Stacks

Supplemental Information: Spatial and temporal activity of wildlife on and surrounding cannabis farms

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Supplemental Information

Appendix S1

Appendix Table 1. Single species occupancy model results, given as estimate means and standard deviations.

	Detection Covariates								
Species	**Intercept**	**Cannabis**	**Type**	**ViewDist**	**JDate**	**JDate^2**	**HAI**	**DAI**	**Misfires**
bear	-2.57 (0.32)*	0.03 (0.16)	-0.22 (0.25)	-0.06 (0.14)	1.09 (0.23)*	-1.36 (0.31)*	0.32 (0.17)	-0.26 (0.21)	-0.71 (0.27)*
deer	-1.71 (0.1)*	0.25 (0.05)*	0.74 (0.09)*	0.09 (0.04)*	0.27 (0.05)*	-0.6 (0.06)*	0.23 (0.03)*	-0.02 (0.06)	0.04 (0.09)
bobcat	-6.32 (0.99)*	0.91 (0.47)	-0.39 (0.53)	0.19 (0.28)	0.62 (0.31)	0.02 (0.37)	-4.99 (2.06)*	0.79 (0.26)*	0.59 (0.58)
coyote	-2.93 (0.3)*	0.42 (0.25)	0.97 (0.24)*	0.47 (0.13)*	0.26 (0.21)	-1.48 (0.38)*	0.03 (0.05)	0.42 (0.1)*	-0.24 (0.26)
gray fox	-3.17 (0.21)*	0.13 (0.07)	0.64 (0.16)*	0.34 (0.07)*	-0.06 (0.08)	0.0 (0.09)	0.01 (0.05)	0.22 (0.04)*	0.58 (0.18)*
jackrabbit	-1.81 (0.21)*	-0.15 (0.08)*	1.39 (0.14)*	0.09 (0.06)	-0.49 (0.12)*	-1.12 (0.17)*	0.52 (0.06)*	0.24 (0.08)*	-0.46 (0.15)*
raccoon	-4.0 (0.56)*	-1.56 (0.44)*	0.39 (0.41)	-0.02 (0.21)	-0.05 (0.34)	0.51 (0.76)	-0.03 (0.08)	0.19 (0.14)	0.91 (0.4)*
skunk	-3.37 (0.24)*	0.05 (0.12)	1.12 (0.18)*	0.04 (0.08)	0.16 (0.12)	-0.91 (0.16)*	0.27 (0.04)*	-0.04 (0.07)	0.5 (0.22)*
ground squirrel	0.22 (0.45)	0.76 (0.2)*	-2.06 (0.26)*	0.41 (0.12)*	-0.91 (0.25)*	-1.35 (0.36)*	-0.02 (0.05)	-0.15 (0.13)	0.33 (0.35)
gray squirrel	-1.56 (0.13)*	-0.06 (0.08)	-0.12 (0.11)	0.03 (0.06)	0.07 (0.06)	-0.08 (0.07)	0.05 (0.14)	-0.37 (0.1)*	-0.43 (0.15)*
turkey	-2.67 (0.35)*	0 (0.21)	0.12 (0.29)	-0.19 (0.12)	-0.1 (0.18)	-0.29 (0.25)	0.23 (0.14)	-0.1 (0.13)	0.52 (0.27)*
California quail	-3.23 (0.91)*	-1.68 (0.69)*	-1.22 (0.78)	0.54 (0.28)	-0.42 (0.66)	-0.7 (0.98)	-0.1 (0.12)	0.57 (0.32)	-0.11 (0.63)
mountain quail	-6.62 (1.1)*	-1.04 (0.42)*	1.43 (0.5)*	0.44 (0.2)*	0.11 (0.3)	0.14 (0.35)	-0.14 (1.31)	-3.97 (2.87)	2.15 (0.47)*
dog	-4.46 (0.29)*	-0.34 (0.14)*	0.89 (0.22)*	0.29 (0.1)*	-0.08 (0.1)	-0.06 (0.11)	0.07 (0.04)	1.64 (0.08)*	-0.16 (0.24)

	Occupancy Covariates						
Species	**Reg1**	**Reg2**	**Reg3**	**Cannabis**	**Elevation**	**Forest**	**Roads**
bear	-0.35 (1.24)	-0.23 (0.58)	5.06 (3)*	-0.19 (0.89)	-0.28 (0.85)	0.02 (0.38)	0.85 (1.24)
deer	3.75 (1.68)*	4.65 (1.73)*	0.48 (0.77)	1.03 (0.54)*	-0.68 (0.42)	-0.07 (0.39)	-0.1 (0.51)
bobcat	2.73 (3.35)	-3.19 (2.24)	4.22 (3.99)	-1.37 (2.27)	-0.12 (1.43)	0.94 (1.99)	1.08 (1.61)
coyote	-7.55 (2.79)*	1.85 (0.89)*	-10.24 (3.05)*	0.75 (1.28)	-2.46 (1.57)	0.11 (0.7)	-2.17 (1.51)
gray fox	-0.46 (0.6)	-0.55 (0.42)	2.53 (0.77)*	-0.9 (0.42)*	-0.11 (0.4)	-0.21 (0.28)	-0.62 (0.43)
jackrabbit	-3.91 (1.23)*	1.64 (0.63)*	-3.41 (1.16)*	0.14 (0.62)	-0.36 (0.56)	-1.13 (0.41)*	-0.98 (0.55)
raccoon	-8.05 (2.78)*	0.37 (1.16)	-8.25 (3.4)*	2.62 (1.44)*	0.53 (2.25)	0.57 (0.83)	-1.97 (1.62)
skunk	2.05 (2.07)	1.24 (0.5)*	-0.97 (0.98)	0 (0.54)	-1.34 (0.57)*	-0.1 (0.35)	-0.53 (0.47)
ground squirrel	-1.94 (0.99)*	-1.04 (0.51)*	-3.57 (1.43)*	-1.01 (0.56)	-0.51 (0.74)	-0.84 (0.42)*	-0.13 (0.6)
gray squirrel	1.68 (0.61)*	0.13 (0.41)	0.45 (0.68)	0.51 (0.42)	-1.03 (0.38)*	1.13 (0.29)*	0.81 (0.41)*
turkey	-0.8 (0.87)	0.83 (0.43)*	-6.88 (1.56)*	0.72 (0.45)	-3.44 (0.84)*	0.6 (0.33)	0.52 (0.51)
California quail	-6.88 (3.37)*	-0.86 (1.13)	-2.85 (4.26)	3.7 (1.71)*	-0.93 (2.48)	-0.21 (0.98)	-3.77 (2.23)*
mountain quail	1.29 (2.85)	-6.43 (2.54)*	5.16 (3.13)	4.04 (2.23)*	2.63 (1.89)	-0.25 (1.04)	0.07 (1.75)
dog	2.69 (2.41)	9.23 (2.85)*	2.68 (2.7)	-3.39 (1.56)*	-2.85 (1.88)	-2.92 (1.34)*	3.75 (2.11)*

Cells with a star (*) indicate that the 95% credible interval for that estimate does not overlap zero. Wild animal species are listed in descending body size order, with domestic dogs at the end.

Appendix S2

Appendix S2. The full equation and derivation.

Inference on the effect of distance to cannabis on nocturnality

Following Rivera et al., we can define a "nocturnality factor" at site i, θ_i, as

$$\theta_i = \frac{\psi_{i,3}}{\psi_{i,\text{cond}}}$$

where

$$\psi_i^{\text{cond}} = \psi_i^2 + \psi_i^3 + \psi_i^4$$

This value gives the ratio between the probability that the species uses site i during the night only to the probability that the species occupies the site at all (ψ_i^{cond}).

For each species, we want to ask the question: does a species' nocturnality vary credibly with change in the distance of a site to cannabis (all else held equal)? Since θ_i is only indirectly connected to the parameters representing the effects of cannabis on occupancy β_c^{Night} and β_c^{Day}, there is no parameter that directly corresponds to this value.

However, we can calculate a partial derivative of nocturnality with respect to distance to cannabis, $\frac{d\theta}{dc}$. For a given distance to cannabis c,

$$\theta = \frac{\psi_3}{\psi_{\text{cond}}}$$

Based on the model equations provided in the main text,

$$\psi_3 = \frac{\phi_3}{\sum \boldsymbol{\phi}}$$

$$= \frac{e^{\beta_c^{\text{Night}} c + k}}{e^{\beta_c^{\text{Night}} c + k} + e^{\beta_c^{\text{Day}} c + k} + e^{\beta_c^{\text{Night}} c + \beta_c^{\text{Day}} c + k} + 1}$$

and

$$\psi_{\text{cond}} = \frac{e^{\beta_c^{\text{Night}} c + k} + e^{\beta_c^{\text{Day}} c + k} + e^{\beta_c^{\text{Night}} c + \beta_c^{\text{Day}} c + k}}{e^{\beta_c^{\text{Night}} c + k} + e^{\beta_c^{\text{Day}} c + k} + e^{\beta_c^{\text{Night}} c + \beta_c^{\text{Day}} c + k} + 1}$$

where k is used in place of constants that do not depend on c.

Therefore,

$$\theta = \frac{e^{\beta_c^{\text{Night}} c + k}}{e^{\beta_c^{\text{Night}} c + k} + e^{\beta_c^{\text{Day}} c + k} + e^{\beta_c^{\text{Night}} c + \beta_c^{\text{Day}} c + k}}$$

Taking a partial derivative of θ with respect to c, we find that nocturnality changes with distance to cannabis for a given value of c as

$$\frac{d\theta}{dc} = \frac{(\beta_c^{\text{Night}} - \beta_c^{\text{Day}}(e^{\beta_c^{\text{Night}} c} + 1))e^{(\beta_c^{\text{Night}} + \beta_c^{\text{Day}})c}}{(e^{(\beta_c^{\text{Night}} + \beta_c^{\text{Day}})c} + e^{\beta_c^{\text{Night}} c} + e^{\beta_c^{\text{Day}} c})^2}$$

This value, though complicated, is easily calculated for a given value of c. Note that since c still appears in the partial derivative, the value will depend on the choice of c (though not on the level of other covariate data). We compute this value for three levels of c representing 0 m, 100 m, and

1000 m from cannabis. We then generate a posterior predictive distribution of $\frac{d\theta}{dc}$ at those values for each species. If the 95% credible interval of one of those posterior distributions does not overlap zero, we interpret this as evidence that the species' nocturnality (its propensity to use space only nocturnally as opposed to during the day) depends on the distance of the site to cannabis.