Nutrient Flows and Biogeomorphic Feedbacks: Linking Seabird Guano to Plant traits and Morphological Change on Sandy Islands

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1 Supplements

S1: Number of breeding pairs per species per islands.

	Zuiderduin	Rottumerplaat	Rottumeroog	Richel	Griend
Larus argentatus and Larus fuscus	796	4519	794	687	1270
Chroicocephalus ridibundus	13				5282
Phalacrocorax carbo	267			64	
Larus canus	13		45		
Thalasseus sandvicensis					2797
Platalea leucorodia					54
Sterna paradisaea					67
Sterna hirundo					312

S2: Contributions and loadings per environmental variable to the primary PC axes that explain at least 85% of total variance.

	Contributions (%)		Loadings	
	PC1	PC2	PC1	PC2
Distance from coast	32	36	0.56	-0.60
Soil organic matter	52	0	0.72	0.03
Mean Elevation in 2022	16	64	-0.40	-0.80

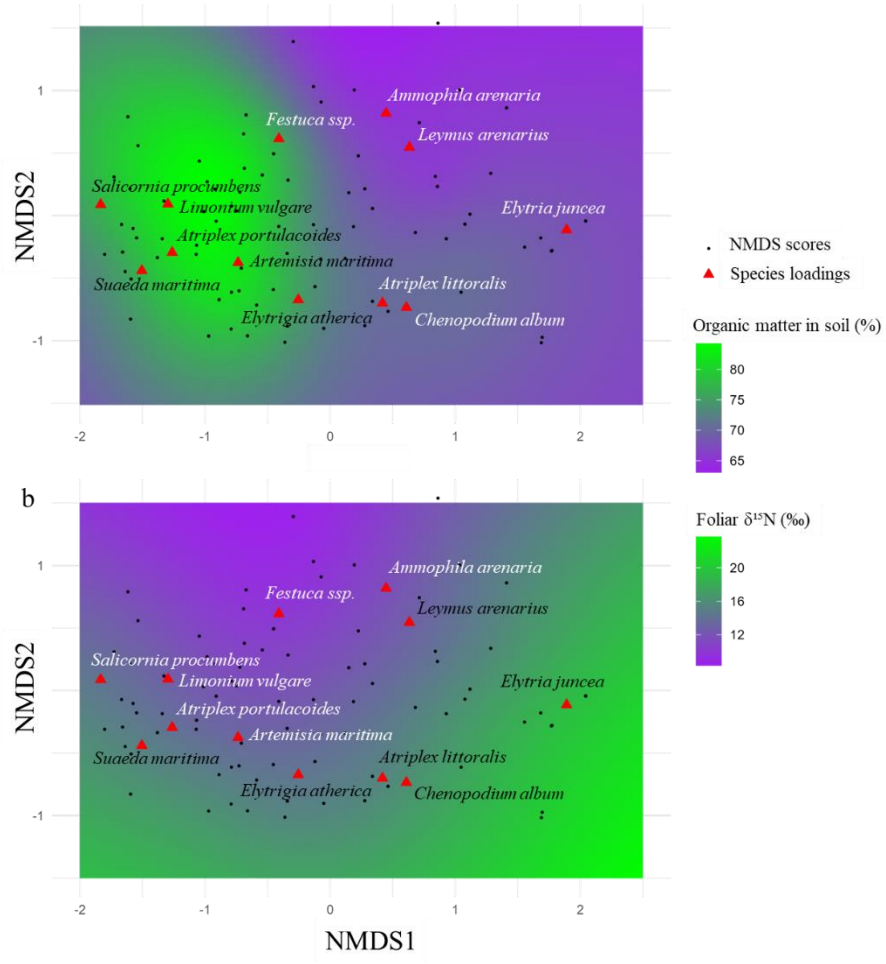
S3: Contributions and loadings per vegetation trait to the primary PC axes that explain at least 85% of total variance.

	Contributions (%)			Loadings		
	PC1	PC2	PC3	PC1	PC2	PC3
C:N ratio	3	48	1	-0.18	-0.69	-0.08
C	26	0	11	-0.51	-0.04	-0.33
N	1	49	2	-0.10	0.70	-0.12
Vegetation height	33	0	10	-0.58	-0.05	0.31
Vegetation root depth	14	1	46	-0.37	0.08	-0.68
Vegetation biomass	23	2	31	-0.48	0.16	0.56

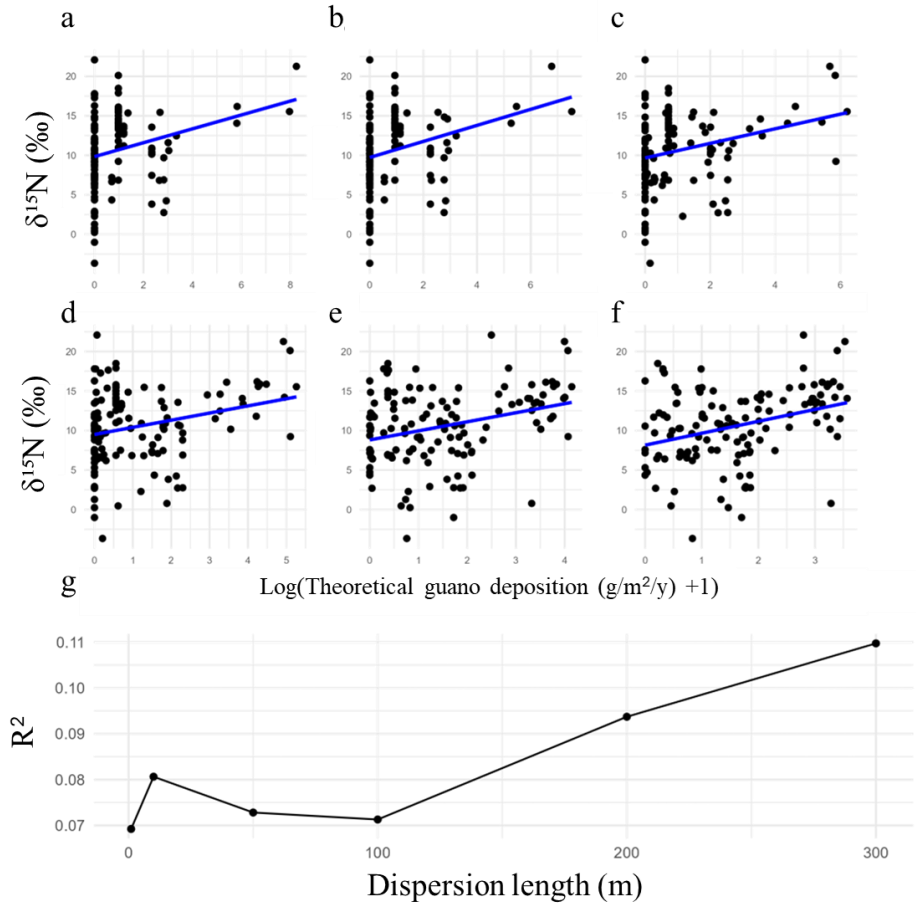
S4: Number of cells, Coordinates and descriptive statistics of the five islands analysed in this study. Descriptive statistics of NDVI, GI and Z are given for the years 2022 and 2021 and displayed as (Mean ± SD).

Variable	**Zuiderduin**	**Richel**	**Rottumeroog**	**Rottumerplaat**	**Griend**
Number of cells	68279	10979	128465	501266	79591
Area (ha)	61	10	116	451	72

Longitude	53°31'0"N	53°17'50"N	53°32'25"N	53°32'30"N	53°15'55"N
Latitude	6°35'0"E	5°8'5"E	6°34'55"E	6°28'51"E	5°15'15"E
$NDVI_{2021}$	0.311 ± 0.212	0.334 ± 0.153	0.332 ± 0.186	0.343 ± 0.199	0.461 ± 0.180
$NDVI_{2022}$	0.312 ± 0.180	0.328 ± 0.156	0.327 ± 0.173	0.302 ± 0.189	0.442 ± 0.200
GI_{2021} (d^{-1})	0.001 ± 0.001	0.002 ± 0.002	0.002 ± 0.001	0.001 ± 0.001	0.003 ± 0.001
GI_{2022} (d^{-1})	0.001 ± 0.001	0.002 ± 0.001	0.001 ± 0.001	0.001 ± 0.001	0.002 ± 0.001
Z_{2021} (m)	1.437 ± 0.425	1.517 ± 0.343	2.113 ± 1.042	1.858 ± 1.095	1.569 ± 0.990
Z_{2022} (m)	1.426 ± 0.408	2.210 ± 0.734	2.210 ± 1.098	1.908 ± 1.126	1.866 ± 0.760



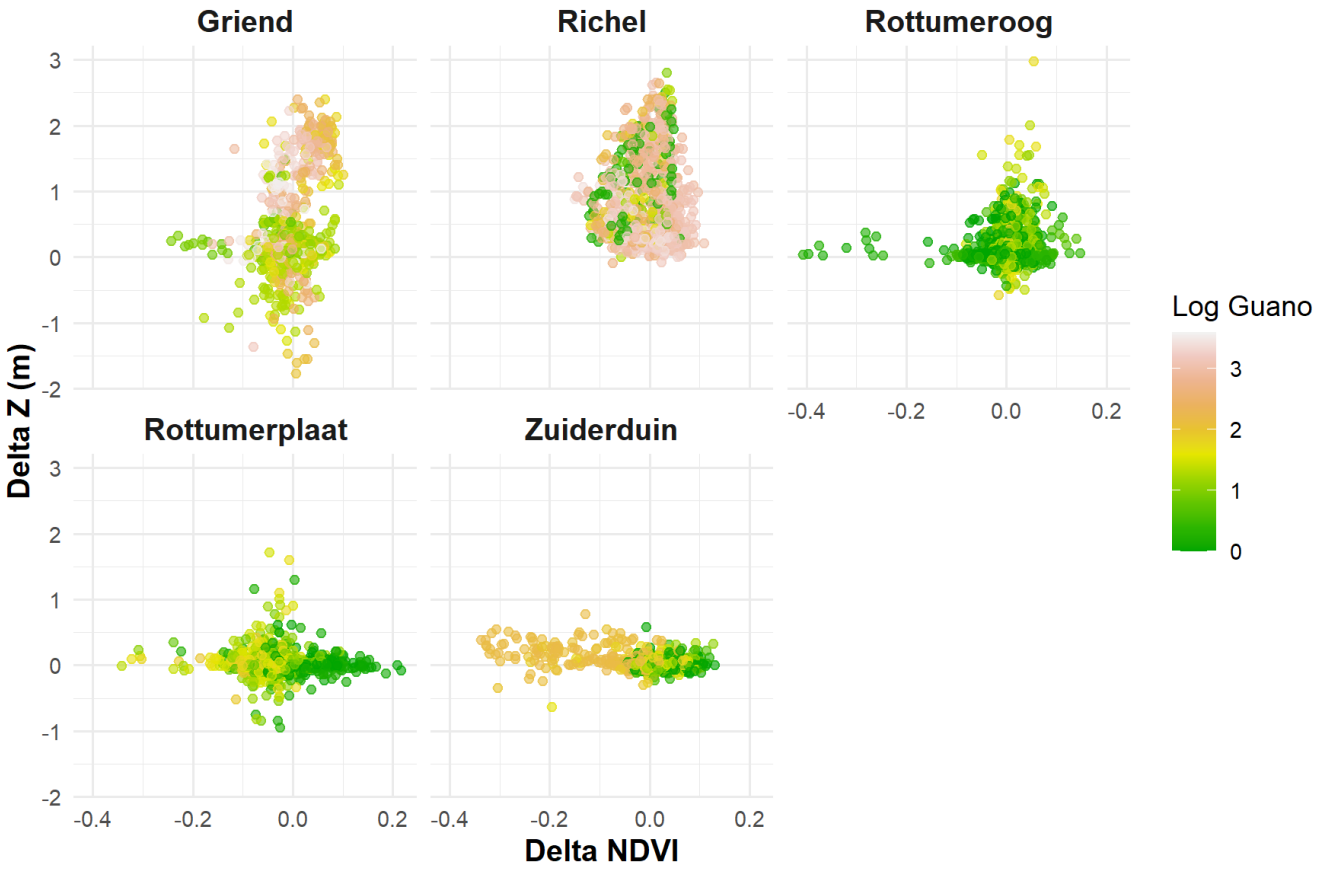
S5: Prediction of organic matter in the soil (a), and foliar $\delta^{15}N$ (b) based on NMDS scores of plot locations. Here, organic matter and foliar $\delta^{15}N$ values are explained by a smoothed interaction effect between NMDS1, and NMDS2 (s(NMDS1,NMDS2)), $p<0.05$. We solved for larger scale spatial autocorrelation by a tensor smoother on coordinates (te(X,Y)), $p<0.05$. Smoothers were performed by GAMs from the mgcv package in R (Wood & Augustin, 2002), however this was term was not used for prediction purposes, only for improving the accuracy of the s(NMDS1,NMDS2) smoother.



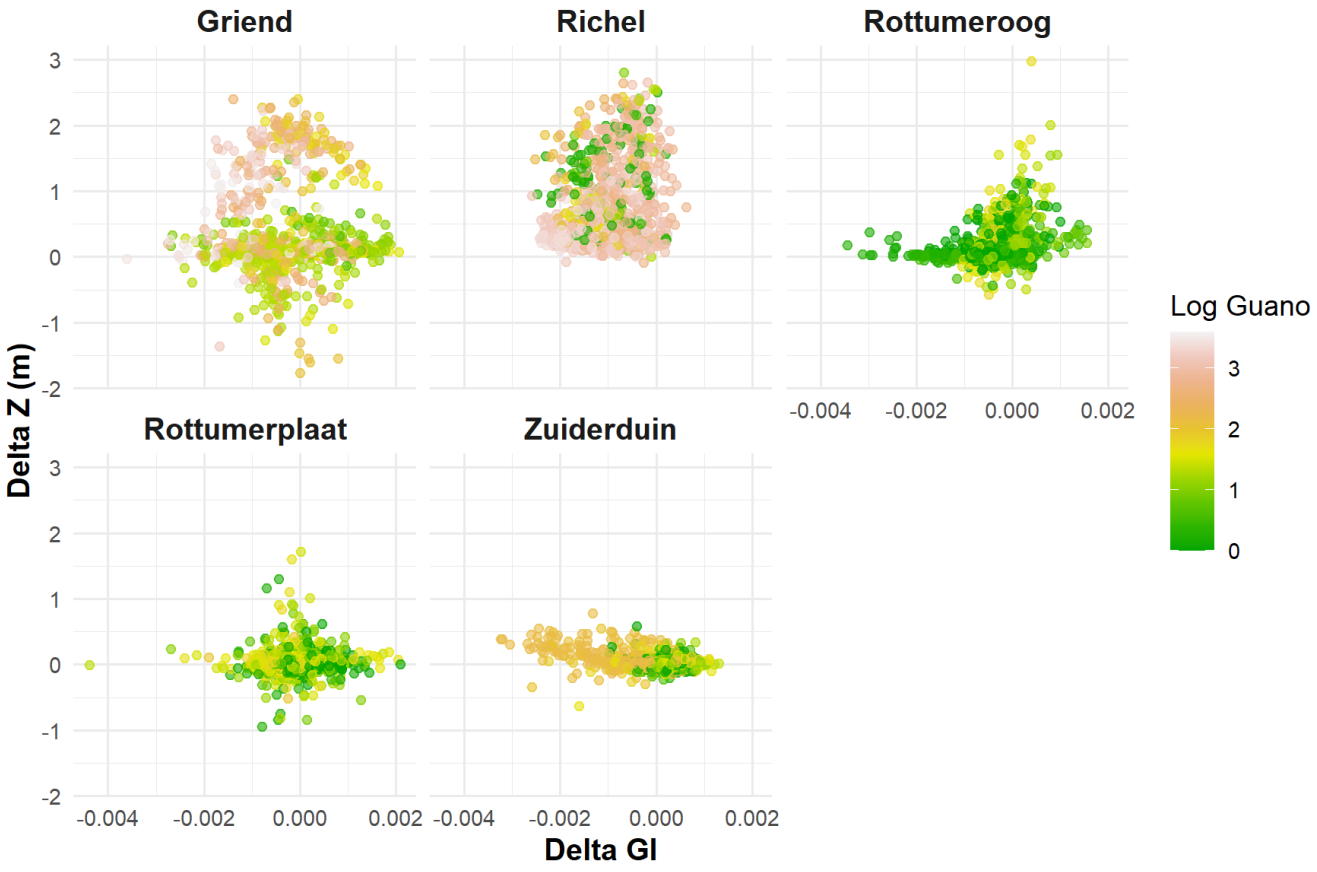
S6: Relationship between $\delta^{15}N$ and theoretical guano deposition computed by the data-informed model for different dispersion lengths (1, 10, 50, 100, 200, 300 m) for panels A-F respectively. Panel G shows the change of the R^2 as a function of the dispersion length.

S7: Summary of posterior distributions of coefficient values are expressed as (Mean ± SD).

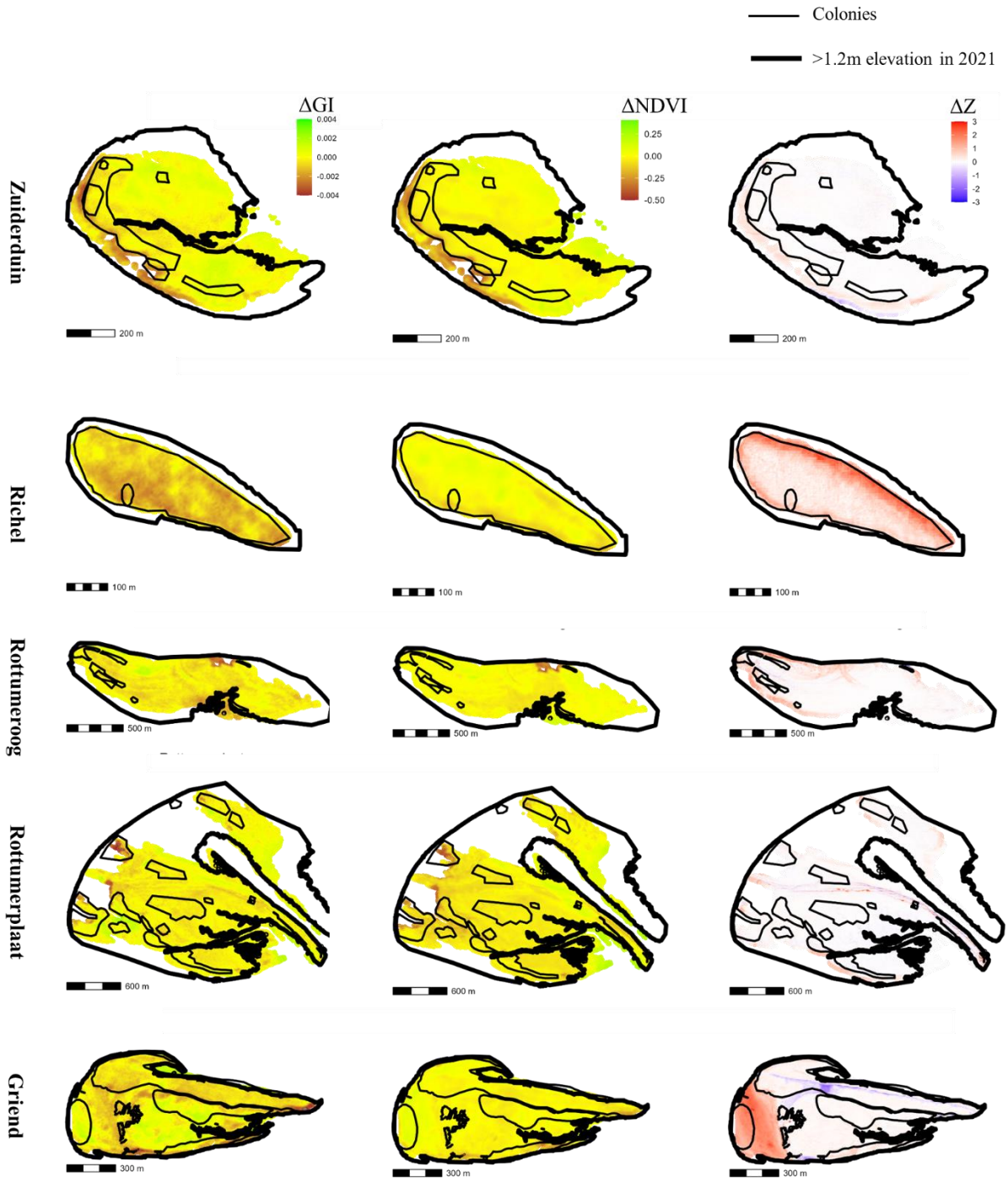
Predictor	GI-Based Model	NDVI-Based Model
(Intercept)	0.132 ± 0.035	0.134 ± 0.042
Log(Guano+1)	0.050 ± 0.024	0.037 ± 0.028
Vegetation Change (ΔGI or ΔNDVI)	-0.038 ± 0.012	0.038 ± 0.026
Vegetation State in 2021 (GI or NDVI)	-0.014 ± 0.011	0.010 ± 0.014
Elevation (2021)	-0.080 ± 0.007	-0.081 ± 0.007
Island (Richel)	0.731 ± 0.144	0.802 ± 0.169
Island (Rottumeroog)	0.085 ± 0.095	0.071 ± 0.112
Island (Rottumerplaat)	-0.182 ± 0.078	-0.203 ± 0.093
Island (Zuiderduin)	-0.259 ± 0.103	-0.294 ± 0.123
Log(Guano+1) × Vegetation Change	0.010 ± 0.005	-0.033 ± 0.010
Vegetation Change × Richel	-0.034 ± 0.015	-0.187 ± 0.034
Vegetation Change × Rottumeroog	0.111 ± 0.021	-0.029 ± 0.036
Vegetation Change × Rottumerplaat	0.033 ± 0.017	-0.054 ± 0.032
Vegetation Change × Zuiderduin	0.014 ± 0.017	0.001 ± 0.029



S8: Relationships between delta Z (m) (change in elevation), and delta NDVI (change in vegetation presence), per island. Delta's are computed based on the difference between 2022 and 2021. The color expresses log-transformed guano deposition in g/m^2/y on the original scale.



S9: Relationships between delta Z (m) (change in elevation), and delta GI (change in vegetation presence), per island. Delta's are computed based on the difference between 2022 and 2021. The color expresses log-transformed guano deposition in g/m²/y on the original scale.



S10: Spatially explicit values of ΔGI, ΔNDVI, and ΔZ.