Calibration Report: High N Sedimentary Site Base Case

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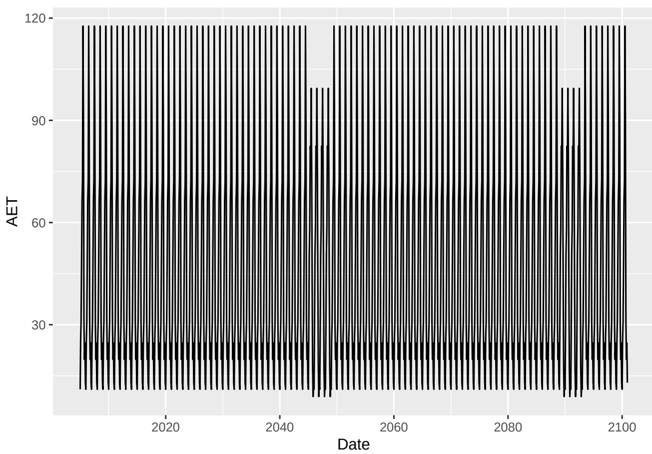
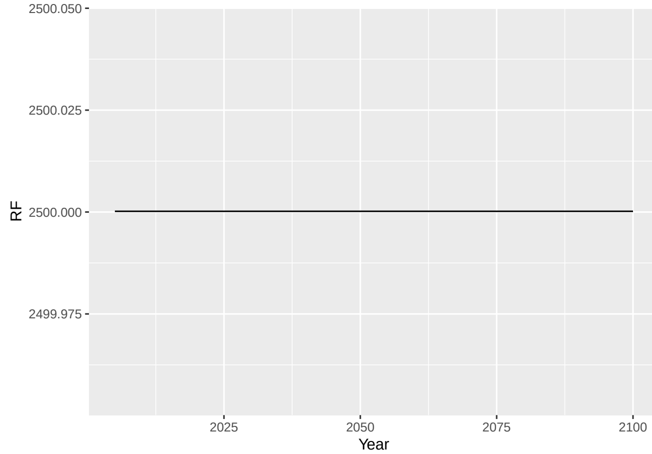
Hydrology





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	26.00	37.53	4.87	53.4	66.6	4.08	8.40	71.5	0.535	191.7	33.7	5.26	25.4	4.60	130.0	61.7
Layer 2	18.80	31.83	4.47	74.0	40.2	3.97	6.78	81.3	0.252	112.4	11.9	12.12	14.5	4.84	82.5	29.9
Layer 3	13.99	24.04	2.54	89.9	29.2	2.56	9.16	86.1	0.000	155.2	24.8	14.02	21.8	4.66	107.8	47.4
Layer 4	6.61	12.14	1.82	93.0	25.3	2.33	11.95	89.1	0.000	98.5	25.4	16.25	21.5	4.67	68.3	30.2
Layer 5	3.25	6.02	1.32	94.2	23.5	2.62	10.85	101.4	0.000	83.5	30.8	18.59	23.7	4.62	57.2	26.3
Layer 6	5.19	9.52	2.42	102.8	23.1	4.38	10.34	109.3	0.000	89.9	26.9	20.96	22.2	4.65	62.1	27.8
Layer 7	6.09	11.42	2.28	109.5	21.0	5.29	11.25	116.2	0.000	77.6	22.0	23.44	19.9	4.70	54.4	23.2
Layer 8	5.98	11.99	2.14	113.5	20.9	7.30	11.74	118.6	0.000	76.2	20.4	25.25	19.0	4.72	53.7	22.5

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	26	12	39	14	21	19.9	184	53	71	40	1.20	0.23	17	5.7	209	59	1.2	0.33	127	32	6.7	3.9	21	9.0	4.5
2	26	12	39	14	21	19.9	184	53	71	40	1.20	0.23	17	5.7	209	59	1.2	0.33	127	32	6.7	3.9	21	9.0	4.6
3	26	12	39	14	21	19.9	184	53	71	40	1.20	0.23	17	5.7	209	59	1.2	0.33	127	32	6.7	3.9	21	9.0	4.8
4	17	10	30	13	15	8.8	203	55	71	75	0.97	0.20	19	4.0	194	55	1.5	1.01	54	16	4.9	6.0	25	5.7	5.2
5	17	10	30	13	15	8.8	203	55	71	75	0.97	0.20	19	4.0	194	55	1.5	1.01	54	16	4.9	6.0	25	5.7	5.5
6	17	10	30	13	15	8.8	203	55	71	75	0.97	0.20	19	4.0	194	55	1.5	1.01	54	16	4.9	6.0	25	5.7	5.8
7	17	10	30	13	15	8.8	203	55	71	75	0.97	0.20	19	4.0	194	55	1.5	1.01	54	16	4.9	6.0	25	5.7	6.1
8	17	10	30	13	15	8.8	203	55	71	75	0.97	0.20	19	4.0	194	55	1.5	1.01	54	16	4.9	6.0	25	5.7	6.3

[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

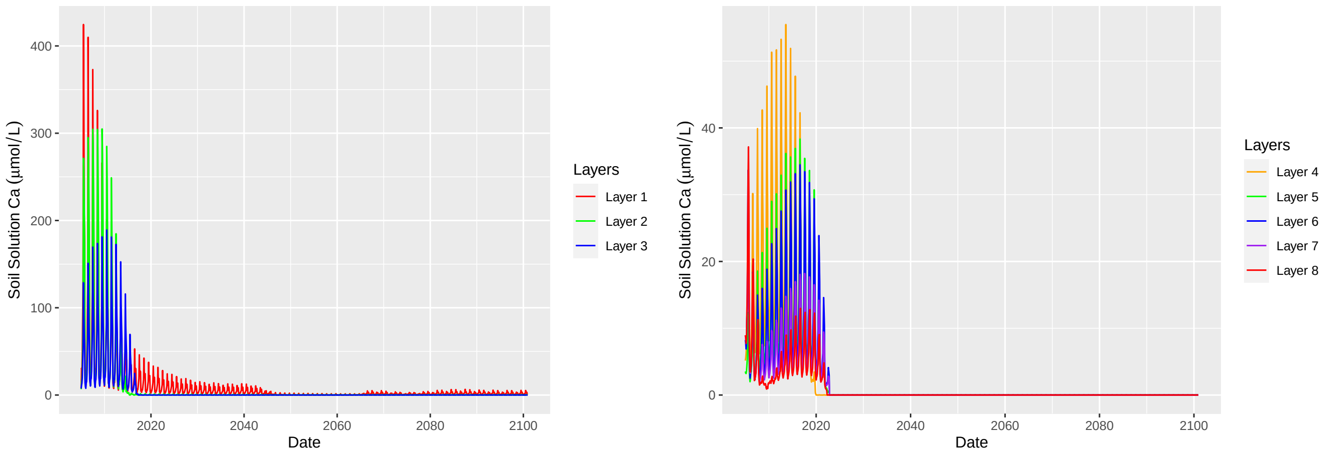


Figure 1: Monthly Calcium Concentrations by Soil Layer

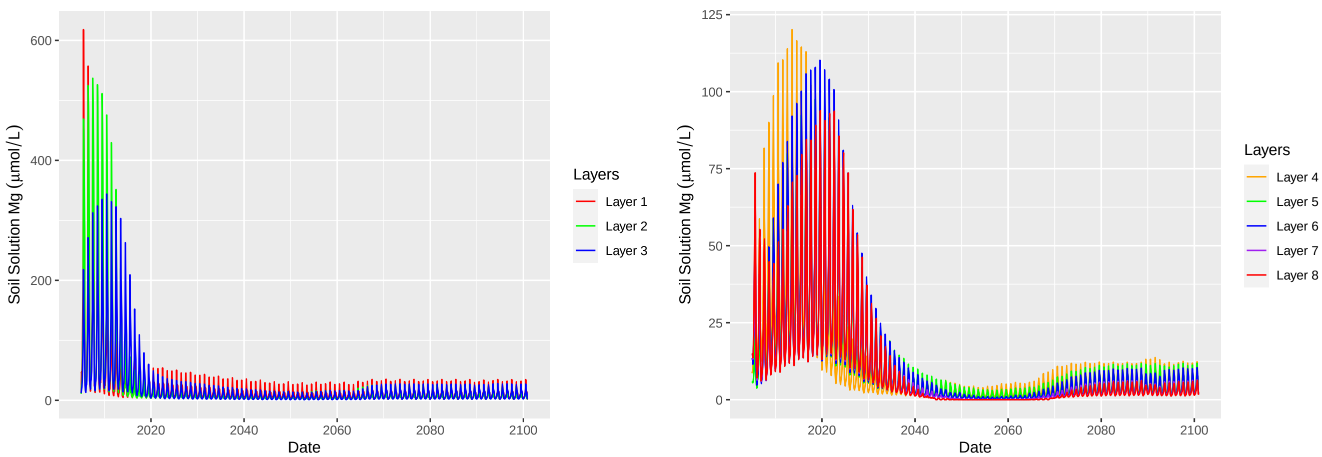


Figure 2: Monthly Magnesium Concentrations by Soil Layer

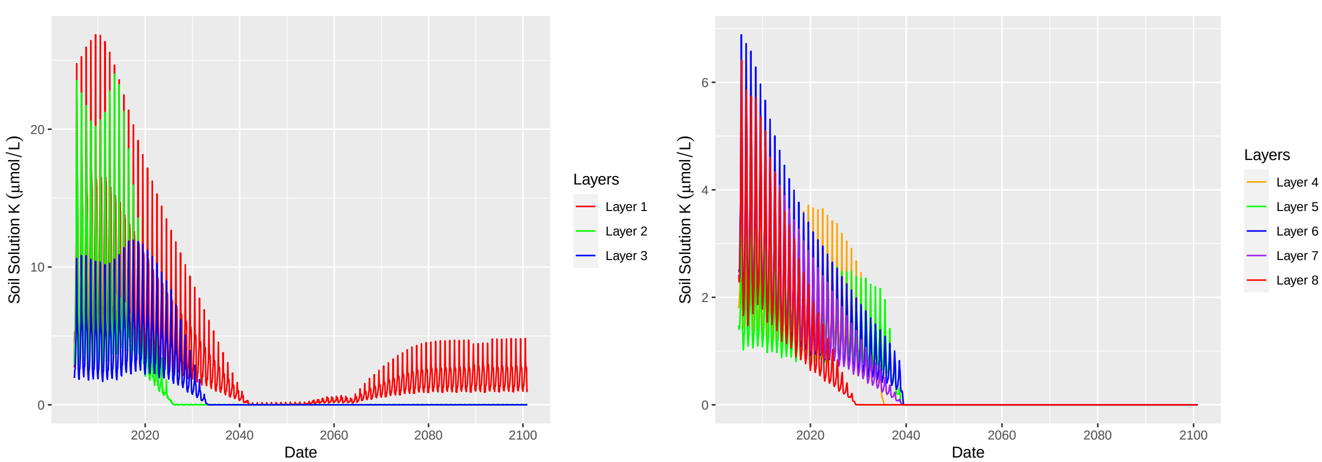


Figure 3: Monthly Potassium Concentrations by Soil Layer

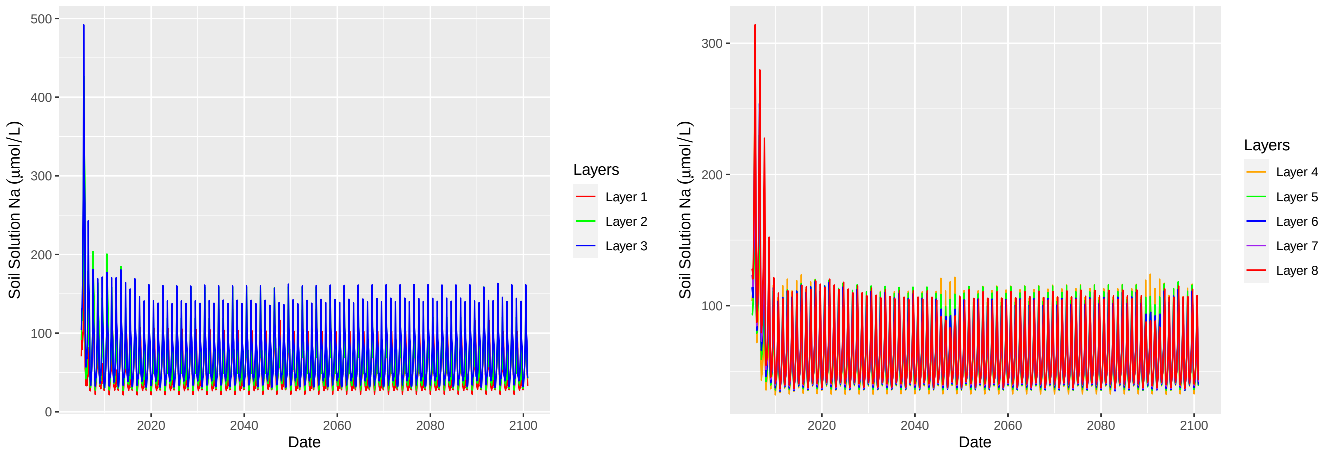


Figure 4: Monthly Sodium Concentrations by Soil Layer

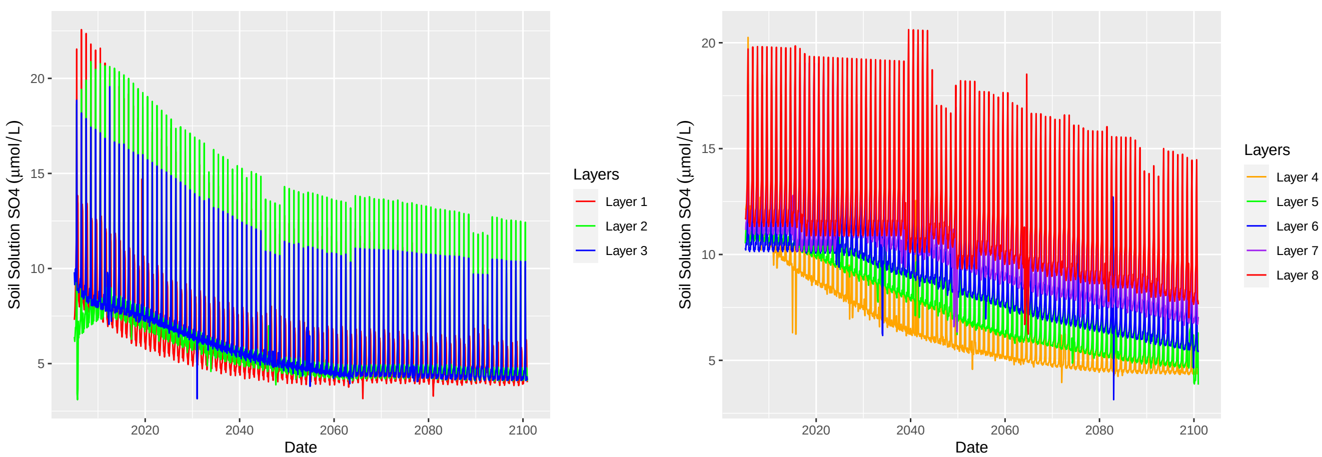


Figure 5: Monthly Sulfate Concentrations by Soil Layer

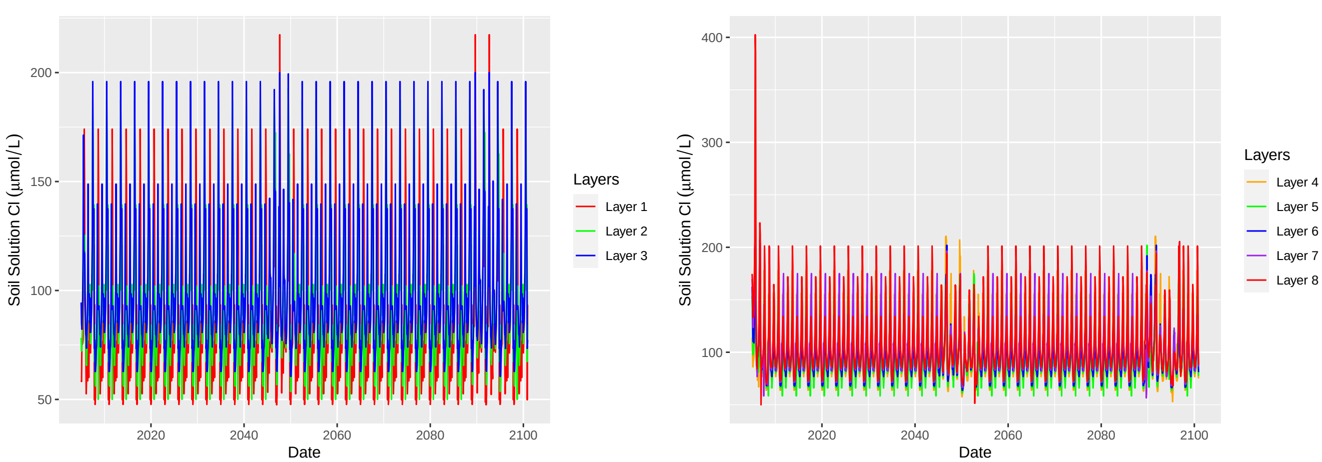


Figure 6: Monthly Chloride Concentrations by Soil Layer

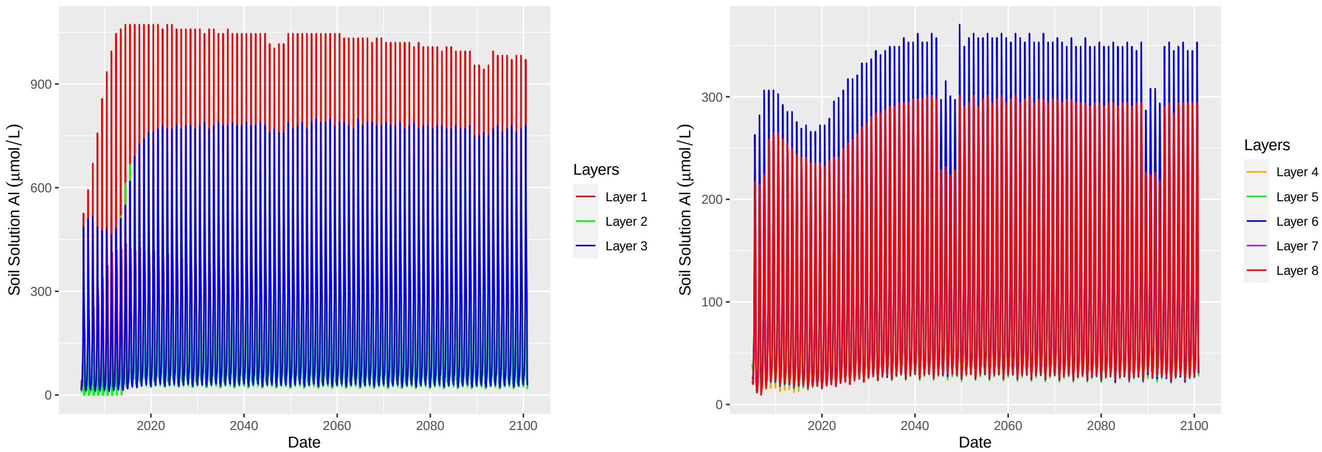


Figure 7: Monthly Aluminum Concentrations by Soil Layer

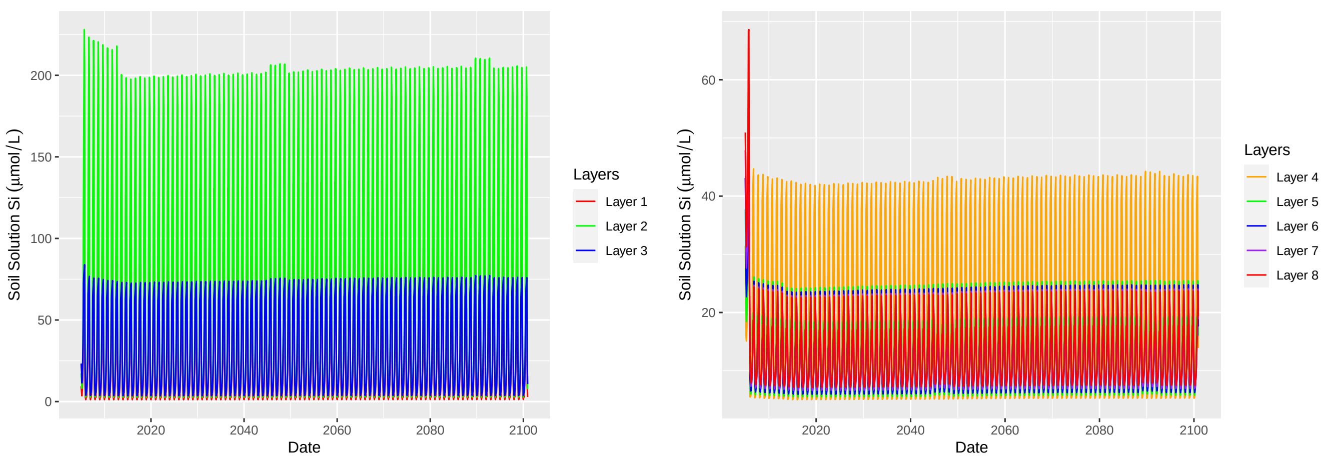


Figure 8: Monthly SiO2 Concentrations by Soil Layer

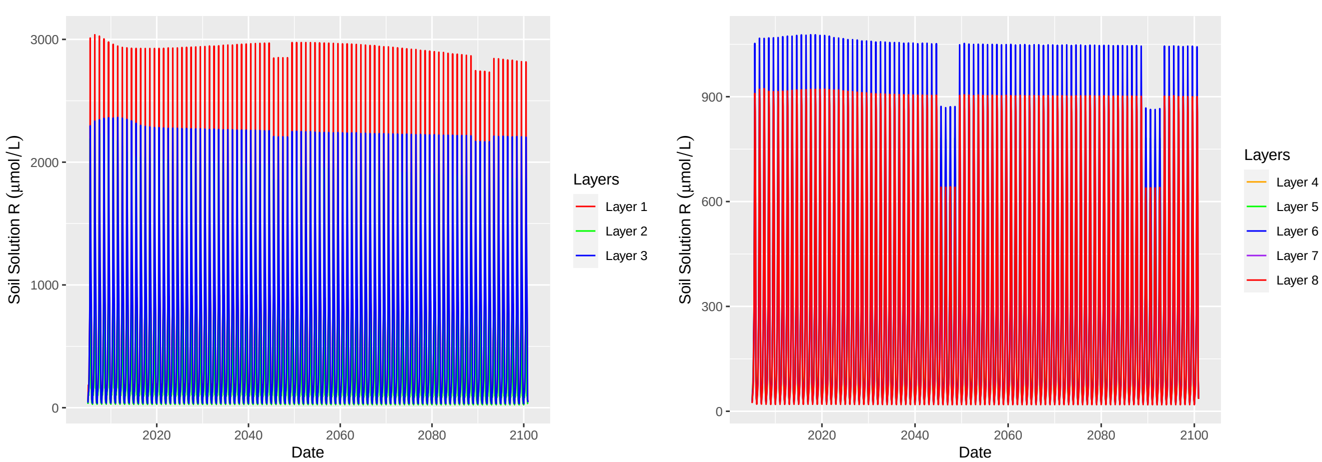


Figure 9: Monthly Organic Acid Base (R-) Concentrations by Soil Layer

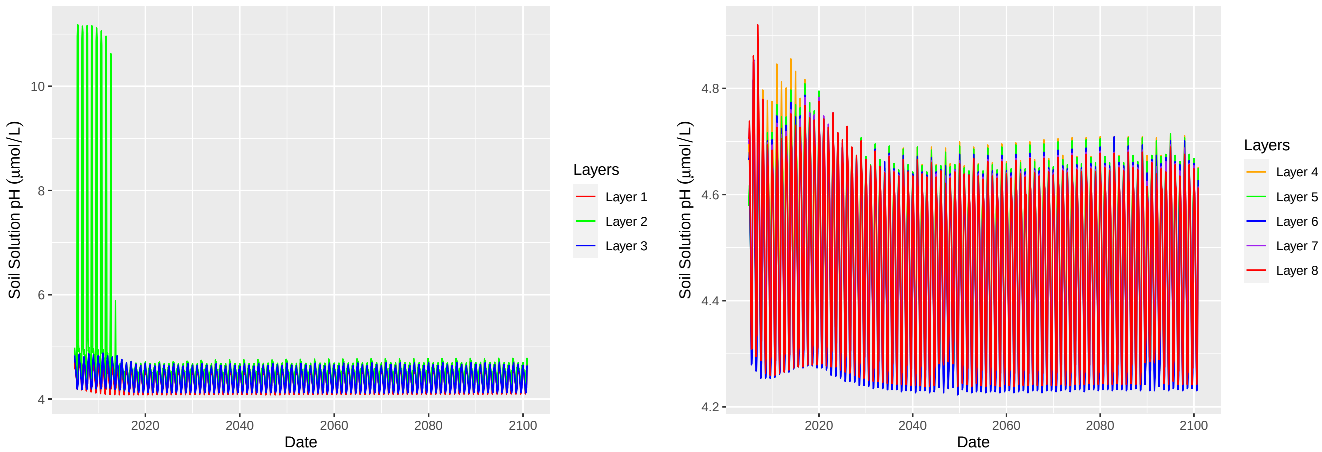


Figure 10: Monthly pH by Soil Layer

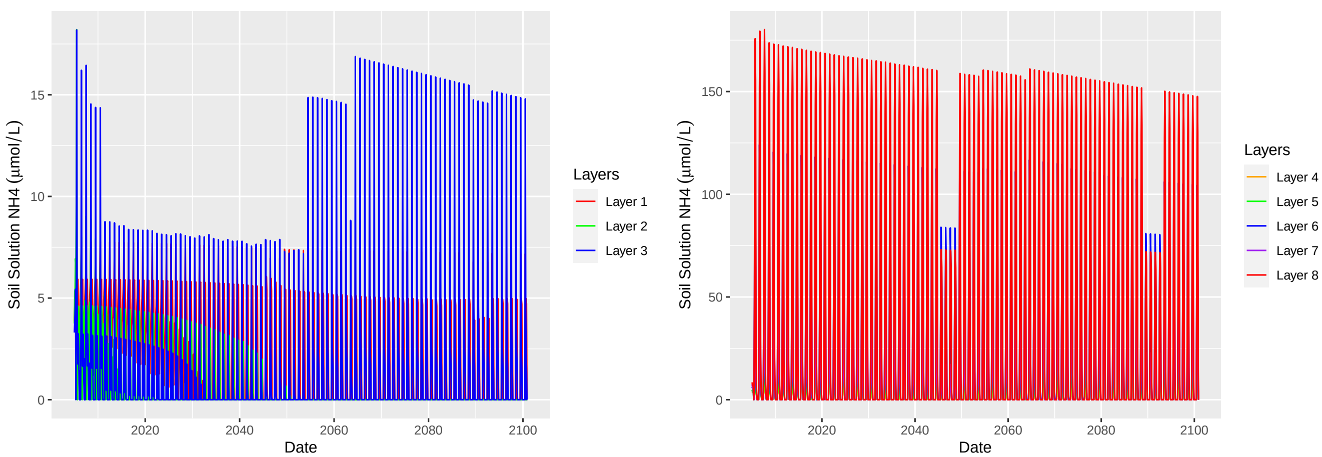


Figure 11: Yearly Ammonium concentration by Soil Layer

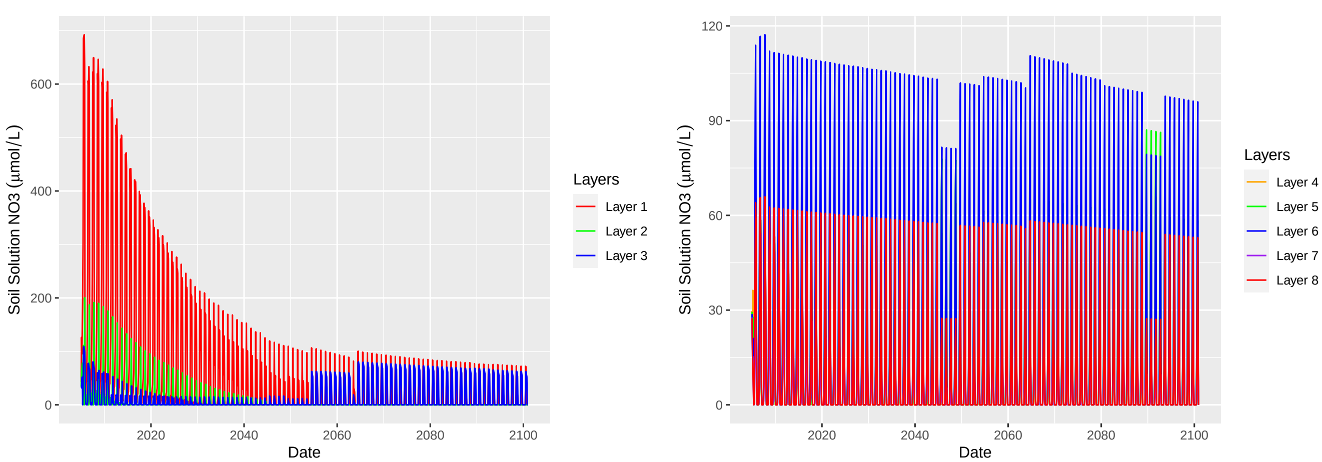
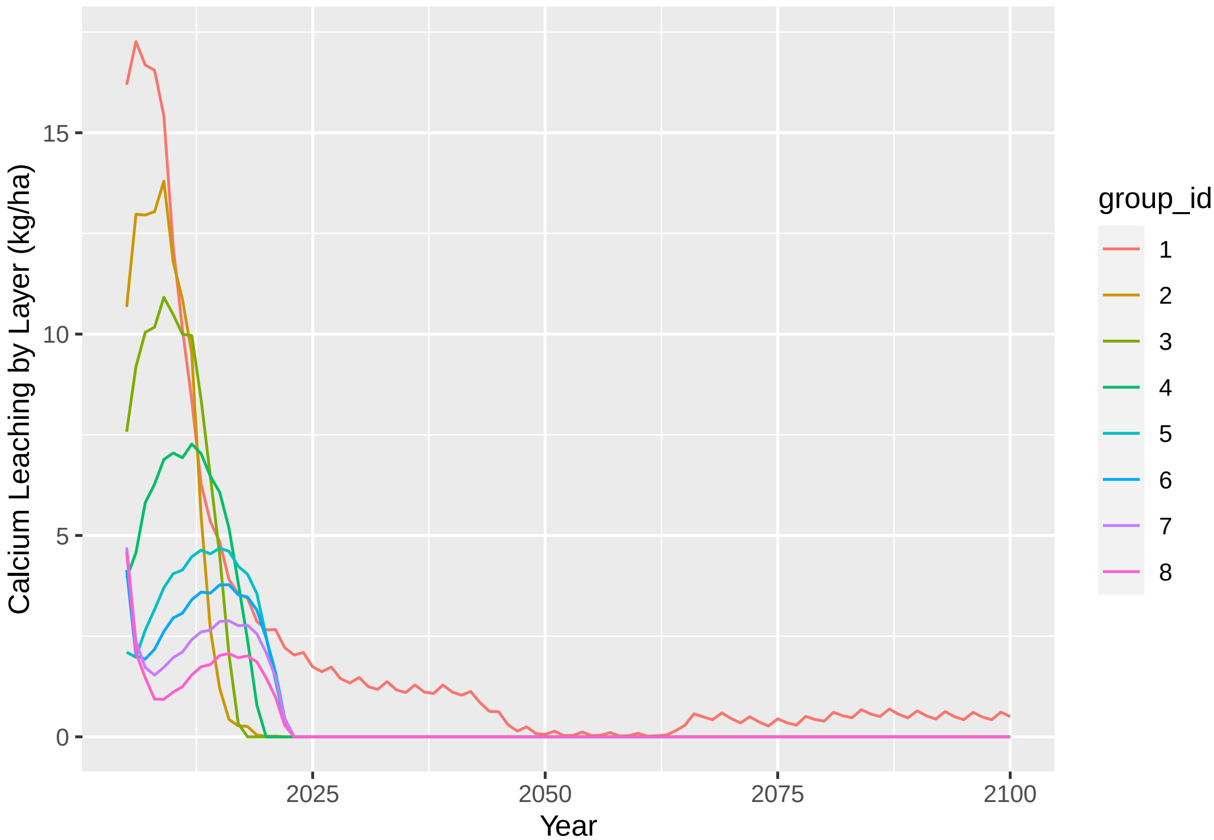


Figure 12: Yearly Nitrate concentration by Soil Layer

Lysimeter Comparisons



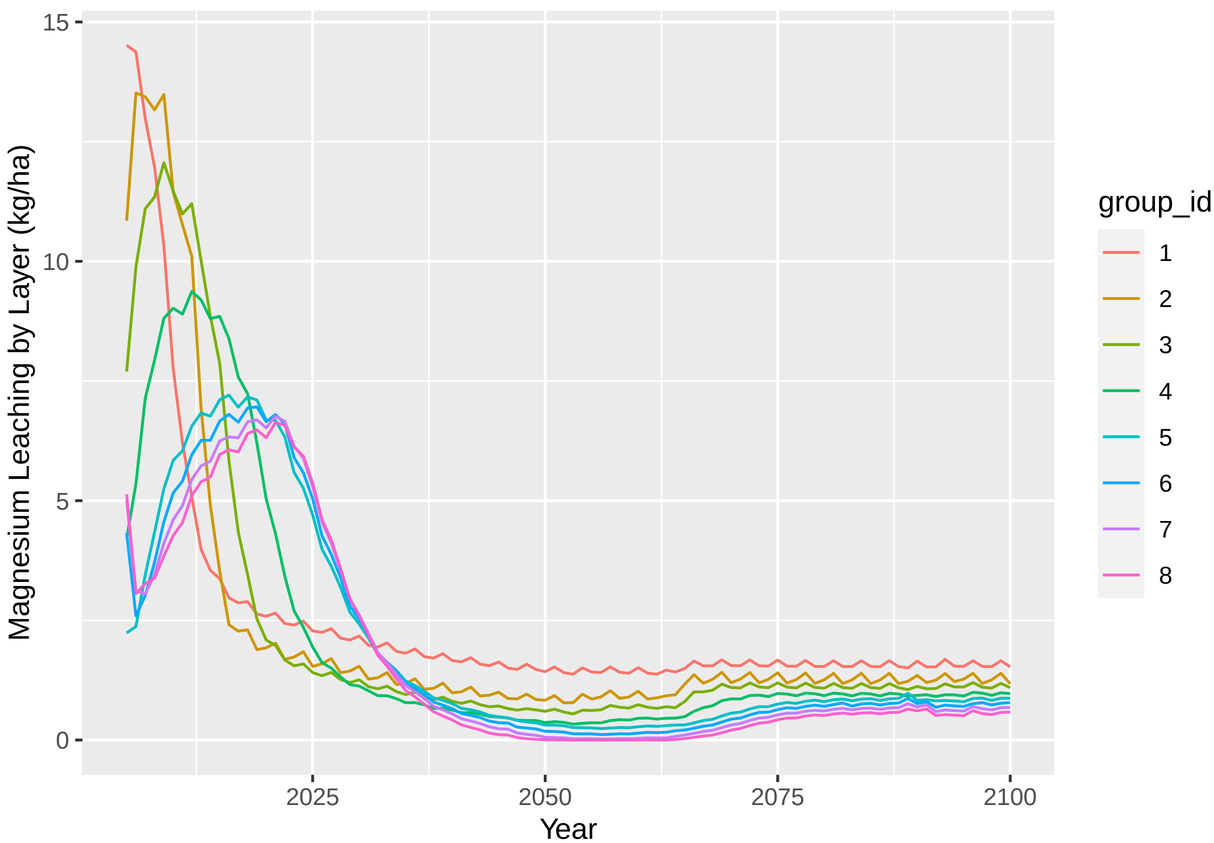


Table 3: Simulated Lysimeter Fluxes by Depth (2005-2006)

		kg/ha											
Depth	YEAR	Ca	Mg	K	Na	NO3	NH4	SO4	Cl	P	DOC	Al	Si
2	2005	11	11	2.7	34	12.0	0.97	3.4	50	0.11	17	0.088	7.8
2	2006	13	14	2.7	16	6.8	0.69	3.6	48	0.11	17	0.092	5.4
8	2005	4.6	5.1	1.3	41	6.4	2.1	5.3	75	0	12	0.26	15.1
8	2006	2.1	3.1	1.0	33	4.3	1.4	5.3	45	0	12	0.24	6.2

Table 4: Actual Average Lysimeter Fluxes (2005)

	kg/ha												
Depth	NH4	NO3	TN	DOC	TP	Cl	SO4	Ca	Mg	K	Na	Al	Si
20	0.247777178	9.763424509	16.05235558	16.52820633	0.015397959	147.7048599	7.135287478	14.6687802	16.66489783	1.089048305	84.64727009	1.026315671	15.44797242
100	0.207849949	5.757736987	11.92369571	10.69157732	0.024684756	105.034089	6.944387278	9.669335876	11.42146102	1.013541339	70.18746399	0.216742935	20.16864975

Weathering Results

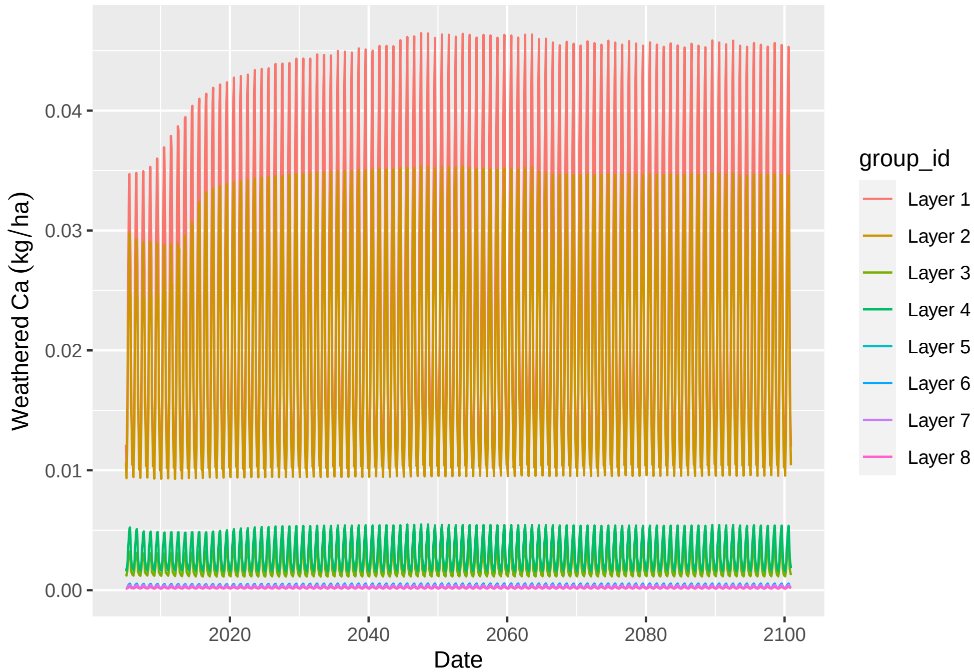


Figure 13: Calcium Weathering (All Layer)

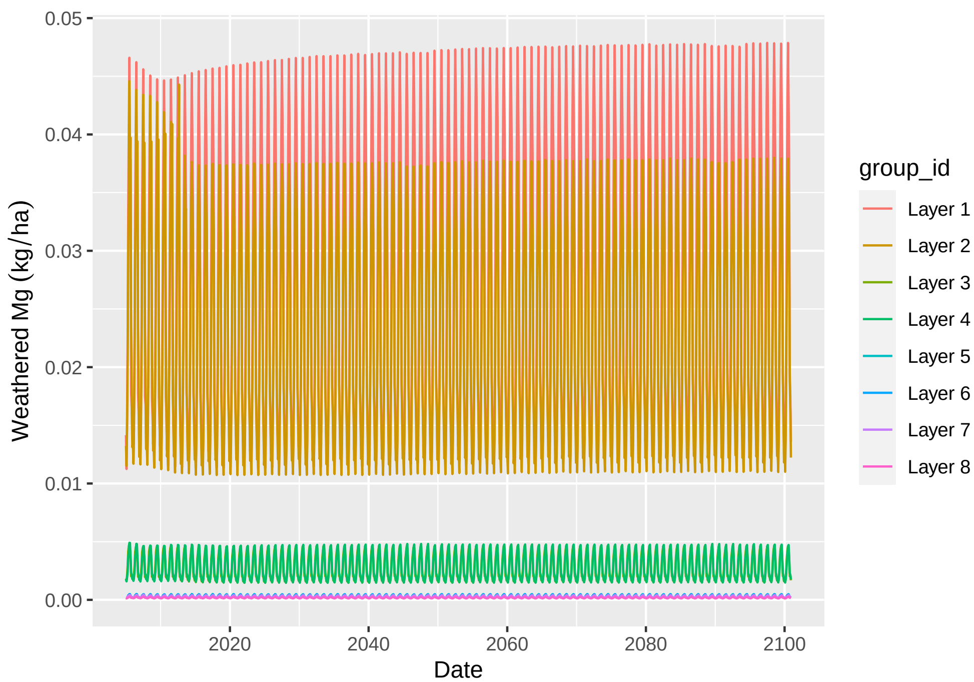


Figure 14: Magnesium Weathering (All Layer)

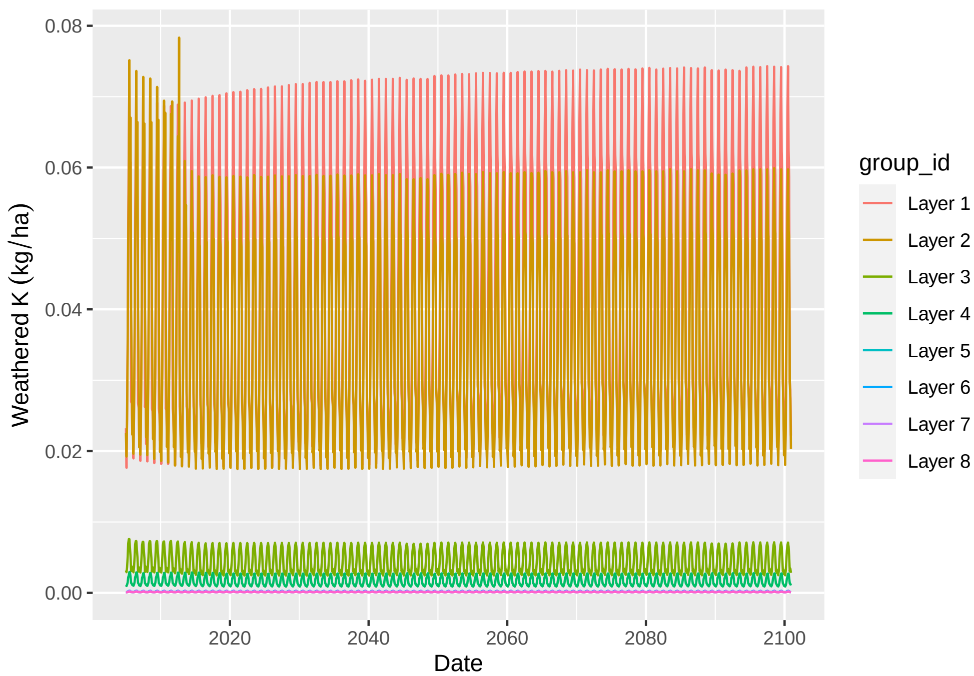


Figure 15: Potassium Weathering (All Layer)

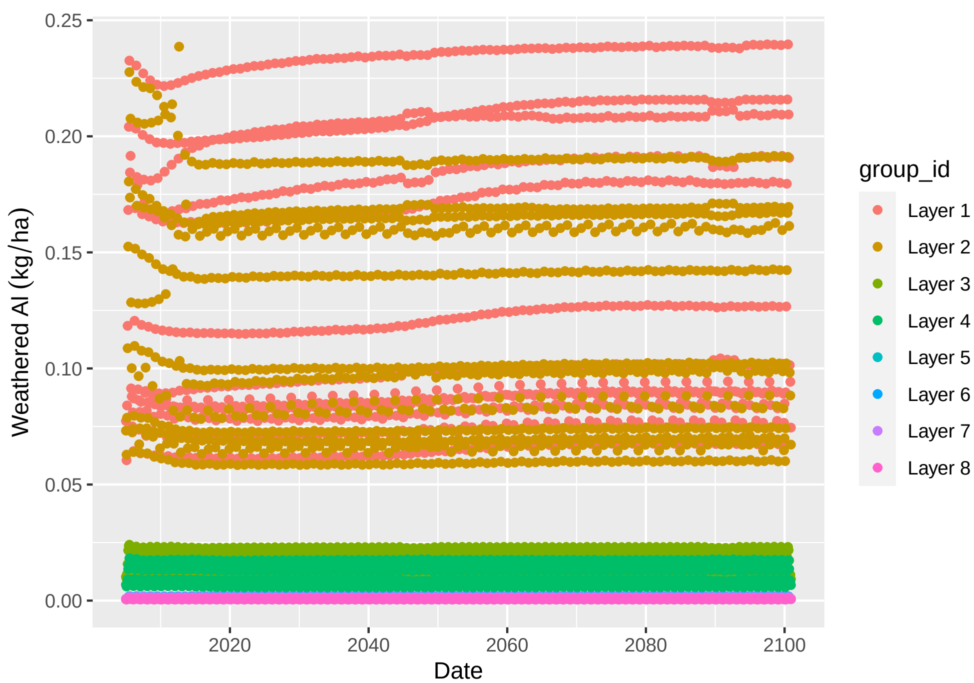


Figure 16: Aluminum Weathering (All Layer)

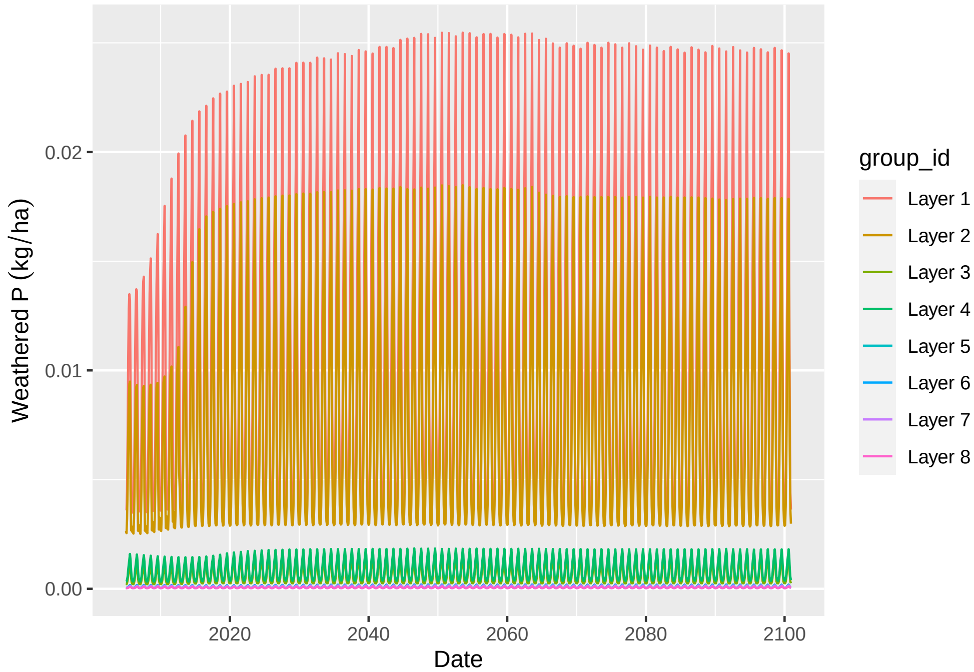


Figure 17: Phosphate Weathering (All Layer)

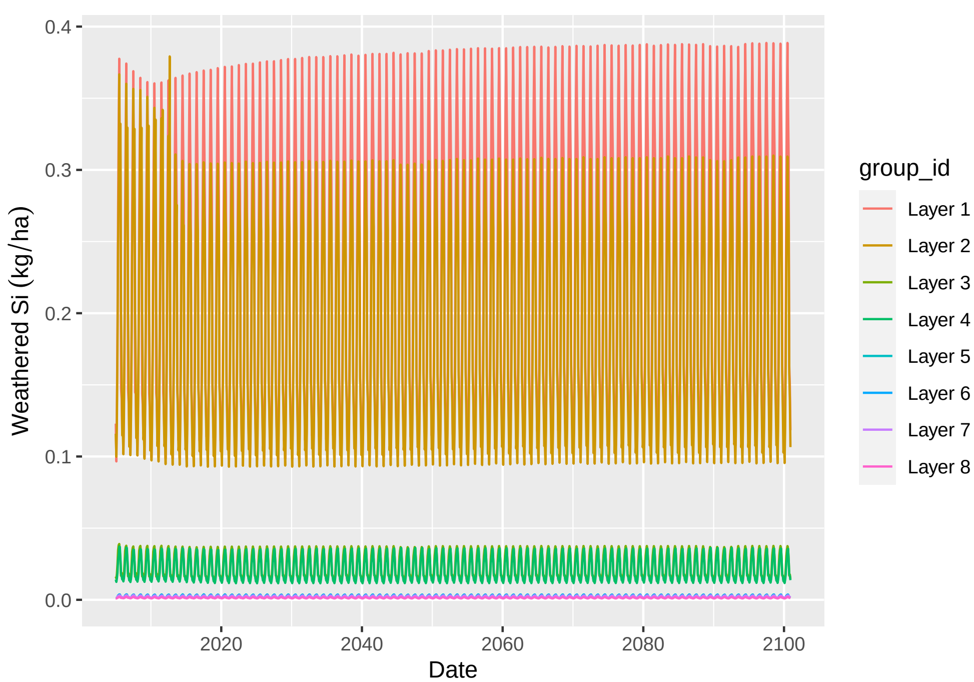


Figure 18: Silica Weathering (All Layer)

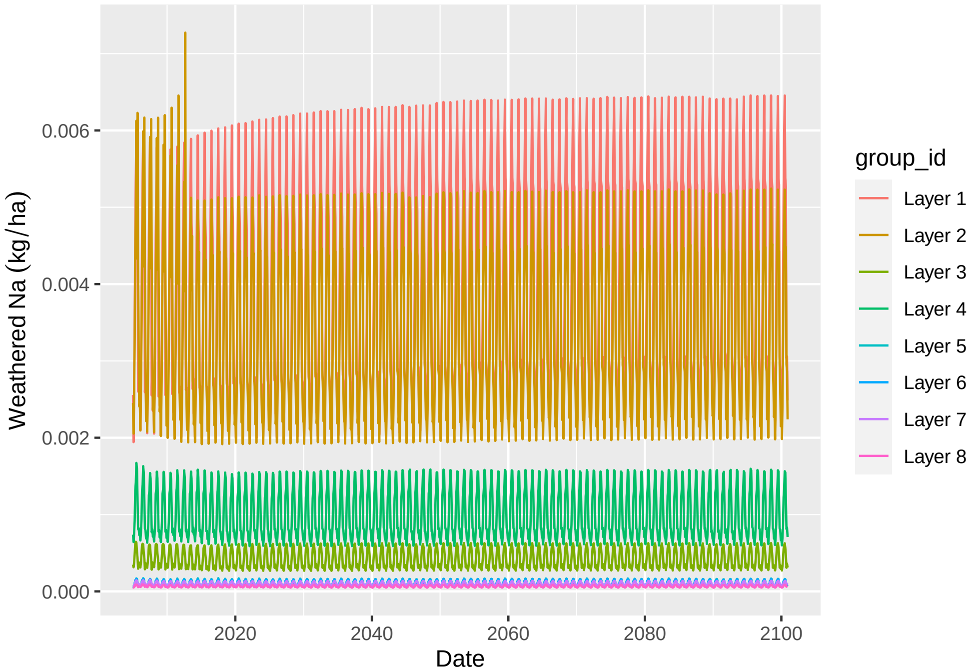
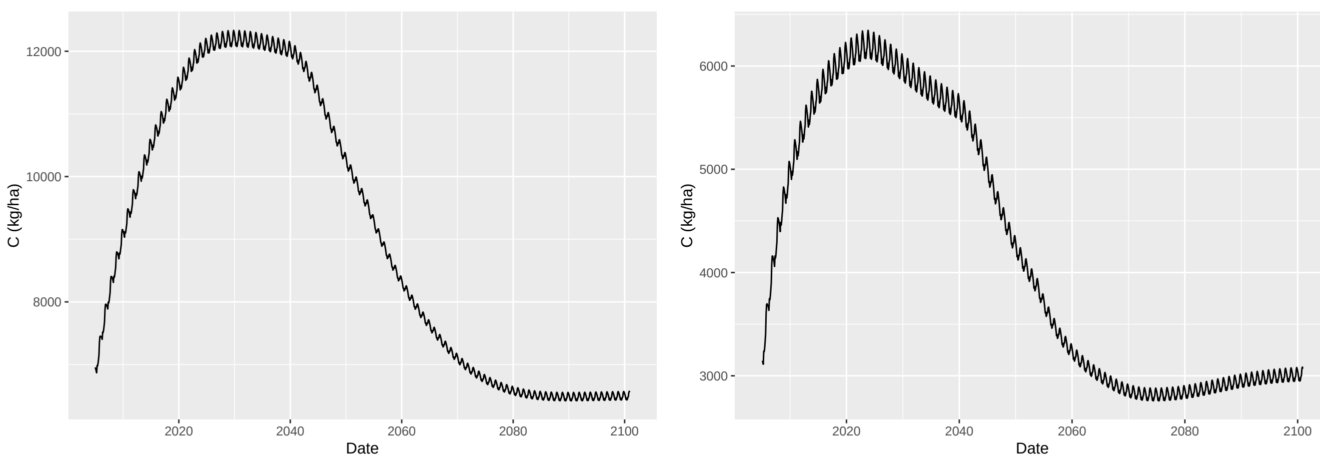


Figure 19: Sodium Weathering (All Layer)

Litter Pool Results

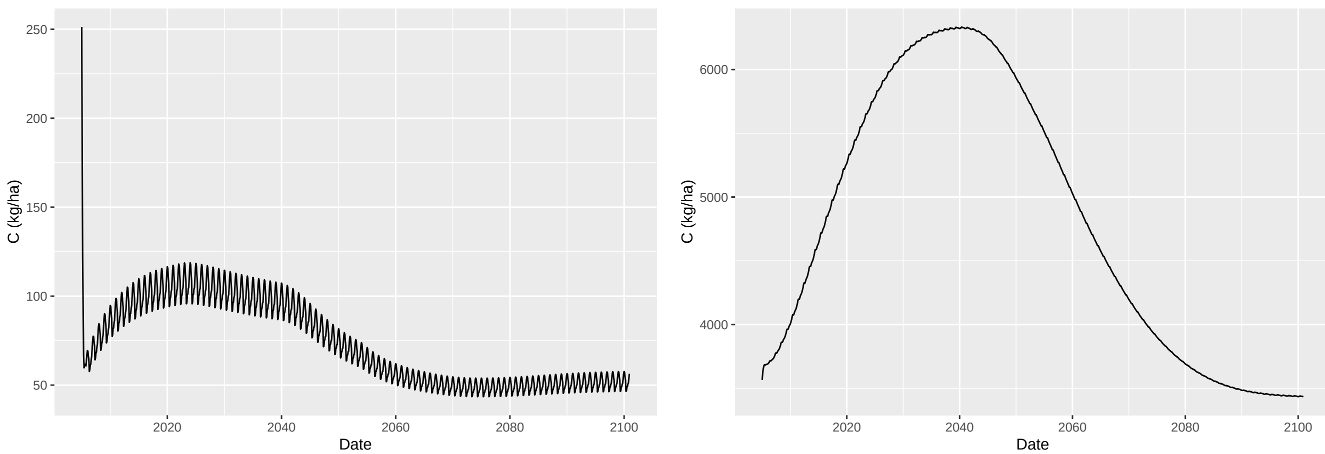


(a) Total forest floor carbon content (kg/ha)

(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 (Edmonds and Chappell, 1993). 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 Edmonds and Chappel, 1993. 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.

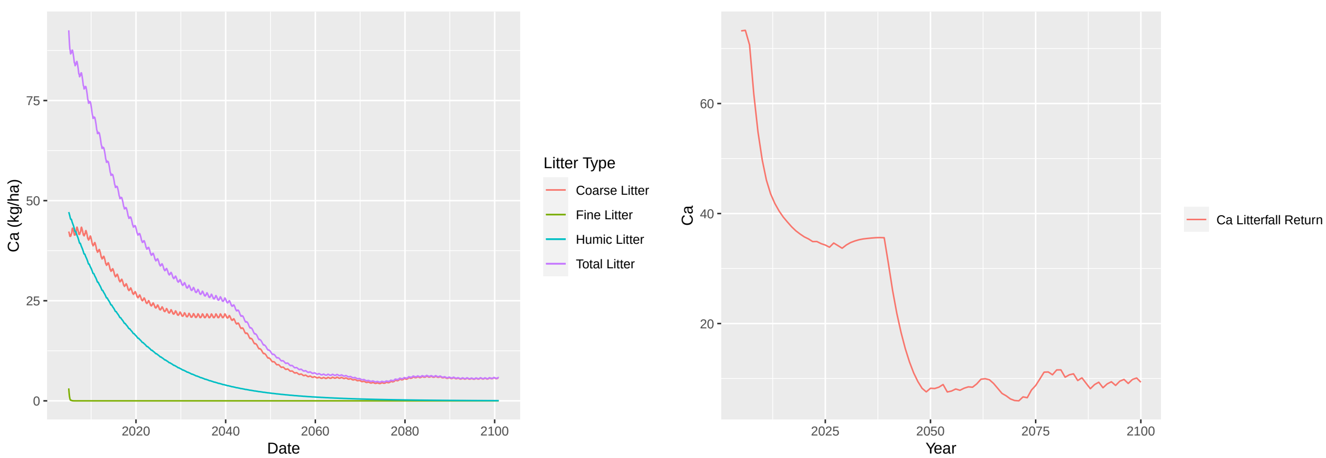


(a) Carbon content of fine litter (kg/ha)

(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.

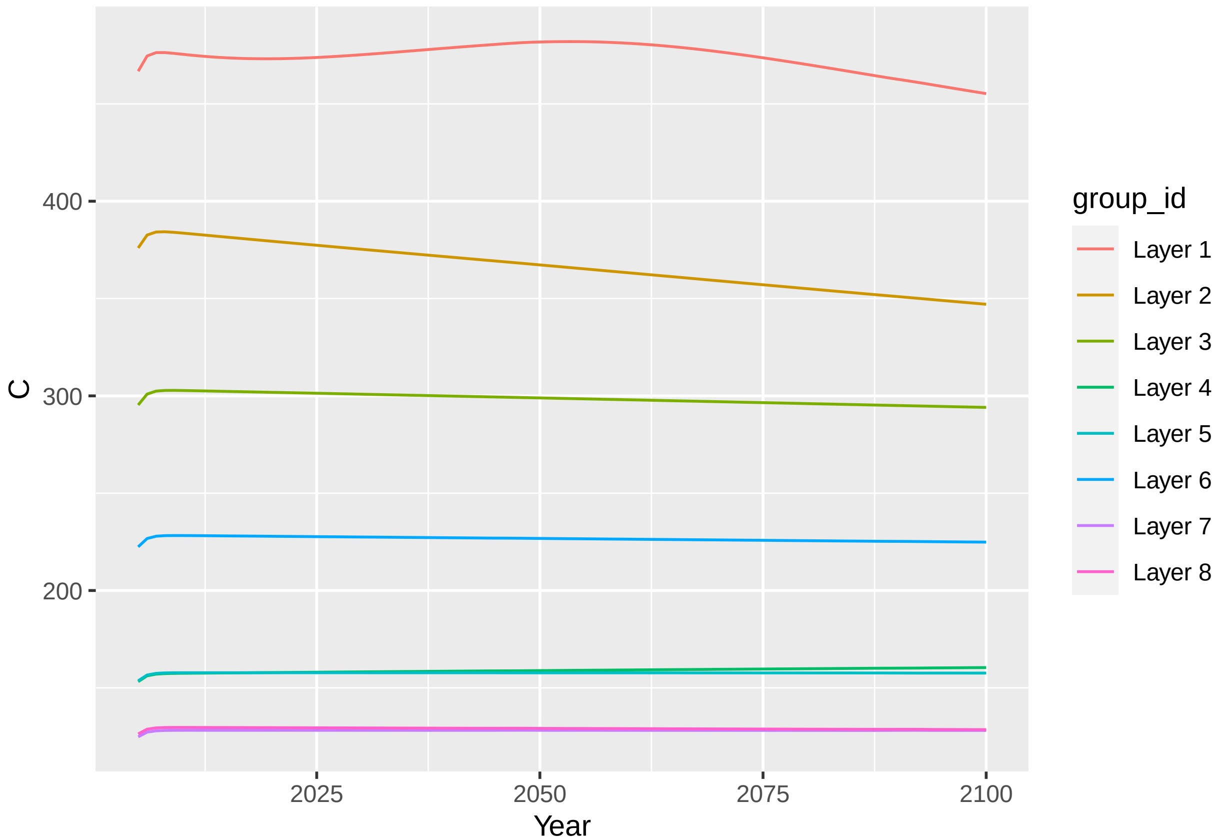


(a) Ca Content in each litter decomposition stage (kg/ha)

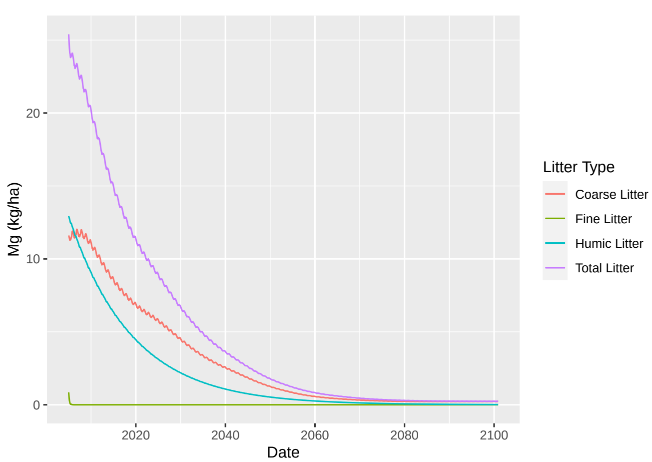
(b) Ca net annual return in litterfall (kg/ha)

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

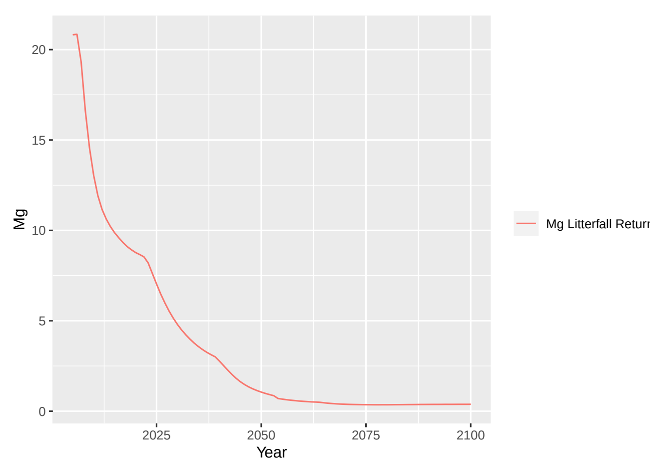
Soil Organic Matter Results



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.

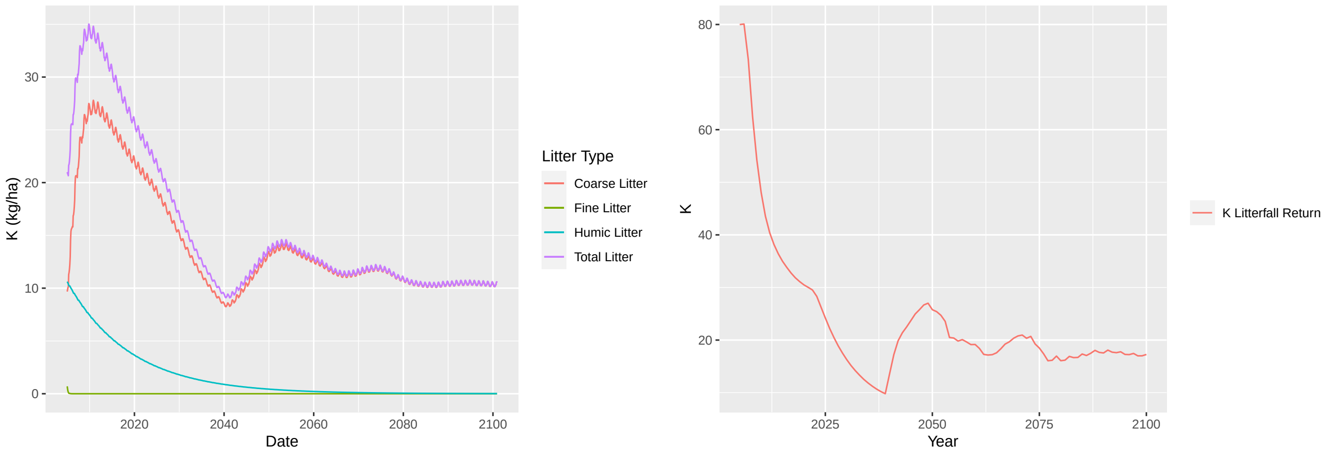


(a) Mg Content in each litter decomposition stage (kg/ha)



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

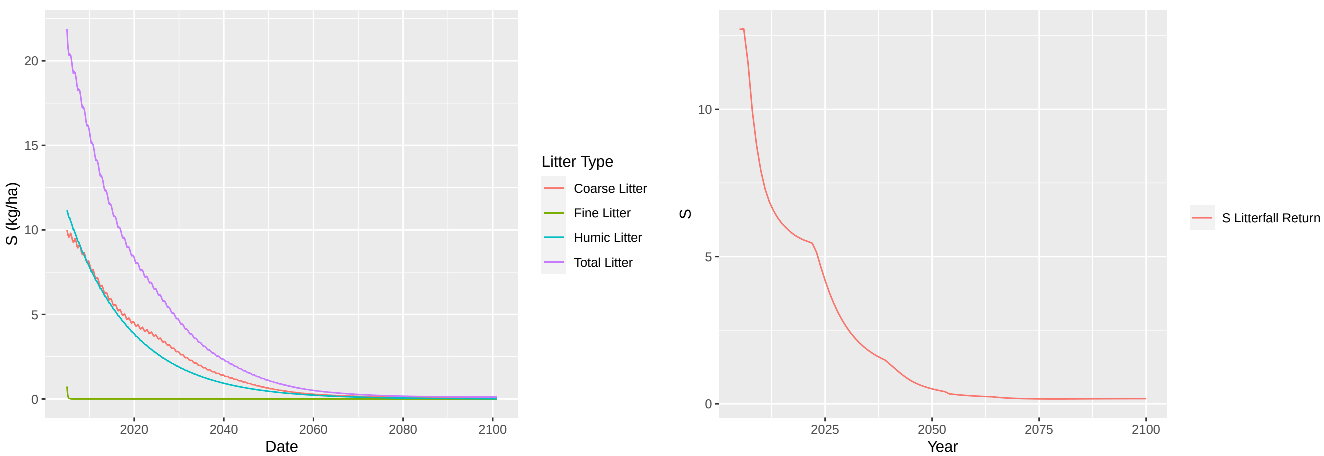
Figure 23: Forest Floor/O-horizon Mg content over time (a). and net annual Mg return in litterfall (b).



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

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

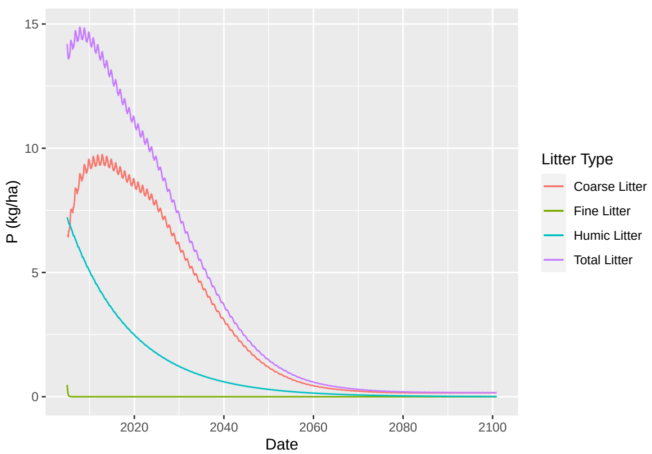
Figure 24: Forest Floor/O-horizon K content over time (a). and net annual K return in litterfall (b).



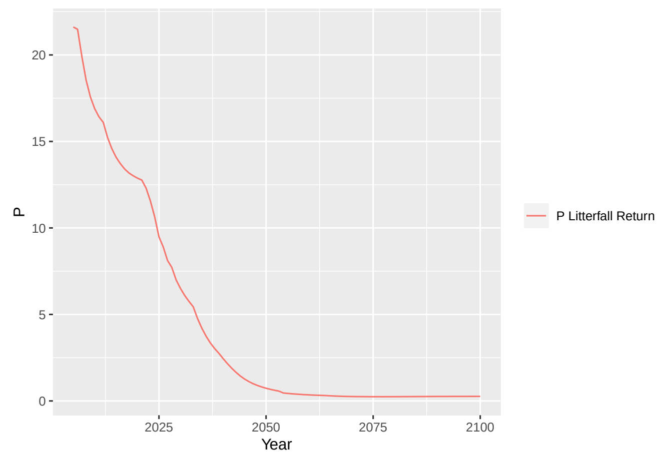
(a) S Content in each litter decomposition stage (kg/ha)

(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).

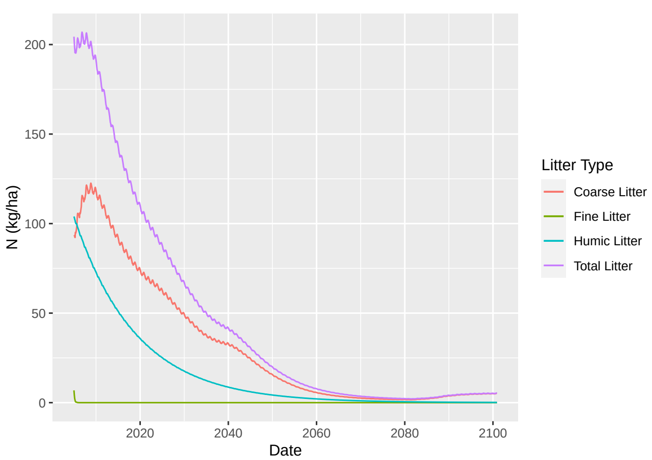


(a) P Content in each litter decomposition stage (kg/ha)

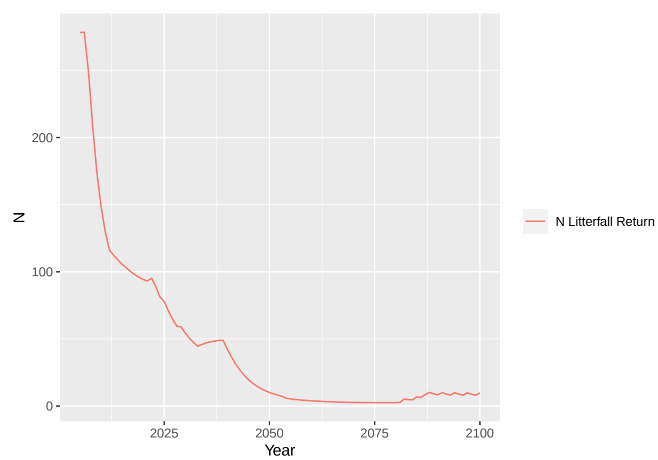


(b) P net annual return in litterfall (kg/ha)

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



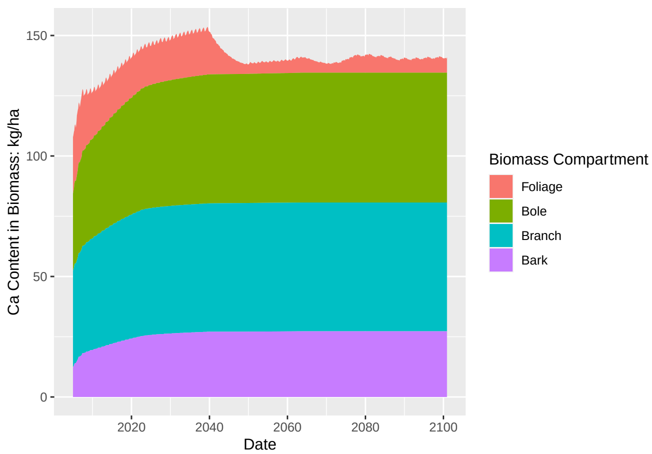
(a) N Content in each litter decomposition stage (kg/ha)



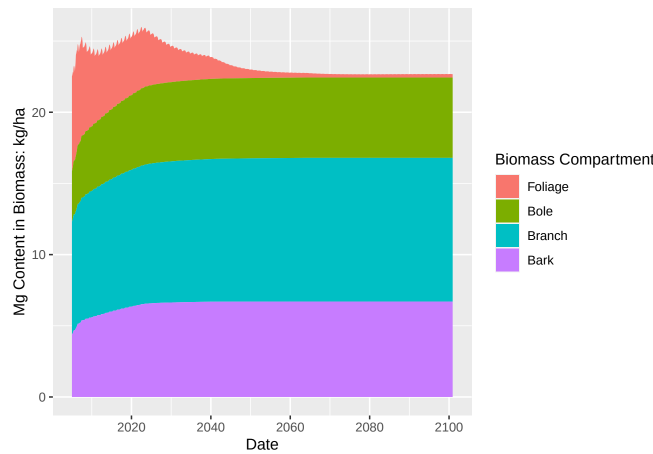
(b) N net annual return in litterfall (kg/ha)

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

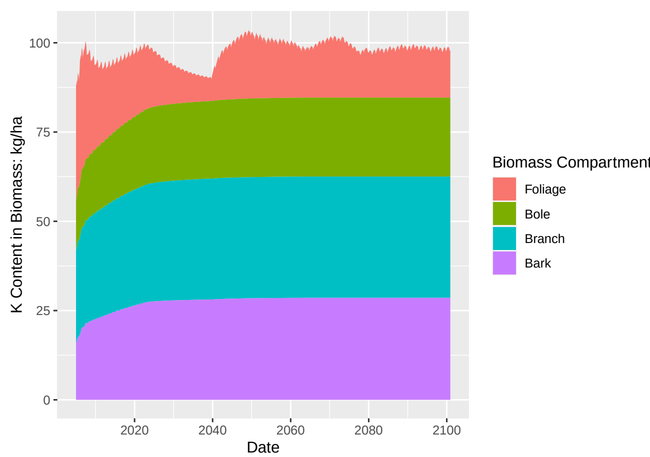
Tree Nutrient Content



(a) Calcium content in each biomass compartment

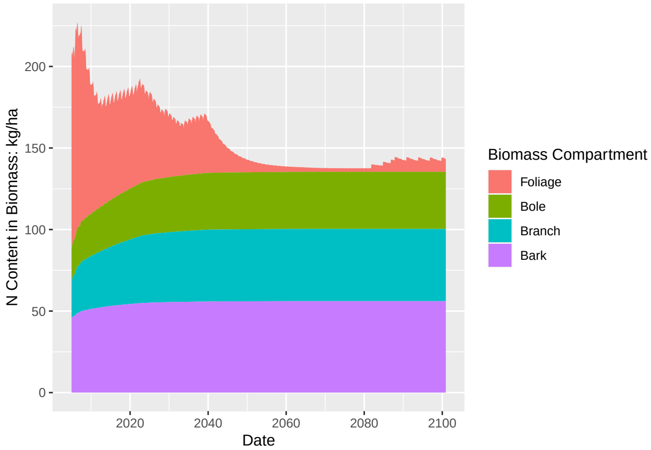


(b) Magnesium content in each biomass compartment

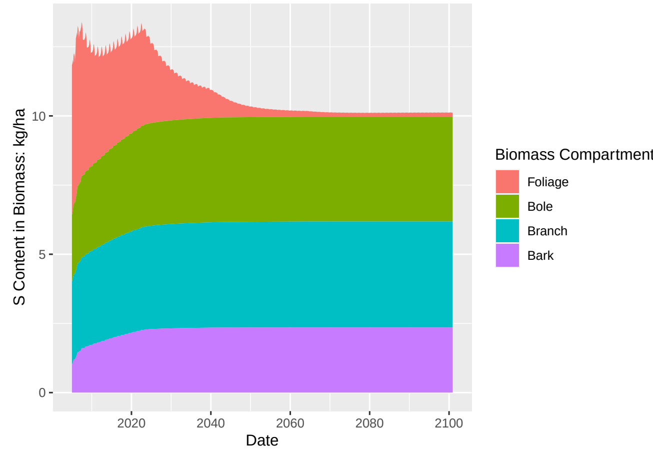


(c) Potassium content in each biomass compartment

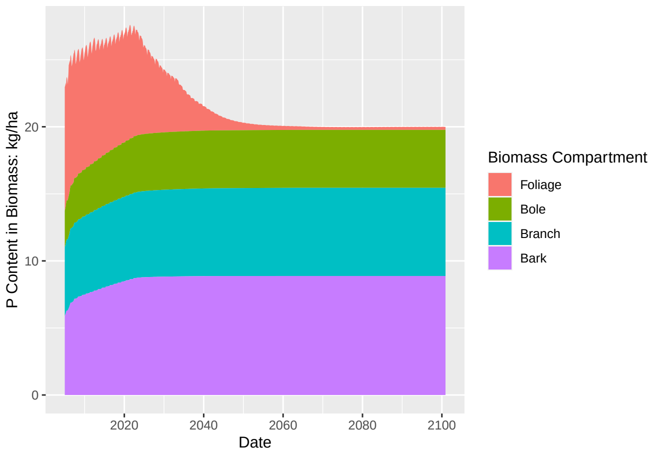
Figure 28: Base Cation Nutrient Content in Simulated Forest



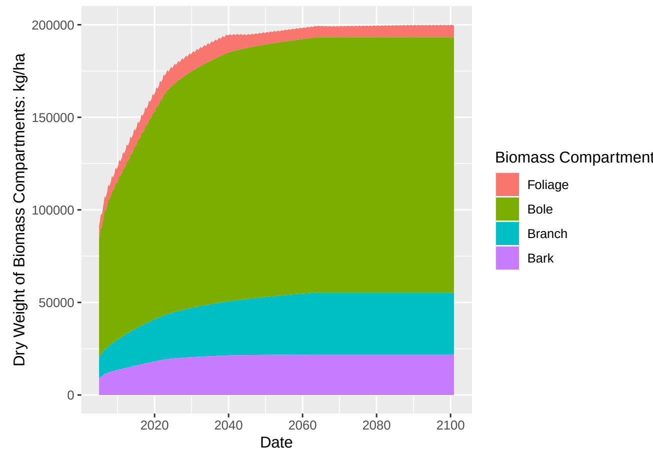
(a) Nitrogen content in each biomass compartment



(b) Sulfur content in each biomass compartment



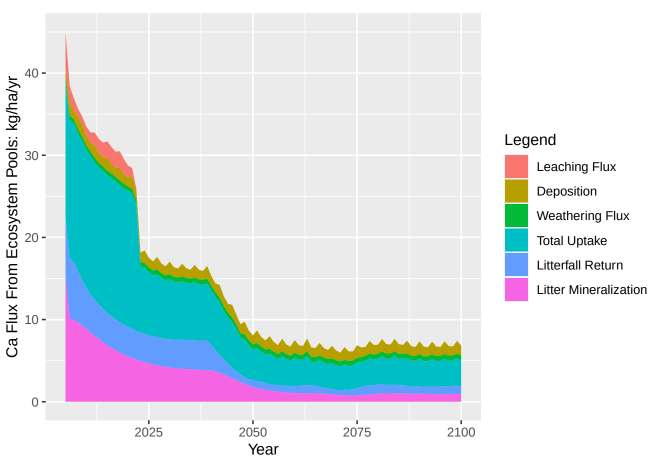
(c) Phosphorous content in each biomass compartment



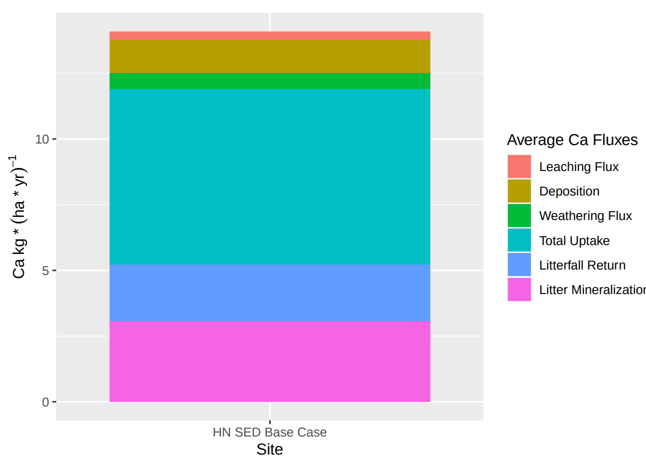
(d) Biomass of each compartment

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

Analysis 1: Stack Flux Data

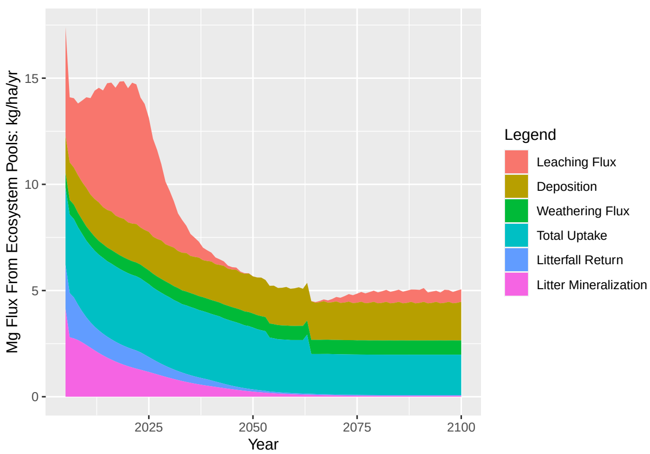


(a) Ca input and output fluxes over time

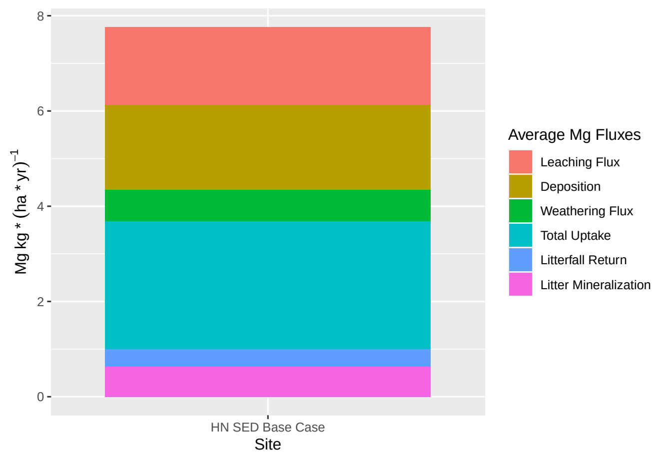


(b) Total Average Ca input and output fluxes

Figure 30: Calcium input and output comparison graphs

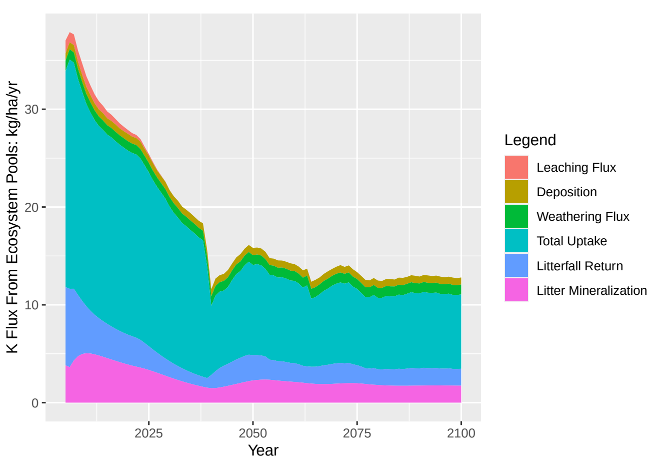


(a) Mg input and output fluxes over time

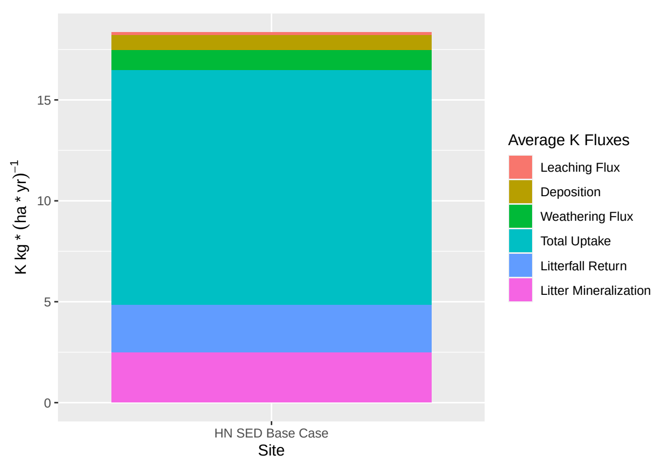


(b) Total Average Mg input and output fluxes

Figure 31: Magnesium input and output comparison graphs

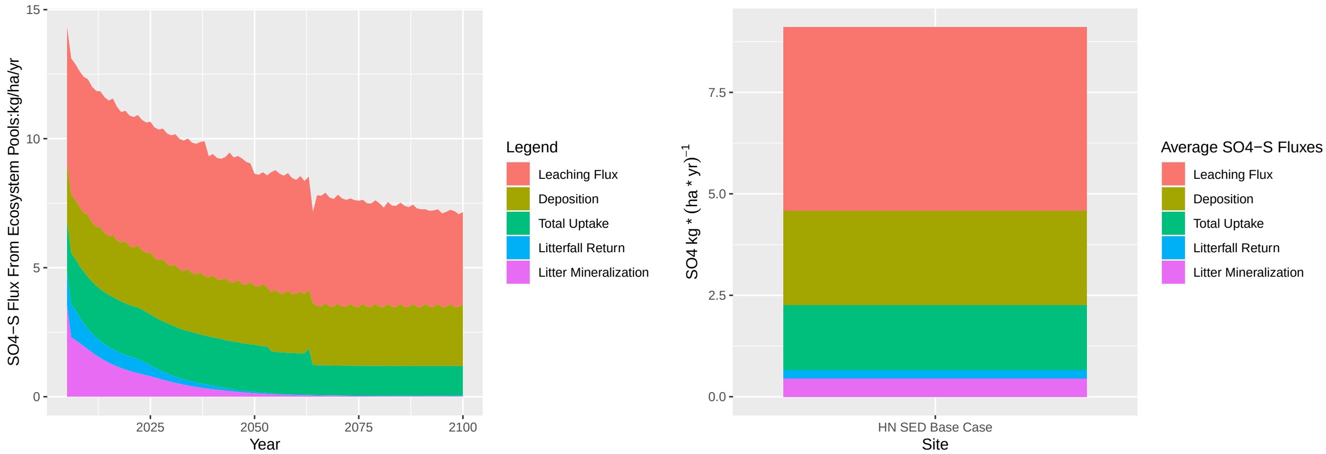


(a) K input and output fluxes over time



(b) Total Average K input and output fluxes

Figure 32: Potassium input and output comparison graphs

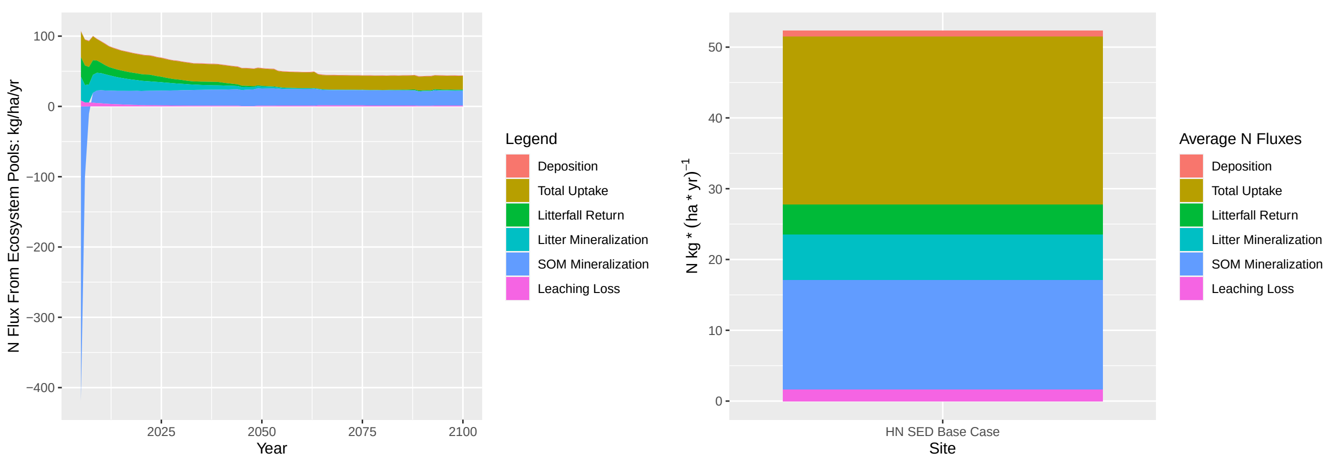


(a) S input and output fluxes over time

(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

Notice how SOM mineralization starts off highly negative (-500+ kg/ha/yr N). This is strange as the SOM pool is set such that it starts with the same concentration of N (roughly a C:N of 18) as is entered for the microbial target concentration. It does not make sense that so much N would be initially uptaken into the SOM pool, this could be a coding error in NutsFor or an issue with initial parameter entry.

Cation Exchange Capacity

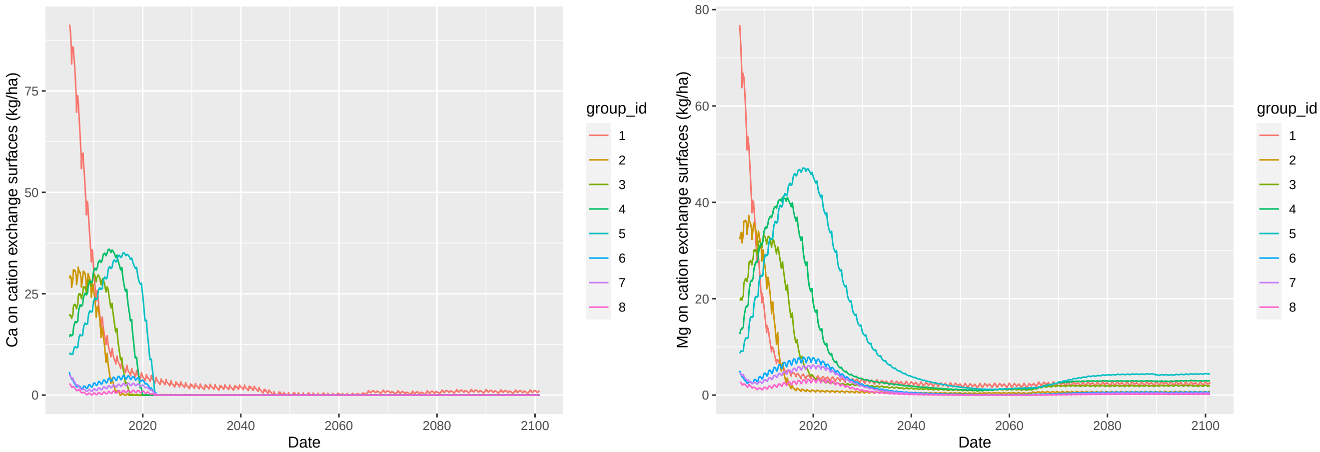


Figure 35: Calcium and Magnesium on exchangerover time

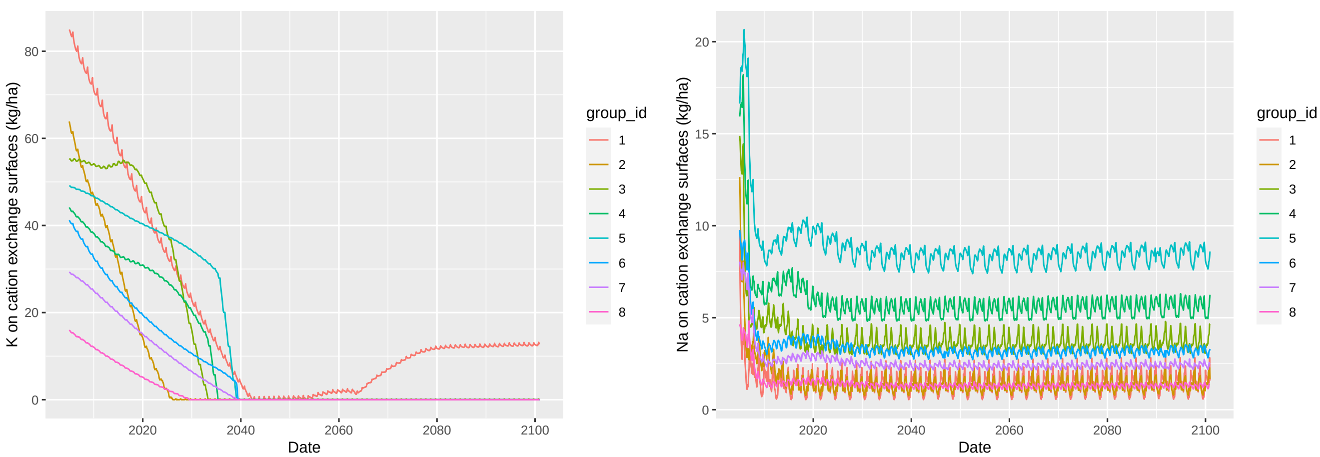


Figure 36: Potassium and Sodium on exchangerover time

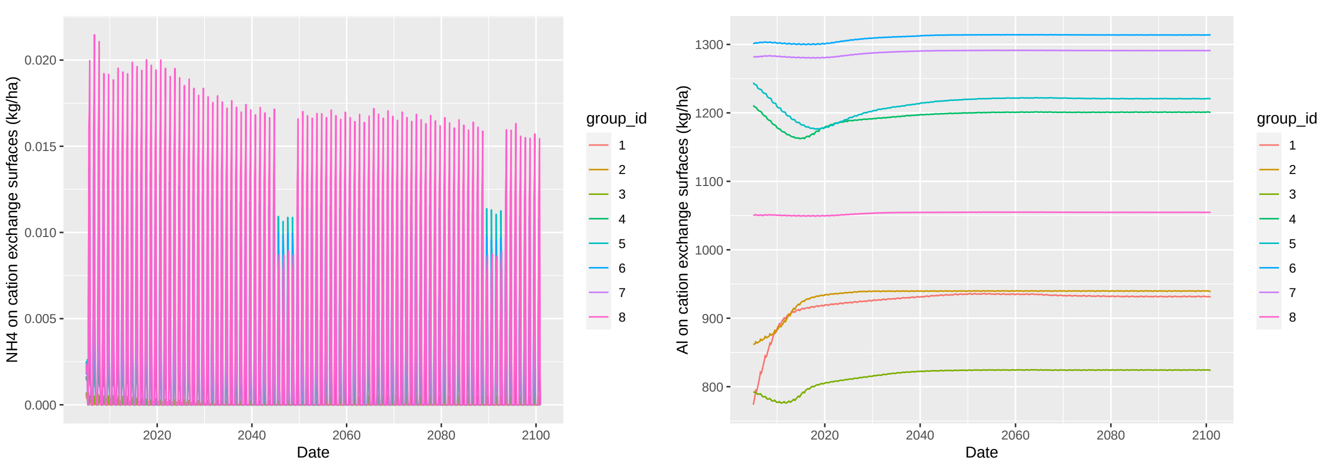
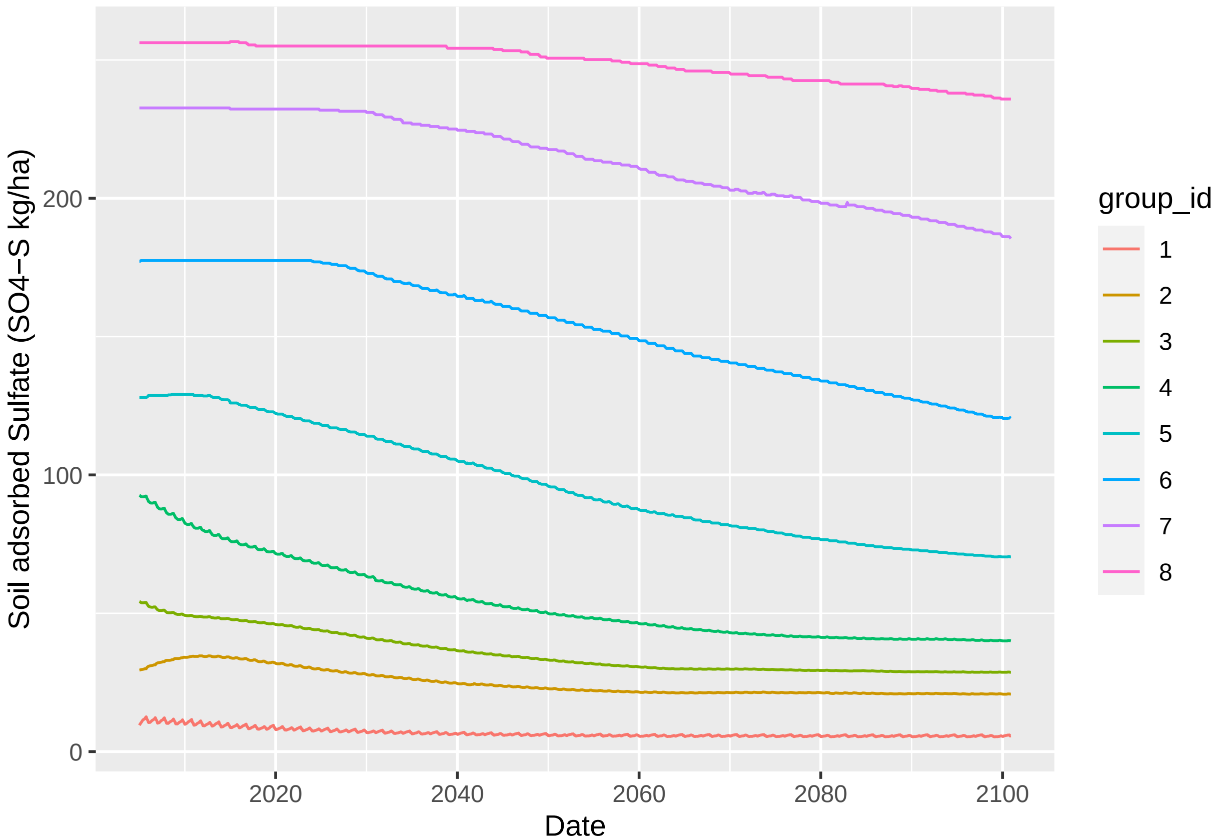
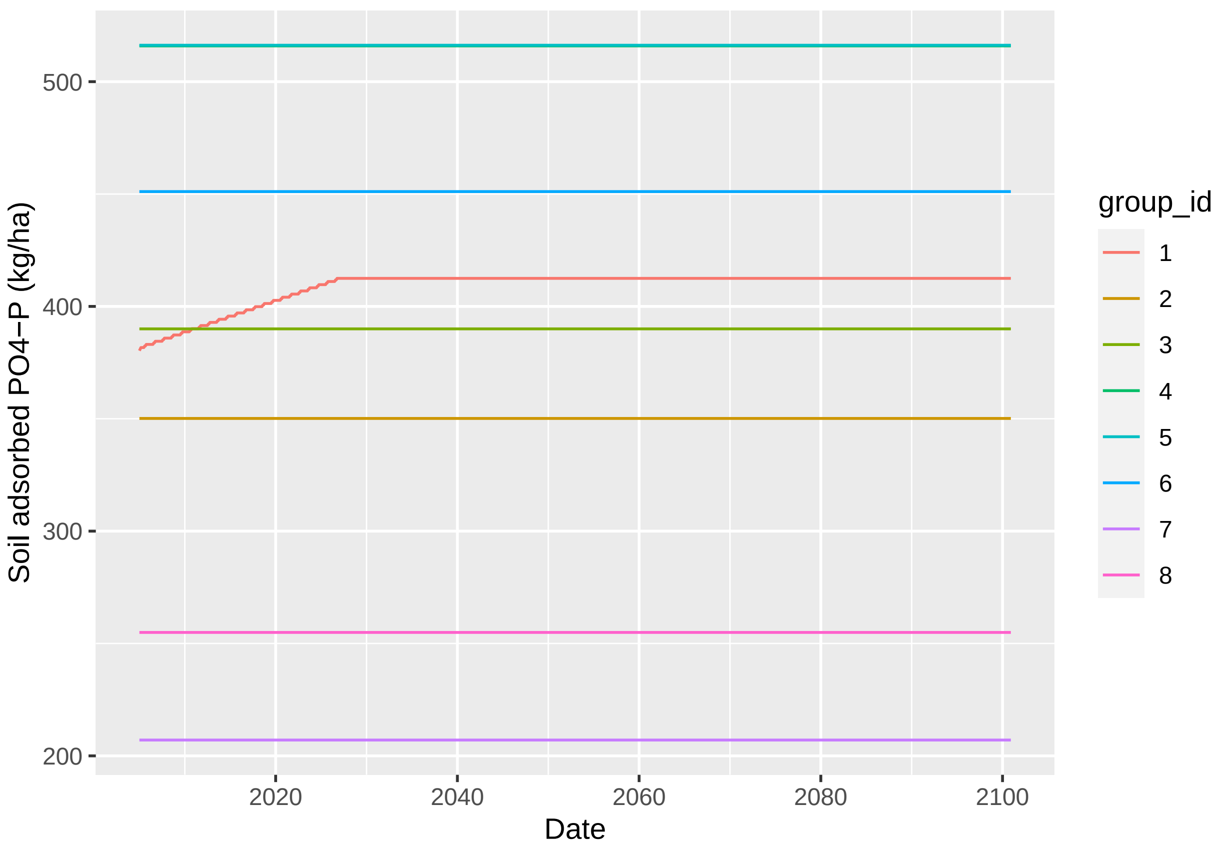
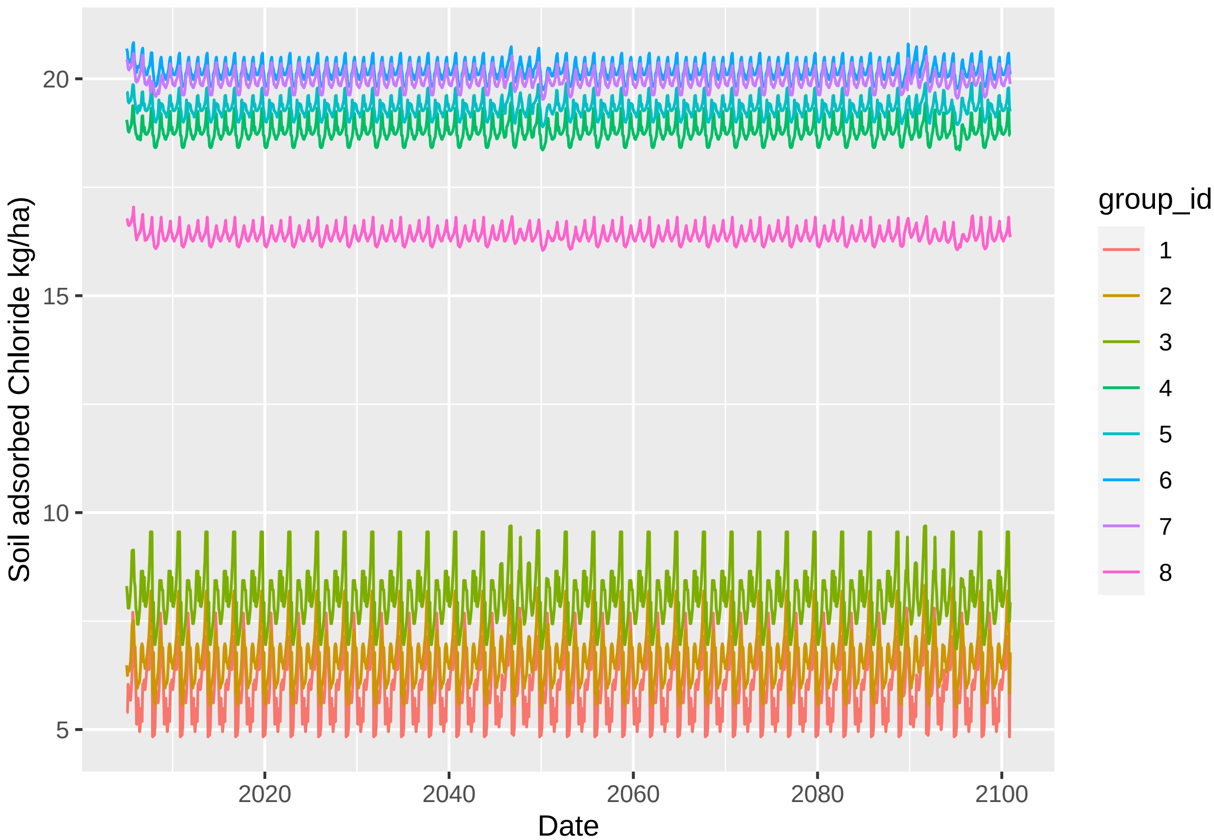


Figure 37: Ammonium and Aluminum on exchangerover time

Anion Exchange Capacity



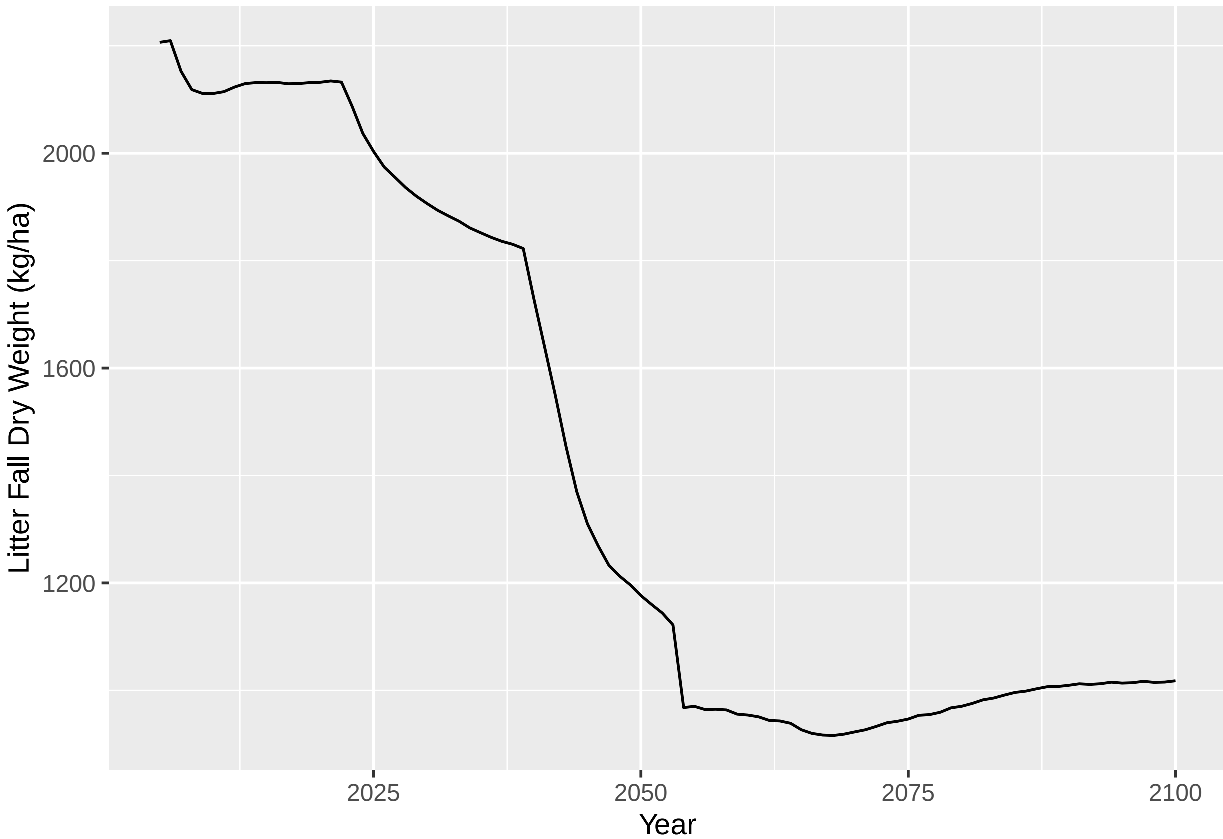




The phosphate adsorption is set from the original parameterization I received from Gregory. It tends to build up, which implies a high soil solution concentration (adsorption is determined by concentration).

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



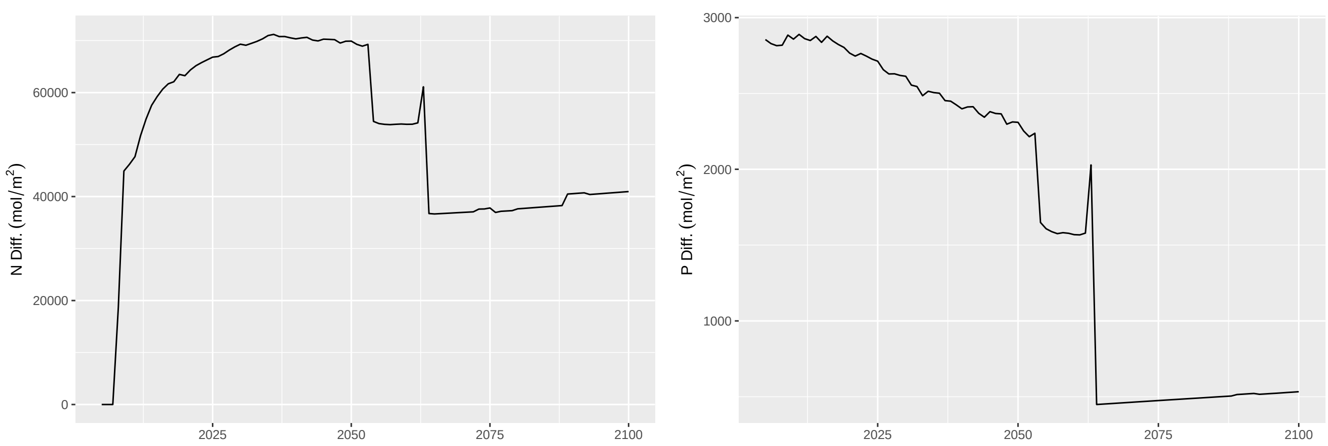


Figure 38: N and P Potential Uptake to Actual Uptake Difference

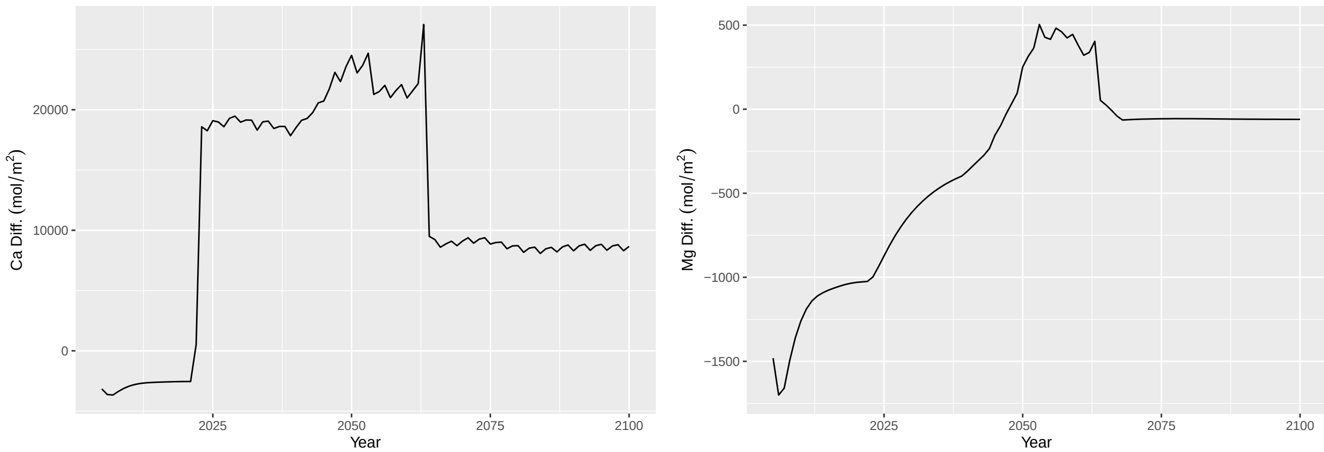


Figure 39: Ca and Mg Potential Uptake to Actual Uptake Difference

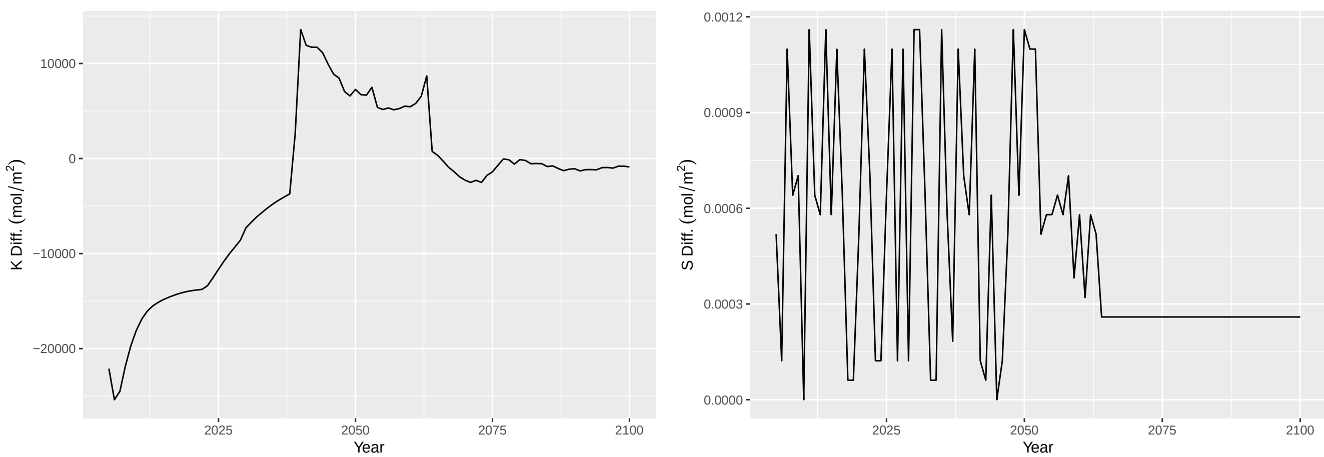


Figure 40: K and S Potential Uptake to Actual Uptake Difference

For the high N sedimentary site, the current calibration clearly shows Ca and P limitation. P limitation is effectively the same as in the low N sedimentary site as I used the exact same adsorbed P pool initially, although the SOM contains more organically bound P than in the low N scenario. The additional organic P is the reason why a strong phosphate adsorption response is seen in this site, as the decomposition rate and P release rates are enough to stimulate high enough phosphate concentrations to stimulate adsorption.