

SUPPLEMENTARY MATERIAL

Philosophical Transactions of the Royal Society B

Nearby night lighting, rather than sky glow, is associated with habitat selection by a top predator in human-dominated landscapes

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This Supplementary Material contains

Table S1.- Number of locations per individual and size of the respective MCPs.

Table S2.- Generalized linear mixed models results from a global model with day and night data.

Table S3.- Generalized linear mixed models results for a model with night light data only.

Table S4.- Generalized linear mixed models results for a model with day light data only.

Table S5.- Weighted and unweighted generalized linear mixed models results for a model with night data only.

Figure S1.- Temporal autocorrelation in VIIRS data.

Figure S2.- Correlation matrix among variables.

Figure S3.- Global model.

Figure S4.- Predicted values for the random slope effects for zenith brightness and upward radiance.

Table S1.-

ID	Mountain lion	Random	MCP km²
F007	1109	1109	865.15
F008	525	1000	75.18
F013	762	1000	645.68
F014	1278	1278	964.28
F015	236	1000	109.15
F018	7250	7250	2784.80
F019	47	1000	24.03
F020	5866	5866	855.79
F021	409	1000	129.57
F028	1090	1090	1327.97
F029	423	1000	410.01
F035	1455	1455	761.82
F038	2805	2805	451.68
F041	2238	2238	546.10
F042	685	1000	628.99
F043	2744	2744	875.90
F044	2657	2657	1038.81
F045	1434	1434	417.07
F047	2237	2237	386.59
F048	1422	1422	1612.15
F049	1845	1845	337.03
F050	1202	1202	164.33
F051	927	1000	197.32
F052	464	1000	129.72
F055	1605	1605	210.23
F061	1019	1019	219.79
F062	1383	1383	348.57
F085	805	1000	122.81
F089	1373	1373	121.09
F090	2101	2101	224.45
F092	888	1000	63.75
F094	1053	1053	447.41
F095	5921	5921	533.44
F105	3298	3298	185.67
F121	2881	2881	107.20
F126	3711	3711	211.04
F137	1743	1743	148.83
F138	319	1000	82.66
F139	828	1000	97.63
F253	966	1000	174.54
F255	376	1000	59.34
F256	466	1000	924.97
F257	1422	1422	92.56
F258	1393	1393	288.27
F291	1443	1443	355.67

F307	591	1000	64.86
F312	1336	1336	75.87
F315	808	1000	55.09
F320	310	1000	113.75
M001	1212	1212	482.51
M002	721	1000	500.10
M005	619	1000	1931.73
M006	377	1000	2841.46
M009	594	1000	266.27
M010	733	1000	563.77
M016	522	1000	537.42
M017	1375	1375	2646.61
M022	64	1000	100.17
M026	154	1000	136.27
M027	2714	2714	1665.91
M031	340	1000	108.81
M032	1506	1506	671.35
M037	1325	1325	1163.56
M039	1275	1275	860.65
M040	2312	2312	1334.57
M046	1465	1465	428.73
M053	1304	1304	3538.98
M056	868	1000	4386.09
M057	1507	1507	1010.46
M058	716	1000	604.14
M059	681	1000	415.22
M060	540	1000	1124.45
M063	190	1000	24.03
M064	1481	1481	743.76
M067	915	1000	823.12
M086	554	1000	201.26
M087	306	1000	214.79
M091	978	1000	75.65
M093	4780	4780	1486.62
M096	316	1000	471.93
M106	1348	1348	480.65
M107	2419	2419	508.76
M108	75	1000	0.26
M109	3659	3659	826.98
M110	1541	1541	611.37
M118	4926	4926	1940.17
M119	169	1000	293.76
M120	446	1000	512.56
M122	5472	5472	1453.64
M125	697	1000	714.83
M145	1255	1255	310.79
M146	1194	1194	285.66
M250	1034	1034	275.41
M251	2076	2076	496.60
M252	1414	1414	601.74

M254	1833	1833	241.61
M294	393	1000	383.06
M299	1719	1719	2529.49
M313	1148	1148	320.87
M316	756	1000	260.36
M317	946	1000	907.44
M321	371	1000	617.44
Total	146484	167608	

Table S1.- Number of GPS locations for every of the 102 mountain lions, including both mountain lion and random locations. The size of the 100% Minimum Convex Polygon (MCP) for every mountain lion is also showed. Females are identified with “F” and males with “M”.

Table S2.-

Predictors	<i>Global model</i>			<i>Null model</i>		
	<i>Log-Odds</i>	<i>CI</i>	<i>p</i>	<i>Log-Odds</i>	<i>CI</i>	<i>p</i>
(Intercept)	-0.79	-1.29 – -0.29	0.002	-0.72	-1.01 – -0.43	< 0.001
<i>Distance to minor road</i>	0.11	0.09 – 0.12	< 0.001			
<i>Distance to water point</i>	-0.31	-0.32 – -0.30	< 0.001			
<i>Slope</i>	-0.21	-0.22 – -0.20	< 0.001			
<i>Distance to major highway</i>	-0.11	-0.12 – -0.10	< 0.001			
<i>Deer habitat suitability</i>	0.53	0.52 – 0.54	< 0.001			
<i>Distance to shrubland</i>	-0.33	-0.34 – -0.31	< 0.001			
<i>Distance to grassland</i>	-0.07	-0.08 – -0.06	< 0.001			
<i>Distance to forest</i>	-0.34	-0.35 – -0.32	< 0.001			
<i>Age class [Subadult]</i>	0.07	-0.52 – -0.66	0.824			
<i>Gender [M]</i>	-0.20	-0.78 – -0.39	0.511			
<i>Night [TRUE]</i>	0.03	0.01 – 0.05	0.003			
Random Effects						
σ^2	3.29			3.29		
τ_{00}	0.86 _{ml_id}			0.83 _{ml_id}		
	2.37 _{idyear}			2.34 _{idyear}		
ICC	0.50			0.49		
N	102 _{ml_id}			102 _{ml_id}		
	201 _{idyear}			201 _{idyear}		
Observations	210772			210772		
AUC	75.72%			64.45%		
AIC	240733.7			268742.0		
Marginal R ² / Conditional R ²	0.129 / 0.560			0.000 / 0.491		

Table S2.- Generalized linear mixed models results from a global model with day and night data. Log-odds, 95 % confidence interval, and p-value ($\alpha = 0.05$) for parameters included to predict habitat selection by mountain lions. We run two models consisting of a full model with all environmental variables, mountain lion id and year as random effects, and a null model with no fixed effects and mountain lion id and year as random effects.

Table S3.-

Predictors	Model 1 night			Model 2 night			Model 3 night		
	Log-Odds	CI	p	Log-Odds	CI	p	Log-Odds	CI	p
(Intercept)	0.40	- 1.80 – 2. 60	0.72 2	-1.81	- 6.32 – 2. 71	0.43 3	-2.28	- 6.95 – 2. 40	0.34 0
Distance to road	0.06	0.04 – 0. 07	<0.0 01	0.01	- 0.01 – 0. 03	0.24 9			
Distance to stream	-0.30	-0.31 – - 0.28	<0.0 01	-0.28	-0.30 – - 0.26	<0.0 01			
Slope	-0.25	-0.26 – - 0.23	<0.0 01	-0.28	-0.30 – - 0.27	<0.0 01			
Distance state highway	-0.25	-0.26 – - 0.23	<0.0 01	-0.27	-0.28 – - 0.25	<0.0 01			
Deer habitat suitability	0.51	0.49 – 0. 53	<0.0 01	0.49	0.47 – 0. 51	<0.0 01			
Distance to shrub	-0.28	-0.30 – - 0.25	<0.0 01	-0.27	-0.29 – - 0.24	<0.0 01			
Distance to grassland	-0.09	-0.11 – - 0.08	<0.0 01	-0.11	-0.12 – - 0.09	<0.0 01			
Distance to forest	-0.33	-0.34 – - 0.31	<0.0 01	-0.46	-0.48 – - 0.44	<0.0 01			
Age class [Subadult]	0.05	- 0.48 – 0. 58	0.84 1	-0.39	- 1.50 – 0. 72	0.48 9			
Sex [M]	-0.15	- 0.69 – 0. 38	0.57 8	0.08	- 1.04 – 1. 19	0.89 2			
Zenith brightness	-0.42	-0.45 – - 0.40	<0.0 01	0.23	- 0.06 – 0. 51	0.11 6	0.47	0.24 – 0. 70	<0.0 01
Upward radiance	-0.38	-0.42 – - 0.35	<0.0 01	-7.61	-9.66 – - 5.56	<0.0 01	-8.29	-10.56 – - 6.02	<0.0 01

Natural illumination	2.44	- 2.14 – 7.02	0.29	0.74	- 8.47 – 9.95	0.87	0.06	- 9.38 – 9.50	0.99
σ^2	3.29		3.29		3.29				
τ_{00}	0.69 ml_id		5.75 ml_id		6.41 ml_id				
	1.91 idyear		3.07 idyear		3.07 idyear				
τ_{11}		2.05 ml_id.'Zenith illumination'		127.82 ml_id.VIIRS					
		103.08 ml_id.VIIRS		1.34 ml_id.'Zenith illumination'					
ICC	0.44		0.73		0.74				
N	102 ml_id		102 ml_id		102 ml_id				
	201 idyear		201 idyear		201 idyear				
Observations	104736		104736		104736				
AUC	77.76%		82.60%		76.84%				
AIC	116430.1		107454.2		118696.3				
Marginal R ² / Conditional R ²	0.222 / 0.565		0.832 / 0.954		0.835 / 0.957				

Table S3.- Generalized linear mixed models results for a model with night light data.

Log-odds, 95 % confidence interval, and p-value ($\alpha = 0.05$) for parameters included within the global model used to predict habitat selection of mountain lions in California. *Model 1 night* includes all parameters, and mountain lion id and year as random effects in the model. *Model 2 night* consists of a complete model with all terms, mountain lion identity and year as random effects, and random slopes and intercepts for ALAN variables (upward radiance and zenith brightness) with fixed intercept variance. *Model 3 night* is a model that only includes light variables, mountain lion id and year as random effects, and slopes and intercepts for light variables.

Table S4.-

Predictors	Model 1 day			Model 2 day			Model 3 day		
	Log-Odds	CI	p	Log-Odds	CI	p	Log-Odds	CI	p
(Intercept)	- 0.87	-1.33 -- -0.41 2.30	<0.001	- 0.01	-3.37 -- 0.03 -- -0.00	<0.001	-2.54	-3.26 -- -1.82	<0.001
Distance to road	0.03	0.02 -- 0.05	<0.001	- 0.01	- 0.03 -- 0.00	0.137			
Distance to stream	- 0.29	-0.30 -- -0.27 0.26	<0.001	- 0.26	-0.28 -- 0.25	<0.001			
Slope	- 0.22	-0.24 -- -0.21 0.26	<0.001	- 0.26	-0.28 -- 0.25	<0.001			
Distance state highway	- 0.27	-0.29 -- -0.26 0.29	<0.001	- 0.29	-0.31 -- 0.27	<0.001			
Deer habitat suitability	0.52	0.50 -- 0.53	<0.001	0.51	0.49 -- 0.53	<0.001			
Distance to shrub	- 0.25	-0.27 -- -0.23 0.26	<0.001	- 0.26	-0.29 -- 0.24	<0.001			
Distance to grassland	- 0.10	-0.11 -- -0.08 0.12	<0.001	- 0.12	-0.13 -- 0.10	<0.001			
Distance to forest	- 0.32	-0.34 -- -0.30 0.48	<0.001	- 0.48	-0.50 -- 0.46	<0.001			
Age class [Subadult]	0.11	-0.43 -- -0.66 0.68	0.682	- 0.68	- 1.92 -- 0.56	0.282			
Sex [M]	- 0.26	-0.80 -- 0.28 0.88 -- 1.58	0.338	0.35	- 0.88 -- 1.58	0.575			
Zenith brightness	- 0.42	-0.44 -- -0.39 0.08	<0.001	0.08	- 0.37 -- 0.52	0.733	0.41	0.15 -- 0.66	0.002
Upward radiance	- 0.41	-0.45 -- -0.37 7.59	<0.001	- 7.59	-9.85 -- 5.32	<0.001	-8.92	-12.13 -- -5.72	<0.001
Natural illumination	0.01	0.00 -- 0.02	0.044	0.02	0.00 -- 0.03	0.009	0.02	0.01 -- 0.03	0.001
σ^2	3.29			3.29			3.29		

τ_{00}	0.72 <small>ml_id</small>	7.56 <small>ml_id</small>	11.21 <small>ml_id</small>
	1.99 <small>idyear</small>	3.18 <small>idyear</small>	3.27 <small>idyear</small>
τ_{11}		5.14 <small>ml_id.Zenith illumination</small>	260.98 <small>ml_id.VIIRS</small>
		125.84 <small>ml_id.VIIRS</small>	1.60 <small>ml_id.Zenith illumination</small>
ICC	0.45	0.77	0.81
N	102 <small>ml_id</small>	102 <small>ml_id</small>	102 <small>ml_id</small>
	200 <small>idyear</small>	200 <small>idyear</small>	200 <small>idyear</small>
<hr/>			
Observations	105919	105919	105919
AUC	77.58%	82.70%	77.27%
AIC	117463.8	108138.7	119723.9
Marginal R ² / Conditional R ²	0.215 / 0.569	0.815 / 0.957	0.812 / 0.965

Table S4.- Generalized linear mixed models results for a model with daylight data.

Log-odds, 95 % confidence interval, and p-value ($\alpha = 0.05$) for parameters included within the global model used to predict habitat selection of mountain lions in California. *Model 1 day* includes all parameters, and mountain lion identity and year as random effects in the model. *Model 2 day* consists of a complete model with all terms, mountain lion id and year as random effects, and random slopes and intercepts for ALAN variables (upward radiance and zenith brightness) with fixed intercept variance. *Model 3 day* is a model that only includes light variables, mountain lion identity and year as random effects, and slopes and intercepts for light variables.

Table S5.-

Predictors	Model without weights			Model with weights		
	Log-Odds	CI	p	Log-Odds	CI	p
(Intercept)	-1.87	-6.27 – -2.52	0.403	-11.64	-17.66 – -5.63	<0.001
Distance to minor road	0.02	0.00 – 0.03	0.034	0.03	0.02 – 0.04	<0.001
Distance to water point	-0.28	-0.30 – -0.27	<0.001	-0.32	-0.34 – -0.31	<0.001
Slope	-0.28	-0.30 – -0.26	<0.001	-0.32	-0.33 – -0.31	<0.001
Distance to major highway	-0.27	-0.29 – -0.25	<0.001	-0.24	-0.25 – -0.23	<0.001
Deer habitat suitability	0.48	0.46 – 0.50	<0.001	0.49	0.48 – 0.50	<0.001
Distance to shrubland	-0.28	-0.31 – -0.26	<0.001	-0.23	-0.25 – -0.21	<0.001
Distance to grassland	-0.12	-0.14 – -0.10	<0.001	-0.10	-0.12 – -0.09	<0.001
Distance to forest	-0.45	-0.47 – -0.43	<0.001	-0.42	-0.43 – -0.41	<0.001
Age class [Subadult]	-0.38	-1.46 – -0.70	0.488	-0.88	-2.39 – -0.62	0.251
gender [M]	0.20	-0.88 – -1.29	0.713	0.56	-0.95 – -2.08	0.468
Zenith brightness	0.23	-0.04 – -0.49	0.098	0.33	0.02 – -0.64	0.037
VIIRS	-7.35	-9.23 – -5.47	<0.001	-10.09	-13.13 – -7.06	<0.001
Natural illumination	0.70	-8.27 – -9.67	0.878	-4.18	-16.39 – -8.04	0.503
Random Effects						
σ^2	3.29			3.29		
τ_{00}	5.36 ml_id			12.18 ml_id		
		3.02 $idyear$		3.43 $idyear$		
τ_{11}	1.79 $ml_id.Zenith\ brightness$			2.49 $ml_id.Zenith\ brightness$		
	85.43 $ml_id.VIIRS$			235.76 $ml_id.VIIRS$		

ρ_{01}		
ρ_{01}		
ICC	0.72	0.83
N	102 ml_id	102 ml_id
	201 idyear	201 idyear
Observations	104736	104736
Marginal R ² / Conditional R ²	0.829 / 0.952	0.846 / 0.973

Table S5.- Generalized linear mixed models results for a model with night data. Log-odds, 95 % confidence interval, and p-value ($\alpha = 0.05$) for parameters included within the global model used to predict habitat selection of mountain lions in California. *Model without weights* includes all parameters, mountain lion identity and year as random effects in the model and random slopes and intercepts for ALAN variables (upward radiance and zenith brightness) with fixed intercept variance. *Model with weights* consists of the same model but with a weighted likelihood. To this end, we created a weight variable, where the mountain lion used points had weight 1, and available points obtained a large weight following Muff et al. 2020 approach.

Figure S1.-

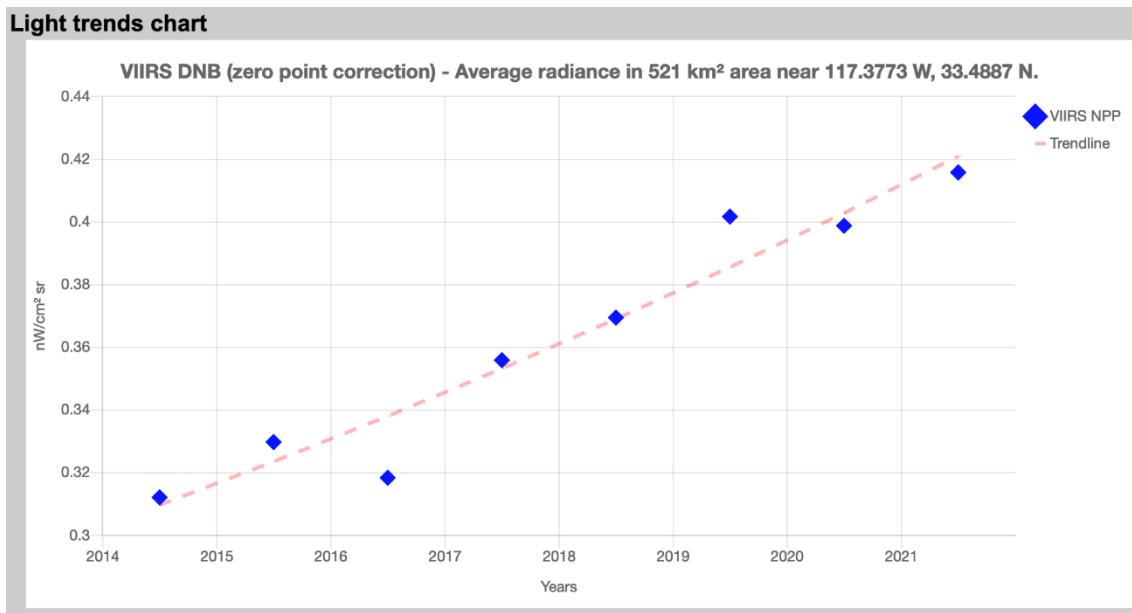


Figure S1.- Temporal autocorrelation in VIIRS data in an area randomly selected in the study region to exemplify how VIIRS values, although increasing annually, were highly correlated among successive years for a certain locality.

Figure S2.-

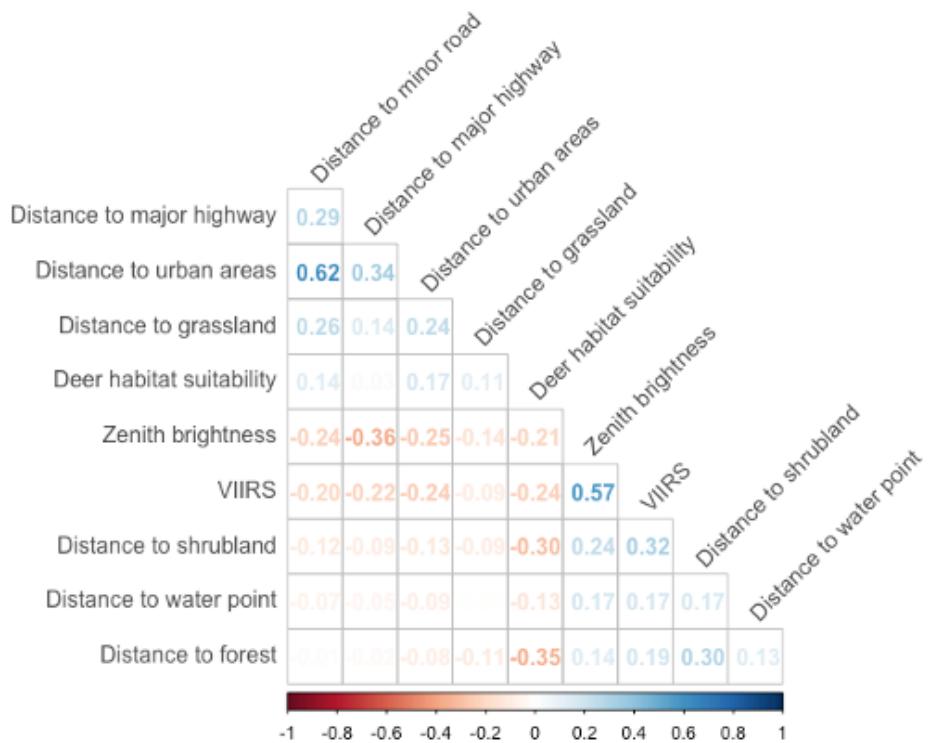


Figure S2.- Correlation matrix with the Pearson parametric coefficient among predictors.

Blue colours imply positive correlations and red colours negative ones.

Figure S3.-

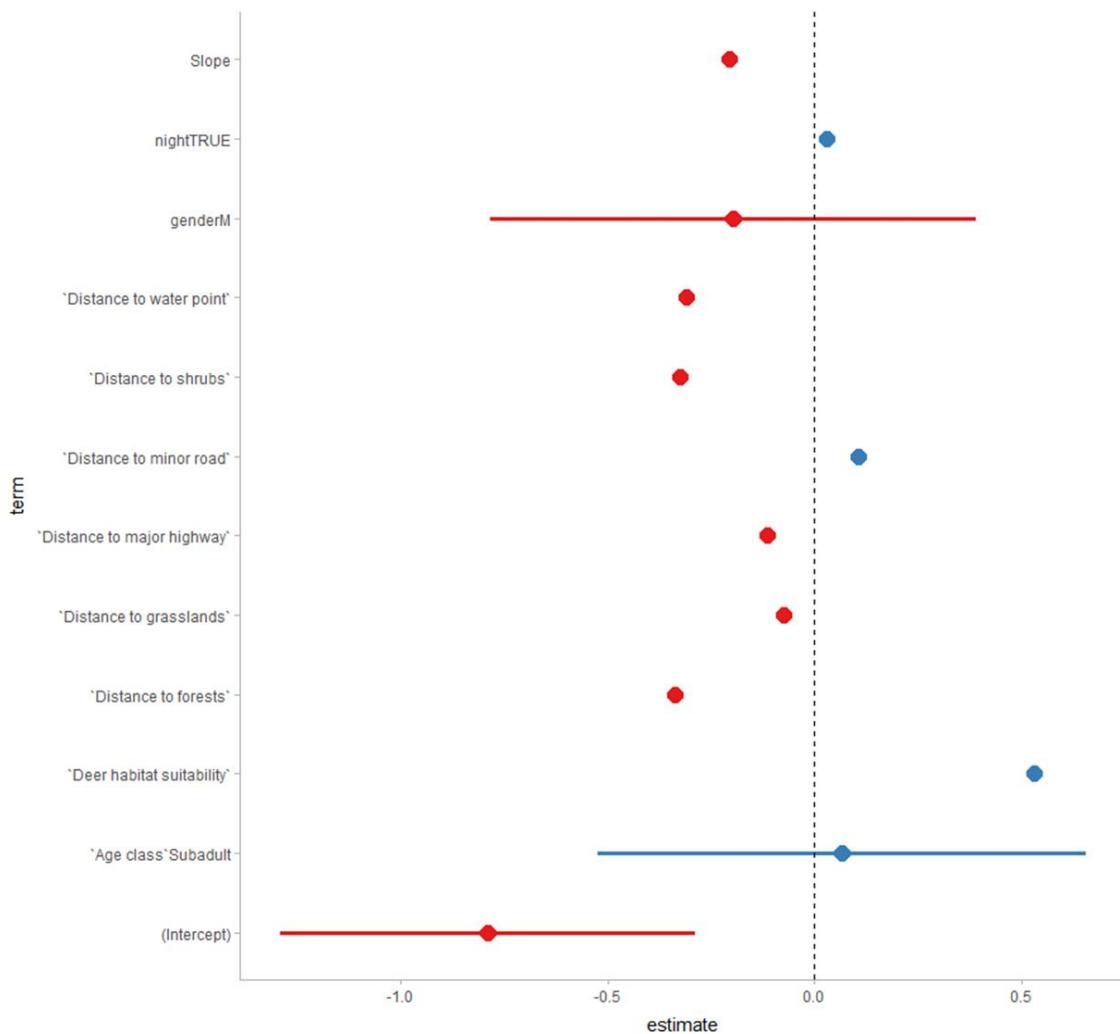


Figure S3.- Standardized coefficients from the global generalized linear mixed models of the mountain lion habitat selection with both day and night light data. Points indicate the mean coefficients, thick bars indicate the 95% credible intervals of the coefficient values. Red and blue line colours indicate negative, and positive effects, respectively. The reference level for the categorical variable Age class is “Adult” and for the gender “Female”. The overlap of the error bars with the dashed line at zero indicates that the effect of the parameter is not statistically significant (i.e. $p > 0.05$).

Figure S4.-

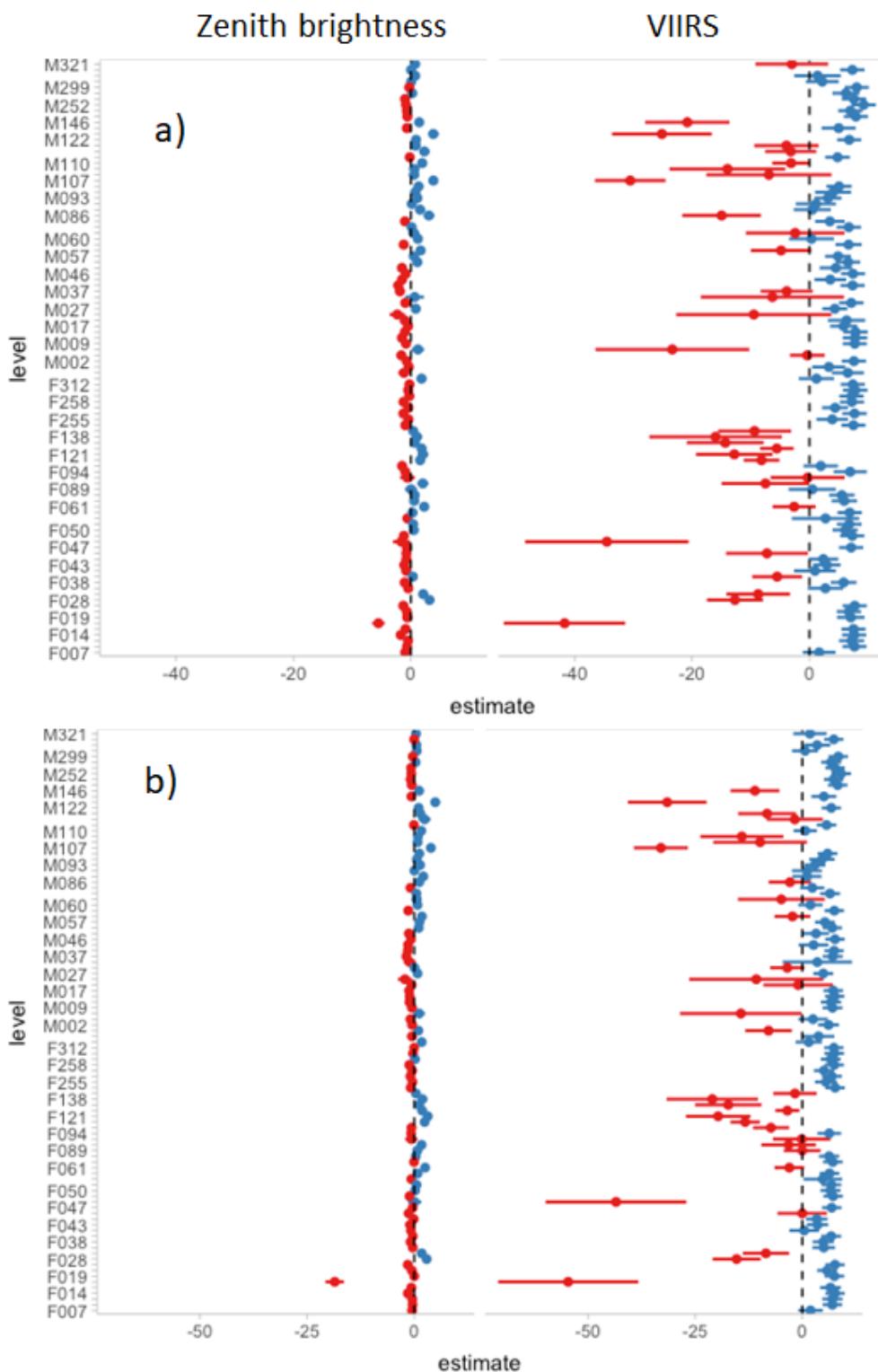


Figure S4.- Predicted values for the random slope effects for zenith brightness and upward radiance (VIIRS) from the generalized linear mixed models of the mountain lion habitat selection for a) night and b) day light data. Points indicate the mean coefficients, thick bars indicate the 95% credible intervals of the coefficient values. Red and blue line colours indicate negative, and positive effects, respectively.