Supplementary Material for:

Incorporating anthropogenic effects into trophic ecology: predator-prey interactions in a human-dominated landscape

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Detailed description of hunting grounds

Wild mammal populations and hunting activities are regulated by legislation authorized by the Ministry of Environment and Climate Change. All the hunting grounds adhere to the same legislation, and are most often managed by public hunting organizations or the State Forest Administration for at least 10 years, although hunting grounds are now more often taken over by private organizations (Salvatori *et al.* 2002; http://agvps.ro/despre/vanatoare-in-romania/). The number of animals in each hunting ground is recorded by the managers, mainly from sign surveys (e.g. snow tracking) and direct sightings (Salvatori *et al.* 2002). Nevertheless, track count results conducted by the hunting ground managers do not account for animals that range across hunting grounds. Therefore, the risk of double counting may cause over-estimated populations, especially of the large predators (Salvatori *et al.* 2002). Data on animal populations, hunting quotas, and harvested animals need to be reported to the state authority and are made publically available (www.mmediu.ro/beta/domenii/paduri/vanatoare/). However, for several new privately managed hunting grounds this data is not yet available, and long-term data on large predator populations was available from 35 hunting grounds in the study area (Figure 1). The size of the hunting grounds in the study area ranged between 71 km^2 and 212 km^2, with a mean size of 122 km^2.

Reference

Salvatori V., Okarma H., Ionescu O., Dovhanych Y., Find'o S., Boitani L. (2002) Hunting legislation in the Carpathian Mountains: implications for the conservation and management of large carnivores. Wildlife Biology 8, 3-10.

Figure S1. Boxplots of species encounter rates per camera day at camera locations with and without lure. The boxplots show that the presence of the lure did not affect species encounter rates appreciably and was therefore not included as a random factor in the models.

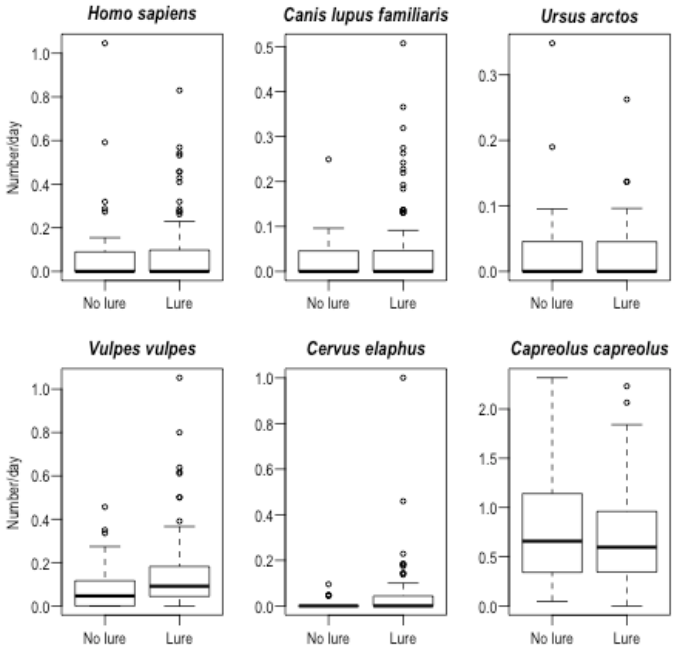


Figure S2. 5 year comparison of reported wolf densities per hunting ground. Wolf densities per hunting ground (i.e. number of reported wolves divided by hunting ground size; www.mmediu.ro/beta/domenii/paduri/vanatoare) were ranked within each year (high rank = low density, low rank = high density). Ranks of hunting grounds for 2006-2009 were then plotted against 2010 ranks. Overall, the ranks of hunting ground wolf densities were similar throughout years.

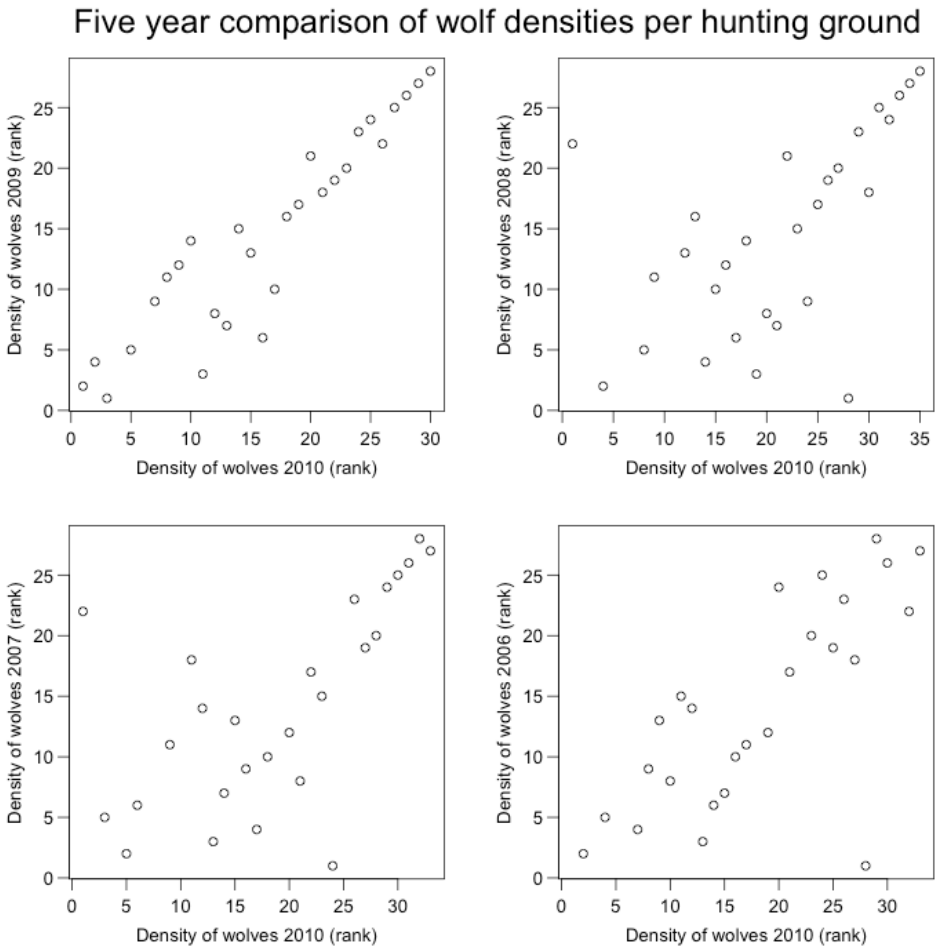


Figure S3. 5 year comparison of reported bear densities per hunting ground. Bear densities per hunting ground (i.e. number of reported bears divided by hunting ground size; www.mmediu.ro/beta/domenii/paduri/vanatoare) were ranked within each year (high rank = low density, low rank = high density). Ranks of hunting ground for 2006-2009 were then plotted against 2010 ranks. Overall, the ranks of hunting ground bear densities were similar throughout years.

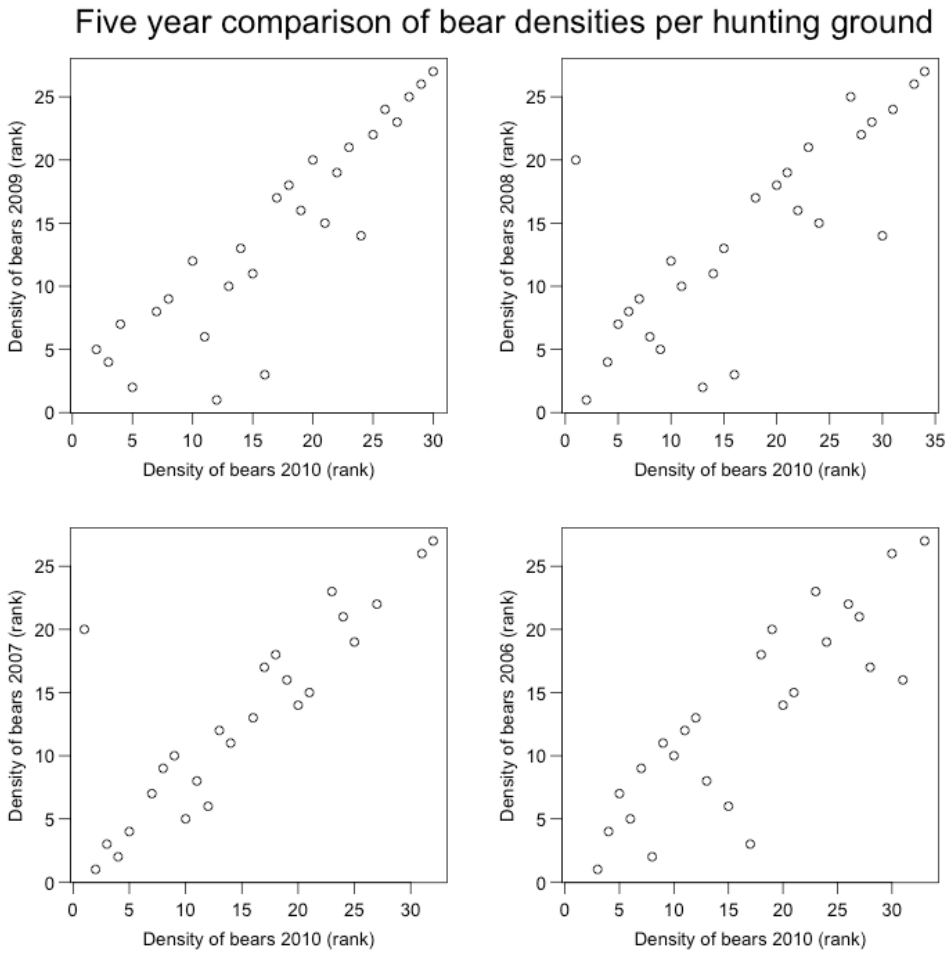
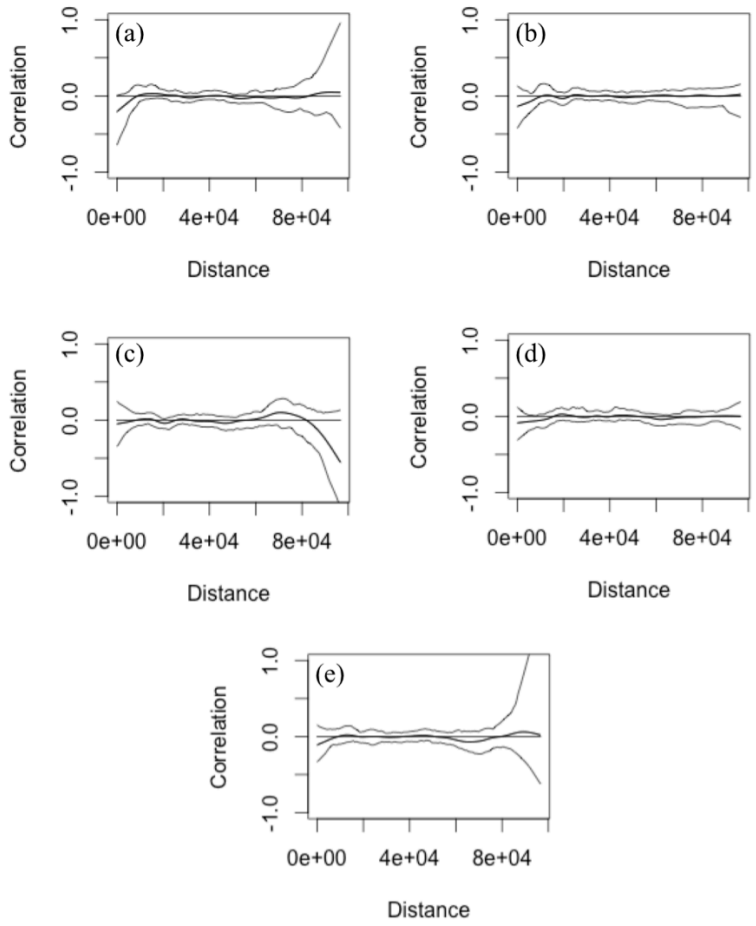


Figure S4. Spline correlograms with 95% confidence intervals of the Pearson residuals from the final generalized mixed effects models as a test for spatial autocorrelation for (a) bear, (b) dog, (c) red fox, (d) red deer, and (e) roe deer models. Spline correlograms were created in the 'ncf' package in R (Bjornstad 2013). No obvious autocorrelation was detected in any of the final generalized mixed effects models and we did not need to correct for this factor. As reported in the main text, however, we included hunting ground as a random effect to account for spatial non-independence.



Reference

Bjornstad O.N. (2013) ncf: spatial nonparametric covariance functions. R package version 1.1-5. http://CRAN.R-project.org/package=ncf

Table S1. Overview of model structures including all variables incorporated in the generalized mixed effects models for each species. Indicated is whether variables were included untransformed or log-transformed. For humans and bears, it is further indicated whether small scale or larger scale data were used. Random effects included in all models were hunting ground and study round. A parameter compensating for overdispersion was included where necessary. An offset parameter accounting for differences in camera days was included in all models. See methods for further details.

	Random effects			
Model including fixed effects	**Ground**	**Round**	**Overdispersion**	**Offset**
Bear ~ human† + wolf* + forest* + pasture	+	+		+
Dog ~ human* + bear†* + wolf* + pasture	+	+		+
Fox ~ human* + bear†* + wolf* + dog + forest + pasture*	+	+	+	+
Red deer ~ human†* + bear†* + wolf + dog* + forest* + pasture*	+	+		+
Roe deer ~ human† + bear†* + wolf + dog* + red deer* + forest + pasture*	+	+	+	+

† ***large scale (hunting ground density for bear variable, average size of nearby villages for human variable)***

**** log transformed***

Table S2. Estimates, both raw and scaled within node, associated standard errors (S.E.) and confidence intervals (C.I., for scaled model only) for generalized mixed effects models of each species. Asterisk (*) indicates that variable is log transformed.

		Non-scaled	Scaled (within node)[†]			
Model	**Fixed effect**	**Estimate ± S.E.**	**Estimate ± S.E.**	**95% C.I.**	**90% C.I.**	**85% C.I.**
Bear model	Human	-0.001 ± 0.000	-2.044 ± 0.782	-3.722, -0.692	-3.434, -0.880	-3.250, -1.011
	Wolf*	-0.523 ± 0.364	-0.300 ± 0.136	-0.593, -0.014	-0.540, -0.065	-0.507, -0.097
	Forest*	0.695 ± 0.415	0.238 ± 0.143	-0.026, 0.533	0.014, 0.484	0.041, 0.452
	Pasture	-0.025 ± 0.011	-0.344 ± 0.154	-0.659, -0.053	-0.606, -0.099	-0.572, -0.129
Dog model	Human*	16.070 ± 2.471	0.623 ± 0.096	0.430, 0.825	0.461, 0.792	0.481, 0.771
	Bear*	0.344 ± 0.265	0.298 ± 0.230	-0.145, 0.831	-0.074, 0.735	-0.028, 0.675
	Wolf*	-0.523 ± 0.364	-0.326 ± 0.227	-0.849, 0.112	-0.754, 0.042	-0.696, -0.003
	Pasture	0.028 ± 0.009	0.393 ± 0.126	0.138, 0.660	0.179, 0.617	0.205, 0.588
Fox model	Human*	-1.136 ± 2.735	-0.046 ± 0.106	-0.258, 0.161	-0.223, 0.128	-0.201, 0.106
	Bear*	-0.120 ± 0.118	-0.104 ± 0.102	-0.308, 0.097	-0.274, 0.064	-0.252, 0.043
	Wolf*	-0.213 ± 0.171	-0.136 ± 0.106	-0.346, 0.075	-0.312, 0.041	-0.290, 0.018
	Dog	1.945 ± 1.182	0.158 ± 0.098	-0.034, 0.354	-0.003, 0.321	0.017, 0.301
	Forest	-0.009 ± 0.006	-0.173 ± 0.115	-0.407, 0.053	-0.368, 0.016	-0.342, -0.008
	Pasture*	0.070 ± 0.086	0.084 ± 0.106	-0.126, 0.296	-0.091, 0.261	-0.069, 0.239
Red deer model	Human*	-0.867 ± 0.000	-0.766 ± 0.208	-1.203, -0.383	-1.128, -0.441	-1.081, -0.480
	Bear*	0.572 ± 0.290	0.492 ± 0.250	0.010, 1.031	0.089, 0.935	0.140, 0.875
	Wolf	-15.396 ± 7.012	-0.569 ± 0.259	-1.134, -0.074	-1.033, -0.154	-0.969, -0.207
	Dog*	-0.195 ± 0.074	-0.358 ± 0.136	-0.636, -0.100	-0.590, -0.141	-0.560, -0.167
	Forest*	0.121 ± 0.410	0.040 ± 0.140	-0.225, 0.327	-0.183, 0.279	-0.156, 0.249
	Pasture*	0.163 ± 0.135	0.201 ± 0.167	-0.120, 0.539	-0.069, 0.483	-0.036, 0.447
Roe deer model	Human	-0.000 ± 0.000	-0.111 ± 0.063	-0.237, 0.012	-0.216, -0.008	-0.203, -0.020
	Bear*	-0.144 ± 0.082	-0.124 ± 0.071	-0.272, 0.017	-0.247, -0.007	-0.231 -0.022
	Wolf	3.115 ± 1.929	0.115 ± 0.071	-0.026, 0.262	-0.003, 0.237	0.012, 0.221
	Dog*	0.039 ± 0.032	-0.072 ± 0.059	-0.188, 0.044	-0.169, 0.025	-0.157, 0.013
	Red deer*	-0.064 ± 0.035	-0.106 ± 0.058	-0.221, 0.008	-0.202, -0.010	-0.190, -0.022
	Forest	-0.002 ± 0.003	-0.033 ± 0.060	-0.153, 0.086	-0.133, 0.067	-0.121, 0.054
	Pasture*	0.030 ± 0.049	0.037 ± 0.061	-0.082, 0.158	-0.063, 0.138	-0.050, 0.125

[†]*Because of convergence issues for the fox model, scaled estimates ± S.E. and confidence intervals could be calculated only after the random effect with the lowest variance assigned (hunting ground, variance < 0.001) was removed from the model.*