The following supplement accompanies the article

Using life-history traits to explain bird population responses to changing weather variability

Anouk Cormont[1,2,*], Claire C. Vos[1], Chris A. M. van Turnhout[3], Ruud P. B. Foppen[3], Cajo J. F. ter Braak[4]

[1]Alterra, Wageningen UR, PO BOX 47, 6700 AA Wageningen, The Netherlands
[2]Land Use Planning Group, Wageningen University, PO Box 47, 6700 AA Wageningen, The Netherlands
[3]SOVON, Dutch Centre for Field Ornithology, PO Box 6521, 6503 GA Nijmegen, The Netherlands
[4]Biometris, Department of mathematical and statistical methods, Wageningen UR, PO Box 100, 6700 AC Wageningen, The Netherlands

*Email: anouk.cormont@wur.nl

Climate Research 49: 59–71 (2011)

Supplement 1. LTE method

Here we describe the linear trait–environment (LTE) method, which is the linear counterpart of the fourth-corner method of Dray & Legendre (2008). See below for a detailed comparison. The LTE method relates the quantitative environmental variable x to the quantitative species trait z via the species–site data y. It differs from the fourth-corner method by using a multivariate linear regression model for the species–site data, thus allowing negative values y. In our application, sites are years and $y_{ik} = \ln[\text{index}_{\text{year\_}i,\ \text{species\_}k}/\text{index}_{\text{year\_}i-1,\text{species\_}k}]$.

NOTATION

The value of environmental variable x at site i is denoted by x_i, the value of the trait z of species k is denoted by z_k, and the population growth rate y of species k in site i is denoted by y_{ik} (i = 1,…, n; k = 1, …, m). All these values are interval scaled, taking values on the real line.

MODEL

The LTE method starts from a multivariate linear regression of the species–site data using a single predictor variable x. This regression can be expressed as m separate simple linear regressions, one for each species:

$$y_{ik} = a_k + b_k x_i + \varepsilon_{ik} \quad (1)$$

where a_k and b_k are the intercept and slope for species k with respect to environmental variable x, respectively, and ε_{ik} is a noise variable with a mean of 0 and a species-specific variance. This models the environmentally structured variation in the species–site data. We define the amount of environmentally structured variation by the sum across species of the regression sum of squares, SS_x. We now relate this variation to the species trait z by a simple regression of the species-specific slopes (b_k) vs. trait z, that is:

$$b_k = c + dz_k + \delta_k \quad (2)$$

where c and d are the intercept and slope for trait z and δ_k is a species-specific noise variable with a mean of 0. By inserting this equation into Eqn (1), we obtain one regression model for all $n \times m$ data points:

$$y_{ik} = a_k + cx_i + dz_k x_i + \varepsilon^*_{ik} \quad (3)$$

with $\varepsilon^*_{ik} = \varepsilon_{ik} + \delta_k x_i$, an error term with a mean of 0. Note that the errors are no longer independent. The trait–environment relationship is represented by the coefficient d and the amount of trait–environment variation is expressed as the sum of squares, SS_{xz}, associated with the term $z_k x_i$. Eqn (3) could also be expressed as a linear mixed model, but we do not do so because we estimate parameters by least-squares and perform statistical tests by Monte Carlo permutation.

FITTING THE MODEL

The least-squares estimate of the coefficient d, $\hat{d}$, can be calculated most easily by subtracting the means of x and z from x_i and z_k, respectively, and by continuing with the centered versions, denoted by the vectors **x** and **z**. With $\mathbf{Y} = [y_{ik}]$, the matrix with species–site data, we then have (see also Takane et al. 1991, Takane & Hunter 2001):

$$\hat{d} = (\mathbf{x}^T\mathbf{x})^{-1}\mathbf{x}^T\mathbf{Y}\mathbf{z}(\mathbf{z}^T\mathbf{z})^{-1} \text{ and } SS_{xz} = \hat{d}^2 \sum_{i,k} (x_i z_k)^2 \quad (4)$$

These results can be derived by noting that the term $z_k x_i$ is orthogonal to all terms a_k and x_i, *e.g.* for the latter:

$$\sum_{i,k} z_k x_i^2 = 0 \quad (5)$$

so that $\hat{d}$ can be obtained by regressing a response with elements y_{ik} on the single predictor with elements $x_i z_k$ using all $n \times m$ data points and by re-expressing the least-squares estimate in terms of the vectors **x** and **z** and matrix **Y**.

TESTING STATISTICAL SIGNIFICANCE

Dray & Legendre (2008) evaluated 6 permutation-based significance tests for testing the trait–environment relationship, but none faithfully controlled the type I error. This means that these tests may indicate a trait–environment relationship more frequently than the nominal significance level (e.g. 0.05) when in fact no such relationship exists. C. J. F. Ter Braak et al. (unpubl.) showed that their sixth method (the combined method) can be transformed into a sequential test that does control the type I error. The new test is carried out as follows.

(1) Select a test statistic that is sensitive to the strength of the trait–environment relationship, for which we use SS_{xz}, and compute its value for the data, yielding F_0.

(2) Randomly permute the values in x and compute the statistic using the permuted x, yielding F_1. Repeat this operation so as to yield the additional values F_2, …, F_K, where K is the number of permutations. We used $K = 999$.

(3) Compute the Monte Carlo significance level, i.e. compute the number of values of F_0, F_1, …, F_K that is greater than or equal to F_0 (this number is thus at least 1), and divide by K+1. Denote the result by α_1.

(4) Randomly permute the values in z and compute the statistic using the permuted z, yielding G_1. Repeat this operation so as to yield the additional values G_2, …, G_K, where K is the number of permutations.

(3) Compute the Monte Carlo significance level, i.e. compute the number of values of F_0, G_1, …, G_K that is greater than or equal to F_0 (this number is thus at least 1), and divide by K+1. Denote the result by α_2.

(4) The final Monte Carlo significance level, α, is the maximum of the 2 significance levels, i.e. $\alpha = \max(\alpha_1, \alpha_2)$.

TRAIT–ENVIRONMENT CORRELATION

The fourth-corner problem linking 2 quantitative variables yields an easy to interpret correlation (Dray & Legendre 2008). For the LTE method we define the trait–environment correlation (R) as the Pearson correlation between the species-specific slopes (b_k) and the trait z. It can be shown that R^2 is the fraction of the environmentally structured variation that can be explained by the trait, i.e. $R^2 = SS_{xz}/SS_x$. Note the caveat in the interpretation that R can be high even when the environmentally structured variation is small. For this reason, the squared correlation is less suited for testing.

DISCUSSION

One may wonder why we use the simple test statistic SS_{xz} instead of an F-type statistic which compares the regression mean square with the error mean square, as is optimal in permutation tests for testing the significance of one or more regression terms in the presence of other (so-called nuisance) terms (Anderson & Legendre 1999, Anderson & Robinson 2001, Ter Braak & Šmilauer 2002). The reason is that models other than Eqn (3) can be formulated that are equally appealing but that yield another error mean square. For example, by also expressing a_k as a linear function of z, we obtain a standard model with main effects for x and z and the interaction between x and z, that is:

$$y_{ik} = c_0 + c_1 x_i + c_2 z_k + c_3 x_i z_k + \varepsilon_{ik}^{**} \quad (6)$$

One can verify that the least-squares estimates of d in Eqn (3) and of c_3 in Eqn (6) are equal. The amounts of trait–environment variation are equal as well. A third model with the same interaction parameter and the same amount of trait–environment variation is a model with free parameters for sites (rows) and species (species) and an interaction term between x and z, that is:

$$y_{ik} = r_i + c_k + dx_i z_k + \varepsilon_{ik}^{***} \quad (7)$$

This model can simply be expressed as:

$$\tilde{y}_{ik} = dx_i z_k + \varepsilon_{ik}^{***} \quad (8)$$

where $\tilde{y}_{ik}$ is the double-centered version of y_{ik}, i.e. $\tilde{y}_{ik} = y_{ik} - y_{i+}/m - y_{+k}/n + y_{++}/nm$, where we use the notation that a '+' replacing an index means the sum over the index. So, only one term remains, making it unnecessary to use an F–type statistic. The proposed permutation test is thus based on a model with all variation that is either environmentally structured or trait-structured, but not both, removed. Here 'all' means variation related not only to our specific x or z, but to any environmental variable or trait.

Comparison of LTE with the fourth-corner method

The fourth-corner method (Dray & Legendre 2008) calculates a weighted Pearson correlation between the trait and the environmental variable by using all species–site combinations as cases, the measure of abundance as a weight and by assigning to each case the trait and the environmental value of the combination. This generates a weighted data set of $n \times m$ cases with 2 variables. As zero abundance implies zero weight, the standard fourth-corner method calculates the correlation between trait and environmental variable for the species–site combinations with positive abundance. The method thus has particular appeal for presence–absence data, for which it was originally developed (Legendre et al. 1997), and for abundance data with many zeroes. As weights must be non-negative, the method cannot be used with a measure of (change in) abundance that can be negative, e.g. when an index value decreases from one year to the next.

Whereas the standard fourth-corner method relates to doubly constrained correspondence analysis and the method of weighted averaging (i.e. methods that have appeal for unimodal relationships in niche studies; Ter Braak & Prentice 1988), the LTE method relates similarly to doubly constrained principal component analysis and linear regression. This relationship to linear methods may appear a step in the wrong direction in terms of model complexity. However, because we apply the method to log ratios or population growth rates, the method is well suited to analyze unimodal data, as shown in section 3.9 of Ter Braak & Šmilauer (2002).

LITERATURE CITED: see article

Table S1. Species used for analysis in the **Y** and **Z** matrices and their traits (1: species holds trait; 0: species does not hold trait). For abbreviations of traits, see Table 1. M: marshland species; F: forest species

Abbreviation	Species	Common name	lownest	fdpl	fdinvert	fdpisci	fdmeat	altr	resid	pmigr	migr	habitat
AARU	*Acrocephalus arundinaceus*	Great reed warbler	0	0	1	0	0	1	0	0	1	M
ACAU	*Aegithalos caudatus*	Long-tailed tit	0	0	1	0	0	1	1	0	0	M, F
ACLY	*Anas clypeata*	Northern shoveler	1	1	0	0	0	0	0	1	0	M
ACRE	*Anas crecca*	Teal	1	1	0	0	0	0	0	1	0	M
AFUL	*Aythya fuligula*	Tufted duck	1	0	1	0	0	0	0	1	0	M
AGEN	*Accipiter gentilis*	Goshawk	0	0	0	0	1	1	1	0	0	F
ANIS	*Accipiter nisus*	Sparrowhawk	0	0	0	0	1	1	0	1	0	F
AOTU	*Asio otus*	Long-eared owl	0	0	0	0	1	1	0	1	0	F
APAL	*Acrocephalus palustris*	Marsh warbler	0	0	1	0	0	1	0	0	1	M
APUR	*Ardea purpurea*	Purple heron	0	0	0	1	0	1	0	0	1	M
ASCH	*Acrocephalus schoenobaenus*	Sedge warbler	0	0	1	0	0	1	0	0	1	M
ASCI	*Acrocephalus scirpaceus*	Reed warbler	0	0	1	0	0	1	0	0	1	M
ASTR	*Anas strepera*	Gadwall	1	1	0	0	0	0	0	1	0	M
BBUT	*Buteo buteo*	Buzzard	0	0	0	0	1	1	0	1	0	F
BSTE	*Botaurus stellaris*	Bittern	1	0	0	1	0	1	1	0	0	M
CAER	*Circus aeruginosus*	Western marsh harrier	1	0	0	0	1	1	0	0	1	M
CBRA	*Certhia brachydactyla*	Short-toed treecreeper	0	0	1	0	0	1	1	0	0	F
CCANN	*Carduelis cannabina*	Linnet	0	1	0	0	0	1	0	1	0	F
CCANO	*Cuculus canorus*	Cuckoo	0	0	1	0	0	1	0	0	1	M, F
CCHL	*Chloris chloris*	Greenfinch	0	1	0	0	0	1	0	1	0	F
CCOR	*Corvus corone*	Carrion crow	0	0	0	0	0	1	1	0	0	F
CMON	*Corvus monedula*	Jackdaw	0	0	1	0	0	1	1	0	0	F
COEN	*Columba oenas*	Stock pigeon	0	1	0	0	0	1	0	1	0	F
COLO	*Cygnus olor*	Mute swan	1	1	0	0	0	0	1	0	0	M
CPAL	*Columba palumbus*	Wood pigeon	0	1	0	0	0	1	0	1	0	M, F

ERUB	*Erithacus rubecula*	Robin	0	0	1	0	0	1	0	1	0	M, F
ESCH	*Emberiza schoeniclus*	Reed bunting	0	0	1	0	0	1	0	1	0	M
FATR	*Fulica atra*	Coot	1	1	0	0	0	0	0	1	0	M
FCOE	*Fringilla coelebs*	Chaffinch	0	0	1	0	0	1	0	1	0	F
FHYP	*Ficedula hypoleuca*	Pied flycatcher	0	0	1	0	0	1	0	0	1	F
FSUB	*Falco subbuteo*	Hobby	0	0	1	0	0	1	0	0	1	F
FTIN	*Falco tinnunculus*	Kestrel	0	0	0	0	1	1	0	1	0	F
GCHL	*Gallinula chloropus*	Moorhen	1	0	1	0	0	0	1	0	0	M
GGLA	*Garrulus glandarius*	Jay	0	1	0	0	0	1	1	0	0	M, F
HICT	*Hippolais icterina*	Icterine warbler	0	0	1	0	0	1	0	0	1	F
LLUS	*Locustella luscinioides*	Savi's warbler	1	0	1	0	0	1	0	0	1	M
LMEG	*Luscinia megarhynchos*	Nightingale	0	0	1	0	0	1	0	0	1	M, F
LNAE	*Locustella naevia*	Grasshopper warbler	1	0	1	0	0	1	0	0	1	M
LSVE	*Luscinia svecica*	Bluethroat	0	0	1	0	0	1	0	0	1	M
MSTR	*Muscicapa striata*	Spotted flycatcher	0	0	1	0	0	1	0	0	1	F
OORI	*Oriolus oriolus*	Golden oriole	0	0	1	0	0	1	0	0	1	F
PACRI	*Parus cristatus*	Crested tit	0	0	1	0	0	1	1	0	0	F
PATE	*Parus ater*	Coal tit	0	0	1	0	0	1	1	0	0	F
PCAE	*Parus caeruleus*	Blue tit	0	0	1	0	0	1	1	0	0	M, F
PCAR	*Phalacrocorax carbo*	Cormorant	0	0	0	1	0	1	0	1	0	M
PCOLC	*Phasianus colchicus*	Pheasant	1	1	0	0	0	0	1	0	0	F
PCOLL	*Phylloscopus collybita*	Chiffchaff	0	0	1	0	0	1	0	0	1	M, F
PLEU	*Platalea leucorodia*	Spoonbill	0	0	0	1	0	1	0	0	1	M
PMAJ	*Parus major*	Great tit	0	0	1	0	0	1	1	0	0	M, F
PMOD	*Prunella modularis*	Dunnock	0	0	1	0	0	1	1	0	0	M, F
PMON	*Parus montanus*	Willow tit	0	0	1	0	0	1	1	0	0	M, F
POCRI	*Podiceps cristatus*	Great crested grebe	1	0	0	1	0	0	0	1	0	M
PPAL	*Parus palustris*	Marsh tit	0	0	1	0	0	1	1	0	0	F
PPHO	*Phoenicurus phoenicurus*	Redstart	0	0	1	0	0	1	0	0	1	F
PPIC	*Pica pica*	Magpie	0	0	0	0	0	1	1	0	0	F
PPYR	*Pyrrhula pyrrhula*	Bullfinch	0	1	0	0	0	1	1	0	0	F
PSIB	*Phylloscopus sibilatrix*	Wood warbler	1	0	1	0	0	1	0	0	1	F
PTRO	*Phylloscopus trochilus*	Willow warbler	1	0	1	0	0	1	0	0	1	M, F
PVIR	*Picus viridis*	Green woodpecker	0	0	1	0	0	1	1	0	0	F

RAQU	*Rallus aquaticus*	Water rail	1	0	1	0	0	0	0	1	0	M
RIGN	*Regulus ignicapillus*	Firecrest	0	0	1	0	0	1	0	1	0	F
RPEN	*Remiz pendulinus*	Penduline tit	0	0	1	0	0	1	0	1	0	M
RREG	*Regulus regulus*	Goldcrest	0	0	1	0	0	1	1	0	0	F
SATR	*Sylvia atricapilla*	Blackcap	0	0	1	0	0	1	0	0	1	M, F
SBOR	*Sylvia borin*	Garden warbler	0	0	1	0	0	1	0	0	1	M, F
SCOM	*Sylvia communis*	Whitethroat	0	0	1	0	0	1	0	0	1	M, F
SEUR	*Sitta europaea*	Nuthatch	0	0	1	0	0	1	1	0	0	F
STUR	*Streptopelia turtur*	Turtle dove	0	1	0	0	0	1	0	0	1	M, F
SVUL	*Sturnus vulgaris*	Starling	0	0	1	0	0	1	0	1	0	F
TMER	*Turdus merula*	Blackbird	0	0	1	0	0	1	1	0	0	M, F
TPHI	*Turdus philomelos*	Song thrush	0	0	1	0	0	1	0	1	0	F
TRUF	*Tachybaptus ruficollis*	Little grebe	1	0	1	0	0	0	0	1	0	M
TTRO	*Troglodytes troglodytes*	Winter wren	0	0	1	0	0	1	1	0	0	M, F
TVIS	*Turdus viscivorus*	Mistle thrush	0	0	1	0	0	1	0	1	0	F

Table S2: Correlations between weather variables. Grey shading indicates a relatively high Pearson score. For abbreviations of weather variables, see Table 2

	NB_IJnsen	NB_IJnsen *t*–1	NB_tempcoldmonth	NB_tempcoldmonth *t*–1	NB_frostdays	NB_frostdays *t*–1	NB_rain	NB_rain *t*–1	NB_snowdays	NB_snowdays *t*–1	B_temp	B_temp *t*–1	B_tempaprmay	B_tempaprmay *t*–1	B_rain	B_rain *t*–1	B_heavyraindays	B_heavyraindays *t*–1	B_drydays	B_drydays *t*–1	B_squall	B_squall *t*–1	B_heatwave	B_heatwave *t*–1
NB_IJnsen	–	0.31	–0.87	–0.29	0.90	0.37	–0.49	–0.35	0.38	0.27	–0.41	–0.29	–0.50	–0.13	–0.04	–0.30	–0.25	0.04	–0.02	0.17	–0.02	–0.04	–0.07	–0.17
NB_IJnsen *t*–1	0.31	–	–0.41	–0.86	0.18	0.90	0.05	–0.50	–0.27	0.40	–0.19	–0.39	0.12	–0.51	0.31	–0.03	0.19	–0.28	0.04	–0.04	–0.26	0.00	–0.28	–0.06
NB_tempcoldmonth	–0.87	–0.41	–	0.48	–0.74	–0.37	0.46	0.39	–0.39	–0.39	0.64	0.50	0.47	0.25	0.03	0.34	0.34	0.12	0.22	0.00	0.15	0.16	0.28	0.26
NB_tempcoldmonth *t*–1	–0.29	–0.86	0.48	–	–0.20	–0.75	–0.13	0.48	0.14	–0.40	0.38	0.55	–0.07	0.46	–0.25	–0.01	–0.18	0.38	0.06	0.28	0.27	0.13	0.35	0.26
NB_frostdays	0.90	0.18	–0.74	–0.20	–	0.22	–0.42	–0.49	0.33	0.07	–0.32	–0.19	–0.46	–0.13	0.02	–0.25	–0.21	–0.05	–0.07	0.23	–0.01	0.08	0.12	–0.17
NB_frostdays *t*–1	0.37	0.90	–0.37	–0.75	0.22	–	0.03	–0.42	–0.16	0.33	–0.14	–0.29	0.00	–0.46	0.29	0.02	0.25	–0.20	0.06	–0.06	–0.29	–0.02	–0.29	0.11
NB_rain	–0.49	0.05	0.46	–0.13	–0.42	0.03	–	0.04	0.04	–0.15	0.45	0.05	0.41	0.36	0.34	0.55	0.23	0.05	–0.03	–0.49	–0.05	0.32	0.31	–0.12
NB_rain *t*–1	–0.35	–0.50	0.39	0.48	–0.49	–0.42	0.04	–	0.22	0.08	0.06	0.38	0.22	0.39	–0.26	0.35	–0.05	0.22	–0.02	–0.06	0.27	–0.03	–0.13	0.33
NB_snowdays	0.38	–0.27	–0.39	0.14	0.33	–0.16	0.04	0.22	–	0.04	–0.30	–0.20	–0.50	0.34	0.12	0.19	–0.33	0.22	–0.49	–0.01	0.03	0.12	–0.17	0.02
NB_snowdays *t*–1	0.27	0.40	–0.39	–0.40	0.07	0.33	–0.15	0.08	0.04	–	0.00	–0.36	0.07	–0.51	–0.17	0.02	–0.20	–0.26	–0.01	–0.38	0.09	–0.04	–0.35	–0.25
B_temp	–0.41	–0.19	0.64	0.38	–0.32	–0.14	0.45	0.06	–0.30	0.00	–	0.31	0.31	0.07	0.03	0.30	0.26	0.10	0.37	–0.22	0.19	0.34	0.58	–0.01
B_temp *t*–1	–0.29	–0.39	0.50	0.55	–0.19	–0.29	0.05	0.38	–0.20	–0.36	0.31	–	0.42	0.35	–0.08	0.14	0.05	0.19	0.27	0.25	0.12	0.22	0.27	0.59
B_tempaprmay	–0.50	0.12	0.47	–0.07	–0.46	0.00	0.41	0.22	–0.50	0.07	0.31	0.42	–	–0.12	0.15	0.43	0.19	0.05	0.05	–0.26	0.09	–0.03	0.08	0.04
B_tempaprmay *t*–1	–0.13	–0.51	0.25	0.46	–0.13	–0.46	0.36	0.39	0.34	–0.51	0.07	0.35	–0.12	–	0.02	0.21	–0.12	0.15	–0.04	–0.02	0.34	0.12	0.40	0.12
B_rain	–0.04	0.31	0.03	–0.25	0.02	0.29	0.34	–0.26	0.12	–0.17	0.03	–0.08	0.15	0.02	–	–0.02	0.17	–0.03	–0.42	0.13	0.15	0.11	–0.03	0.08
B_rain *t*–1	–0.30	–0.03	0.34	–0.01	–0.25	0.02	0.55	0.35	0.19	0.02	0.30	0.14	0.43	0.21	–0.02	–	0.21	0.19	–0.27	–0.41	0.09	0.12	–0.01	–0.04
B_heavyraindays	–0.25	0.19	0.34	–0.18	–0.21	0.25	0.23	–0.05	–0.33	–0.20	0.26	0.05	0.19	–0.12	0.17	0.21	–	–0.12	0.28	–0.07	0.13	0.05	–0.06	0.21
B_heavyraindays *t*–1	0.04	–0.28	0.12	0.38	–0.05	–0.20	0.05	0.22	0.22	–0.26	0.10	0.19	0.05	0.15	–0.03	0.19	–0.12	–	–0.22	0.23	–0.22	0.19	–0.05	–0.03
B_drydays	–0.02	0.04	0.22	0.06	–0.07	0.06	–0.03	–0.02	–0.49	–0.01	0.37	0.27	0.05	–0.04	–0.42	–0.27	0.28	–0.22	–	–0.06	–0.08	0.17	0.34	0.09
B_drydays *t*–1	0.17	–0.04	0.00	0.28	0.23	–0.06	–0.49	–0.06	–0.01	–0.38	–0.22	0.25	–0.26	–0.02	0.13	–0.41	–0.07	0.23	–0.06	–	–0.05	–0.01	0.01	0.40
B_squall	–0.02	–0.26	0.15	0.27	–0.01	–0.29	–0.05	0.27	0.03	0.09	0.19	0.12	0.09	0.34	0.15	0.09	0.13	–0.22	–0.08	–0.05	–	–0.08	0.16	0.02
B_squall *t*–1	–0.04	0.00	0.16	0.13	0.08	–0.02	0.32	–0.03	0.12	–0.04	0.34	0.22	–0.03	0.12	0.11	0.12	0.05	0.19	0.17	–0.01	–0.08	–	0.09	0.13
B_heatwave	–0.07	–0.28	0.28	0.35	0.12	–0.29	0.31	–0.13	–0.17	–0.35	0.58	0.27	0.08	0.40	–0.03	–0.01	–0.06	–0.05	0.34	0.01	0.16	0.09	–	–0.05
B_heatwave *t*–1	–0.17	–0.06	0.26	0.26	–0.17	0.11	–0.12	0.33	0.02	–0.25	–0.01	0.59	0.04	0.12	0.08	–0.04	0.21	–0.03	0.09	0.40	0.02	0.13	–0.05	–

Table S3. Correlations between traits. Grey shading indicates a relatively high Pearson score. For abbreviations of traits, see Table 1.

	lownest	fdpl	fdinvert	fdpisci	fdmeat	altr	resid	pmigr	migr
Marshland species									
lownest	–	0.28	–0.32	0.04	0.21	–0.75	–0.13	0.37	–0.23
fdpl	0.28	–	–0.69	–0.17	–0.07	–0.44	–0.03	0.34	–0.28
fdinvert	–0.32	–0.69	–	–0.52	–0.22	0.32	0.10	–0.30	0.19
fdpisci	0.04	–0.17	–0.52	–	–0.06	0.03	–0.06	0.08	–0.01
fdmeat	0.21	–0.07	–0.22	–0.06	–	0.08	–0.10	–0.10	0.18
altr	–0.75	–0.44	0.32	0.03	0.08	–	0.10	–0.60	0.47
resid	–0.13	–0.03	0.10	–0.06	–0.10	0.10	–	–0.41	–0.53
pmigr	0.37	0.34	–0.30	0.08	–0.10	–0.60	–0.41	–	–0.56
migr	–0.23	–0.28	0.19	–0.01	0.18	0.47	–0.53	–0.56	–

	lownest	fdpl	fdinvert	fdmeat	altr	resid	pmigr	migr
Forest species								
lownest	–	0.12	–0.03	–0.08	–0.57	–0.06	–0.15	0.21
fdpl	0.12	–	–0.67	–0.14	–0.33	–0.07	0.23	–0.15
fdinvert	–0.03	–0.67	–	–0.51	0.22	0.07	–0.38	0.30
fdmeat	–0.08	–0.14	–0.51	–	0.04	–0.16	0.39	–0.20
altr	–0.57	–0.33	0.22	0.04	–	–0.15	0.08	0.09
resid	–0.06	–0.07	0.07	–0.16	–0.15	–	–0.55	–0.57
pmigr	–0.15	0.23	–0.38	0.39	0.08	–0.55	–	–0.38
migr	0.21	–0.15	0.30	–0.20	0.09	–0.57	–0.38	–

Table S4. Species-specific regression coefficients (b_k) resulting from the LTE analyses for marshland species. For abbreviations of species names, see Table S1; for abbreviations of weather variables, see Table 2

Abbreviation	NB_IInsen	NB_IInsen *t*–1	NB_tempcoldmonth	NB_tempcoldmonth *t*–1	NB_frostdays	NB_frostdays *t*–1	NB_rain	NB_rain *t*–1	NB_snowdays	NB_snowdays *t*–1	B_temp	B_temp *t*–1	B_tempaprmay	B_tempaprmay *t*–1	B_rain	B_rain *t*–1	B_heavyraindays	B_heavyraindays *t*–1	B_drydays	B_drydays *t*–1	B_squall	B_squall *t*–1	B_heatwave	B_heatwave *t*–1
AARU	0.08	0.06	–0.13	–0.13	0.07	0.05	0.02	–0.08	0.05	0.02	–0.09	0.00	0.00	0.01	0.11	0.10	0.04	–0.08	–0.12	–0.14	0.08	–0.01	–0.03	0.00
ACAU	–0.05	–0.09	0.14	0.08	–0.04	–0.05	–0.10	0.21	–0.06	–0.06	0.00	0.14	0.01	0.03	–0.02	–0.17	0.21	–0.02	0.26	0.08	0.17	0.07	–0.02	0.07
ACLY	0.00	–0.01	–0.01	0.01	0.00	–0.02	–0.10	0.04	0.05	–0.08	–0.09	–0.06	–0.04	0.02	0.17	0.02	–0.06	0.12	–0.37	0.42	–0.03	–0.04	–0.02	0.00
ACRE	–0.01	–0.08	0.05	0.16	–0.05	–0.06	–0.09	0.29	0.11	–0.09	–0.08	0.00	–0.02	0.05	–0.12	0.39	–0.26	0.71	–0.39	0.25	–0.12	0.07	–0.09	–0.04
AFUL	0.01	0.00	–0.03	0.01	0.00	0.01	–0.01	–0.01	0.03	0.01	0.00	–0.05	–0.02	0.01	0.13	–0.03	–0.10	–0.03	–0.18	0.01	0.05	–0.07	0.00	–0.01
APAL	0.07	0.01	–0.09	–0.01	0.06	–0.01	–0.11	0.06	0.05	0.05	–0.06	–0.01	0.00	–0.01	–0.06	–0.02	–0.11	0.07	–0.09	0.17	0.07	0.06	–0.01	0.00
APUR	0.02	0.03	–0.01	–0.01	0.02	0.04	0.00	–0.01	0.01	0.04	0.05	0.02	0.01	–0.02	0.12	0.05	0.22	–0.03	–0.03	0.06	0.09	–0.02	0.00	0.04
ASCH	0.02	0.06	–0.04	–0.09	0.00	0.07	0.07	0.06	0.00	0.06	–0.03	0.03	0.01	–0.01	–0.02	0.04	0.19	–0.08	0.15	–0.06	0.03	0.06	–0.03	0.04
ASCI	0.05	0.01	–0.08	–0.01	0.04	0.01	–0.05	–0.05	0.04	0.06	0.03	–0.03	–0.02	–0.02	–0.03	0.00	–0.01	0.00	–0.04	–0.06	0.05	0.03	0.01	0.00
ASTR	–0.09	–0.12	0.16	0.19	–0.09	–0.07	0.03	0.24	–0.02	–0.10	0.06	0.09	–0.02	0.06	–0.06	–0.11	–0.02	0.15	0.13	0.08	0.07	–0.06	0.04	0.04
BSTE	–0.09	0.04	0.11	–0.06	–0.09	0.04	0.35	–0.02	–0.01	–0.01	0.10	–0.05	0.02	0.01	0.21	0.32	0.23	0.06	–0.12	–0.33	–0.06	0.08	–0.02	–0.02
CAER	0.02	0.01	–0.03	–0.03	0.02	0.00	0.05	–0.05	0.01	0.01	–0.03	–0.02	0.00	0.01	–0.09	0.09	–0.01	–0.11	–0.06	–0.10	0.06	–0.01	0.01	0.00
CCANO	0.05	0.00	–0.06	0.04	0.03	0.01	–0.15	0.04	0.04	0.02	–0.02	0.01	–0.01	–0.01	–0.03	–0.07	–0.08	0.13	0.00	0.16	0.02	0.01	–0.01	0.02
COLO	–0.08	–0.09	0.17	0.09	–0.08	–0.03	0.18	0.14	–0.03	–0.14	0.04	0.10	–0.02	0.07	0.08	–0.16	–0.05	0.10	0.32	–0.08	–0.06	0.09	0.04	0.04
CPAL	0.03	–0.01	–0.02	0.03	0.02	–0.01	–0.06	0.06	0.01	0.03	0.02	0.01	0.00	0.00	–0.19	0.03	0.02	–0.05	0.12	–0.01	0.02	–0.06	0.02	0.00
DMAJ	0.04	–0.04	–0.06	0.08	0.06	–0.05	–0.17	0.03	0.06	0.01	–0.07	0.03	0.01	–0.01	–0.07	0.06	–0.08	–0.02	–0.27	0.24	0.06	0.00	–0.02	0.01
ERUB	–0.09	–0.02	0.07	0.04	–0.07	–0.03	–0.04	–0.08	–0.09	0.03	0.10	0.05	0.00	–0.02	–0.35	0.15	0.10	–0.08	0.08	–0.24	–0.04	–0.01	–0.01	0.00
ESCH	0.03	–0.01	–0.01	0.02	0.03	0.00	–0.01	–0.01	0.04	–0.01	0.00	0.02	–0.01	0.01	0.02	0.10	–0.05	0.05	–0.10	0.07	0.03	0.02	0.01	0.01
FATR	0.04	–0.02	–0.04	0.03	0.05	–0.01	–0.01	–0.07	0.05	0.00	0.03	–0.03	–0.02	0.00	0.01	–0.04	0.01	0.01	–0.02	–0.02	–0.01	–0.02	0.02	–0.01
GCHL	–0.13	–0.04	0.18	0.05	–0.10	–0.04	0.22	0.16	–0.06	–0.05	0.07	0.09	0.04	0.02	0.13	0.11	0.22	0.04	–0.03	–0.01	0.08	–0.01	0.01	0.03
GGLA	0.08	0.00	–0.07	–0.05	0.03	0.05	–0.17	0.13	0.03	–0.03	–0.14	0.03	–0.02	0.02	0.21	–0.33	–0.03	0.00	0.19	0.03	–0.01	–0.12	–0.06	0.03

LLUS	–0.03	0.03	0.03	–0.05	–0.02	0.01	0.20	0.01	–0.02	0.00	0.03	0.01	0.03	0.00	0.05	0.16	0.10	0.02	–0.05	–0.10	0.00	0.03	0.02	–0.01
LMEG	–0.07	–0.07	0.02	0.18	–0.06	–0.08	–0.34	0.06	–0.01	0.00	–0.03	0.04	–0.06	0.02	–0.76	0.21	–0.24	–0.05	–0.15	0.25	0.01	–0.03	–0.04	0.02
LNAE	0.03	0.01	–0.01	–0.01	0.02	0.01	–0.16	0.08	–0.04	–0.01	–0.07	0.07	0.02	–0.01	–0.11	–0.14	–0.09	–0.10	0.23	0.31	–0.01	–0.13	0.02	0.05
LSVE	0.09	0.02	–0.13	–0.04	0.08	0.03	–0.07	–0.09	0.05	0.05	–0.05	–0.03	–0.01	–0.01	–0.10	–0.05	–0.08	–0.11	0.07	–0.08	–0.07	–0.01	0.00	–0.01
PCAE	0.03	0.00	–0.01	–0.02	0.01	–0.01	–0.15	0.18	–0.02	0.07	–0.01	0.01	0.03	–0.02	–0.05	0.02	0.08	0.03	–0.01	0.07	0.17	–0.12	–0.02	0.00
PCAR	0.02	0.01	–0.06	–0.02	0.02	0.00	–0.16	0.01	0.01	0.05	–0.05	0.00	0.00	–0.04	–0.28	–0.05	0.05	0.00	0.14	0.01	–0.16	0.02	–0.04	0.02
PCOLL	0.05	0.07	–0.06	–0.06	0.05	0.04	–0.13	–0.21	–0.07	0.07	0.05	–0.01	0.00	–0.05	–0.06	–0.32	0.06	–0.19	0.51	0.00	–0.10	0.14	0.01	–0.02
PLEU	–0.07	0.13	0.00	–0.12	–0.02	0.07	0.76	–0.63	0.01	0.00	0.17	–0.16	–0.01	0.01	0.45	–0.11	–0.13	–0.35	–0.10	–0.48	–0.30	0.51	0.10	–0.06
PMAJ	0.08	0.01	–0.09	–0.02	0.07	0.00	–0.27	0.03	0.01	0.04	–0.05	0.03	0.00	–0.03	–0.06	–0.10	–0.05	0.04	0.05	0.12	0.03	–0.05	–0.01	0.02
PMOD	–0.04	0.01	0.05	–0.01	–0.02	–0.01	–0.05	0.01	–0.09	0.03	0.05	0.08	0.05	–0.03	–0.10	0.04	0.02	–0.04	0.16	–0.04	0.04	–0.04	0.01	0.01
PMON	0.00	0.00	–0.06	–0.01	–0.01	0.01	–0.17	0.05	0.00	0.01	–0.07	0.03	–0.01	–0.01	–0.15	0.01	0.17	–0.08	–0.07	–0.11	0.00	–0.01	–0.05	0.05
POCRI	0.01	–0.04	–0.01	0.03	0.00	–0.03	0.02	0.15	0.06	–0.02	–0.07	–0.05	–0.01	0.03	0.09	–0.01	–0.10	–0.08	–0.26	–0.02	0.11	–0.13	0.01	0.01
PTRO	0.06	0.01	–0.08	0.00	0.05	0.01	–0.07	–0.05	0.03	–0.01	–0.04	–0.01	–0.01	0.00	–0.03	–0.03	–0.15	0.00	–0.01	0.10	–0.05	–0.04	0.02	–0.01
RAQU	–0.05	0.03	0.05	–0.05	–0.03	0.04	0.32	–0.12	–0.01	–0.05	0.06	–0.05	0.02	0.02	0.22	0.35	0.12	–0.01	–0.20	–0.34	–0.06	–0.06	0.02	–0.06
RPEN	0.17	–0.05	–0.30	–0.08	0.12	–0.05	–0.56	–0.26	0.09	–0.05	–0.31	–0.32	–0.14	–0.03	0.10	–1.00	–0.48	0.06	–0.07	0.29	–0.26	–0.26	–0.06	–0.13
SATR	–0.01	0.02	0.04	–0.02	0.00	0.00	0.03	–0.04	–0.01	–0.02	–0.01	0.01	0.03	–0.02	0.12	–0.05	–0.06	0.03	0.06	0.11	–0.07	0.03	0.00	0.01
SBOR	0.10	0.01	–0.11	0.00	0.09	0.01	–0.15	–0.04	0.07	0.01	–0.06	–0.01	–0.03	0.00	0.09	–0.18	–0.12	–0.02	–0.04	0.23	0.04	0.01	0.01	0.02
SCOM	0.08	0.04	–0.16	–0.03	0.06	0.03	–0.27	–0.06	0.01	0.09	–0.06	–0.04	–0.01	–0.03	–0.03	–0.21	–0.23	–0.08	–0.06	0.08	0.05	–0.10	–0.02	–0.02
STUR	–0.03	0.02	0.03	0.05	–0.01	–0.01	–0.23	–0.11	–0.09	0.05	0.07	–0.05	0.00	–0.04	–0.03	–0.24	–0.01	–0.37	0.06	0.20	0.15	–0.14	0.03	0.00
TMER	–0.01	0.03	0.03	–0.06	0.01	0.01	0.07	–0.02	–0.06	0.02	0.03	0.03	0.04	–0.01	–0.13	0.26	0.10	–0.03	0.06	–0.13	0.04	0.00	0.02	–0.02
TRUF	–0.23	–0.04	0.43	0.08	–0.19	–0.03	0.93	0.20	–0.09	–0.10	0.34	0.05	0.11	0.05	0.29	0.59	0.35	0.49	0.20	–0.38	0.04	0.24	0.12	–0.06
TTRO	–0.18	0.08	0.21	–0.16	–0.14	0.04	0.62	–0.21	–0.13	0.00	0.20	–0.01	0.09	–0.03	0.29	0.34	0.30	–0.09	0.07	–0.64	–0.14	0.10	0.03	–0.05

Table S5. Species-specific regression coefficients (b_k) resulting from the LTE analyses for forest species. For abbreviations of species names, see Table S1; for abbreviations of weather variables, see Table 2

Abbreviation	NB_IJnsen	NB_IJnsen t–1	NB_tempcoldmonth	NB_tempcoldmonth t–1	NB_frostdays	NB_frostdays t–1	NB_rain	NB_rain t–1	NB_snowdays	NB_snowdays t–1	B_temp	B_temp t–1	B_tempaprmay	B_tempaprmay t–1	B_rain	B_rain t–1	B_heavyraindays	B_heavyraindays t–1	B_drydays	B_drydays t–1	B_squall	B_squall t–1	B_heatwave	B_heatwave t–1
ACAU	0.01	0.00	–0.01	0.03	–0.01	0.00	–0.05	0.07	0.00	0.05	0.03	–0.03	0.00	0.00	–0.04	–0.05	0.01	–0.10	0.07	–0.11	0.10	–0.04	0.01	–0.02
AGEN	0.04	–0.06	–0.13	0.07	0.04	–0.06	–0.19	0.06	0.09	0.01	–0.11	–0.06	–0.04	–0.01	–0.16	–0.12	–0.16	0.05	–0.26	0.12	–0.10	–0.10	0.04	–0.01
ANIS	–0.07	–0.07	0.10	0.02	–0.06	–0.06	–0.02	0.09	–0.06	–0.04	0.01	–0.04	0.00	–0.01	–0.17	–0.17	–0.07	–0.04	0.28	–0.14	–0.10	–0.08	–0.07	–0.03
AOTU	–0.10	–0.08	0.15	0.09	–0.09	–0.07	–0.09	0.37	–0.01	–0.01	0.02	0.10	0.02	0.01	–0.58	0.58	–0.02	0.29	–0.06	–0.02	0.02	–0.07	–0.10	0.03
BBUT	0.02	–0.04	–0.05	0.03	0.02	–0.02	–0.05	0.09	0.07	0.01	–0.04	–0.06	–0.02	–0.01	–0.02	–0.02	–0.07	0.05	–0.13	–0.03	–0.01	–0.04	0.02	–0.01
CBRA	0.01	–0.03	0.01	0.04	0.01	–0.02	0.00	0.00	0.00	0.01	0.04	–0.01	–0.01	0.01	0.00	–0.05	–0.11	0.00	–0.01	–0.05	0.07	–0.01	0.01	–0.02
CCANN	–0.01	0.01	0.01	0.02	0.01	0.00	0.08	–0.08	–0.04	–0.02	0.04	0.09	0.02	0.02	0.00	–0.04	–0.02	–0.11	0.09	0.11	0.00	0.03	–0.01	0.01
CCANO	0.02	0.01	–0.02	0.00	0.04	0.00	0.07	–0.11	0.03	0.02	0.05	–0.02	0.00	–0.01	0.21	–0.02	–0.07	0.06	–0.10	0.07	0.04	0.14	0.02	–0.02
CCHL	–0.04	0.01	0.07	–0.01	–0.02	0.01	0.18	0.00	–0.02	–0.02	0.05	0.05	0.03	0.01	0.02	0.12	0.12	–0.14	0.18	–0.07	–0.07	0.03	–0.04	0.01
CCOR	0.04	–0.02	–0.07	0.05	0.01	–0.02	–0.04	–0.02	0.05	0.00	–0.03	–0.05	–0.04	0.01	0.06	–0.26	–0.14	0.11	–0.09	0.13	–0.01	0.00	0.04	–0.01
CMON	0.00	0.01	–0.02	–0.03	0.02	0.01	0.13	–0.10	0.04	–0.05	–0.02	–0.02	–0.02	0.01	0.19	–0.01	0.06	0.03	–0.10	0.04	–0.10	0.07	0.00	0.00
COEN	0.02	0.02	–0.02	0.00	0.01	0.03	–0.10	–0.03	–0.03	–0.01	–0.01	0.01	–0.01	–0.01	–0.06	–0.12	0.10	–0.08	0.22	0.07	–0.05	–0.03	0.02	0.02
CPAL	0.01	–0.02	0.00	0.04	0.00	–0.01	–0.04	0.05	0.03	–0.01	–0.01	0.01	–0.02	0.01	–0.03	0.00	0.00	0.04	–0.02	0.09	0.02	–0.01	0.01	0.02
DMAJ	0.02	0.01	–0.02	–0.02	0.02	0.01	0.06	–0.04	0.02	0.00	0.00	0.00	0.00	0.01	0.04	0.02	–0.03	0.04	–0.01	–0.04	0.00	0.06	0.02	0.00
DMIN	0.00	–0.03	0.03	0.04	0.03	–0.04	–0.08	0.02	–0.01	–0.05	–0.02	0.06	0.01	0.00	0.08	–0.07	–0.01	0.05	0.04	0.28	0.02	0.14	0.00	0.02
ECIT	0.03	0.05	–0.07	–0.10	0.05	0.02	–0.08	–0.22	–0.06	0.08	0.01	–0.06	0.02	–0.06	0.09	–0.10	–0.03	–0.15	–0.08	–0.08	0.05	–0.08	0.03	–0.07
ERUB	–0.09	0.00	0.10	–0.02	–0.07	–0.01	0.23	0.02	–0.01	–0.01	0.05	0.02	0.03	0.00	–0.03	0.30	0.14	0.06	–0.13	–0.18	–0.01	0.05	–0.09	0.00
FCOE	0.01	–0.03	–0.01	0.03	0.01	–0.02	–0.05	0.06	0.02	0.00	0.00	0.02	–0.02	0.01	–0.07	–0.03	0.03	0.01	0.00	–0.02	0.05	–0.01	0.01	0.02
FHYP	0.03	0.01	0.02	0.05	0.01	0.03	–0.02	–0.07	–0.03	–0.02	0.11	0.01	–0.03	0.01	0.12	–0.26	0.12	0.07	0.35	0.12	0.02	0.14	0.03	0.02
FSUB	0.14	0.04	–0.18	–0.20	0.15	0.06	–0.20	–0.31	0.06	0.03	–0.18	–0.23	–0.04	–0.06	0.25	–0.23	0.26	–0.41	–0.24	–0.17	0.07	–0.17	0.14	–0.04
FTIN	–0.09	–0.17	0.12	0.17	–0.06	–0.14	–0.25	0.45	–0.02	–0.08	–0.09	0.08	–0.01	0.06	–0.37	0.13	–0.25	–0.17	–0.19	0.03	0.20	–0.21	–0.09	0.03

GGLA	0.06	–0.03	–0.06	0.05	0.04	–0.01	–0.13	0.00	0.04	–0.01	–0.02	0.01	–0.04	0.02	–0.12	–0.08	–0.17	0.10	0.02	0.02	0.00	0.00	0.06	0.00
HICT	–0.07	0.04	0.10	–0.01	–0.07	0.04	0.06	0.08	–0.04	–0.03	0.02	0.15	0.04	0.00	0.31	–0.08	0.26	–0.27	0.14	0.22	0.01	–0.08	–0.07	0.11
LMEG	–0.01	0.07	–0.05	–0.09	0.00	0.06	0.16	–0.10	0.02	–0.03	–0.05	0.00	0.00	0.03	0.12	0.18	–0.09	–0.16	–0.20	–0.15	–0.06	0.04	–0.01	0.01
MSTR	–0.02	0.05	0.04	–0.01	–0.03	0.05	0.14	–0.13	–0.02	–0.01	0.08	–0.02	0.00	0.01	0.14	0.00	0.08	–0.06	0.10	–0.04	0.00	0.08	–0.02	0.00
OORI	0.05	0.05	–0.08	–0.09	0.05	0.05	0.01	–0.17	–0.01	0.02	–0.04	0.06	0.01	–0.01	0.35	–0.18	–0.10	0.02	–0.04	–0.05	0.03	0.10	0.05	0.00
PACRI	0.09	–0.02	–0.11	0.04	0.06	–0.02	–0.23	0.02	0.07	0.02	–0.08	–0.06	–0.03	–0.01	–0.06	–0.13	–0.10	0.17	–0.15	0.25	0.01	–0.08	0.09	–0.02
PATE	0.01	–0.05	0.00	0.11	0.00	–0.06	–0.14	0.04	0.00	0.00	0.00	0.05	0.00	0.00	–0.14	–0.16	–0.15	0.24	0.02	0.21	0.01	0.03	0.01	0.00
PCAE	0.05	–0.03	–0.03	0.03	0.04	–0.01	–0.15	0.08	0.04	–0.02	–0.07	0.04	–0.02	0.02	–0.09	0.02	–0.03	0.01	–0.02	0.11	0.04	–0.06	0.05	0.03
PCOLC	0.05	–0.01	–0.08	0.02	0.05	–0.01	–0.14	–0.03	0.05	0.00	–0.06	0.01	–0.03	0.01	–0.04	–0.01	–0.13	–0.05	–0.19	0.13	0.04	–0.08	0.05	0.01
PCOLL	0.00	0.09	0.00	–0.10	0.00	0.05	0.03	–0.21	–0.09	0.07	0.07	–0.07	0.00	–0.05	0.06	–0.23	0.17	–0.23	0.40	–0.05	–0.08	0.12	0.00	–0.05
PMAJ	0.05	–0.03	–0.04	0.02	0.06	–0.01	–0.17	0.03	0.02	0.00	–0.04	0.06	–0.01	0.01	–0.15	0.03	–0.01	–0.02	0.02	0.08	0.06	–0.01	0.05	0.03
PMOD	–0.02	0.00	0.03	0.01	–0.02	0.01	0.06	0.01	0.00	0.00	0.05	0.01	–0.01	0.01	–0.03	0.09	0.07	–0.07	0.04	–0.17	0.02	0.05	–0.02	0.01
PMON	0.06	–0.02	–0.08	0.04	0.06	–0.01	–0.19	–0.05	0.04	–0.01	–0.06	–0.03	–0.03	0.01	–0.11	–0.07	–0.22	–0.02	–0.10	0.13	0.02	–0.08	0.06	–0.01
PPAL	0.04	–0.06	–0.02	0.08	0.04	–0.04	–0.16	0.05	0.03	–0.03	–0.04	0.06	–0.01	0.00	–0.12	–0.11	–0.08	0.00	0.08	0.13	–0.01	0.00	0.04	0.03
PPHO	0.03	0.01	–0.06	–0.02	0.03	0.02	–0.10	–0.06	–0.02	–0.01	–0.05	0.03	0.00	0.01	0.00	–0.04	–0.10	–0.04	–0.07	–0.01	0.03	–0.02	0.03	0.00
PPIC	0.01	0.01	–0.03	–0.01	–0.02	0.01	–0.06	0.02	0.01	–0.01	–0.07	–0.02	–0.01	0.00	–0.07	–0.09	–0.10	0.07	–0.07	0.12	–0.09	–0.18	0.01	0.03
PPYR	0.03	–0.05	–0.03	0.10	0.02	–0.05	–0.17	0.13	0.04	–0.03	–0.05	–0.02	–0.02	0.02	0.00	–0.13	–0.23	0.08	–0.09	0.31	0.01	–0.05	0.03	–0.01
PSIB	0.00	0.08	–0.09	–0.14	–0.01	0.00	0.11	0.06	0.06	0.12	–0.10	–0.08	0.07	–0.07	–0.02	0.30	–0.21	0.28	–0.26	–0.09	–0.26	0.08	0.00	–0.08
PTRO	0.04	0.03	–0.05	–0.01	0.02	0.03	–0.02	–0.03	0.01	0.00	–0.01	–0.02	–0.02	0.01	–0.02	–0.02	–0.04	0.06	0.04	0.11	–0.03	–0.05	0.04	0.00
PVIR	–0.04	–0.03	0.02	0.04	–0.03	–0.03	0.09	0.01	0.02	0.00	0.03	0.00	–0.01	0.02	0.03	–0.04	–0.11	–0.04	–0.13	–0.11	0.04	–0.02	–0.04	0.01
RIGN	–0.18	0.10	0.28	–0.10	–0.15	0.05	0.49	0.04	–0.23	0.04	0.23	0.07	0.12	–0.05	–0.06	0.27	0.52	0.02	0.59	–0.19	0.02	0.15	–0.18	–0.01
RREG	–0.13	0.01	0.23	0.03	–0.16	–0.01	0.30	0.37	–0.12	–0.01	0.15	0.04	0.09	–0.01	–0.02	0.26	0.31	0.52	0.36	–0.13	–0.06	0.04	–0.13	–0.03
SATR	–0.02	0.05	0.02	–0.05	–0.02	0.03	0.12	–0.11	–0.02	0.03	0.06	–0.06	0.00	–0.01	0.15	–0.01	0.08	–0.10	0.00	–0.06	0.04	0.00	–0.02	–0.02
SBOR	0.06	0.02	–0.05	–0.03	0.05	0.03	–0.08	–0.05	0.03	0.01	–0.01	–0.01	–0.03	0.00	0.03	–0.06	0.01	–0.08	0.07	0.13	0.03	–0.01	0.06	0.01
SCOM	0.07	0.06	–0.13	–0.04	0.03	0.05	–0.22	0.08	0.01	0.08	–0.09	0.02	0.00	–0.01	–0.20	0.02	–0.06	0.03	–0.02	0.06	0.04	–0.12	0.07	0.02
SEUR	0.06	–0.07	–0.06	0.05	0.07	–0.04	–0.05	–0.01	0.06	–0.02	–0.04	0.05	–0.02	0.03	–0.13	0.05	–0.19	0.01	–0.12	–0.15	0.04	0.04	0.06	0.01
STUR	0.00	0.06	–0.02	–0.07	0.00	0.05	0.03	–0.19	0.02	0.01	0.05	–0.08	–0.02	–0.03	0.20	0.00	0.03	0.04	–0.04	–0.06	–0.10	0.14	0.00	0.00
SVUL	0.03	0.03	–0.06	–0.01	0.03	0.03	–0.03	–0.06	0.05	0.00	–0.02	–0.01	–0.02	0.00	0.04	0.10	–0.05	0.02	–0.17	0.08	0.01	0.01	0.03	0.03
TMER	–0.03	0.00	0.03	–0.01	–0.02	0.00	0.07	0.03	0.00	–0.01	0.01	–0.01	0.00	0.01	0.00	0.10	0.09	–0.02	–0.06	–0.10	0.01	0.02	–0.03	0.00
TPHI	–0.09	–0.02	0.15	0.02	–0.07	–0.01	0.20	0.11	–0.05	–0.05	0.06	0.05	0.03	0.02	0.09	0.21	0.20	0.02	–0.03	–0.11	0.08	0.03	–0.09	0.01
TTRO	–0.18	0.05	0.20	–0.10	–0.14	0.03	0.55	–0.11	–0.09	–0.03	0.15	–0.02	0.06	0.00	0.23	0.32	0.40	–0.13	–0.05	–0.51	–0.07	0.05	–0.18	–0.03
TVIS	–0.02	0.01	0.03	–0.04	–0.01	0.01	0.14	–0.14	–0.02	0.01	0.06	–0.03	0.00	–0.01	0.07	–0.09	0.08	–0.09	0.15	–0.20	–0.03	0.04	–0.02	–0.02

Fig. S1. Occurrence of weather variables in 1984–2005. For abbreviations of weather
see Table 2. (–) dimensionless

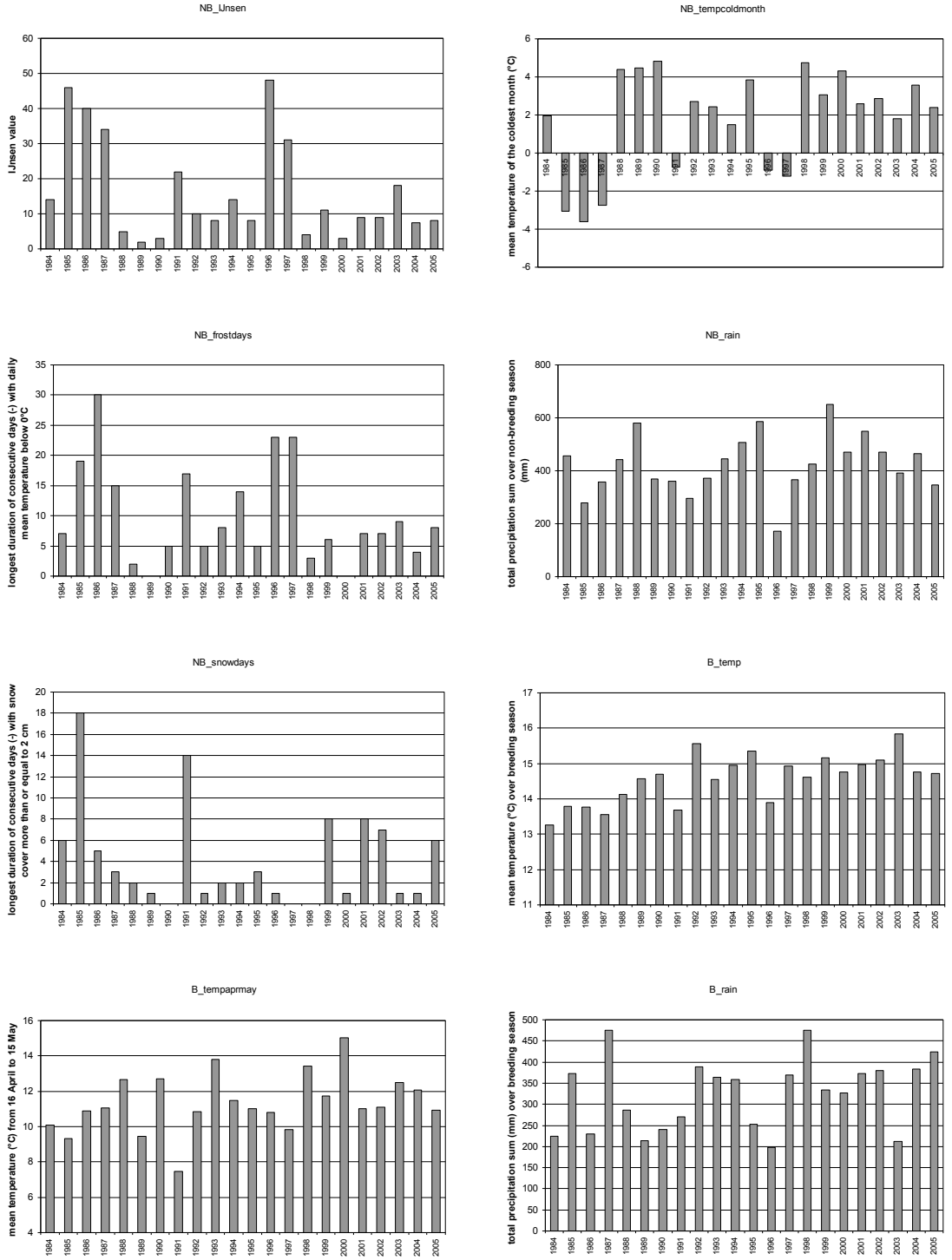
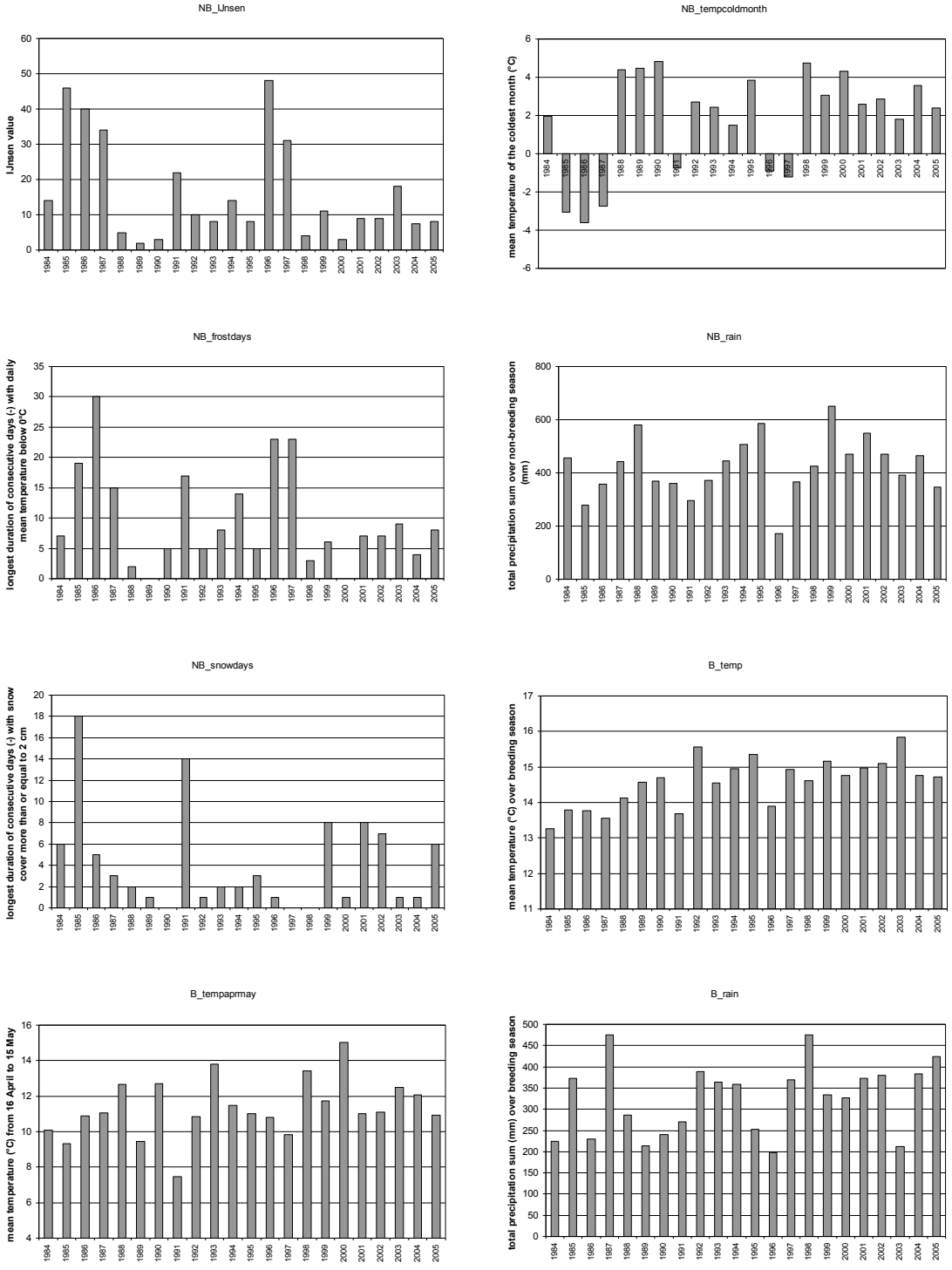
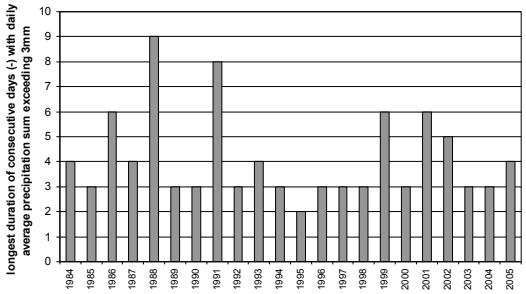


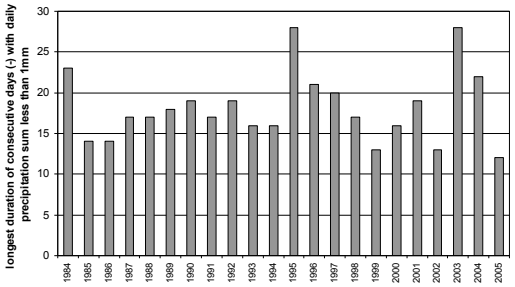
Fig. S1. Occurrence of weather variables in 1984–2005. For abbreviations of weather
see Table 2. (–) dimensionless



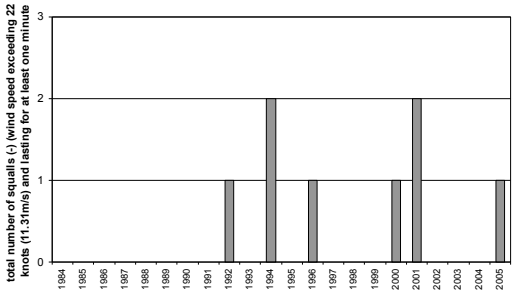
B_heavyraindays



B_drydays



B_squall



B_heatwave