# Trace Elements in High-Elevation Forest Soils: Six Mountains in Maine

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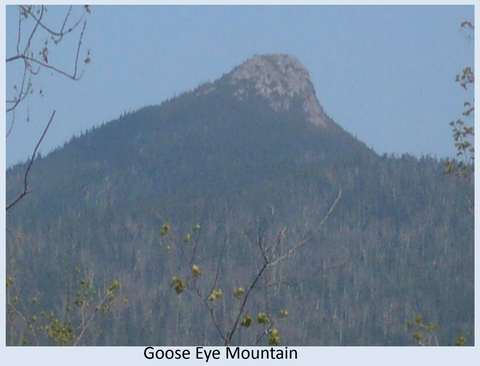
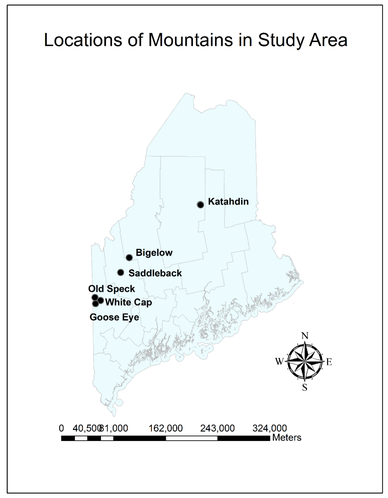
## Introduction and Objectives

Human activity, sometimes stretching back centuries, has caused short- and long-range transport of trace elements. High elevation forest soils are particularly sensitive to deposition of trace elements. Once deposited, site characteristics such as community composition, soil pH, and soil clay and organic matter content strongly affect trace element retention and cycling. The explanation of trace element contamination patterns depends so much on highly site-specific factors that models and extrapolations have met with limited success.

The purpose of this research project was to assess spatial and temporal changes in trace element concentrations on six mountains in Maine. This study looked at trace elements in high elevation systems that have been previously studied, so results (and their interpretations) can be compared.



Goose Eye Mountain

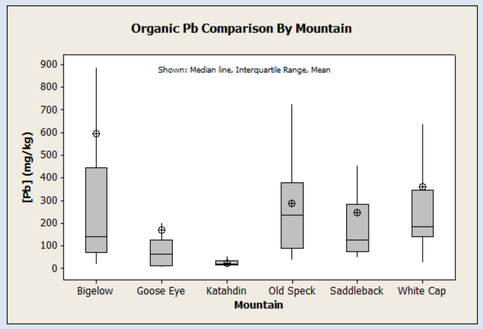



## Methods

- The six mountains were sampled previously in 1979 (Hanson, 1980) and 1996 (Evans et al., 2004).
- A sample site was chosen at the base of each mountain, at every subsequent 305 m (± 43 m), and then just below tree line, if soil was present.
- At each elevation, O and A horizon samples were collected.
- Foliage samples were collected at the same elevations as the soil samples.
- Mineral soil samples were processed using U.S EPA Method 3050.
- Organic and vegetation samples were ashed at 450° C and processed using U.S. EPA Method 3051A.
- Concentrations of As, Cd, Co, Cr, Cu, Mn, Ni, Pb, V, and Zn were determined by ICP-OES using EPA Method 6010.

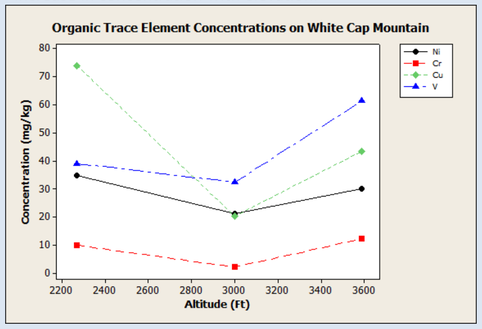
## Results

### Organic




Trace element concentrations in the organic horizon were highest on Bigelow for the majority of trace elements. Concentrations of all trace elements except Cd were lowest on Katahdin. Bigelow had the most variation in trace element concentrations and Katahdin had the least. Arsenic concentrations exceeded the Maine Remedial Action Guideline more often than other trace elements.

In general, trace element concentrations were higher at the base and top elevations on each mountain, and lower at mid elevations. This also manifests itself as an overall increase in concentration with elevation.




View from Bigelow Mountain's West Peak (1263 m), showing an alpine tundra community

### Mineral vs. Organic

In general, trace element concentrations were lower in the surface mineral horizons than in the organic horizons. Results were less variable for mineral samples than for organic.

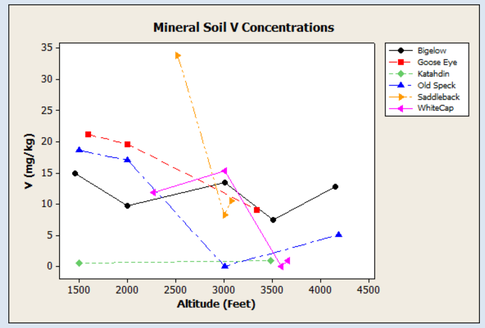
### Relationships Among Trace Elements

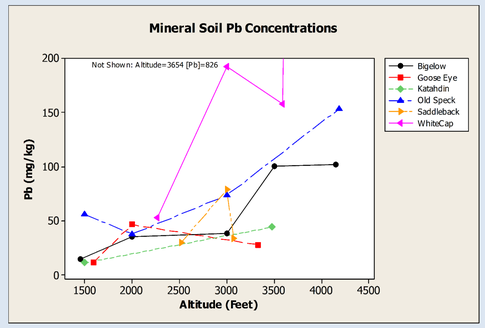
In the organic horizons, there were more significant (r >0.06, P<0.05) relationships between elements than in the mineral soils.

Very strong relationships (r > 0.9) among Zn, Cu, and Mn existed in both the mineral and organic horizons

### Mineral

Some elements, like Pb, Co, and V, exhibited more or less linear trends, decreasing with elevation. A notable exception to this trend is Pb, whose median concentrations increased with increasing altitude on all mountains in the study.
Chromium, by contrast, was elevated at the base elevation, then decreased, then increased .




On the way up Goose Eye Mt

### Vegetation

- Concentrations of trace elements in Balsam fir generally decreased with elevation.
- Trace element concentrations in paper birch generally exceeded those of Balsam fir on mountains where they occurred together.

### Comparisons to Other Studies

#### Soils

- In general, trace element concentrations in the organic horizons have increased over time, except on Katahdin.
- In the mineral horizons, trace element concentrations were similar to or lower than those from previous studies.

#### Vegetation

- Trace element concentrations in vegetation, especially balsam fir, were lower than literature values, except for Zn and Cd.
- Results were similar to values previously found in Maine, in similar vegetation.

White Cap Mountain

## Discussion

- The elevated As results are likely due to inputs from mafic parent material, which is naturally rich in As in Maine.
- Other studies of trace elements in high-elevation forest soils in this area have shown a decreasing trend from Southwest to Northeast, thus our low values for Katahdin may be explained by increasing distance from the source of contamination.
- That concentrations in the organic horizons increased with elevation was expected, as were the higher results for organic compared to mineral.
- The decreasing trend with elevation in the mineral soil is especially interesting because Pb did not exhibit this trend, suggesting a different source for Pb. At high altitudes, frost heaving may be mixing atmospherically deposited Pb with mineral soil in deeper layers. The highly organic nature of soils at the highest altitudes could affect the extent to which Pb is preferentially retained, given the affinity of ligands in organic material for Pb. The deposition, retention, cycling, and exportation of trace elements in high-elevation ecosystems depends highly on site-specific factors, including regional meteorology, geography, climate/precipitation, nearby anthropogenic sources, parent material, community composition, etc.
- The strong correlations among Zn, Cu, and Mn in both the organic and mineral layers suggest a common source.