Supporting Information

Abundance patterns of mammals across Russia explained by remotely-sensed vegetation productivity and snow indices

Table of Contents

Table S1: The number of regions in which a species occurred according to the range maps, the number which were included in analysis, the number of regions that were excluded from analysis as outliers based on Bonferroni test, the number of regions for which there were only few available years, the area of suitable habitat in [million km^2], the total area of range in [million km^2], and the percentage of missing data for which we interpolated (i.e. filled) density estimates from adjacent years for each of our eight species. 4

Table S2: Suitable habitat based on the MODIS IGBP land cover classification for the eight mammal species. X indicates a land cover class that we included as suitable habitat; blank cell indicates a class was not considered suitable habitat. The species are European hare (*Lepus europaeus*), moose (*Alces alces*), roe deer (*Capreolus pygargus Pallas, Capreolus capreolus Linnaeus*), brown bear (*Ursus arctos*), wild boar (*Suc scrofa*), lynx (*Felis lynx*), red fox (*Vulpes vulpes*), and wolf (*Canis lupus*) across Russian's regions. 6

Table S3: Percentage of explanatory variables that were included in the top-twelve models with all explanatory variables. Variables marked with an asterisk (*) were removed from further analysis due to multicollinearity. (**) Indicates that two variables were highly correlated, so only one of variables was included in the model (in the model for wild boar we replaced end of the frozen season with length of the frozen season). Selected variables are bolded. The species are European hare (*Lepus europaeus*), moose (*Alces alces*), roe deer (*Capreolus pygargus Pallas, Capreolus capreolus Linnaeus*), brown bear (*Ursus arctos*), wild boar (*Suc scrofa*), lynx (*Felis lynx*), red fox (*Vulpes vulpes*), and wolf (*Canis lupus*) across Russian's regions. 7

Table S4: Variance inflation factors (VIFs) for the top model for each species across Russian's regions. 9

Table S5: Results of the 10-fold cross validation of the top model. MAE is the mean absolute error [individuals/km^2], RMSE the root mean squared error [individuals/km^2], R^2 the average coefficients of determination for the 10-folds of our cross validation, SD the standard deviation around the R^2 for the10-folds, R^2 the coefficient of determination of full model. The species are European hare (*Lepus europaeus*), moose (*Alces alces*), roe deer (*Capreolus pygargus Pallas, Capreolus capreolus Linnaeus*), brown bear (*Ursus arctos*), wild boar (*Suc scrofa*), lynx (*Felis lynx*), red fox (*Vulpes vulpes*), and wolf (*Canis lupus*) across Russian's regions. 11

Table S6: Correlation between the average population density over 30 years (1981-2010) and the average densities for 1981-1991, 1991-2000, and 2001-2010 for each of eight mammal species across Russian's regions. 12

Table S7: P-values resulting from asymptotic tests for the equality of coefficients of variation from k populations, and p-values from modified signed-likelihood ratio test (MSLRT) for equality of CVs that test the difference between CVs for three decades. 13

Figure S1: Some of our explanatory variables: a) elevation (m) from SRTM; b) annual mean temperature (°C); c) annual precipitation (mm); d) human footprint index (%); e) the Dynamic Habitat Indices (DHIs) shown in RGB where variation DHI was assigned to red, cumulative DHI to green, and minimum DHI to blue; f) stable land cover based on MODIS International Geosphere-Biosphere Programme (IGBP classification) for the regions of Russia: 0-water, 1-evergreen needle leaf forest, 2-evergreen broadleaf forest, 3-deciduous needle leaf forest, 4-deciduous broadleaf forest, 5-mixed forest, 6-closed shrub lands, 7-open shrub lands, 8-woody savannas, 9-savannas, 10-grassland, 11-permanent wetland ,12-cropland, 13-urban and built-up, 14-cropland/natural vegetation mosaic, 15-snow and ice, 16-barren or sparsely vegetated; g) days of snow-covered ground; h) end of the frozen season. The projection of the map is Albers equal area conic projection (Datum D European 1950). 14

Figure S2: Map of Russia's regions. The projection of the map is Albers equal area conic projection (Datum D European 1950)..... 16

Figure S3: Population dynamics for eight species; abundance estimates from raw Winter Track Count data. The species are European hare (*Lepus europaeus*), moose (*Alces alces*), roe deer (*Capreolus pygargus Pallas, Capreolus capreolus Linnaeus*), brown bear (*Ursus arctos*), wild boar (*Suc scrofa*), lynx (*Felis lynx*), red fox (*Vulpes vulpes*), and wolf (*Canis lupus*) across Russian's regions. 17

Figure S4: Workflow of the statistical analysis. 19

Figure S5**:** Normal QQ plot for the residuals of the top model for eight species. The species are European hare (*Lepus europaeus*), moose (*Alces alces*), roe deer (*Capreolus pygargus Pallas, Capreolus capreolus Linnaeus*), brown bear (*Ursus arctos*), wild boar (*Suc scrofa*), lynx (*Felis lynx*), red fox (*Vulpes vulpes*), and wolf (*Canis lupus*) across Russian's regions. 20

Figure S6: Coefficient of variation of population densities among regions by year. The species are European hare (*Lepus europaeus*), moose (*Alces alces*), roe deer (*Capreolus pygargus Pallas, Capreolus capreolus Linnaeus*), brown bear (*Ursus arctos*), wild boar (*Suc scrofa*), lynx (*Felis lynx*), red fox (*Vulpes vulpes*), and wolf (*Canis lupus*) across Russian's regions. 22

Figure S7: Boxplots of population densities for the three periods. The species are European hare (*Lepus europaeus*), moose (*Alces alces*), roe deer (*Capreolus pygargus Pallas, Capreolus capreolus Linnaeus*), brown bear (*Ursus arctos*), wild boar (*Suc scrofa*), lynx (*Felis lynx*), red fox (*Vulpes vulpes*), and wolf (*Canis lupus*) across Russian's regions. 24

Figure S8: Spline correlograms for eight species' top model residuals, with 95% confidence intervals shown in gray, over entire time period 1981-2010 (first column), 1981-1990 (second column), 1991-2000 (third column), and 2001-2010 (forth column), based on 1,000 permutations with distance 5,000 km for all species except European hare, for which distance was 2,000. The species are European hare (*Lepus europaeus*), moose (*Alces alces*), roe deer (*Capreolus pygargus Pallas, Capreolus capreolus Linnaeus*), brown bear (*Ursus arctos*), wild boar (*Suc*

scrofa), lynx (*Felis lynx*), red fox (*Vulpes vulpes*), and wolf (*Canis lupus*) across Russian's regions..... 27

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Species	**Number of regions included in range map**	**Number of regions included in analysis**	**Number of regions excluded from analysis**	**Number of regions with no data or few available years**	**Area of suitable habitat (million km^2)**	**Area of range (million km^2)**	**Percent of missing data filled**
European hare (*Lepus europaeus*)	59	50	6*	3	2.80	2.92	7.67
Moose (*Alces alces*)	62	62	0	0	10.62	13.64	3.6
Roe deer (*Capreolus pygargus Pallas & C. capreolus Linnaeus*)	59	48	0	11	3.98	4.89	3.7
Brown bear (*Ursus arctos*)	50	39	1	10	7.03	11.88	3.8
Wild boar (*Suc scrofa*)	65	64	0	1	4.95	5.77	3.6
Lynx (*Felis lynx*)	65	52	1	12	6.97	13.26	15.7
Red fox (*Vulpes vulpes*)	71	71	0	0	15.86	16.15	34.9

Wolf (*Canis lupus*)	70	69	0	1	16.18	16.46	3.3

[*] One region was an outlier based on Bonferroni outlier test and we also did not include the five regions in which European hare has been introduced.

Table S2: Suitable habitat based on the MODIS IGBP land cover classification for the eight mammal species. X indicates a land cover class that we included as suitable habitat; blank cell indicates a class was not considered suitable habitat. The species are European hare (*Lepus europaeus*), moose (*Alces alces*), roe deer (*Capreolus pygargus Pallas, Capreolus capreolus Linnaeus*), brown bear (*Ursus arctos*), wild boar (*Suc scrofa*), lynx (*Felis lynx*), red fox (*Vulpes vulpes*), and wolf (*Canis lupus*) across Russian's regions.

Land cover classes	European hare	Moose	Roe deer, wild boar	Brown bear	Lynx	Red fox	Wolf
0-water							
1 -evergreen needle leaf forest	X	X	X	X	X	X	X
2-evergreen broadleaf forest	X	X	X	X	X	X	X
3-deciduous needle leaf forest		X	X	X	X	X	X
4-deciduous broadleaf forest	X	X	X	X	X	X	X
5-mixed forest	X	X	X	X	X	X	X
6-closed shrub lands							X
7-open shrub lands		X				X	X
8-woody savannas		X	X	X	X	X	X
9-savannas			X	X	X	X	X
10-grassland	X					X	X
11-permanent wetland		X	X	X	X	X	X
12-cropland	X		X			X	X
13-urban and built-up							
14-cropland/natural vegetation	X		X	X		X	X
15-snow and ice							
16-barren or sparsely vegetated							

Table S3: Percentage of explanatory variables that were included in the top-twelve models with all explanatory variables. Variables marked with an asterisk (*) were removed from further analysis due to multicollinearity. (**) Indicates that two variables were highly correlated, so only one of variables was included in the model (in the model for wild boar we replaced end of the frozen season with length of the frozen season). Selected variables are bolded. The species are European hare (*Lepus europaeus*), moose (*Alces alces*), roe deer (*Capreolus pygargus Pallas, Capreolus capreolus Linnaeus*), brown bear (*Ursus arctos*), wild boar (*Suc scrofa*), lynx (*Felis lynx*), red fox (*Vulpes vulpes*), and wolf (*Canis lupus*) across Russian's regions.

Explanatory variables	European hare	Moose	Roe deer	Brown bear	Wild boar	Lynx	Red fox	Wolf
Cumulative DHI	0	17	0	0	83	8	67	17
Minimum DHI	0	75	0	0	42	0	92	42
Variation DHI	0	0	0	8	0	17	67	100
Road density*	33	57	0	0	0	83	17	0
HFI	92	100	42	0	0	83	58	58
Elevation	25	17	8	100	50	33	33	0
BIO1	17	33	58	0	17	33	42	0
BIO2	17	0	0	8	50	25	0	50
BIO3	25	33	50	75	92	8	0	50
BIO4	17	33	0	50	33	33	33	17
BIO5	33	75	25	25	0	25	0	17
BIO6	8	0	33	17	17	0	8	42
BIO7	17	0	33	25	0	0	58	0
BIO8	33	0	17	0	25	0	8	0
BIO9	0	0	0	83	0	17	25	17
BIO10*	25	33	50	50	17	75	0	33
BIO11	8	33	58	50	33	17	0	50
BIO12	0	0	17	0	0	42	0	0
BIO13	42	0	50	0	0	58	25	67
BIO14	0	0	17	0	0	0	8	0

BIO15	33	17	75	0	8	42	17	0
BIO16*	8	8	17	0	8	17	0	0
BIO17	0	0	17	0	0	0	0	0
BIO18*	8	0	25	25	17	0	25	0
BIO19	33	0	8	0	0	17	0	0
DWOS WHI	67	25	50	8	1	0	0	92
DWS WHI	58	0	0	67	17	0	33	0
Start WHI	25	0	0	42	25	8	50	0
Length WHI**	8	8	0	0	75	0	0	0
End WHI**	17	83	0	33	33	8	0	0

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106 Table S4: Variance inflation factors (VIFs) for the top model for each species across Russian's
107 regions.

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Specie	Explanatory variables included in the model	VIF of variable
European hare (*Lepus europaeus*)	Human footprint index	1
	Precipitation of wettest quarter	2
	Duration of snow-free frozen ground	2
	End of the frozen season	2
Moose (*Alces alces*)	Minimum DHI	1
	Human footprint index	2
	Maximum temperature of warmest month	3
	End of the frozen season	2
Roe deer (*Capreolus pygargus Pallas & C. capreolus Linnaeus*)	Human footprint index	4
	Precipitation seasonality	4
Brown bear (*Ursus arctos*)	Variation DHI	2
	Elevation	2
	Maximum temperature of warmest month	2
	Precipitation seasonality	2
	Duration of snow-covered ground	2
	End of the frozen season	2
Wild boar (*Suc scrofa*)	Cumulative DHI	1
	Human footprint index	2
	Elevation	3
	Isothermality	2
	Length of the frozen season	2
Lynx (*Felis lynx*)	Elevation	1
	Precipitation seasonality	1
	End of the frozen season	1

Red fox (*Vulpes vulpes*)	Cumulative DHI	3
	Minimum DHI	3
	Variation DHI	5
	Human footprint index	3
	Elevation	3
	Isothermality	3
	Maximum temperature of warmest month	5
	Start of the frozen season	2
Wolf (*Canis lupus*)	Variation DHI	2
	Human footprint index	2
	Maximum temperature of warmest month	4
	Precipitation of wettest quarter	2
	Duration of snow-free frozen ground	1

Table S5**:** Results of the 10-fold cross validation of the top model. MAE is the mean absolute error [individuals/km^2], RMSE the root mean squared error [individuals/km^2], R^2 the average coefficients of determination for the 10-folds of our cross validation, SD the standard deviation around the R^2 for the10-folds, R^2 the coefficient of determination of full model. The species are European hare (*Lepus europaeus*), moose (*Alces alces*), roe deer (*Capreolus pygargus Pallas, Capreolus capreolus Linnaeus*), brown bear (*Ursus arctos*), wild boar (*Suc scrofa*), lynx (*Felis lynx*), red fox (*Vulpes vulpes*), and wolf (*Canis lupus*) across Russian's regions.

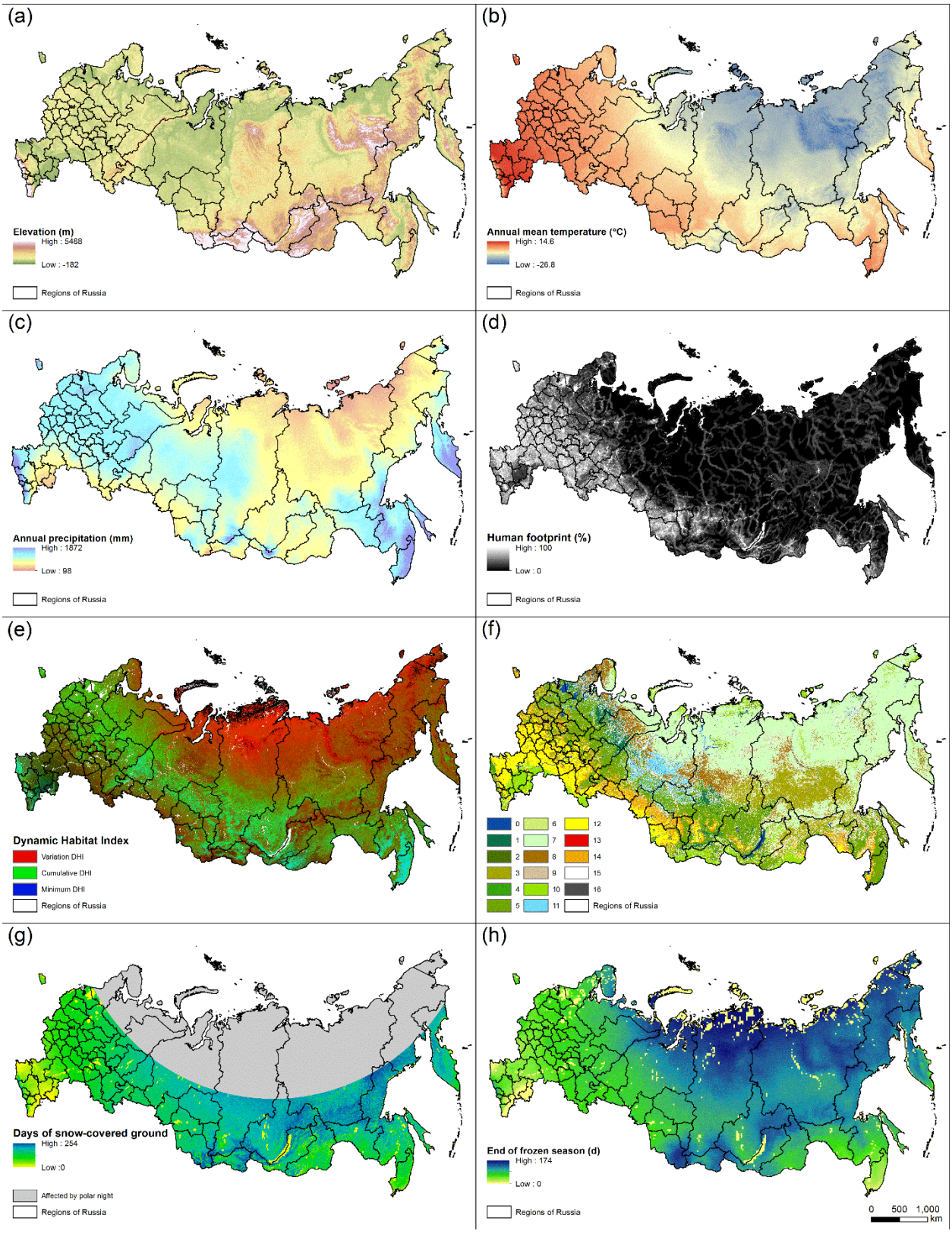
Species	MAE	RMSE	R^2 average of folds	SD of R^2	R^2 full model
European hare	0.12	0.14	0.89	0.06	0.86
Moose	0.18	0.23	0.82	0.12	0.83
Roe deer	0.28	0.33	0.57	0.26	0.45
Brown bear	0.25	0.30	0.48	0.40	0.66
Wild boar	0.03	0.04	0.70	0.20	0.74
Lynx	0.25	0.30	0.36	0.33	0.51
Red fox	0.12	0.15	0.88	0.08	0.89
Wolf	0.16	0.21	0.69	0.18	0.71

Table S6: Correlation between the average population density over 30 years (1981-2010) and the average densities for 1981-1991, 1991-2000, and 2001-2010 for each of eight mammal species across Russian's regions.

Periods	1981-1990	1991-2000	2001-2010	1981-1990	1991-2000	2001-2010
	European hare (*Lepus europaeus*)			Moose (*Alces alces*)		
30-year average	0.95	0.97	0.96	0.97	0.99	0.97
1981-1990		0.84	0.82		0.94	0.91
1991-2000			0.97			0.95
	Roe deer (*Capreolus pygargus Pallas & C. capreolus Linnaeus*)			Brown bear (*Ursus arctos*)		
30-year average	0.91	0.97	0.97	0.97	0.98	0.98
1981-1990		0.83	0.82		0.95	0.90
1991-2000			0.92			0.93
	Wild boar (*Suc scrofa*)			Lynx (*Felis lynx*)		
30-year average	0.95	0.97	0.97	0.99	0.98	0.93
1981-1990		0.90	0.87		0.95	0.88
1991-2000			0.89			0.87
	Red fox (*Vulpes vulpes*)			Wolf (*Canis lupus*)		
30-year average	0.88	0.98	0.96	0.97	0.99	0.98
1981-1990		0.87	0.73		0.96	0.91
1991-2000			0.91			0.96

Table S7: P-values resulting from asymptotic tests for the equality of coefficients of variation from k populations, and p-values from modified signed-likelihood ratio test (MSLRT) for equality of CVs that test the difference between CVs for three decades.

Species	Asymptotic test	MSLRT
European hare (*Lepus europaeus*)	1	1
Moose (*Alces alces*)	1	1
Roe deer (*Capreolus pygargus Pallas & C. capreolus Linnaeus*)	1.74	1
Brown bear (*Ursus arctos*)	1	1
Wild boar (*Suc scrofa*)	0.82	0.76
Lynx (*Felis lynx*)	1	1
Red fox (*Vulpes vulpes*)	0.32	0.16
Wolf (*Canis lupus*)	1	1



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142 

143 **[double column]** Figure S2**:** Map of Russia's regions. The projection of the map is
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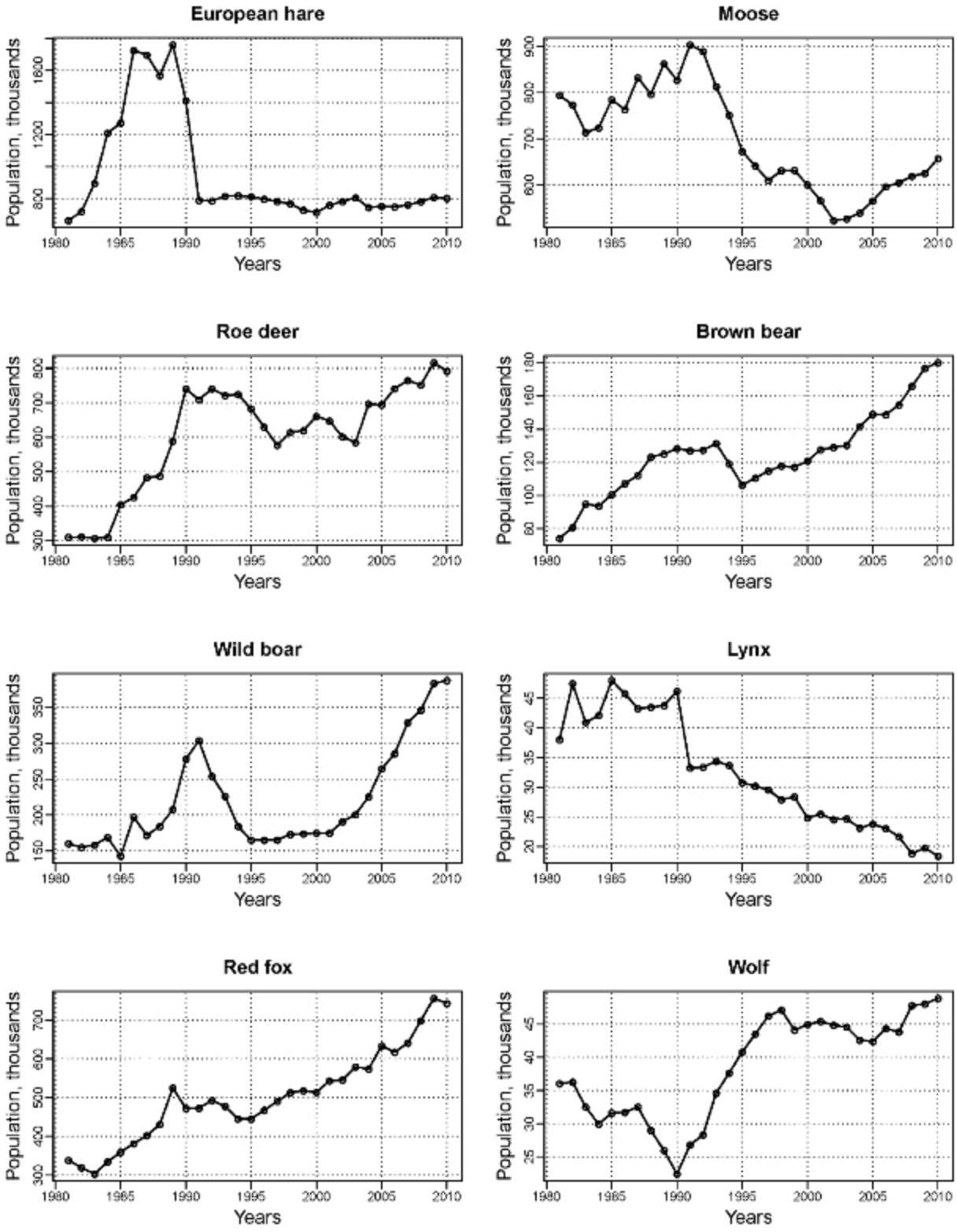

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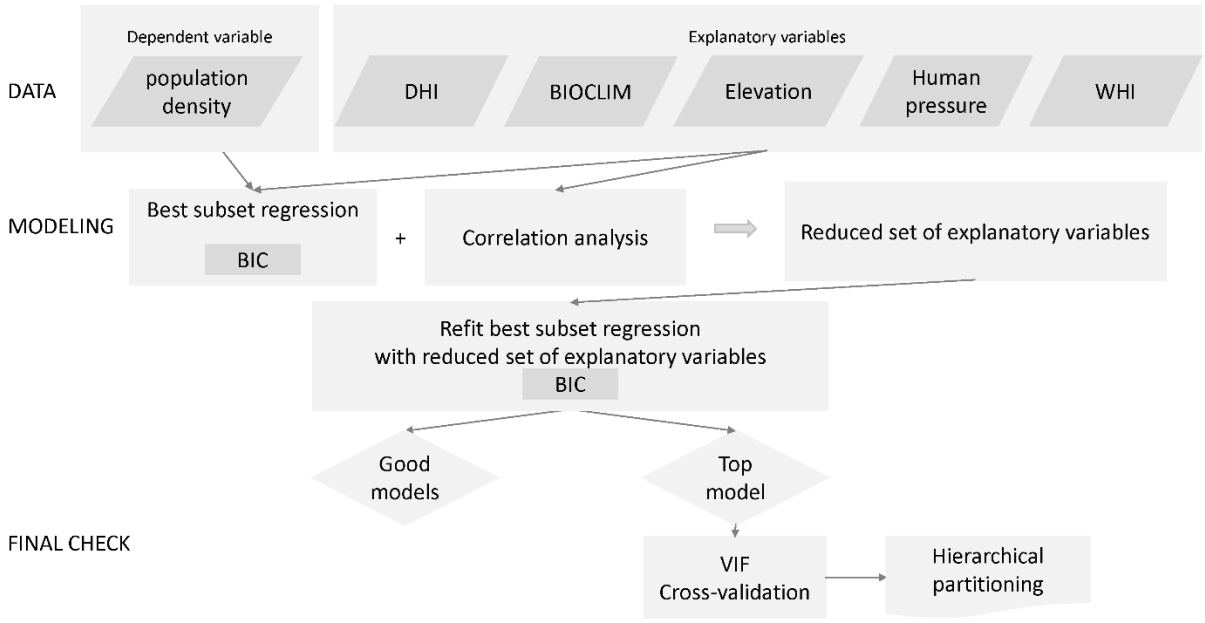

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154 **[single column]** Figure S4**:** Workflow of the statistical analysis.

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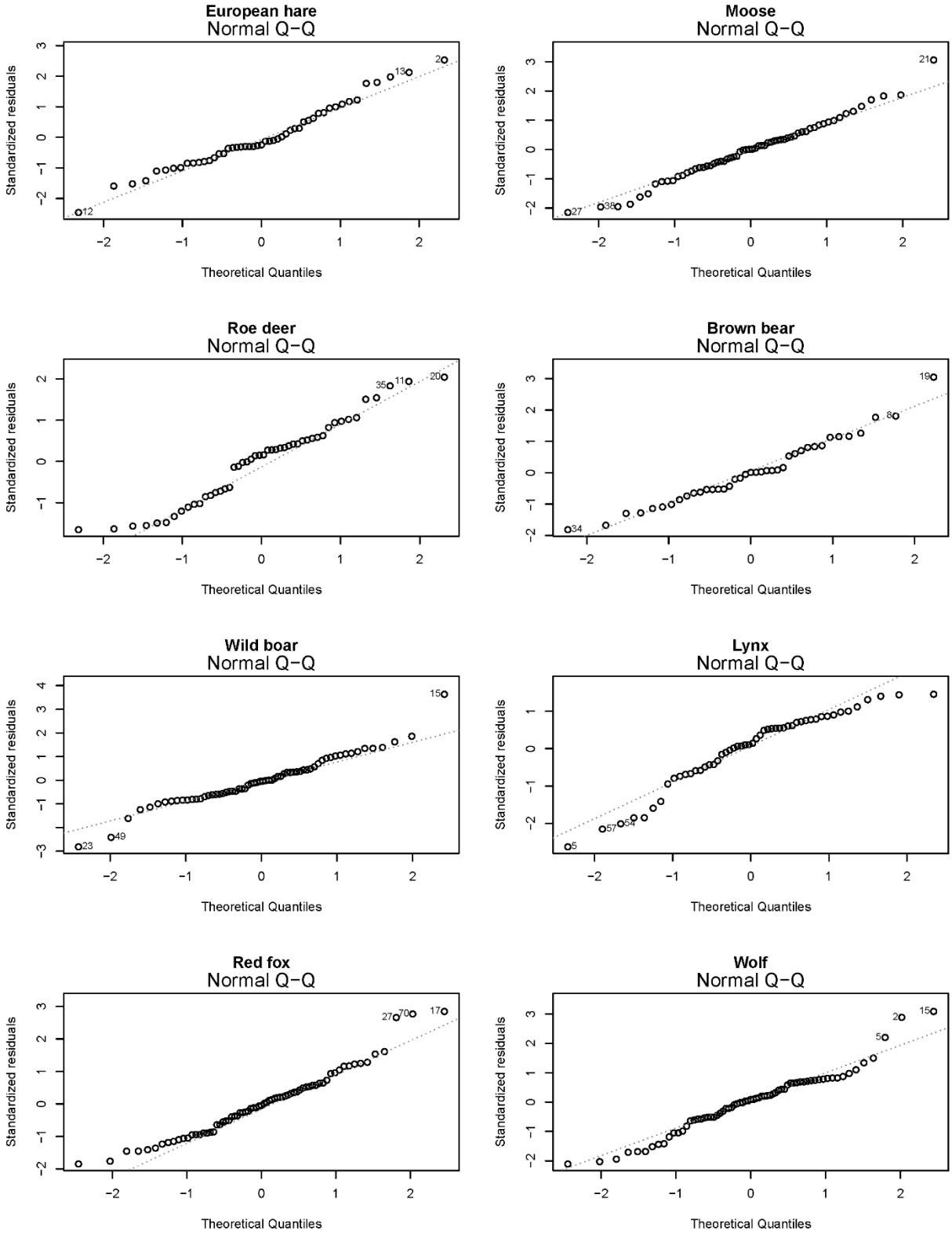

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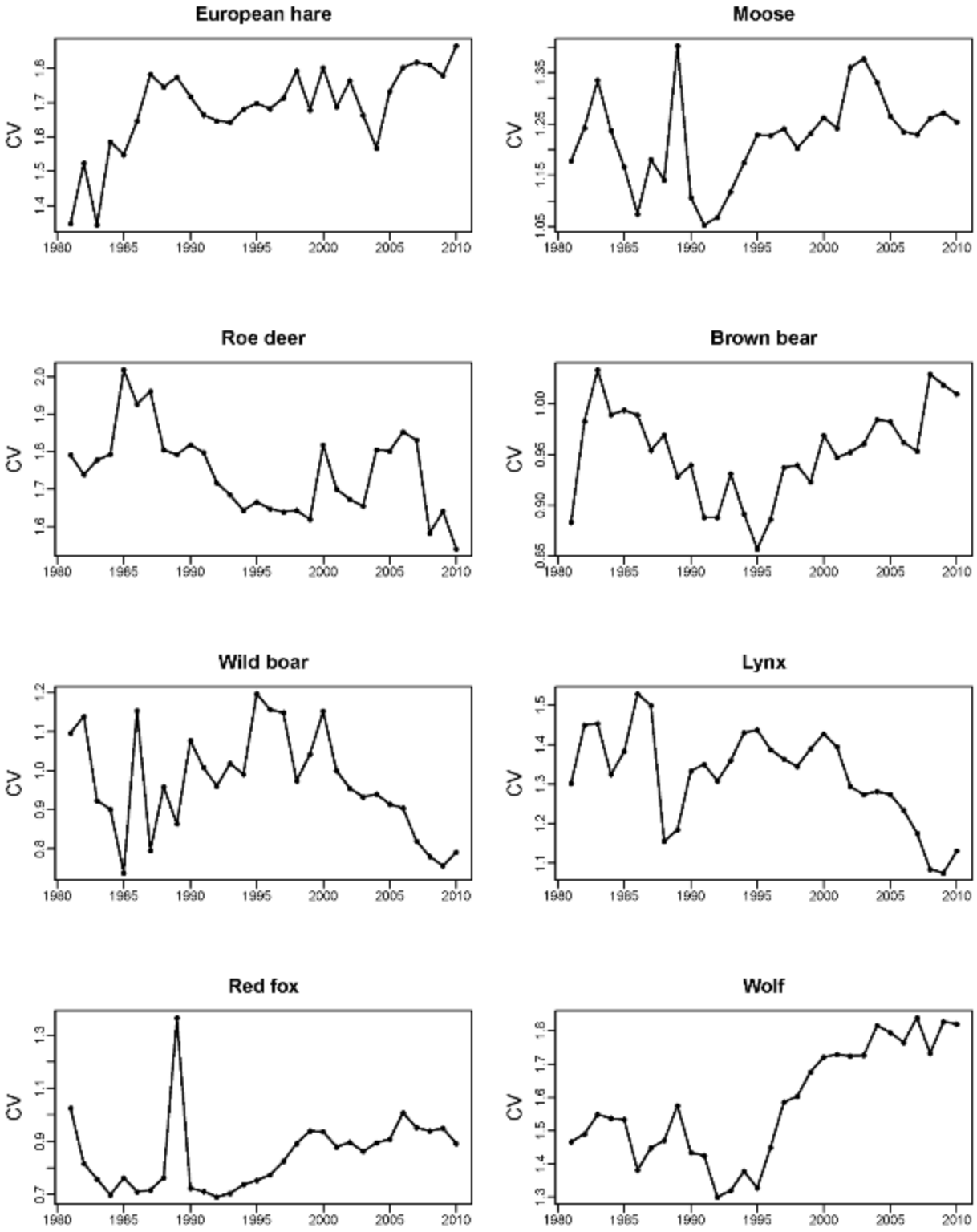

163

164 **[double column]** Figure S6: Coefficient of variation of population densities among
165 regions by year. The species are European hare (*Lepus europaeus*), moose (*Alces alces*), roe deer

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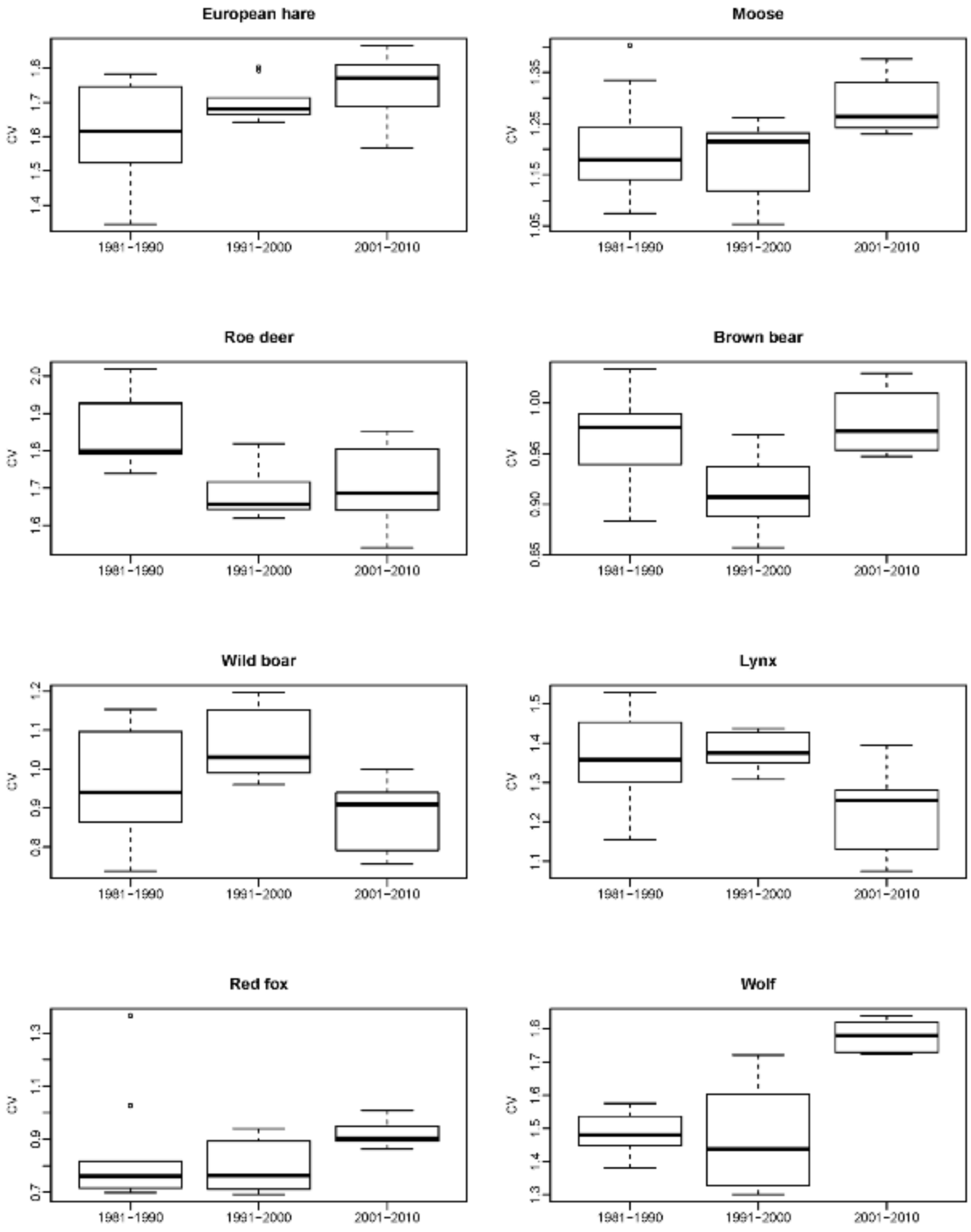

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170 **[double column]** Figure S7: Boxplots of population densities for the three periods. The
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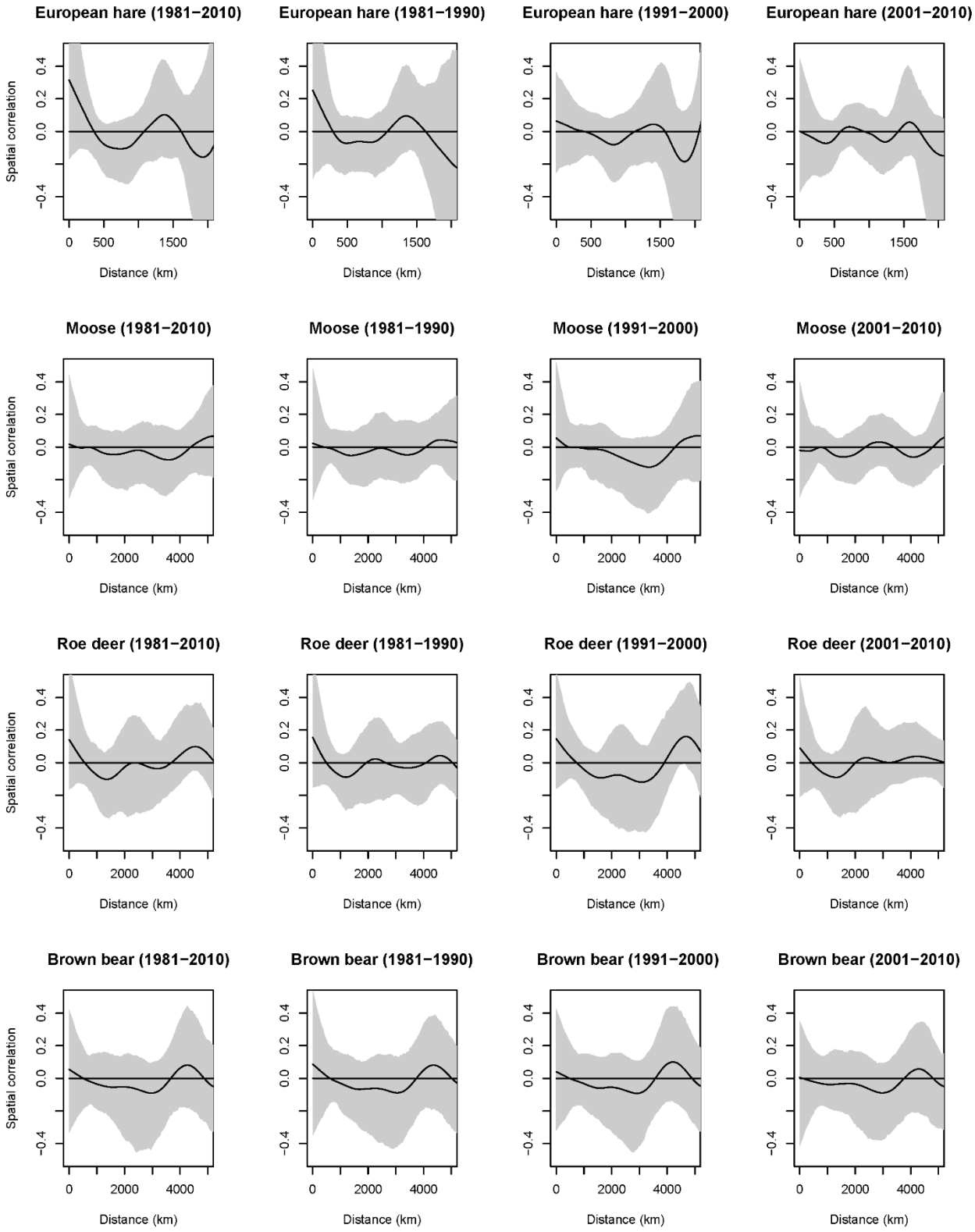
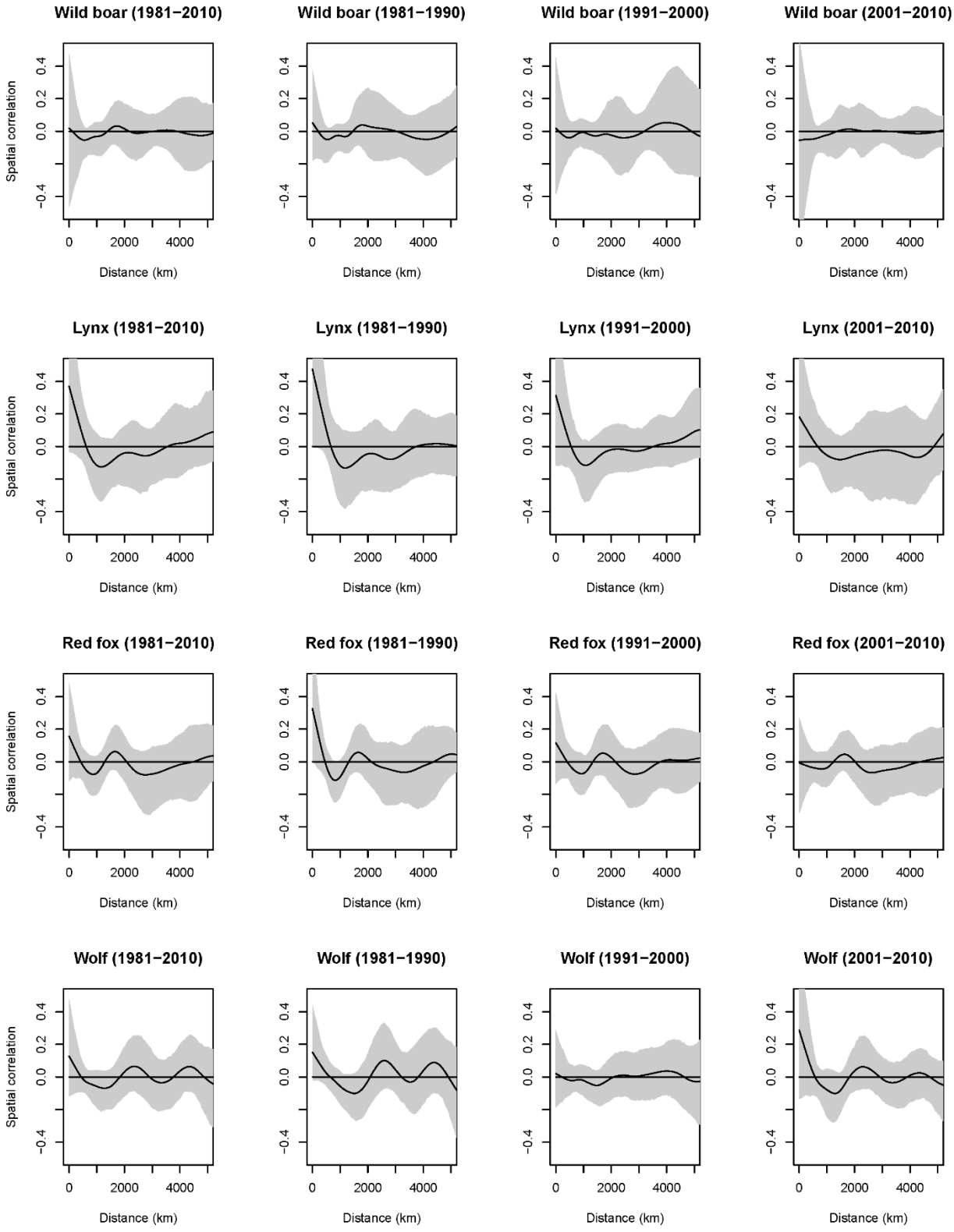

European hare (1981–2010)
European hare (1981–1990)
European hare (1991–2000)
European hare (2001–2010)
Moose (1981–2010)
Moose (1981–1990)
Moose (1991–2000)
Moose (2001–2010)
Roe deer (1981–2010)
Roe deer (1981–1990)
Roe deer (1991–2000)
Roe deer (2001–2010)
Brown bear (1981–2010)
Brown bear (1981–1990)
Brown bear (1991–2000)
Brown bear (2001–2010)
Spatial correlation
Distance (km)

176
177



178

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