Ecography

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Supplementary material

Appendix 1

Study location

The model was calibrated and validated in the Netherlands. The mean summer temperature in the Netherlands is 16.4 °C and the mean winter temperature is 3.2 °C, the mean annual precipitation is 754 mm and the precipitation surplus is 191 mm (Royal Netherlands Meteorological Institute (KNMI); www.knmi.nl).

The length of the environmental gradients was for all variables (nitrogen mineralisation, oxygen stress, pH and disturbance) comparable to the global gradient. For example, the range of soil nitrogen mineralization reported in our study was similar to the soil nitrogen mineralization range in a global meta-analysis performed by Ordoñez et al. 2009. Also the acidity, disturbance and respiration stress gradients cover a large part of the global gradient (Figure 4).

Soil fertility estimates

In the seven data sources, total carbon had been determined either by $K_2Cr_2O_7$ (Kurmies) destruction, element analyzer or as loss upon ignition. Soil samples were taken in the top 20 cm of the soil. Total nitrogen had been determined either by an element analyzer, Kjeldahl destruction or H_2O_2 destruction, which were assumed to be comparable.

To allow calculation of soil N mineralisation, total carbon and nitrogen content of the top 20 cm of the soil were used as input to a simplified nitrogen mineralisation model developed by Ordoñez et al. (2009) based on the CENTURY model (Parton et al. 1987). Total nitrogen accounts for historical factors including nitrogen deposition (a control analysis, adding nitrogen deposition estimates (http://www.pbl.nl/nl/themasites/gcn/index.html; van Jaarsveld 2004) to the nitrogen mineralisation showed no improvement when regressed against traits). Mineralisation is modulated by soil texture, temperature, precipitation and reference evapotranspiration (according to Makkink 1957). The correction factor for temperature on mineralisation was calculated based on mean monthly temperature. The correction factor for moisture was calculated using precipitation and reference evapotranspiration data (available from the Royal Netherlands Meteorological Institute; KNMI). The carbon transfer from the pools is modulated by soil texture. Texture data (percentage of sand, silt and clay) was obtained either from original literature sources or from a 1:50,000 soil map of the Netherlands.

Water availability

Daily groundwater levels were calculated from forthnightly series of groundwater levels measured with piezometers located closely to the plots (www.dinoloket.nl). These observed groundwater levels (minimum period three years) were first interpolated to daily values and then extrapolated to a 30-years period with help of Menyanthes (Von Asmuth et al. 2002). As is shown by Bartholomeus et al.(2008), a 30 years time frame of daily values is needed to get a robust estimate of the moisture conditions as experienced by plants. Therefore observed groundwater levels (minimum period three years) were first interpolated to daily values and then extrapolated to a 30-years period using the Menyanthes software package (Von Asmuth et al. 2002; see Appendix S1 for details). These daily values were subsequently used in a detailed soil water atmosphere plant model (SWAP, Van Dam et al. 2008) together with soil texture, air temperature, rainfall and evapotranspiration data to calculate gas filled porosity and soil temperature for different layers in the soil profile. These variables were then used to calculate the actual and potential root respiration. A difference between the potential and actual root respiration -equalling the respiration stress experienced by a plant- may occur because of an oxygen deficiency in the root zone. The yearly maximum respiration reduction in a 10-day period averaged across 30 years was taken as a measure of oxygen stress (RS – kg O_2 m^{-2} 10 d^{-1}). For a detailed description of this procedure, see Bartholomeus (2009).

Disturbance

For all plots, information about the frequency and type of management activities was available through reports. The disturbance agents in the dataset were predominantly mowing and/or grazing and for a few plots sod cutting or trampling

Acidity

Soil acidity measures differed within the dataset. Therefore, to get comparable estimates, pH-$CaCl_2$ and pH-H_2O were transformed to pH-KCl estimates using equations from Fotyma et al. (1998) and Wamelink et al. (2005), respectively.

Vegetation type classification

To study the effect of the number of vegetation types on the differentiating power of the GMDF, five different vegetation type classifications were used. These classifications were based on the four different hierarchical scales available within the phytosociological classification: class, order, alliances and associations (following the standards of Schaminée et al. 1995a, Schaminée et al. 1995b, Schaminée et al. 1996, Schaminée et al. 1998, Stortelder et al. 1999). Aggregation towards coarser classification levels is based on species composition and in some vegetation types on vegetation structure (Schaminée et al. 1995b) and results in a decreasing number of vegetation types with coarser scales. We omitted vegetation types of aquatic, salt and brackish environments, because other processes (e.g. salt tolerance) are a more important driver of species occurrence. This led to 73 vegetation types at the associations level, 73 vegetation types (1), 53 vegetation types at the alliances level (2), 38 vegetation types at the order level (3) and 28 vegetation types at the class level (4) in the SynBioSys dataset. Additionally, within the level of alliances, some alliances that were floristically related, were combined (based on Schaminée et al. 1995b), while alliances characterized by floristic heterogeneity (like forest borders and wall vegetation) which additionally did not have a functional entity, were removed (aggregated alliance).

Testing the effect of the number of vegetation types on the performance

To test the effect of number of vegetation types without interference of uncertainties in trait-environment relations and sample size effects, relevé mean trait values were calculated from the species identities using the trait database and used to predict a vegetation type for all relevés. The 16,293 relevés used previously (SynBioSys) were split into a calibration set and a validation set. From this set, at least 40 trait relevé means per vegetation type were used to calibrate the pdfs of the GMDF and at least 20 relevés were used to predict the vegetation types (SynBioSys validation set). Setting this restriction, the number of relevés that could be used for analysis varied from 10,057 to 11,308 depending on the classification.

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Table A1 Description of 15 vegetation types used in this study (aggregated alliance). Habitat requirements and dominant species and datasource of these vegetation types are given. All studies contained information on species absence/presence, nutrient supply, soil acidity and disturbance. In total 263 (semi) natural ecosystems in the Netherlands

Veg.	**Description**	**10 most dominant plant and moss species**	**# in dataset**	**Main data source**
A	High-productive wetland communities	*Phragmites australis, Typha angustifolia, Carex acuta, Carex riparia, Carex paniculata, Calla palustris, Bolboschoenus maritimus, Cicuta virosa, Lemna minor and Cladium mariscus.*	11	Olde Venterink et al. 2001
B	Peatlands (mostly groundwater fed)	*Potentilla palustris, Salix repens, Hydrocotyle vulgaris, Schoenus nigricans, Phragmites australis, Carex diandra, Agrostis canina, Calliergonella cuspidate, Sphagnum palustre and Sphagnum fallax*	32	Ertsen et al. 1998, Olde Venterink et al. 2001, Kemmers et al. 2001,

		(+S. flexuosum).		
C	Peatlands (rainwater fed) and wet heath	*Erica tetralix, Molinia caerulea, Oxycoccus palustris, Empetrum nigrum, Calluna vulgaris, Sphagnum magellanicum, Sphagnum fallax (+ S. flexuosum), Sphagnum papillosum, Sphagnum palustre and Sphagnum fallax.*	3	Ertsen et al. 1998
D	Inundated and grazed grasslands and pioneer communities	*Agrostis stolonifera, Poa trivialis, Persicaria hydropiper, Alopecurus geniculatus, Ranunculus repens, Potentilla anserine, Festuca rubra ag. (incl. F. arenaria), Tephroseris palustris, Lolium perenne and Chenopodium rubrum.*	12	Ertsen et al. 1998, Schaffers 2002
E	Grasslands at nutrient-poor sandy soils	*Festuca filiformis, Corynephorus canescens Festuca rubra ag. (incl. F. arenaria),*	16	Ordoñez et al. 2010, Kemmers et al. 2001, Ertsen

		Festuca ovina ag. (incl. F. cinerea, F. filiformis), Agrostis capillaries, Polytrichum piliferum, Hypnum cupressiforme s.l. species, Hypnum cupressiforme v.lacunosum, Syntrichia ruralis v. arenicola and Dicranum scoparium.		et al. 1998
F	Grassland at moderately dry calcareous soils	*Brachypodium pinnatum, Carex flacca Leontodon hispidus, Centaurea scabiosa Sanguisorba minor, Briza media, Helictotrichon pubescens, Festuca rubra ag. (incl. F. arenaria), Ctenidium molluscum and Calliergonella cuspidate.*	2	Schaffers 2002
G	Grasslands at moderately nutrient-poor and wet soils.	*Molinia caerulea, Cirsium dissectum, Anthoxanthum odoratum, Carex panacea, Holcus lanatus, Juncus acutiflorus,*	29	Olde Venterink et al. 2001, Ertsen et al. 1998

	Frequently inundated	*Agrostis canina, Phragmites australis, Calliergonella cuspidate and Rhytidiadelphus squarrosus*		
H	Hay(pastures) - grasslands at nutrient-rich, moderately wet clayey soils. Sensitive to inundations	*Festuca rubra ag. (incl. F. arenaria), Lolium perenne, Arrhenatherum elatius, Poa trivialis, Trifolium repens, Cynosurus cristatus, Holcus lanatus, Alopecurus pratensis, Ranunculus acris and Trifolium pratense.*	16	Schaffers 2002, Ertsen et al. 1998,
I	Grasslands and dry heath at nutrient-poor soils	*Calluna vulgaris, Empetrum nigrum, Erica tetralix, Hypnum cupressiforme s.l. species, Molinia caerulea, Pohlia nutans, Pleurozium schreberi, Hypnum jutlandicum, Dicranum scoparium and Cladina portentosa*	20	Ertsen et al. 1998, Schaffers 2002
J	Frequently disturbed	*Secale cereale, Elytrigia repens, Hordeum*	4	Ertsen et al. 1998

	arable land and ruderal places	*murinum, Apera spica-venti, Tanacetum vulgare, Stellaria media, Artemisia vulgaris, Polygonum aviculare, Chenopodium album, Poa annua and Urtica Dioica.*		
K	Shrublands and forests, Periodically flooded, nutrient-rich soils	*Salix alba, Urtica dioica, Phragmites australis, Salix viminalis, Poa trivialis, Calystegia sepium, Filipendula ulmaria, Epilobium hirsutum, Salix triandra and Phalaris arundinacea.*	12	Ordoñez et al. 2010, Schaffers 2002,
L	Shrubland and forest communities at very wet, nutrient-rich, peaty soils.	*Alnus glutinosa, Betula pubescens, Salix cinerea, Calamagrostis canescens, Molinia caerulea, Solanum dulcamara, Phragmites australis, Sphagnum fimbriatum, Sphagnum fallax (+ S. flexuosum) and Mnium hornum*	0	
M	Shrub vegetation at	*Crataegus monogyna, Ligustrum vulgare,*	0	

	moderately wet to dry, calcareous soils	*Sambucus nigra, Rubus caesius, Hippophae rhamnoides, Prunus spinosa, Urtica dioica, Ulmus minor, Rosa canina and Clematis vitalba.*		
N	Forest communities at nutrient-poor, acid soils	*Quercus robur, Pinus sylvestris, Deschampsia flexuosa, Fagus sylvatica, Vaccinium myrtillus, Molinia caerulea, Pteridium aquilinum, Betula pendula, Pleurozium schreberi and Hypnum jutlandicum.*	96	van Dobben and de Vries 2001, Ordoñez et al. 2010
O	Forest communities at nutrient-rich soils	*Quercus robur, Fraxinus excelsior, Corylus avellana, Hedera helix, Anemone nemorosa, Carpinus betulus, Lamiastrum galeobdolon, Acer pseudoplatanus, Fagus sylvatica and Ranunculus ficaria.*	10	Ordoñez et al. 2010, Stuijfzand et al. 2005

Appendix 2

Species values for specific stem density were obtained using the sources listed below.

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