Deep Soil: Modeling and Significance of Soil Carbon and Nitrogen in Subsurface Layers

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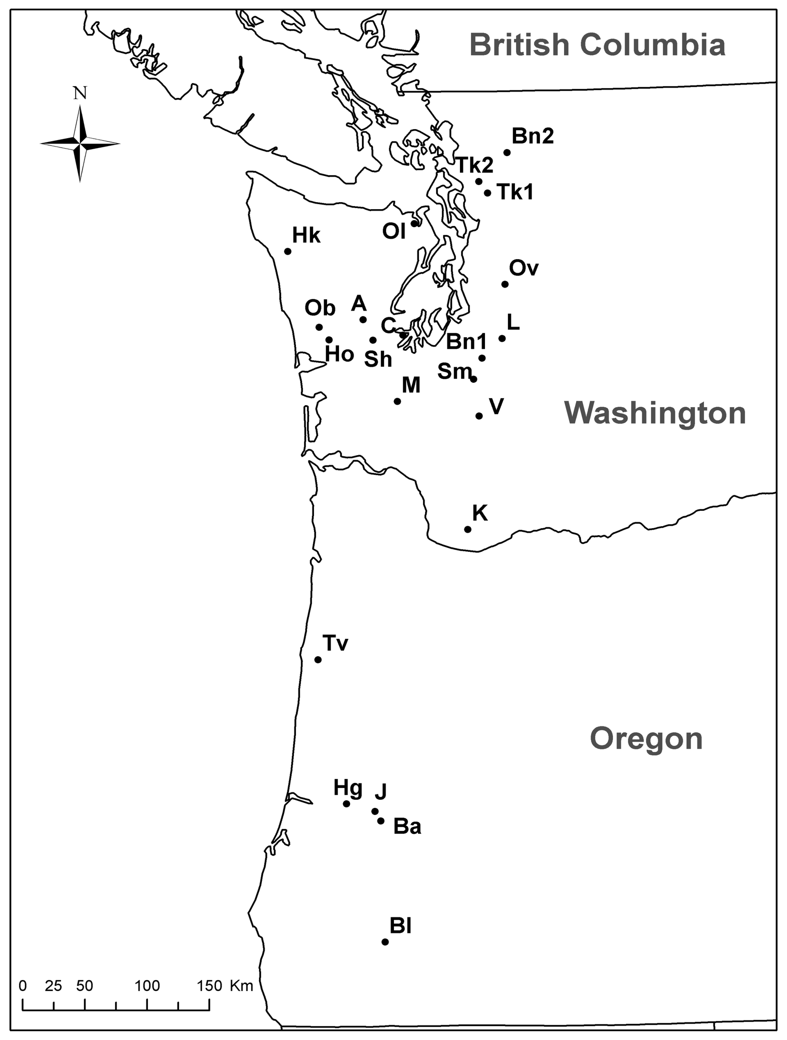
Methods

- 22 study sites selected from intensively managed plantations across the Pacific Northwest Douglas-fir zone
- Excavator used to dig at least 2.5 m deep soil pits
- Bulk density samples taken at intervals of:
  - 0 to 0.2 m
  - 0.2 to 0.5 m
  - 0.5 to 1.0 m
  - 1.0 to 1.5 m
  - 1.5 to 2.0 m
  - 2.0 to 2.5 m
- Forest floor gathered from randomly placed 0.3 x 0.3 m quadrat
- Samples analyzed for C & N

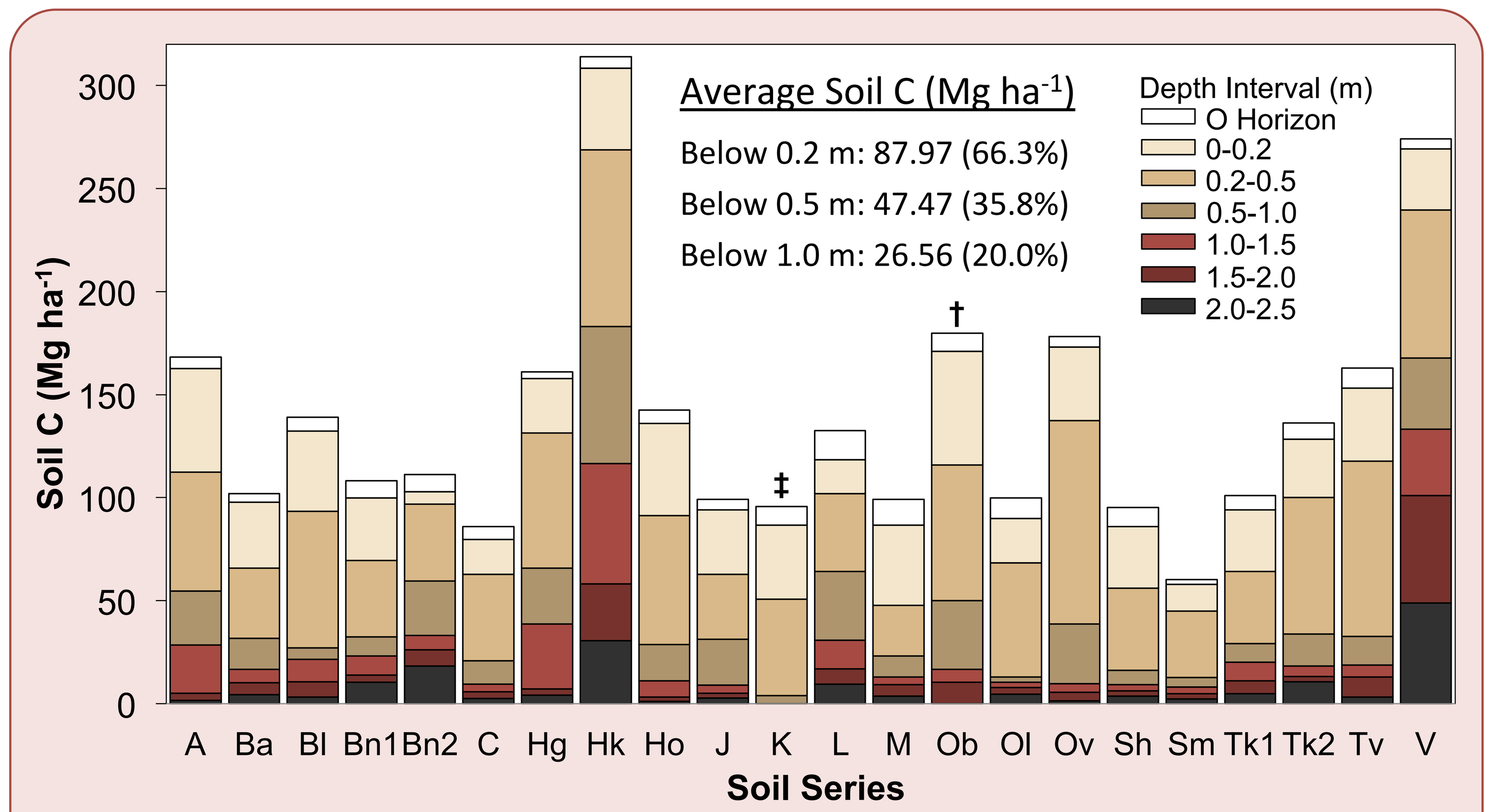


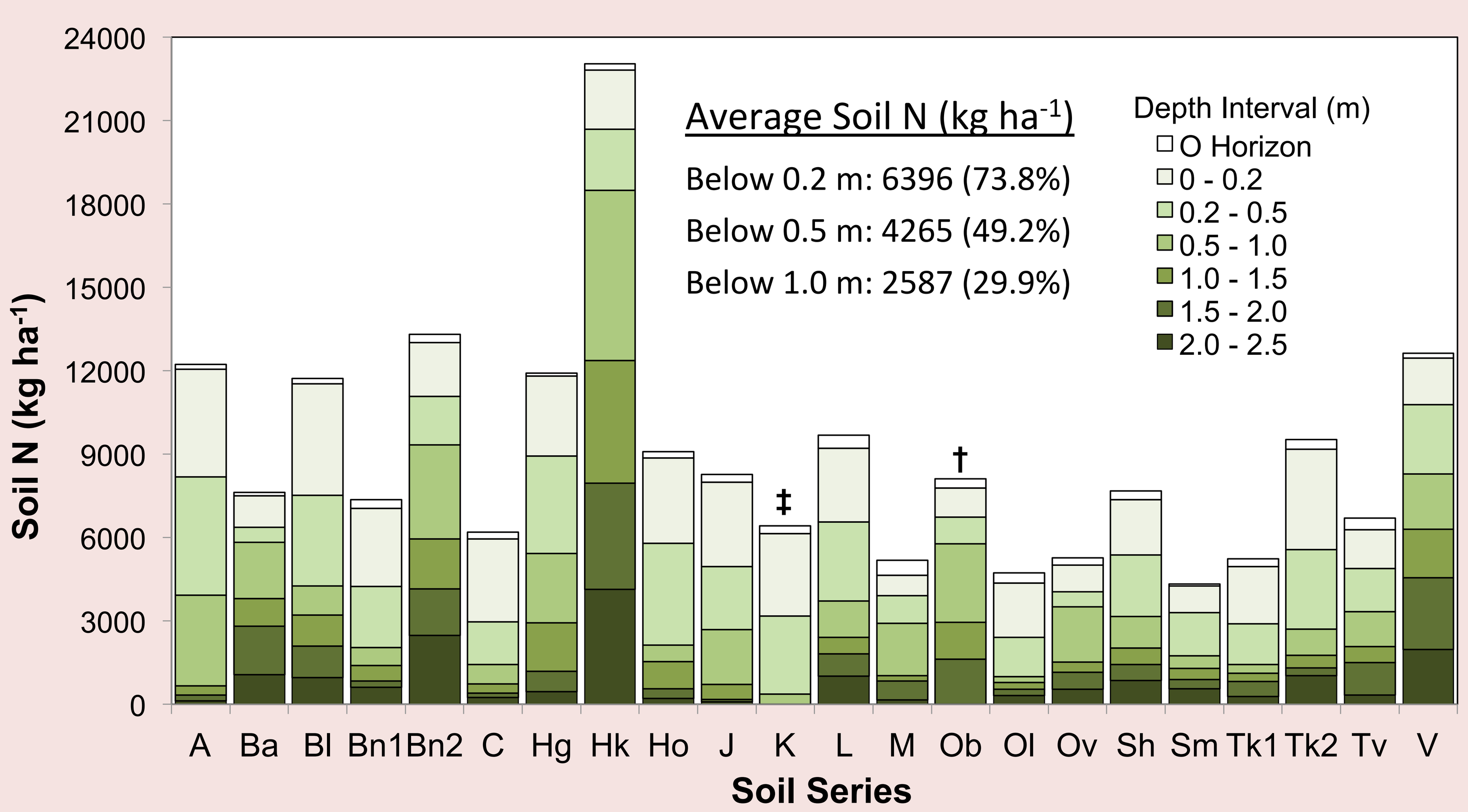
Modeling

We examined 5 models for ability to predict Total C (C_t) and Total N (N_t):

- Langmuir Equation (C & N): $C_t = C_{max}\, a\, D / (1 + a\, D)$
- Logarithmic Function (C & N): $C_t = a + b \ln(D)$
- Type III Exponential Function (C & N): $C_t = a\, e^{b/D}$
- First Degree Inverse Polynomial (C only): $C_t = D / (a + b\, D)$
- Log-Log Function (N only): $\ln(N_t) = a * \ln(D) + b$

Where *a*, *b*, and C_{max} are fitted constants, and D is depth.





Figures 2 & 3. Soil C (Mg ha^{-1}) and soil N (kg ha^{-1}) within each sampled depth interval for 22 forest soils in western Washington and Oregon. † Soil pit excavation impeded by compacted glacial till at 2.0 m. ‡ Soil pit reached igneous bedrock at 1.0 m.

Soil Carbon

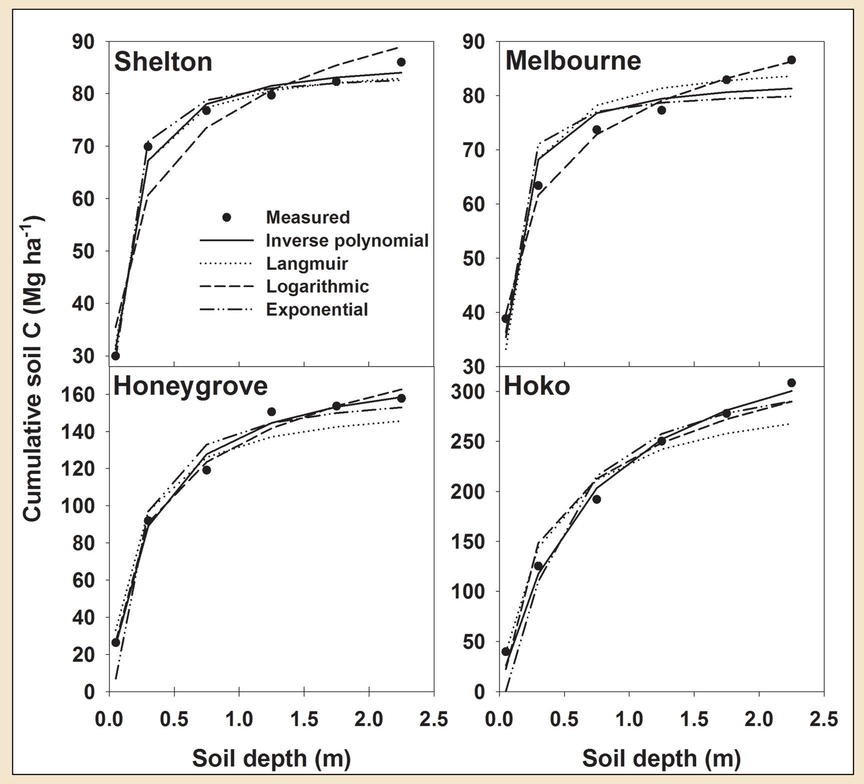


Figure 4. Cumulative soil C profiles (sample interval midpoints are plotted) for four soil series, representative of the range of profiles from 22 forest soils in western Washington and Oregon. Four functions are fit to the data for each soil series.

Shelton and Melbourne series have similar total soil C, but Melbourne accumulates C more gradually.

Honeygrove is an intermediate shape compared to Shelton and Melbourne series.

Hoko has the highest total soil C of all sites and accumulates C gradually.

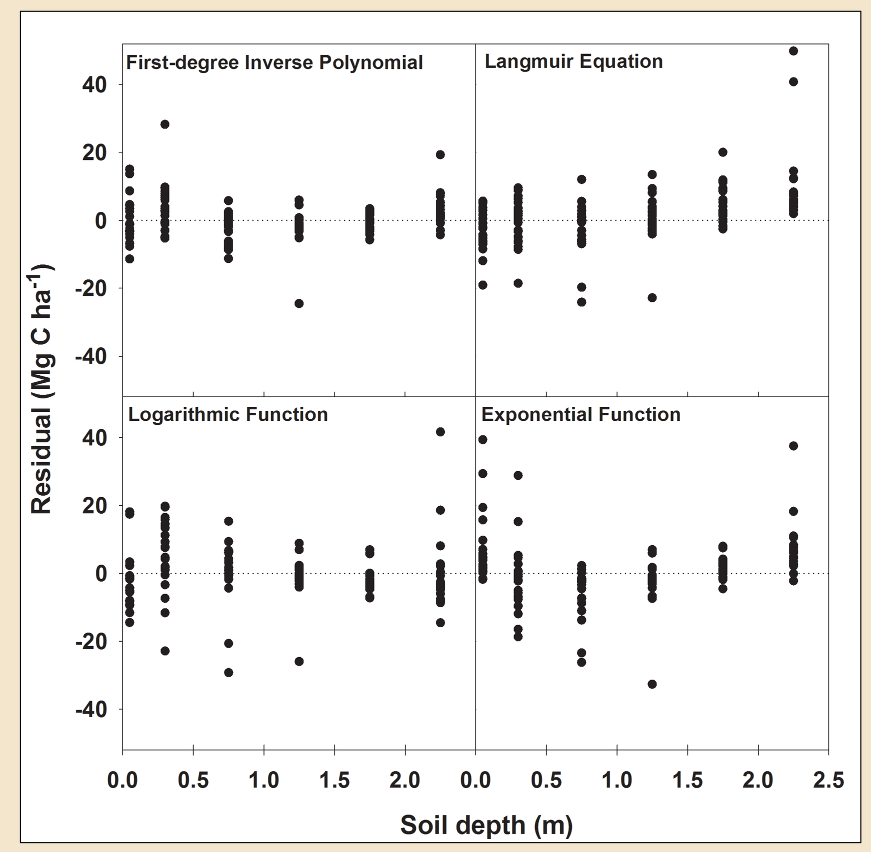
Figure 5. Residuals produced by fitting four different functions to 22 cumulative soil C profiles (0-2.5-m depth) of forest soils in western Washington and Oregon.

The first-degree inverse polynomial residuals show no consistent bias. This model fits the data well.

The Langmuir equation tends to slightly underestimate at depth.

The logarithmic function tends to underestimate near the surface, and overestimate at depth.

The exponential function tends to overestimate at the surface and underestimate at depth.



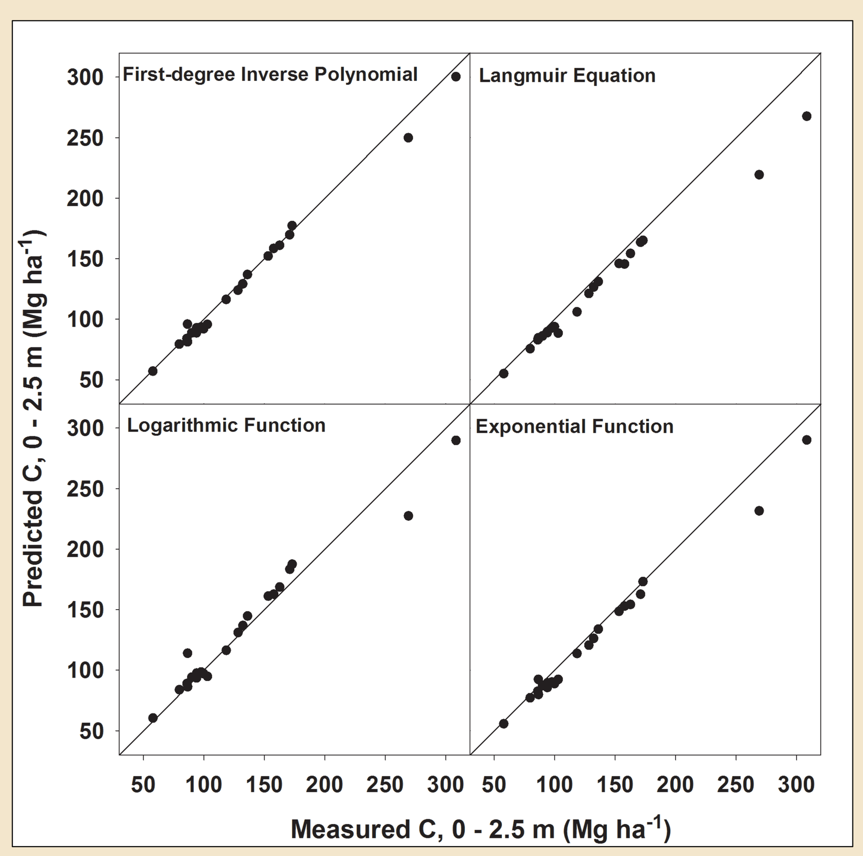


Figure 6. Predicted versus measured soil C for all 22 soils, based on four functions fit to cumulative soil C profiles (0-2.5 m depth).

The first-degree inverse polynomial function and Langmuir equation fit the data best. The logarithmic function consistently overestimates total soil C, while the exponential function consistently underestimates it.

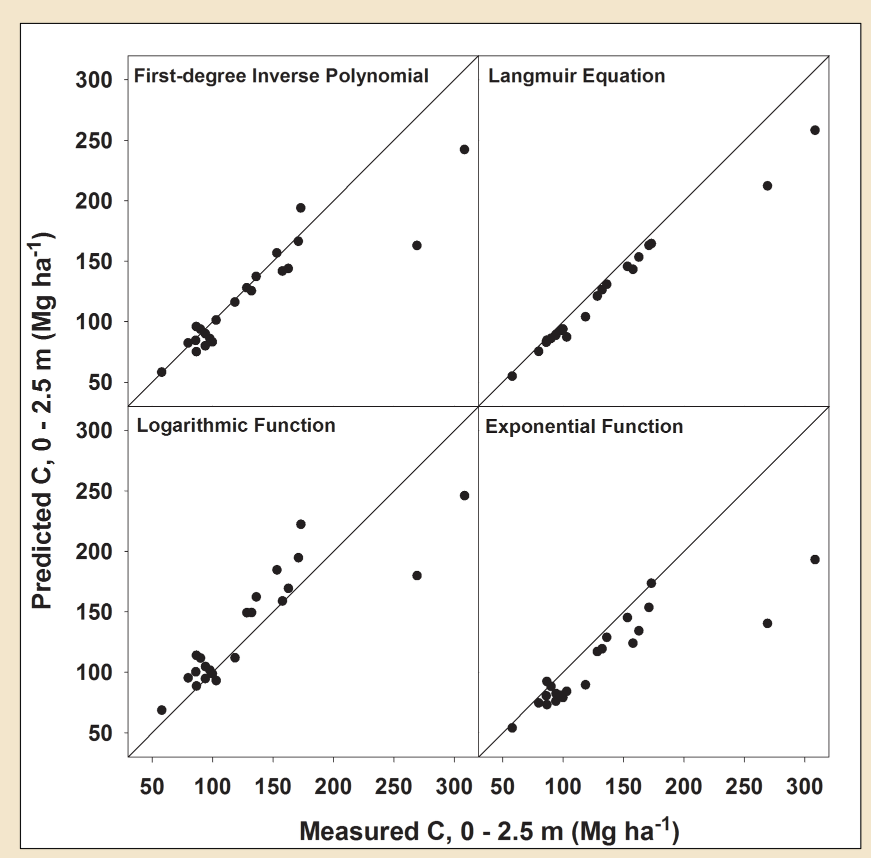
None of the models fit the Hoko and Vailton soils well. These soils carried the most soil C in deep layers.

Figure 7. Predicted versus measured soil C based on four functions fit to cumulative soil C profiles to a 1.0-m depth that were subsequently used to predict C to a 2.5-m depth.

With truncated data, error increases for all modeling functions.

The Langmuir equation projects soil C to 2.5 m most accurately.

None of the equations model the Hoko or Vailton sites well. These soils contain large quantities of noncrystalline minerals that can adsorb organic matter and preserve it from decomposition.



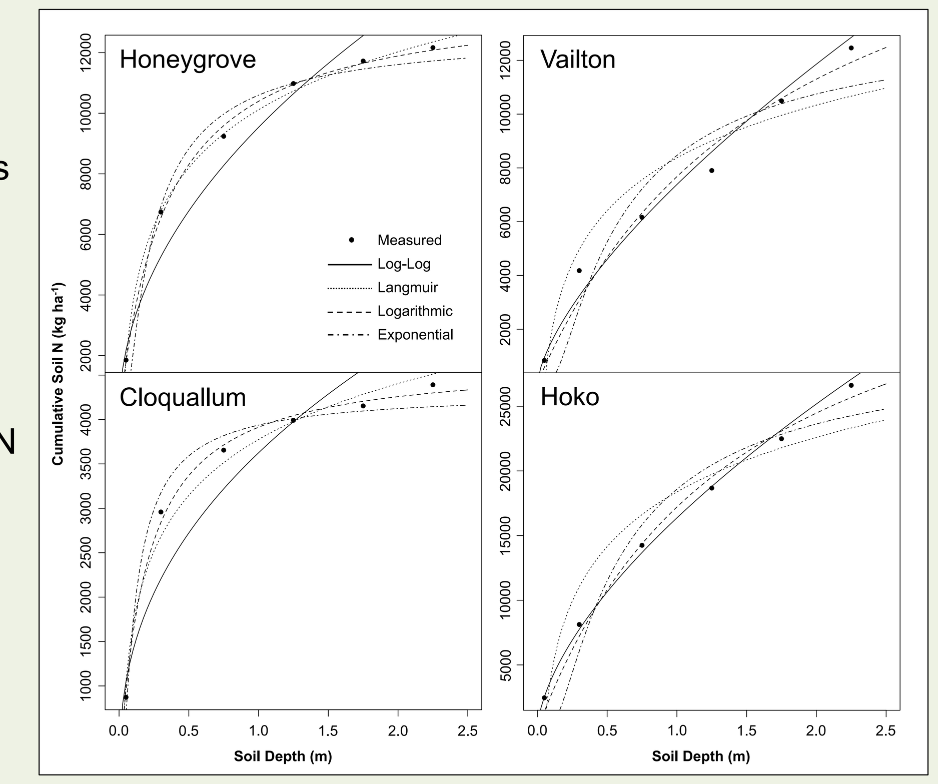
Soil Nitrogen

Figure 8. Cumulative soil N profiles (sample interval midpoints are plotted) for four soil series, representative of the range of profiles from 22 forest soils in western Washington and Oregon. Four functions are fit to the data for each soil series .

Honeygrove and Vailton have similar total soil N, but Vailton accumulates N more gradually down the profile.

Cloquallum carries most of its soil N in surface layers and becomes asymptotic quickly.

Hoko has the most total soil N of all sites and accumulates N gradually.



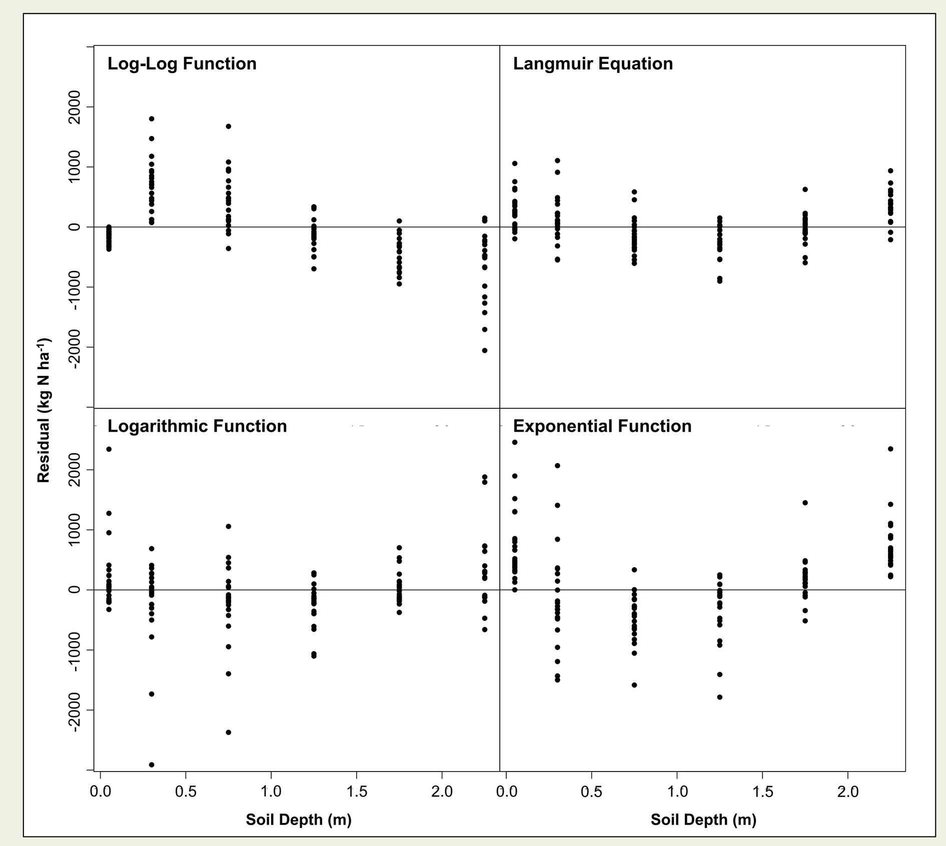


Figure 9. Residuals produced by fitting four different functions to 22 cumulative soil N profiles (0-2.5-m depth) of forest soils in western Washington and Oregon.

The log-log function consistently underestimates near the surface and overestimates at depth.

The Langmuir equation has the smallest and most evenly distributed residuals.

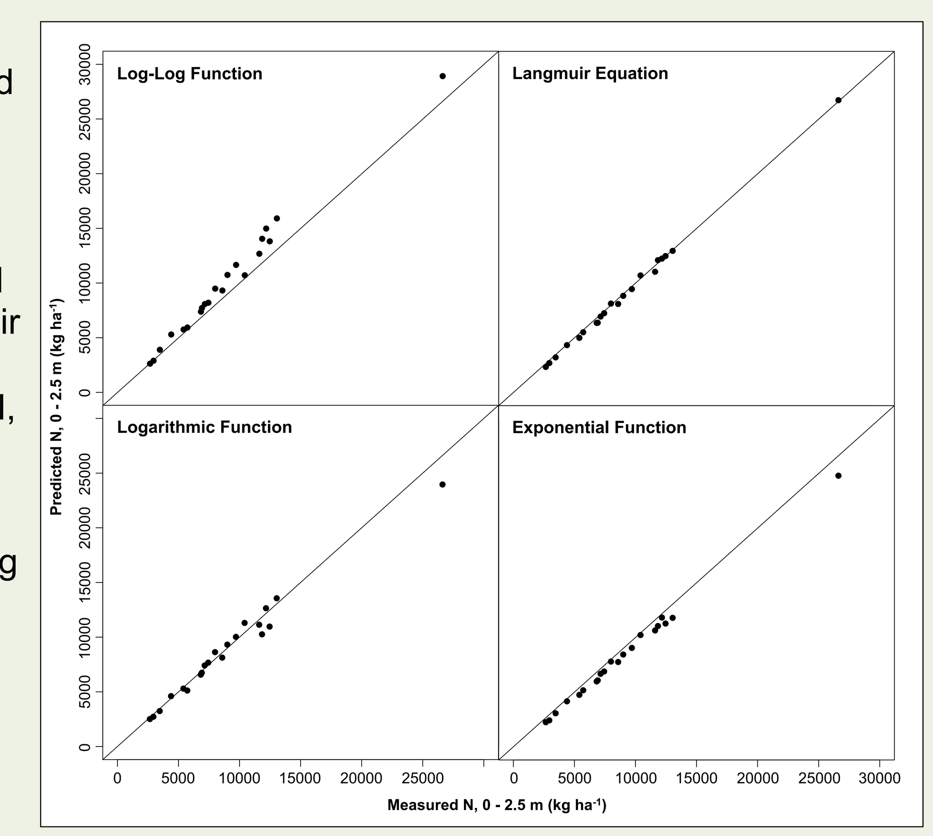
The logarithmic function residuals show little consistent bias, but some residuals are large.

The exponential function consistently underestimates N at depth.

Figure 10. Predicted versus measured soil N for all 22 soils, based on four functions fit to cumulative soil N profiles (0-2.5 m depth).

The Langmuir equation fits the data best. The logarithmic function fits well but has higher error than the Langmuir equation. The log-log function consistently overestimates total soil N, while the exponential function consistently underestimates it.

The largest error occurs with modeling the Hoko site, which has by far the most soil N.



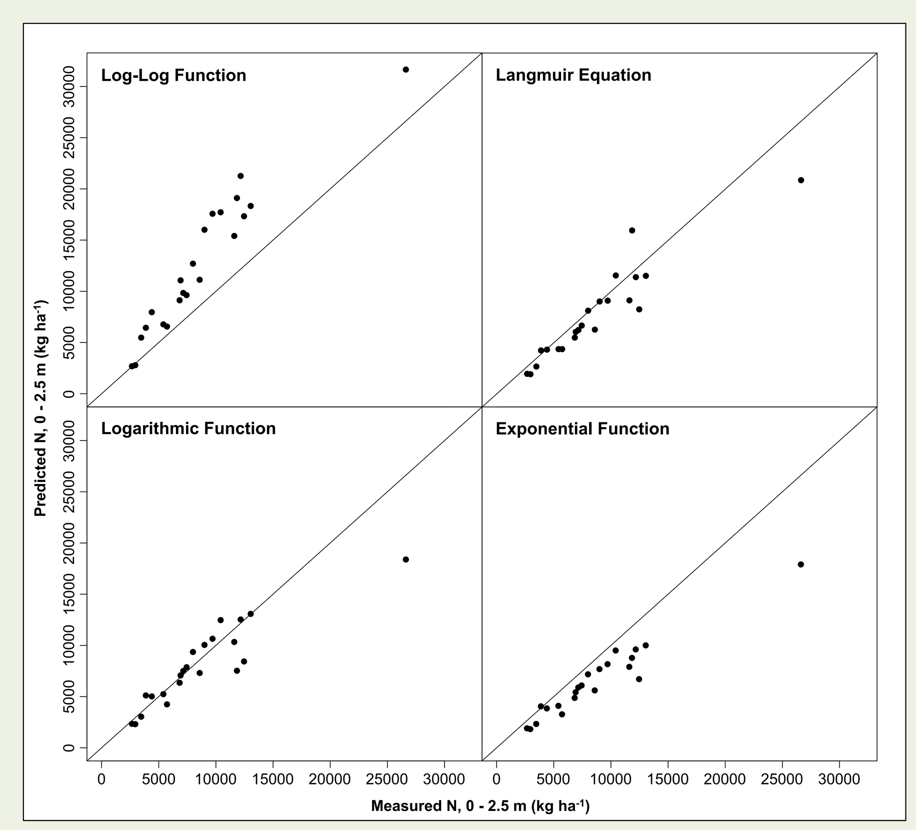


Figure 11. Predicted versus measured soil N based on four functions fit to cumulative soil N profiles to a 1.0-m depth that were subsequently used to predict N to a 2.5-m depth.

With truncated data, error increases for all modeling functions.

The Langmuir equation projects soil N to 2.5 m most accurately.

None of the equations model the Hoko series well. This series is classified as ferrihydritic and contains a large quantity of noncrystalline or nanocrystalline iron minerals. These can adsorb and preserve organic matter from decomposition.

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