Appendix A: Results of Structural Equation Models (SEMs)

Contents

1 Introduction

In this appendix the detailed SEM results are provided from applying differnt models to the data of the low and medium-altitude hay meadows (EUNIS R2.2) and the mountain hay meadows (R2.3). As measure of species richness either the total species richness or the number of the target species were used.

2 Main model

In this chapter we applied the data to the conceptual model as described in the section *conceptual model* in the main body of the manuscript for a detailed description of the model. The main model is depicted as a causal diagram in the following figure.

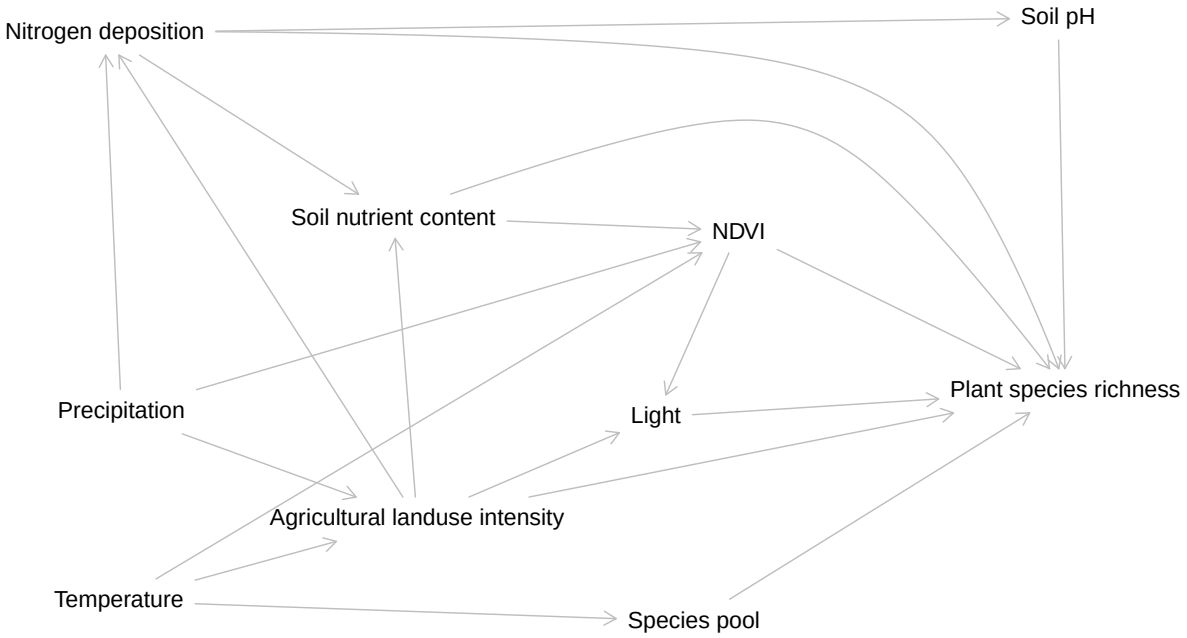

Figure A 1: Conceptual model used in the SEM.

Based on the conceptual model the following equations were used to analyse the data:

$$\begin{aligned} Plant\ species\ richness = {} & Nitrogen\ deposition + Soil\ alkalinity + Soil\ nutrient\ content + NDVI + \\ & Light + Landuse\ intensity + Species\ pool \end{aligned} \quad (1)$$

$$Soil\ alkalinity = Nitrogen\ deposition \quad (2)$$

$$Soil\ nutrient\ content = Nitrogen\ deposition + Landuse\ intensity \quad (3)$$

$$NDVI = Soil\ nutrient\ content + Precipitation + Temperature \quad (4)$$

$$Light = NDVI + Landuse\ intensity \quad (5)$$

$$Nitrogen\ deposition = Precipitation + Landuse\ intensity \quad (6)$$

$$Landuse\ intensity = Temperature + Precipitation \quad (7)$$

$$Species\ pool = Temperature \quad (8)$$

These formulas were implemented and applied to the data using the R-package `brms` (Bürkner 2021). The results are shown in the following tables. The same results are also depicted in Figure 3 in the main body of the manuscript.

Table A 1: SEM Results from applyig the structural equation model for the **total species richness** applied to the to the data of the **low and medium-altitude hay meadows** (EUNIS R2.2).

Equation	Response	Predictor	Coefficient	2.5%-Quantile	97.5%-Quantile
(1)	Plant species richness	Nitrogen deposition	-0.11	-0.19	-0.04
(1)	Plant species richness	Soil alkalinity	0.65	0.52	0.78
(1)	Plant species richness	Soil nutrient content	-0.28	-0.35	-0.21
(1)	Plant species richness	NDVI	0.00	-0.02	0.02
(1)	Plant species richness	Light	-0.24	-0.34	-0.14
(1)	Plant species richness	Landuse intensity	-0.24	-0.45	-0.02
(1)	Plant species richness	Species pool	-0.01	-0.02	0.01
(4)	NDVI	Soil nutrient content	-0.20	-0.44	0.03
(4)	NDVI	Precipitation	1.20	0.87	1.55
(4)	NDVI	Temperature	-1.92	-3.12	-0.67
(5)	Light	NDVI	-0.03	-0.05	-0.01
(5)	Light	Landuse intensity	0.06	-0.08	0.21
(2)	Soil alkalinity	Nitrogen deposition	-0.17	-0.21	-0.12
(3)	Soil nutrient content	Nitrogen deposition	0.19	0.11	0.28
(3)	Soil nutrient content	Landuse intensity	1.29	1.05	1.52
(6)	Nitrogen deposition	Precipitation	0.44	0.36	0.51
(6)	Nitrogen deposition	Landuse intensity	0.62	0.41	0.82
(7)	Landuse intensity	Temperature	-0.05	-0.17	0.08
(7)	Landuse intensity	Precipitation	-0.09	-0.12	-0.05
(8)	Species pool	Temperature	-0.95	-2.55	0.61

Table A 2: SEM Results from applyig the structural equation model for the **numer of target species** applied to the to the data of the **low and medium-altitude hay meadows** (EUNIS R2.2).

Equation	Response	Predictor	Coefficient	2.5%-Quantile	97.5%-Quantile
(1)	Plant species richness	Nitrogen deposition	-0.07	-0.27	0.12
(1)	Plant species richness	Soil alkalinity	3.22	2.90	3.54
(1)	Plant species richness	Soil nutrient content	-0.73	-0.90	-0.57
(1)	Plant species richness	NDVI	-0.01	-0.06	0.04
(1)	Plant species richness	Light	0.90	0.60	1.18
(1)	Plant species richness	Landuse intensity	-0.62	-1.14	-0.12
(1)	Plant species richness	Species pool	-0.04	-0.07	0.00
(4)	NDVI	Soil nutrient content	-0.21	-0.45	0.04
(4)	NDVI	Precipitation	1.20	0.87	1.54
(4)	NDVI	Temperature	-1.89	-3.11	-0.65
(5)	Light	NDVI	-0.03	-0.04	-0.01
(5)	Light	Landuse intensity	0.06	-0.08	0.21
(2)	Soil alkalinity	Nitrogen deposition	-0.17	-0.22	-0.12
(3)	Soil nutrient content	Nitrogen deposition	0.19	0.11	0.28
(3)	Soil nutrient content	Landuse intensity	1.29	1.06	1.52
(6)	Nitrogen deposition	Precipitation	0.44	0.37	0.51
(6)	Nitrogen deposition	Landuse intensity	0.62	0.41	0.82
(7)	Landuse intensity	Temperature	-0.04	-0.17	0.08
(7)	Landuse intensity	Precipitation	-0.09	-0.12	-0.05
(8)	Species pool	Temperature	-0.97	-2.53	0.60

Table A 3: SEM Results from applyig the structural equation model for the **total species richness** applied to the to the data of the **lmountain altitude hay meadows** (EUNIS R2.3).

Equation	Response	Predictor	Coefficient	2.5%-Quantile	97.5%-Quantile
(1)	Plant species richness	Nitrogen deposition	-0.20	-0.25	-0.15
(1)	Plant species richness	Soil alkalinity	0.64	0.57	0.71
(1)	Plant species richness	Soil nutrient content	-0.27	-0.32	-0.22
(1)	Plant species richness	NDVI	0.00	-0.02	0.02
(1)	Plant species richness	Light	-0.46	-0.52	-0.40
(1)	Plant species richness	Landuse intensity	-0.37	-0.45	-0.30
(1)	Plant species richness	Species pool	-0.01	-0.01	0.00
(4)	NDVI	Soil nutrient content	0.51	0.37	0.64
(4)	NDVI	Precipitation	0.94	0.81	1.08
(4)	NDVI	Temperature	0.40	0.18	0.63
(5)	Light	NDVI	-0.04	-0.05	-0.02
(5)	Light	Landuse intensity	0.21	0.16	0.26
(2)	Soil alkalinity	Nitrogen deposition	-0.08	-0.11	-0.05
(3)	Soil nutrient content	Nitrogen deposition	0.31	0.26	0.35
(3)	Soil nutrient content	Landuse intensity	0.74	0.66	0.82
(6)	Nitrogen deposition	Precipitation	0.44	0.39	0.48
(6)	Nitrogen deposition	Landuse intensity	1.11	1.05	1.17
(7)	Landuse intensity	Temperature	0.82	0.78	0.86
(7)	Landuse intensity	Precipitation	-0.11	-0.13	-0.08
(8)	Species pool	Temperature	1.20	0.55	1.86

Table A 4: SEM Results from applyig the structural equation model for the **numer of target species** applied to the to the data of the **mountain altitude hay meadows** (EUNIS R2.3).

Equation	Response	Predictor	Coefficient	2.5%-Quantile	97.5%-Quantile
(1)	Plant species richness	Nitrogen deposition	-0.85	-0.98	-0.72
(1)	Plant species richness	Soil alkalinity	1.60	1.44	1.75
(1)	Plant species richness	Soil nutrient content	-0.65	-0.77	-0.52
(1)	Plant species richness	NDVI	0.01	-0.02	0.05
(1)	Plant species richness	Light	-0.55	-0.69	-0.40
(1)	Plant species richness	Landuse intensity	-0.84	-1.03	-0.65
(1)	Plant species richness	Species pool	0.01	0.00	0.02
(4)	NDVI	Soil nutrient content	0.50	0.37	0.64
(4)	NDVI	Precipitation	0.94	0.81	1.08
(4)	NDVI	Temperature	0.40	0.17	0.63
(5)	Light	NDVI	-0.04	-0.05	-0.02
(5)	Light	Landuse intensity	0.21	0.16	0.26
(2)	Soil alkalinity	Nitrogen deposition	-0.08	-0.10	-0.05
(3)	Soil nutrient content	Nitrogen deposition	0.31	0.26	0.35
(3)	Soil nutrient content	Landuse intensity	0.74	0.66	0.82
(6)	Nitrogen deposition	Precipitation	0.44	0.39	0.48
(6)	Nitrogen deposition	Landuse intensity	1.11	1.05	1.17
(7)	Landuse intensity	Temperature	0.82	0.78	0.86
(7)	Landuse intensity	Precipitation	-0.11	-0.13	-0.08
(8)	Species pool	Temperature	1.19	0.52	1.87

3 Starting model

We started the analyses with a simpler model that is shown in the following graph. Only later we adapted this starting model based on the graphical model by DeMalach (2018) to the main model. The results of this simpler model probably has shaped our conclusion. Accordingly, we also present the results of this model here. This simpler model is a selection of the variables from the main model, except for Inclination. In this simpler model we used inclination of the terrain at the sampling site as a proxi for the landuse intensity (higher inclination = lower landuse intensity). In the main model we then replaced inclination by the landuse intensity index.

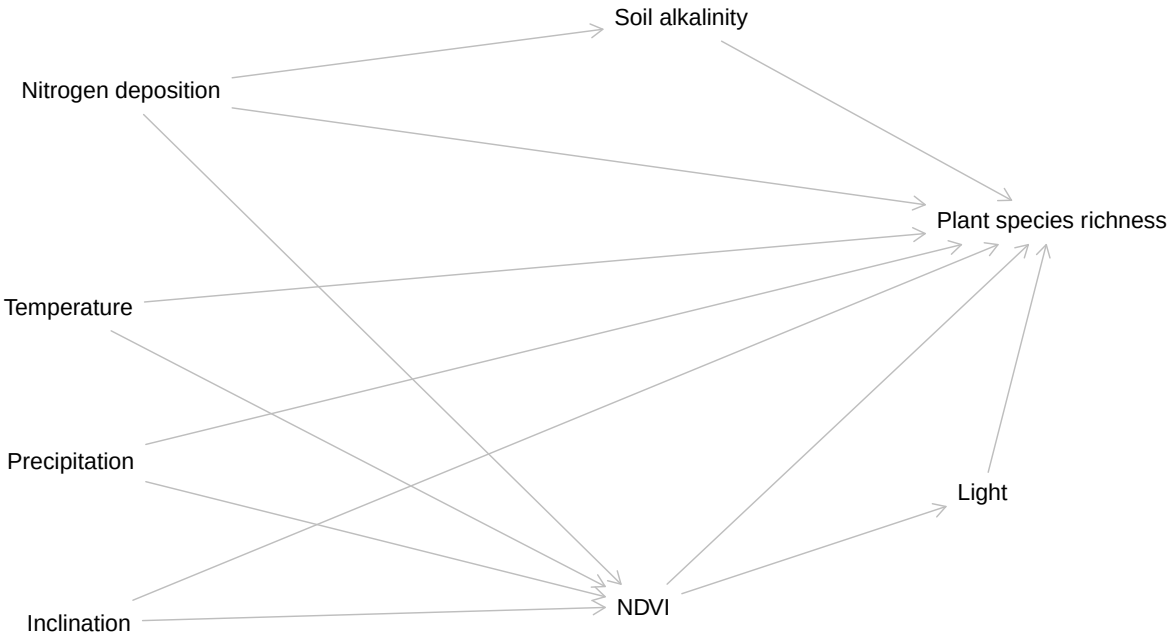

Figure A 2: Conceptual model used in the SEM.

Based on the conceptual model the following equations were used to analyse the data:

$$\begin{aligned} Plant\ species\ richness &= Nitrogen\ deposition + Soil\ alkalinity + Temperature + Precipitation + \\ &\quad Inclination + NDVI + Light \end{aligned} \tag{9}$$

$$Soil\ alkalinity = Nitrogen\ deposition \tag{10}$$

$$NDVI = Nirogen\ deposition + Temperature + Precipitation + Inclination \tag{11}$$

$$Light = NDVI \tag{12}$$

These formulas were implemented and applied to the data using the R-package `brms` (Bürkner 2021). The results are shown in the following tables.

Table A 5: SEM Results from applyig the structural equation model depicted in Fig. 3 for the **total species richness** applied to the to the data of the **low and medium-altitude hay meadows** (EUNIS R2.2).

Equation	Response	Predictor	Coefficient	2.5%-Quantile	97.5%-Quantile
(17)	Plant species richness	Nitrogen deposition	-0.11	-0.18	-0.03
(17)	Plant species richness	Soil alkalinity	0.81	0.68	0.93
(17)	Plant species richness	Temperature	-0.52	-0.80	-0.23
(17)	Plant species richness	Precipitation	0.13	0.05	0.22
(17)	Plant species richness	Inclination	0.04	0.02	0.05
(17)	Plant species richness	NDVI	0.01	-0.01	0.03
(17)	Plant species richness	Light	-0.20	-0.29	-0.11
(18)	Soil alkalinity	Nitrogen deposition	-0.16	-0.20	-0.12
(19)	NDVI	Nitrogen deposition	0.48	0.19	0.77
(19)	NDVI	Temperature	-1.93	-3.10	-0.80
(19)	NDVI	Precipitation	1.01	0.66	1.36
(19)	NDVI	Inclination	0.03	-0.01	0.08
(20)	Light	NDVI	-0.03	-0.05	-0.02

Table A 6: SEM Results from applyig the structural equation model depicted in Fig. 3 for the **numer of target species** applied to the to the data of the **low and medium-altitude hay meadows** (EUNIS R2.2).

Equation	Response	Predictor	Coefficient	2.5%-Quantile	97.5%-Quantile
(17)	Plant species richness	Nitrogen deposition	-0.20	-0.40	0.00
(17)	Plant species richness	Soil alkalinity	3.66	3.35	3.97
(17)	Plant species richness	Temperature	-0.26	-1.00	0.46
(17)	Plant species richness	Precipitation	0.31	0.07	0.55
(17)	Plant species richness	Inclination	0.07	0.05	0.10
(17)	Plant species richness	NDVI	0.01	-0.03	0.05
(17)	Plant species richness	Light	1.00	0.77	1.24
(18)	Soil alkalinity	Nitrogen deposition	-0.16	-0.20	-0.12
(19)	NDVI	Nitrogen deposition	0.48	0.17	0.79
(19)	NDVI	Temperature	-1.91	-3.14	-0.72
(19)	NDVI	Precipitation	1.01	0.67	1.35
(19)	NDVI	Inclination	0.03	-0.02	0.08
(20)	Light	NDVI	-0.03	-0.05	-0.02

Table A 7: SEM Results from applyig the structural equation model depicted in Fig. 3 for the **total species richness** applied to the to the data of the **lmountain altitude hay meadows** (EUNIS R2.3).

Equation	Response	Predictor	Coefficient	2.5%-Quantile	97.5%-Quantile
(17)	Plant species richness	Nitrogen deposition	-0.53	-0.58	-0.48
(17)	Plant species richness	Soil alkalinity	0.61	0.54	0.68
(17)	Plant species richness	Temperature	0.05	-0.02	0.13
(17)	Plant species richness	Precipitation	0.36	0.32	0.40
(17)	Plant species richness	Inclination	0.04	0.03	0.05
(17)	Plant species richness	NDVI	-0.04	-0.05	-0.02
(17)	Plant species richness	Light	-0.33	-0.38	-0.28
(18)	Soil alkalinity	Nitrogen deposition	-0.08	-0.10	-0.06
(19)	NDVI	Nitrogen deposition	0.51	0.35	0.66
(19)	NDVI	Temperature	0.19	-0.06	0.45
(19)	NDVI	Precipitation	0.78	0.64	0.93
(19)	NDVI	Inclination	-0.01	-0.04	0.01
(20)	Light	NDVI	-0.01	-0.02	0.01

Table A 8: SEM Results from applyig the structural equation model depicted in Fig. 3 for the **numer of target species** applied to the to the data of the **mountain altitude hay meadows** (EUNIS R2.3).

Equation	Response	Predictor	Coefficient	2.5%-Quantile	97.5%-Quantile
(17)	Plant species richness	Nitrogen deposition	-1.76	-1.91	-1.61
(17)	Plant species richness	Soil alkalinity	1.57	1.42	1.73
(17)	Plant species richness	Temperature	0.12	-0.07	0.29
(17)	Plant species richness	Precipitation	0.83	0.73	0.91
(17)	Plant species richness	Inclination	0.09	0.07	0.10
(17)	Plant species richness	NDVI	-0.06	-0.09	-0.03
(17)	Plant species richness	Light	-0.24	-0.37	-0.10
(18)	Soil alkalinity	Nitrogen deposition	-0.08	-0.10	-0.06
(19)	NDVI	Nitrogen deposition	0.51	0.35	0.67
(19)	NDVI	Temperature	0.19	-0.07	0.45
(19)	NDVI	Precipitation	0.79	0.65	0.93
(19)	NDVI	Inclination	-0.01	-0.03	0.01
(20)	Light	NDVI	-0.01	-0.02	0.01

4 Correlation of predictor variables

The following two figures show the pairwise correlation matrix of the predictor variables that we used in the main model.

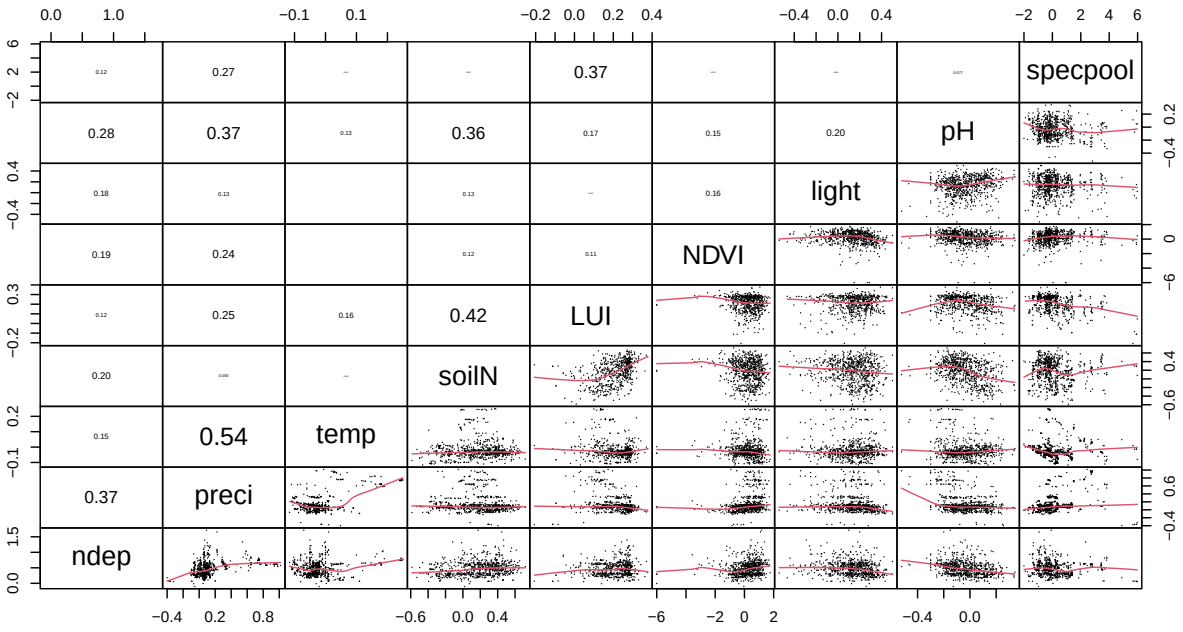

Figure A 3: Pairwise correlation plot using the data of the lowland hay meadows.

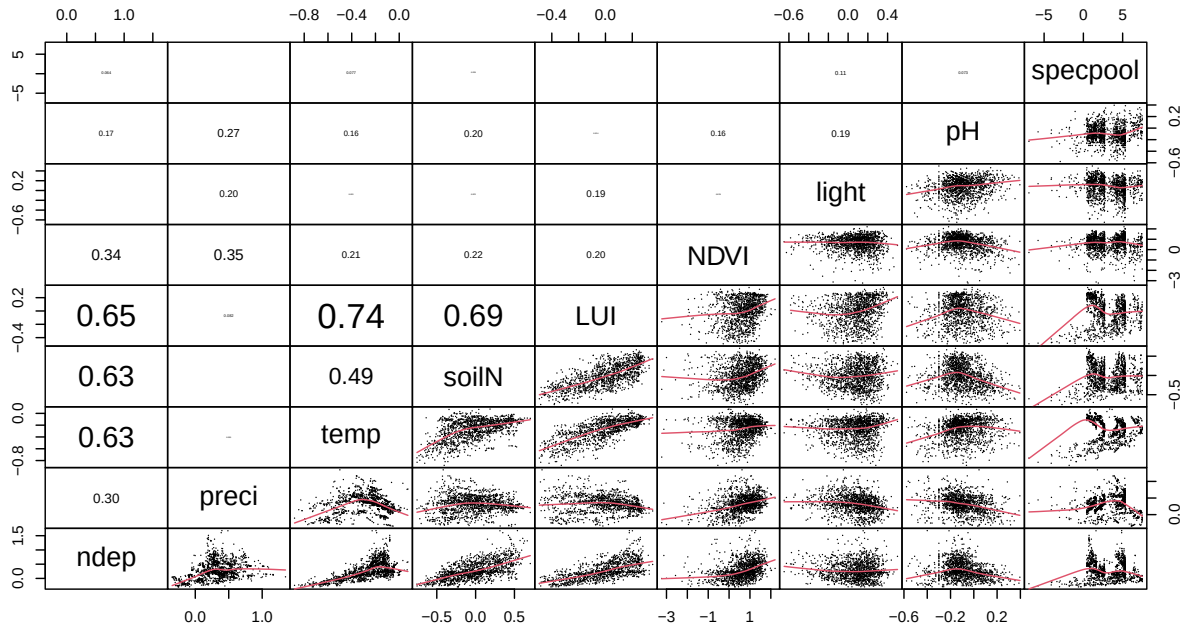

Figure A 4: Pairwise correlation plot using the data of the mountain hay meadows.

References

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