

Summary of Progress

Kaveh

30 December 2020

Contents

Project Progress	1
Learning Outcomes Progress	8
References	8

Project Progress

Recent progress on my project has been centered around the calibration of NutsFor towards the 4 base case sites I'm representing in my work. I first started by exploring the model, shifting its parameters and observing outputs. I did this by writing a R program that reads NutsFor data files and visualizes them after each model run. Once I understood how the model's parameters functioned together, I calibrated the model by individually calibrating each sub-module within the larger model. The order of calibration was chosen based on the hierarchical relationship between the model's sub-systems proposed for the Nutrient Cycling Model (Munson et al. 1992). For instance, hydrology will have the most control over model outputs, and should therefore be calibrated first. Deposition and throughfall fluxes will determine nutrient fluxes in the organic layers, and is calibrated second. Organic matter decomposition and buildup will control cation and anion nutrient release rates, and is calibrated third. Anion concentrations can push cations off of the CEC and into solution, they thus control cation concentrations and should be calibrated forth. Cation concentrations are dependent on all previous 4 systems, and are calibrated last. I additionally added the N-Cycle calibration process. N-Cycling dynamics were placed before anion calibration but after SOM C calibration.

1). Hydrology

I used evaporation data for the Oregon Coast region(Safley et al. 2009), and drainage data from (Perakis and Sinkhorn 2011) to calibrate evapotranspiration and water leaching fluxes in my simulated sites. I assumed the same hydrological outputs between the basalt and sedimentary sites. I also assumed that hydrology was constant over time.

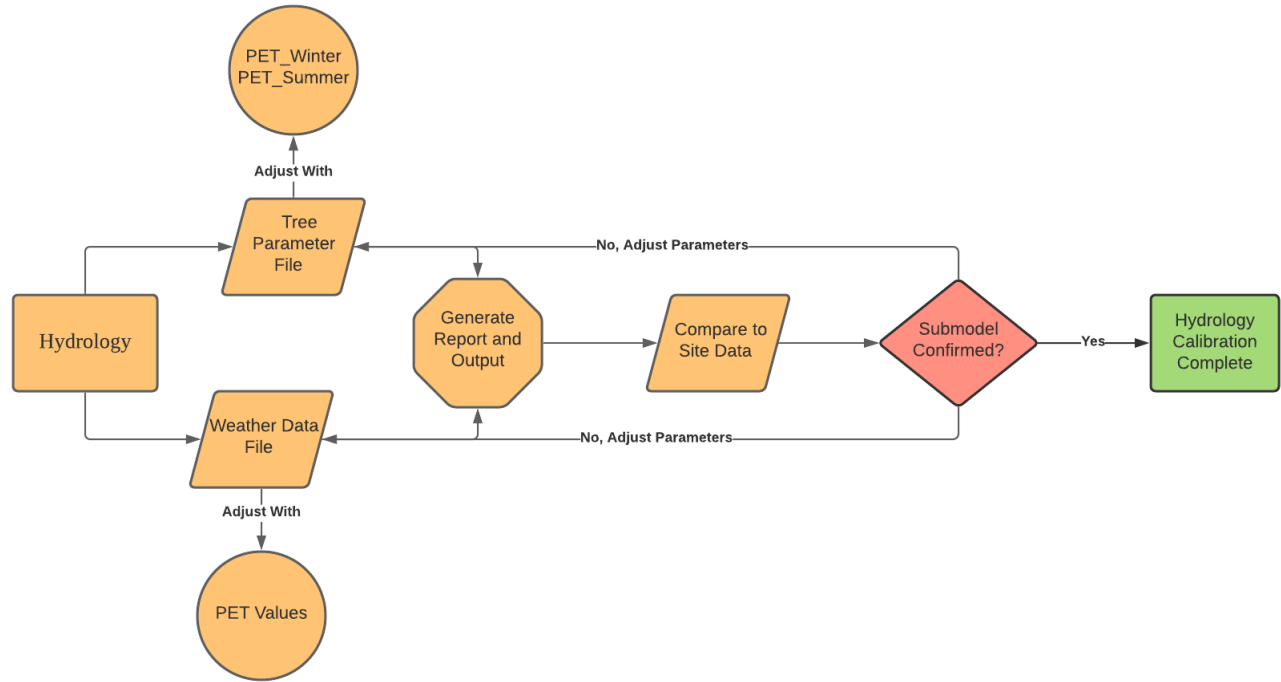


Figure 1: Hydrology calibration workflow

2). Through fall and Deposition

Little was known about throughfall concentrations within the range of interest. Nearby throughfall data was confounded by site rain chemistry differences (Sollins et al. 1980). I instead made no assumptions about throughfall concentrations, except for K^+ , which is generally known to leach in high concentrations from leaf and needle surfaces (Sollins et al. 1980; Tukey 1970).

Similar to throughfall concentrations, little was known about Dry deposition of nutrient elements, I thus made no assumptions about the input of nutrients from dry deposition.

[Wet deposition data was taken from the National Atmospheric Deposition Program's wet deposition data taken for the ALSEA OR02 site ("National Atmospheric Deposition Program (NRSP-3)." 2020). Rainfall concentrations for the years of 2005-2006 were used for the calibration of the model, and repeated over the length of the simulation for predictive simulations. This was necessary as NADP monitoring for the ALSEA site stopped in 2007.

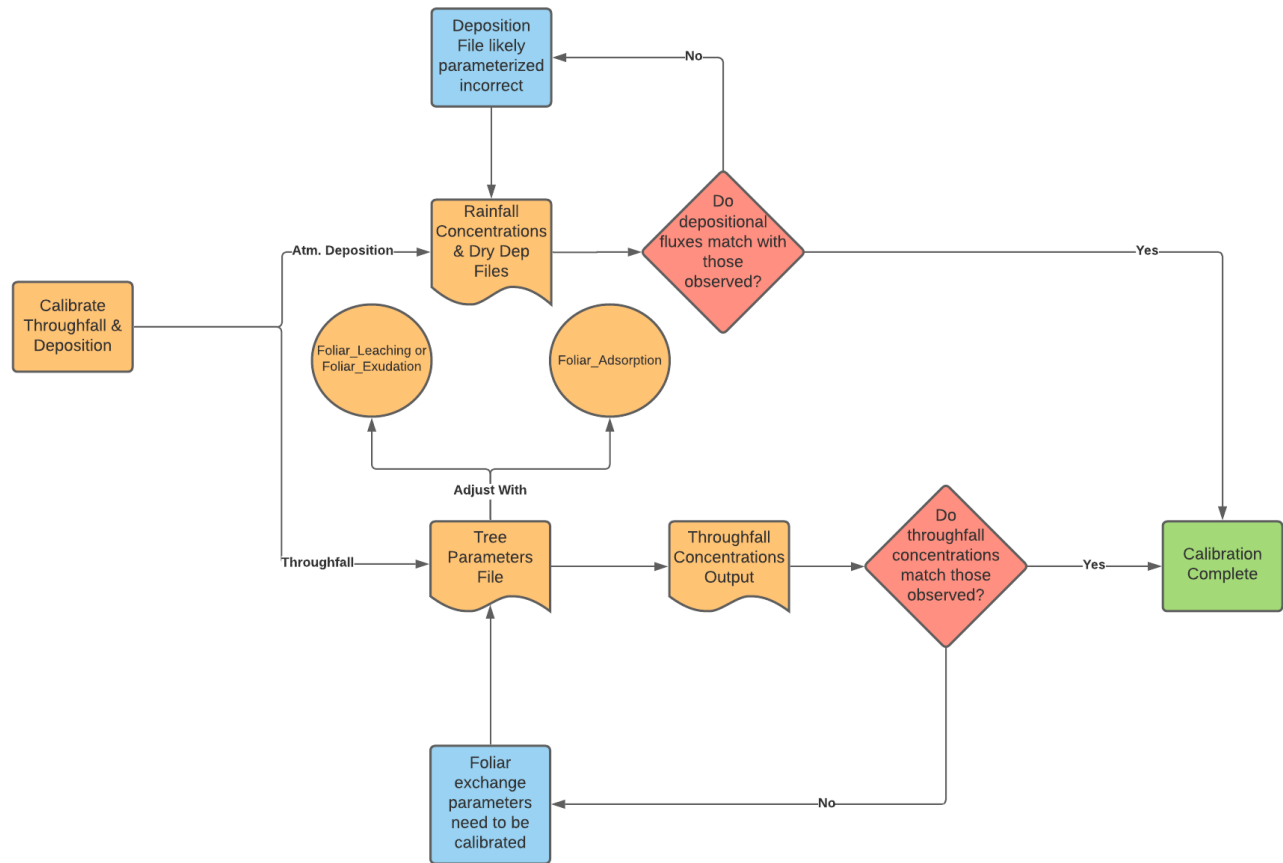


Figure 2: Throughfall and Deposition calibration workflow

3). Soil Organic Matter

Litter C pool and SOM C pool content was calibrated using decomposition parameters in the model. The litter C pool was allowed to build up over time following data from (Cole et al. 1995; Tarrant and Miller 1963; and Klopatek 2008). The SOM C pool was kept stable over the initial short term calibration, the idea is to keep SOM C stable over the entire simulation time period (~500 years).

Once the SOM C and Litter C buildup matched observed trends and roughly aligned with the known magnitude of C buildup, parameters were accepted.

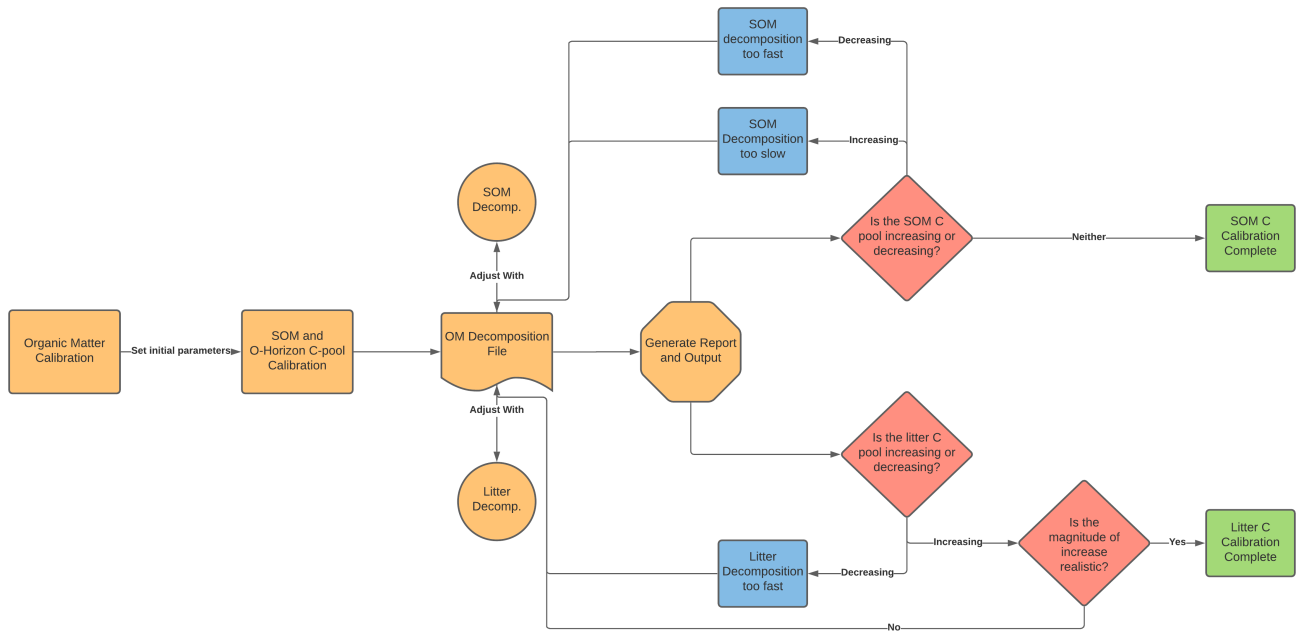


Figure 3: Organic Carbon calibration workflow

4). N Cycle Calibration

The N-Cycle was calibrated by first setting nitrification rates to those observed in (Perakis and Sinkhorn 2011). N-release rates from the organic matter pools were then changed accordingly until soil solution concentrations and nutrient fluxes of NO_3^- and NH_4^+ matched those observed.

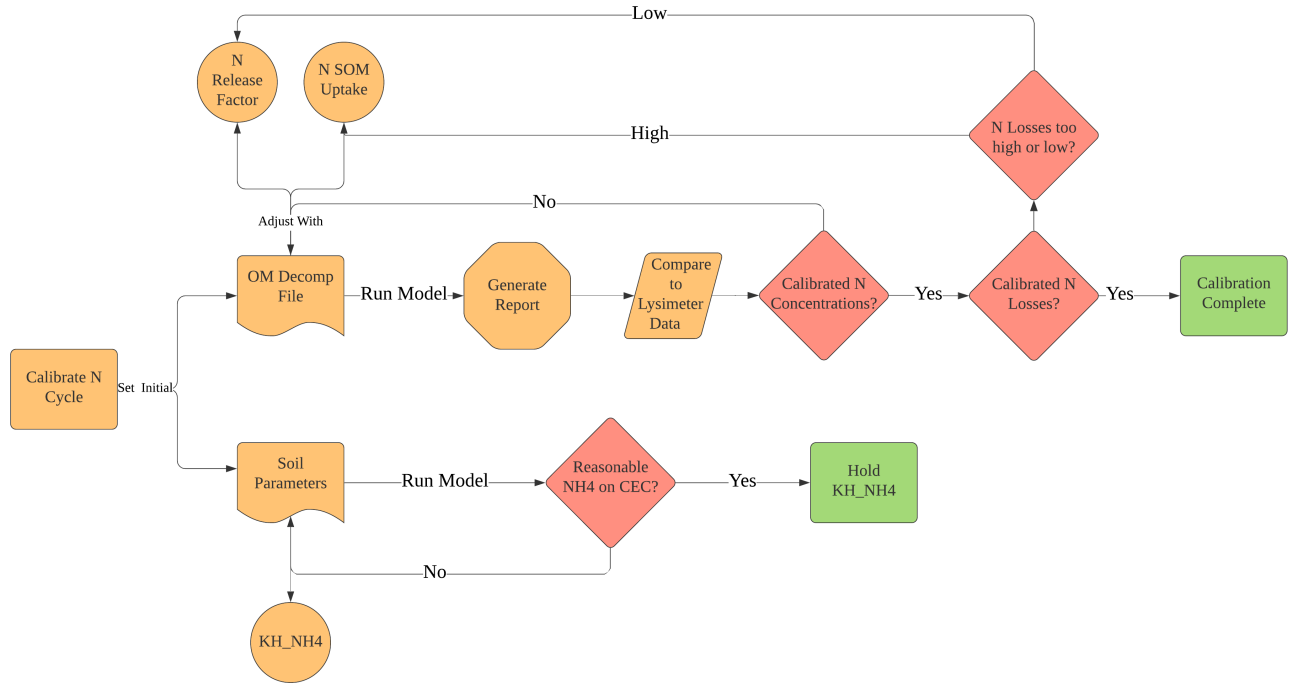


Figure 4: N-Cycle Calibration Workflow

5). Anion Calibration

Parameters controlling anion concentrations were calibrated until soil solution concentrations of anions matched those observed in lysimeter data. This was done for sulfate, phosphate, and chloride, organic acids (R^-) were not measured, the concentrations of R^- were separately calibrated to balance ANC and pH. As a point of additional constraint, leaching fluxes of anions were observed at the 20cm and 100cm layers to ensure simulated S-losses did not exceed or go below those observed in nature.

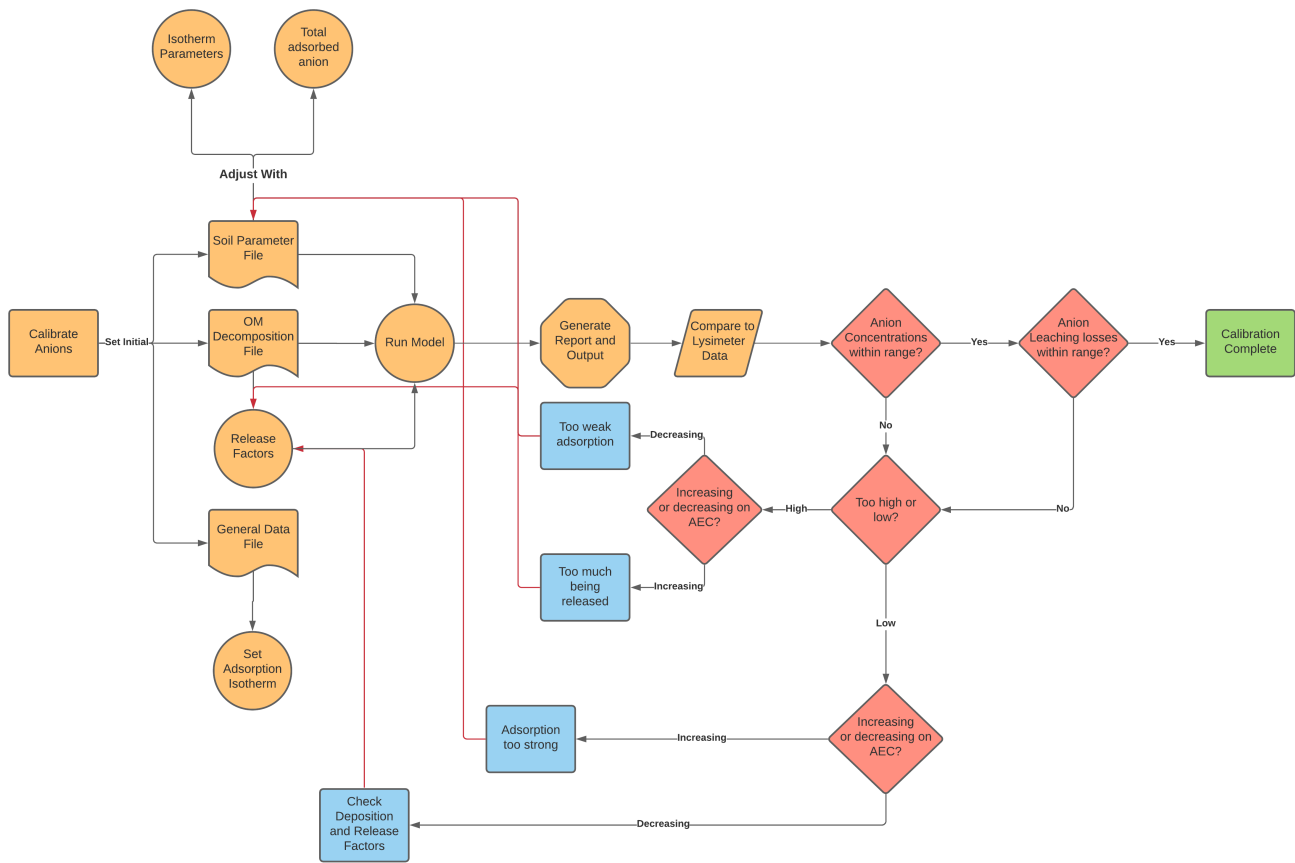


Figure 5: Anion Calibration Workflow

6). Cation calibration

Cation Calibration is similar to anion calibration, the parameters which are changed during calibration are the Gapon Coefficients, microbial uptake parameters, or the organic matter release factor. I used lysimeter measured concentrations to constrain calibration of parameters, I also used lysimeter measured leaching fluxes at 20cm and 100cm depth to constrain nutrient losses. The calibration was deemed complete when simulated two year monthly concentrations fell within the average range of those observed.

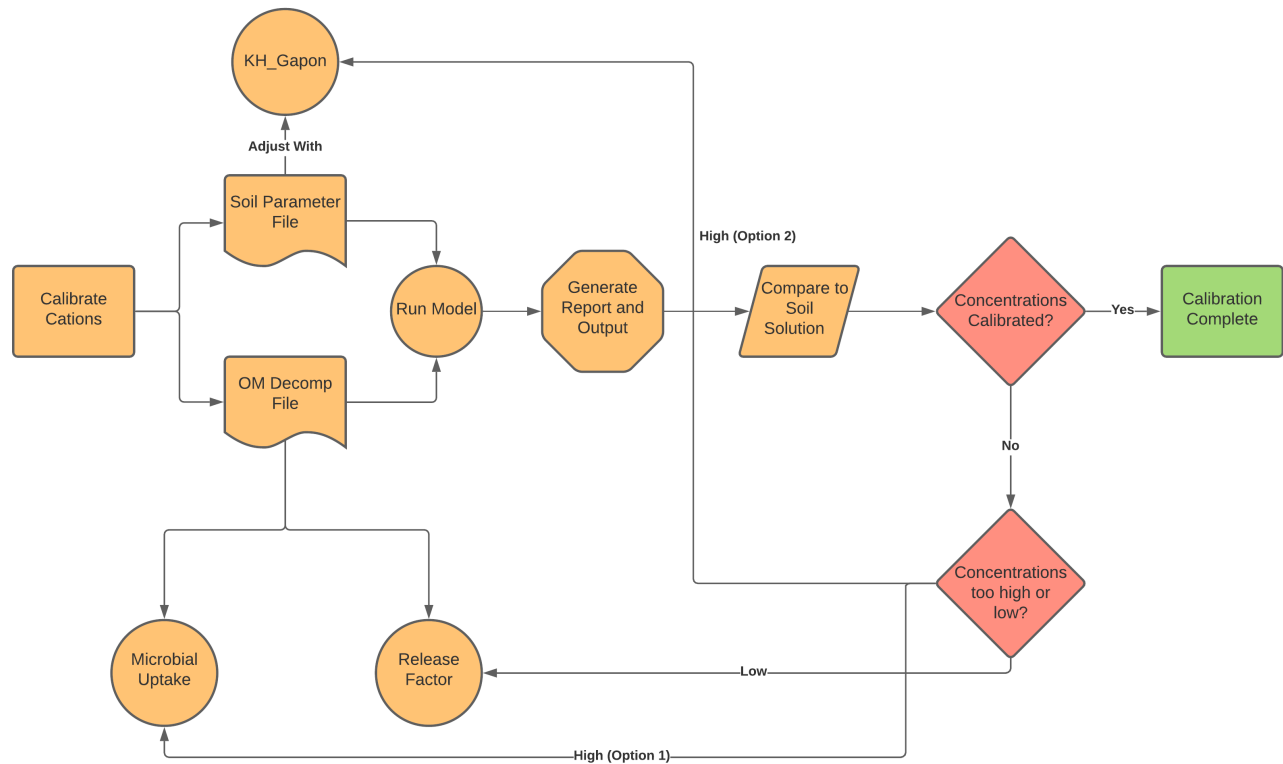


Figure 6: Cation Calibration Workflow

7). Final Calibration

After all sub-modules were calibrated to two years, I ran the simulation for 10 years to catch potential unrealistic behavior of the simulation on a longer timescale. I then re-calibrated the model using the same workflows as pictured above until long term simulated outputs were realistic within selected bounds of constraint.

8). Alternative Calibration: Basalt Sites

We have no direct measurements of soil solution concentrations or fluxes for basalt sites as we do sedimentary sites. Calibration for these sites was therefore based in the establishment of higher level ecosystem responses, such as plant nutrient acquisition, biomass acquisition, mineral weathering fluxes, and exchangeable pool concentrations, as constraints on calibration.

Initial soil solution concentrations of metallic species was approximated from basalt lysimeter data in (Sollins et al. 1980) and (Hedin, Vitousek, and Matson 2003). I did not use these sites to calibrate monthly or long term soil solution concentrations, as the bedrock of the Sollins 1980 site was magnesium poor and the Hedin et al., 2003 site in a tropical hydrological and temperature regime. Instead, this information was used to set selectivity coefficients for the soil.

The same C, N, P, and S data used for the low N sedimentary site was used to calibrate the low N basalt site, and the same for the high N sites.

The model was then run for 2 years, and outputs were monitored for unrealistic behavior. “Unrealistic” behavior was determined using datasets outside of those used for calculating initial parameters. For instance, large short term losses of nutrient cations from the exchangeable pool would be unrealistic, but long term losses would be expected if the output flux of nutrients (leaching and uptake) exceed input fluxes (mineral weathering and deposition) (Richter et al. 1994).

Learning Outcomes Progress

Due to the COVID-19 pandemic, some learning outcomes will be completed through different means than those suggested in my Learning Outcomes.

FES 525 will be replaced by another class altogether as desired by the graduate school.

Rather than attending a forest policy seminar to fill the policy learning outcome, I will be taking a policy class in the spring.

References

- Cole, Dale W., Jana E. Compton, R. L. Edmonds, Peter S. Homann, and H. Van Miegroet. 1995. "Comparison of Carbon Accumulation in Douglas Fir and Red Alder Forests." In *Carbon Forms and Functions in Forest Soils*, 527–46. John Wiley & Sons, Ltd. <https://doi.org/10.2136/1995.carbonforms.c24>.
- Hedin, Lars O., Peter M. Vitousek, and Pamela A. Matson. 2003. "Nutrient Losses over Four Million Years of Tropical Forest Development." *Ecology* 84 (9): 2231–55. <https://doi.org/10.1890/02-4066>.
- Klopatek, Jeffrey M. 2008. "Litter Decomposition Contrasts in Second- and Old-Growth Douglas-Fir Forests of the Pacific Northwest, USA." *Plant Ecology* 196 (1): 123–33.
- Munson, R. K., S. Liu, S. A. Gherini, D. W. Johnson, K. J. Wilkinson, R. J. M Hudson, K. S. White, and K. S. Summers. 1992. "NuCM Code Version 2.0: An IBM PC Code for Simulating Nutrient Cycling in Forest Ecosystems." 3412 Hillview Avenue, Palo Alto, California 94304: Electric Power Research Institute.
- "National Atmospheric Deposition Program (NRSP-3)." 2020.
- Perakis, Steven S., and Emily R. Sinkhorn. 2011. "Biogeochemistry of a Temperate Forest Nitrogen Gradient." *Ecology* 92 (7): 1481–91. <https://doi.org/10.1890/10-1642.1>.
- Richter, D. D., D. Markewitz, C. G. Wells, H. L. Allen, R. April, P. R. Heine, and B. Urrego. 1994. "Soil Chemical Change During Three Decades in an Old-Field Loblolly Pine (*Pinus Taeda* L.) Ecosystem." *Ecology* 75 (5): 1463–73. <https://doi.org/10.2307/1937469>.
- Safley, L. M, Carl DuPoldt, Frank Geter, Donald Stettler, and Timothy Murphy. 2009. "Part 651: Appendix 10E." In *Agricultural Waste Management Field Handbook*. United States Department of Agriculture, NRCS.
- Sollins, P., C. C. Grier, F. M. McCorison, K. Cromack, R. Fogel, and R. L. Fredriksen. 1980. "The Internal Element Cycles of an Old-Growth Douglas-Fir Ecosystem in Western Oregon." *Ecological Monographs* 50 (3): 261–85. <https://doi.org/10.2307/2937252>.
- Tarrant, Robert F., and Richard E. Miller. 1963. "Accumulation of Organic Matter and Soil Nitrogen Beneath A Plantation of Red Alder and Douglas-Fir." *Soil Science Society of America Journal* 27 (2): 231–34. <https://doi.org/10.2136/sssaj1963.03615995002700020041x>.
- Tukey, H B. 1970. "The Leaching of Substances from Plants." *Annual Review of Plant Physiology* 21 (1): 305–24. <https://doi.org/10.1146/annurev.pp.21.060170.001513>.