Nutrients come and go, but C:N ratios are forever:
A continental scale perspective on changing C:N ratios from land to water.

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Rationale

- Carbon and nitrogen cycles are often tightly coupled because of nitrogen limitations to plant activity and energetic restrictions on nitrogen fixation.
- C:N ratios are often used as indicators of ecosystem health and productivity
- Environmental conditions like vegetation, climate, disturbance and land use history, and N deposition affect C:N ratios and their transfer between pools
- Processes like the resorption of nutrients, preferential decomposition of N rich organic matter, and anaerobic decomposition modify C:N ratios

Research question:

How do biome specific environmental conditions affect C and N use and storage within a watershed?

Hypotheses:

1. C:N ratios are consistent: sites with a high C:N ratio in one pool will have higher C:N ratios in other pools.
2. Higher temperatures and longer growing seasons will cause both higher respiration and more plant C accumulation.
3. Higher precipitation will cause more denitrification.
4. Higher N mineralization and N inputs will cause more N leaching to waters.

Sites and data source

Data collected from 2018—2021 by the National Ecological Observation Network (NEON) for 47 terrestrial and 27 aquatic sites. 21 sites were considered co-located; they are within 25 km of each other and are part of the same watershed or ecoregions (figure 1).

Leaf, root and soil chemistry were collected from terrestrial sites. Stream, groundwater and stream sediment chemistry were collected from aquatic sites.

Methodology

- Mean C and N concentrations in roots, leaves, litter, organic and mineral soils (individually and combined), and stream sediment.
- Mean flow-weighted DOC and TDN concentrations in stream water. Mean DOC and TDN concentrations in groundwater.
- Mean C:N or DOC:TDN ratios in each pool at each site.
- Linear regression between C:N ratios for each pool.
- Linear regression between the residuals from C:N ratio comparisons and environmental variables (mean annual temperature, mean annual precipitation, N mineralization rate, mean N wet deposition, elevation, growing season)

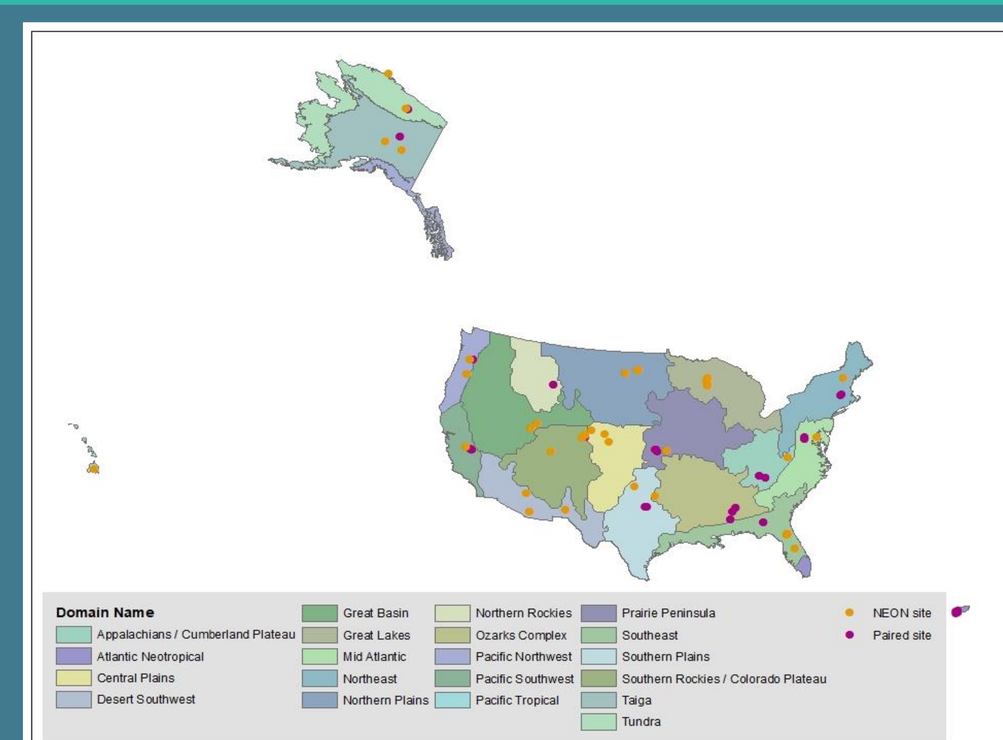

Figure 1: Location of the NEON sites. Paired sites are highlighted in purple.

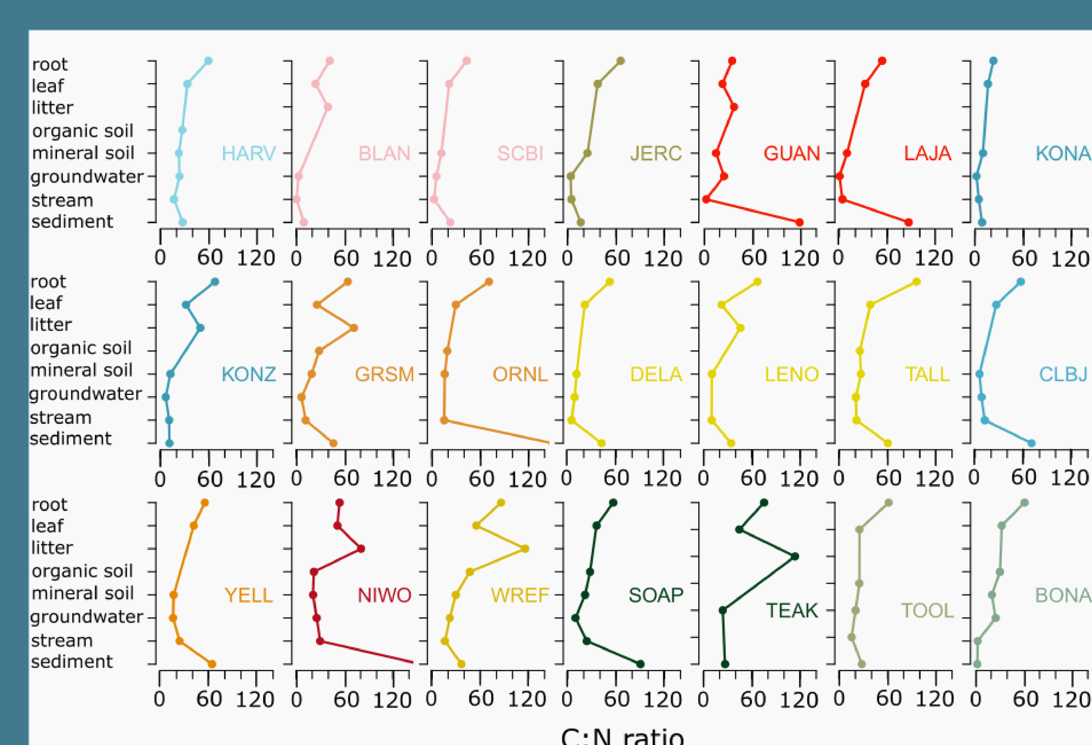

Figure 2: Changes in mean C:N ratio between each pool at each site. Actual values are represented by a point, missing values between pools are interpolated. Site order is defined by domain, sites in the same domain are represented in the same color.

Litter C:N ratio on average two times leaf C:N ratio.
This represents ~ 50% N resorption during leaf senescence.

Species at warmer sites tend to produce more C rich litter (H2). ▶

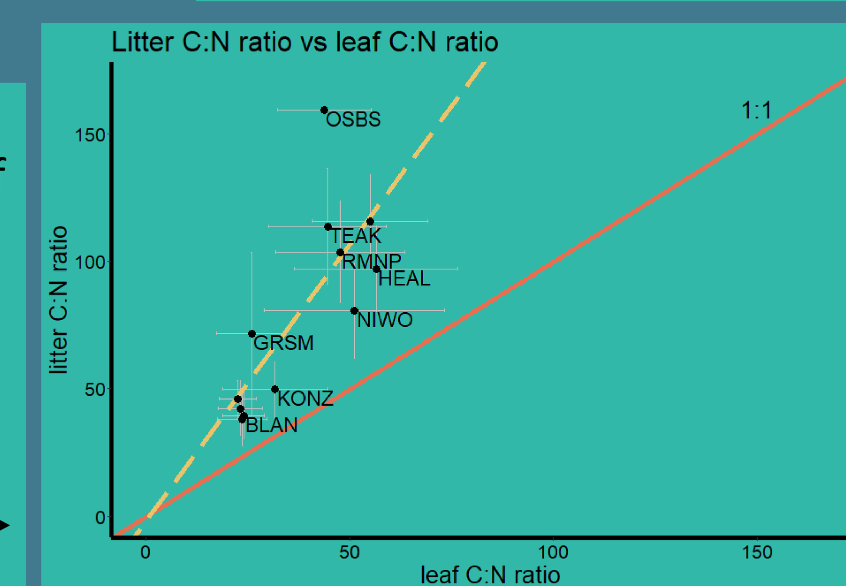

Figure 3: Mean litter C:N ratio related to mean leaf C:N ratio ($y = 2.17x - 1.49$, $R^2 = 0.53$, $p < 0.01$).

Root C:N ratio is generally higher than leaf C:N ratio, we attribute this to the difference in metabolic activity rates between the two organs.

Species at sites with higher temperatures and mineralization rates tend to have higher root N. ▶

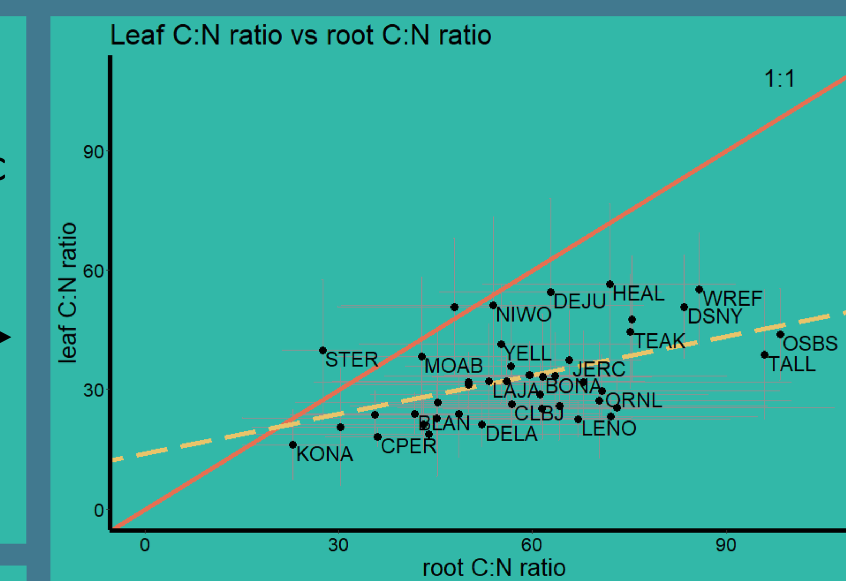

Figure 4: Mean leaf C:N ratio related to mean root C:N ratio ($y = 0.33x + 13.92$, $R^2 = 0.23$, $p < 0.01$).

Soil C:N ratio is on average ~15% the litter C:N ratio. Contrast between C rich litter and N retention capacity of soils.

No other environmental variables explained the scatter around this relationship (H2, H3). ▼

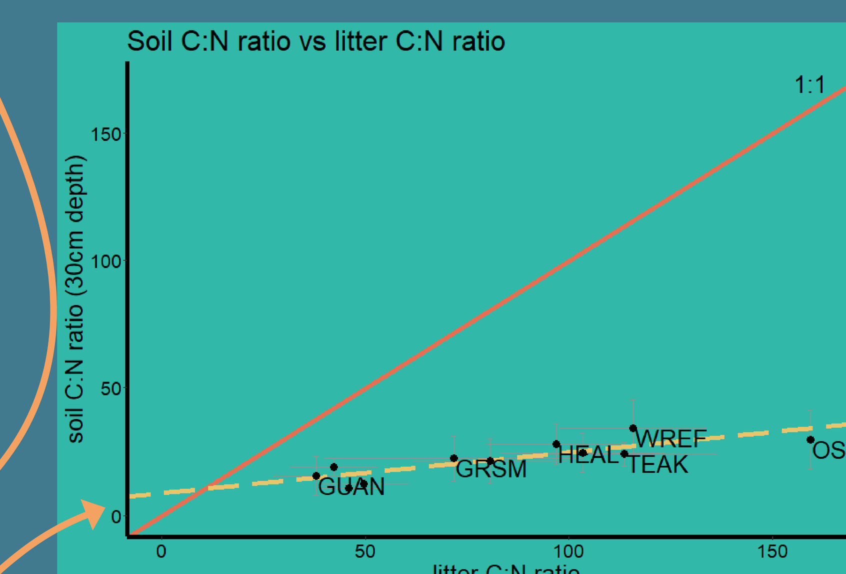

Figure 5: Mean soil C:N ratio related to mean litter C:N ratio ($y = 0.16x + 8.72$, $R^2 = 0.67$, $p < 0.01$).

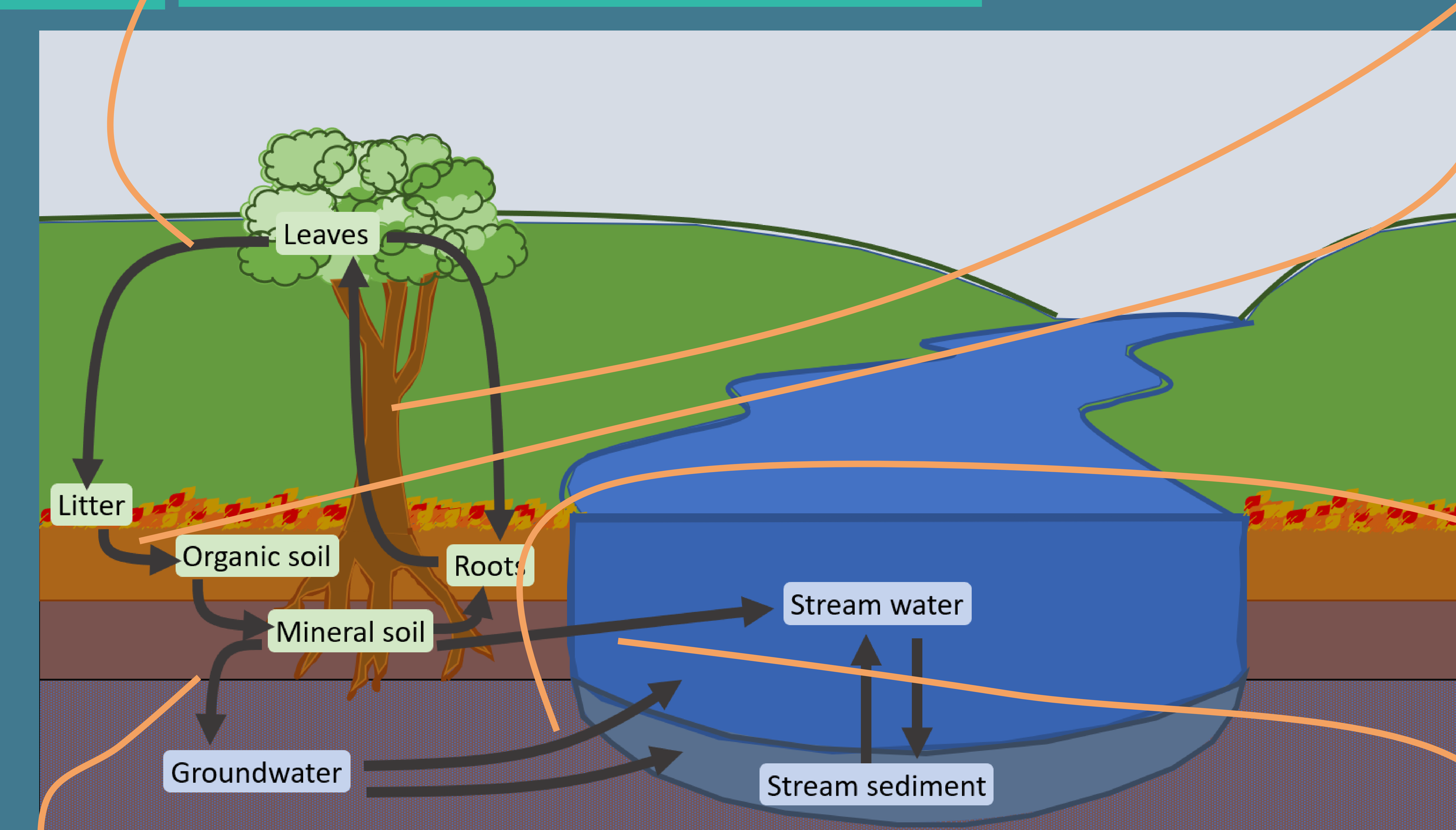

Figure 6: Conceptual diagram illustrating interactions between adjacent pools in a watershed. Data on pools collected from terrestrial sites are identified in light green and data collected from aquatic sites are identified in light blue. Interactions between non-adjacent pools are not included on this poster.

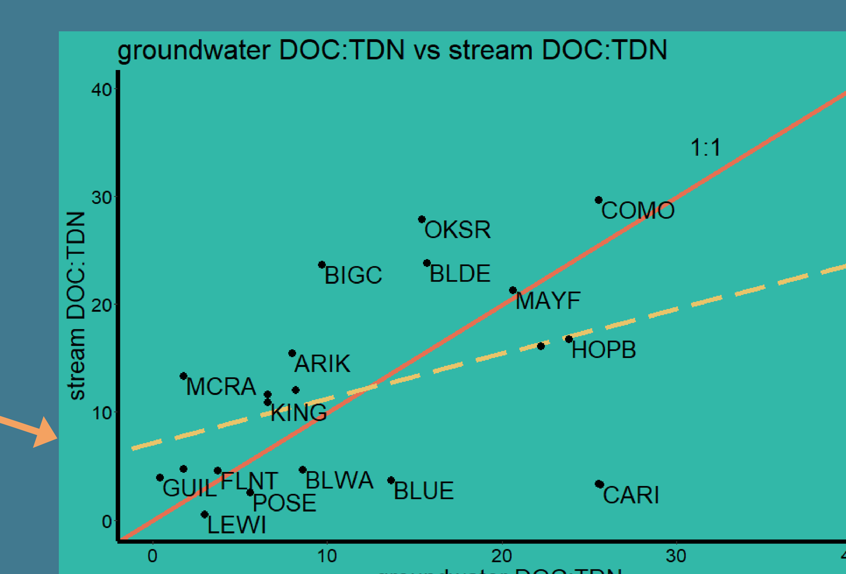

Figure 7: Mean stream DOC:TDN ratio related to mean groundwater DOC:TDN ratio ($y = 0.45x + 7.45$, $R^2 = 0.13$, $p < 0.05$).

▲ Stream DOC:TDN is ~2 times greater and significantly related to groundwater DOC:TDN.

Elevation tends to increases C transfer to streams. Growing season length tends to decreases C transfer to streams

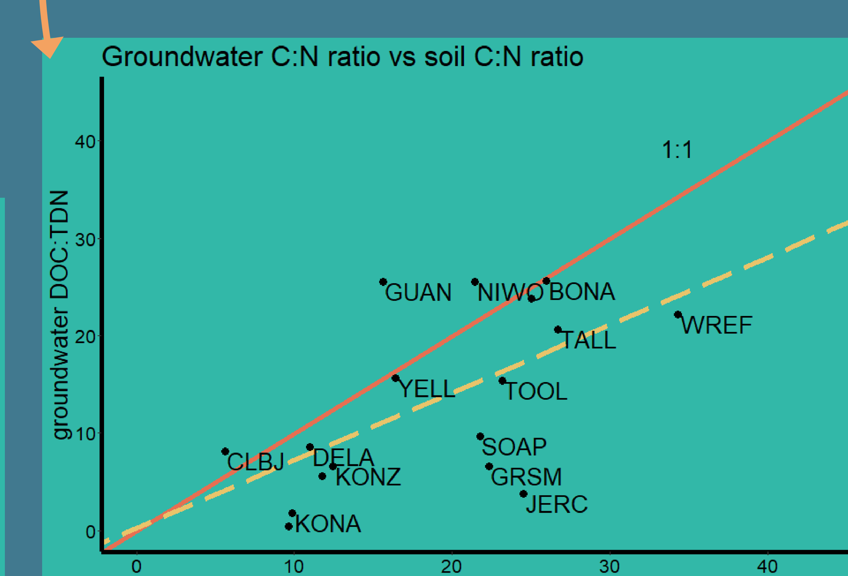

Figure 6: Mean groundwater DOC:TDN ratio related to mean soil C:N ratio ($y = 0.65x + 1.1$, $R^2 = 0.30$, $p < 0.01$).

▲ Groundwater DOC:TDN is significantly related to soil C:N ratio.

No other environmental variables explained the scatter around this relationship (H3, H4).

Stream DOC:TDN is ~2 times greater and significantly related to soil C:N.

Temperature and growing season length tends to decrease C transfer to streams (H2, H3, H4). ▶

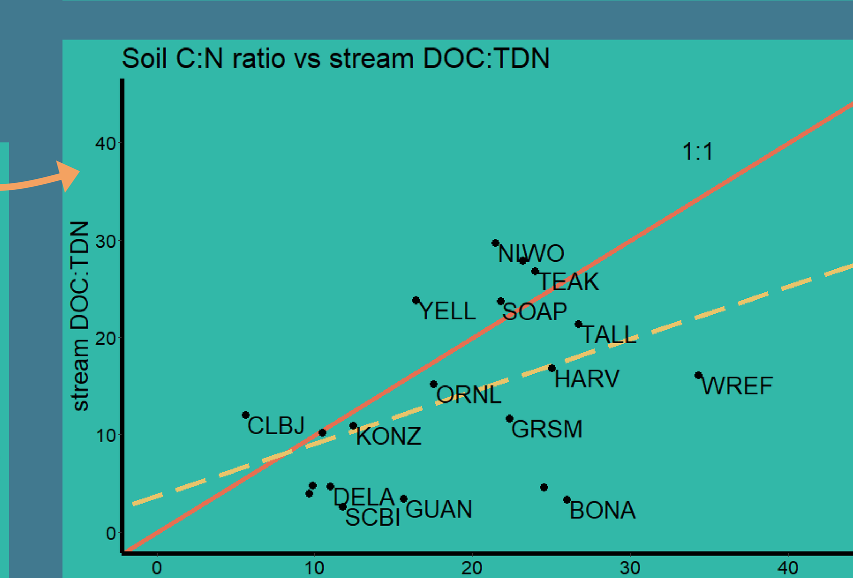

Figure 8: Mean stream DOC:TDN ratio related to mean soil C:N ratio ($y = 0.54x + 3.73$, $R^2 = 0.15$, $p < 0.1$).

Conclusions and future directions:

- Leaf C:N ratio is strongly correlated to all other pools, except stream sediments ($p > 0.1$), suggesting that vegetation drives changes in C:N ratios.
- Confirm the effect of environmental factors through multivariate analysis.
- Modeling changes in C:N ratios, C content and N content between different pools, how do the data respond when compared to ecosystems models (e.g. PnET).

On average, the relationships found above accurately represent changes in C:N ratios between pools.

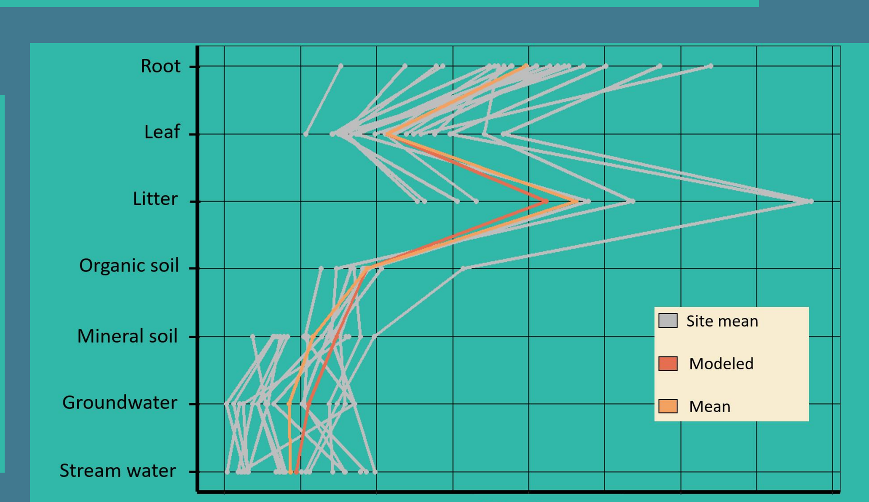

Figure 9: Mean C:N ratios for each pool at each site (grey) compared to the mean values across all sites (light orange), and the estimated mean based on the relationships calculated between each pool individually (dark orange). The mean root and organic soil C:N ratios were used to calculate all other values depicted in the modeled line.

Acknowledgements and references:

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