Compositional modelling of the impact of source lithology on the plant ionome

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Plant Ionome

Ionome

- describes all the mineral nutrients and trace elements found in a plant.
- varies with respect to the plant's environment.

Applications for ionome variability:

- tracing plant material
- spatial anomaly detection
- as proxies
- ...

Can the ionome variability be related to specific environmental parameters, e.g. element sources?

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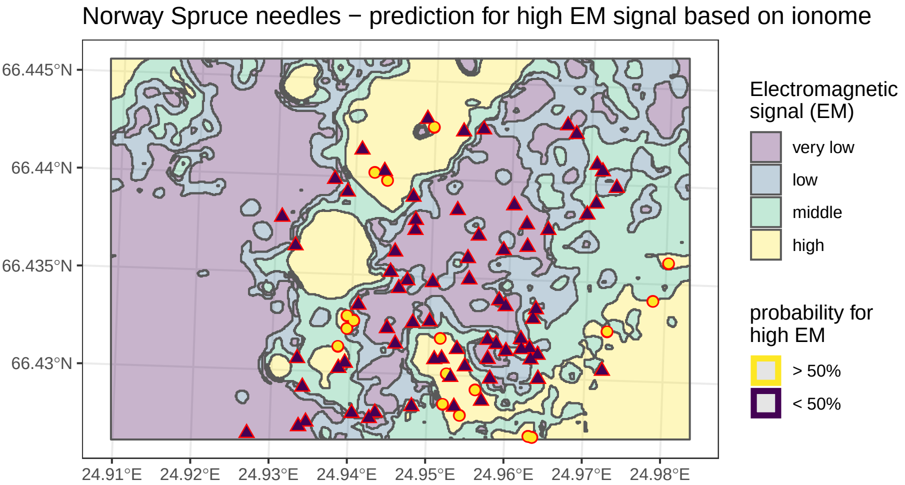
Case study

Prospect Rajapalot, Ylitornio, North Finland



Case study

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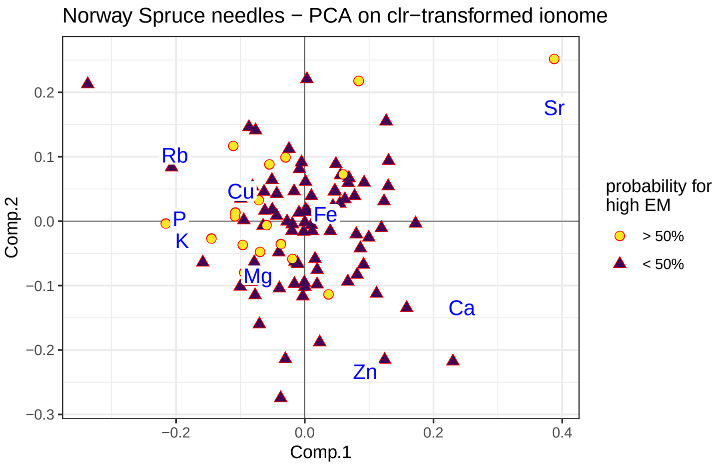
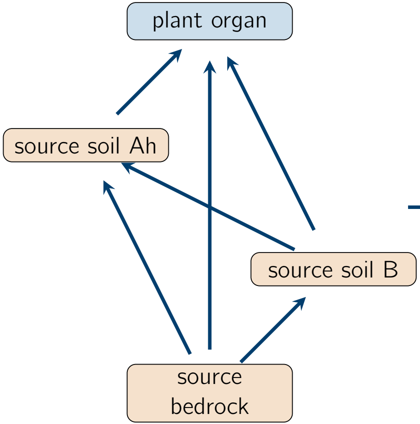


How can we test for the nutrients’s source?

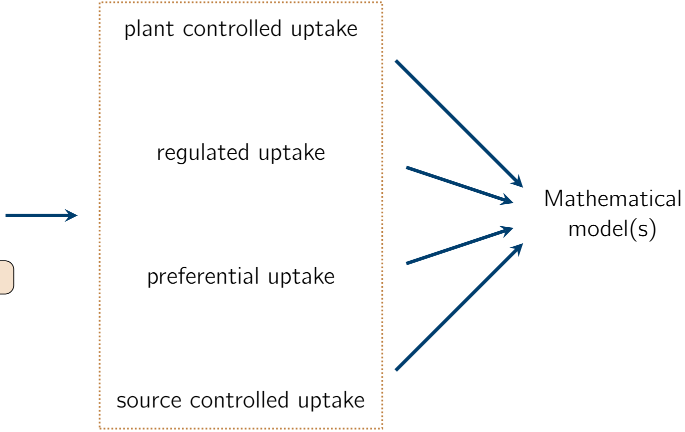
- transported sediment cover?
- bedrock?
- ions mobilized through weathering processes?

Developing models

Simplified conceptual model



Defining uptake models, for example:



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Using the ionome and CoDa concept for modelling

. . . instead of using single element concentrations

Ionome implies multi-element approach:

- ionome composition is based on physiological processes: uptake, translocation, etc.
- only the combination of the element concentrations contains the full information

Compositional Data (CoDa) concept adresses calculating with concentrations to avoid:

- negative bias
- spurious correlations
- results depend on element selection (subcomposition)

Solution

use (log-)ratios! - e.g. pairwise log-ratios (pwlr)

Modelling

Examples of models for element uptake from source (**s**) to plant organ (**p**) based on pwlr-transformation:

regulated uptake

$$\ln \frac{p_i}{p_j} = a + b \cdot \ln \frac{s_i}{s_j}$$

Linear model: Is $b = 0$? →

specific uptake (plant controlled)

$$\ln \frac{p_i}{p_j} = a + 0 \cdot \ln \frac{s_i}{s_j} = a$$

Linear model ↓

preferential uptake

$$\ln \frac{p_i}{p_j} = a + 1 \cdot \ln \frac{s_i}{s_j} = a + \ln \frac{s_i}{s_j}$$

T-test: Is $a = 0$? →

unspecific uptake (source controlled)

$$\ln \frac{p_i}{p_j} = 0 + 1 \cdot \ln \frac{s_i}{s_j} = \ln \frac{s_i}{s_j}$$

Results

Norway Spruce needles - nutrients

Tested sources

1. bedrock geochemistry (based on drill cores)
2. soil B horizon (XRF, Aqua regia and Ionic Leach)
3. soil Ah horizon (Aqua regia and leach based on sodium pyrophosphate)

Results for two simplified uptake models

Unspecific uptake:

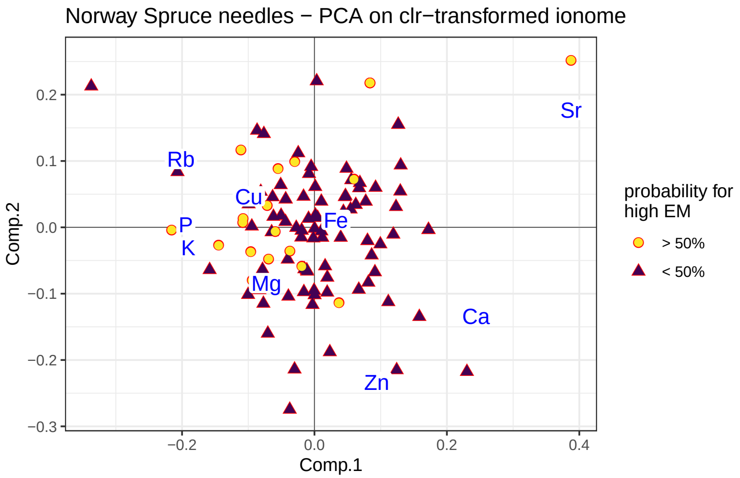
- nearly all log-ratios differ between the various sources and plant
- even Sr/Ca and Rb/K changes between source and plant

Regulated uptake:

- for several sources plant log-ratios depend on source log-ratios
- P, Fe, Zn (Mg) for soil B horizon
- K, Rb, P, Ca (Sr) for bedrock

Results

Norway Spruce needles - nutrients



Tests for regulated uptake model suggest:

- B horizon influences P, Fe, Zn (Mg)
- bedrock influences K, Rb, P, Ca (Sr)

Thank you!

Questions & Answers at session 12e, Thursday, June 25, 13:30 - 14:30 (HST)
Friday, June 26, 01:30 - 02:30 (Europe/Berlin)

Please submit questions also online before the session.

Acknowledgement

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