Fig. S1 Map of the study area. The study area is located on the western Pihlajasaari island (aerial photograph) ca. 2 km off the coast of Helsinki, surrounded by the Gulf of Finland, the northern part of the Baltic Sea. Nine rock pools (numbered 1–9 on the lower map) were sampled on a rocky outcrop on the southwestern part of the island. Aerial photograph: National Land Survey of Finland (2023)

Table S1 Summary statistics for the environmental variables over the nine study sites for each sampling day (1–12)

Sampling	Variable	Min	Max	Mean	Median	St. dev.	Variance
1	Total P ($\mu g\ L^{-1}$)	52.0	173.0	258.6	80.2	37.8	1.4E+03
	N:P ratio	10.0	21.3	16.5	17.7	4.2	1.8E+01
	pH	7.9	9.6	–	9.1	0.6	3.3E-01
	Conductivity ($\mu S\ cm^{-1}$)	152	8640	5006	6190	3327.1	1.1E-01
	Temperature (°C)	9.5	10.7	10.1	10.0	0.3	1.1E+07
	Depth (m)	0.17	0.41	0.30	0.28	0.1	5.8E-03
	Area (m^2)	1.47	17.23	6.54	5.72	5.6	3.1E+01
2	Total P ($\mu g\ L^{-1}$)	65.8	318.4	182.7	184.0	96.2	9.3E+03
	N:P ratio	11.9	30.0	19.9	20.7	5.8	3.4E+01
	pH	10	8.8	–	8.5	0.7	4.3E-01
	Conductivity ($\mu S\ cm^{-1}$)	154	15830	6823	7910	5186.9	3.4E-01
	Temperature (°C)	14.4	16.3	15.9	16.1	0.6	2.7E+07
	Depth (m)	0.16	0.34	0.24	0.24	0.1	4.4E-03
	Area (m^2)	0.57	18.5	5.94	2.62	7.0	4.9E+01
3	Total P ($\mu g\ L^{-1}$)	37.7	154.5	77.5	73.8	35.0	1.2E+03
	N:P ratio	7.9	24.3	18.1	19.8	5.2	2.7E+01
	pH	7.5	9.9	–	9.0	0.8	6.4E-01
	Conductivity ($\mu S\ cm^{-1}$)	170	10110	6019	6900	3753.1	1.5E+00
	Temperature (°C)	13.6	17.5	15.4	15.1	1.2	1.4E+07
	Depth (m)	0.17	0.38	0.28	0.27	0.1	4.9E-03
	Area (m^2)	1.06	34.43	8.66	4.79	11.0	1.2E+02
4	Total P ($\mu g\ L^{-1}$)	41.9	737.2	243.7	227.8	222.3	4.9E+04
	N:P ratio	10.6	40.3	23.3	21.5	11.3	1.3E+02
	pH	7.1	9.4	–	7.8	0.8	6.4E-01
	Conductivity ($\mu S\ cm^{-1}$)	219	19370	6732	3930	6603.9	3.0E-01
	Temperature (°C)	15.7	17.5	16.3	16.3	0.5	4.4E+07
	Depth (m)	0.09	0.34	0.24	0.26	0.1	5.6E-03
	Area (m^2)	0.58	32.28	8.19	4.77	10.6	1.1E+02
5	Total P ($\mu g\ L^{-1}$)	92.2	1131.4	436.5	356.2	324.6	1.1E+05
	N:P ratio	9.6	34.5	17.6	15.2	7.6	5.9E+01
	pH	7.6	9.2	–	8.7	0.6	3.6E-01
	Conductivity ($\mu S\ cm^{-1}$)	333	30880	11849	10190	10959.0	2.7E+00
	Temperature (°C)	20.1	24.2	22.1	21.5	1.6	1.2E+08
	Depth (m)	0.13	0.28	0.22	0.23	0.1	3.0E-03
	Area (m^2)	0.42	14.39	4.52	3.35	4.6	2.1E+01

Sampling	Variable	Min	Max	Mean	Median	St. dev.	Variance
6	Total P (μg L^{-1})	36.4	417.2	141.4	116.7	119.1	1.4E+04
	N:P ratio	8.8	42.8	20.4	20.9	10.4	1.1E+02
	pH	7.5	9.4	−	9.1	0.7	4.5E-01
	Temperature (°C)	13	20.5	17.8	18.2	2.2	4.9E+00
	Conductivity (μS cm^{-1})	408	12800	7829	9750	4134.3	1.7E+07
	Depth (m)	0.2	0.33	0.25	0.24	0.0	1.7E-03
	Area (m^2)	0.73	14.7	5.07	4.65	4.4	1.9E+01
7	Total P (μg L^{-1})	56.6	379.0	160.6	101.6	111.6	1.2E+04
	N:P ratio	9.6	29.8	18.9	18.3	6.9	4.8E+01
	pH	7.1	9.9	−	8.4	0.9	7.9E-01
	Temperature (°C)	17.6	22.7	20.5	20.5	1.7	2.8E+00
	Conductivity (μS cm^{-1})	150	10190	4258	5120	3830.2	1.5E+07
	Depth (m)	0.18	0.37	0.26	0.24	0.1	4.0E-03
	Area (m^2)	1.05	38.45	8.92	4.48	12.3	1.5E+02
8	Total P (μg L^{-1})	82.2	401.4	232.3	205.4	121.7	1.5E+04
	N:P ratio	11.9	27.6	17.8	17.3	5.0	2.5E+01
	pH	7.0	9.1	−	7.7	0.7	4.4E-01
	Temperature (°C)	22.4	26.3	24.0	23.8	1.2	1.5E+00
	Conductivity (μS cm^{-1})	171	12140	5835	6690	4676.0	2.2E+07
	Depth (m)	0.17	0.38	0.24	0.22	0.1	5.3E-03
	Area (m^2)	1	31.3	6.80	2.09	10.0	9.9E+01
9	Total P (μg L^{-1})	89.5	978.7	338.3	251.1	311.8	9.7E+04
	N:P ratio	14.5	116.2	41.7	23.7	39.6	1.6E+03
	pH	7.5	9.2	−	8.0	0.6	3.4E-01
	Temperature (°C)	19.1	21.8	20.1	19.9	1.0	9.3E-01
	Conductivity (μS cm^{-1})	26	32790	8484	4790	10672.7	1.1E+08
	Depth (m)	0.11	0.32	0.20	0.17	0.1	4.7E-03
	Area (m^2)	0.36	14.5	3.91	1.78	4.8	2.3E+01
10	Total P (μg L^{-1})	48.7	482.0	123.8	79.2	137.4	1.9E+04
	N:P ratio	11.6	90.4	37.0	31.3	25.2	6.4E+02
	pH	7.2	9.3	−	7.9	0.7	4.8E-01
	Temperature (°C)	17.8	20.5	18.9	18.7	0.8	6.1E-01
	Conductivity (μS cm^{-1})	306	12260	6335	7310	4412.0	1.9E+07
	Depth (m)	0.2	0.33	0.27	0.26	0.0	1.4E-03
	Area (m^2)	1.12	17.02	5.55	5.05	5.1	2.6E+01
11	Total P (μg L^{-1})	87.7	240.3	165.9	181.3	64.0	4.1E+03
	N:P ratio	11.2	41.6	19.0	16.4	9.8	9.5E+01
	pH	6.1	7.6	−	6.8	0.5	2.9E-01
	Temperature (°C)	18.9	20	19.4	19.3	0.3	1.0E-01
	Conductivity (μS cm^{-1})	59	6510	3112	2570	2950.1	8.7E+06
	Depth (m)	0.18	0.39	0.27	0.26	0.1	4.4E-03
	Area (m^2)	1.13	41.13	9.63	5.43	13.0	1.7E+02

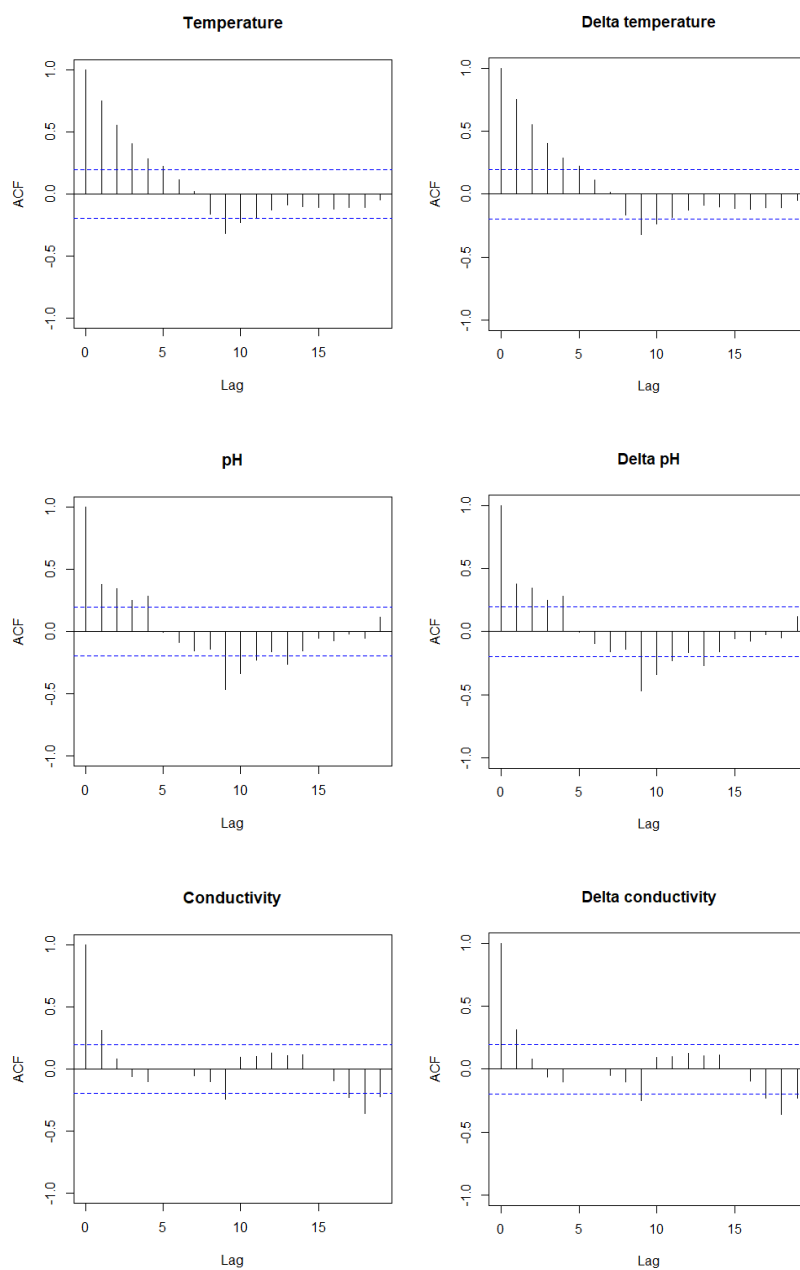| Sampling	Variable	Min	Max	Mean	Median	St. dev.	Variance
12	Total P ($\mu g\ L^{-1}$)	56.8	237.4	122.4	90.9	63.9	4.1E+03
	N:P ratio	10.6	20.9	16.3	15.9	4.0	1.6E+01
	pH	6.2	8.8	–	7.3	0.8	6.1E-01
	Temperature (°C)	16.1	17.4	16.6	16.5	0.5	2.3E-01
	Conductivity ($\mu S\ cm^{-1}$)	75	8400	3964	4930	3254.5	1.1E+07
	Depth (m)	0.17	0.37	0.28	0.29	0.1	4.2E-03
	Area (m^2)	0.98	35.45	9.04	5.1	11.3	1.3E+02

Fig. S2 Temporal autocorrelation for selected environmental variables. Shown is the autocorrelation function (acf) for each lag. Each vertical line extending to the blue horizontal dashed lines represents significant temporal autocorrelation for the given lag

Table S2 Spearman rank correlation coefficients for taxonomic, functional and environmental temporal beta diversity indices (TBIs), and for environmental (expressed as temporal change between each consecutive sampling day pair with the sign 'Δ') and spatial variables including categorical variables for sampling day (1–12) and study site (1–9). Shown are three significance levels according to the P value of each pairwise correlation: – non-significant, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. Bolded correlation coefficients are statistically significant ($P < 0.05$)

	Taxonomic TBI	Functional TBI	Environmental TBI	ΔTotal P	ΔN:P ratio	ΔpH	ΔConductivity	ΔTemperature	ΔDepth	ΔArea	Distance to sea	Isolation	Sampling day	Site
TBI$_{Tax}$		**0.37**	**−0.43**	0.02	0.05	−0.07	−0.06	−0.07	0.12	0.03	**0.32**	−0.18	0.14	0.19
TBI$_{Func}$	***		−0.06	−0.06	0.09	0.07	−0.09	**−0.22**	0.05	−0.06	0.19	**−0.32**	0.11	0.03
TBI$_{Env}$	***	−		0.04	−0.16	−0.01	−0.06	0.06	−0.08	0.02	**−0.34**	0.14	−0.15	**−0.22**
ΔTotal P	−	−	−		−0.07	**−0.24**	0.15	**0.41**	**−0.63**	**−0.44**	−0.02	−0.03	−0.14	0.00
ΔN:P ratio	−	−	−	−		0.10	**0.31**	−0.10	**−0.22**	**−0.24**	0.00	−0.05	−0.14	0.09
ΔpH	−	−	−	*	−		0.17	**−0.28**	0.16	−0.01	−0.05	0.03	0.03	0.00
ΔCond.	−	−	−	−	**	−		0.19	**−0.32**	**−0.37**	−0.07	−0.04	−0.18	−0.06
ΔTemp.	−	*	−	***	−	**	−		**−0.33**	**−0.25**	−0.02	0.00	**−0.46**	0.01
ΔDepth	−	−	−	***	*	−	**	***		**0.55**	0.04	0.01	**0.21**	0.01
ΔArea	−	−	−	***	*	−	***	*	***		0.02	−0.04	0.08	0.06
Dist. to sea	**	−	***	−	−	−	−	−	−	−		0.08	0.00	**−0.25**
Isolation	−	**	−	−	−	−	−	−	−	−	−		0.00	**−0.58**
Day	−	−	−	−	−	−	−	***	*	−	−	−		0.00
Site	−	−	*	−	−	−	−	−	−	−	*	***	−	

Table S3 Temporal beta diversity values for the taxonomic and functional presence-absence data and for the environmental data for each site between the 11 sampling day pairs, and for the whole time period from sampling day 1 to 12 ($N = 108$). For taxonomic and functional data, the total temporal beta diversity is decomposed into gains and losses. Statistically significant ($P < 0.05$) temporal beta diversity values are bolded. The statistical significance is based on the P value of a paired t test, corrected for multiple testing

Sampling	Site	TBI$_{Tax}$			TBI$_{Func}$			TBI$_{Env}$
		Total	Gains	Losses	Total	Gains	Losses	Total
1–2	1	0.568	0.205	0.364	0.106	0.021	0.085	4.348
	2	0.259	0.074	0.185	0.000	0.000	0.000	5.232
	3	0.419	0.258	0.161	0.073	0.024	0.049	4.384
	4	0.378	0.133	0.244	0.056	0.000	0.056	2.521
	5	0.389	0.083	0.306	0.077	0.026	0.051	2.776
	6	0.630	0.204	0.426	0.070	0.023	0.047	2.549
	7	0.500	0.179	0.321	0.095	0.024	0.071	2.757
	8	0.516	0.177	0.339	0.050	0.000	0.050	3.381
	9	0.625	0.219	0.406	0.067	0.000	0.067	3.394
2–3	1	0.457	0.272	0.185	0.116	0.047	0.070	4.377
	2	0.370	0.241	0.130	0.073	0.049	0.024	4.645
	3	0.449	0.232	0.217	0.095	0.071	0.024	4.147
	4	0.511	0.311	0.200	0.081	0.081	0.000	2.153
	5	0.571	0.286	0.286	0.081	0.027	0.054	2.129
	6	0.333	0.167	0.167	0.100	0.025	0.075	3.417
	7	0.244	0.089	0.156	0.077	0.026	0.051	3.738
	8	0.241	0.172	0.069	0.026	0.026	0.000	3.486
	9	0.579	0.105	0.474	0.077	0.000	0.077	1.914
3–4	1	0.325	0.133	0.193	0.024	0.000	0.024	3.075
	2	0.419	0.226	0.194	0.045	0.045	0.000	2.937
	3	0.324	0.147	0.176	0.070	0.023	0.047	4.298
	4	0.472	0.264	0.208	0.050	0.025	0.025	2.282
	5	0.448	0.241	0.207	0.029	0.000	0.029	2.528
	6	0.400	0.175	0.225	0.128	0.077	0.051	2.430
	7	0.350	0.150	0.200	0.081	0.027	0.054	3.132
	8	0.333	0.256	0.077	0.073	0.049	0.024	5.679
	9	0.510	0.510	0.000	0.122	0.122	0.000	1.671
4–5	1	0.400	0.267	0.133	0.070	0.070	0.000	1.668
	2	0.463	0.254	0.209	0.045	0.000	0.045	2.835
	3	0.365	0.159	0.206	0.050	0.000	0.050	**6.667**
	4	0.512	0.073	0.439	0.135	0.027	0.108	1.934
	5	**0.548**	0.290	0.258	0.081	0.081	0.000	2.325
	6	0.378	0.267	0.111	0.105	0.026	0.079	4.181
	7	0.333	0.271	0.063	0.077	0.077	0.000	4.004
	8	0.311	0.144	0.167	0.000	0.000	0.000	3.430
	9	0.289	0.158	0.132	0.091	0.023	0.068	2.559

Sampling	Site	TBI$_{Tax}$			TBI$_{Func}$			TBI$_{Env}$
5–6	1	0.447	0.053	0.395	0.045	0.000	0.045	1.446
	2	0.324	0.169	0.155	0.070	0.047	0.023	3.827
	3	0.322	0.153	0.169	0.073	0.073	0.000	6.316
	4	0.385	0.192	0.192	0.152	0.061	0.091	1.441
	5	0.538	0.154	0.385	0.122	0.073	0.049	4.263
	6	0.429	0.250	0.179	0.100	0.100	0.000	1.809
	7	0.388	0.102	0.286	0.024	0.000	0.024	2.812
	8	0.348	0.180	0.169	0.045	0.045	0.000	4.677
	9	**0.680**	0.060	0.620	0.135	0.000	0.135	1.581
6–7	1	0.538	0.128	0.410	0.050	0.000	0.050	1.788
	2	0.292	0.092	0.200	0.095	0.024	0.071	5.040
	3	0.373	0.118	0.255	0.070	0.023	0.047	3.285
	4	0.400	0.267	0.133	0.118	0.088	0.029	2.649
	5	0.429	0.238	0.190	0.077	0.000	0.077	2.884
	6	0.489	0.106	0.383	0.189	0.000	0.189	4.088
	7	0.514	0.216	0.297	0.111	0.000	0.111	3.277
	8	0.453	0.253	0.200	0.021	0.021	0.000	2.072
	9	0.590	0.513	0.077	0.111	0.111	0.000	2.267
7–8	1	0.586	0.310	0.276	0.105	0.053	0.053	1.766
	2	0.286	0.125	0.161	0.050	0.025	0.025	4.064
	3	0.333	0.178	0.156	0.050	0.000	0.050	1.983
	4	0.455	0.212	0.242	0.077	0.077	0.000	3.448
	5	0.455	0.227	0.227	0.111	0.056	0.056	3.823
	6	0.500	0.219	0.281	**0.235**	0.176	0.059	1.939
	7	0.450	0.300	0.150	0.135	0.135	0.000	1.702
	8	0.429	0.204	0.224	0.042	0.021	0.021	3.153
	9	0.491	0.236	0.255	0.050	0.025	0.025	2.191
8–9	1	**0.684**	0.645	0.039	0.163	0.140	0.023	2.294
	2	0.333	0.137	0.196	0.135	0.027	0.108	**6.675**
	3	0.321	0.226	0.094	0.073	0.073	0.000	3.719
	4	0.520	0.120	0.400	0.135	0.000	0.135	2.036
	5	0.500	0.200	0.300	0.111	0.056	0.056	2.295
	6	0.548	0.290	0.258	0.135	0.054	0.081	4.064
	7	0.500	0.111	0.389	0.167	0.000	0.167	2.559
	8	0.561	0.195	0.366	0.067	0.000	0.067	1.775
	9	0.439	0.246	0.193	0.073	0.049	0.024	2.952
9–10	1	0.535	0.152	0.384	0.064	0.021	0.043	2.722
	2	0.357	0.250	0.107	0.105	0.105	0.000	**7.435**
	3	0.367	0.183	0.183	0.045	0.023	0.023	2.612
	4	0.545	0.364	0.182	0.118	0.088	0.029	2.745
	5	0.500	0.300	0.200	0.053	0.053	0.000	1.091
	6	0.467	0.200	0.267	0.135	0.081	0.054	1.663
	7	0.548	0.355	0.194	0.125	0.094	0.031	3.321
	8	0.573	0.333	0.240	0.091	0.068	0.023	2.525
	9	0.390	0.186	0.203	0.048	0.024	0.024	1.526

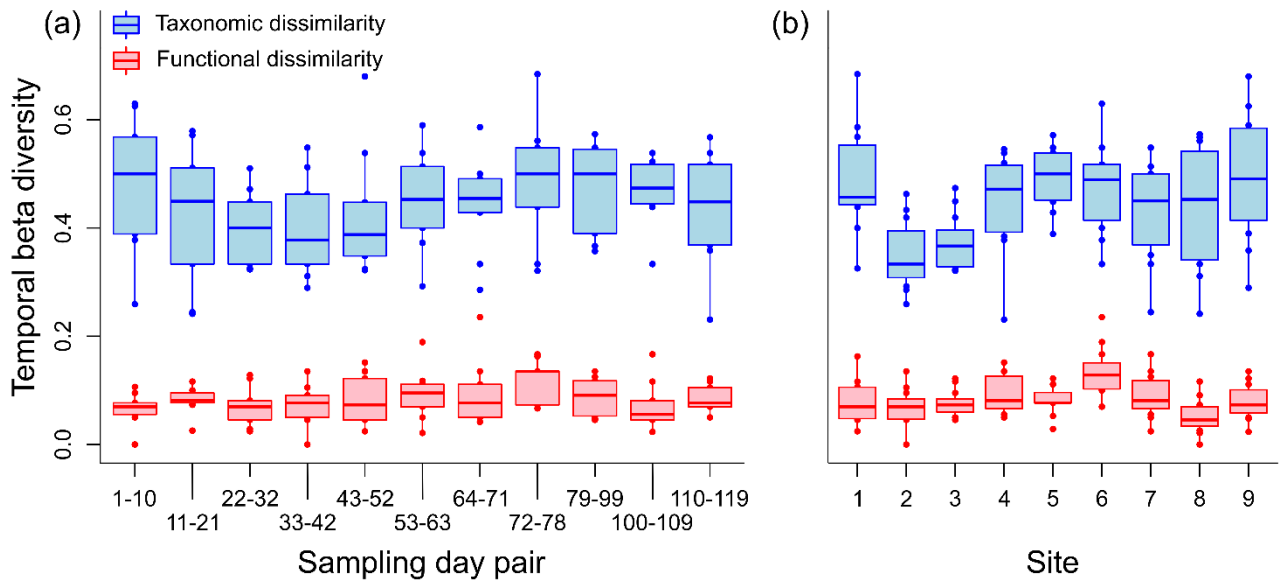| Sampling	Site	TBI_{Tax}			TBI_{Func}			TBI_{Env}
10–11	1	0.439	0.053	0.386	0.045	0.000	0.045	2.698
	2	0.333	0.133	0.200	0.048	0.024	0.024	4.233
	3	0.474	0.211	0.263	0.116	0.047	0.070	2.685
	4	0.538	0.269	0.269	0.081	0.054	0.027	3.800
	5	0.478	0.261	0.217	0.077	0.026	0.051	2.530
	6	0.517	0.276	0.241	0.167	0.056	0.111	3.997
	7	0.444	0.222	0.222	0.056	0.056	0.000	2.879
	8	0.522	0.149	0.373	0.045	0.000	0.045	1.774
	9	0.462	0.173	0.288	0.023	0.023	0.000	3.070
11–12	1	0.448	0.069	0.379	0.077	0.000	0.077	2.628
	2	0.433	0.250	0.183	0.070	0.047	0.023	5.356
	3	0.368	0.211	0.158	0.122	0.049	0.073	2.890
	4	0.231	0.115	0.115	0.050	0.050	0.000	2.687
	5	0.538	0.308	0.231	0.077	0.051	0.026	1.987
	6	0.517	0.241	0.276	0.105	0.105	0.000	4.248
	7	0.483	0.431	0.052	0.050	0.050	0.000	2.378
	8	0.568	0.432	0.135	0.116	0.070	0.047	2.136
	9	0.358	0.245	0.113	0.070	0.023	0.047	2.550
1–12	1	0.770	0.049	0.721	0.163	0.000	0.163	3.289
	2	0.516	0.274	0.242	0.095	0.071	0.024	2.691
	3	0.621	0.328	0.293	0.073	0.024	0.049	2.707
	4	0.579	0.132	0.447	0.100	0.075	0.025	4.126
	5	0.444	0.111	0.333	0.000	0.000	0.000	2.918
	6	0.745	0.170	0.574	0.116	0.047	0.070	4.741
	7	0.611	0.361	0.250	0.023	0.000	0.023	5.239
	8	0.667	0.405	0.262	0.070	0.047	0.023	2.513
	9	0.706	0.294	0.412	0.067	0.000	0.067	3.183

Fig. S3 (a) Temporal and (b) spatial variation in temporal beta diversity between the 11 sampling day pairs and nine study sites, respectively. Shown are median (the horizontal line), lower and upper quartiles (the box vertical limits) and lower and upper 95-percentiles (the whiskers). The dots represent the observed values; outliers are falling 1.5-fold outside the quartiles
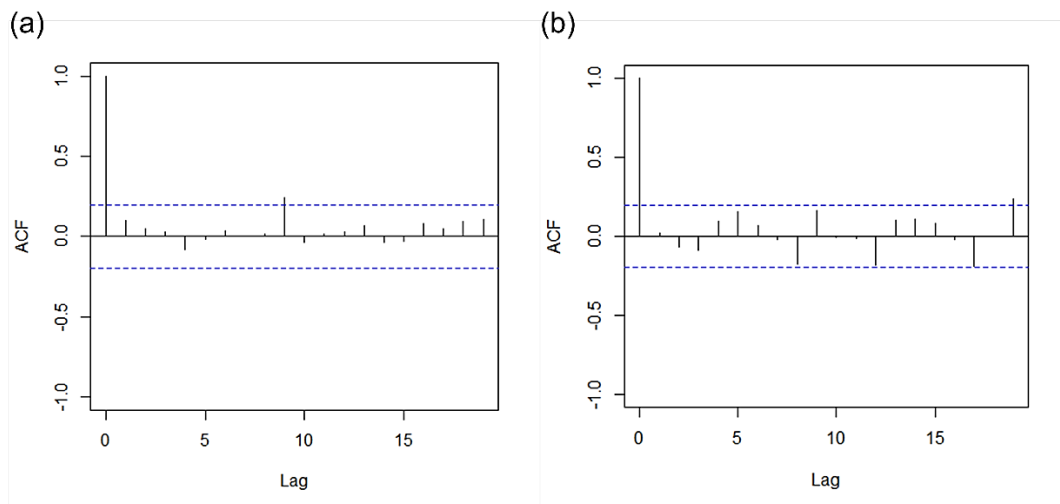

Fig. S4 Temporal autocorrelation for the residuals of the generalized linear models for (a) taxonomic and (b) functional temporal beta diversity index, based on Sorensen index calculated for the presence-absence data. Shown is the autocorrelation function (acf) for each lag. Each vertical line extending to the blue horizontal dashed lines represents significant temporal autocorrelation for the given lag

Table S4 Results of the distance-based redundancy analysis for Sorensen dissimilarity index calculated for the taxonomic and functional presence-absence data, constrained by a factor representing the 12 sampling days. Shown is the model variance, and the proportion of the constrained variance explained by the first two canonical axes. The explanatory power of the model was assessed by R^2; the statistical significance is based on the F test and indicated by the P value: * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Model		Sum of Sq.	F	Pr(>F)		R^2	Adj. R^2
TBI_{Tax}	CAP 1	0.8801	3.0266	0.036	*	0.11	0.01
	CAP 2	0.5898	2.0285	0.482			
	Sampling day	3.5931	1.1234	0.040	*		
	Residual	27.9148					
	Total	31.5080					
TBI_{Func}	CAP 1	0.3114	6.2573	0.005	**	0.13	0.03
	CAP 2	0.1069	2.1485	0.961			
	Sampling day	0.7208	1.3167	0.036	*		
	Residual	4.7773					
	Total	5.4980					

Literature Cited

National Land Survey of Finland (2023) *Paikkatietoikkuna*. https://kartta.paikkatietoikkuna.fi/