Characterizing Sediment Source Variability

Landscape and Land Use Influences on Fingerprint Properties

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Acknowledgements

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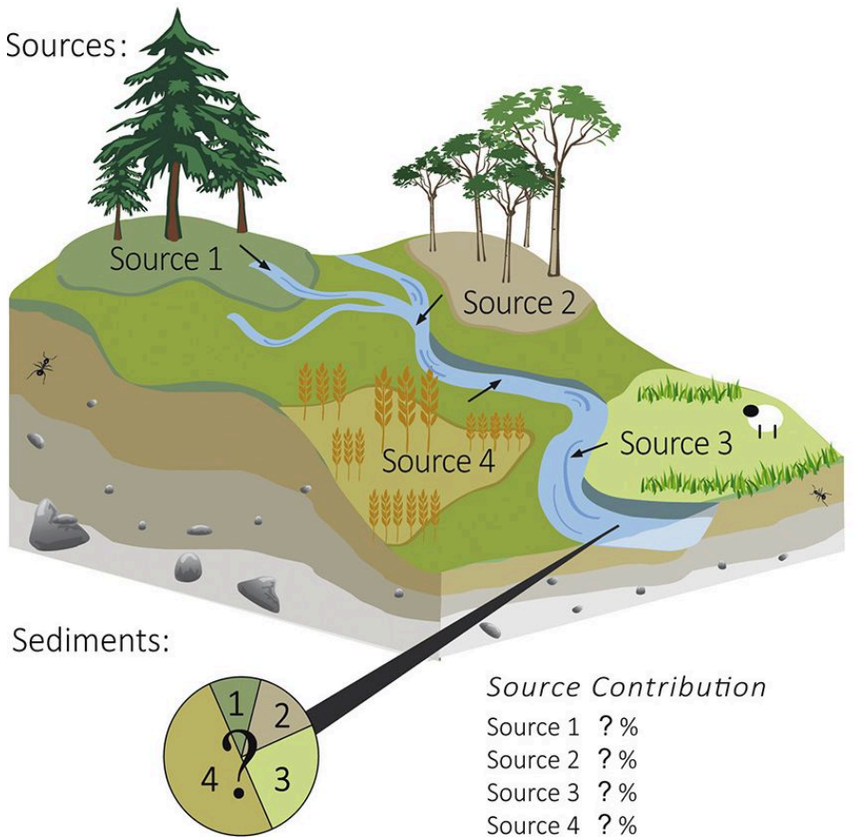
Introduction

- Sediment fingerprinting links sources to downstream sediment
  - Using soil/sediment properties as fingerprints (tracers)
  - Provide an estimate of the relative contribution from each source
- Used to understand watershed processes and guide management practices

Sediment Fingerprinting

1. Identify potential sources of sediment
    - Land use, geology, erosion processes
2. Characterize sediment sources
    - Sampling
    - Soil properties
3. Collect downstream sediment
    - Suspended, bed, floodplain
4. Estimate relative proportion from each source
    - Mixing model



Gaspar et al 2019

Research question

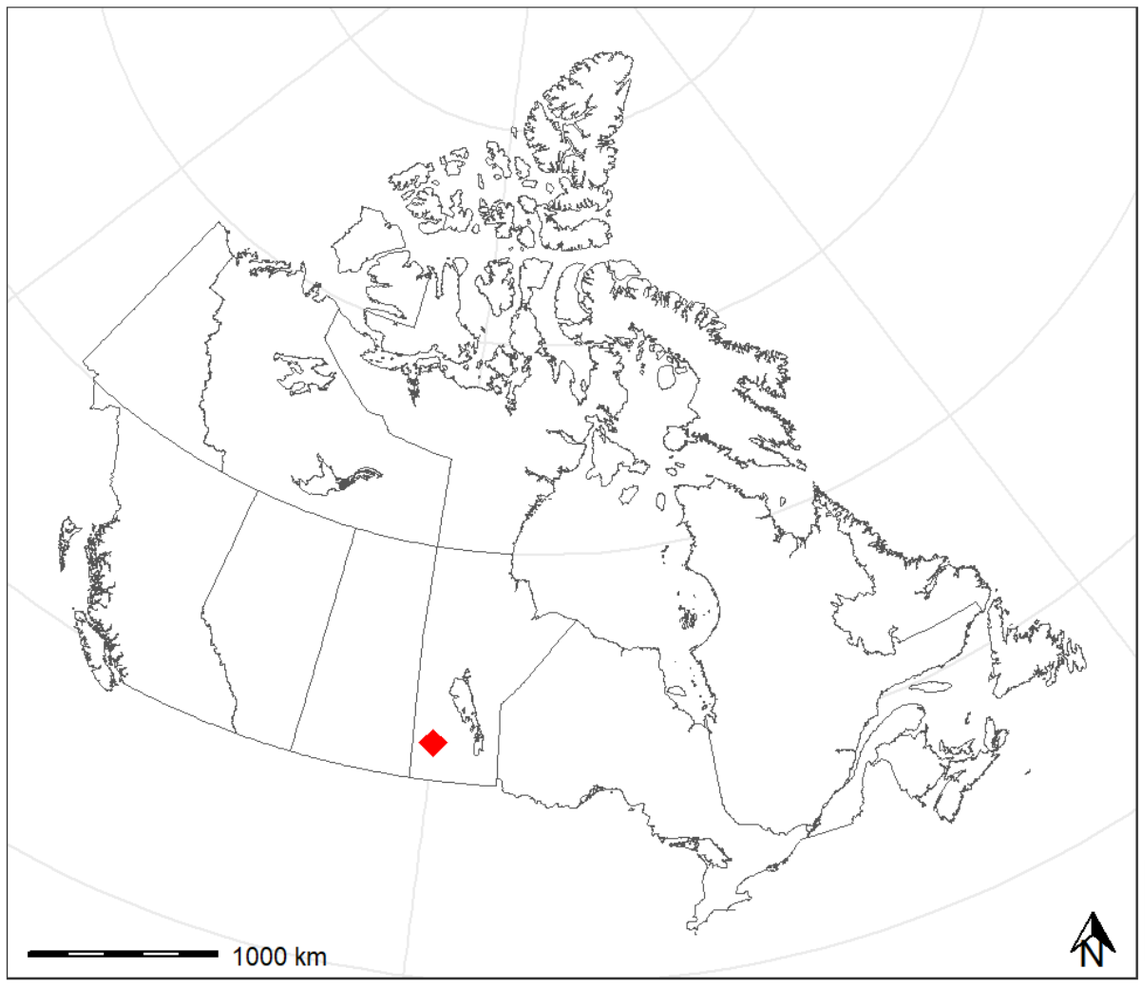
- Characterizing the sources of sediment is an important step
- Focus has been on:
  - Novel fingerprints
  - Fingerprint selection
- What about the sampling design?
  - Logistics
  - Cost
  - Judgement vs systematic
  - Prior information

Objectives

Using a range of soil colour and geochemical properties across two contrasting land uses:

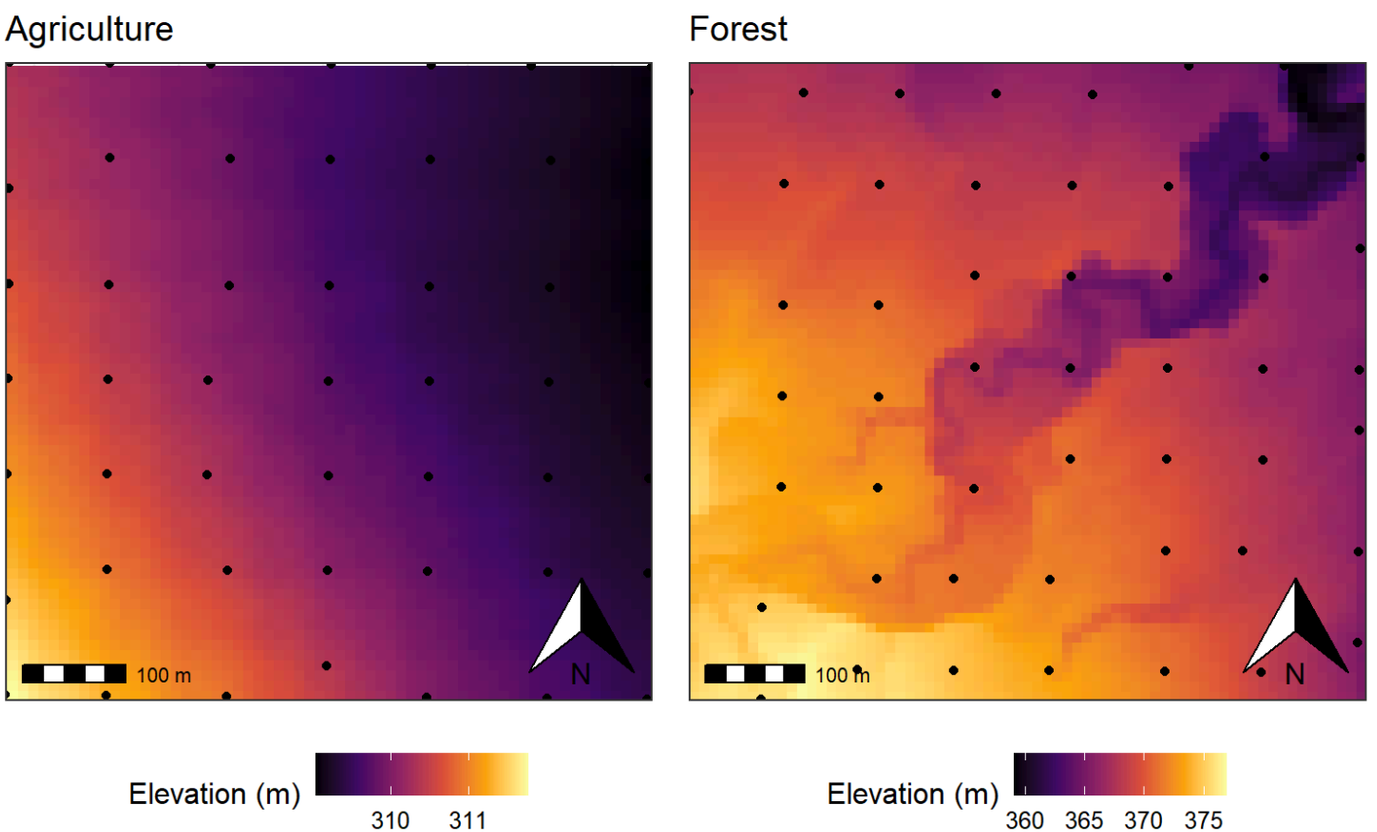
1. Quantify the variability
2. Characterize the spatial patterns
3. Assess the the importance of terrain attributes

Location



Sampling

- Surface soil
- 49 points at 100m spacing



Lab analysis

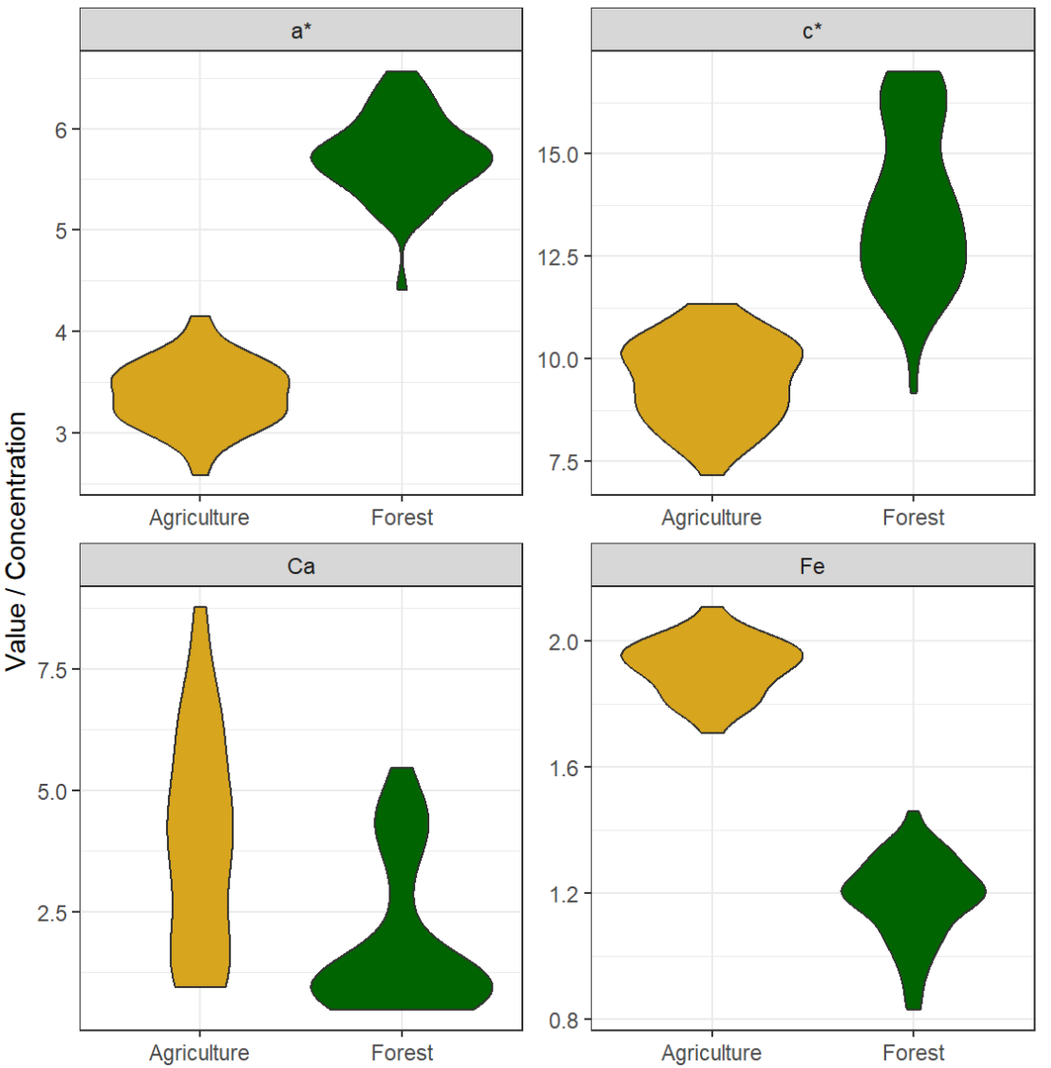
- Sieved to < 63 um
- Geochemistry
  - Aqua-regia
  - 51 geochemical elements
- Spectral reflectance
  - FieldSpecPro
  - 15 colour coefficients

Based on previous work (Luna Miño et al. 2024)

- Ca, Co, Cs, Fe, Li, La, Nb, Ni, Rb, and Sr
- *a*, b*, h*, and x*

Univariate analysis

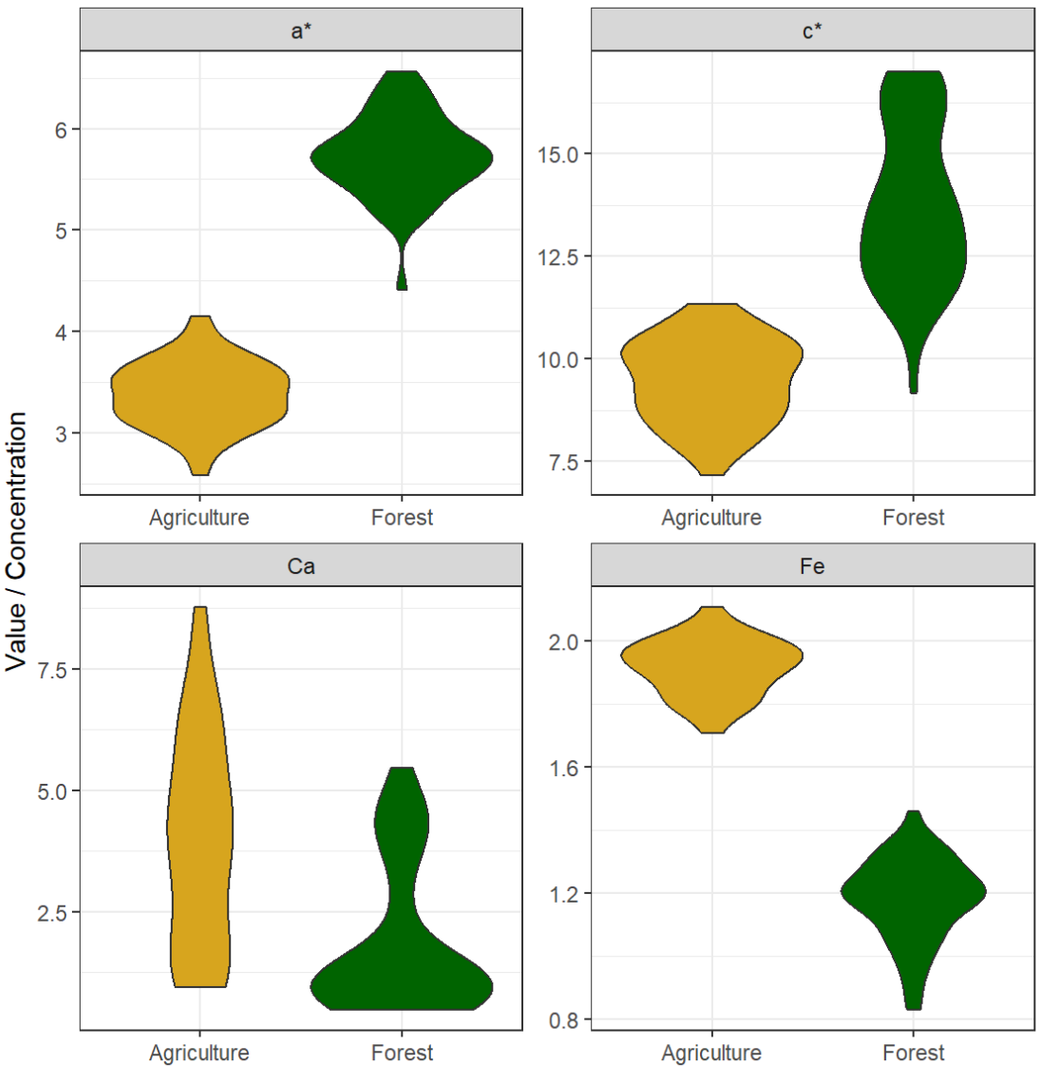
- Mean
- Standard deviation
- Skewness
- Coefficient of variation



Univariate analysis

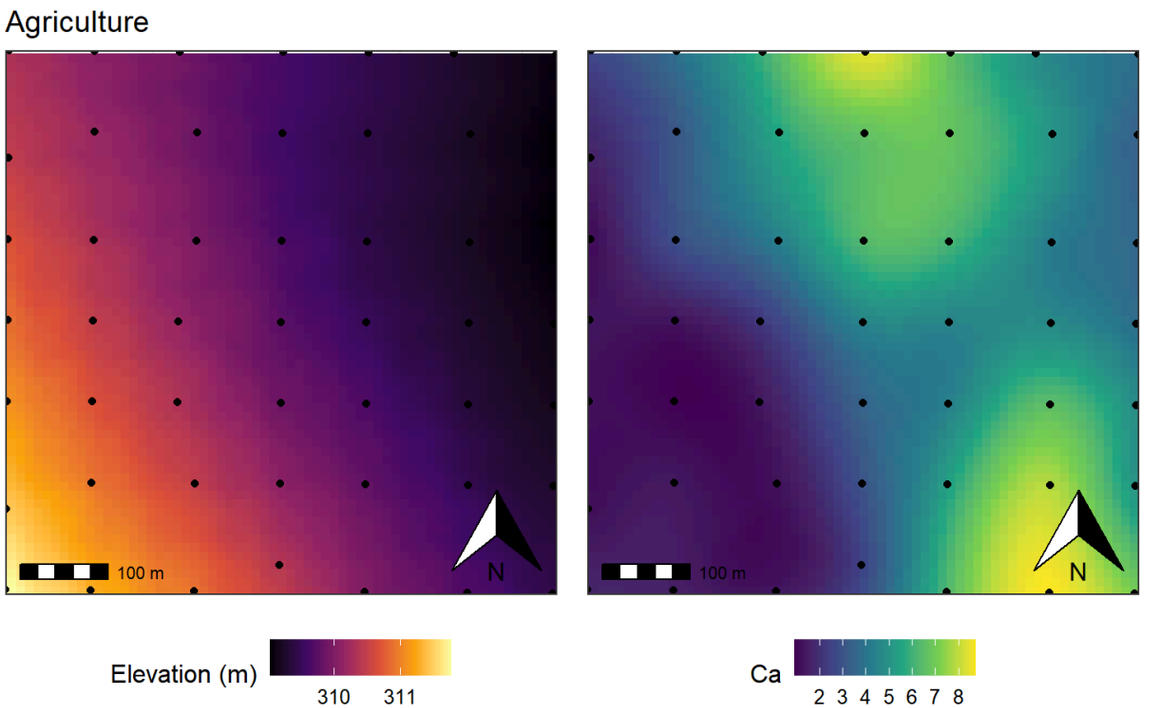
Overall

- **Colour** properties and the **agricultural** land use
  - Exhibited lower variability and more symmetrical data
- Forested site has a more complex topography and geomorphic setting (floodplain)
  - Greater variability in SOM and grain size
- Colour properties make ideal fingerprints
- Differences between sites makes direct comparisons a bit tricky
  - Transformations?



Geospatial analysis

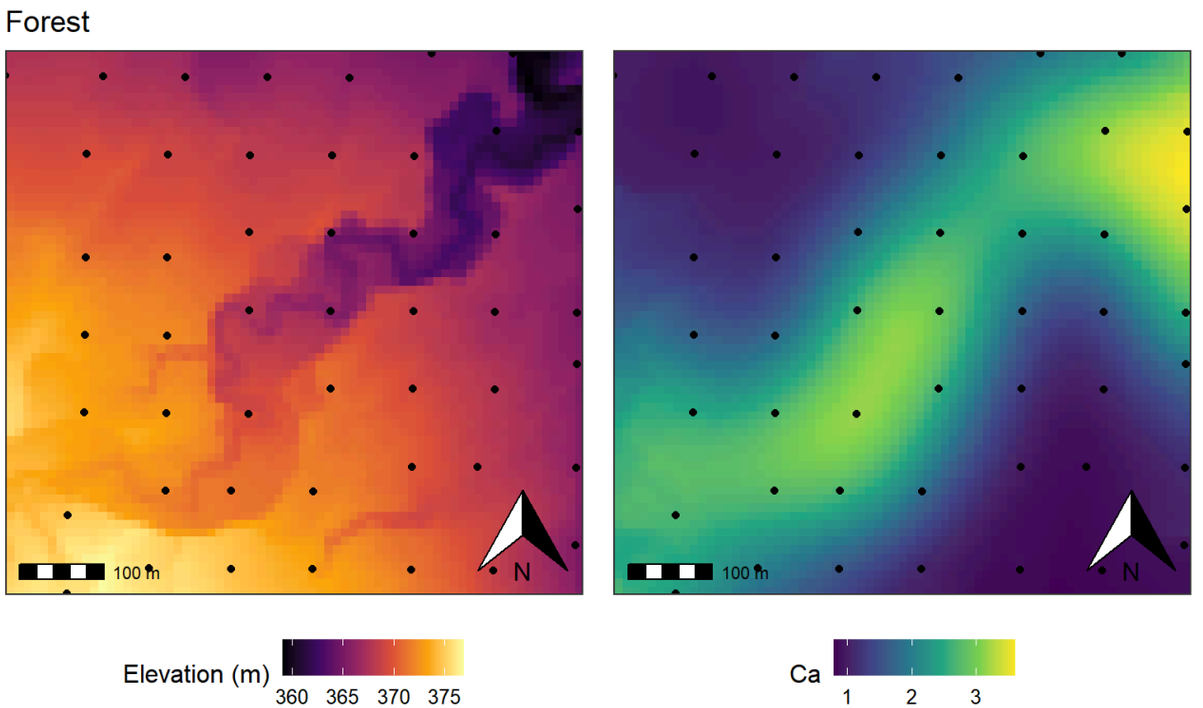
- Spatial autocorrelation
  - Semivariograms
- Interpolation and mapping
  - Kriging



Nugget = 0.0
Sill = 7.2
Range = 580m
Spatial Class = Strong

Geospatial analysis

- Spatial autocorrelation
  - Semivariograms
- Interpolation and mapping
  - Kriging

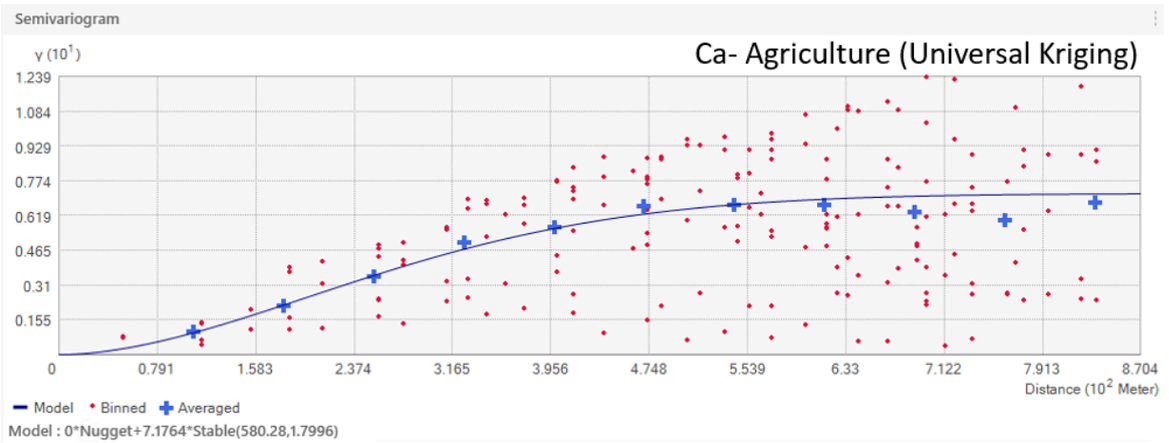


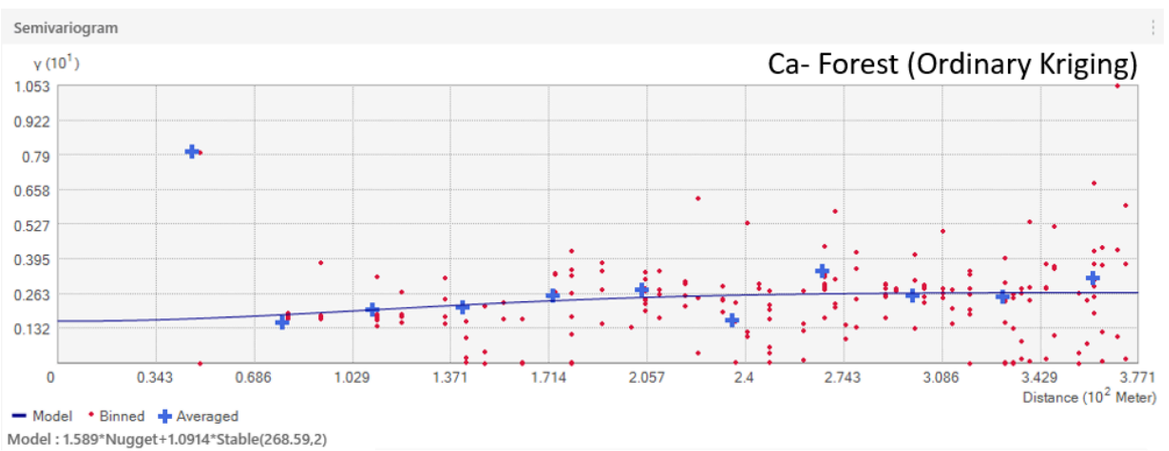
Nugget = 1.6
Sill = 2.7
Range = 269m
Spatial Class = Moderate

Geospatial analysis

Semivariogram interpretation

- Small nugget reflects low measurement or sampling error
- Small sill indicates low overall variance
- Small range indicate spatial correlation persists over short distances

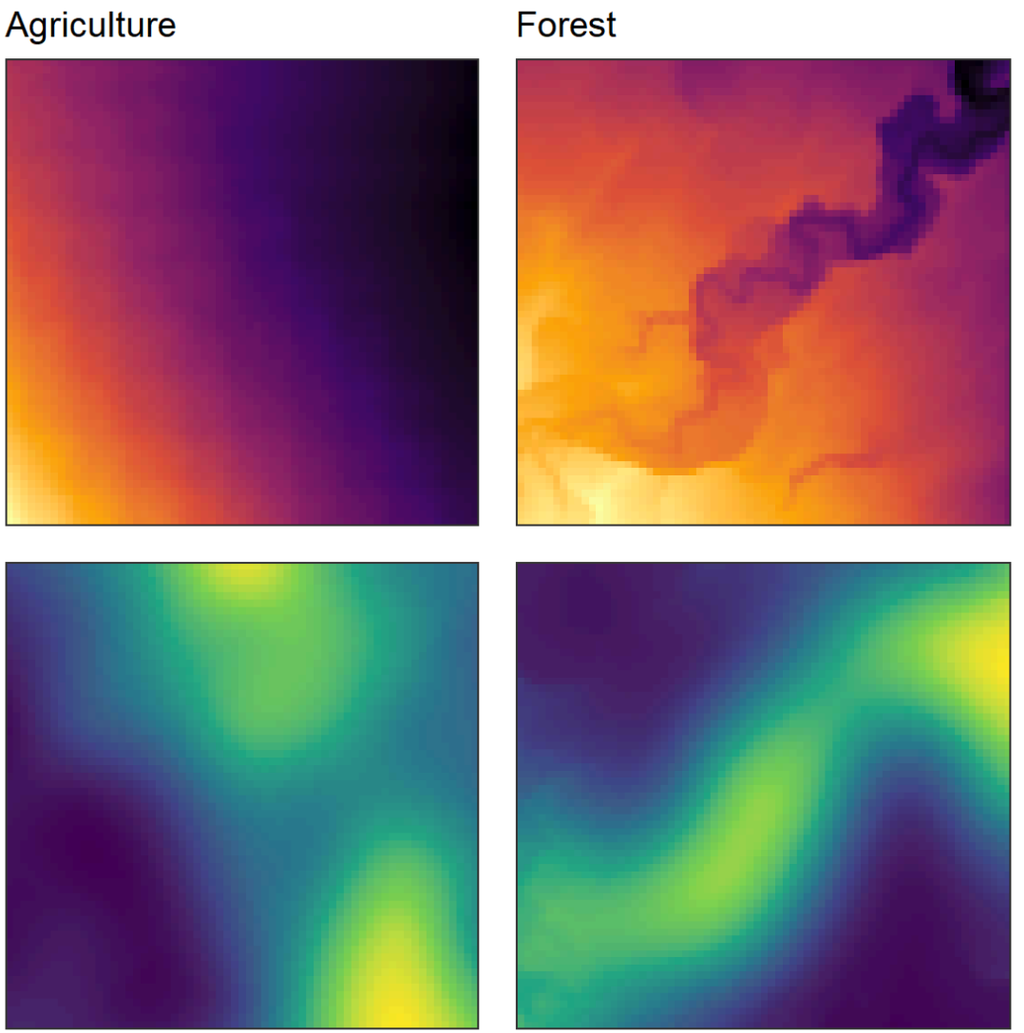




Geospatial analysis

Spatial autocorrelation

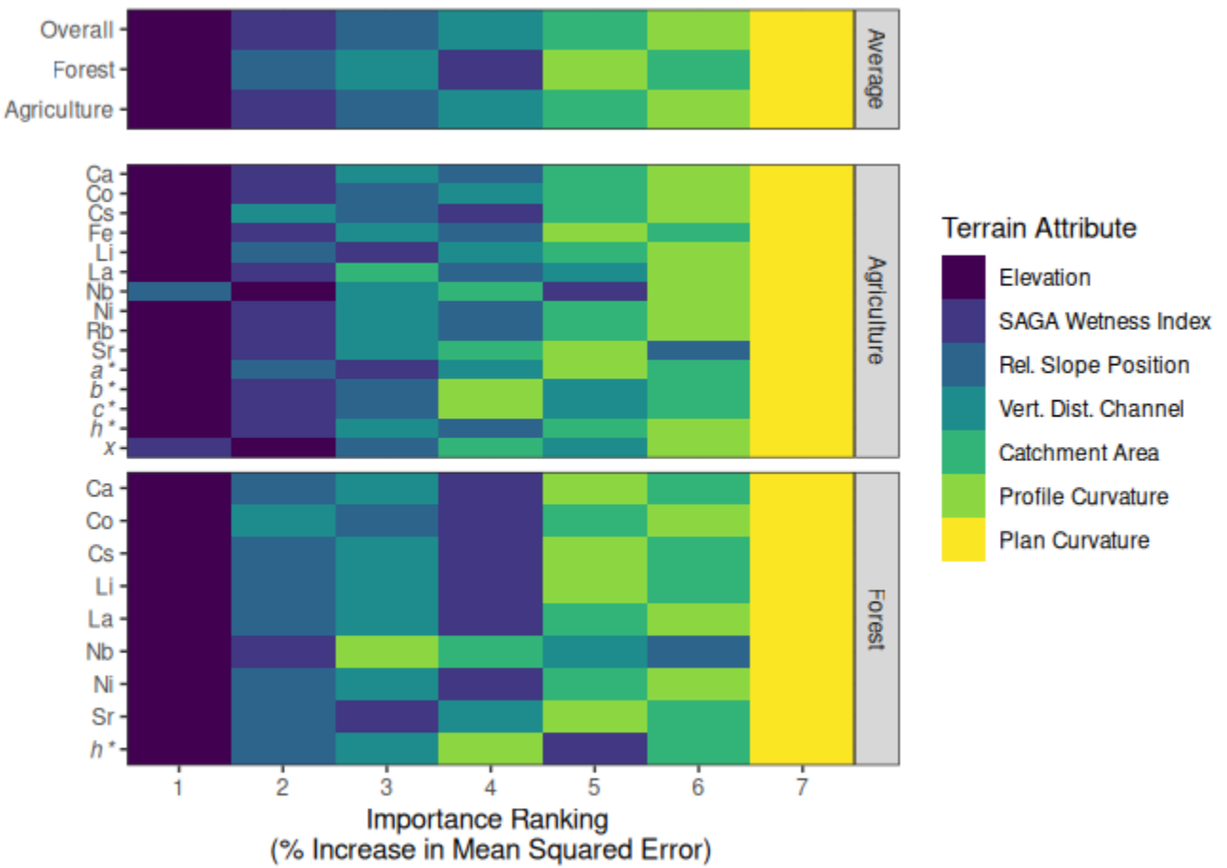
- Soil properties at the **agricultural site** exhibited **stronger** spatial autocorrelation
  - 6 soil properties at the forested site exhibited **no** spatial autocorrelation
- Soil properties presented patterns that roughly matches the topography



Terrain analysis

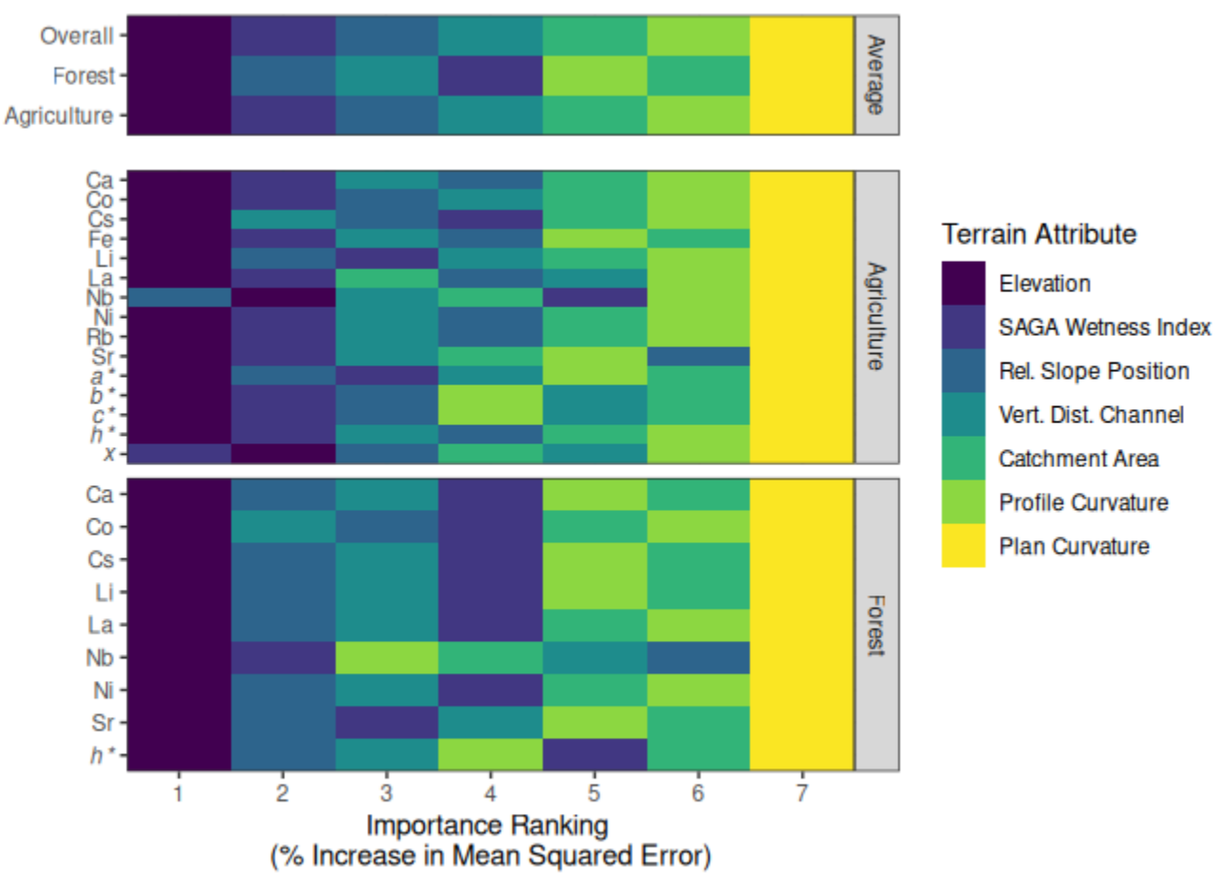
- Terrain attributes
  - System for Automated Geoscientific Analyses (SAGA)
  - Random Forest Regression

1. Plan curvature
2. Profile curvature
3. SAGA wetness index
4. Catchment area
5. Relative slope position
6. Vertical channel network distance



Terrain analysis

- Elevation was ranked as the most important predictor
  - SAGA Wetness Index
  - Relative Slope Position
- Patterns linked to hydrologic properties and processes
- Terrain attributes can be used to guide sampling and interpret data



Conclusions

- Agricultural site:
  - Gently sloping terrain
  - Lower variability
  - Approximately normal data distributions
  - Moderate to strong spatial autocorrelation

- Forested site:
  - Complex terrain
  - Higher variability
  - Data often non-normal
  - Fewer properties with spatial autocorrelation

Conclusions

- Topographic effects evident in many soil property patterns
- Top terrain predictors: elevation, SAGA Wetness Index, and relative slope position
  - Terrain–soil relationships were inconsistent in strength and direction
- Terrain-driven spatial patterns can inform more targeted soil sampling

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