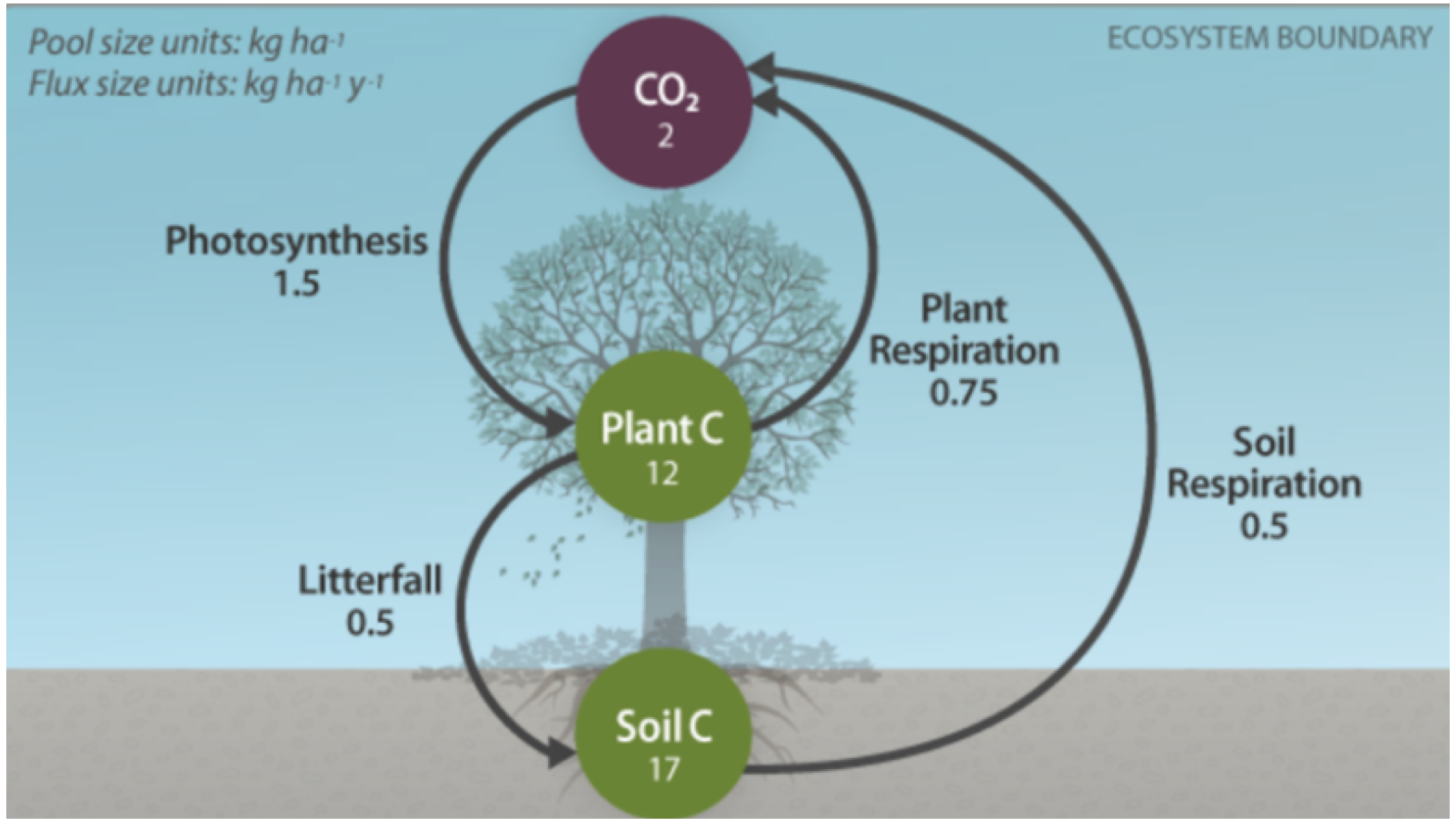
WP4: Nutriënten cycli in groendaken

WP4: Nutrient cycles in green roofs

Nutrient cycles and green roof ecosystem services

-C sequestration -> C cycle



WP4: Nutrient cycles in green roofs

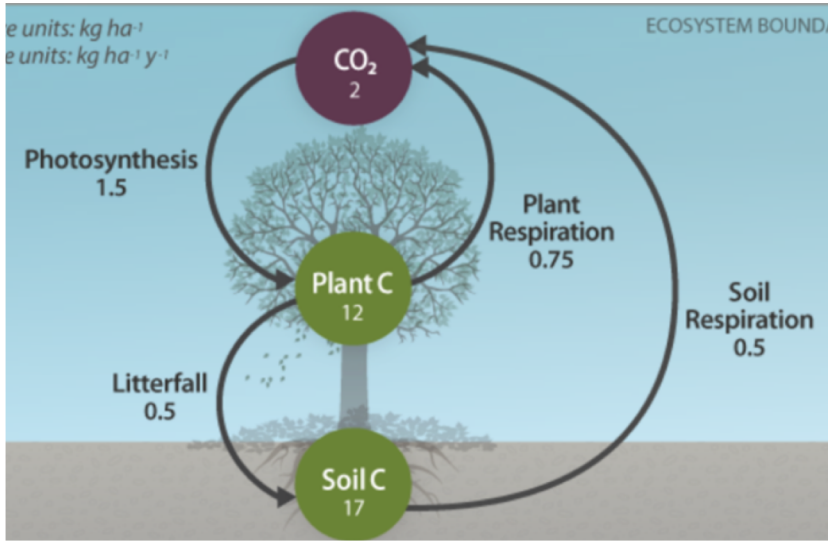
Nutrient cycles and green roof ecosystem services

-water quality = nutrient retention -> N and P cycles

WP4: Nutrient cycles in green roofs

The C cycle: C sequestration

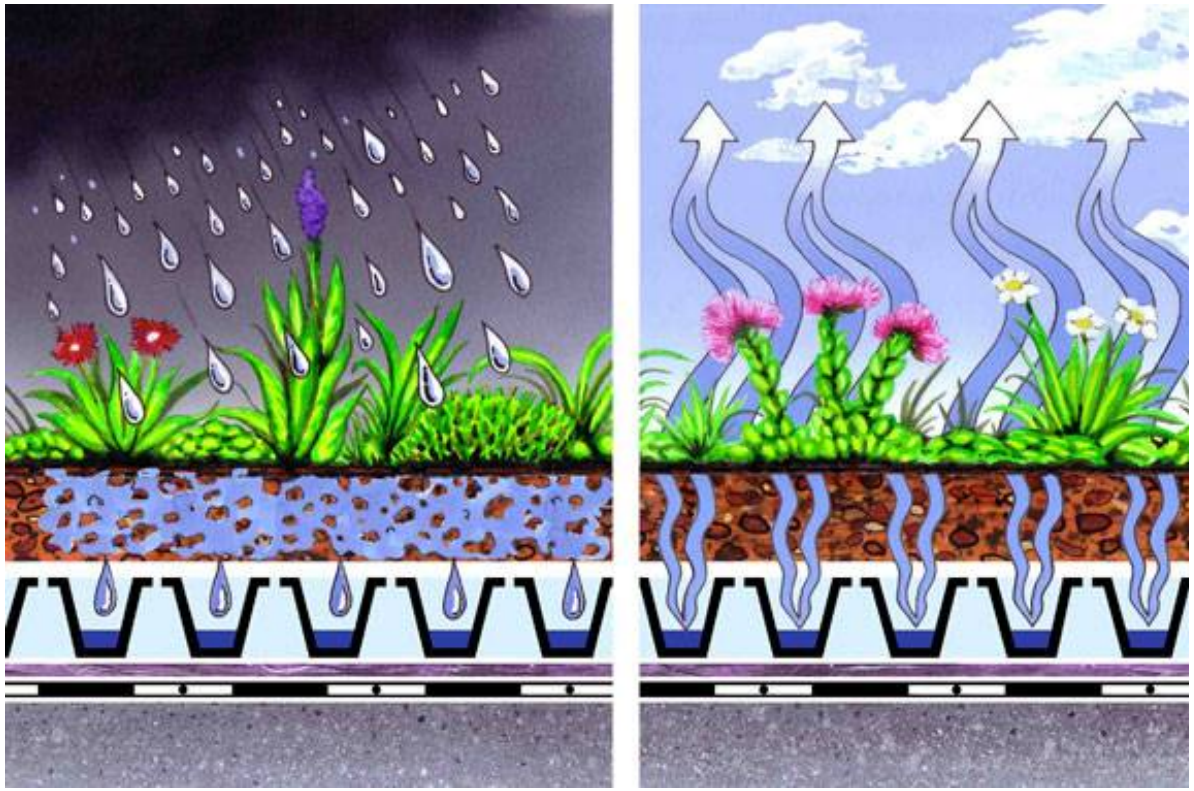
-Do green roofs sequester significant amounts of C?
-If yes, in which pools?
-How much in comparison with natural ecosystems?
-Societal impact?
-Can we increase it?



WP4: Nutrient cycles in green roofs

The N cycle: water quality

-Do green roofs have a significant buffer effect on nutrients?
-Can we increase this effect?



WP4: Nutrient cycles in green roofs

Two experiments

C cycle

-Do green roofs sequester significant amounts of C?
-If yes, in which pools?
-How much in comparison with natural ecosystems?
-Societal impact?
-Can we increase it?

N cycle

-Do green roofs have a significant buffer effect on nutrients?
-Can we increase this effect?

EXPERIMENT 1
EXPERIMENT 2

WP4: Nutrient cycles in green roofs

Experiment 1: measuring ecosystem services

-12 existing roofs:
- -Variable age
- -two vegetation types
- -Fertilization (Y/N)
- -Different substrate depths

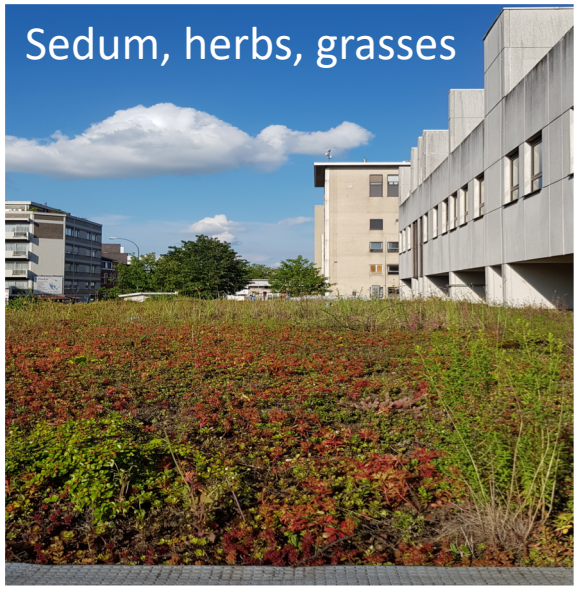
Table 1: Characteristics of the studied extensive green roofs: roof ID, location, roof area, construction year, vegetation type, fertilization (Y= fertilized, N=not fertilized), average substrate depth.

Roof ID	Location	Area (m^2)	Construction year	Vegetation type	Fertilization (Y/N)	Average substrate depth (cm)
1	Ghent	25	2014	Diverse	N	7.0
2	Ghent	110	2005	Sedum-only	N	6.0
3	Ghent	588	2013	Sedum-only	Y	5.0
4	Ghent	76	2015	Diverse	N	8.0
5	Hasselt	432	2015	Diverse	Y	11.0
6	Hasselt	108	2012	Sedum-only	Y	5.0
7	Hasselt	175	2004	Diverse	N	8.0
8	Hasselt	225	2015	Diverse	Y	12.0
9	Antwerp	280	2008	Sedum-only	Y	4.5
10	Antwerp	708	2014	Sedum-only	Y	6.0
11	Antwerp	777	2009	Diverse	Y	8.5
12	Antwerp	312	2015	Diverse	Y	8.5

WP4: Nutrient cycles in green roofs

Experiment 1: measuring ecosystem se

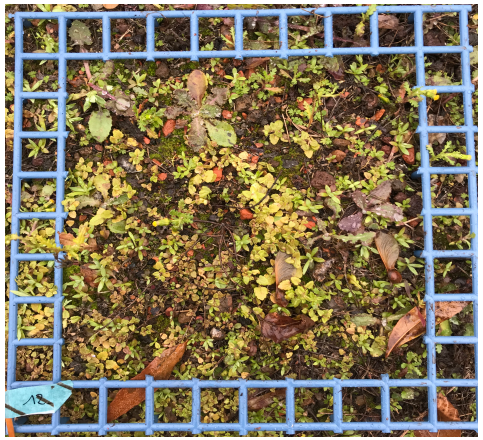
-Impressions



WP4: Nutrient cycles in green roofs

Experiment 1: measuring ecosystem services

-Sample collection
  - -3 timepoints: April ‘19 (spring), July ’19 (summer), October ‘19 (autumn), January ‘20 (winter)
  - -4 random plots (25cmx25cm)
  - -Above ground vegetation / roots / substrate cores



WP4: Nutrient cycles in green roofs

Experiment 1: measuring ecosystem services

-**Analyses**

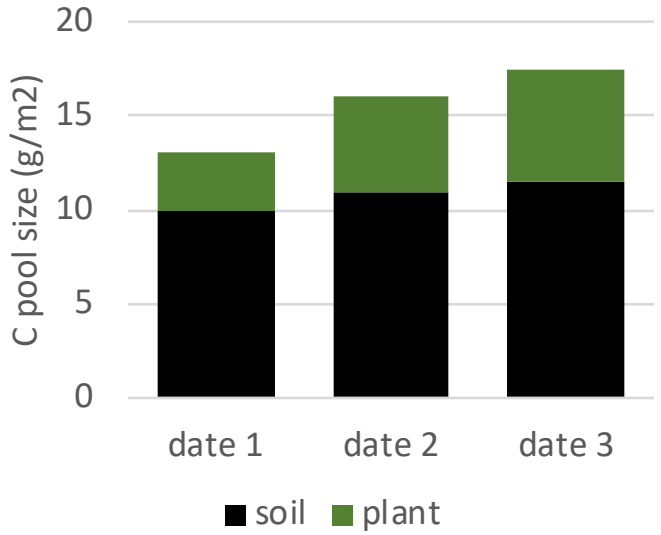
-pools: Total Carbon, Nitrogen and Phosphorus (substrate, vegetation)

-Fluxes: Nitrogen-mineralisation, nitrification

-pH

-**Output**

-C pool dynamics: C sequestration potential



-N and P pool dynamics + N fluxes: nutrient retention (partial)

WP4: Nutrient cycles in green roofs

Experiment 1: measuring ecosystem services

-**Results: C pools**

-Large differences

-Low in comparison with natural ecosystems

-FYI in plants: average 60 gC/m^2

-Vs substrate: 1100 gC/m^2

	TC ($g\ m^{-2}$)
Roof 1	1448 ± 641
Roof 2	924 ± 779
Roof 3	743 ± 164
Roof 4	1382 ± 559
Roof 5	2451 ± 496
Roof 6	862 ± 507
Roof 7	1922 ± 807
Roof 8	2883 ± 293
Roof 9	1047 ± 206
Roof 10	714 ± 306
Roof 11	5142 ± 527
Roof 12	833 ± 255

Table 2: Average values and standard deviation of substrate TC, TN, TP, N-mineralization, net nitrification and pH per roof across all seasons (n=16: values ± S.D.). For each variable, red to green gradient colors show the maximum to minimum scale. Roofs with diverse vegetation are in bold.

WP4: Nutrient cycles in green roofs

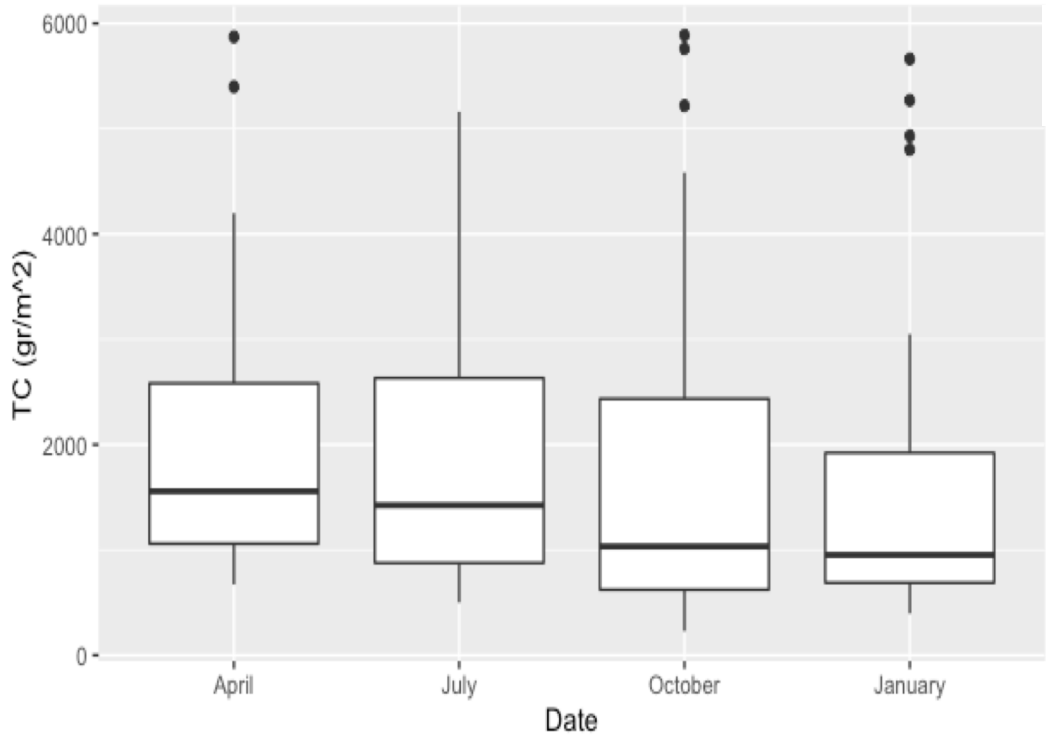
Experiment 1: measuring ecosystem services

-**Results: C pools dynamics**

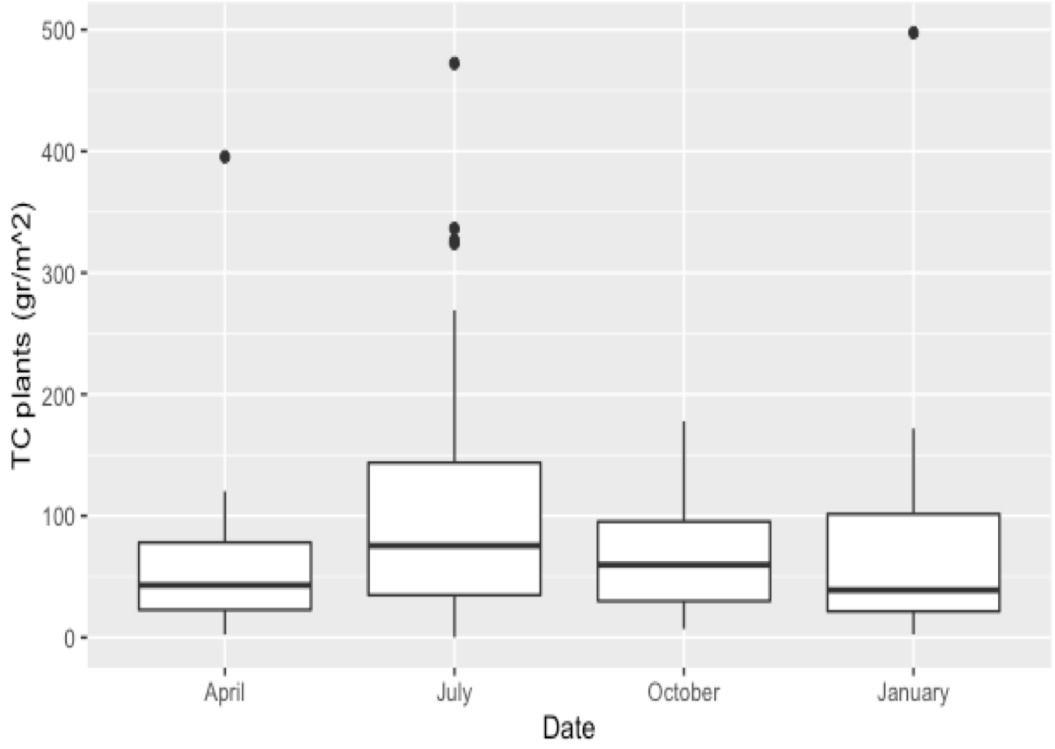
-Substrate: decrease

-Plants: seasonal variations

A)



B)



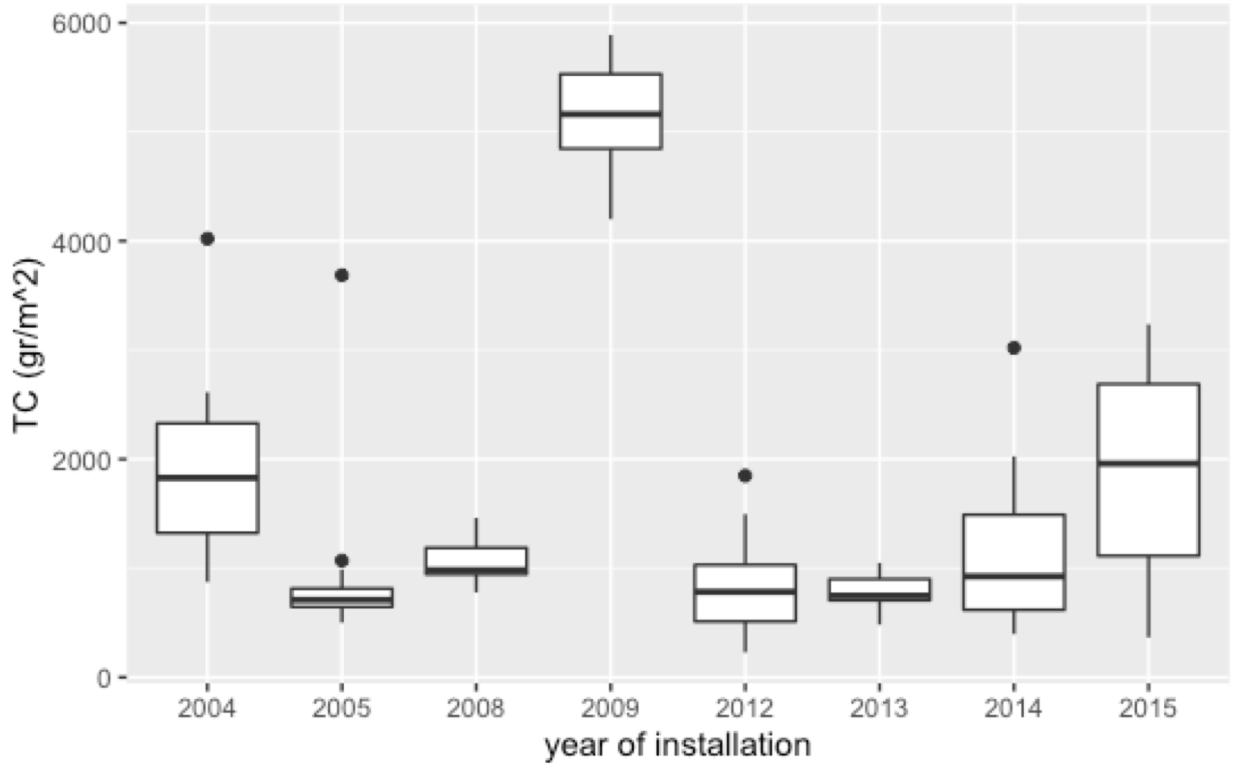
WP4: Nutrient cycles in green roofs

Experiment 1: measuring ecosystem services

-**Results: C pools dynamics**

-Testing effect of green roof age on C pool size -> not significant

-> existing green roofs do not seem to sequester C



WP4: Nutrient cycles in green roofs

Experiment 1: measuring ecosystem services

-**Results: N pools and fluxes**

-Again highly variable

-Low fluxes

-dominated by nitrification

-**Results: P pools**

-Substrates very N rich (P/N)

	TC ($g\ m^{-2}$)	TN ($g\ m^{-2}$)	TP ($g\ m^{-2}$)	N – mineralization (mg N kg^{-1} soil day^{-1})	Net nitrification (mg N kg^{-1} soil day^{-1})	pH
Roof 1	1448 ± 641	90 ± 34	40 ± 8	0.22 ± 0.25	0.21 ± 0.24	6.22 ± 0.59
Roof 2	924 ± 779	58 ± 43	70 ± 12	0.28 ± 0.32	0.29 ± 0.3	6.04 ± 0.11
Roof 3	743 ± 164	48 ± 12	49 ± 9	0.57 ± 0.72	0.57 ± 0.74	6.02 ± 0.14
Roof 4	1382 ± 559	72 ± 27	68 ± 17	0.16 ± 0.29	0.18 ± 0.28	6.06 ± 0.15
Roof 5	2451 ± 496	85 ± 19	124 ± 19	0.71 ± 0.64	0.72 ± 0.67	6.5 ± 0.18
Roof 6	862 ± 507	54 ± 27	74 ± 8	1.2 ± 1.28	1.45 ± 1.66	5.61 ± 0.25
Roof 7	1922 ± 807	103 ± 46	78 ± 10	0.6 ± 0.39	0.62 ± 0.39	5.78 ± 0.34
Roof 8	2883 ± 293	90 ± 10	137 ± 12	0.18 ± 0.14	0.19 ± 0.16	6.69 ± 0.08
Roof 9	1047 ± 206	38 ± 9	80 ± 18	0.48 ± 0.39	0.51 ± 0.4	5.81 ± 0.14
Roof 10	714 ± 306	46 ± 22	48 ± 10	1.44 ± 1.18	1.53 ± 1.25	5.64 ± 0.31
Roof 11	5142 ± 527	167 ± 29	147 ± 21	2.06 ± 1.57	2.11 ± 1.56	5.9 ± 0.19
Roof 12	833 ± 255	62 ± 17	43 ± 10	0.61 ± 0.31	0.64 ± 0.28	6.56 ± 0.29

Table 2: Average values and standard deviation of substrate TC, TN, TP, N-mineralization, net nitrification and pH per roof across all seasons (n=16: values ± S.D.). For each variable, red to green gradient colors show the maximum to minimum scale. Roofs with diverse vegetation are in bold.

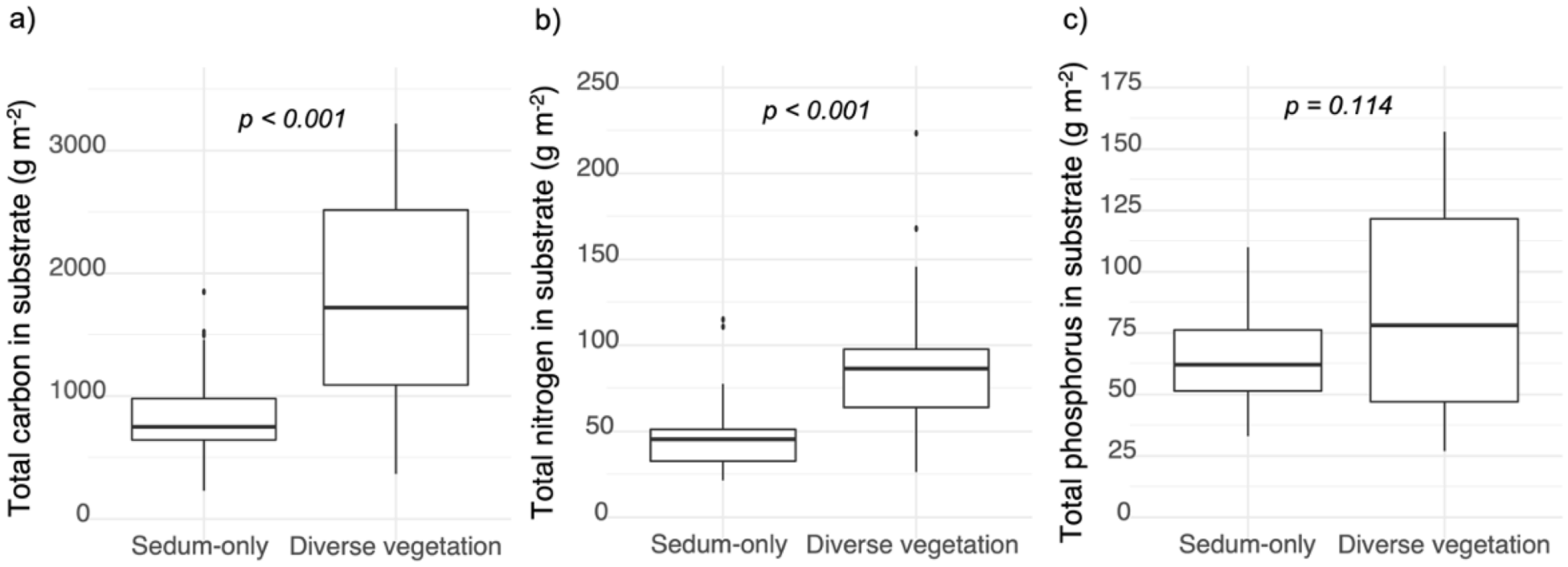
WP4: Nutrient cycles in green roofs

Experiment 1: measuring ecosystem services

-**Results: what can explain variation in C, N and P sizes, then?**

-Intensive green roofs = larger pools

-Substrate composition?



WP4: Nutrient cycles in green roofs

Experiment 1: measuring ecosystem services

-**Summary:**

-C sequestration service non-existing in already established roofs

-C and N-low, but P rich environment

-Variability in pool sizes partly explained by vegetation type

WP4: Nutrient cycles in green roofs

Experiment 2: enhancing ecosystem service delivery

-48 experimental roofs:
- -Sedum / sedum+herbs Vegetation
- -High/ low Substrate depth
- -+/- Organic matter
- -+/- Fertilization
- -+/- Biochar

- -3 reps
- -Not full-factorial

Vegetation	Substrate depth	Substrate type	Fertiliser	Biochar
Sedum spp.	6 cm	conventional		
		conventional + additional OM		
	12 cm	conventional		
		conventional + additional OM		
Sedum spp. + herbs/grasses	12 cm	conventional		
		conventional + additional OM		

WP4: Nutrient cycles in green roofs

Experiment 2: enhancing ecosystem service delivery

-Impressions

WP4: Nutrient cycles in green roofs

Experiment 2: enhancing ecosystem service delivery

-Impressions

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-Impressions

WP4: Nutrient cycles in green roofs

Experiment 2: enhancing ecosystem service delivery

-Impressions

WP4: Nutrient cycles in green roofs

Experiment 2: enhancing ecosystem service delivery

Sample collection

-Installation end of April ’19

-Sampling substrate + leachate

- -May ‘19 (beginning)
- -Sep ‘19
- -May ‘20
- -Sep ’20
- -Sep ‘21

-Extra leachate sampling

- -Jun ‘19, Jul ‘19, Aug ‘19 --> to see what happens in the first months after installation (lot of leaching?)

WP4: Nutrient cycles in green roofs

Experiment 2: enhancing ecosystem service delivery

Analyses

-pools: Total Carbon, Nitrogen and Phosphorus (substrate, vegetation)

-Fluxes: Nitrogen-mineralisation, nitrification

-pH

Output

-C pool dynamics: C sequestration potential

-N and P pool dynamics + leachates: nutrient retention

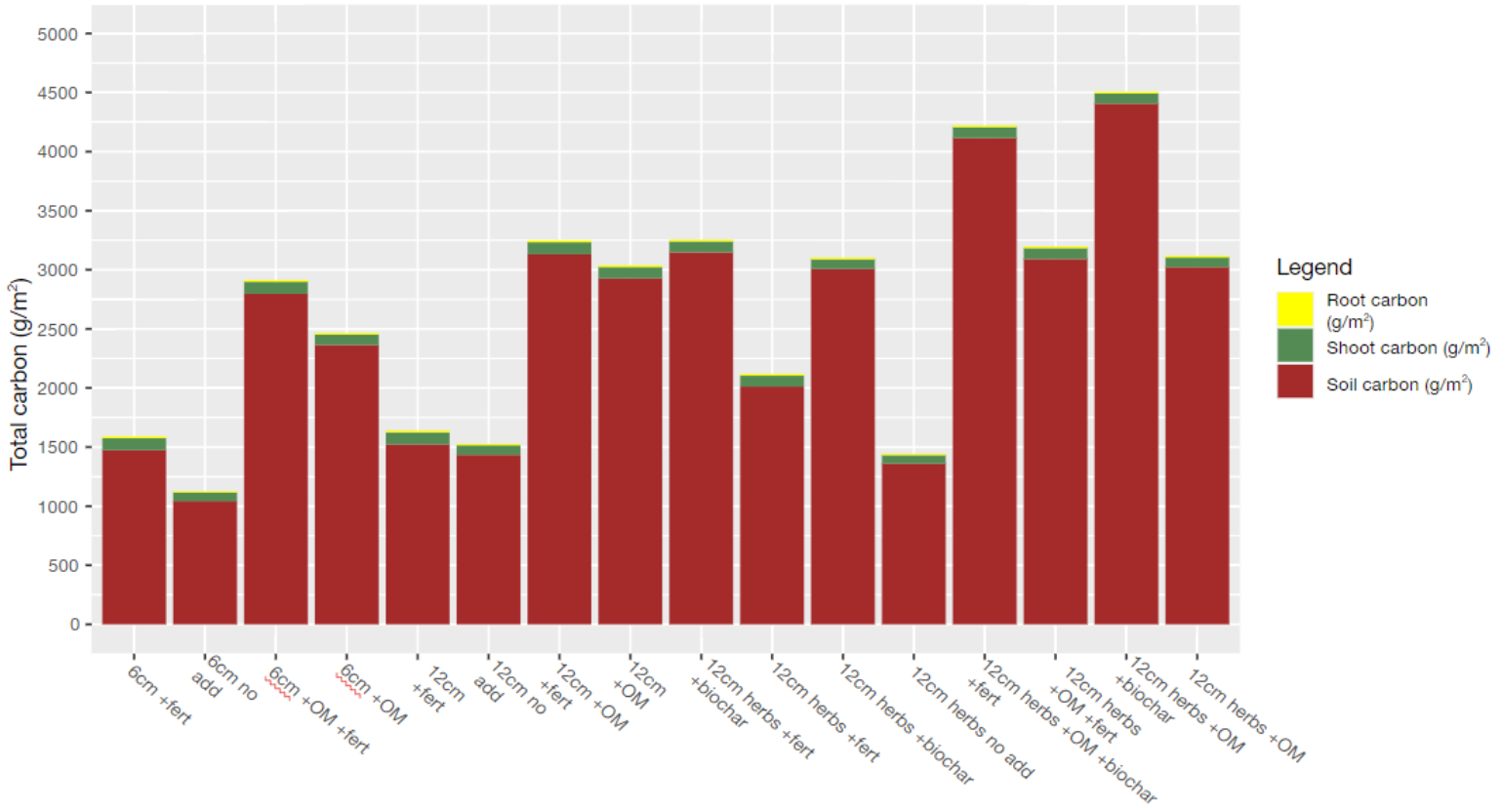
WP4: Nutrient cycles in green roofs

Experiment 2: enhancing ecosystem service delivery

Results: C pool sizes

-Again, in substrate

-X4 differences



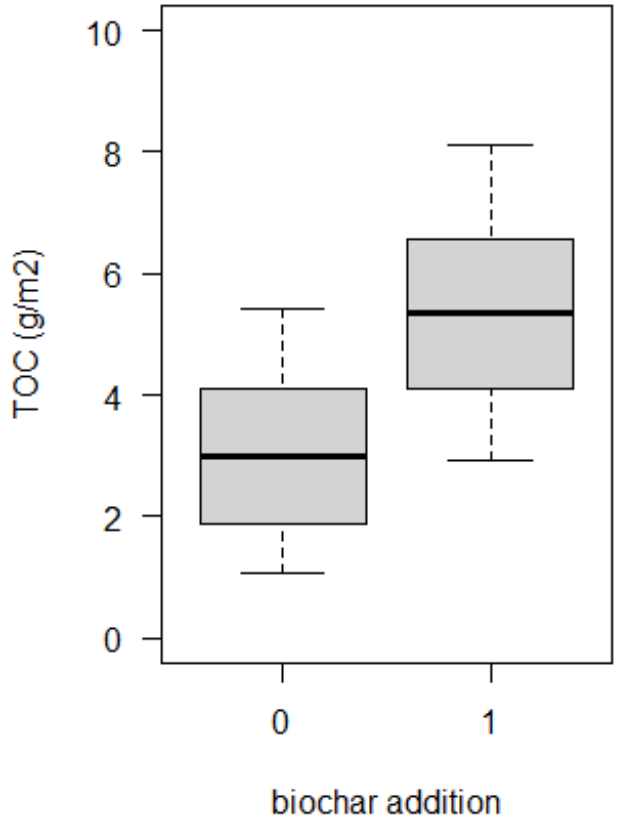
WP4: Nutrient cycles in green roofs

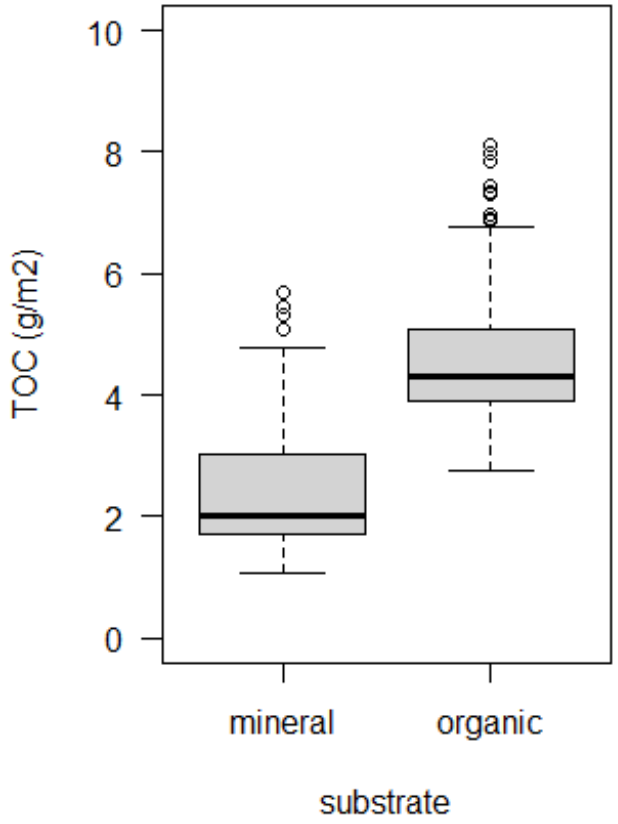
Experiment 2: enhancing ecosystem service delivery

Results: factors influencing C pools

-OM: x2

-Biochar: x2



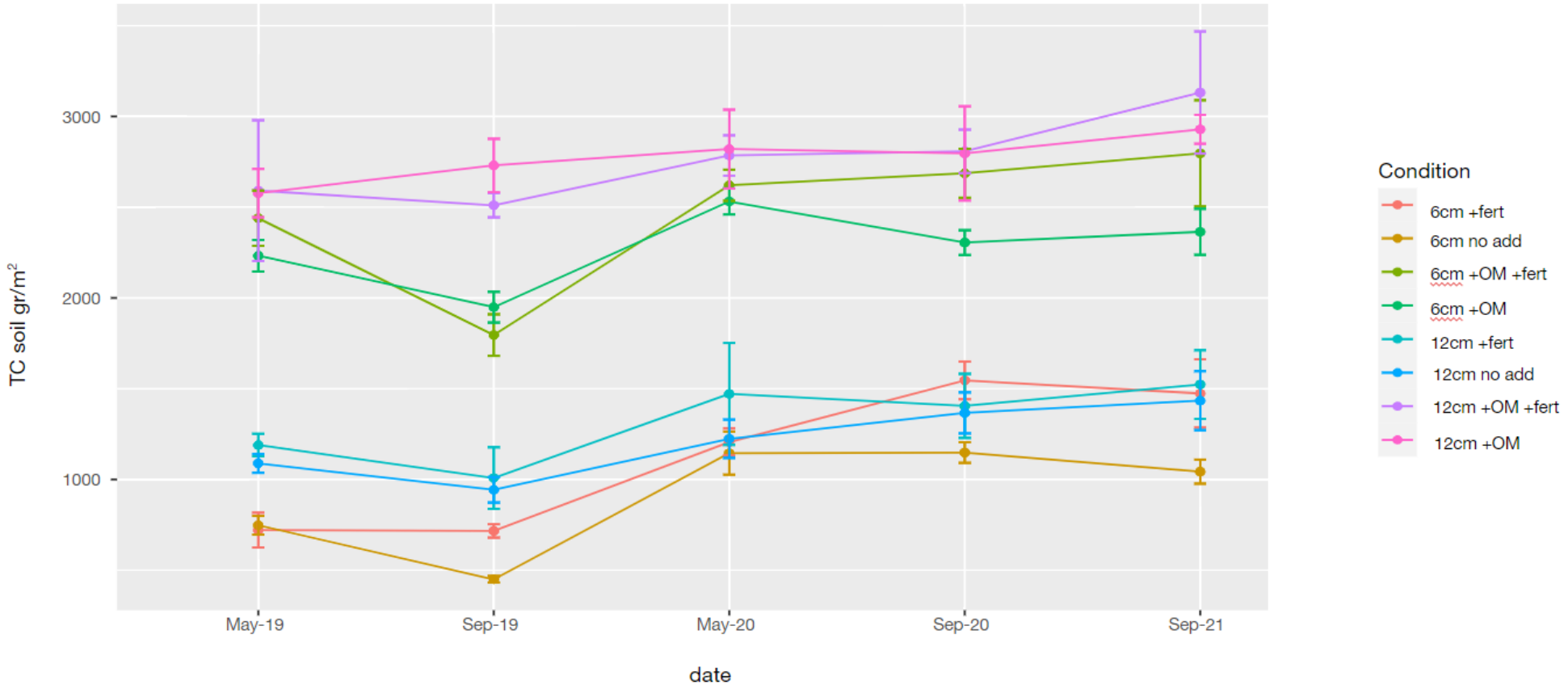


WP4: Nutrient cycles in green roofs

Experiment 2: enhancing ecosystem service delivery

Results: C sequestration

157 +/- 31 g/m^2/y in on average, over 2.5 years (from -273 to +882g/m^2/y)



WP4: Nutrient cycles in green roofs

Experiment 2: enhancing ecosystem service delivery

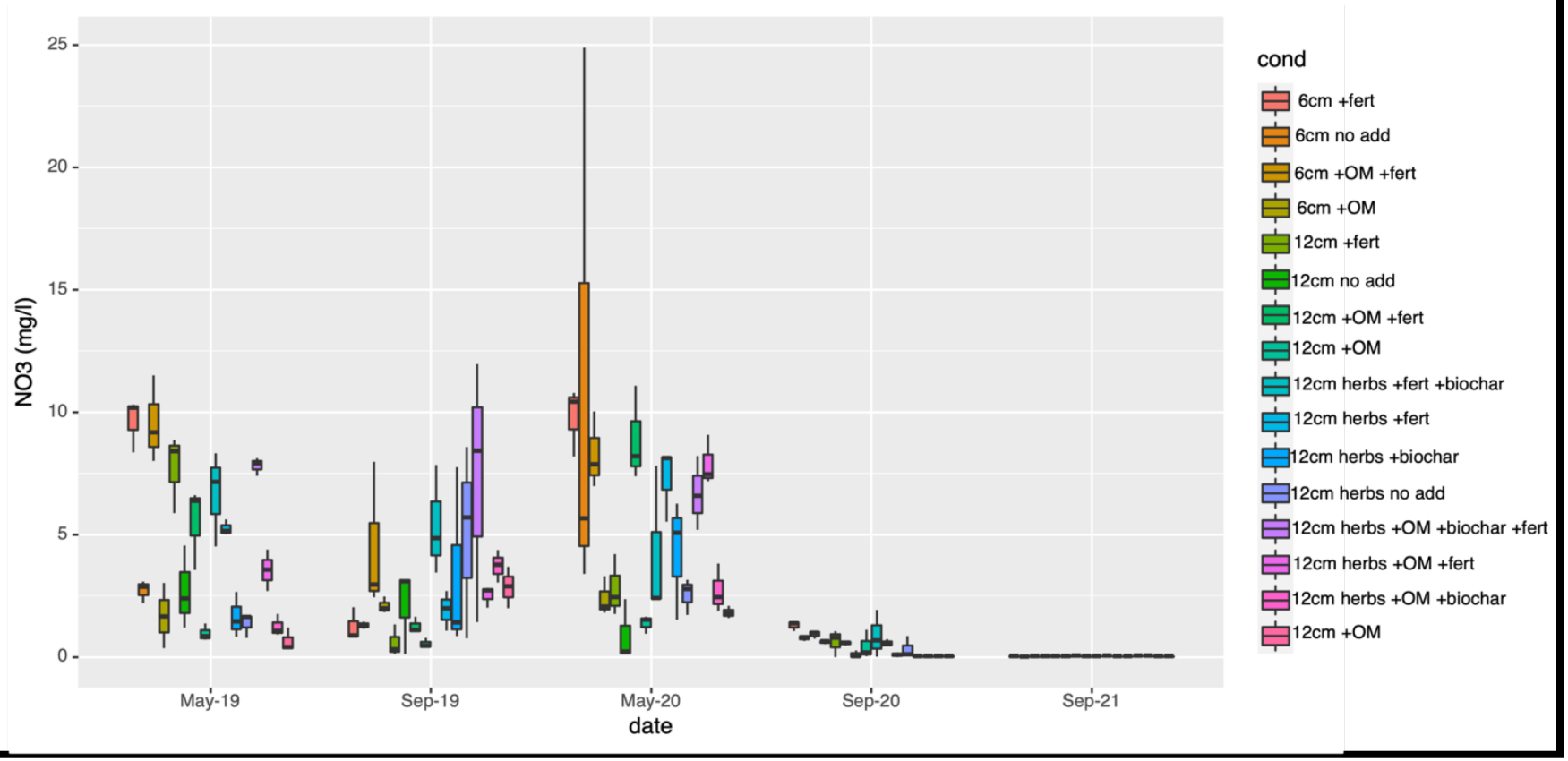
Results: C sequestration

	TC soil (g/m^2)		
Condition	**May'19**	**Sep '21**	**Increase (Sep '21-May'19)**
+ fert + herbs 12cm	1130.42	2011.93	**881.51**
+fert 6cm	720.51	1473.68	**753.17**
+ biochar + herbs 12cm	2389.28	3006.82	**617.54**
+OM +fert +herbs 12cm	2509.79	3091.32	**581.53**
+OM +fert 12cm	2591.28	3131.43	**540.15**
+OM +herbs 12cm	2661.74	3022.84	**361.1**
+OM +fert 6cm	2439.23	2796.64	**357.41**
+OM 12cm	2577.42	2928.71	**351.29**
No add 12cm	1088.62	1433.84	**345.22**
+fert 12cm	1189.41	1522.93	**333.52**
+fert + biochar +herbs 12cm	2850.13	3147.97	**297.4**
No add 6cm	747.58	1042.90	**295.32**
+herbs	1094.89	1359.90	**265.01**
+OM 6cm	2232.37	2364.23	**131.86**
+OM +biochar + herbs	4472.50	4405.95	**-66.55**
+OM +biochar +fert +herbs	4387.76	4114.85	**-272.91**

WP4: Nutrient cycles in green roofs

Experiment 2: enhancing ecosystem service delivery

Results: N leaching



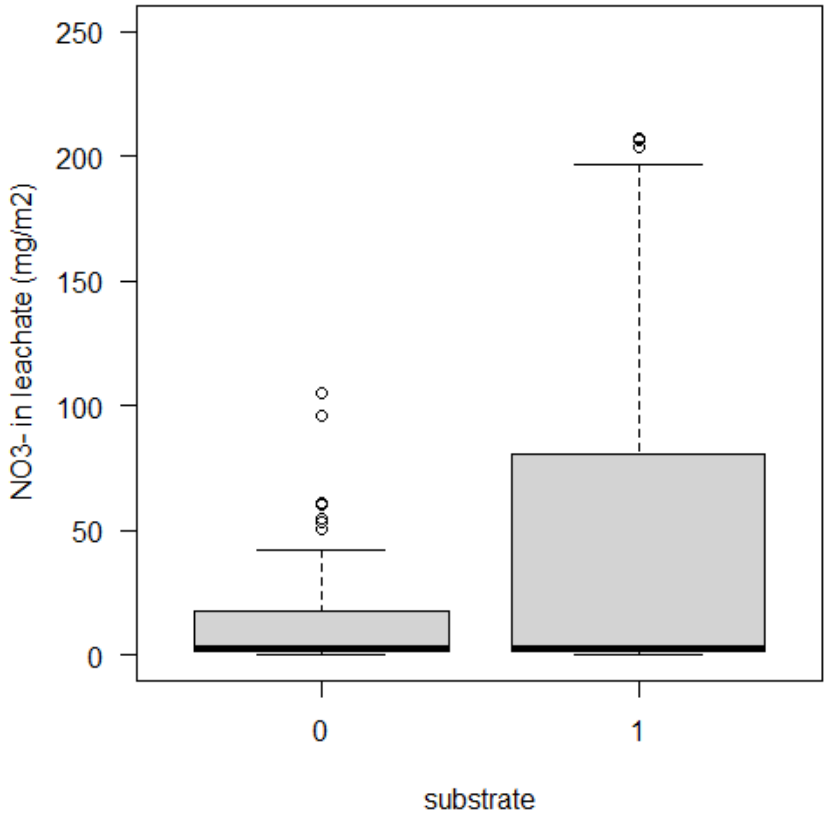
WP4: Nutrient cycles in green roofs

Experiment 2: enhancing ecosystem service delivery

Results: N leaching

-main factor = fertilization
-almost all as nitrate
-any buffer effect overshadowed by fertilization
-non-fertilized: assuming 30kg/ha N depositin
of which 50% in NO3

(hence 1.5 g/m2/year)
Leaching in average only 0.09 g of nitrate-N/m2/y
-> 94% of nitrate-N was retained in the roof.

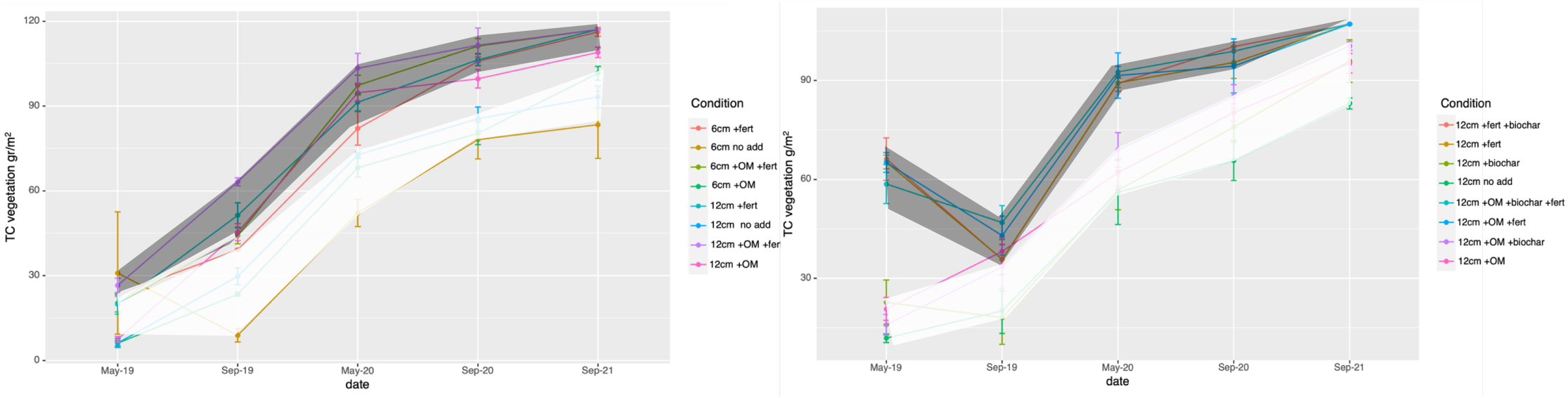


WP4: Nutrient cycles in green roofs

Experiment 2: enhancing ecosystem service delivery

Results: N leaching

-fertilization (grey) had only minor effect on plant cover

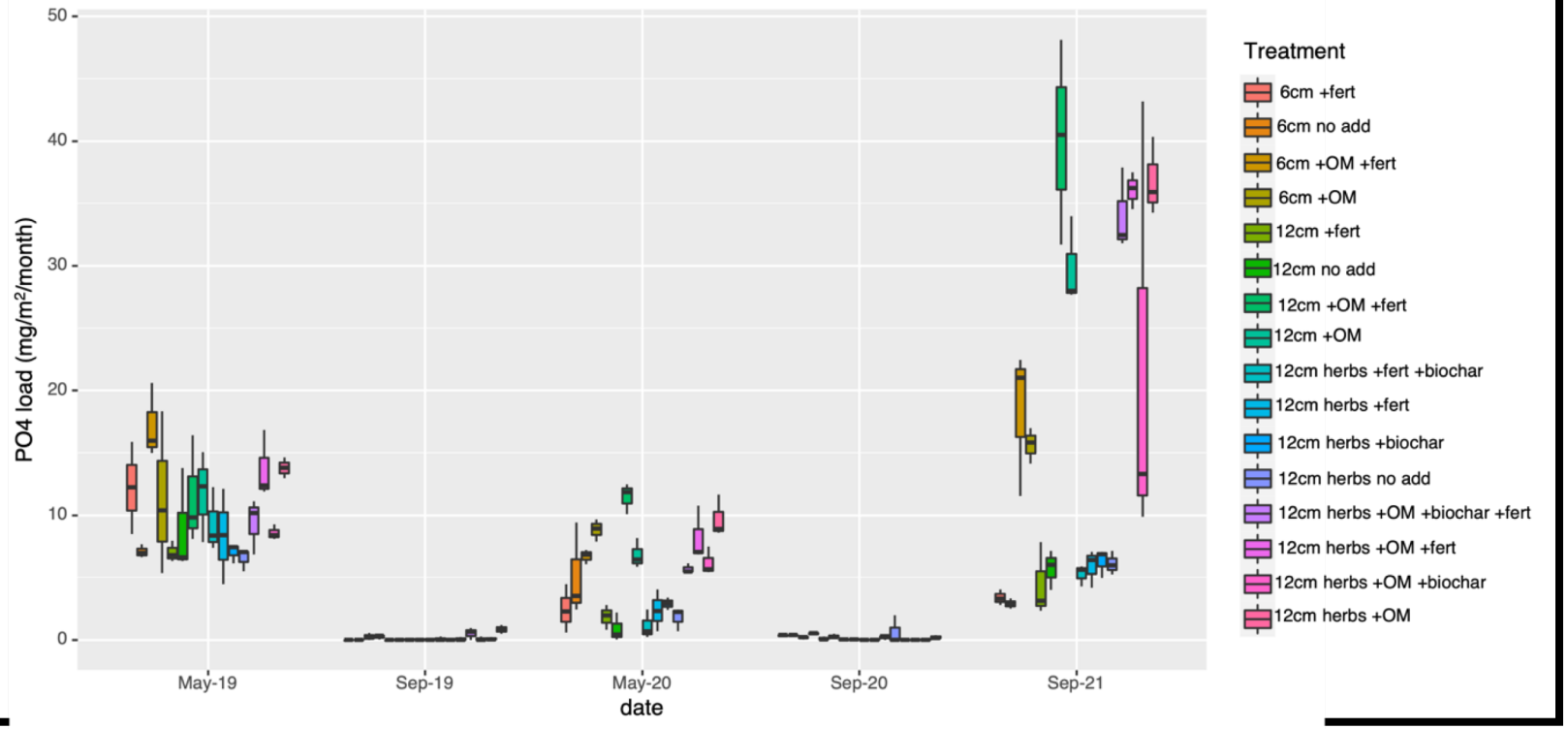


WP4: Nutrient cycles in green roofs

Experiment 2: enhancing ecosystem service delivery

Results: P leaching

- On average a green roof loses 0.23 g/m2/year
- Compared to the stocks (80-120 g/m2), PO4 leaching is low (0-0.04 g/m2)
- Adding OM increases PO4 leaching significantly



WP4: Nutrient cycles in green roofs

Experiment 2: enhancing ecosystem service delivery

-**Summary:**

-Significant C sequestration in first years

-Added OM or biochar does not leach nor decompose -> also sequestered

-Fertilization adds significant N leaching, minor advantage for plant -> necessary?

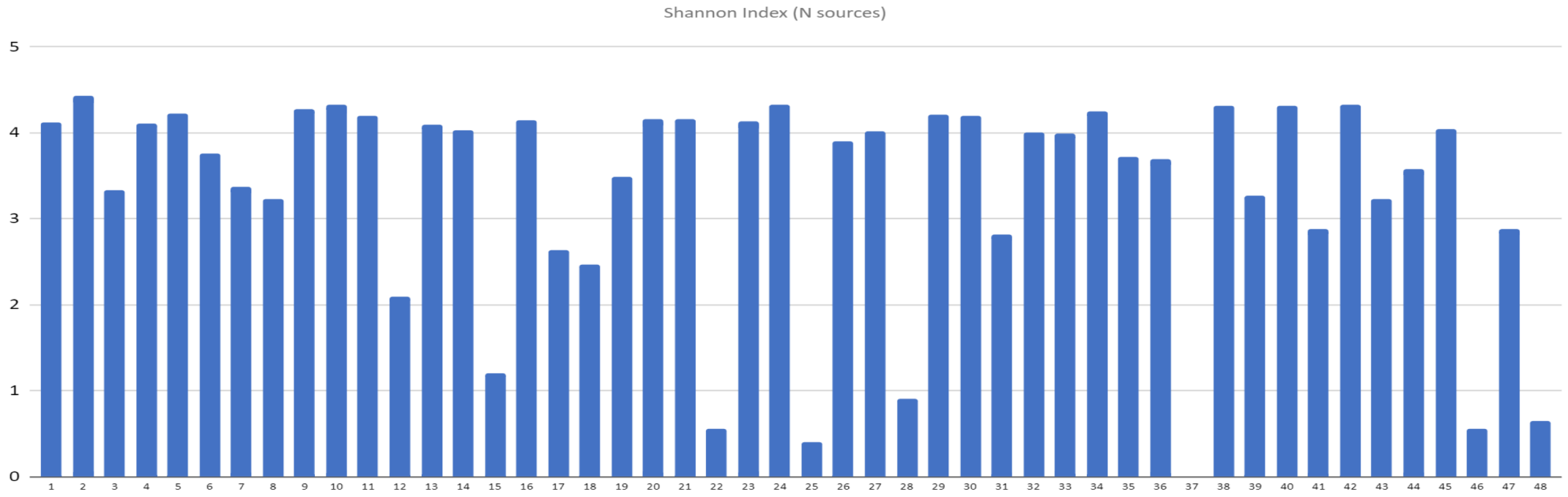
-Lots of P, but does not leach much, so no major issue for water quality

WP4: Nutrient cycles in green roofs

Experiment 1&2: functional diversity

Results: functional diversity

- Based on use of 96 N and 96 P sources -> diversity of functions instead of species
- Method still needs to be set up – data not reliable yet – ongoing work



Questions

Questions that you would like to ask to other partners?