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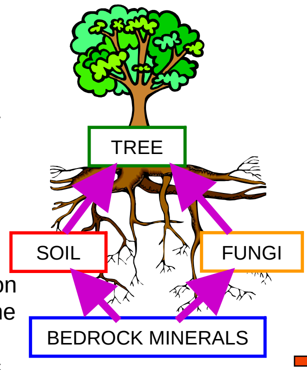
Tracing Calcium in Forest Ecosystems: Ca/Sr and Ca isotopes

BACKGROUND

- o Acid deposition significantly affects forest ecosystems (e.g. the Northeast U.S.)
  - o Effects:
    - o Soil acidification
    - o Leaching of base cations from the soil, especially calcium
    - o Mobilization of aluminum (Al is toxic to both plants and animals)
    - o Increased nitrate availability
    - o Declines in symbioses between plants and mycorrhizal fungi
- o Resulting Ca limitation is correlated with declines in forest health
- o Ca pools (boxes) and fluxes (arrows) are poorly identified and unquantified.
  - o Ca/Sr values are commonly used to identify Ca sources and estimate fluxes (e.g. Blum et al. 2002 and Bailey et al. 1996)
  - o Current methods assume that there is little fractionation between Ca and Sr along the source - foliage path.
  - o There is evidence that trees are directly accessing mineral Ca through symbiotic relationships with mycorrhizal fungi - bypassing the soil Ca pool (Landeweert et al. 2001)



REFERENCES: Bailey, S.W., et al. 1996. Water Resour. Res. 32: 707-719. Blum, J.D., et al. 2002. Nature. 417: 729 - 731. AND Landeweert, R., E. et al. 2001. TREE. 16: 248-254.

RESEARCH DIRECTION

1.) Are Ca and Sr fractionated in terrestrial biogeochemical cycles?
   a.) Is there significant fractionation between Ca and Sr along the source-foliage path?
   b.) If so, what is the magnitude?
2.) Do environmental conditions, N-deposition or fungal associations, enhance this fractionation?
3.) Do Ca isotope ratios provide a more reliable way of tracing the movement of Ca in forest ecosystems? Questions 1 and 2 must be addressed for Ca isotopes.

➤ I am investigating these questions in cultured Scotch pines, controlling the following variables: N species, N supply rate, and presence of mycorrhizal fungi.


Culture set-up


Non-mycorrhizal


Mycorrhizal

PRELIMINARY RESULTS

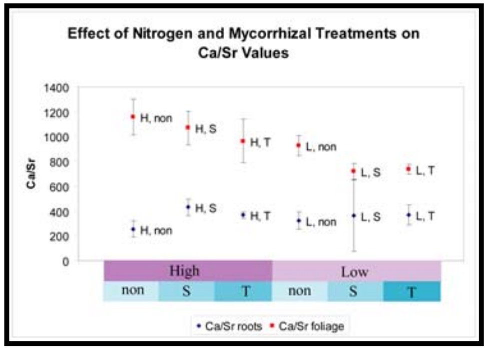


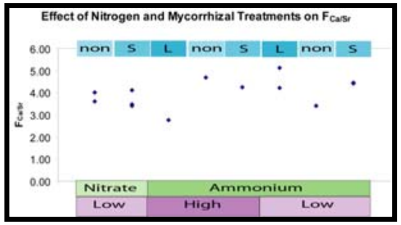
Figure 1: Results from a culture study showing biological fractionation within individual pine seedlings at the one-sigma level (ICP-AES).

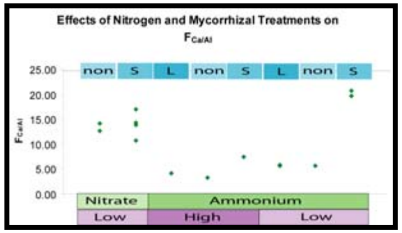
Treatments:
H = high nutrient supply rate
L = low nutrient supply rate
Non = non-mycorrhizal
S = *Suillus luteus*
T = *Thelephora terrestris*

Figures 2 and 3: Effects of nitrogen (high vs. low and nitrate vs. ammonium) and mycorrhizal (non = non-mycorrhizal, S = *Suillus bovinus*, L = *Laccaria laccata*) on enrichment factors, F.

Enrichment Factor,
F_{ratio} = (Needle ratio) / (Root ratio)

- *Suillus* may block plant uptake of aluminum (Fig. 3 below)





CONCLUSIONS AND IMPACTS

- Ca/Sr is not a conservative tracer; ratios of foliage do not represent ratios at soil-root interface.
- Other tracers, e.g. Ca isotopes, are required to constrain Ca cycling in terrestrial systems.
- Development of new tools (tracers) will further our understanding of the Ca cycle in forests.
- Effective forest management practices (e.g. liming), environmental policies, pollution controls, commercial industries (e.g. maple syrup), etc. require a more comprehensive understanding of terrestrial calcium.

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