Which Soil Nutrient Pools Explain Forest Characteristics?

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Introduction

Nutrients enter ecosystems via atmospheric deposition and geological weathering. These nutrients determine site fertility which is highly variable due to the magnitude of soil forming processes (Jenny, 1958).

Exchangeable nutrient pools are readily available for plant uptake, however, they account only partially for the nutrient requirement of trees (Likens, 1994; Likens et al., 1998). Other nutrients are bound up in minerals and take decades to centuries to become readily available.

Quantifying extractable nutrient pools and the more refractory nutrients bound in silicates provides insight on nutrients initially available during soil formation and the current total nutrient concentration of the soil.

Soils nutrient information could be used to explain about 20 years of forest response data through the excavation of quantitative pits.
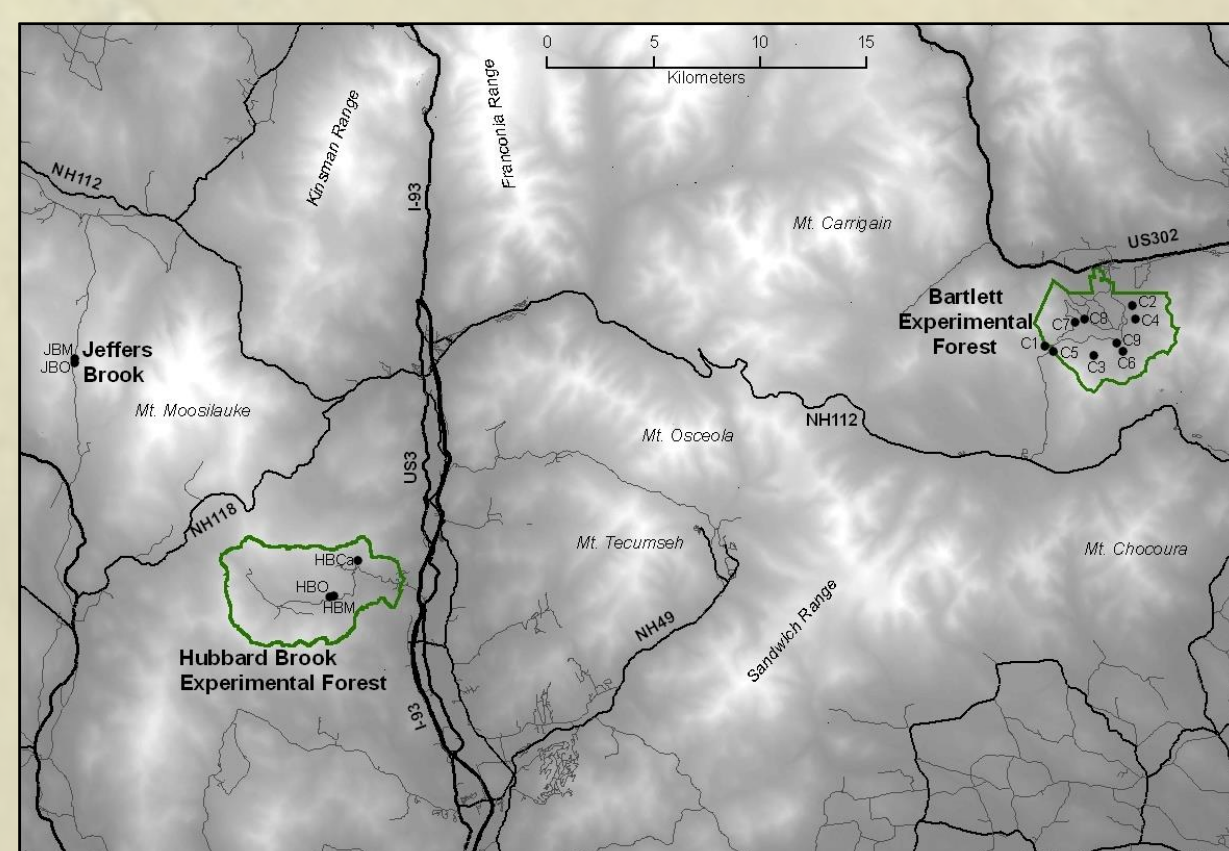
To minimize sampling errors in rocky soils, excavation pits are oftentimes used to sample from an exposed surface, allowing for quantitative sampling of the soil profile with minimal surface horizon contamination (Nezat et al., 2007; Vadeboncoeur et al., 2012).

Objectives

1. Quantify exchangeable, extractable, and total soil nutrients in 11 sites. Al, Ba, C, Ca, Fe, K, Mg, Mn, N, Na, P, Rb, Sr, Ti, and Zn.
2. Correlate the three nutrient pools to preexisting datasets to explain forest characteristics.
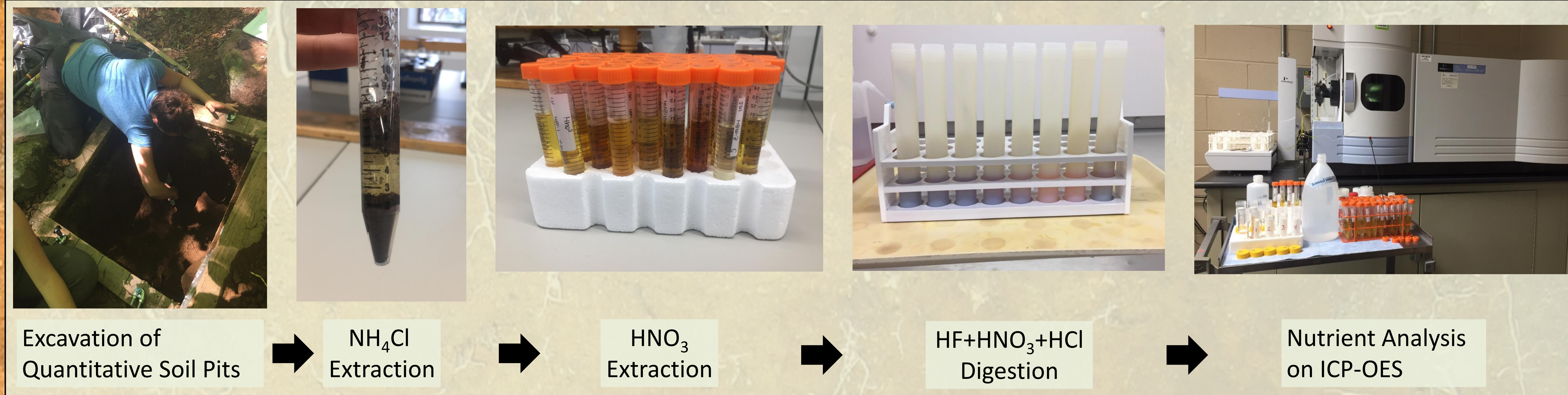
Study Site

This study was conducted in the White Mountain National Forest in NH. To determine forest nutrition, 13 stands were established. Within each stand, four 50x50 m plots were delineated for replication. Among the years 2004, 2010, and 2018, 11 out of the 13 stands were excavated via quantitative soil pits.
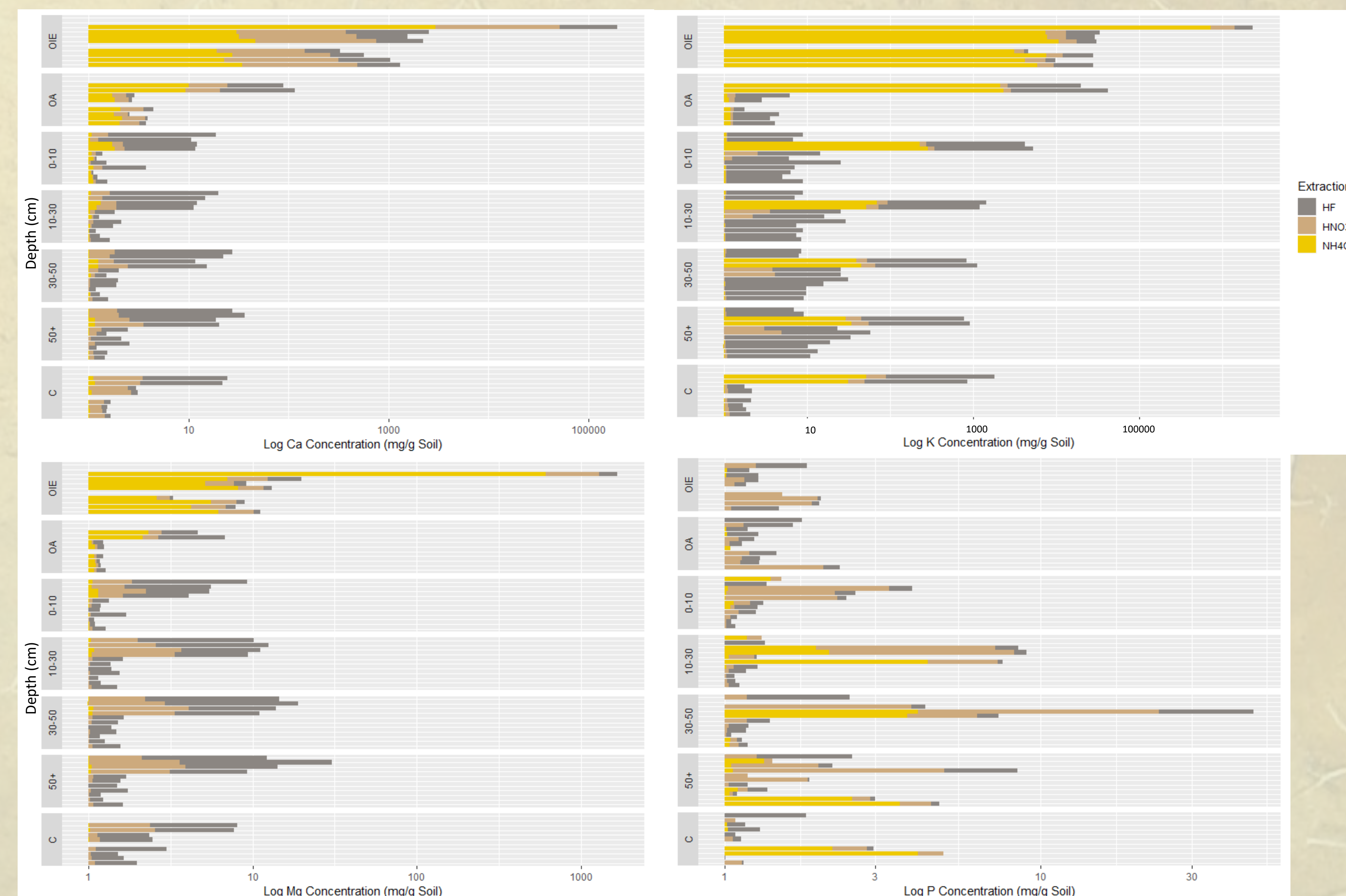

Study Sites

Methods

Excavation of Quantitative Soil Pits → NH_4Cl Extraction → HNO_3 Extraction → $HF+HNO_3+HCl$ Digestion → Nutrient Analysis on ICP-OES

Explanatory variables

These graphs present the raw data of four essential nutrients for plant growth. The colors correlate to the three extractions and are combined to give the total nutrient concentration per depth. The NH_4Cl extraction characterizes the exchangeable nutrients, HNO_3 characterizes the extractable and HF when summed with the other two provides the total.

Forest Responses

Soil Characteristics
- Nitrogen mineralization
- Parent material
- Soil respiration
- Tea bag decomposition

Productivity
- Germinant survival rate
- Sugar maple seed production

Tree Response
- Beech bark disease severity
- Green leaf nutrient content
- Litterfall nutrient content
- Maple sap sweetness
- Root nutrient uptake
- Sap flow
- Tree growth

Predictor Variables

- Nutrient availability as a function of C horizon total nutrients
- Tree growth in response to nutrient availability
- Nutrient uptake as a factor of availability
- Nitrogen mineralization as a factor of C horizon total soil nutrition
- Soil respiration in response to available and extractable nutrients