Appendix B. Model plausibility analysis and model sensitivity analysis

Model plausibility analysis

Observation dataset

To test the plausibility of the model, we used soil C, soil N, and soil C:N ratio of three chronosequences which were used for the statistical analysis in the main text. In addition, we also used above-ground biomass of vascular plants. Above-ground biomass of vascular plants (g m^{-2}) was measured in 2012 as standing crop in summer. The biomass data is available only for a part of the plots for NB. See Table B.1 for overview of the observation dataset for each variable. Since we have simulated for 75 years only, the observed data of oldest successional stages (i.e. 162 years old for NB, 97 years old for LD) were compared to the modelled values of 75 years simulation.

Comparison between model prediction and observation

The model predicted soil C-accumulation reasonably well, although the difference between calcareous and acidic sites in LD was overestimated by the models (Figure B.1a). Soil N accumulation was underestimated by the model, especially for NB and acidic LD dunes (Figure B.1b). For calcareous dunes, the model predicted lower N accumulation in NB than in LD, while the measured values of N-accumulation were higher for NB than LD. Soil C:N ratio was constantly overestimated by the model (Figure B.1c). The increase in soil C:N ratio in the beginning of succession, which was observed clearly in LD, was reproduced by the model. Predicted above-ground plant production was in the same range for old stages of NB, lower for young stages of NB, and generally higher for LD (Figure B.1d).

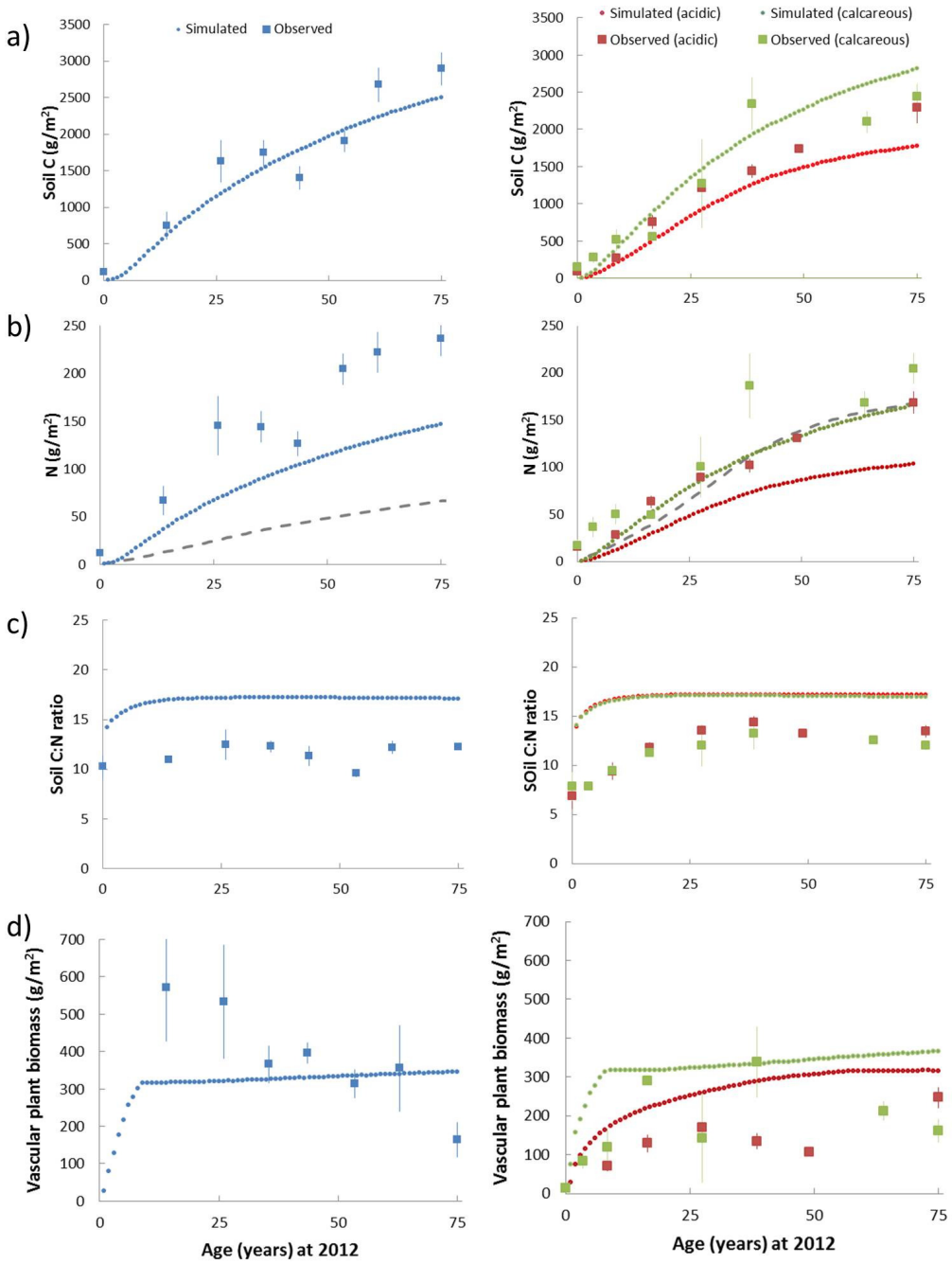


Figure B.1. Simulation results of soil C pool (a), soil N pool (b), soil C:N ratio (c) and vascular plant biomass (d) for calcareous-rich Newborough (NB; left) and calcareous and acidic Luchterduinen (LD; right). Model was run for 75 times for 1-year-old dune (i.e. started as bare sand from January 1st 2012, simulated till December 31th 2012) up to 75-year-old at year 2012 (i.e. started as bare sand from January 1938, simulated till December 31th 2012) with an interval of 1 year. Thus, each point corresponds to a simulation exercise (i.e. the output value at the end of the simulation period). Observed values (average ± SE) in chronosequence are shown with squares. 49-year –old acidic dune of LD and 16.5-year-old calcareous dune of LD have only one observation record and therefore have no SE bars. For the presentation purpose, the observation values of the oldest plots (i.e. 162-year-old in NB and 97-year-old in LD) were plotted as 75-year-old in these figures. Dotted lines in Figure b) are cumulative amount of atmospheric N deposition during each simulation period.

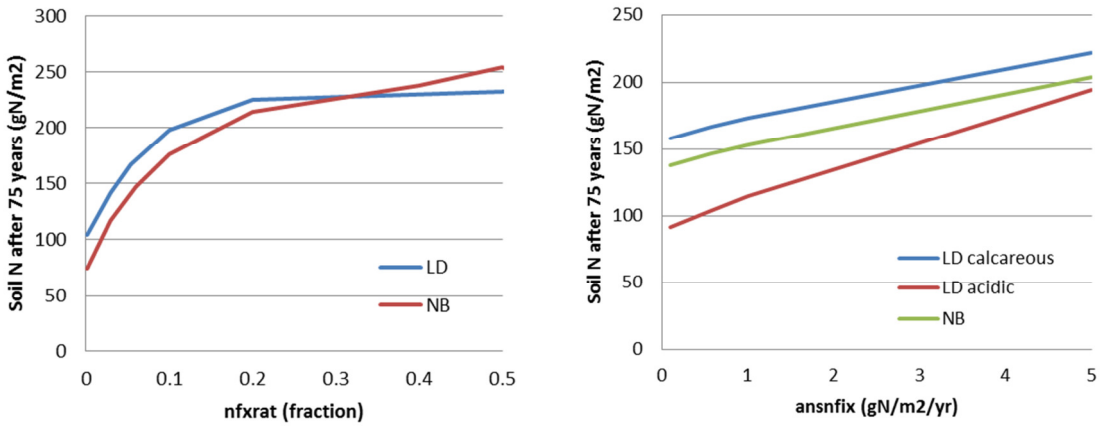
Table B.1. Age classes per chronosequence with number of plots and values (average and SD) for C pool, N pool, C: N ratio and pH of the topsoil, and standing crop of vascular plants.

age class	interval	N	C pool	N pool	C:N ratio	pH	standing crop
y	yr yr^{-1}		kg m^{-2}	kg m^{-2}	g g^{-1}		g m^{-2}
Newborough (NB)							
0	0	6	0.12 ± 0.06	0.012 ± 0.003	10.2 ± 2.6	8.4 ± 0.2	
14	6-22	6	0.75 ± 0.45	0.067 ± 0.037	11.0 ± 0.7	8.1 ± 0.2	570 ± 351
26	22-30	6	1.63 ± 0.70	0.145 ± 0.076	12.5 ± 3.7	7.9 ± 0.3	533 ± 370
35.5	30-41	6	1.75 ± 0.43	0.144 ± 0.040	12.3 ± 1.4	7.9 ± 0.5	366 ± 121
43.5	41-46	6	1.40 ± 0.38	0.126 ± 0.031	11.4 ± 2.4	7.8 ± 0.3	396 ± 68
53.5	46-61	5	1.90 ± 0.31	0.204 ± 0.040	9.6 ± 0.8	7.7 ± 0.3	314 ± 94
61	61-65	6	2.68 ± 0.57	0.222 ± 0.052	12.2 ± 1.6	7.5 ± 0.3	355 ± 282
162	>65	6	2.90 ± 0.54	0.237 ± 0.046	12.3 ± 0.3	6.5 ± 0.5	164 ± 115
Luchterduinen (LD) calcareous							
0	0	5	0.15 ± 0.15	0.017 ± 0.012	7.8 ± 3.2	8.4 ± 0.4	14 ± 20
3.5	1-6	3	0.28 ± 0.12	0.036 ± 0.019	7.9 ± 0.5	7.7 ± 0.2	84 ± 36
8.5	6-11	9	0.51 ± 0.44	0.050 ± 0.031	9.5 ± 1.4	7.5 ± 0.2	119 ± 138
16.5	11-22	1	0.55	0.049	11.3	7.3	290
27.5	22-33	2	1.27 ± 0.84	0.100 ± 0.045	12.0 ± 3.0	6.3 ± 1.5	143 ± 162
38.5	33-44	6	2.34 ± 0.86	0.186 ± 0.084	13.2 ± 3.7	6.4 ± 0.9	339 ± 224
64	54-74	13	2.10 ± 0.51	0.168 ± 0.044	12.6 ± 1.4	5.7 ± 0.7	213 ± 89
97	>74	9	2.44 ± 0.53	0.205 ± 0.048	12.0 ± 1.4	6.0 ± 1.1	162 ± 89
Luchterduinen (LD) acidic							
0	0	6	0.10 ± 0.05	0.015 ± 0.007	6.9 ± 3.0	8.2 ± 0.3	13 ± 14
8.5	1-6	8	0.27 ± 0.11	0.028 ± 0.005	9.4 ± 2.5	7.4 ± 0.5	71 ± 36
16.5	11-22	10	0.75 ± 0.28	0.063 ± 0.021	11.8 ± 1.7	6.4 ± 0.9	129 ± 71
27.5	22-33	8	1.21 ± 0.34	0.089 ± 0.023	13.6 ± 1.3	5.0 ± 0.2	171 ± 106
38.5	33-44	12	1.44 ± 0.32	0.102 ± 0.024	14.4 ± 2.1	4.5 ± 0.3	135 ± 70
49	44-54	1	1.73	0.131	13.3	4.4	107
97	>74	17	2.29 ± 0.87	0.169 ± 0.049	13.5 ± 2.4	4.2 ± 0.3	247 ± 107

Model sensitivity analysis of key parameters

We tested how parameters controlling symbiotic and asymbiotic N fixation influence soil N accumulation after 75 years of simulation (1938-2012). The proportion of symbiotic N fixers has very strong effect on soil N accumulation around the range of dune ecosystems (less than ca. 20%, i.e. *nfxrat* < 0.2) (Fig B.2a). Soil N accumulation does not increase rapidly at higher proportion because the system becomes limited by other factors (e.g. plant production becomes limited by water availability).

Asymbiotic N fixation does have linear effect on soil N accumulation (Fig B.2b). The rate of increase is faster for NB than LD because NB receives less atmospheric N deposition than LD and therefore overflow of N via leaching is less in NB.



a) Proportion symbiotic N fixers'*nfxrat*' b) asymbiotic N fixation '*ansnfix*'

Figure B.2. Changes in model output values of soil N accumulation after 75 years simulation against different levels of proportion of symbiotic N fixers '*nfxrat*' (Fig B.2a) and asymbiotic N fixation '*ansnfix*' (Fig B.2b. The default values for the parameters are *nfxrat*=0.06 for NB, *nfxrat*=0.054 for LD calcareous, *nfxrat*=0.0014 for LD acidic; *ansnfix*=0.57 gN m^{-2} yr^{-1} for all chronosequences.