

Calibration Report: Low N Sedimentary Site Base Case

Kaveh Gholamhossein Siah

26 November 2020

Contents

Hydrology	4
Soil Solution Results	4
Weathering Results	10
Litter Pool Results	12
Soil Organic Matter Results	14
Tree Nutrient Content	17
Analysis 1: Stack Flux Data	18
Cation Exchange Capacity	21
Anion Exchange Capacity	22
Other	24

List of Figures

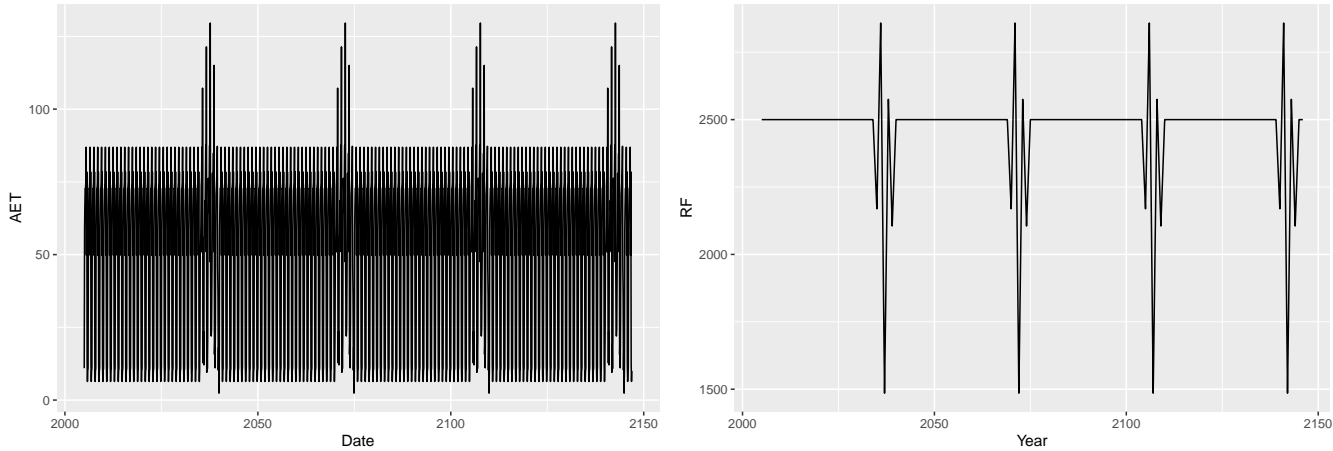
1	Monthly Calcium Concentrations by Soil Layer	6
2	Monthly Magnesium Concentrations by Soil Layer	6
3	Monthly Potassium Concentrations by Soil Layer	6
4	Monthly Sodium Concentrations by Soil Layer	7
5	Monthly Sulfate Concentrations by Soil Layer	7
6	Monthly Chloride Concentrations by Soil Layer	7
7	Monthly Aluminum Concentrations by Soil Layer	8
8	Monthly SiO ₂ Concentrations by Soil Layer	8
9	Monthly Organic Acid Base (R-) Concentrations by Soil Layer	8
10	Monthly pH by Soil Layer	9
11	Yearly Ammonium concentration by Soil Layer	9
12	Yearly Nitrate concentration by Soil Layer	9
13	Calcium Weathering (All Layer)	10
14	Magnesium Weathering (All Layer)	10
15	Potassium Weathering (All Layer)	11
16	Aluminum Weathering (All Layer)	11
17	Phosphate Weathering (All Layer)	11
18	Silica Weathering (All Layer)	12
19	Sodium Weathering (All Layer)	12
20	Forest Floor (O-Layer) Carbon Content Over Simulation Period	12
21	Forest Floor (O-Layer) Carbon Content Over Simulation Period	13
22	Forest Floor/O-horizon Ca content over time (a). and net annual Ca return in litterfall (b).	13
23	Forest Floor/O-horizon Mg content over time (a). and net annual Mg return in litterfall (b).	14
24	Forest Floor/O-horizon K content over time (a). and net annual K return in litterfall (b).	15
25	Forest Floor/O-horizon S content over time (a). and net annual S return in litterfall (b).	15
26	Forest Floor/O-horizon P content over time (a). and net annual P return in litterfall (b).	16
27	Forest Floor/O-horizon N content over time (a). and net annual N return in litterfall (b).	16
28	Base Cation Nutrient Content in Simulated Forest	17
29	N, S, and P Nutrient Contents and biomass per compartment	18
30	Calcium input and output comparison graphs	18
31	Magnesium input and output comparison graphs	19
32	Potassium input and output comparison graphs	19
33	Sulfur input and output comparison graphs	20
34	Nitrogen input and output comparison graphs	20
35	Calcium and Magnesium CEC adsorption over time	21
36	Potassium and Sodium CEC adsorption over time	21
37	Ammonium and Aluminum CEC adsorption over time	21

List of Tables

1	Average Soil Solution Concentrations of Reliable Months (2005-2006)	4
---	---	---

2	Lysimeter Measured Soil Solution Concentrations of Reliable Months (2005)	5
3	Simulated Lysimeter Fluxes by Depth (2005-2006)	10

Hydrology



Soil Solution Results

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

Soil Layer	$\mu\text{mol/L}$															
	Ca	Mg	K	Na	NO3	NH4	SO4	Cl	PO4	DOC	Al	Si	H+	pH	R	HR
Layer 1	13.3	16.2	10.80	52.8	1.1822	2.241	12.4	51.6	0.514	160.0	0.000977	72.7	12.55	4.90	59.8	20.14
Layer 2	14.1	17.1	11.51	67.5	0.6668	1.824	12.6	58.5	0.236	178.7	0.000799	91.1	10.33	4.99	69.2	20.09
Layer 3	13.9	16.8	11.11	77.6	0.3913	1.472	12.5	65.2	0.220	170.4	0.000582	91.6	8.16	5.09	68.4	16.86
Layer 4	10.5	16.4	6.18	75.9	0.1936	0.806	11.4	65.0	0.203	104.2	0.000214	90.3	3.60	5.44	45.3	6.81
Layer 5	11.1	17.3	6.32	81.0	0.1303	0.665	11.5	71.6	0.140	97.0	0.000248	95.0	4.05	5.39	41.7	6.79
Layer 6	10.8	16.7	6.18	81.9	0.1061	0.448	11.4	75.5	0.160	66.3	0.000127	98.4	2.28	5.64	29.7	3.46
Layer 7	11.4	17.7	6.35	84.0	0.0974	0.405	11.5	81.6	0.160	61.6	0.000180	102.5	3.08	5.51	27.0	3.85
Layer 8	11.3	17.7	6.32	85.3	0.0915	0.392	11.4	85.0	0.137	49.3	0.000132	105.4	2.35	5.63	21.9	2.78

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

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	2.76	35	2.17	21	1.46	140	5.7	2.3	2.14	1.1	0.25	18	2.20	174	24	0.07	0.038	136	18	0.996	0.03594	82	16	5.6
2	29	2.76	35	2.17	21	1.46	140	5.7	2.3	2.14	1.1	0.25	18	2.20	174	24	0.07	0.038	136	18	0.996	0.03594	82	16	5.3
3	29	2.76	35	2.17	21	1.46	140	5.7	2.3	2.14	1.1	0.25	18	2.20	174	24	0.07	0.038	136	18	0.996	0.03594	82	16	5.4
4	16	0.84	24	0.83	17	0.89	125	8.0	1.9	0.73	1.2	0.27	12	0.73	159	18	0.05	0.032	68	12	0.021	0.00075	84	15	5.5
5	16	0.84	24	0.83	17	0.89	125	8.0	1.9	0.73	1.2	0.27	12	0.73	159	18	0.05	0.032	68	12	0.021	0.00075	84	15	5.6
6	16	0.84	24	0.83	17	0.89	125	8.0	1.9	0.73	1.2	0.27	12	0.73	159	18	0.05	0.032	68	12	0.021	0.00075	84	15	5.7
7	16	0.84	24	0.83	17	0.89	125	8.0	1.9	0.73	1.2	0.27	12	0.73	159	18	0.05	0.032	68	12	0.021	0.00075	84	15	5.8
8	16	0.84	24	0.83	17	0.89	125	8.0	1.9	0.73	1.2	0.27	12	0.73	159	18	0.05	0.032	68	12	0.021	0.00075	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

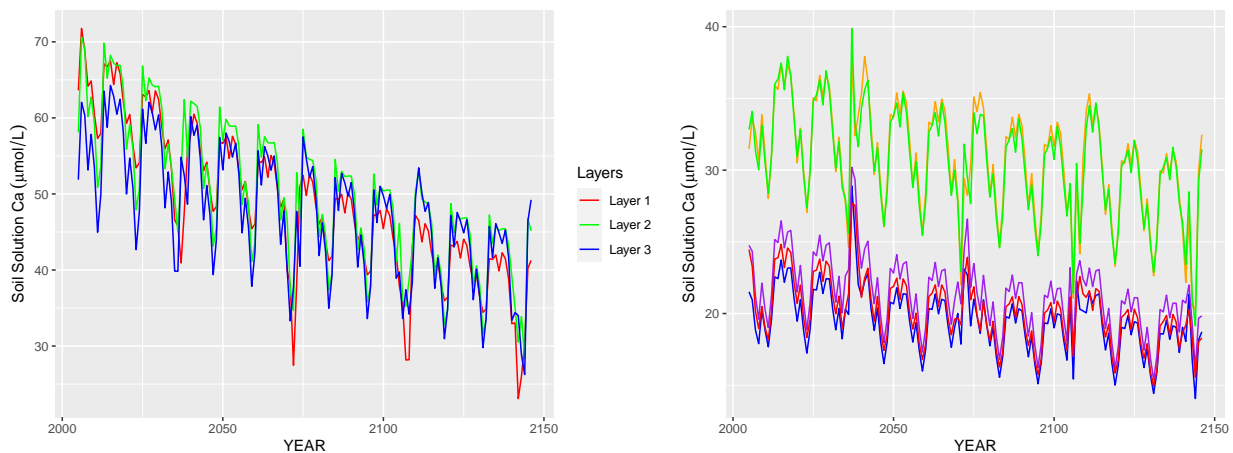


Figure 1: Monthly Calcium Concentrations by Soil Layer

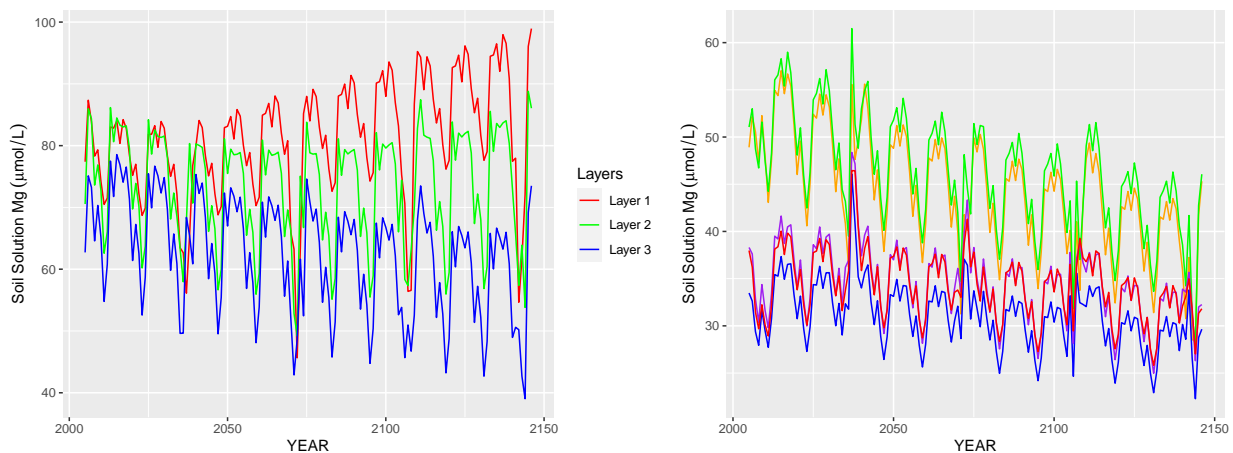


Figure 2: Monthly Magnesium Concentrations by Soil Layer

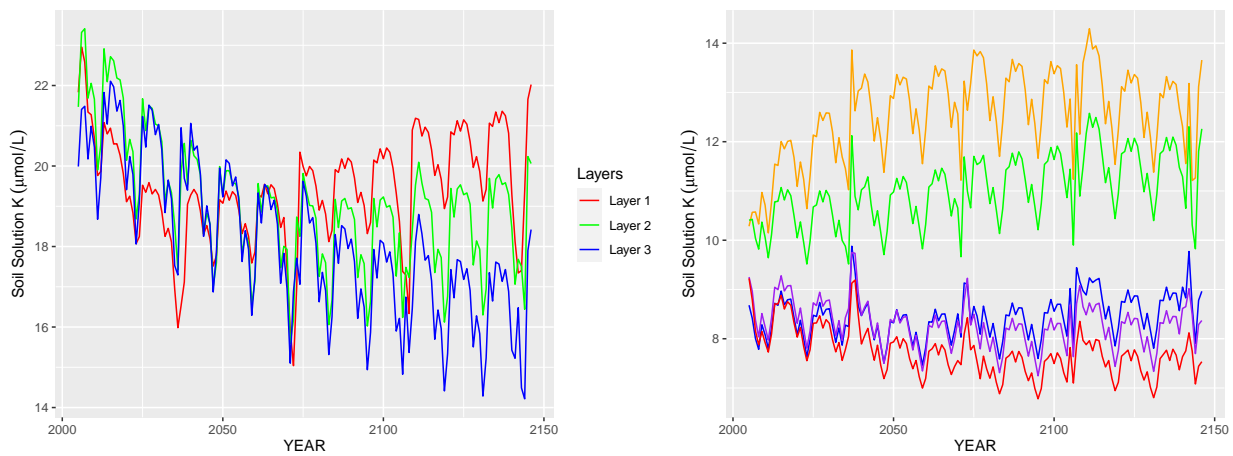


Figure 3: Monthly Potassium Concentrations by Soil Layer

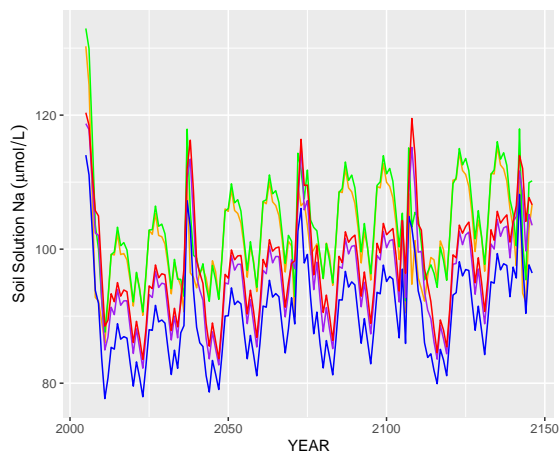
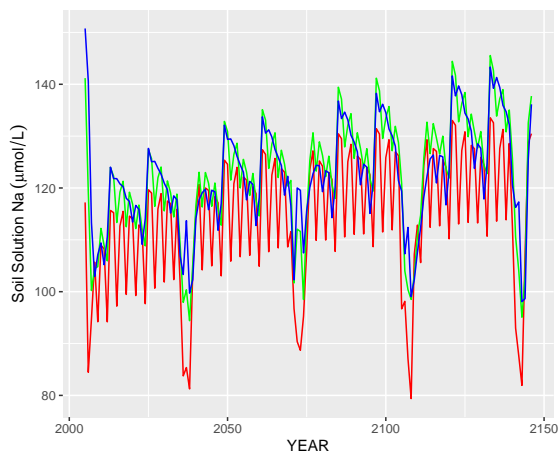


Figure 4: Monthly Sodium Concentrations by Soil Layer

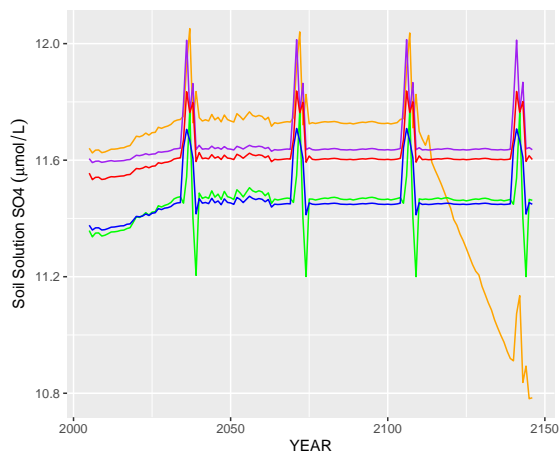
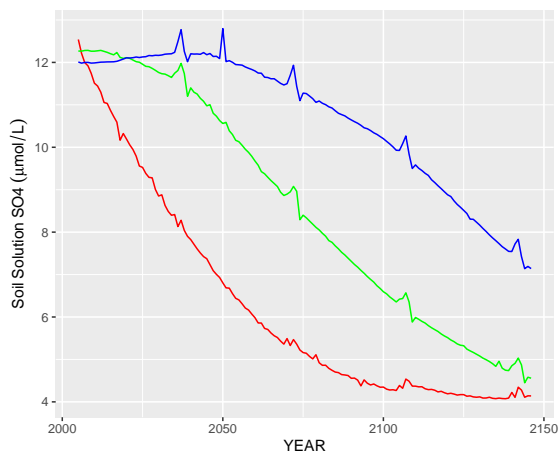


Figure 5: Monthly Sulfate Concentrations by Soil Layer

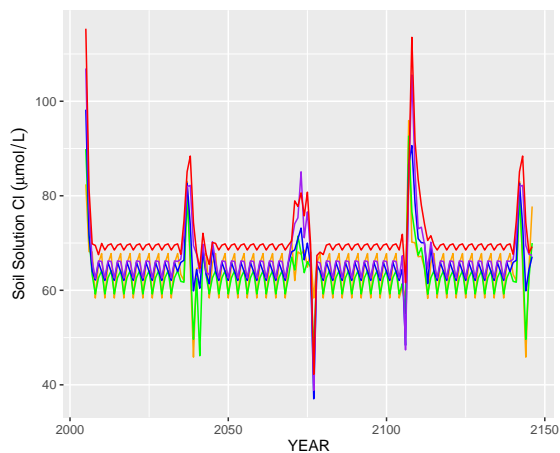
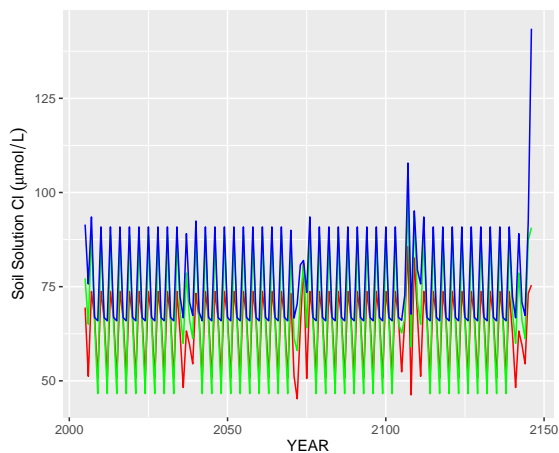


Figure 6: Monthly Chloride Concentrations by Soil Layer

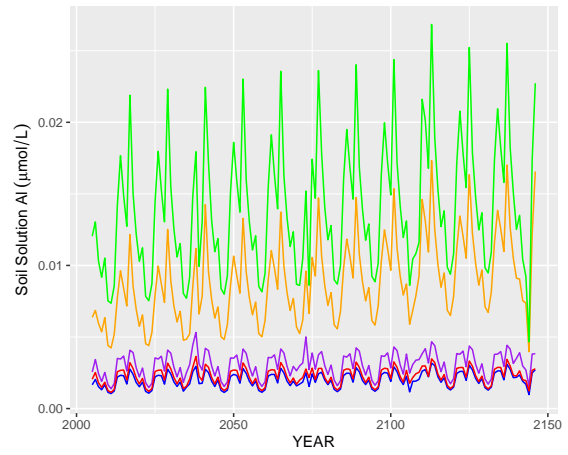
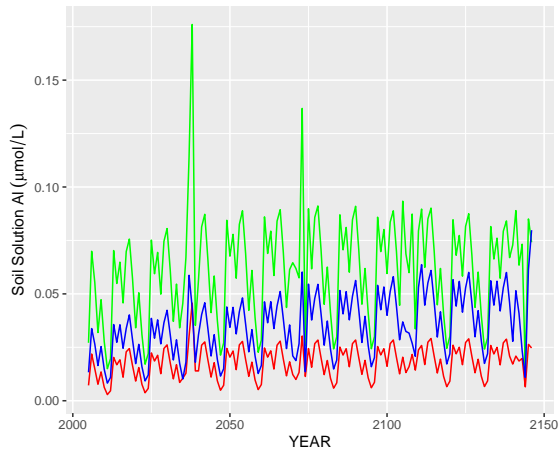


Figure 7: Monthly Aluminum Concentrations by Soil Layer

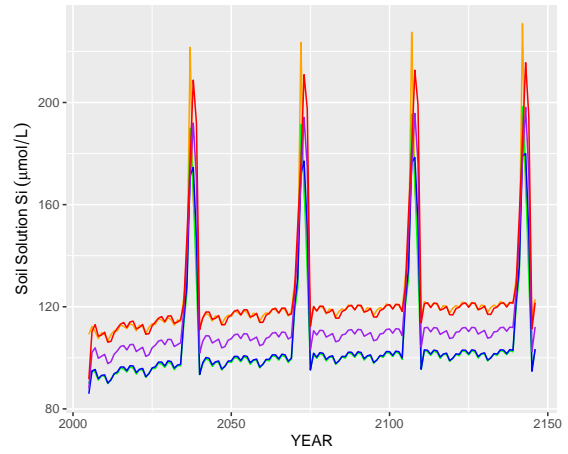
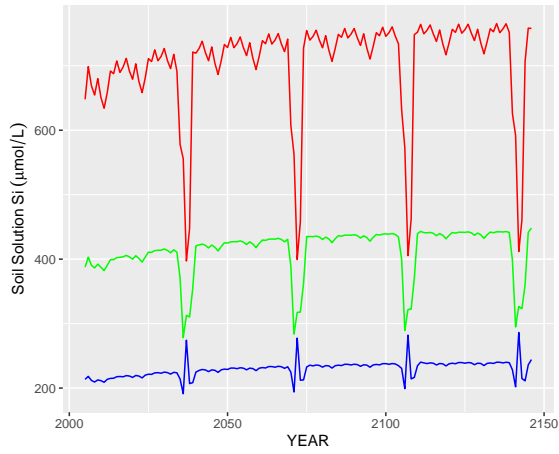


Figure 8: Monthly SiO₂ Concentrations by Soil Layer

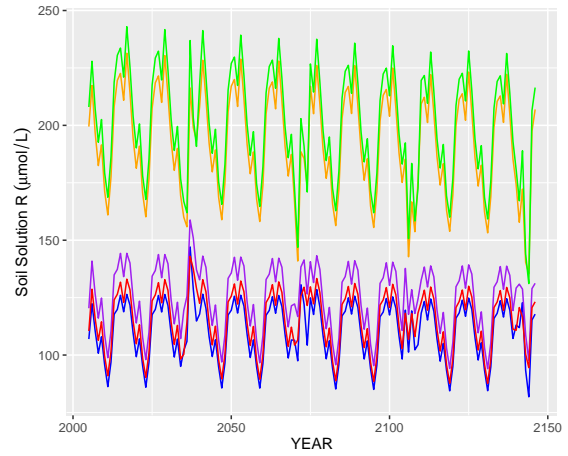
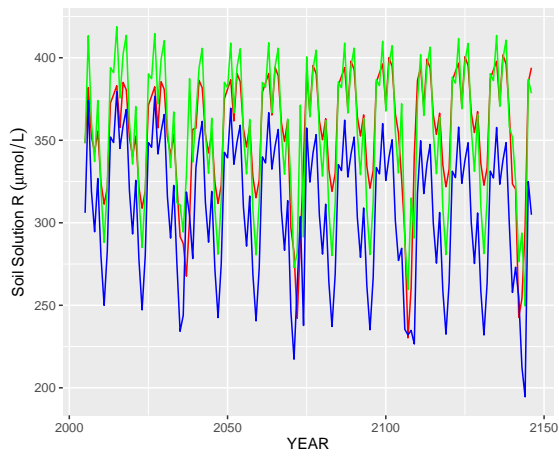


Figure 9: Monthly Organic Acid Base (R⁻) Concentrations by Soil Layer

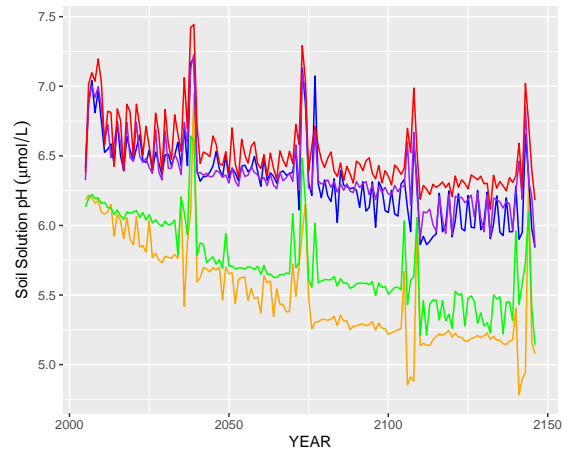
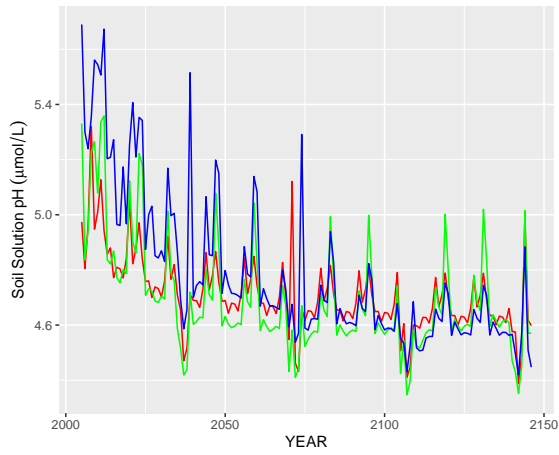


Figure 10: Monthly pH by Soil Layer

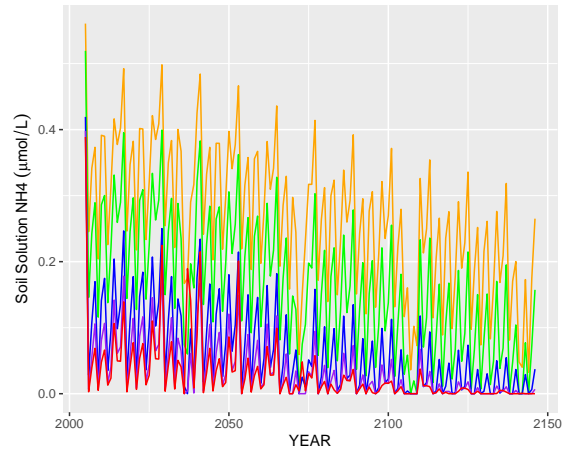
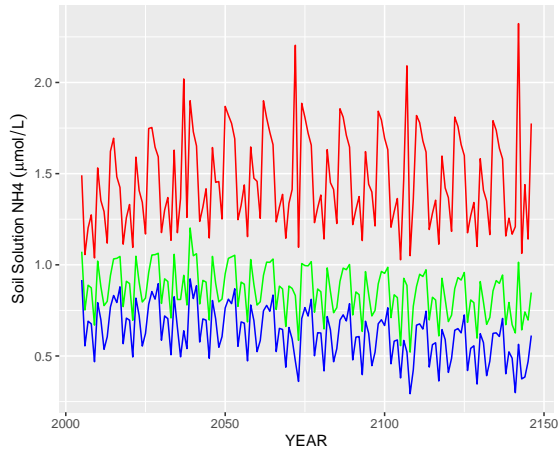


Figure 11: Yearly Ammonium concentration by Soil Layer

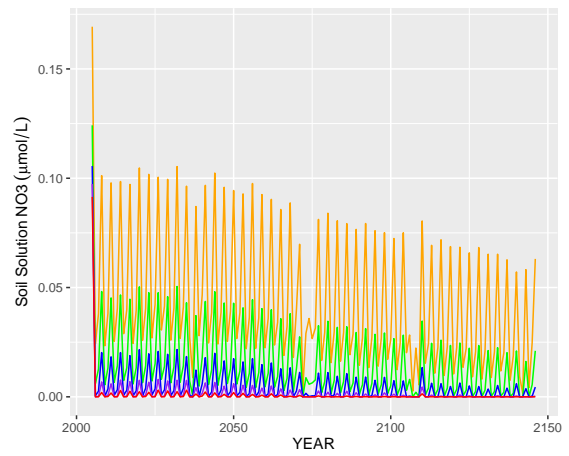
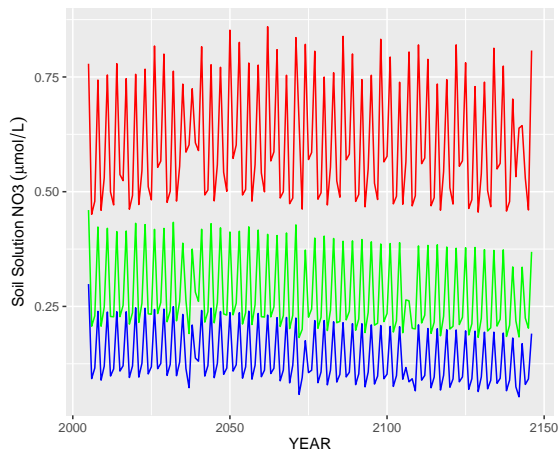


Figure 12: Yearly Nitrate concentration by Soil Layer

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

Depth	YEAR	Ca	Mg	K	Na	NO3	NH4	SO4	Cl	P	DOC	Al	Si
2	2005	8.2	6.0	6.5	25	0.172	0.31	6	34	0.11	28	8.8e-05	49
2	2006	8.8	6.5	6.7	20	0.068	0.23	6	30	0.12	29	2.3e-04	51
8	2005	6.8	6.4	3.4	27	0.046	0.11898	4.7	45	0.059	6.0	6.7e-06	42
8	2006	5.8	5.5	3.1	25	0.000	0.00044	4.7	33	0.057	5.5	8.1e-06	49

Lysimeter Leaching Layers

Weathering Results

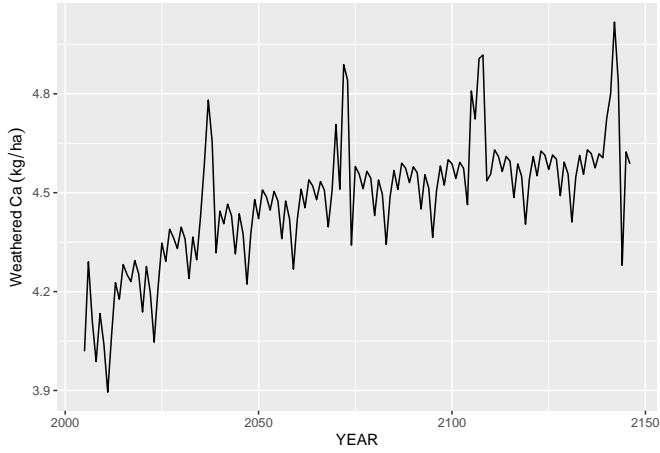


Figure 13: Calcium Weathering (All Layer)

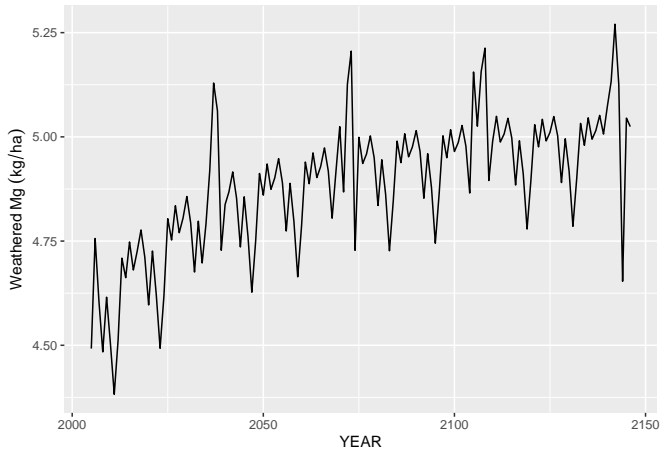


Figure 14: Magnesium Weathering (All Layer)

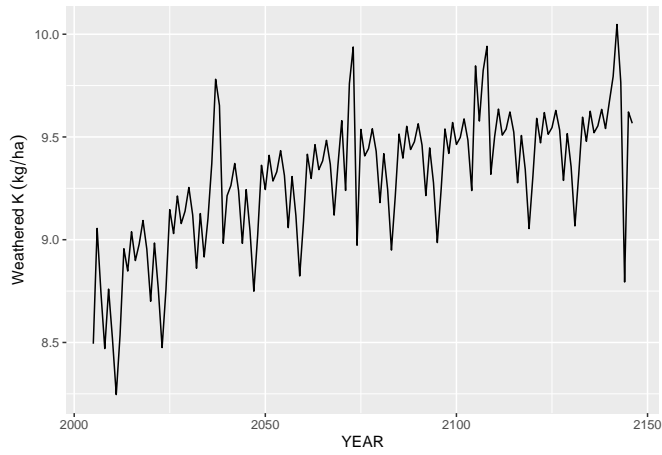


Figure 15: Potassium Weathering (All Layer)

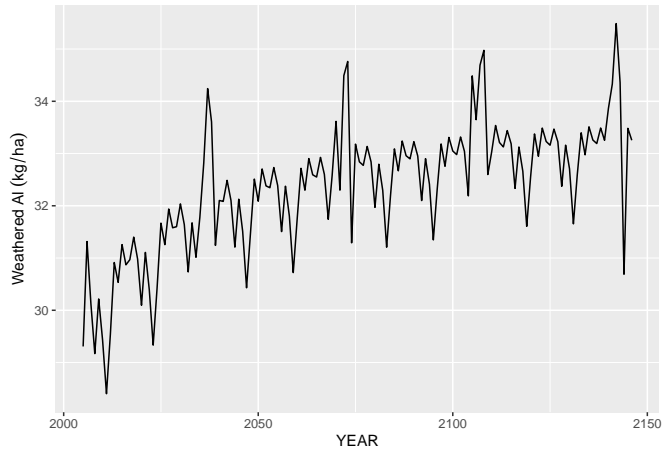


Figure 16: Aluminum Weathering (All Layer)

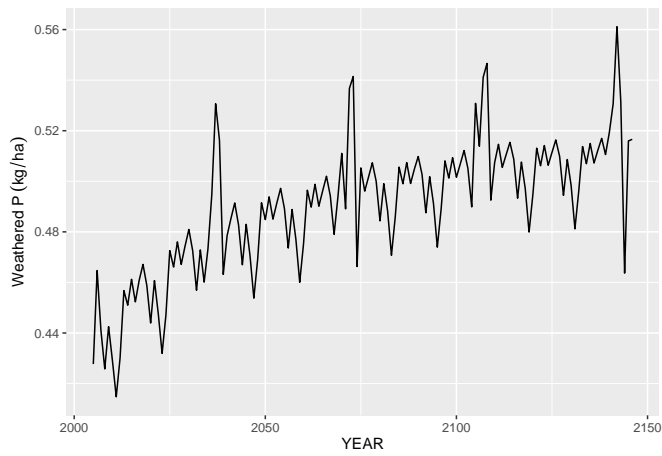


Figure 17: Phosphate Weathering (All Layer)

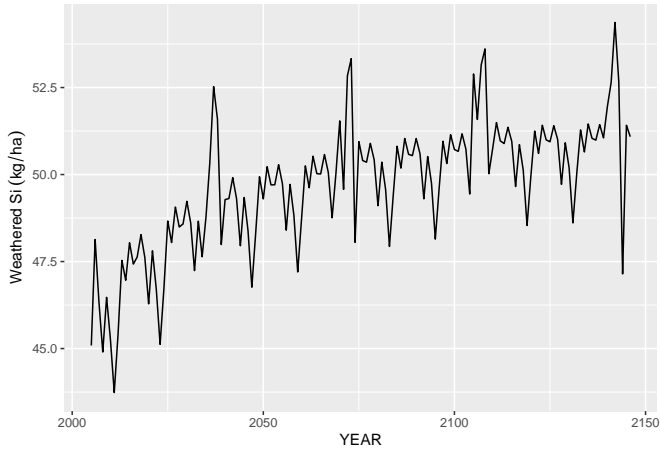


Figure 18: Silica Weathering (All Layer)

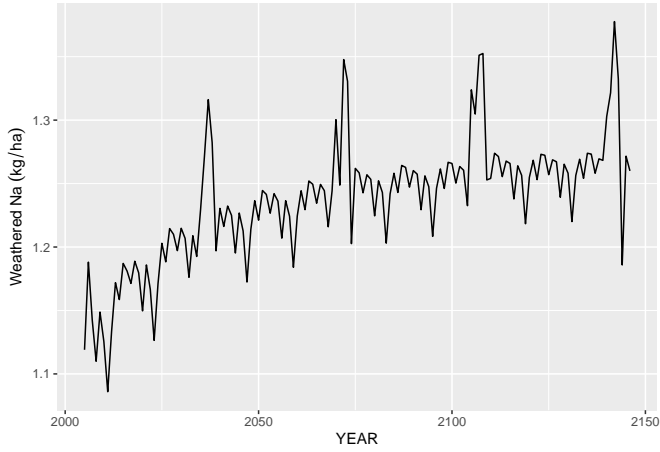
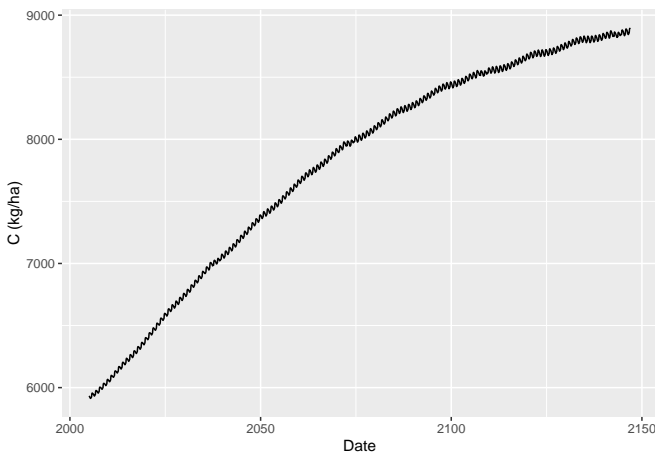
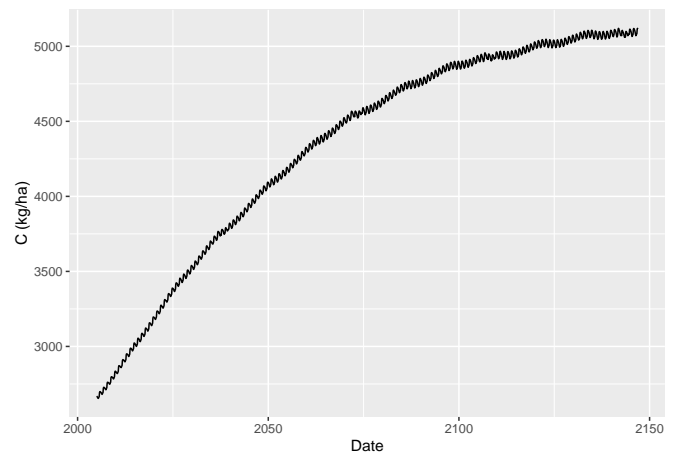


Figure 19: Sodium Weathering (All Layer)

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

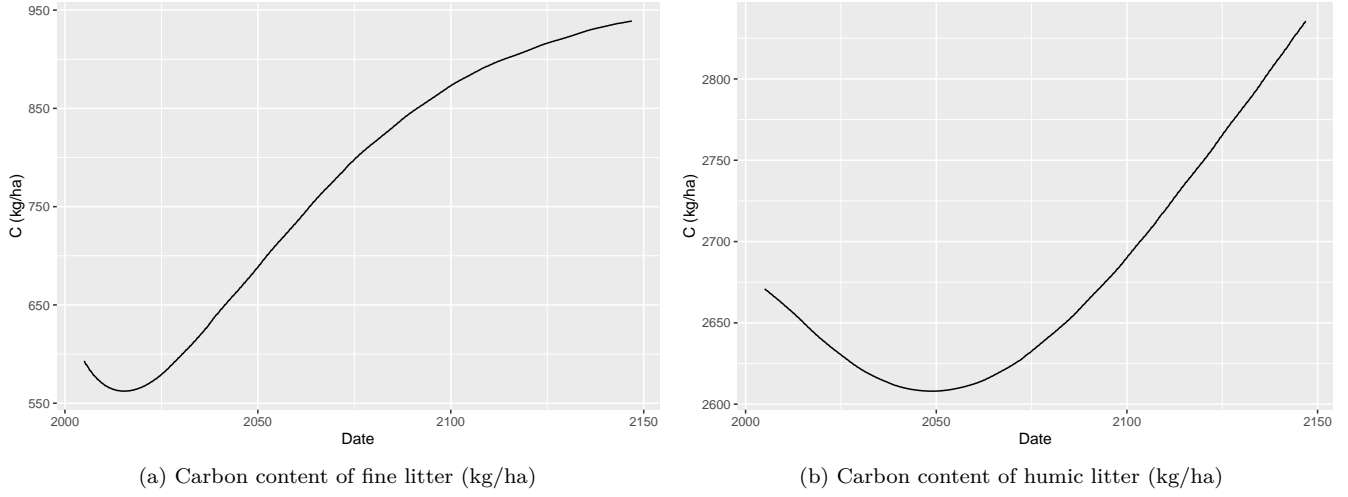


Figure 21: Forest Floor (O-Layer) Carbon Content Over Simulation Period

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.

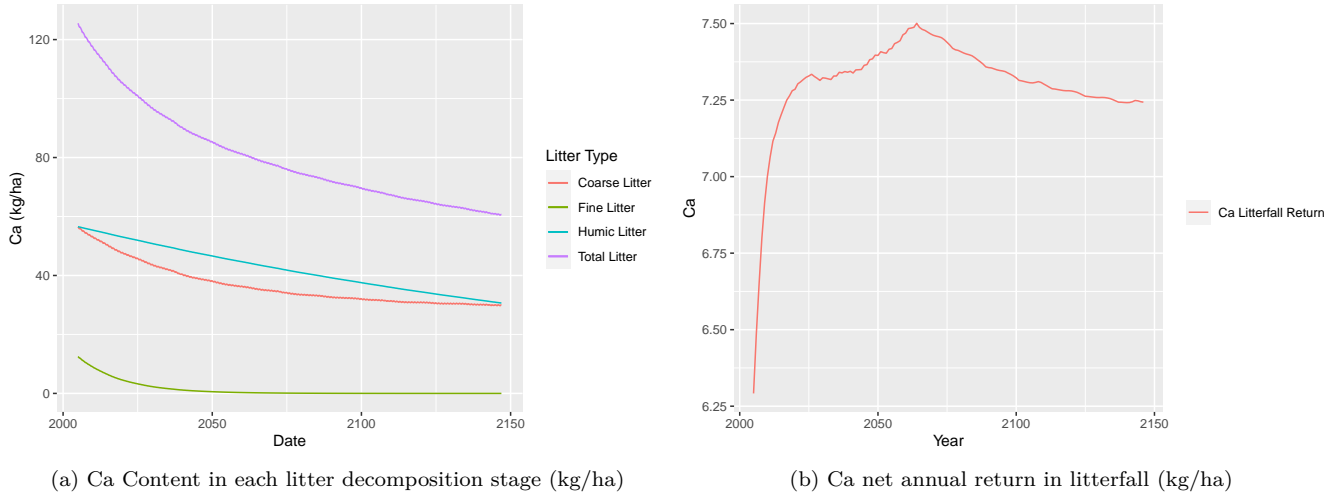
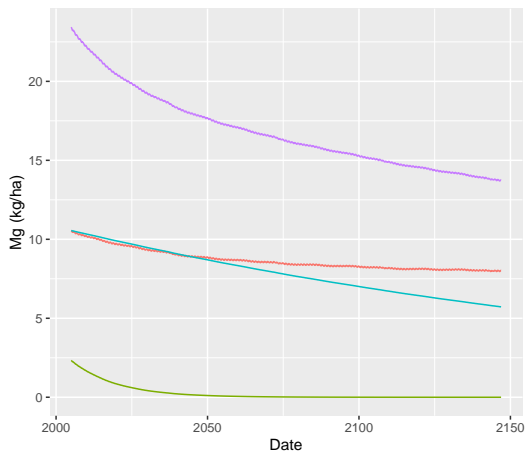
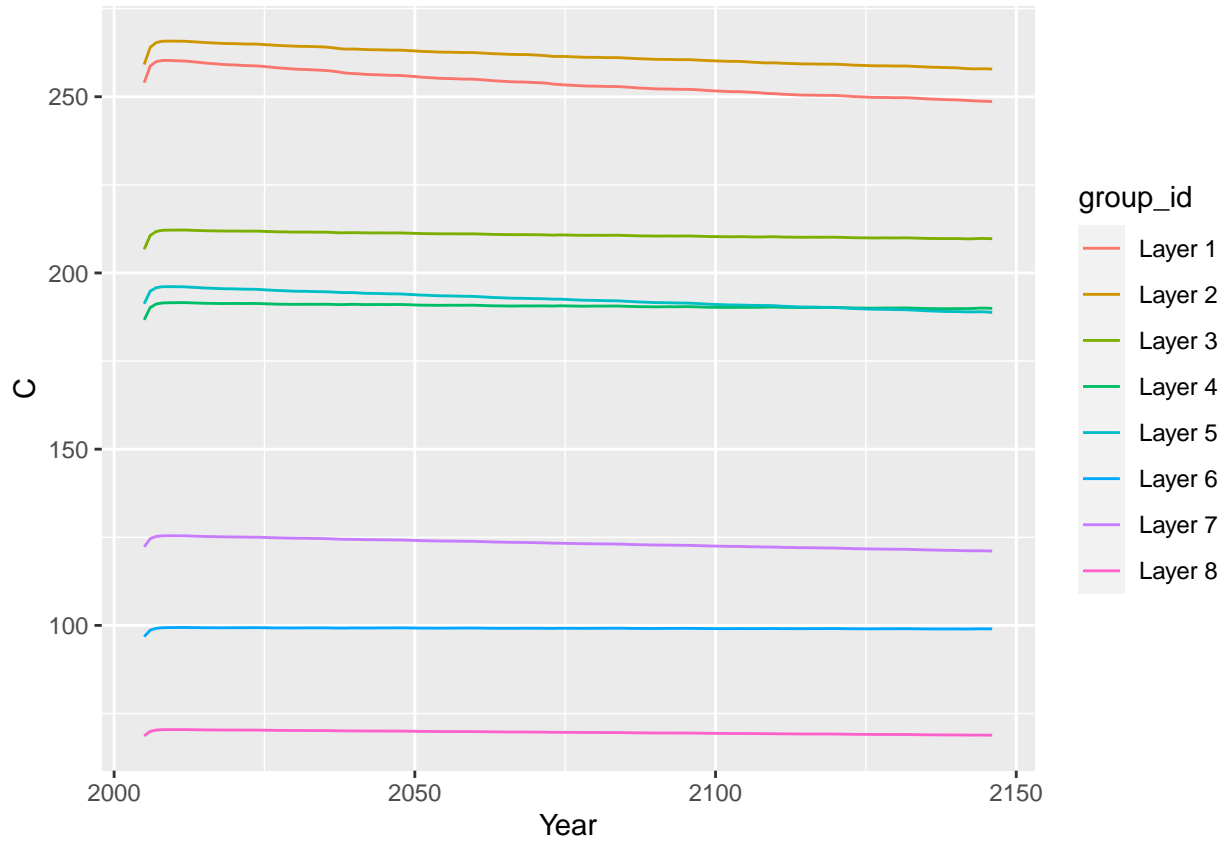
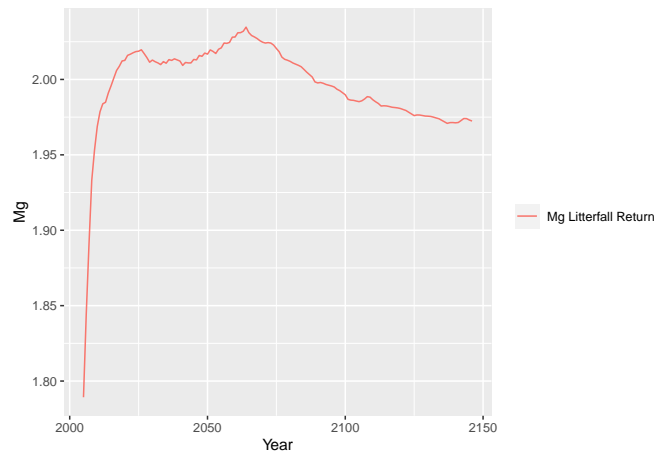


Figure 22: Forest Floor/O-horizon Ca content over time (a). and net annual Ca return in litterfall (b).

Soil Organic Matter Results

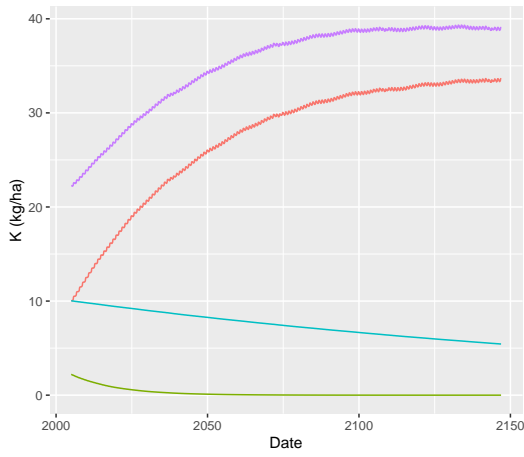


(a) Mg Content in each litter decomposition stage (kg/ha)

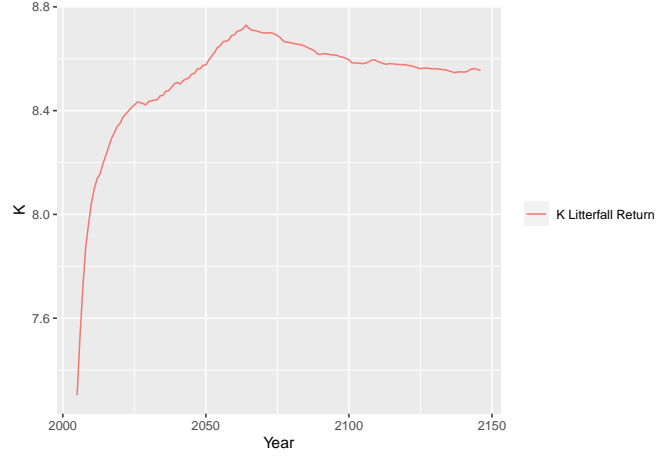


(b) Mg net annual return in litterfall (kg/ha)

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

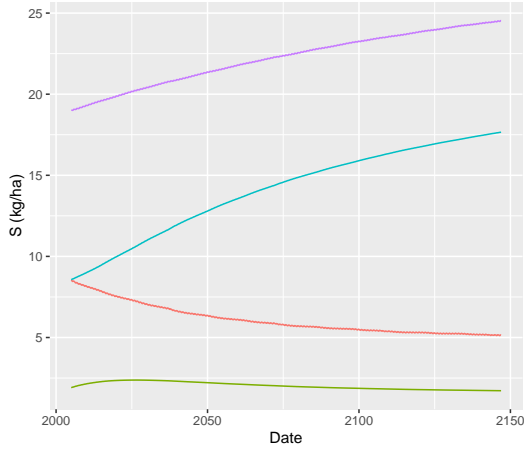


(a) K Content in each litter decomposition stage (kg/ha)

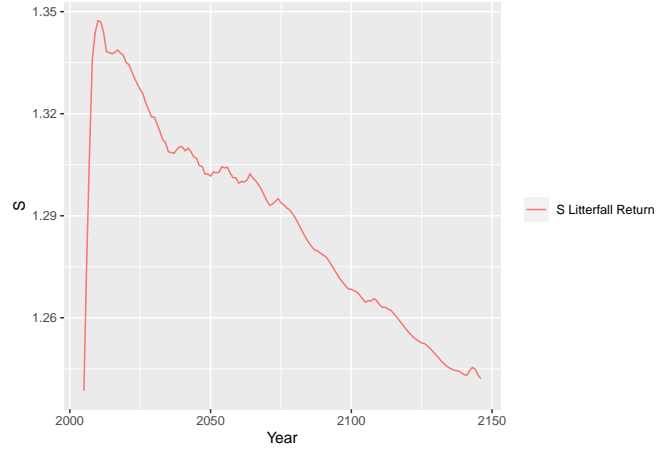


(b) K net annual return in litterfall (kg/ha)

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

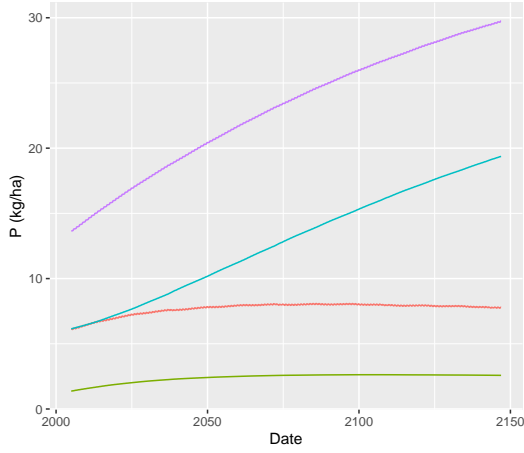


(a) S Content in each litter decomposition stage (kg/ha)

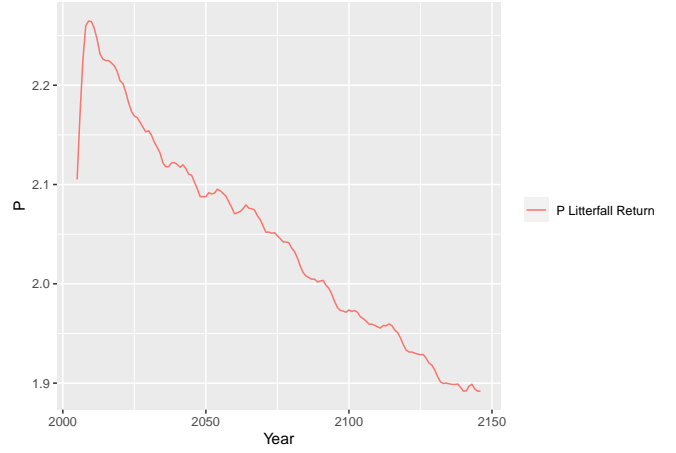


(b) S net annual return in litterfall (kg/ha)

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

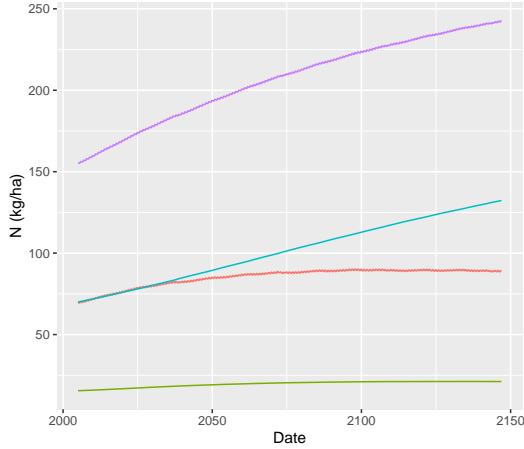


(a) P Content in each litter decomposition stage (kg/ha)

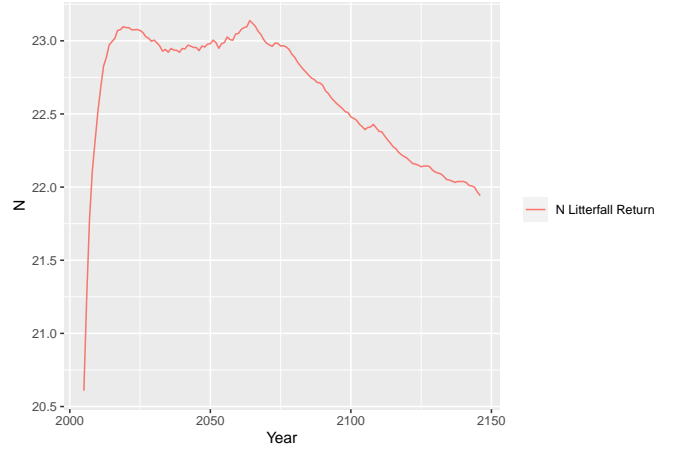


(b) P net annual return in litterfall (kg/ha)

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)

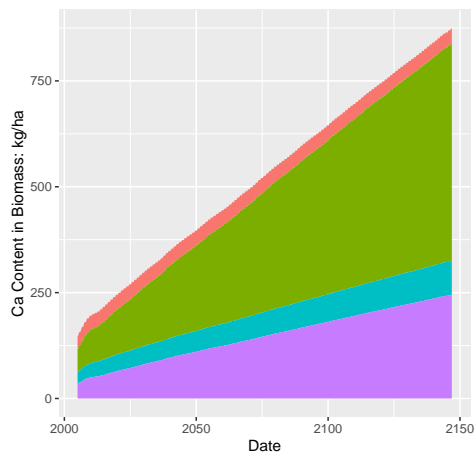


(b) N net annual return in litterfall (kg/ha)

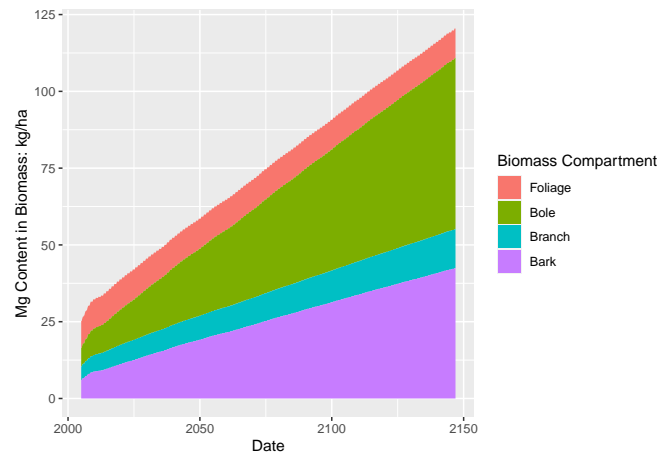
Figure 27: Forest Floor/O-horizon N content over time (a). and net annual N return in litterfall (b).

I plotted the litterfall return rate and the O-horizons next to each other to show that the inability of the O-horizon to build up certain nutrients is not an issue with nutrient release (these values can be set to be very low, such as 0.05 for Ca and Mg, and losses are still observed), but likely due to a gradual depletion of the soil for specific nutrients. The site builds up with N in the O-horizon, and this likely implies that the system is not limited by N, but that base cations are becoming increasingly limited over time, with the exception of K.

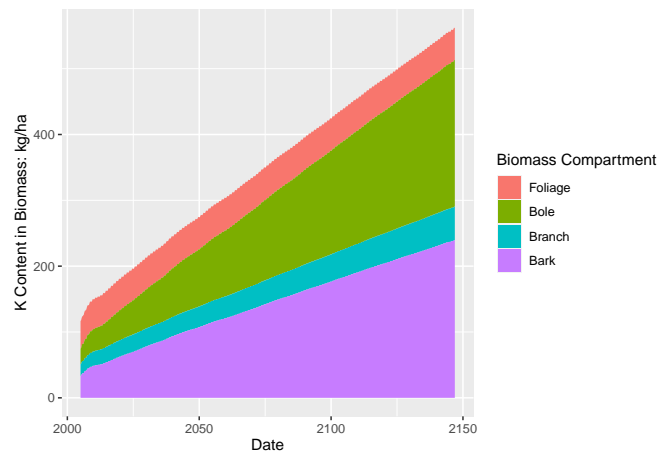
Tree Nutrient Content



(a) Calcium content in each biomass compartment

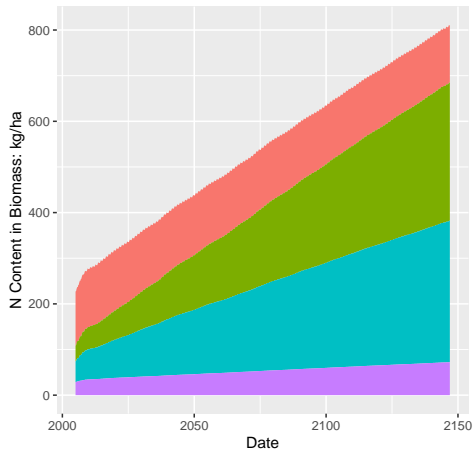


(b) Magnesium content in each biomass compartment

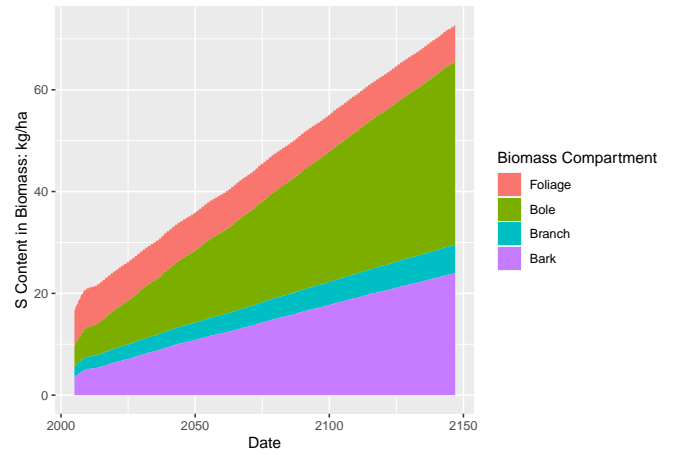


(c) Potassium content in each biomass compartment

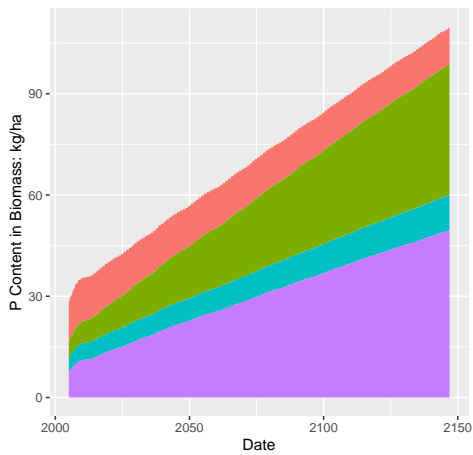
Figure 28: Base Cation Nutrient Content in Simulated Forest



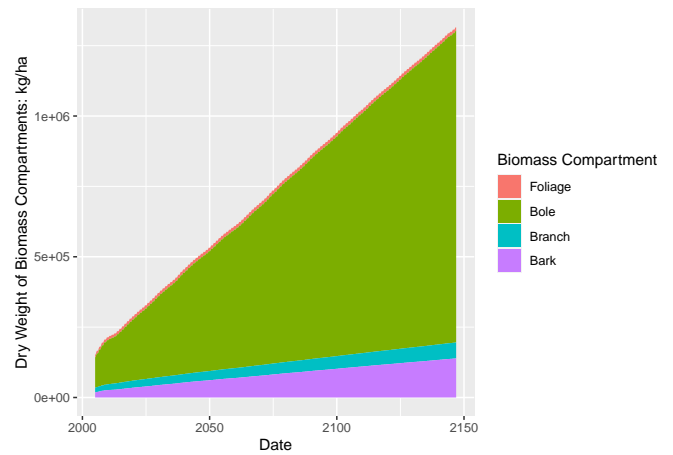
(a) Nitrogen content in each biomass compartment



(b) Sulfur content in each biomass compartment



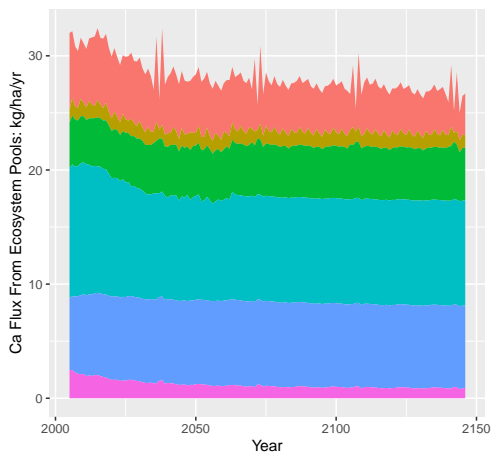
(c) Phosphorous content in each biomass compartment



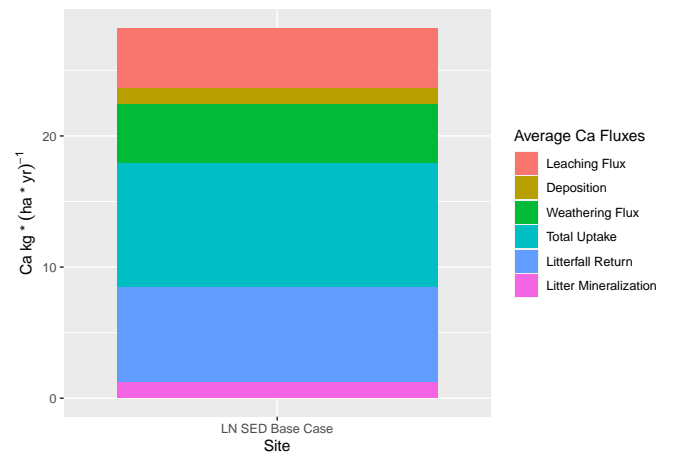
(d) Biomass of each compartment

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

Analysis 1: Stack Flux Data

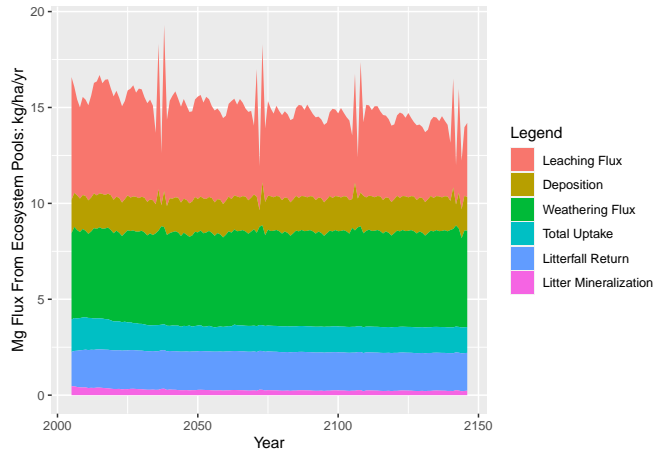


(a) Ca input and output fluxes over time

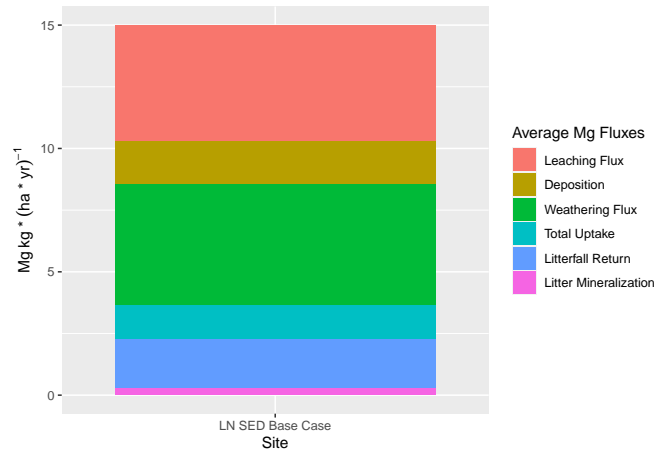


(b) Total Average Ca input and output fluxes

Figure 30: Calcium input and output comparison graphs

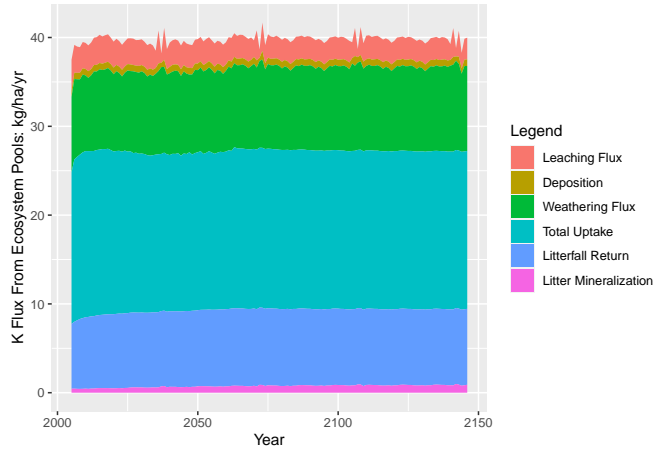


(a) Mg input and output fluxes over time

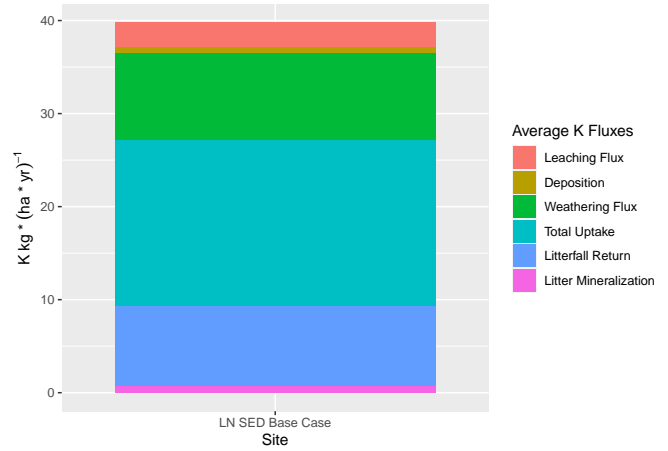


(b) Total Average Mg input and output fluxes

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

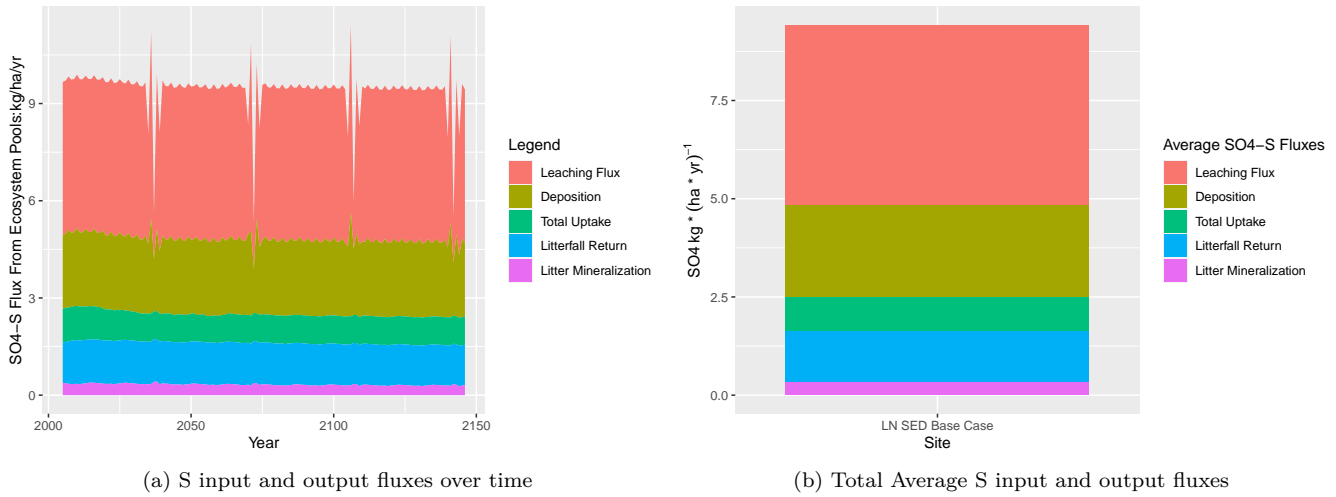


Figure 33: Sulfur input and output comparison graphs

I added back a reasonably large sulfate pool, this caused enhanced S losses which were unrealistic. This likely implies that the system had too much S going through it.

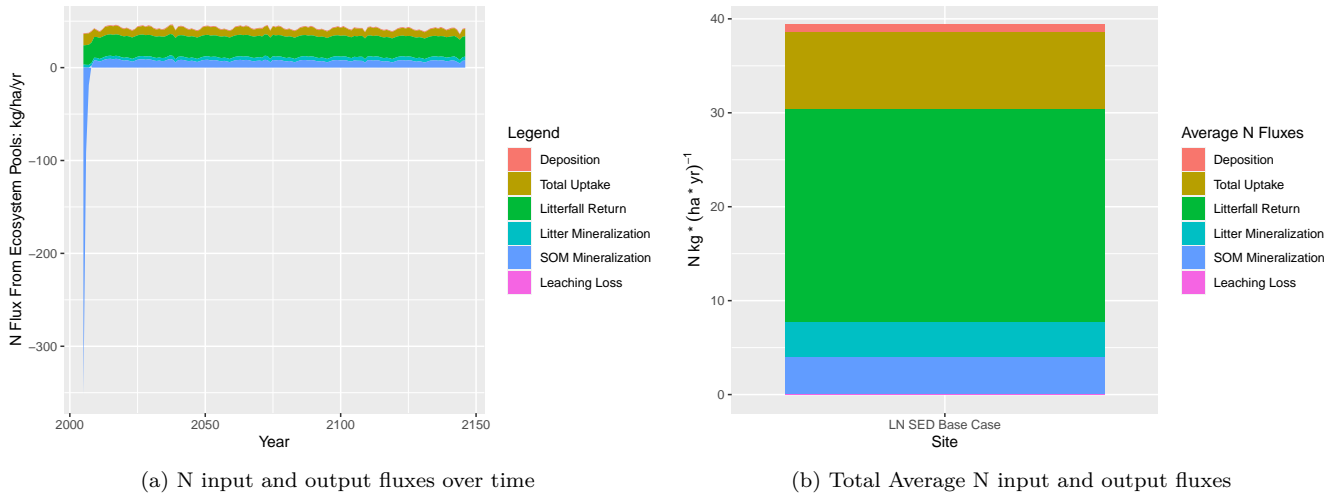


Figure 34: Nitrogen input and output comparison graphs

Notice how SOM mineralization starts off highly negative (-358 kg/ha/yr N); implying a large net N uptake in the microbial pool. The mineralization then balances out and steadily returns N to the soil over time, behaving normally. I do need the microbial pool to help calibrate the N cycle, but I may need to reduce the CEC stabilized N and decrease the N-uptake in the microbial pool. These results likely imply too much N is going through the system and that the microbial pool is too large of an N pool.

Cation Exchange Capacity

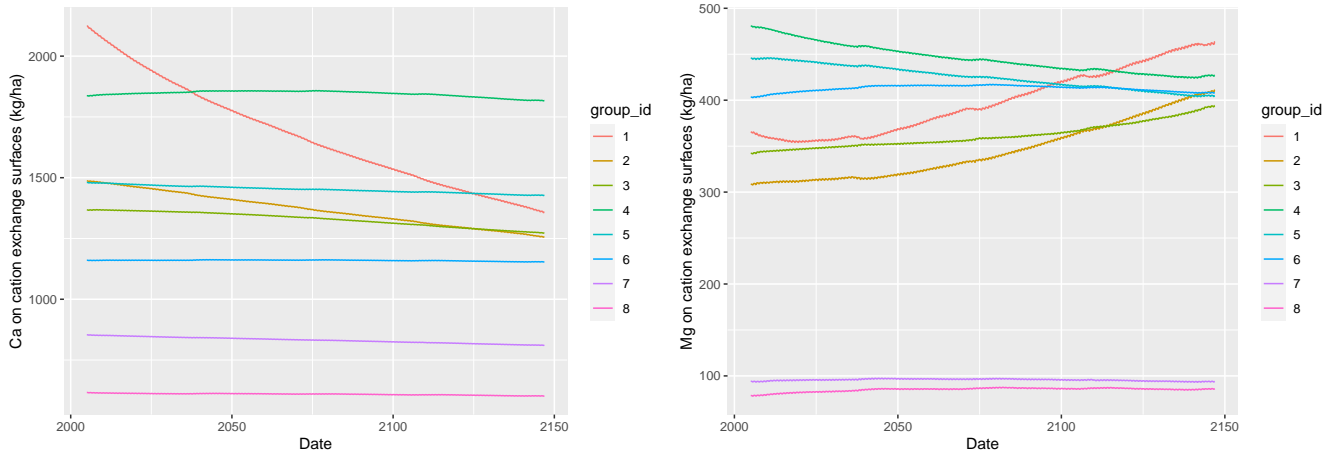


Figure 35: Calcium and Magnesium CEC adsorption over time

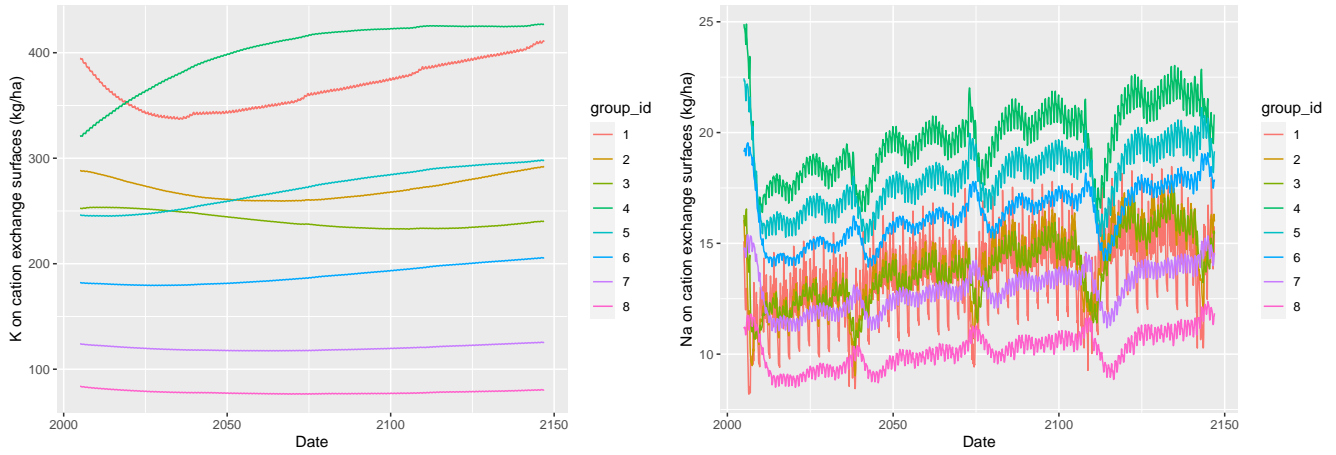


Figure 36: Potassium and Sodium CEC adsorption over time

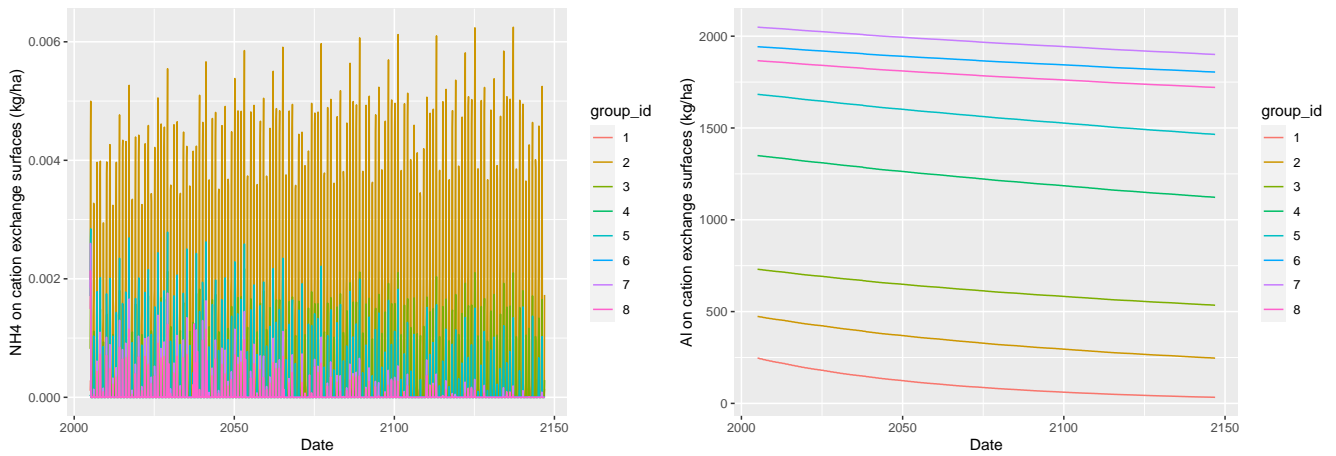
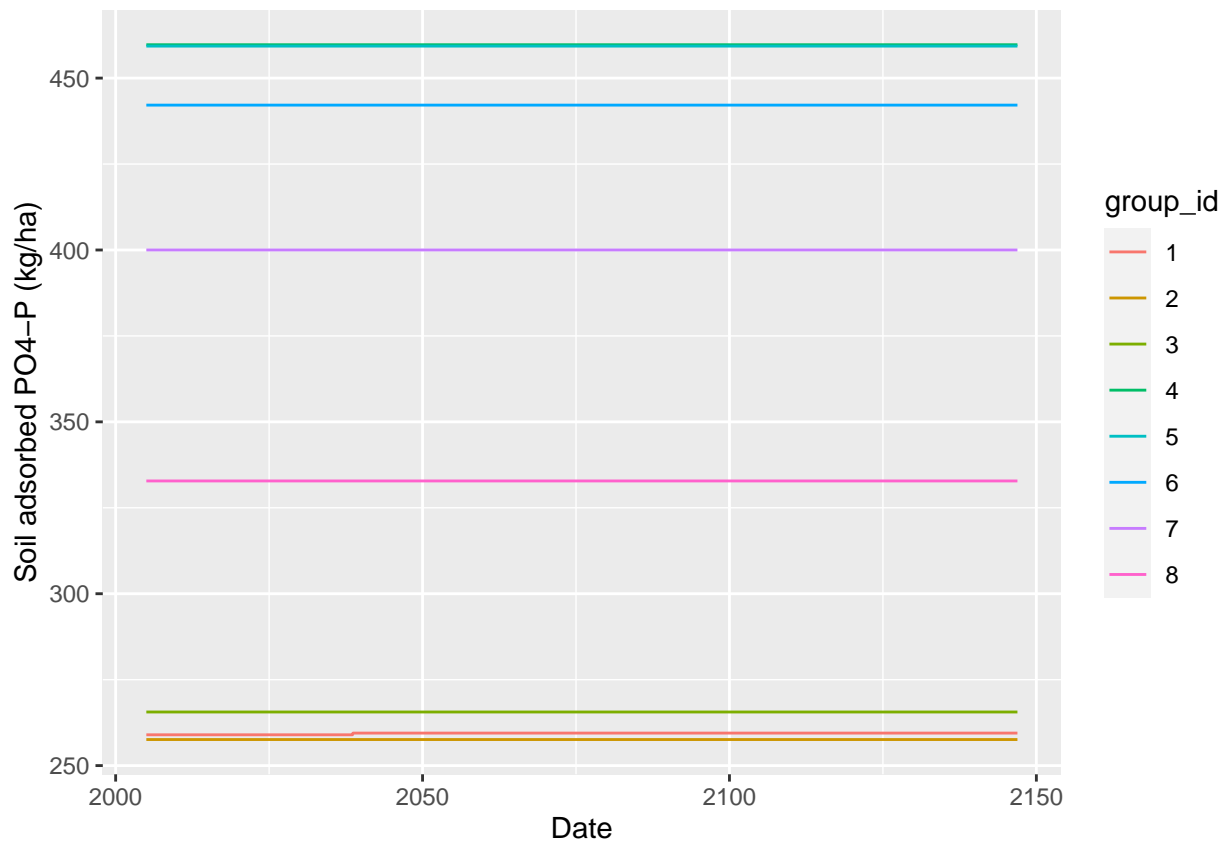
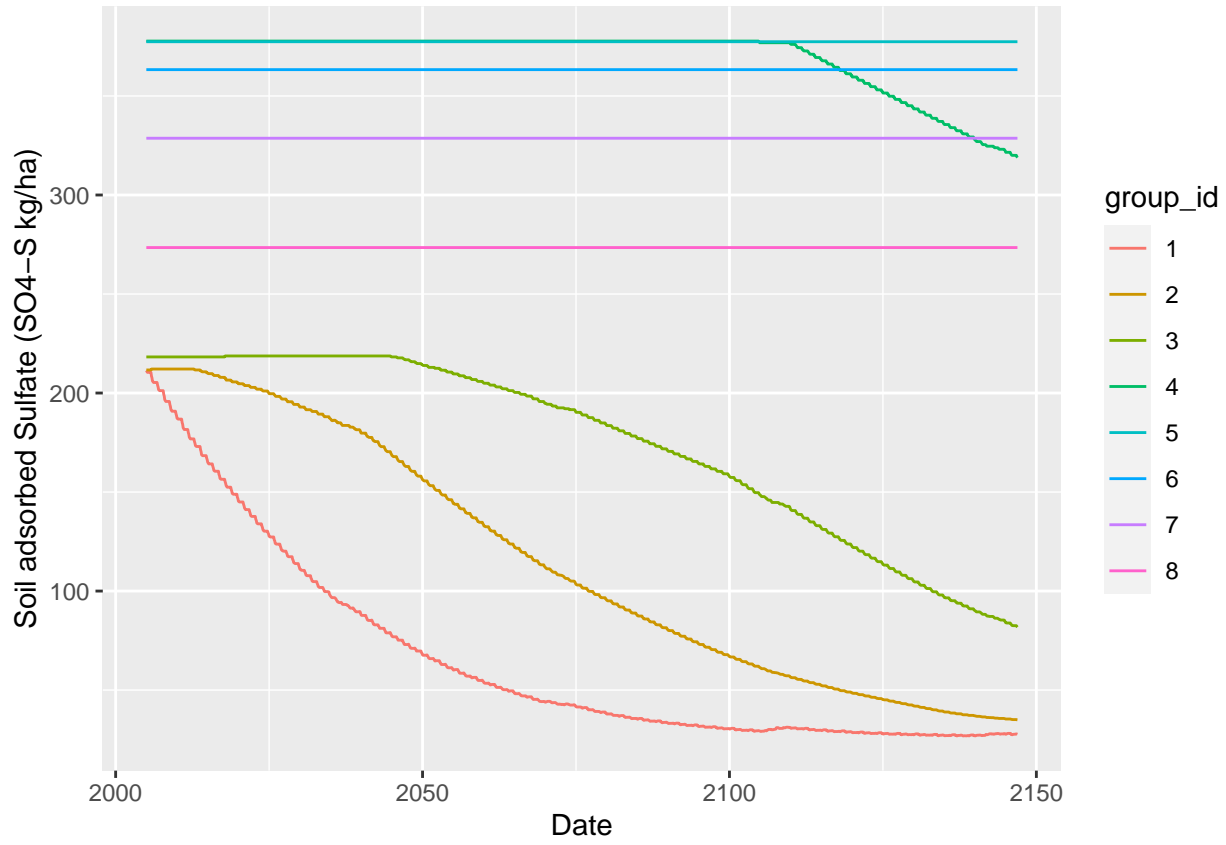
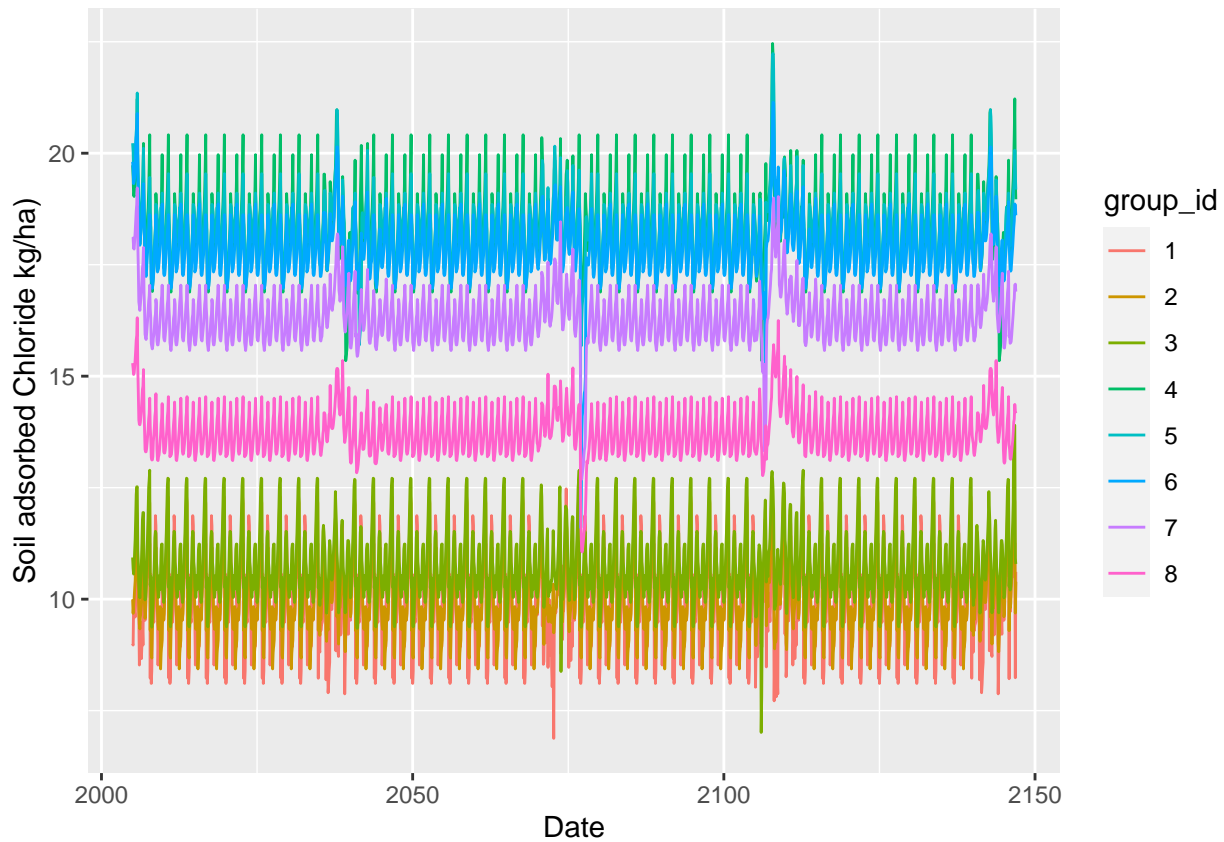


Figure 37: Ammonium and Aluminum CEC adsorption over time

Anion Exchange Capacity





Phosphate seems stable, generally. It should be noted that P uptake is not being modeled in the foliage (it should remain constant so far) and that phosphate adsorption parameters are completely borrowed from the Burgundy site. As for sulfate, I purged the model of the AEC sulfate pool and relegated all soil S to the SOM organic pool.

I further note that the ALSEA rain chemistry seems to be lacking in Na and Cl, when I completely take away Cl adsorption, I don't get anywhere near the concentration of Cl measured in the lysimeters, like I do for sulfate.

Other

