Calibration Report: Low N Sedimentary Site Base Case

Kaveh Gholamhossein Siah

19 December 2020

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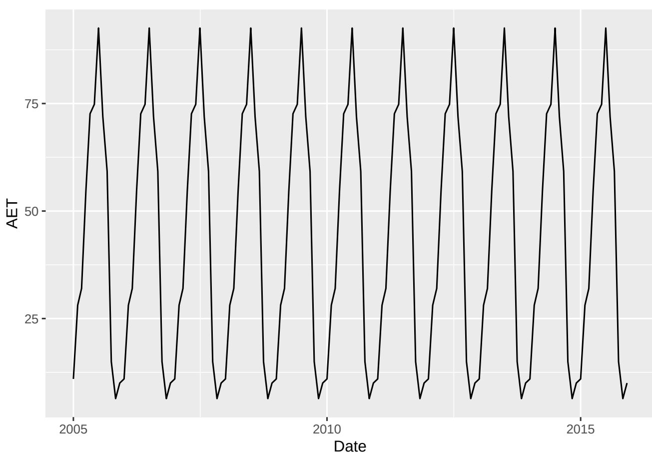
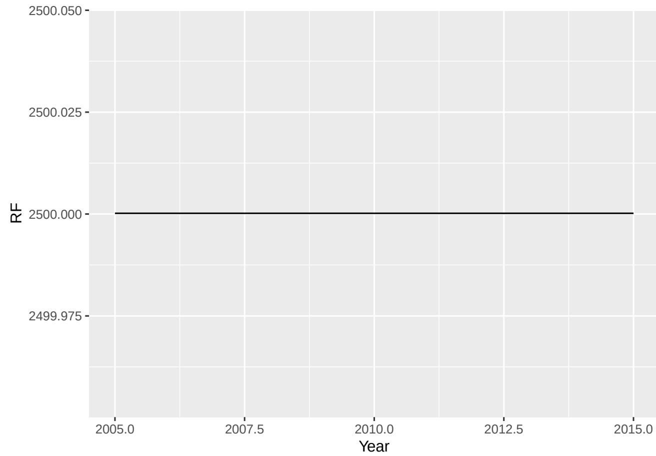
Hydrology





Soil Solution Results

Table 1: Average Soil Solution Concentrations of Reliable Months (2005-2006)

	μmol/L														
Soil Layer	Ca	Mg	K	Na	NO3	NH4	SO4	Cl	PO4	DOC	Al	Si	H+	pH	R	HR
Layer 1	15.8	19.0	10.77	53.9	1.677	3.61	6.36	49.6	0.683	122.5	0.463	62.6	14.46	4.84	89.3	33.12
Layer 2	16.6	20.1	10.98	71.0	1.419	3.50	6.68	47.5	0.275	126.6	0.288	70.5	9.90	5.00	97.8	28.74
Layer 3	15.5	18.7	10.59	82.4	1.264	3.49	9.64	47.2	0.265	113.5	0.461	70.9	6.26	5.20	91.7	21.77
Layer 4	13.1	20.3	6.84	82.8	1.095	2.82	12.23	50.4	0.209	85.3	0.335	71.9	5.02	5.30	71.1	14.26
Layer 5	14.7	22.9	7.18	87.8	0.973	2.55	10.92	57.2	0.143	87.7	0.385	75.5	5.44	5.26	73.1	14.63
Layer 6	15.1	23.5	7.26	89.5	0.881	2.27	10.84	65.3	0.162	63.8	0.181	79.1	3.05	5.52	56.2	7.64
Layer 7	16.1	24.9	7.48	92.4	0.802	2.07	11.45	71.2	0.161	60.6	0.250	82.6	3.95	5.40	52.2	8.39
Layer 8	15.7	24.6	7.37	94.0	0.754	1.95	11.94	74.5	0.137	48.6	0.145	85.1	2.51	5.60	43.0	5.58

Table 2: Lysimeter Measured Soil Solution Concentrations of Reliable Months (2005)

	$\\mu$mol/L																								
Layer	Ca	Ca SD	Mg	Mg SD	K	K SD	Na	Na SD	NO3	NO3 SD	NH4	NH4 SD	SO4	SO4 SD	Cl	Cl SD	P^a	P SD	DOC	DOC SD	Al^b	Al SD	Si^c	Si SD	pH^d
1	29	12.9	30	20	32	17	131	71	2.3	2.14	1.1	0.25	18	2.20	167	109	0.07	0.038	123	28	0.98	0.42	82	16	5.6
2	29	12.9	30	20	32	17	131	71	2.3	2.14	1.1	0.25	18	2.20	167	109	0.07	0.038	123	28	0.98	0.42	82	16	5.3
3	29	12.9	30	20	32	17	131	71	2.3	2.14	1.1	0.25	18	2.20	167	109	0.07	0.038	123	28	0.98	0.42	82	16	5.4
4	14	3.3	24	12	12	20	133	58	1.9	0.73	1.2	0.27	12	0.73	152	87	0.05	0.032	63	30	0.37	0.17	84	15	5.5
5	14	3.3	24	12	12	20	133	58	1.9	0.73	1.2	0.27	12	0.73	152	87	0.05	0.032	63	30	0.37	0.17	84	15	5.6
6	14	3.3	24	12	12	20	133	58	1.9	0.73	1.2	0.27	12	0.73	152	87	0.05	0.032	63	30	0.37	0.17	84	15	5.7
7	14	3.3	24	12	12	20	133	58	1.9	0.73	1.2	0.27	12	0.73	152	87	0.05	0.032	63	30	0.37	0.17	84	15	5.8
8	14	3.3	24	12	12	20	133	58	1.9	0.73	1.2	0.27	12	0.73	152	87	0.05	0.032	63	30	0.37	0.17	84	15	5.8

[a] Average based on TP annual average

[b] Does not distinguish between organic-Al and free Al

[c] Model does not simulate Si uptake

[d] From Hynicka et al., 2017 (10-50cm) extrapolated to 1m

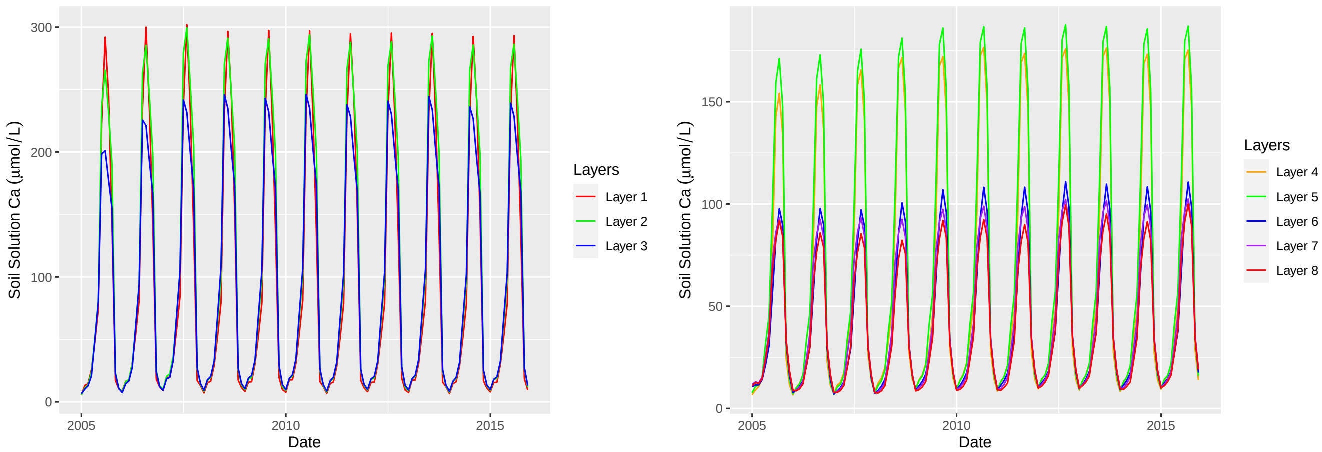


Figure 1: Monthly Calcium Concentrations by Soil Layer

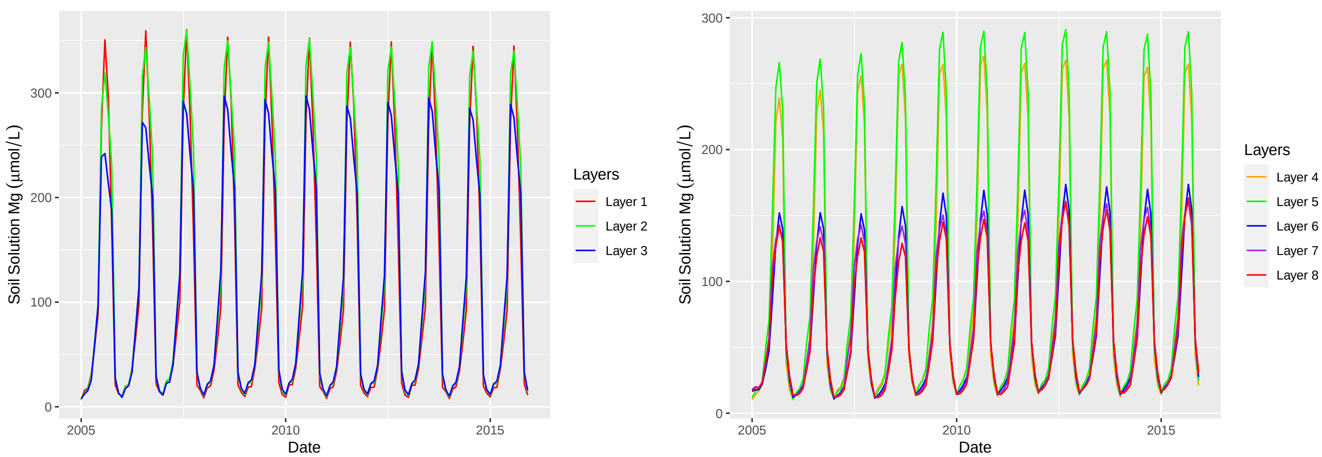


Figure 2: Monthly Magnesium Concentrations by Soil Layer

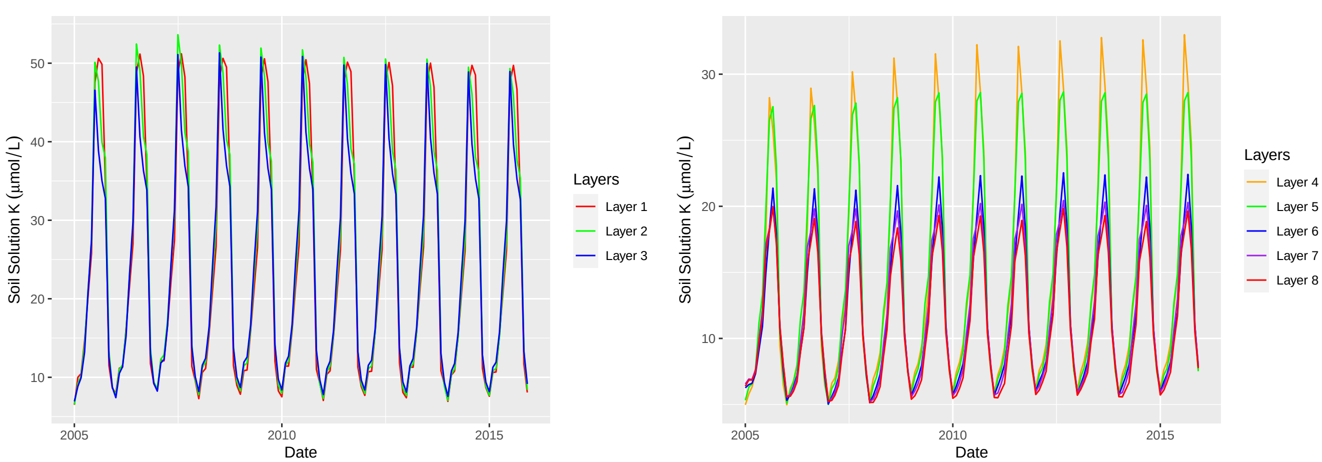


Figure 3: Monthly Potassium Concentrations by Soil Layer

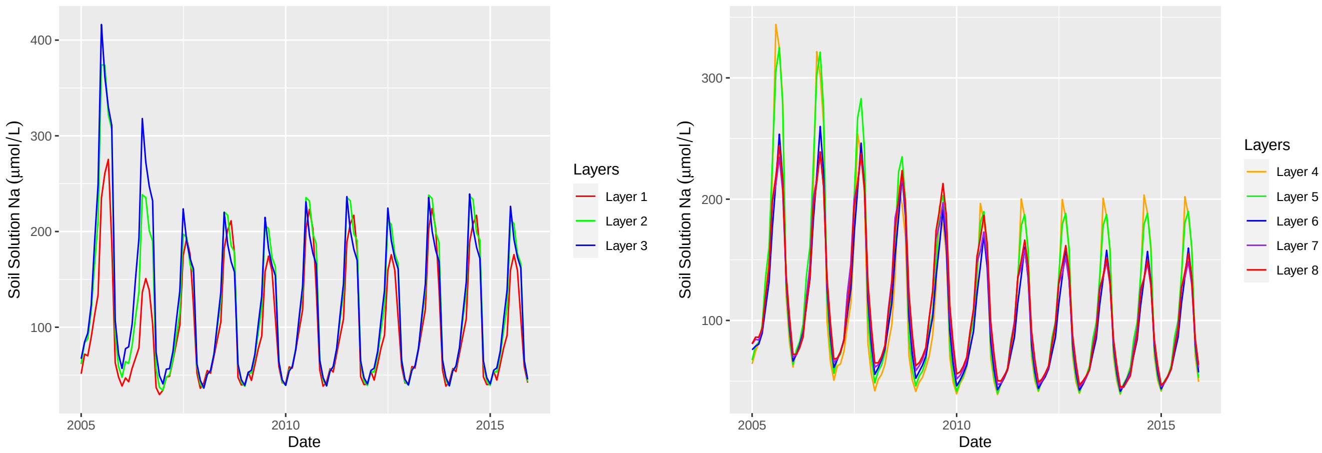


Figure 4: Monthly Sodium Concentrations by Soil Layer

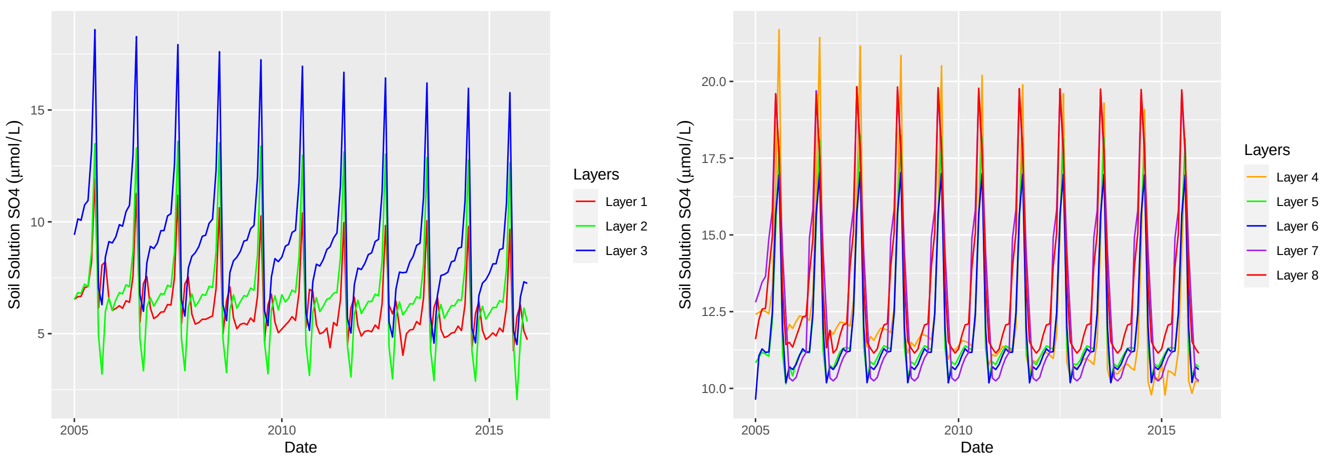


Figure 5: Monthly Sulfate Concentrations by Soil Layer

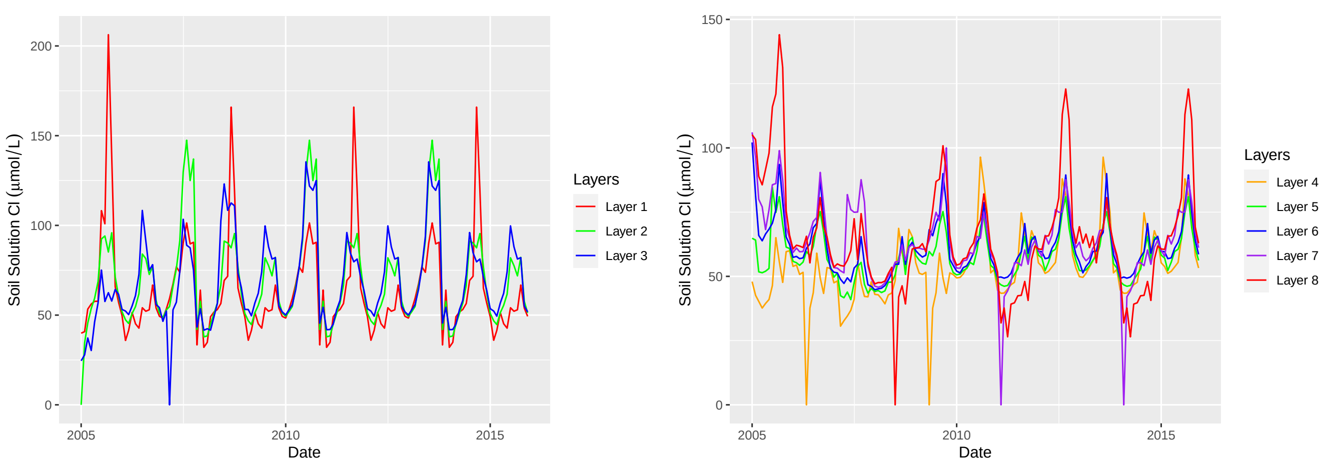


Figure 6: Monthly Chloride Concentrations by Soil Layer

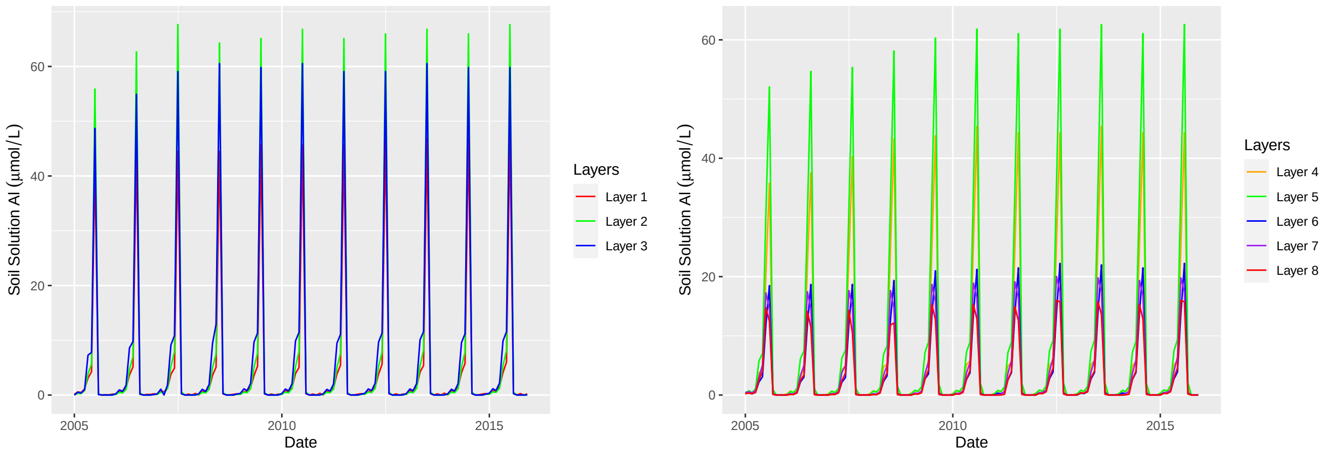


Figure 7: Monthly Aluminum Concentrations by Soil Layer

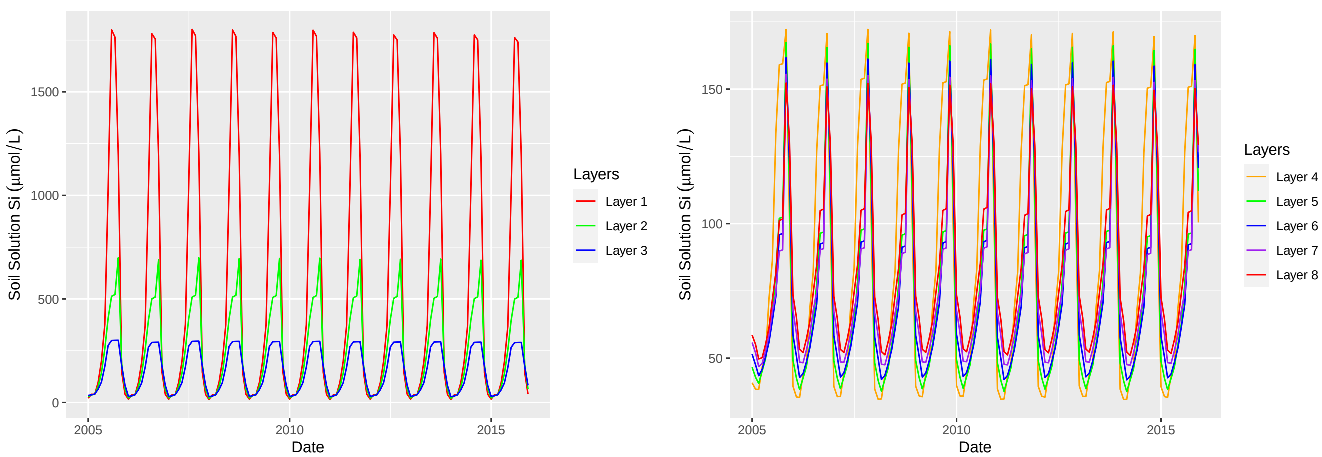


Figure 8: Monthly SiO2 Concentrations by Soil Layer

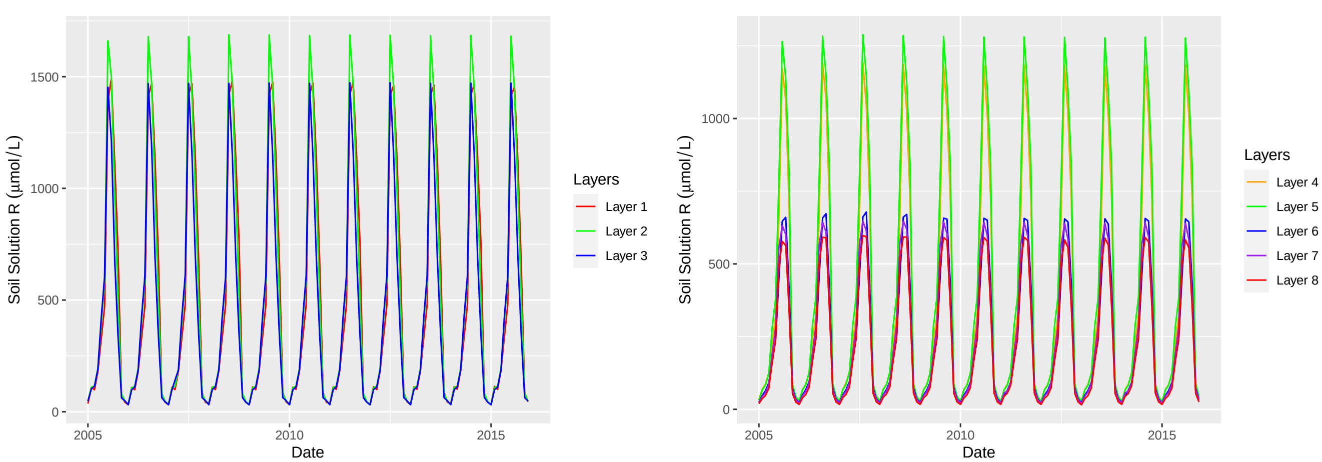


Figure 9: Monthly Organic Acid Base (R-) Concentrations by Soil Layer

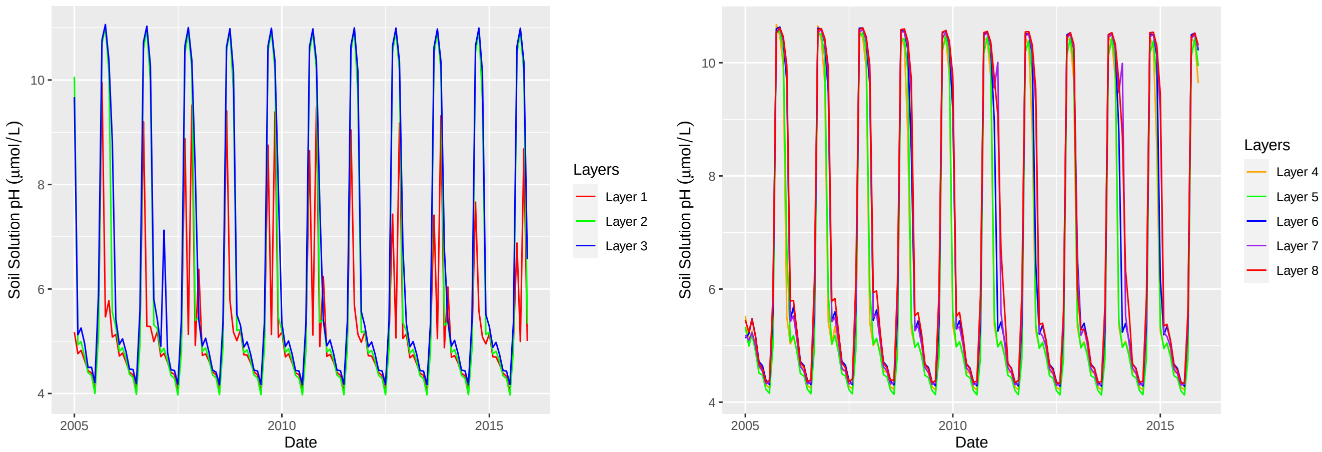


Figure 10: Monthly pH by Soil Layer

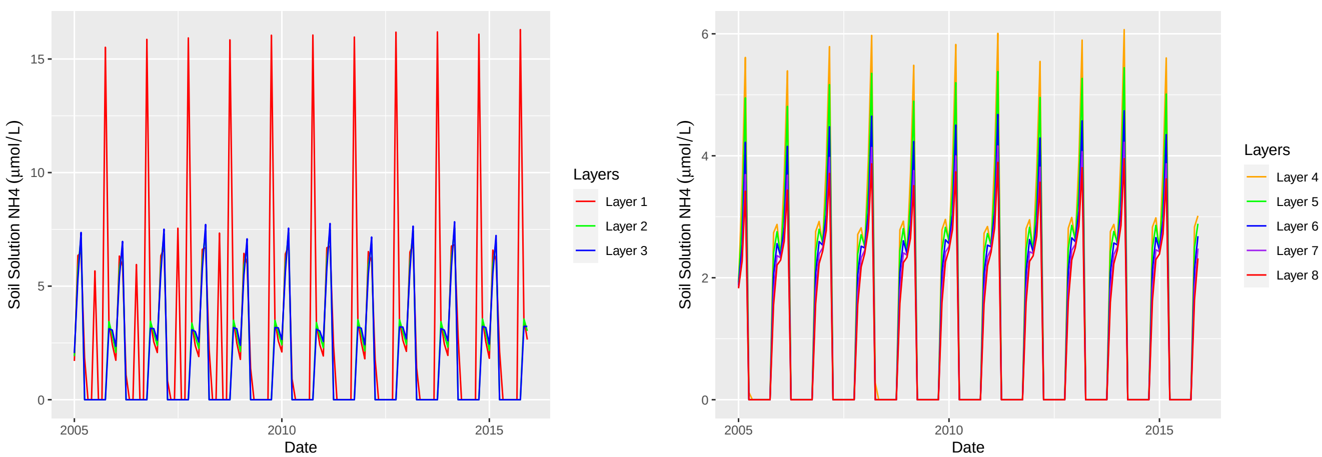


Figure 11: Yearly Ammonium concentration by Soil Layer

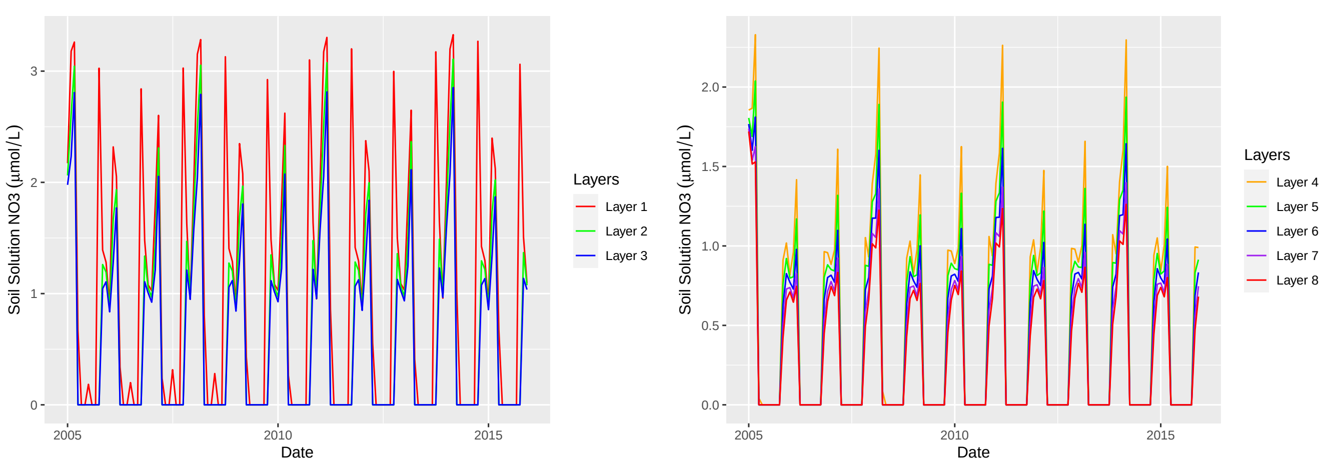
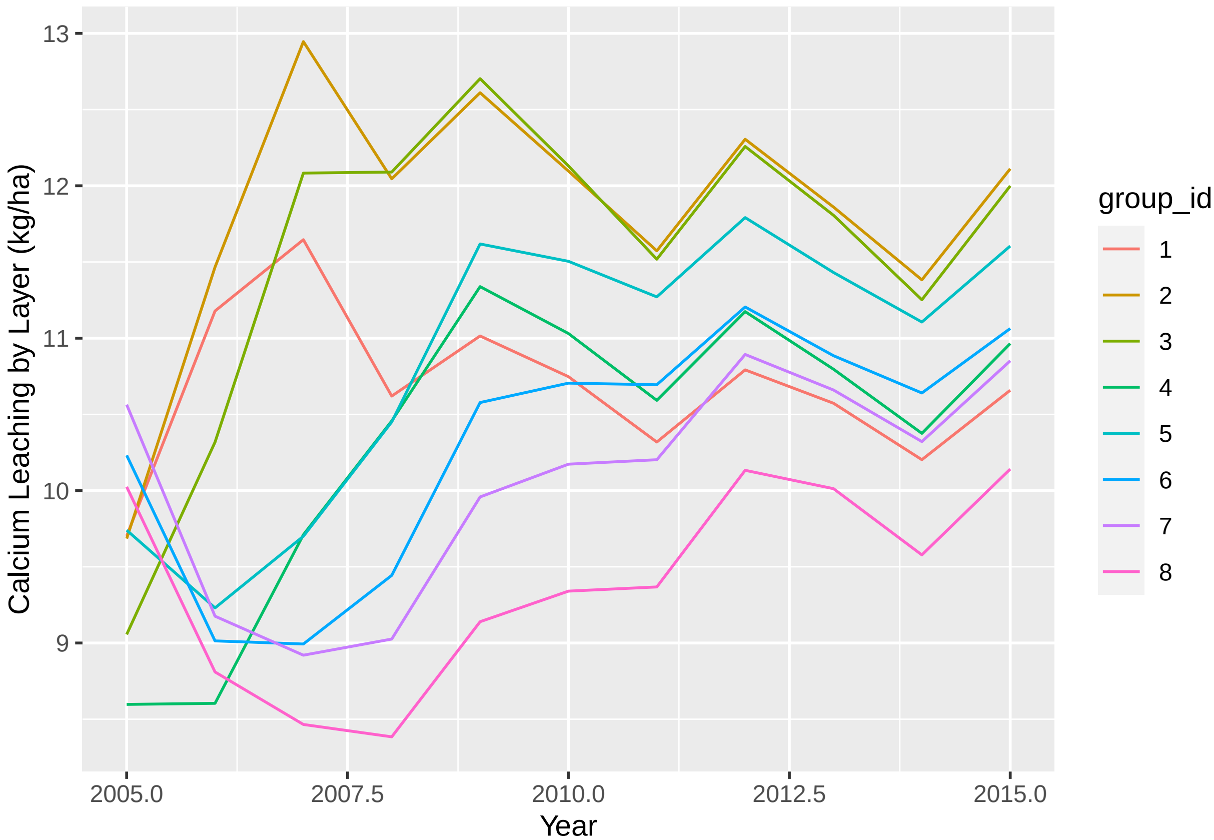


Figure 12: Yearly Nitrate concentration by Soil Layer

Lysimeter Comparisons



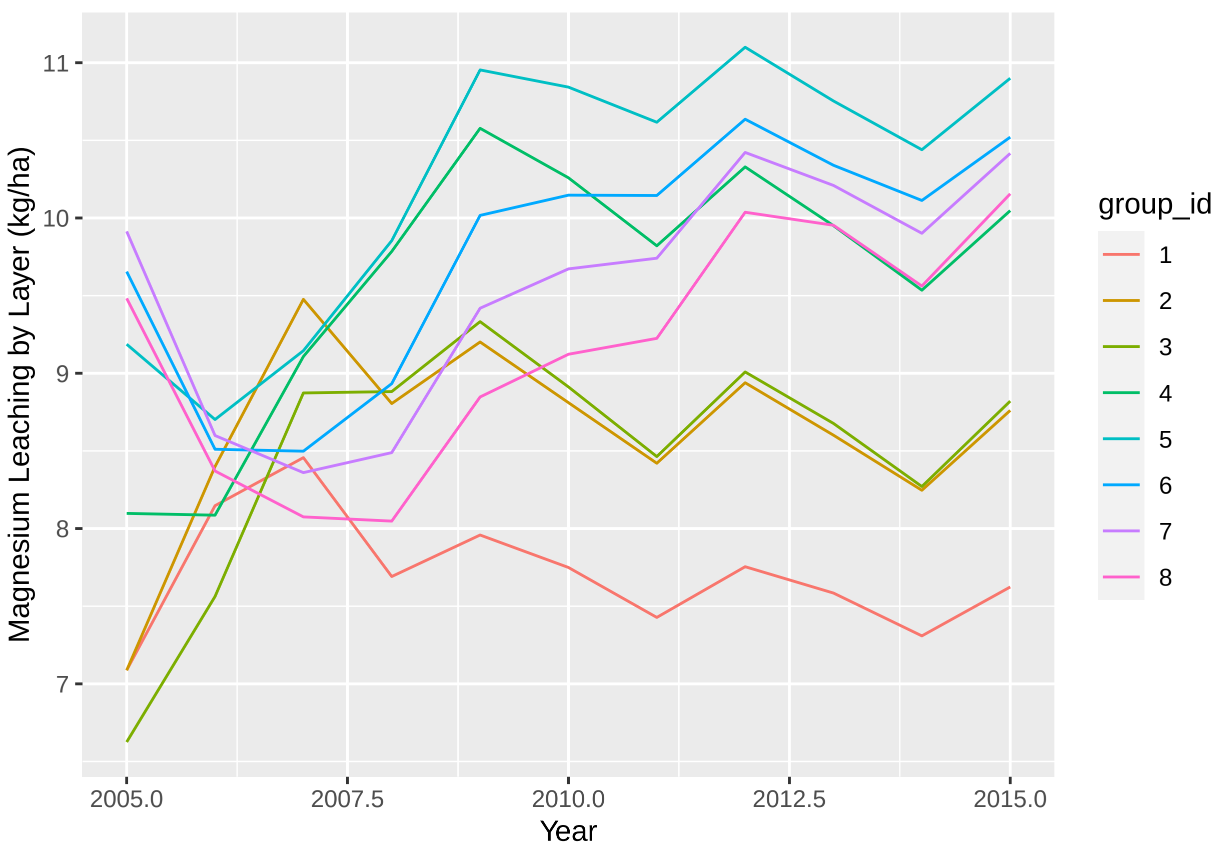


Table 3: Simulated Lysimeter Fluxes by Depth (2005-2006)

		kg/ha											
Depth	YEAR	Ca	Mg	K	Na	NO3	NH4	SO4	Cl	P	DOC	Al	Si
2	2005	9.7	7.1	6.4	29	0.37	0.71	3.3	24	0.13	19	0.018	40
2	2006	11.5	8.4	6.9	20	0.26	0.72	3.4	30	0.13	19	0.021	39
8	2005	10.0	9.5	4.3	32	0.21	0.39	5.2	42	0.061	6.3	0.0095	37
8	2006	8.8	8.4	3.9	30	0.12	0.42	5.2	30	0.062	6.1	0.0086	39

Table 4: Actual Average Lysimeter Fluxes (2005)

	kg/ha																								
Shallow.and.Deep.fluxes	Depth	NH4	NH4.SD	NO3	NO3.SD	TN	TN.SD	DOC	DOC.SD	TP	TP.SD	Cl	Cl.SD	SO4	SO4.SD	Ca	Ca.SD	Mg	Mg.SD	K	K.SD	Na	Na.SD	Al	Al.SD
NA	20	0.210049416	0.018413539	0.29063369	0.903104016	2.584976176	1.323438247	22.79330337	3.780780556	0.045545328	0.013708415	48.12893782	44.34049409	3.239059723	6.167872501	20.40967405	9.071287806	8.894951811	5.785746495	9.522967189	6.371362223	27.29467076	18.51377501	0.340716918	0.126564555
NA	100	0.18482098	0.037686163	0.058428056	0.56180591	0.782891773	1.207801926	7.454929603	2.86204934	0.02941534	0.012838737	38.85767377	30.20293147	4.342785568	2.358188679	7.924881994	1.716262595	6.693254137	3.118581853	2.39035473	6.086366362	27.76582547	13.72230984	0.162624321	0.037249254

Weathering Results

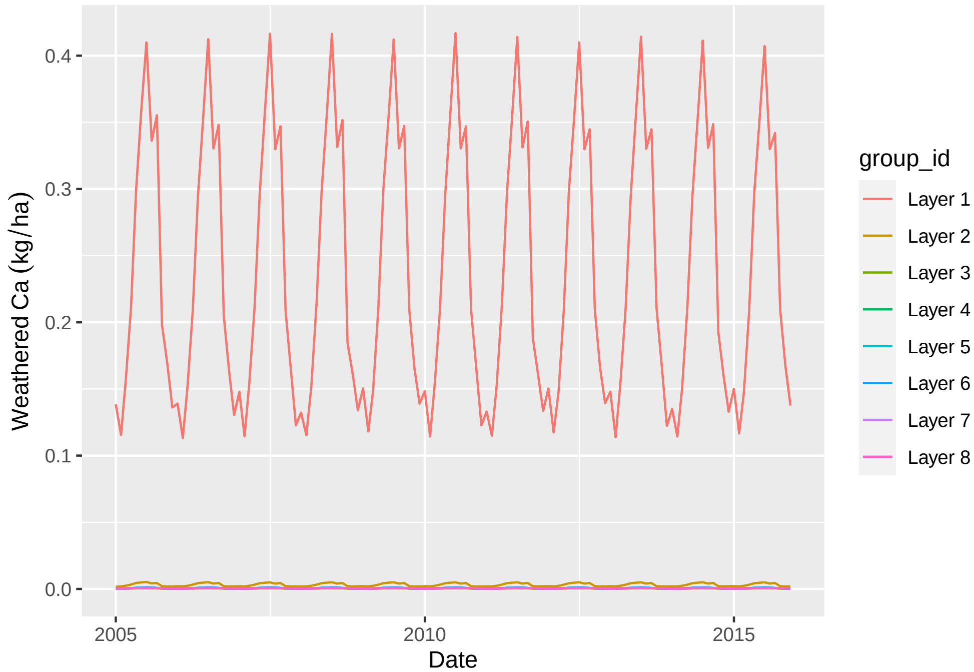


Figure 13: Calcium Weathering (All Layer)

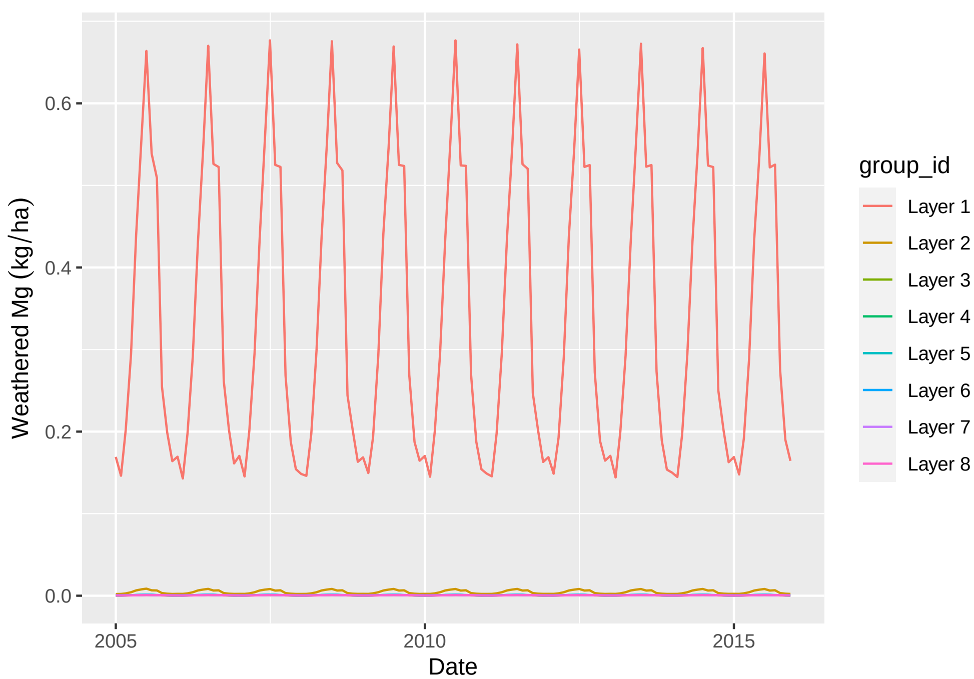


Figure 14: Magnesium Weathering (All Layer)

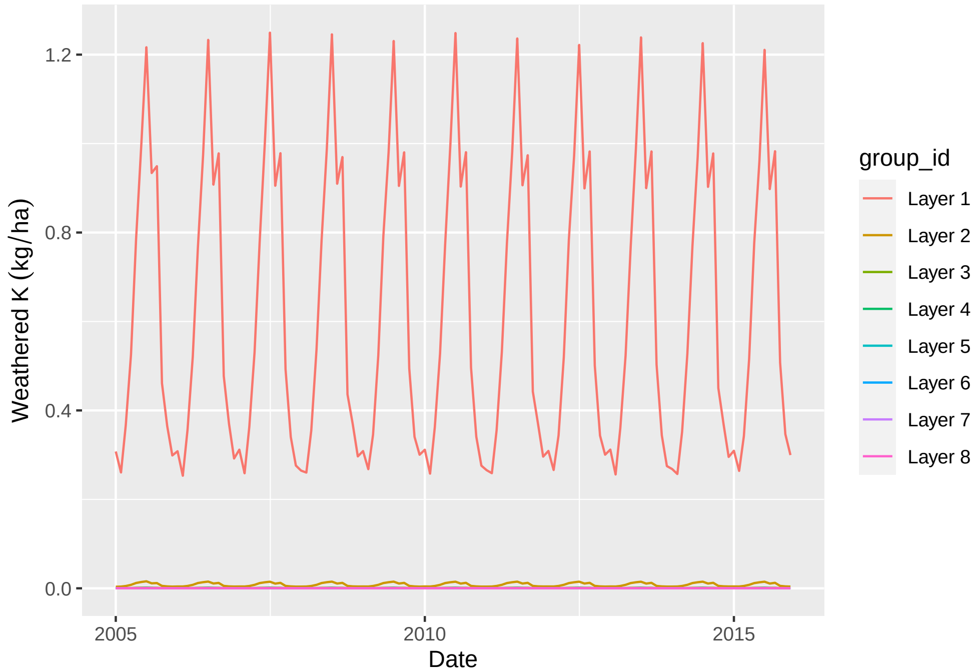


Figure 15: Potassium Weathering (All Layer)

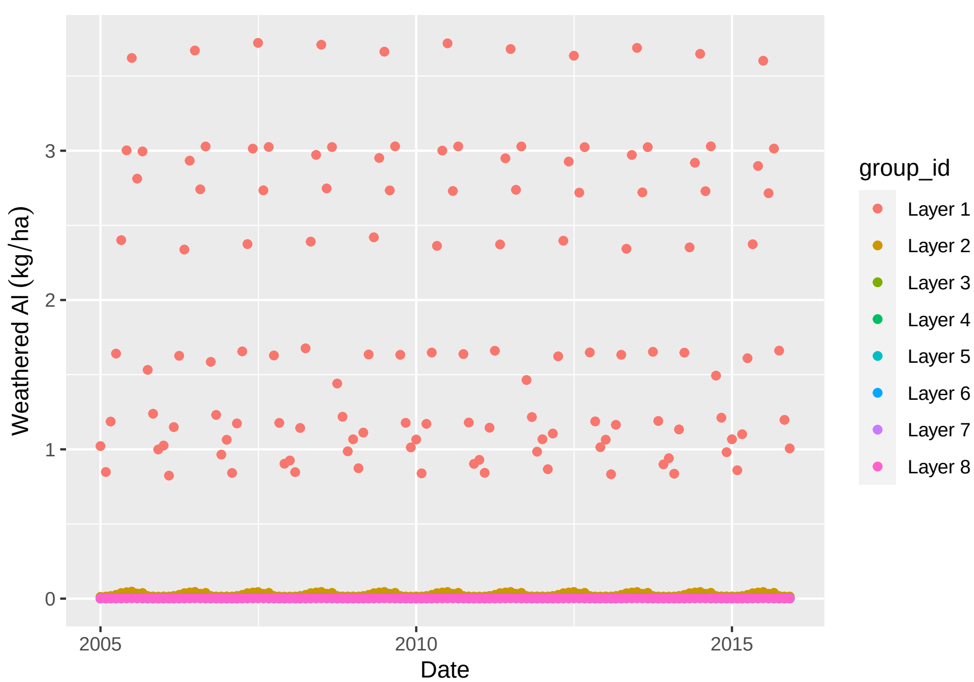


Figure 16: Aluminum Weathering (All Layer)

Figure 17: Phosphate Weathering (All Layer)

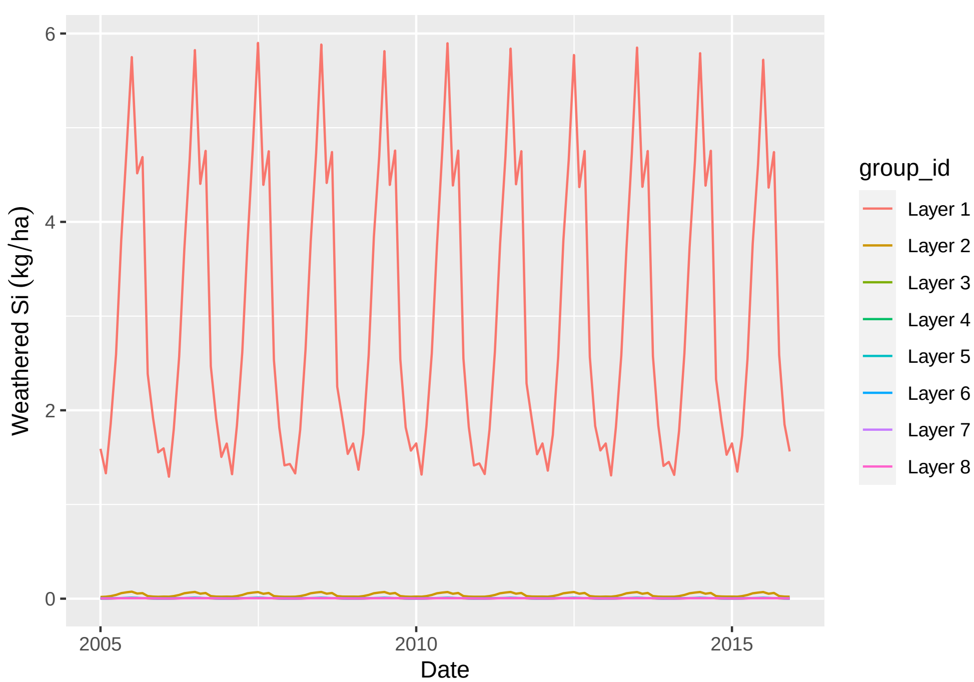


Figure 18: Silica Weathering (All Layer)

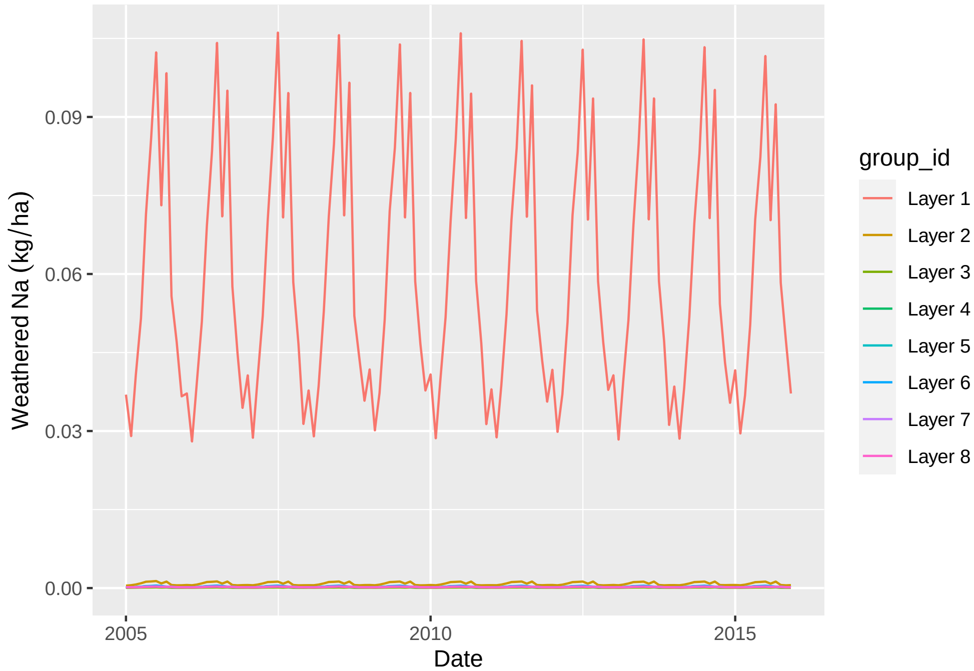
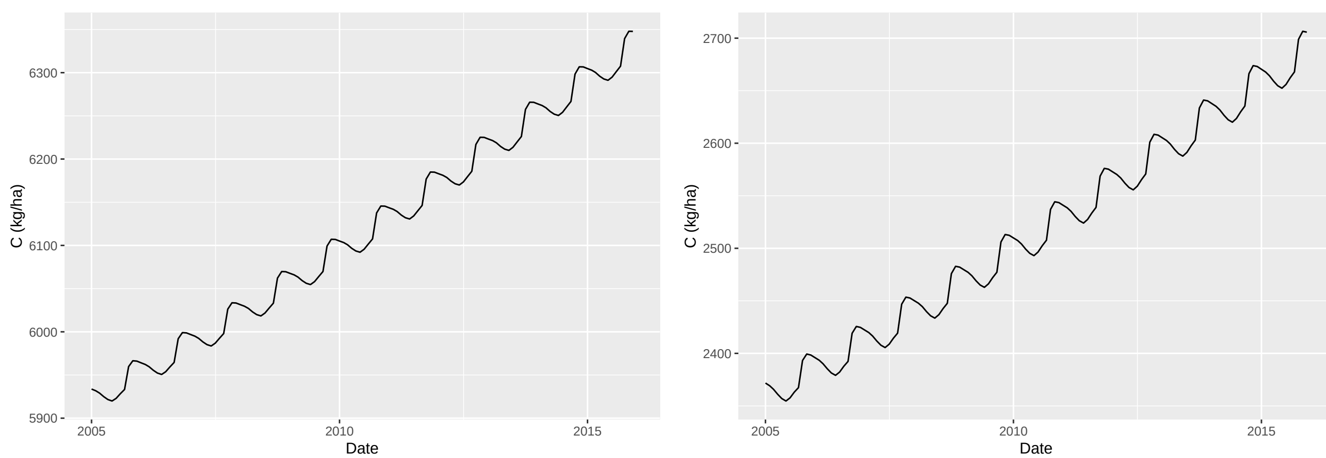


Figure 19: Sodium Weathering (All Layer)

Litter Pool Results

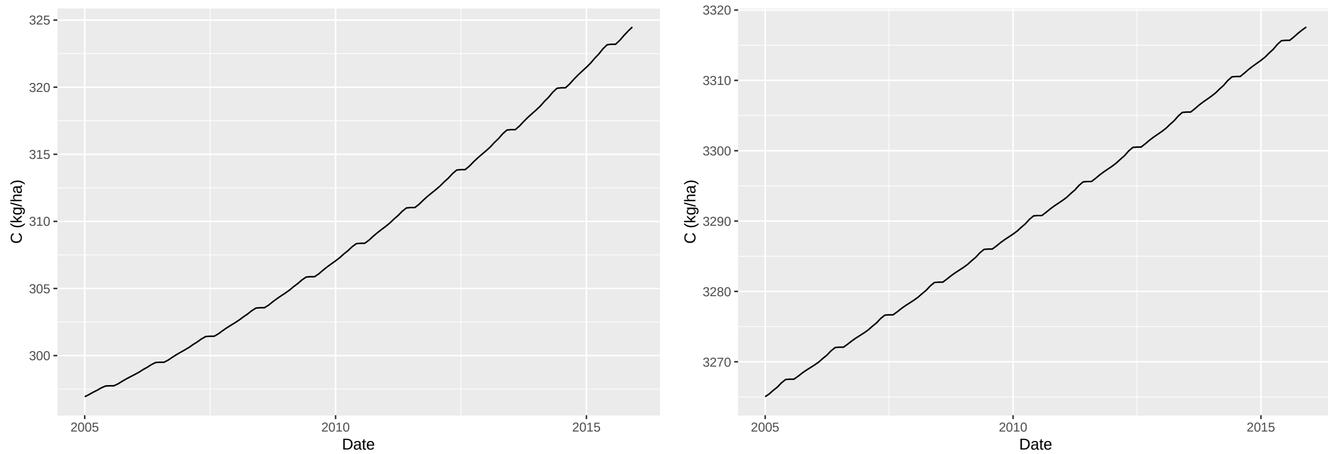


(a) Total forest floor carbon content (kg/ha)

(b) Carbon content of coarse litter (kg/ha)

Figure 20: Forest Floor (O-Layer) Carbon Content Over Simulation Period

Looking at a range of soil carbon studies in Douglas-fir forests of the Pacific Northwest, forest floor (defined as non-mineral OM) C content goes from a lower bound of 3,700 kg C/ha in a 9-yr old stand(Cromack et al. 1999) to 8200 kg C/ha in an average 38 year old stand [edmondsRelationshipsSoilOrganic1994]. These stands were notably N rich compared to the site simulated for the low N site, the soil C should be lower in the simulations as there is about half as much soil N in the low N simulated site as in the sites described in [edmondsRelationshipsSoilOrganic1994]. The high N site has about 21,000 kg N/ha at 1m depth, so it should be modeled to be at the higher end of organic and litter C buildup.

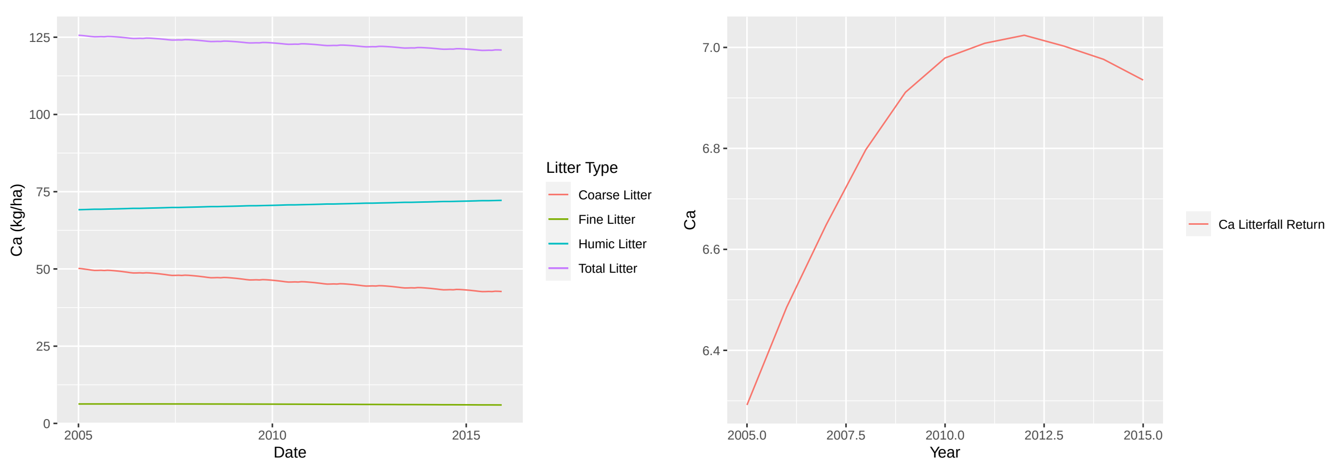


(a) Carbon content of fine litter (kg/ha)

(b) Carbon content of humic litter (kg/ha)

Figure 21: Forest Floor (O-Layer) Carbon Content Over Simulation Period

Note that the fine litter pool (the stage between humus and fresh/coarse litter) is growing in this model. This might deviate from observed behavior.

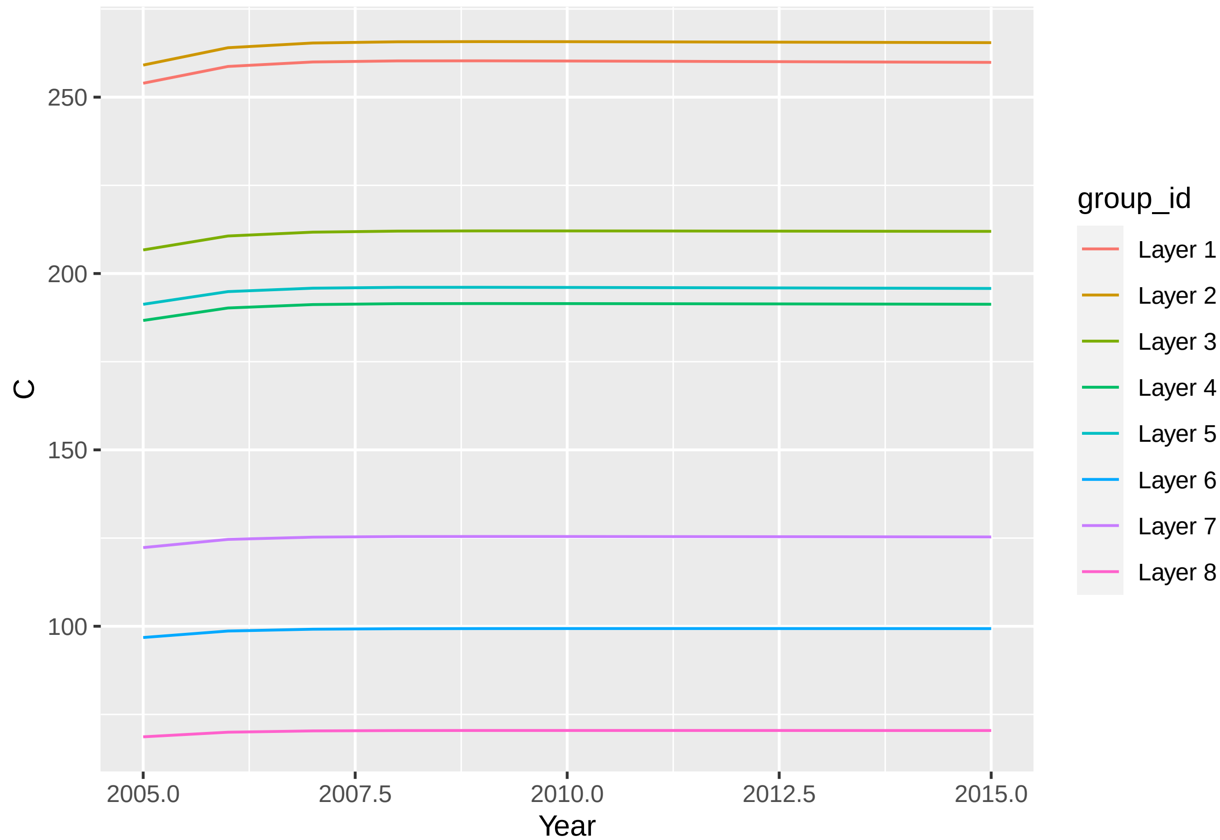


(a) Ca Content in each litter decomposition stage (kg/ha)

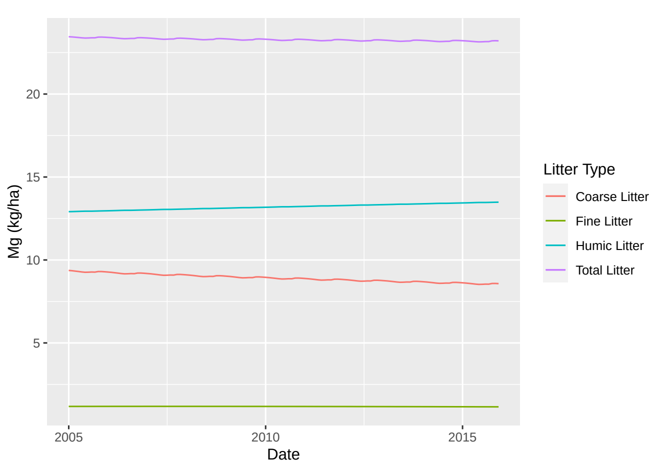
(b) Ca net annual return in litterfall (kg/ha)

Figure 22: Forest Floor/O-horizon Ca content over time (a). and net annual Ca return in litterfall (b).

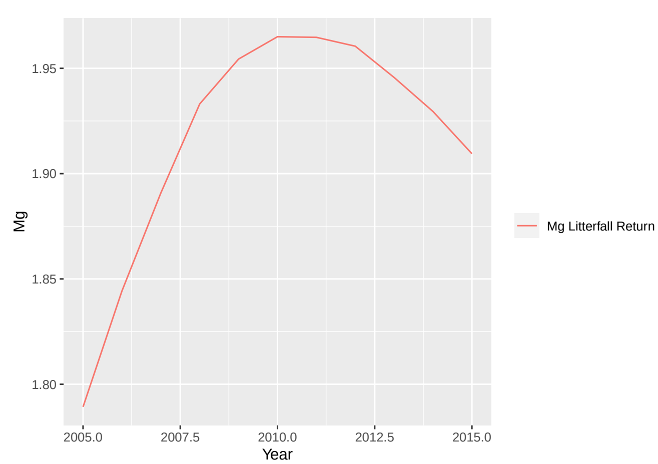
Soil Organic Matter Results



Mineral soil SOM C content is very high compared to other pools of carbon in the ecosystem, soil carbon should buildup over time assuming available surfaces exist for soil carbon "stabilization". In NutsFor, the SOM pool is represented by an active microbial pool, so there are issues with building up SOM in the soil as one might expect from a real stand. Microbial growth is limited by soil moisture and nutrient availability like the tree pool, so it is not a wholly adequate representation of C stabilization. Instead of calibrating this output to show buildup, I calibrated it such that it was "level", thus, soil carbon additions to the mineral soil are dictated by DOC percolation with water flow.

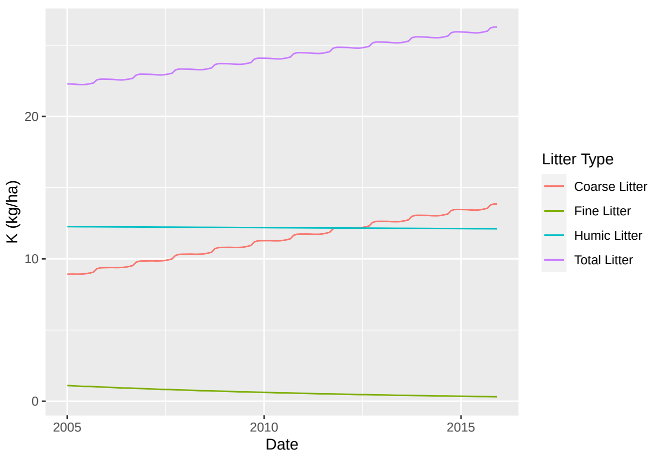


(a) Mg Content in each litter decomposition stage (kg/ha)

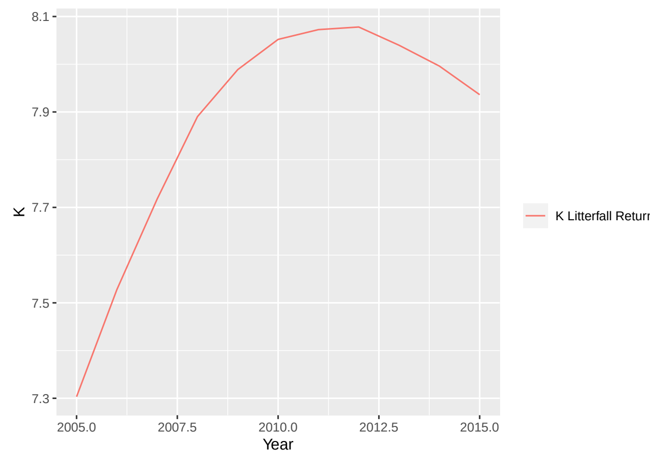


(b) Mg net annual return in litterfall (kg/ha)

Figure 23: Forest Floor/O-horizon Mg content over time (a). and net annual Mg return in litterfall (b).

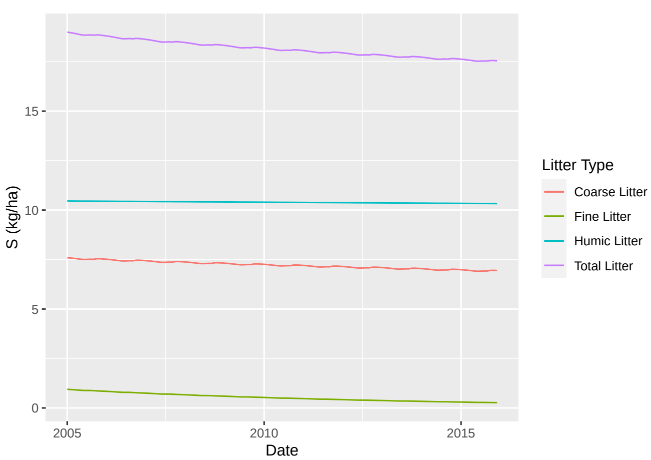


(a) K Content in each litter decomposition stage (kg/ha)

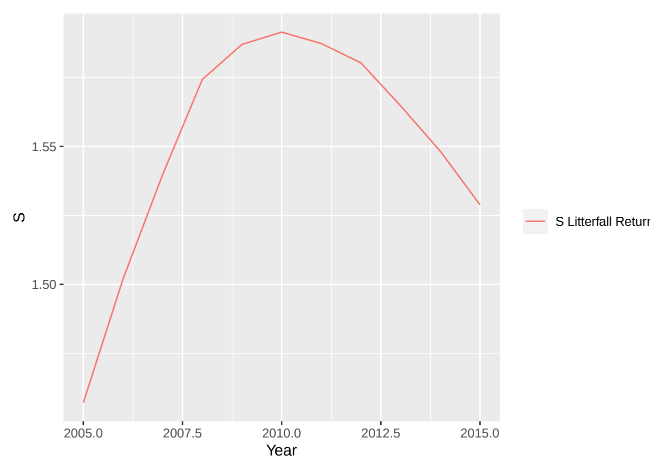


(b) K net annual return in litterfall (kg/ha)

Figure 24: Forest Floor/O-horizon K content over time (a). and net annual K return in litterfall (b).

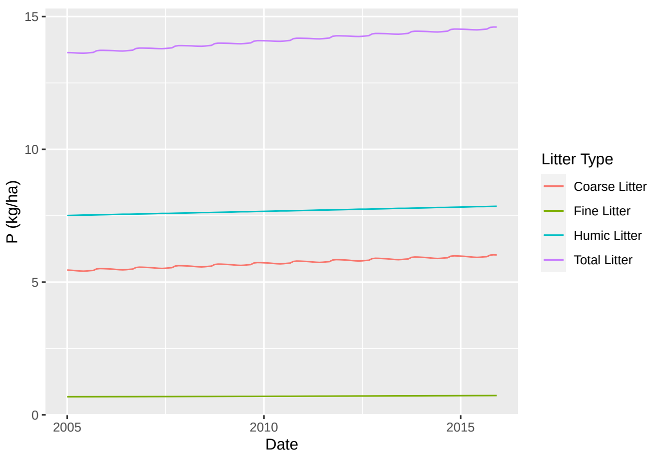


(a) S Content in each litter decomposition stage (kg/ha)

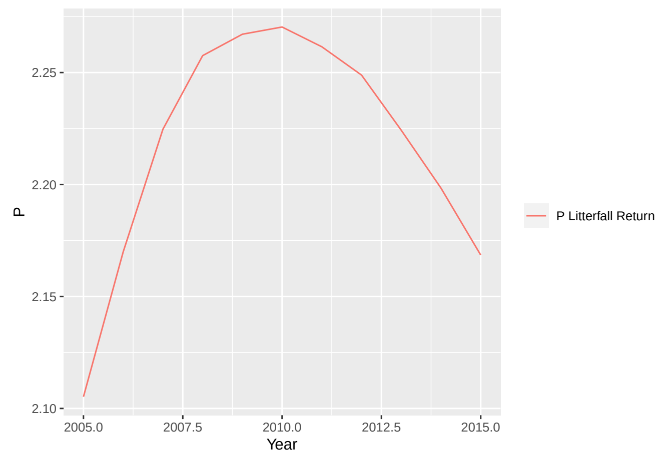


(b) S net annual return in litterfall (kg/ha)

Figure 25: Forest Floor/O-horizon S content over time (a). and net annual S return in litterfall (b).

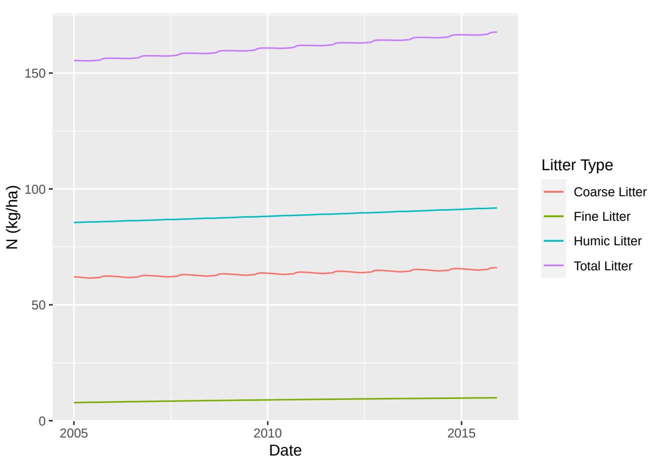


(a) P Content in each litter decomposition stage (kg/ha)

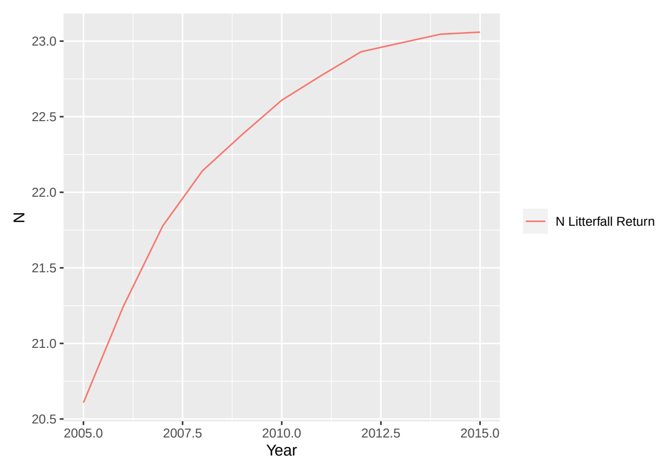


(b) P net annual return in litterfall (kg/ha)

Figure 26: Forest Floor/O-horizon P content over time (a). and net annual P return in litterfall (b).



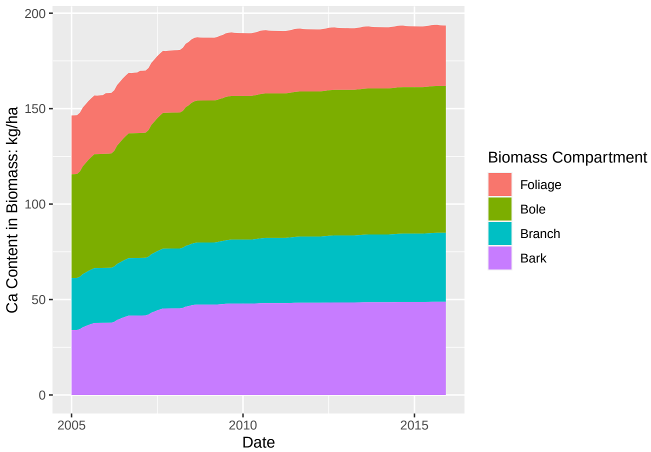
(a) N Content in each litter decomposition stage (kg/ha)



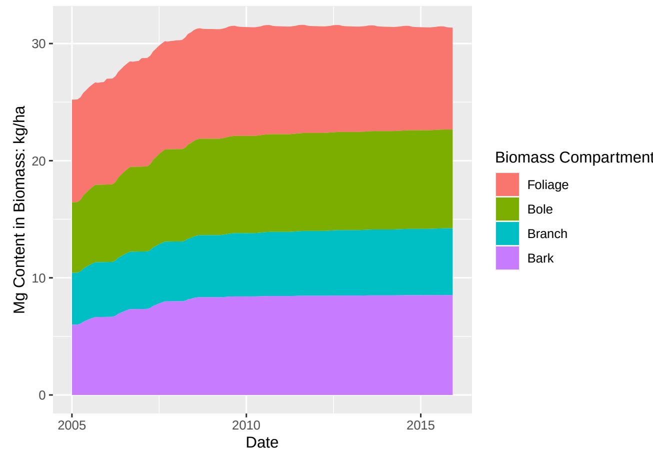
(b) N net annual return in litterfall (kg/ha)

Figure 27: Forest Floor/O-horizon N content over time (a). and net annual N return in litterfall (b).

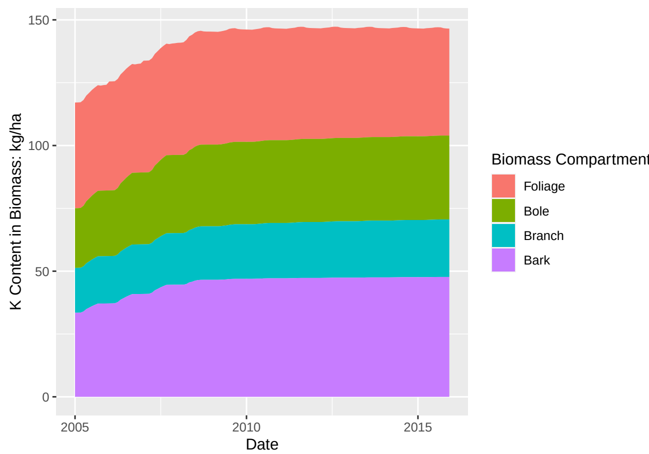
Tree Nutrient Content



(a) Calcium content in each biomass compartment

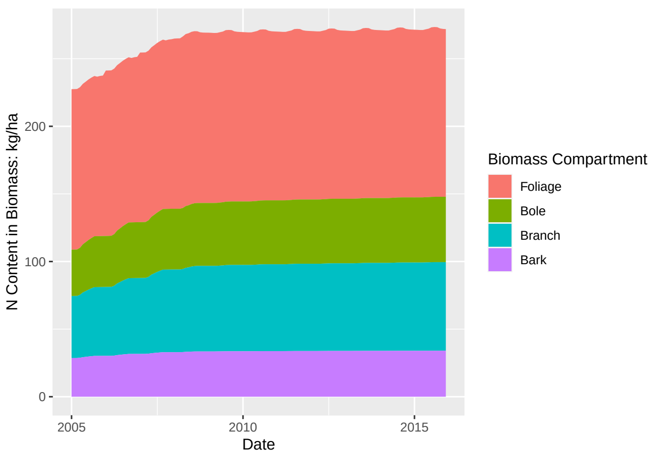


(b) Magnesium content in each biomass compartment

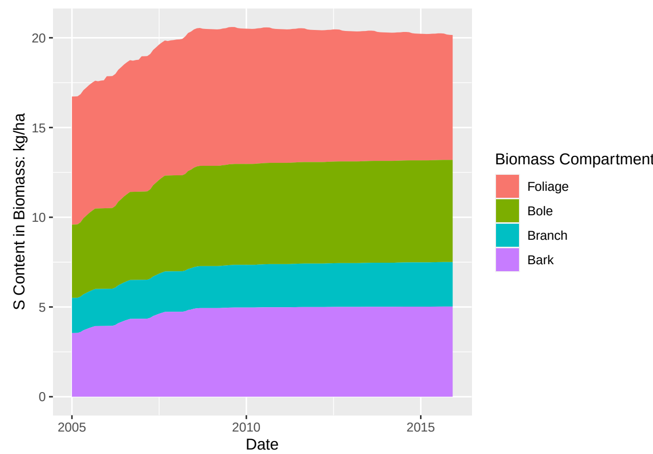


(c) Potassium content in each biomass compartment

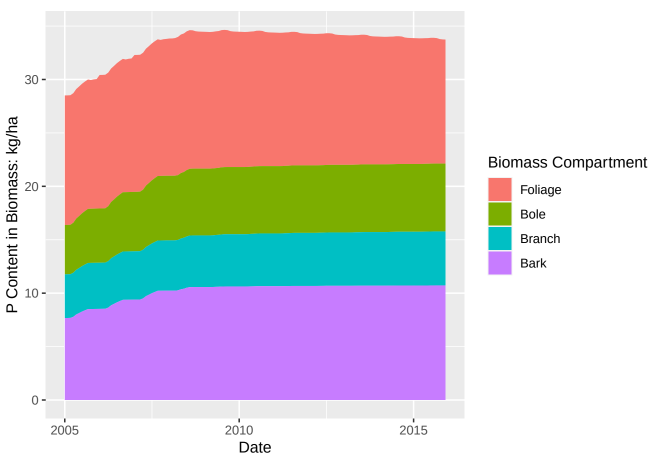
Figure 28: Base Cation Nutrient Content in Simulated Forest



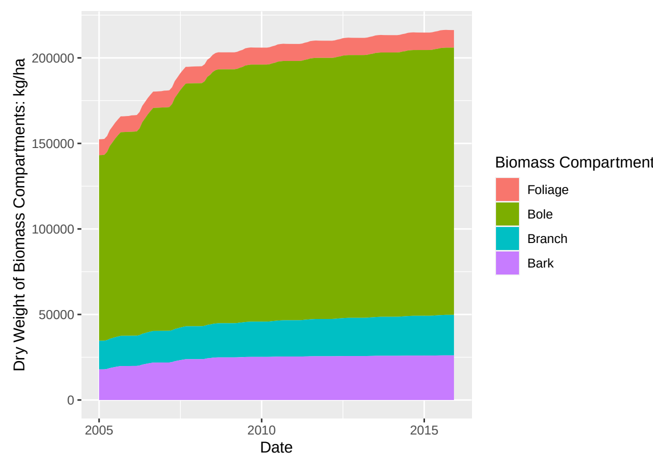
(a) Nitrogen content in each biomass compartment



(b) Sulfur content in each biomass compartment



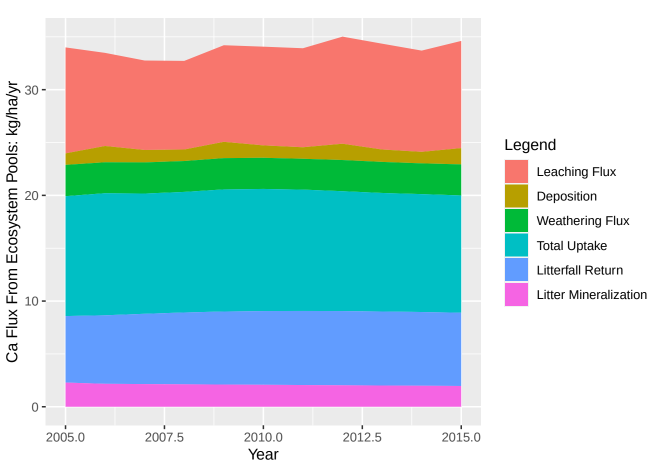
(c) Phosphorous content in each biomass compartment



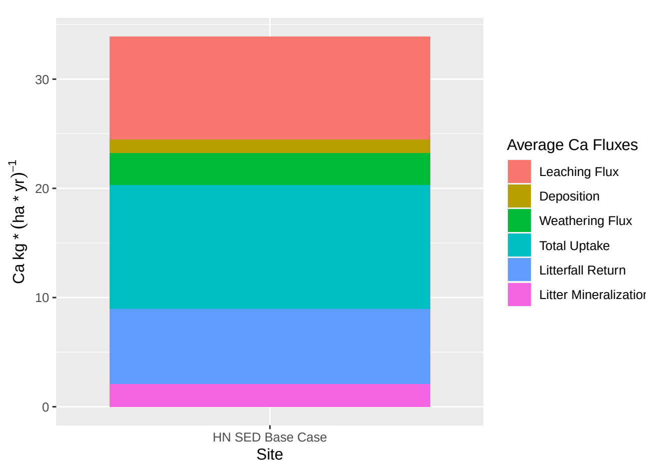
(d) Biomass of each compartment

Figure 29: N, S, and P Nutrient Contents and biomass per compartment

Analysis 1: Stack Flux Data

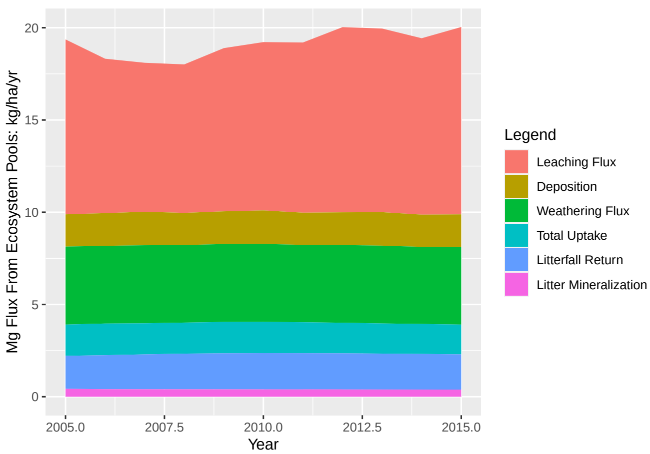


(a) Ca input and output fluxes over time

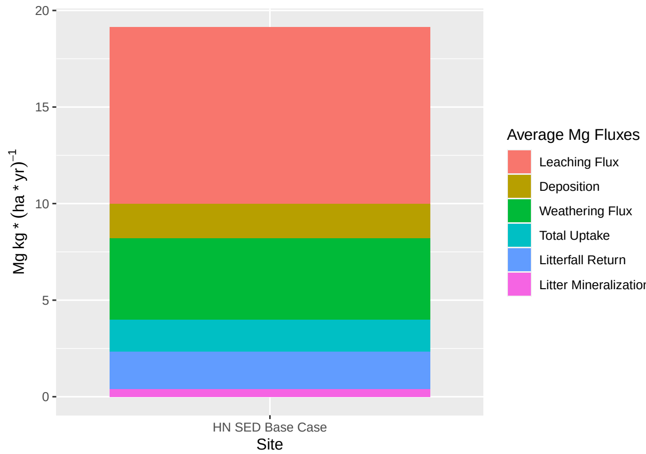


(b) Total Average Ca input and output fluxes

Figure 30: Calcium input and output comparison graphs

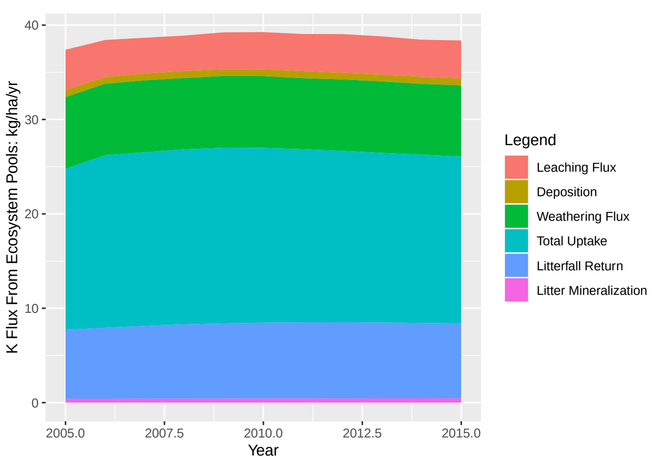


(a) Mg input and output fluxes over time

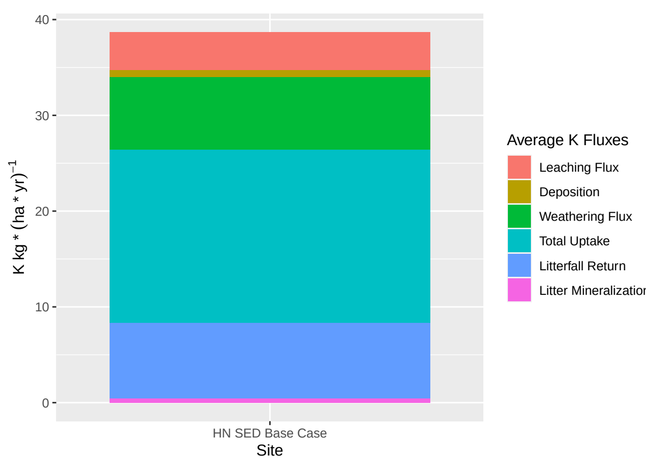


(b) Total Average Mg input and output fluxes

Figure 31: Magnesium input and output comparison graphs

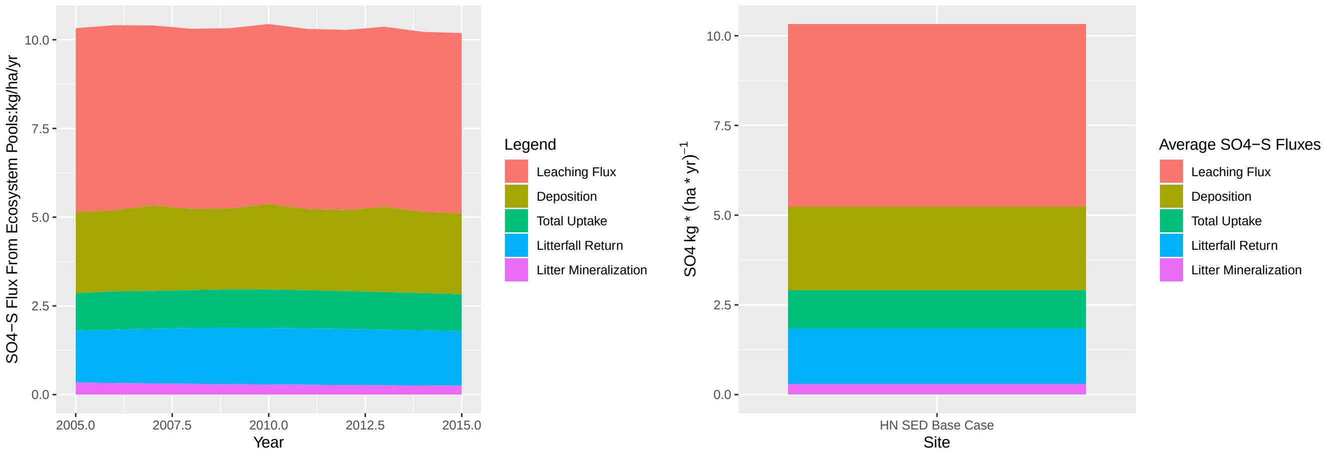


(a) K input and output fluxes over time



(b) Total Average K input and output fluxes

Figure 32: Potassium input and output comparison graphs



(a) S input and output fluxes over time

(b) Total Average S input and output fluxes

Figure 33: Sulfur input and output comparison graphs

The sulfate adsorbed pool depletes itself, the organic sulfur pool becomes increasingly dominant. This behavior is not unreasonable, however I would expect higher sulfate adsorption.

(a) N input and output fluxes over time

(b) Total Average N input and output fluxes

Figure 34: Nitrogen input and output comparison graphs

There looks to be a SOM reporting bug which causes a large negative spike in N mineralization, it does not seem to affect the simulation in terms of N flux or nutrient uptake, which tells me it is likely a reporting error.

Cation Exchange Capacity

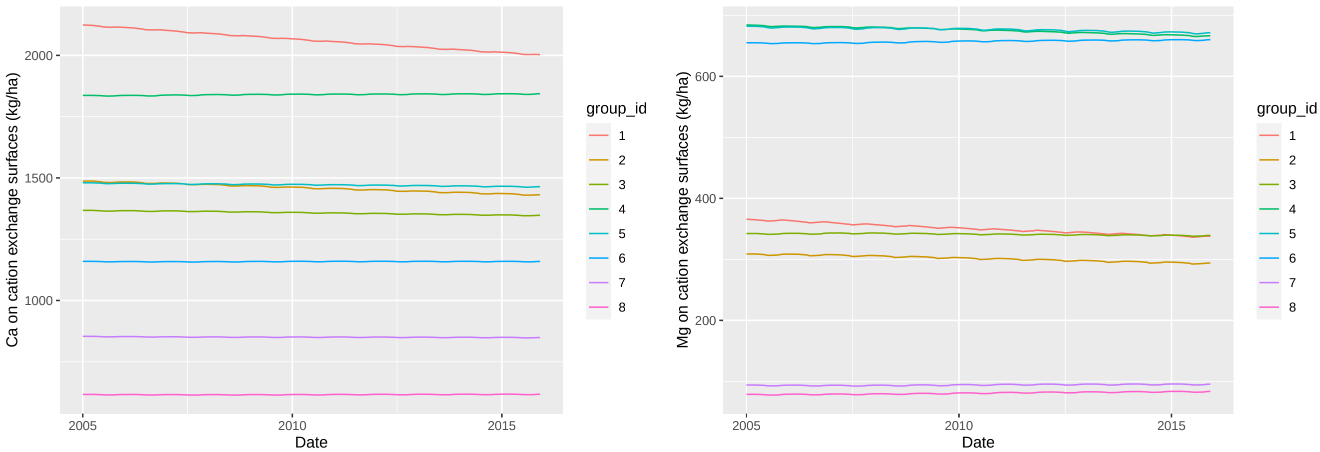


Figure 35: Calcium and Magnesium on exchangerover time

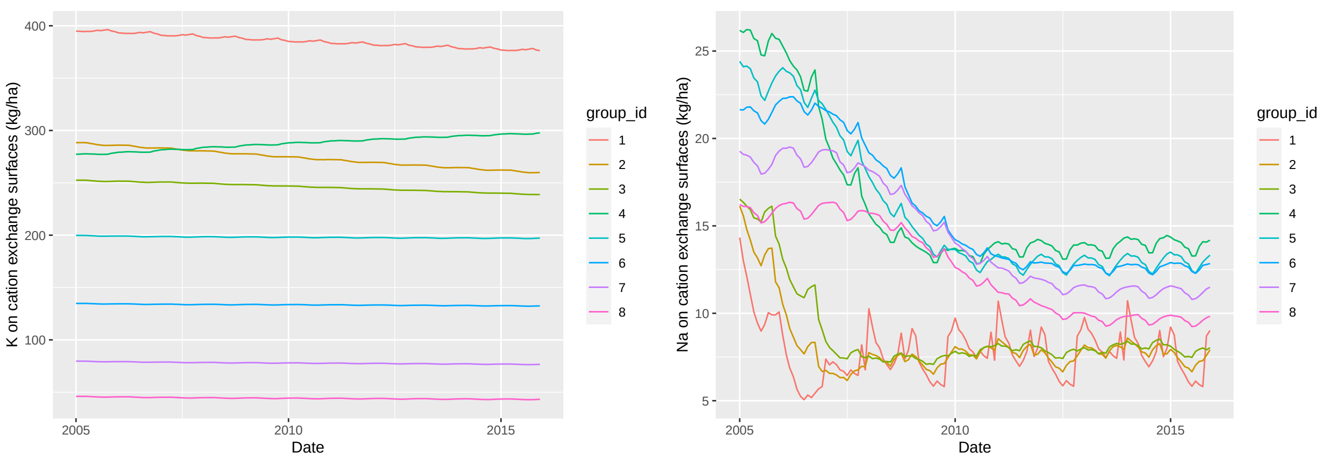


Figure 36: Potassium and Sodium on exchangerover time

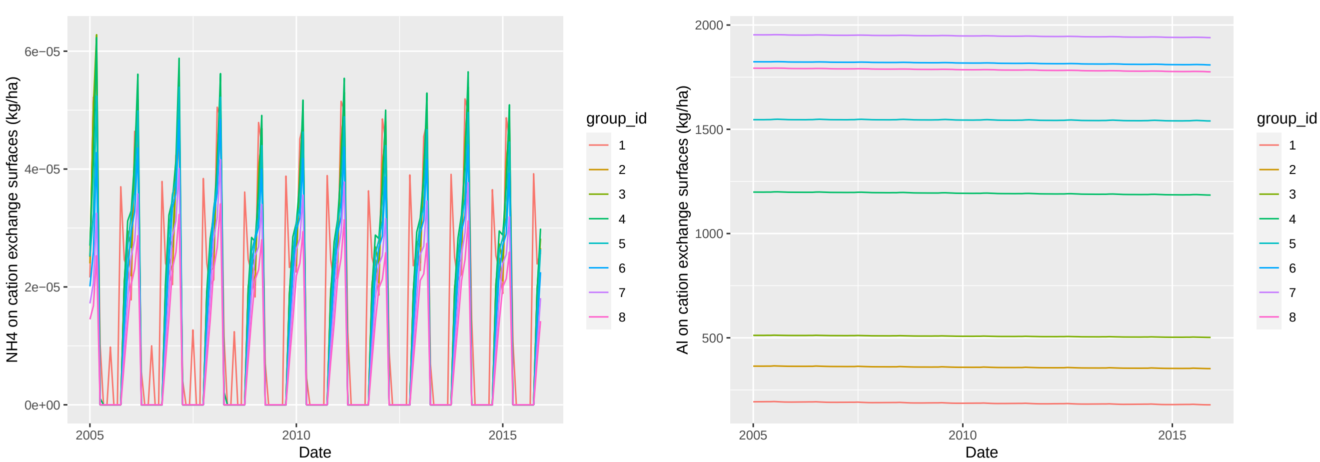
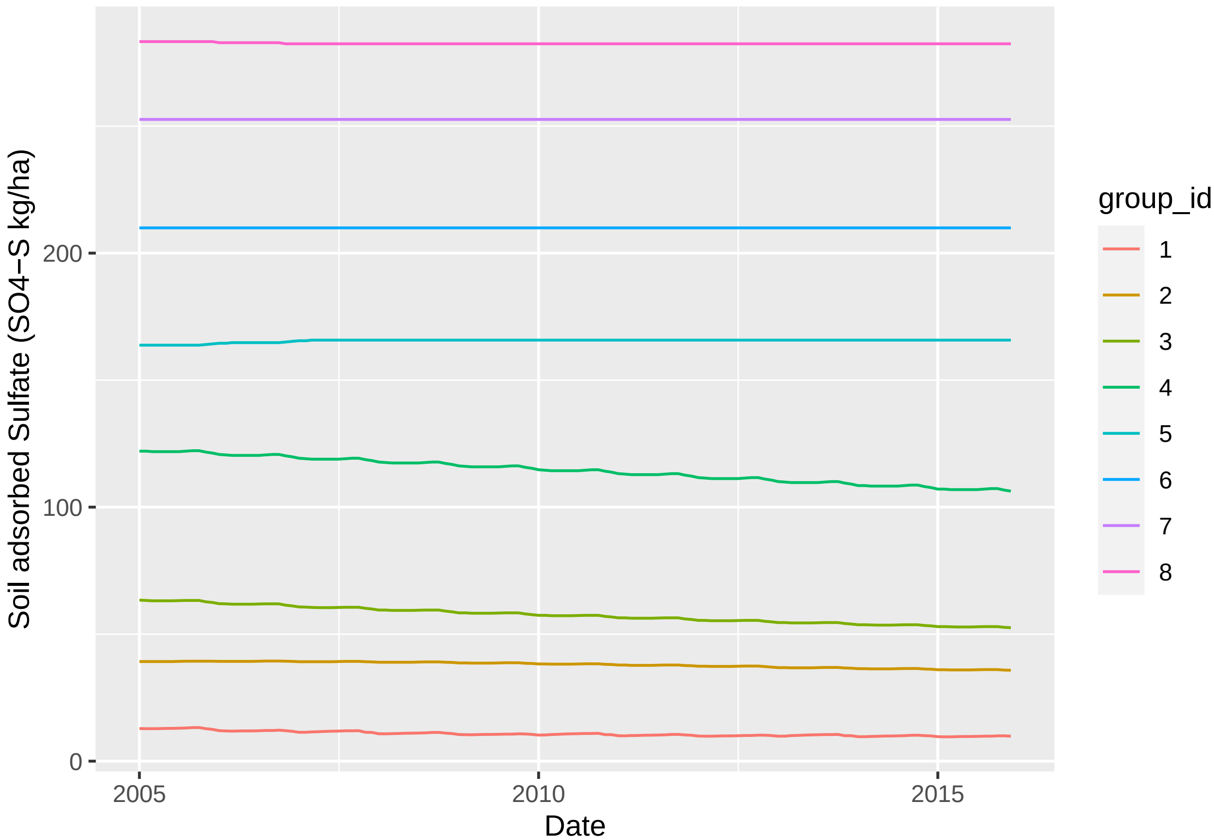
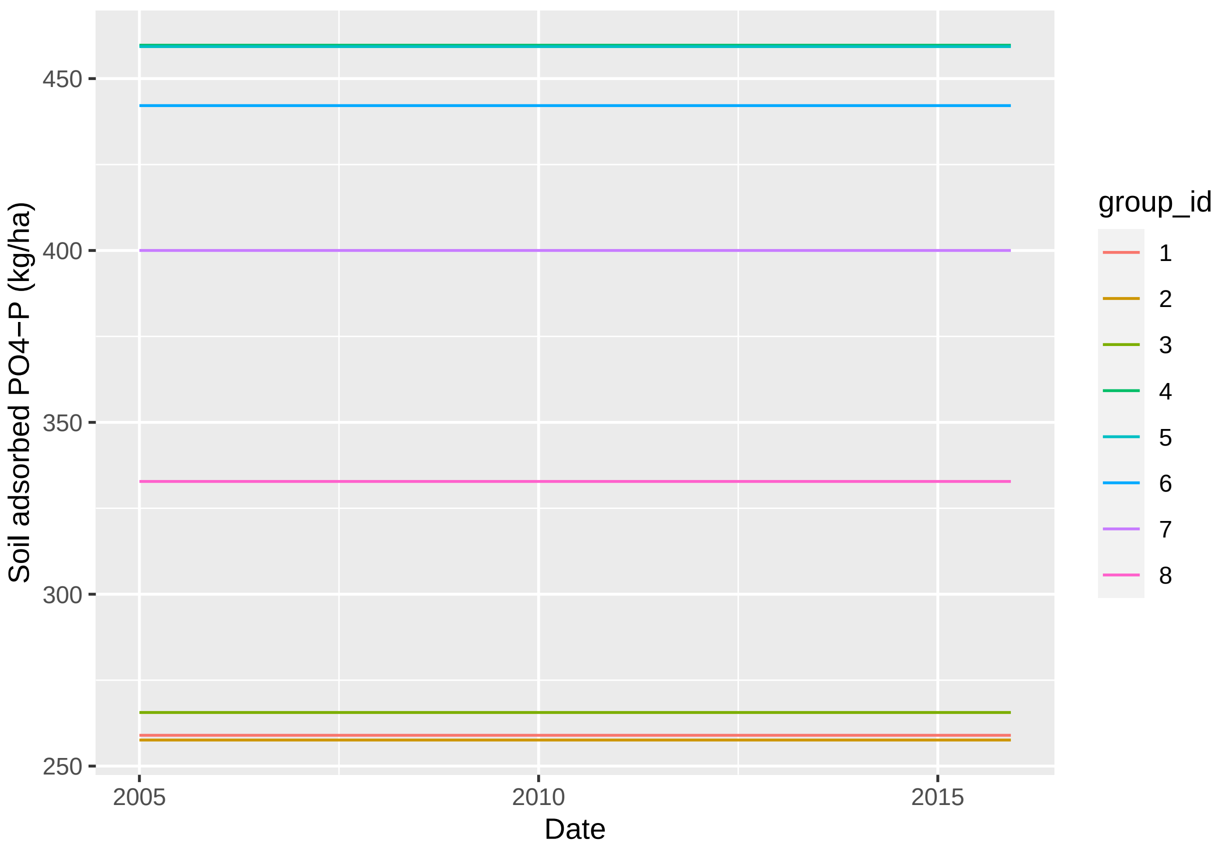


Figure 37: Ammonium and Aluminum on exchangerover time

Anion Exchange Capacity

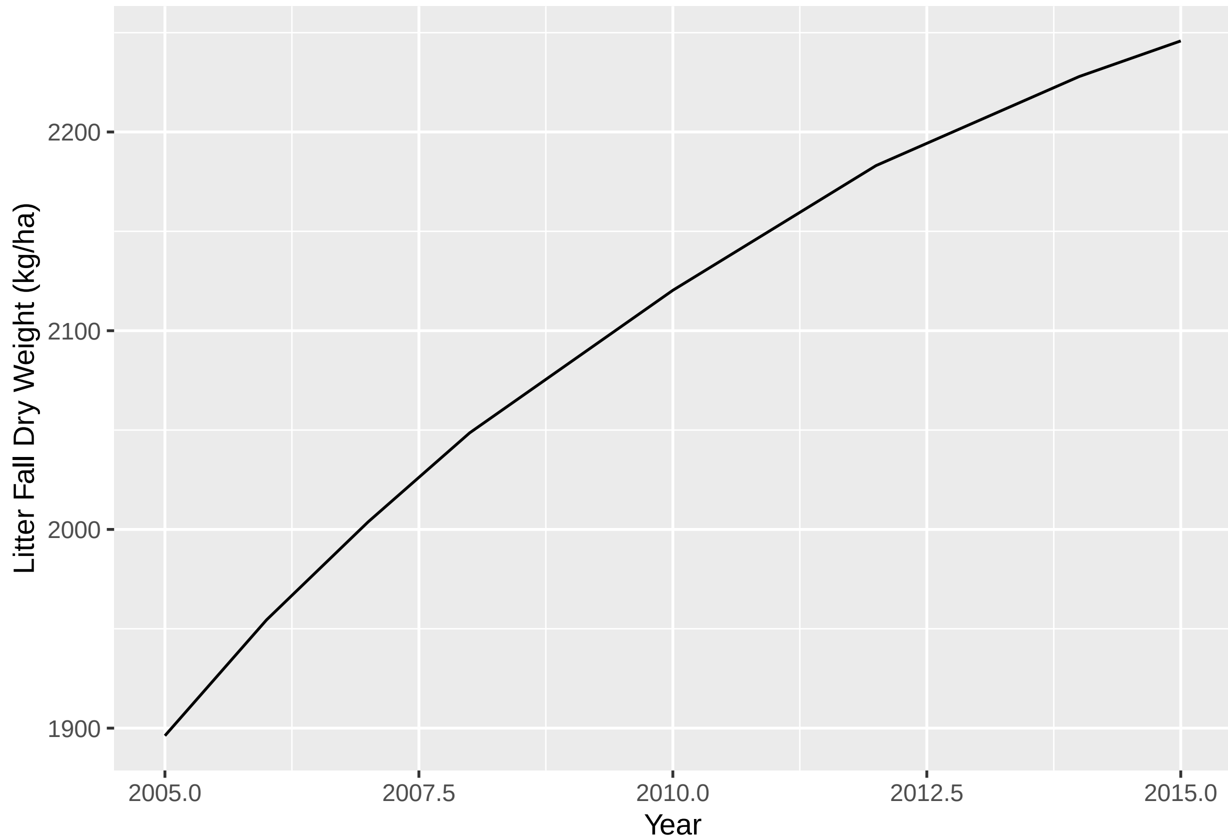




The phosphate adsorption is set from the original parameterization I received from Gregory. It tends to build up, which implies a high soil solution concentration (adsorption is determined by concentration).

Sulfate adsorption is weak and drains easily, I set a low adsorbed sulfate pool following IFS data from the Thompson site (glacial outwash, inceptisol). According to the book *Atmospheric Sulfur Deposition: Environmental and Health Impacts*, sulfur is mostly locked in organic compartments rather than on the adsorption surfaces. We might expect that sulfate, like phosphate, would increase on the AEC, however the input of sulfate relative to the adsorption and uptake of sulfate is likely too low to facilitate adsorption. This is well supported by IFS data that show low sulfate adsorption on potentially high capacity adsorbing soils. The higher sulfate concentrations observed at the high N site could well be due to a higher inherent sulfur pool, possibly a condition of higher sulfate-mineral weathering, or due to a competitive response with phosphate.

Other



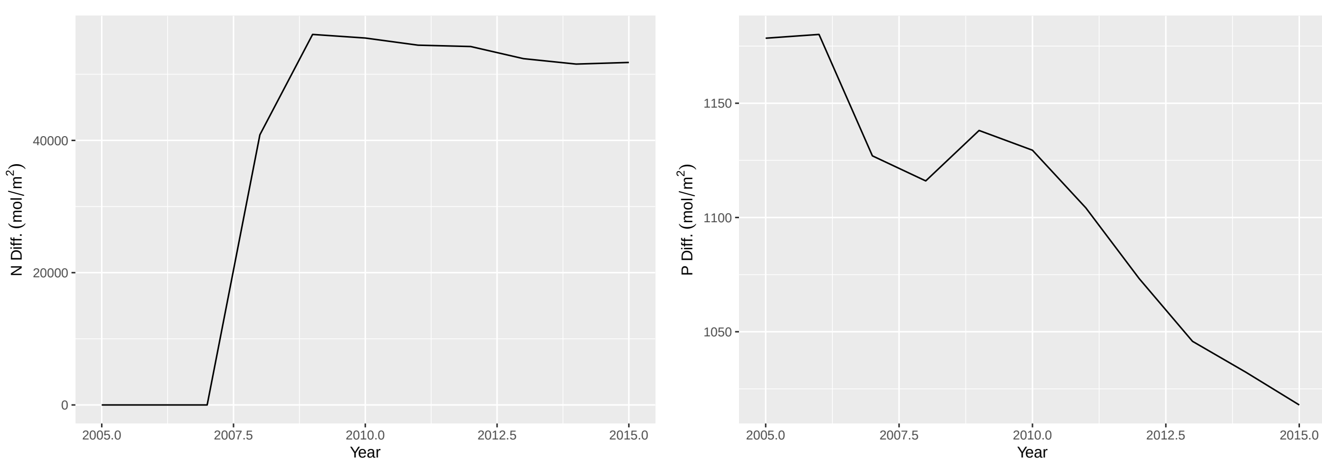


Figure 38: N and P Potential Uptake to Actual Uptake Difference

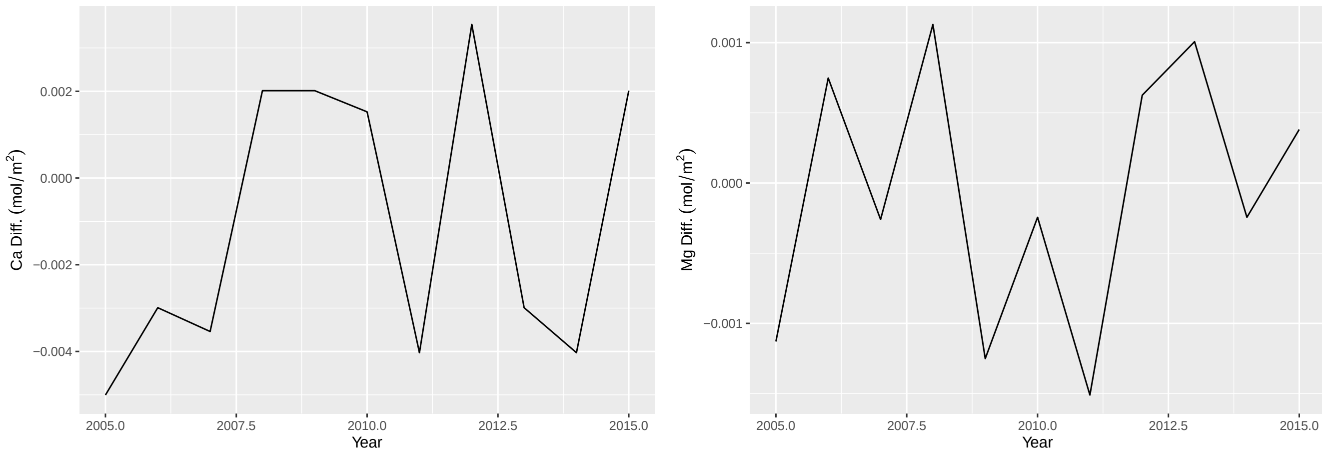


Figure 39: Ca and Mg Potential Uptake to Actual Uptake Difference

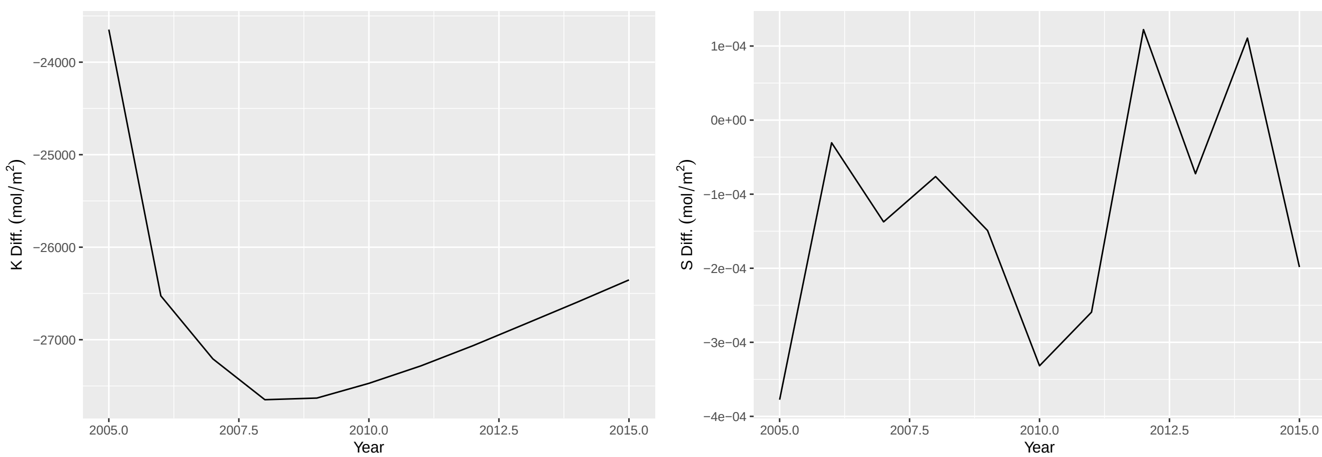


Figure 40: K and S Potential Uptake to Actual Uptake Difference

What I get from this calculation is that for all nutrients except N and P, the stand is able to extract near exactly the required amount of each nutrient for growth. For K, foliar leaching causes excessive total uptake, however the mineral pool is rich enough in K to facilitate this excess uptake. These graphs do not take into consideration that uptake can vary by 20% before growth limitation is induced.

Cromack, Kermit, Richard E. Miller, Harry W. Anderson, Ole T. Helgerson, and Robert B. Smith. 1999. "Soil Carbon and Nutrients in a Coastal Oregon Douglas-Fir Plantation with Red Alder." *Soil Science Society of America Journal* 63 (1): 232–39. https://doi.org/10.2136/sssaj1999.03615995006300010034x.