

Ecography

ECOG-00227

Barnagaud, J.-Y., Barbaro, L., Hampe, A., Jiguet, F. and Archaux, F. 2013. Species' thermal preferences affect forest bird communities along landscape and local scale habitat gradients. – *Ecography* 36: xxx–xxx.

Supplementary material

<i>Sitta europaea</i>	13,02	RES	401	1062	392	71,2	73,1	67,7	42,3	69,1	29,5
<i>Streptopelia decaocto</i>	14,66	RES	286	506							
<i>Streptopelia turtur</i>	15,55	MIGR	366	811	32	1,3		5,2	8,5	3,6	11,4
<i>Sturnus vulgaris</i>	12,36	RES	361	663	132	28,1	29,9	31,3	11,1	15,5	2,3
<i>Sylvia atricapilla</i>	13,19	RES	708	2837	390	63,4	46,3	59,4	56,1	59,1	77,3
<i>Sylvia borin</i>	12,02	MIGR	222	389	32	0,7	4,5	2,1	12,7	0,9	2,3
<i>Sylvia cantillans</i>	17,37	MIGR	18	31							
<i>Sylvia communis</i>	13,39	MIGR	235	363	8			1,0	3,7		
<i>Sylvia curruca</i>	12,31	MIGR	19	20							
<i>Sylvia hortensis</i>	17,5	MIGR	9	14							
<i>Sylvia undata</i>	16,73	RES	10	17							
<i>Troglodytes troglodytes</i>	12,91	RES	615	2139	534	79,1	88,1	90,6	73,0	84,5	81,8
<i>Turdus iliacus</i>	9,35	RES	1	1							
<i>Turdus merula</i>	13,71	RES	704	2799	209	34,0	20,9	36,5	37,0	23,6	27,3
<i>Turdus philomelos</i>	11,6	RES	549	1789	126	18,3	7,5	28,1	18,5	15,5	31,8
<i>Turdus pilaris</i>	10,52	RES	10	12							
<i>Turdus torquatus</i>	9,65	MIGR	3	4							
<i>Turdus viscivorus</i>	12,44	RES	283	580	20	2,0	3,0	5,2	2,6	3,6	2,3
<i>Upupa epops</i>	15,92	MIGR	133	244							

APPENDIX 2. Averaged coefficients for models with unweighted CTI (Figures A2.1 and A2.2), CTI based on tropical migrants only (Figures A2.3 and A2.4), CTI based on resident species and short distance migrants (Figures A2.5 and A2.6). Note that sample size differ because some communities are composed of either migrants only or residents only.

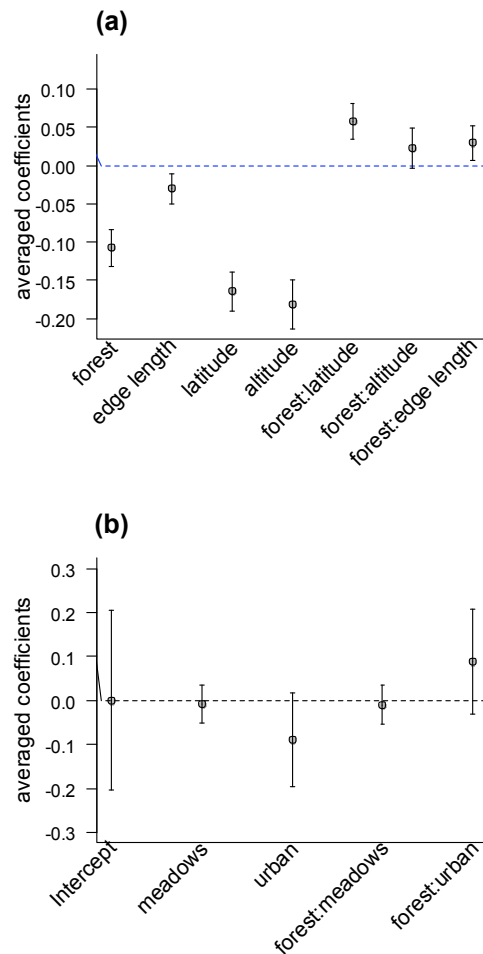


Figure A2.1. Averaged coefficients for models relating birds' community thermal index (CTI) to landscape-level habitat descriptors. CTI are not weighted with species' local abundances (contrary to the main analyses). 3129 French bird communities in 607 4-km² plots contributed to the model. (a) continuous variables (standardized to mean = 0 and sd = 1); (b) categorical variable "dominant land use in the non forest matrix", and interactions. The land use type "agricultural landscapes" is taken as the reference and included in the intercept.

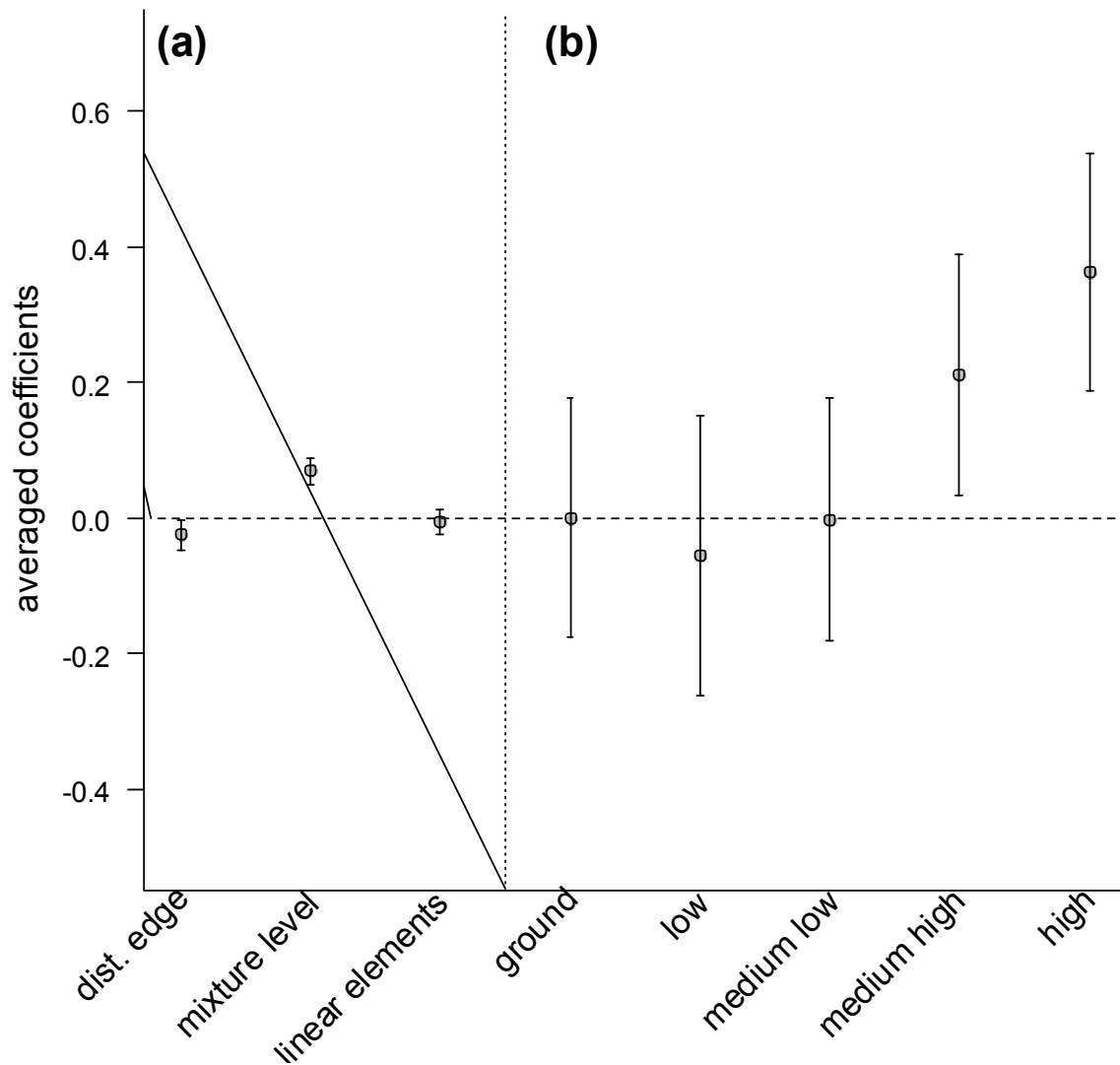


Figure A2.2. Averaged coefficients for local-scale models relating birds' community thermal index (CTI) to local-scale habitat variables. CTI are not weighted with species' local abundances (contrary to the main analyses). 3129 French bird communities in 607 4-km² plots contributed to the model. (a) continuous variables: distance to nearest forest edge (dist. edge), mixture level (proportion of deciduous tree cover relative to total tree cover within 100m), total length of linear elements within 100m (linear elements). (b) dominant tree height within 100m ("ground": 0-1m, reference level set to 0; "low": 1-2m; "medium low": 3-8m; "medium high": 8-16m; high: >16m).

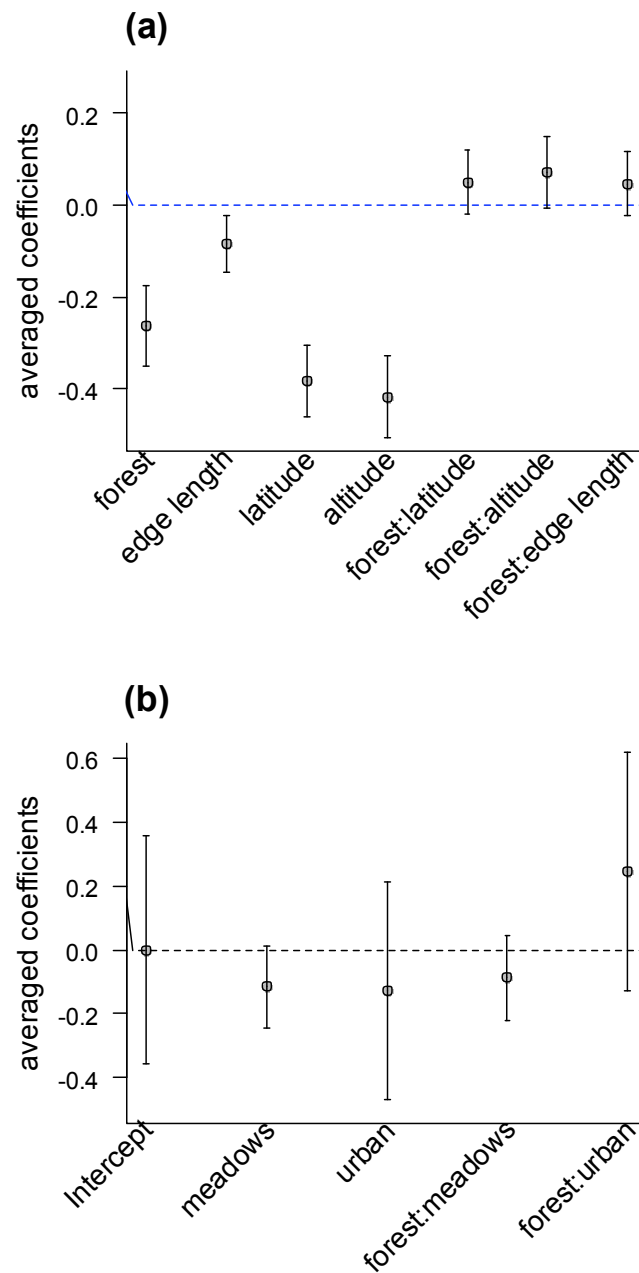


Figure A2.3. Averaged coefficients for models relating birds' community thermal index (CTI) to landscape-level habitat descriptors. Only tropical migrants are considered. 2522 French bird communities in 580 4-km² plots contributed to the model. (a) continuous variables (standardized to mean = 0 and sd = 1); (b) categorical variable "dominant land use in the non forest matrix", and interactions. The land use type "agricultural landscapes" is taken as the reference and included in the intercept.

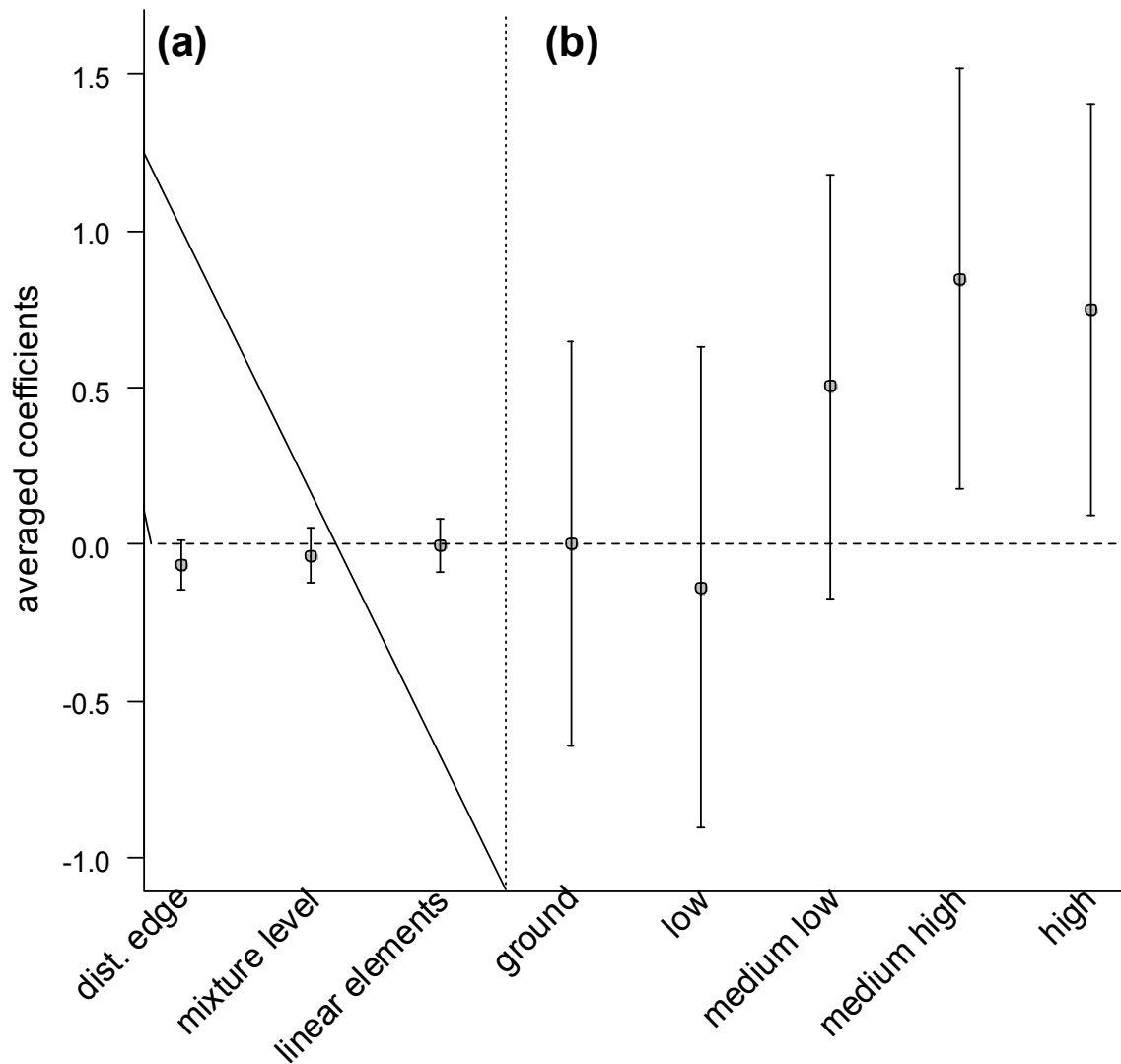


Figure A2.4. Averaged coefficients for local-scale models relating birds' community thermal index (CTI) to local-scale habitat variables. The species set is restricted to tropical migrants. 411 communities contributed to the model. (a) continuous variables: distance to nearest forest edge (dist. edge), mixture level (proportion of deciduous tree cover relative to total tree cover within 100m), total length of linear elements within 100m (linear elements). (b) dominant tree height within 100m ("ground": 0-1m, reference level set to 0; "low": 1-2m; "medium low": 3-8m; "medium high": 8-16m; high: >16m).

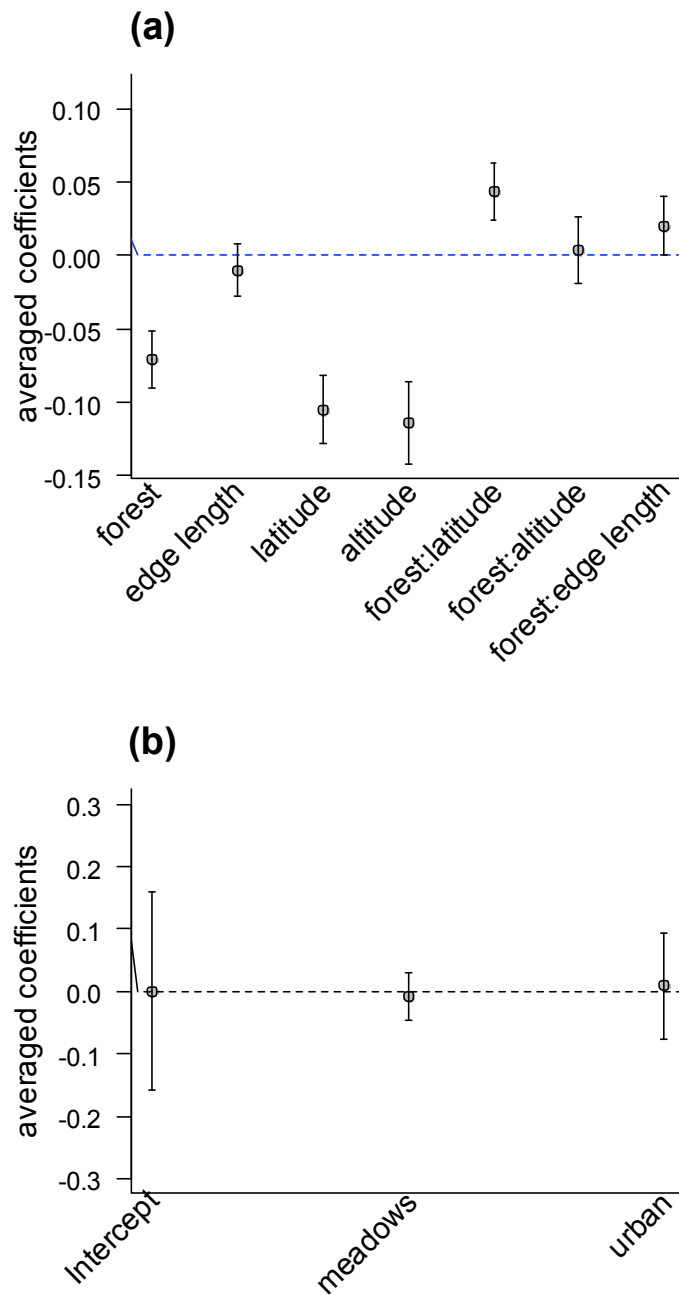


Figure A2.5. Averaged coefficients for models relating birds' community thermal index (CTI) to landscape-level habitat descriptors. Only resident and short distance migratory species are considered. 3128 French bird communities in 607 4-km² plots contributed to the model. (a) continuous variables (standardized to mean = 0 and sd = 1); (b) categorical variable “dominant land use in the non forest matrix”, and interactions. The land use type “agricultural landscapes” is taken as the reference and included in the intercept.

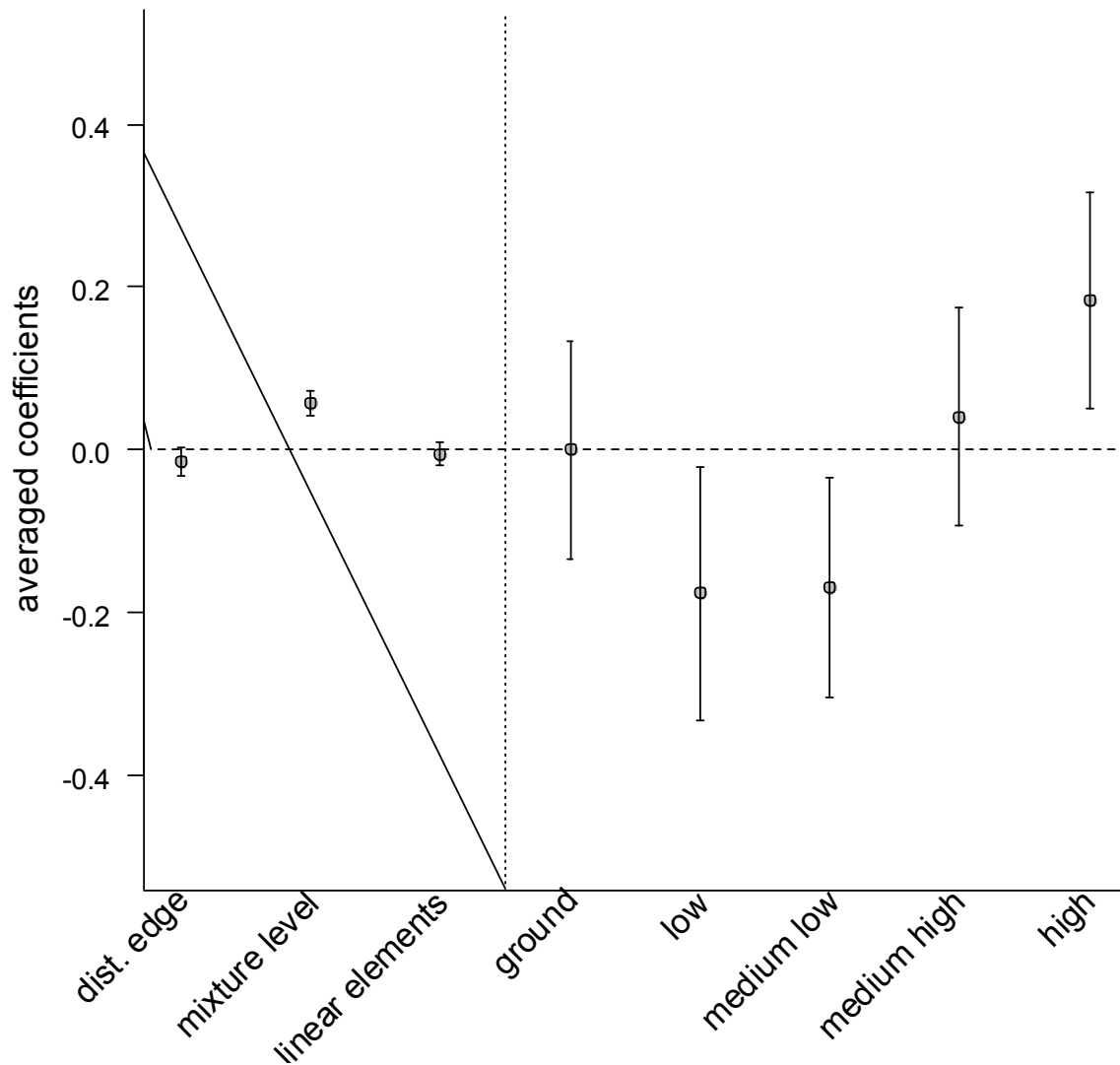


Figure A2.6. Averaged coefficients for local-scale models relating birds' community thermal index (CTI) to local-scale habitat variables. The species set is restricted to resident and short distance migratory species. 659 communities contributed to the model. (a) continuous variables: distance to nearest forest edge (dist. edge), mixture level (proportion of deciduous tree cover relative to total tree cover within 100m), total length of linear elements within 100m (linear elements). (b) dominant tree height within 100m ("ground": 0-1m, reference level set to 0; "low": 1-2m; "medium low": 3-8m; "medium high": 8-16m; high: >16m).

APPENDIX 3. Correlograms for response variables and model residuals. Correlograms are based on Moran's I with equally spaced distance classes.

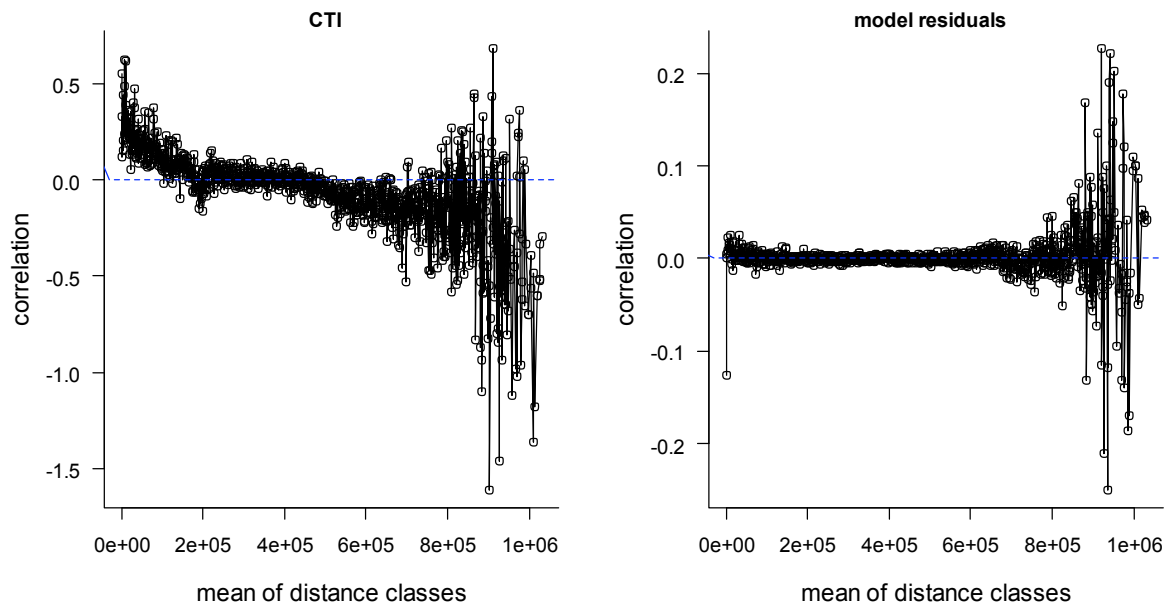


Figure A3.1. Spatial correlograms for models relating birds' community thermal index (CTI) to landscape variables. (a) Autocorrelation of the response variable (CTI), (b) autocorrelation of the residuals of the best model (as selected by AICc). The spatial dependence is measured by Moran's I. Distance classes are equal divisions of the maximum possible distance lag.

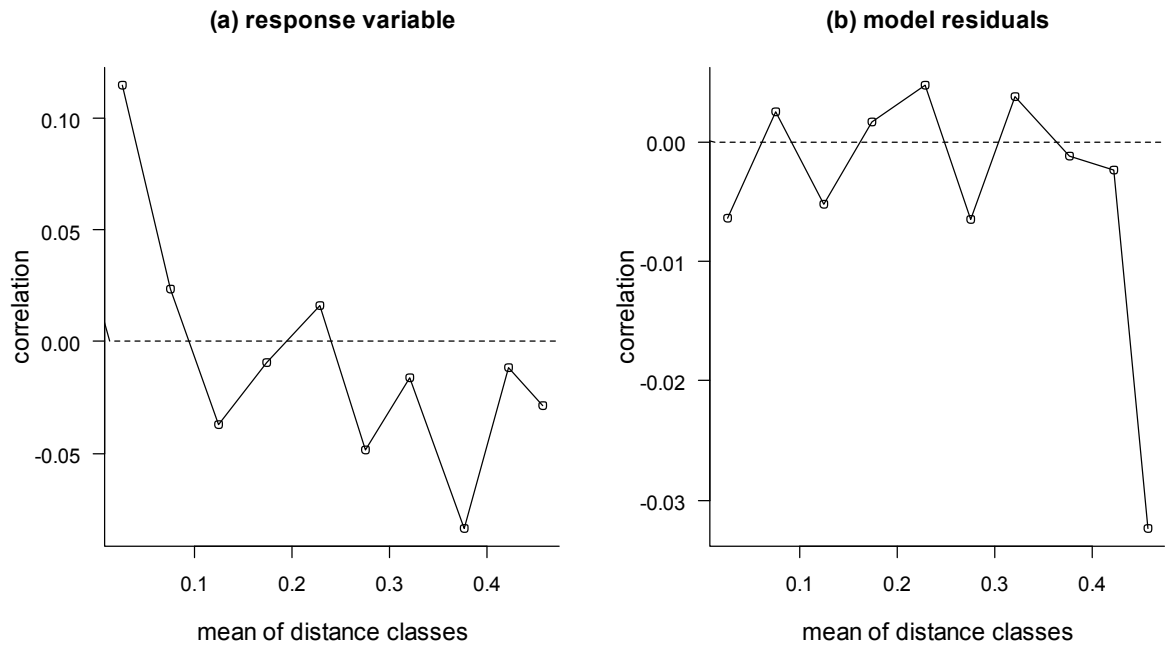


Figure A3.2. Spatial correlograms for models relating birds' community thermal index (CTI) to local habitat variables. (a) Autocorrelation of the response variable (CTI), (b) autocorrelation of the residuals of the best model (as selected by AICc). The spatial dependence is measured by Moran's I. Distance classes are equal divisions of the maximum possible distance lag.

APPENDIX 4. Full model selection tables. Table A4.1 : landscape-scale analysis; Table A4.2: local scale analysis

Table A4.1. Model selection for the relationship between the Community Thermal Index of French forest bird communities and landscape descriptors. Models rely on 3129 bird communities spread into 607 4-km² plots. Variables included in the maximum model: LH (local habitat at the community level, excluded from selection); FA (forest cover in the landscape); AL (altitude of the landscape centroid); LAT (latitude of the landscape centroid); EL (residual forest edge length regressed against forest cover, see methods for details); MA (dominant land use in the non-forest matrix); and relevant interactions.

fixed effects structure	df	AICc	ΔAICc	AICc weight
LH + FA + AL + LAT + EL + + FA : AL + FA : LAT + FA : EL	18	1598,38	0	0,38
LH + FA + AL + LAT + EL + + + FA : LAT + FA : EL	17	1599,8	1,42	0,19
LH + FA + AL + LAT + EL + MA + FA : AL + FA : LAT + FA : EL	20	1599,81	1,44	0,19
LH + FA + AL + LAT + EL + MA + + FA : LAT + FA : EL	19	1601,4	3,02	0,08
LH + FA + AL + LAT + EL + MA + FA : AL + FA : LAT + FA : EL + FA : MA	22	1601,86	3,48	0,07
LH + FA + AL + LAT + EL + FA : AL + FA : LAT	17	1603,76	5,39	0,03
LH + FA + AL + LAT + EL + MA + FA : LAT + FA : EL + FA : MA	21	1604,12	5,74	0,02
LH + FA + AL + LAT + EL + MA + FA : AL + FA : LAT	19	1605,27	6,89	0,01
LH + FA + AL + LAT + EL + + + FA : LAT	16	1606,23	7,85	0,01
LH + FA + AL + LAT + EL + MA + FA : AL + FA : LAT + FA : MA	21	1607,02	8,65	0,01
LH + FA + AL + LAT + FA : AL + FA : LAT	16	1607,33	8,95	0
LH + FA + AL + LAT + EL + MA + + FA : LAT	18	1607,91	9,53	0
LH + FA + AL + LAT + MA + FA : AL + FA : LAT	18	1608,71	10,33	0
LH + FA + AL + LAT + FA : LAT	15	1608,98	10,6	0
LH + FA + AL + LAT + MA + FA : LAT	17	1610,52	12,15	0
LH + FA + AL + LAT + EL + MA + FA : LAT + FA : MA	20	1610,6	12,23	0
LH + FA + AL + LAT + MA + FA : AL + FA : LAT + FA : MA	20	1610,7	12,32	0
LH + FA + AL + LAT + MA + FA : LAT + FA : MA	19	1613,36	14,98	0
LH + FA + AL + LAT + EL + FA : EL	16	1617,95	19,57	0
LH + FA + AL + LAT + EL + FA : AL + FA : EL	17	1619,97	21,59	0
LH + FA + AL + LAT + EL + MA + FA : EL	18	1620,07	21,69	0
LH + FA + AL + LAT + EL + MA + FA : EL + FA : MA	20	1621,7	23,32	0
LH + FA + AL + LAT + EL + MA + FA : AL + FA : EL	19	1622,1	23,72	0
LH + FA + AL + LAT + EL + MA + FA : AL + FA : EL + FA : MA	21	1623,67	25,29	0
LH + FA + AL + LAT + EL	15	1624,35	25,97	0
LH + FA + AL + LAT + EL + FA : AL	16	1626,31	27,93	0
LH + FA + AL + LAT + EL + MA	17	1626,57	28,19	0
LH + FA + AL + LAT	14	1627,46	29,09	0
LH + FA + AL + LAT + EL + MA + FA : MA	19	1628,13	29,75	0

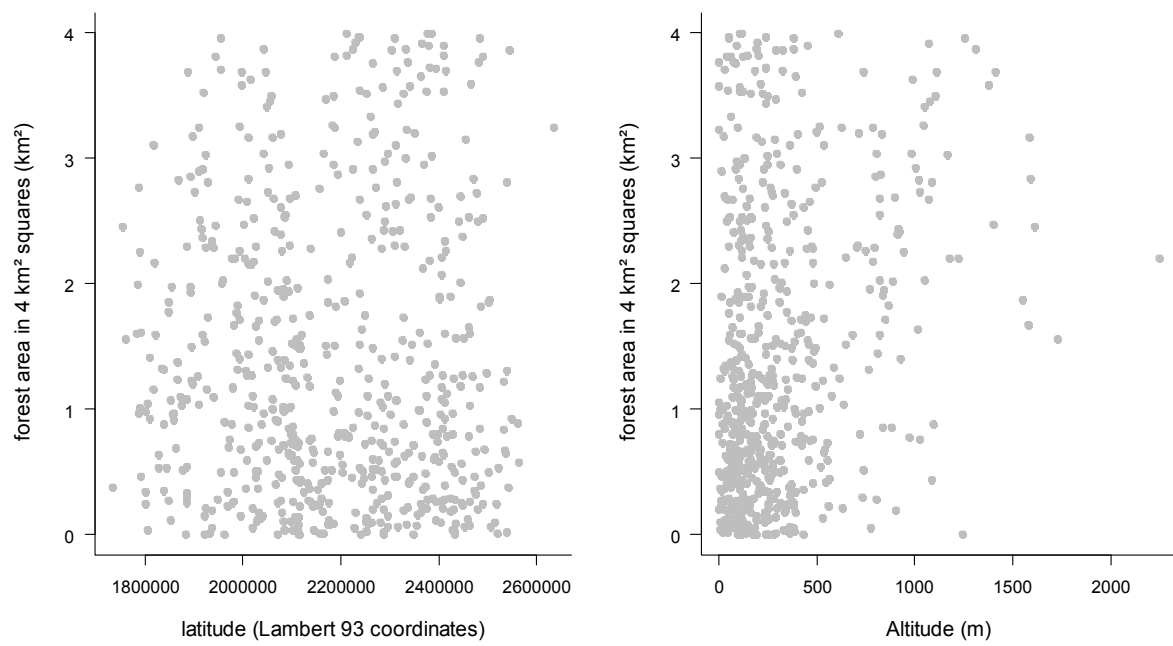
LH + FA + AL + LAT + EL + MA + FA : AL	18	1628,53	30,15	0
LH + FA + AL + LAT + FA : AL	15	1629,48	31,1	0
LH + FA + AL + LAT + MA	16	1629,6	31,22	0
LH + FA + AL + LAT + EL + MA + FA : AL + FA : MA	20	1629,87	31,5	0
LH + FA + AL + LAT + MA + FA : MA	18	1631,31	32,93	0
LH + FA + AL + LAT + MA + FA : AL	17	1631,62	33,24	0
LH + FA + AL + LAT + MA + FA : AL + FA : MA	19	1633,23	34,85	0
LH + + AL + LAT + EL + MA	16	1692,57	94,19	0
LH + FA + LAT + EL + MA + FA : LAT + FA : EL	18	1694	95,62	0
LH + FA + LAT + EL + FA : LAT + FA : EL	16	1694,1	95,72	0
LH + FA + LAT + EL + MA + FA : LAT	17	1694,17	95,79	0
LH + FA + LAT + EL + FA : LAT	15	1694,23	95,86	0
LH + AL + LAT + + MA	15	1695,03	96,65	0
LH + AL + LAT + EL	14	1695,11	96,73	0
LH + FA + LAT + MA + FA : LAT	16	1696,63	98,25	0
LH + FA + LAT + EL + MA + FA : LAT + FA : EL + FA : MA	20	1697,04	98,67	0
LH + FA + LAT + FA : LAT	14	1697,05	98,67	0
LH + FA + LAT + EL + MA + FA : LAT + FA : MA	19	1697,17	98,79	0
LH + + AL + LAT	13	1698,02	99,64	0
LH + FA + LAT + MA + FA : LAT + FA : MA	18	1699,69	101,31	0
LH + FA + LAT + EL	14	1728,64	130,27	0
LH + FA + LAT + EL + FA : EL	15	1728,88	130,51	0
LH + FA + LAT + EL + MA	16	1729,57	131,2	0
LH + FA + LAT + EL + MA + FA : EL	17	1729,79	131,42	0
LH + FA + LAT + EL + MA + FA : MA	18	1730,84	132,46	0
LH + FA + LAT + EL + MA + FA : EL + FA : MA	19	1731,11	132,74	0
LH + FA + LAT	13	1732,02	133,64	0
LH + FA + LAT + MA	15	1732,62	134,24	0
LH + FA + LAT + MA + FA : MA	17	1733,95	135,57	0
LH + FA + AL + MA	15	1782,82	184,44	0
LH + FA + AL + MA + FA : AL	16	1783,99	185,61	0
LH + FA + AL + MA + FA : MA	17	1784,24	185,87	0
LH + FA + AL + EL + MA	16	1784,84	186,46	0
LH + FA + AL	13	1784,99	186,61	0
LH + FA + AL + FA : AL	14	1785,86	187,48	0
LH + FA + AL + EL + MA + FA : AL	17	1786	187,62	0
LH + FA + AL + MA + FA : AL + FA : MA	18	1786,06	187,68	0
LH + FA + AL + EL + MA + FA : EL	17	1786,27	187,89	0
LH + FA + AL + EL + MA + FA : MA	18	1786,27	187,89	0
LH + FA + AL + + EL	14	1786,98	188,6	0
LH + FA + AL + EL + MA + FA : AL + FA : EL	18	1787,27	188,9	0
LH + FA + AL + EL + MA + FA : EL + FA : MA	19	1787,73	189,36	0
LH + FA + AL + EL + FA : AL	15	1787,81	189,44	0
LH + FA + AL + EL + MA + FA : AL + FA : MA	19	1788,08	189,7	0
LH + FA + AL + EL + FA : EL	15	1788,58	190,2	0
LH + FA + AL + EL + + FA : AL + FA : EL	16	1789,26	190,88	0
LH + FA + AL + EL + MA + FA : AL + FA : EL + FA : MA	20	1789,47	191,09	0
LH + LAT + EL + MA	15	1818,38	220,01	0
LH + FA	12	1818,8	220,42	0
LH + FA + MA	14	1820,54	222,16	0
LH + FA + EL	13	1820,72	222,34	0
LH + LAT + MA	14	1820,84	222,46	0
LH + FA + MA + FA : MA	16	1821,4	223,02	0
LH + FA + EL + MA	15	1822,41	224,04	0

LH + FA + EL + FA : EL	14	1822,72	224,35	0
LH + FA + EL + MA + FA : MA	17	1823,27	224,9	0
LH + FA + EL + MA + FA : EL	16	1824,41	226,03	0
LH + FA + EL + MA + FA : EL + FA : MA	18	1825,27	226,9	0
LH + LAT + EL	13	1831,01	232,64	0
LH + LAT	12	1834,27	235,89	0
LH + AL	12	1869,74	271,37	0
LH + AL + MA	14	1871,47	273,09	0
LH + AL + EL	13	1871,65	273,27	0
LH + L + EL + MA	15	1873,37	274,99	0
LH + MA	13	1922	323,62	0
LH	11	1922,87	324,49	0
LH + EL + MA	14	1924	325,62	0
LH + EL	12	1924,81	326,43	0

Table A4.2. Model selection for the relationship between the Community Thermal Index (CTI) of 659 forest bird communities and local habitat structure and composition. Variables included in the maximum model: external edge (distance to the nearest external edge), linear elements (total length of linear elements in a 100-m buffer around the community), mixture level (ratio between surface covered by deciduous trees and total tree surface within 100-m), structure (dominant structure within 100m, categorical variable with five levels).

fixed effects structure	df	AICc	Δ AICc	AICc weight
external edge + mixture + structure	9	-182,2	0	0,63
external edge + linear elements + mixture + structure	10	-180,4	1,76	0,26
mixture + structure	8	-178	4,19	0,08
linear elements + mixture + structure	9	-176,1	6,12	0,03
external edge + structure	8	-152,7	29,48	0
external edge + linear elements + structure	9	-151,1	31,13	0
structure	7	-148,7	33,53	0
linear elements + structure	8	-146,8	35,38	0
mixture	4	108,5	290,74	0
external edge + mixture	5	109,7	291,86	0
linear elements + mixture	5	110	292,17	0
external edge + linear elements + mixture	6	111	293,18	0
-	3	140,6	322,79	0
external edge	4	141,3	323,47	0
linear elements	4	141,8	323,98	0
external edge + linear elements	5	142,3	324,49	0

APPENDIX 5. Latitudinal and altitudinal gradients in forest cover across the French Breeding Bird Survey (FBBS). Forest cover is quantified at the scale of 4-km² FBBS plots (N=607) from CORINE Landcover 2006.



1 APPENDIX 6. Species-level analysis

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3 Variations in the CTI can be driven by either a few species with extreme STIs occurring only
4 at one side of the forest gradient (e.g., cold-dwelling species restricted to large homogeneous
5 forests, or warm-dwelling species occurring only in small and fragmented woods within a
6 non-forest matrix), or by a continuous relationship between species' STI and preference for
7 forested landscapes. To tell apart these two possibilities, we explored the relationship of each
8 of the 107 species with forest cover. We built a binomial mixed model relating each species'
9 presence / absence at the scale of the FBBS plot ($PA_{i,p}$) to forest cover and latitude (equation
10 3).

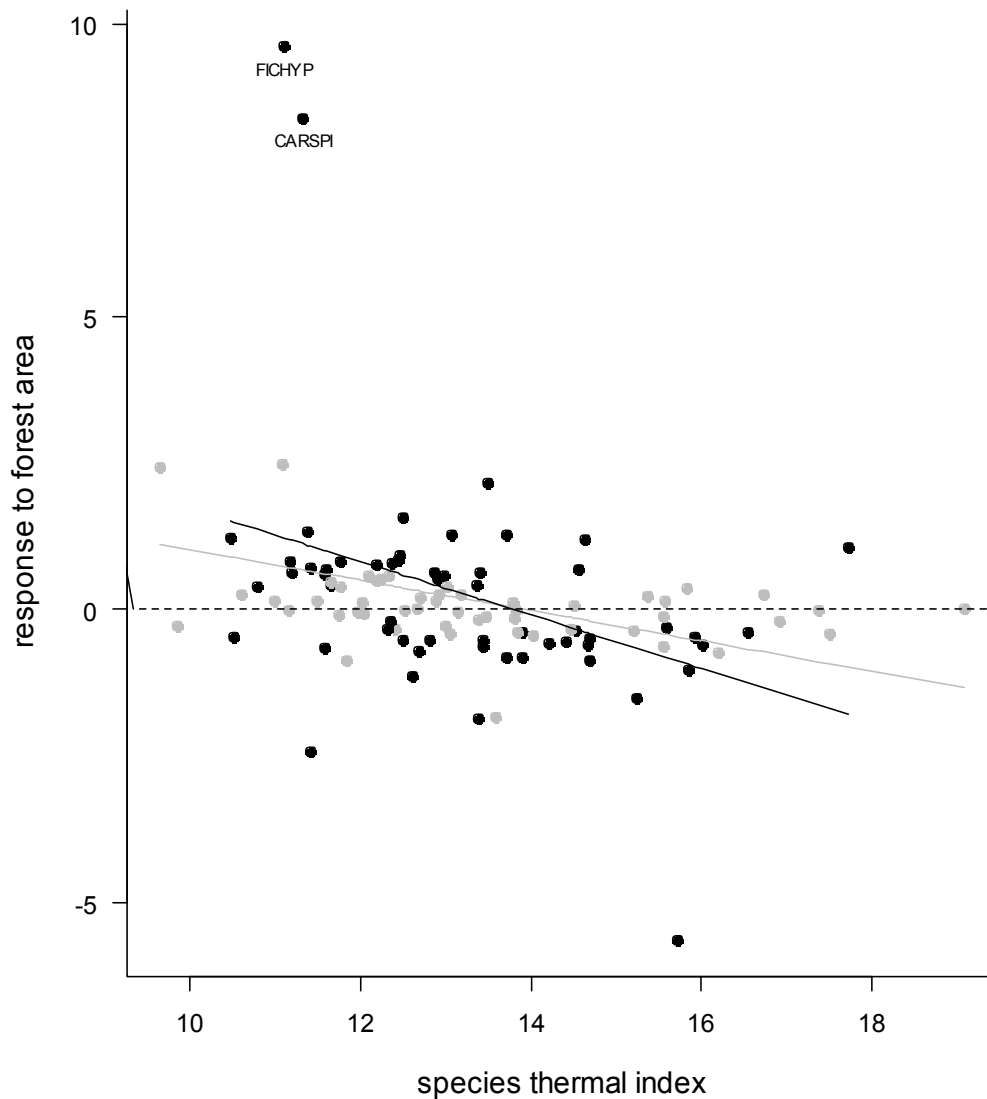
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$$PA_{i,p} = LAT_p + FA_{pz} + \theta_z \quad (3)$$

12 We added random "bioclimatic region" effects (z) on the model intercept and on the slope of
13 the forest cover effect to account for potential differences in species' responses to forest
14 between regions. Note that the presence or absence of a particular species at a point count
15 may depend more on sampling effects and biotic interactions than on its relationship with
16 landscape composition; hence the response variable was expressed at the plot scale. However,
17 we weighted each $PA_{i,p}$ with the number of points per plot to account for between-plot
18 variations in sample size. We subsequently correlated the coefficients of FA_{pz} with specific
19 STI and visually explored the continuity of the relationship between these two variables.

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25 **Figure A6.1.** Relationship between bird species' thermal index (STI, in °C) and their
 26 response to forest cover. Response to forest cover is assessed from a binomial model relating
 27 species' presence absence in 607 French landscapes (4-km² FBBS plots) and the
 28 (standardized) total forest cover in the landscape (adjusted for latitude). The grey regression
 29 line is built from all the species (N = 107, Pearson's R² = 0.09), the black regression line is
 30 built from the subset of species with significant (p≤0.05) responses to forest cover (N = 51,
 31 black dots, Pearson's R²=0.12). The two outliers (FICHYP: *Ficedula hypoleuca* and CARSPI:

32 *Carduelis spinus*) are two forest specialists, removing them did not change qualitatively the

33 results.

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