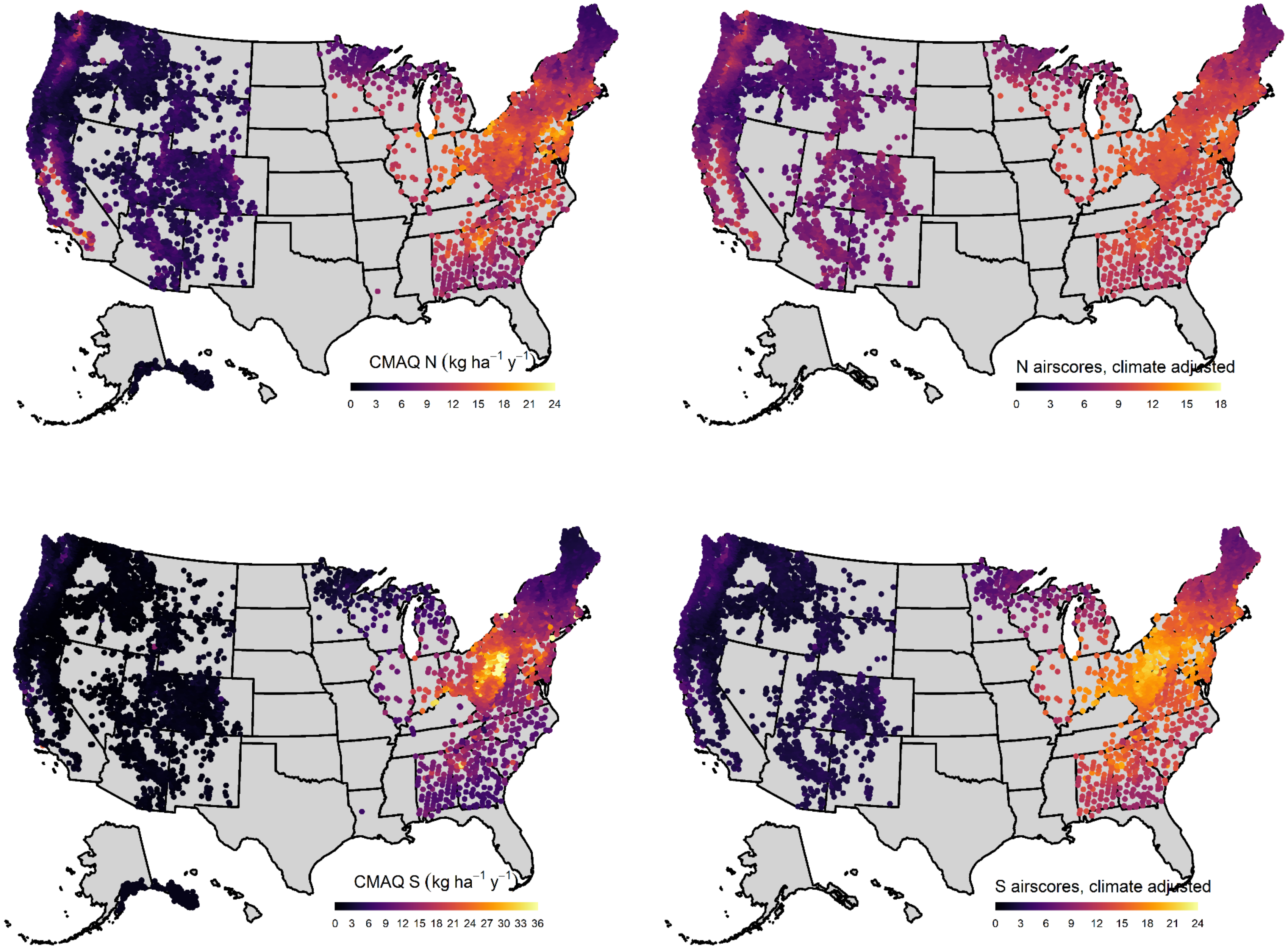
Volume 291, 15 December 2021, 118187

Lichen-based critical loads for deposition of nitrogen and sulfur in US forests ☆

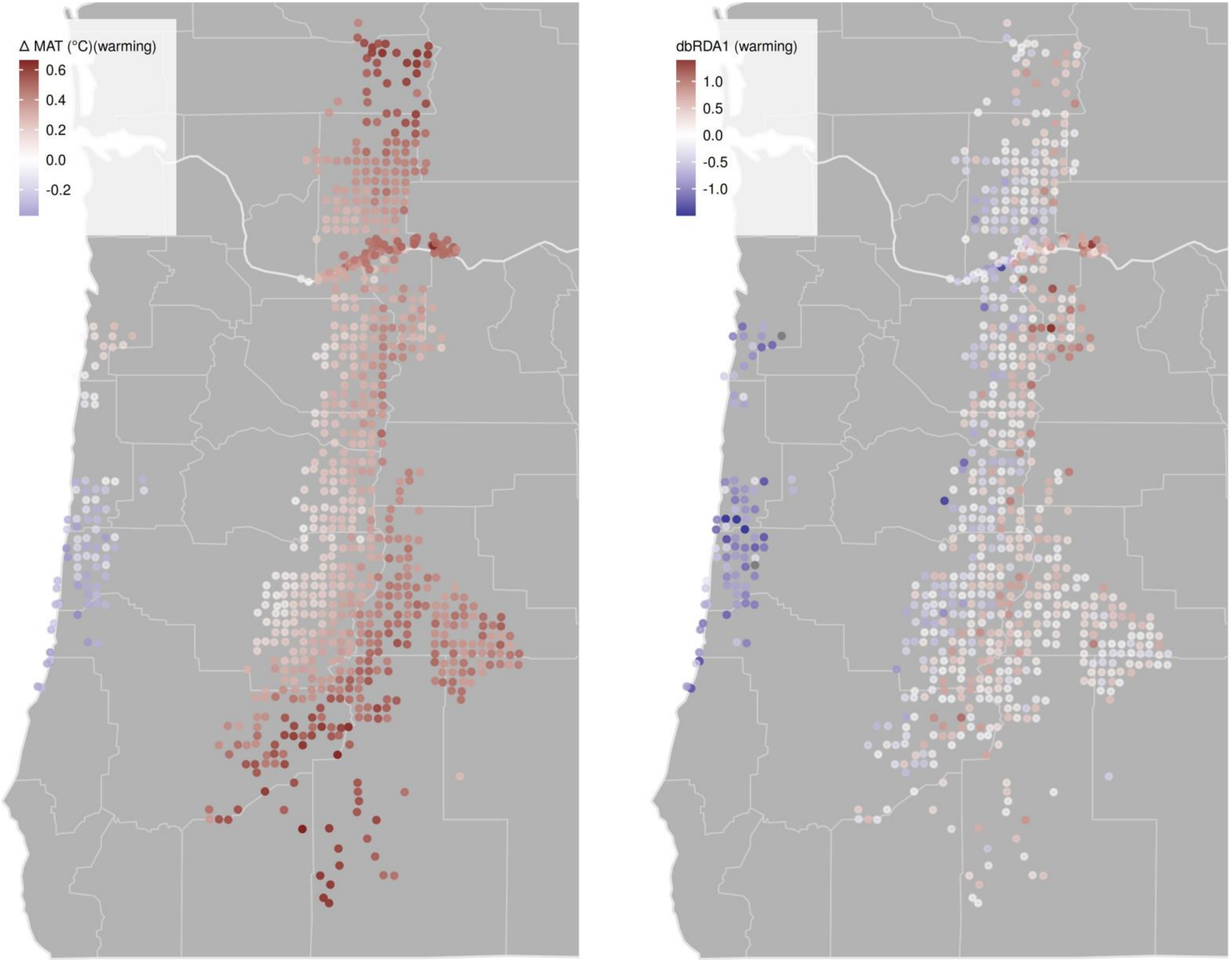
Linda H. Geiser [a], Heather Root [b], Robert J. Smith [a], Sarah E. Jovan [c], Larry St Clair [d], Karen L. Dillman [a]

Mapping site scores

Lichen climate-adjusted 'airscores' track deposition at monitoring sites

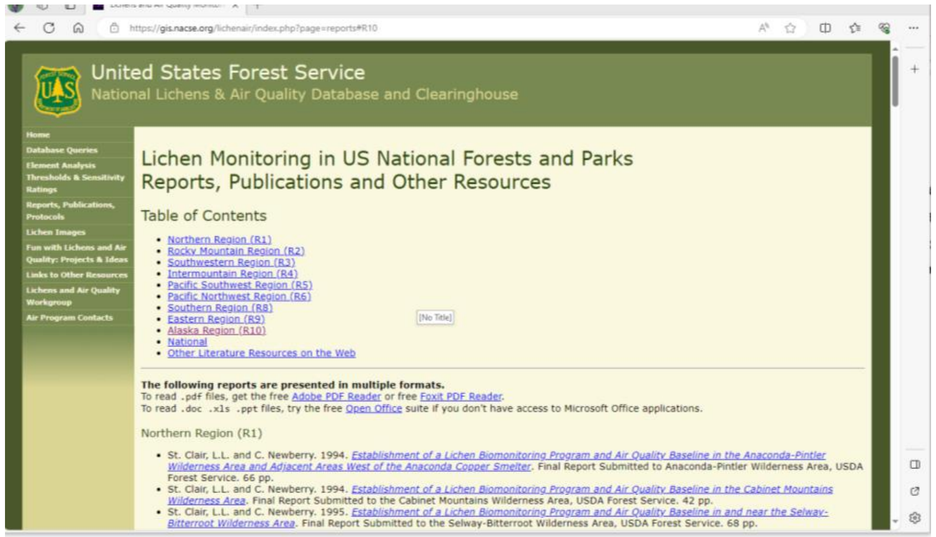


Climate changes mirrored by compositional shifts



Available Resources

- Many publications
- New Website is Forthcoming
- New tools to improve databasing



Lichen communities and species indicate climate thresholds in southeast and south-central Alaska, USA

Heather T. Root[1,3], Bruce McCune[1] and Sarah Jovan[2]

[1] *Department of Botany and Plant Pathology, Oregon State University, 2082 Cordley Hall, Corvallis, OR, 97331, U.S.A.;*

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Environmental Pollution
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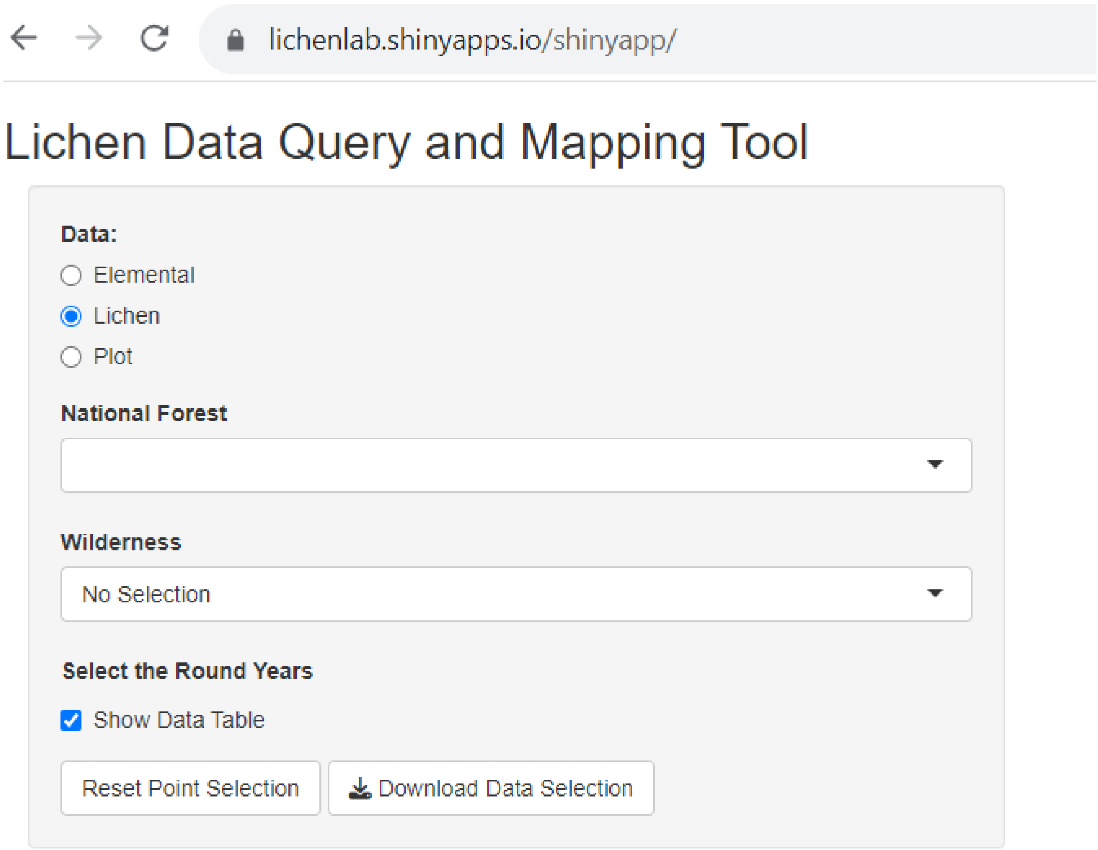
Lichen-based critical loads for deposition of nitrogen and sulfur in US forests ☆

Linda H. Geiser[a], Heather Root[b], Robert J. Smith[a], Sarah E. Jovan[c], Larry St Clair[d], Karen L. Dillman[a]

Lichen bioindicators of nitrogen and sulfur deposition in dry forests of Utah and New Mexico, USA

Heather T. Root[a], Sarah Jovan[b], Mark Fenn[c], Michael Amacher[d], Josh Hall[e], John D. Shaw[f]

Wilderness Stewardship



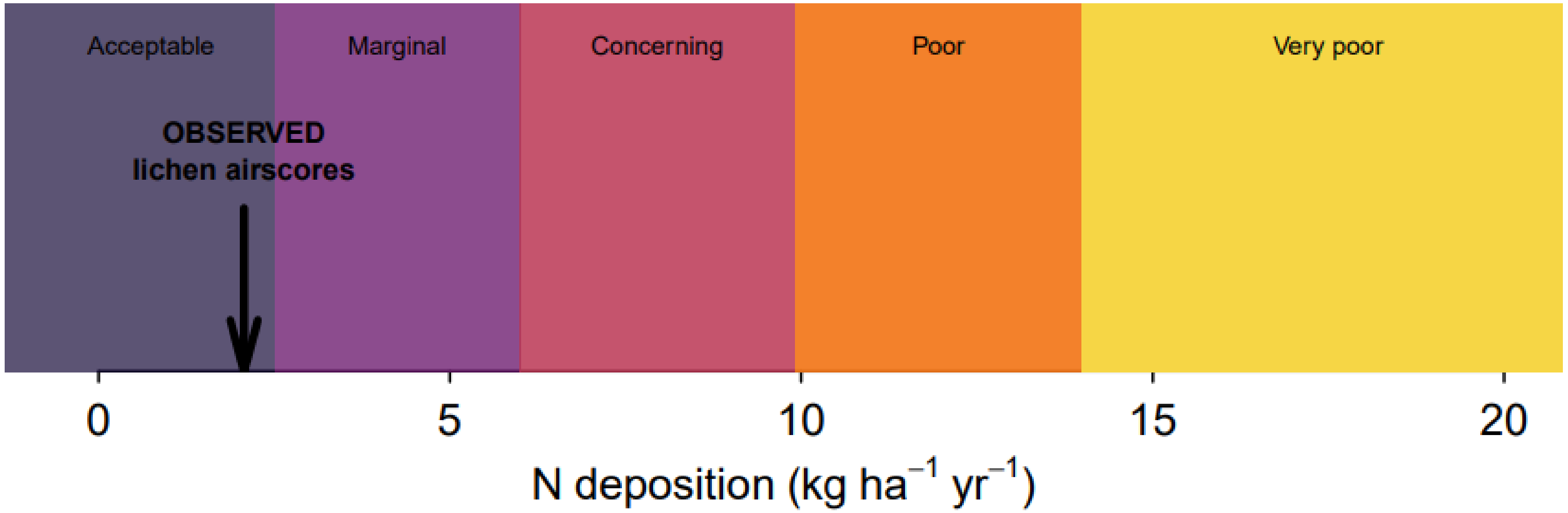
Wilderness Stewardship Lichen Report:
https://ecol.shinyapps.io/wildstew/

Wilderness Air Quality Values
for Mount Hood Wilderness

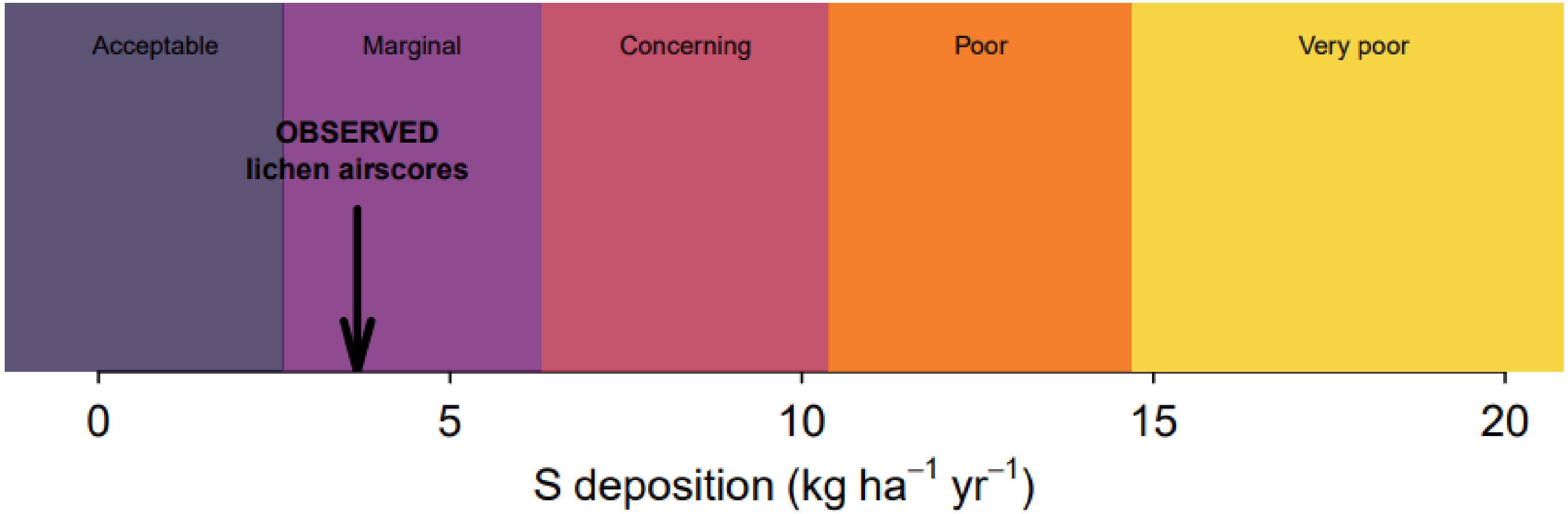
Report prepared: 22 February 2021

Contents

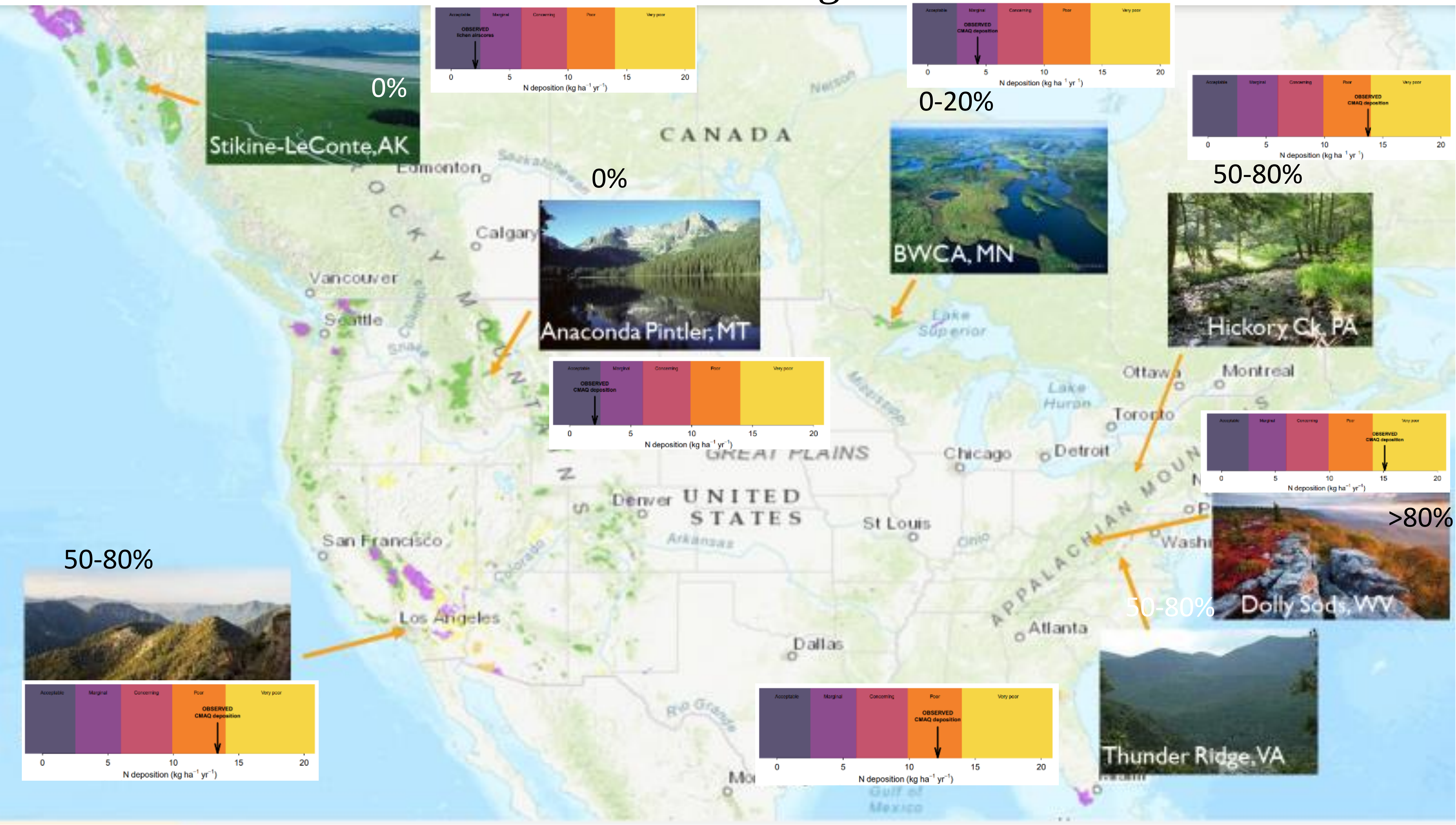
2.1 Nitrogen snapshot



2.2 Sulfur snapshot



Risk lichen richness decline with increasing

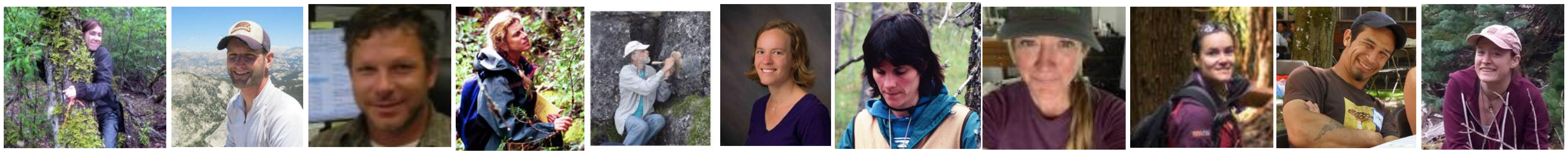


Challenges

- Budget Modernization
- Increased catastrophic fire
- Limited funding
- Data and Lab can be slow

Benefits

- Lichens don’t lie
- Many tools have been developed for analyzing Forest Health
- Proven repeatable protocols
- Baseline and trends data going back 33 years
- Much less expensive for making initial detections



Thank you to Linda Geiser, Bruce McCune, Sarah Jovan, Karen Dillman, Doug Glavich, Heather Root, Rob Smith, Rick Graw ***and many, many more*** *people who have been a part of this program’s history, especially all the Forest Service staff, wilderness program managers, partners, volunteers, and contractors that have contributed over the years!*