

Ecography

ECOG-04743

Smith, M. M. and Goldberg, C. S. 2019. Occupancy in dynamic systems: accounting for multiple scales and false positives using environmental DNA to inform monitoring. – Ecography doi: 10.1111/ecog.04743

Supplementary material

Appendix 1

Table A1: Quantitative PCR assay design for Columbia spotted frog in the Great Basin (*Rana luteiventris*). Assay was validated with 5 of each species listed.

Forward Primer	TTCAATGAATCTGAGGAGGCTTTT
Reverse Primer	GAAAGGAAGGATGAAGTGGAAATGT
Probe	6FAM-AGTAGACAATGCTACCCTC-MGB

Table A2a: A list of covariates used to model occupancy at the watershed level (ψ). Includes mean and range of covariate as well as description and source information.

Covariate	Mean (range)	Description	Source
Precipitation	415.8 (13.8 – 1060.8 mm)	Mean annual precipitation within watershed	PRISM climate group; 30 year normals (1981-2010); 800 m
Temperature	3.39 (0.68 – 7.09 °C)	Mean annual temperature within watershed	PRISM climate group; 30 year normals (1981-2010); 800 m
Slope	0.048 (0.015 – 0.159)	Average slope along stream flowlines within watershed	NHDPlus Dataset
Streams	74.4 (23.3 – 151.6 km)	Sum of stream lengths within watershed	NHDPlus Dataset

Table A2b: A list of covariates used to model occupancy at the site level (θ). Includes mean and range of covariate as well as description and source information.

Covariate	Mean (range) or count	Description	Source
Precipitation	481.5 (202.3 – 1102.5 mm)	Mean annual precipitation of site	PRISM climate group; 30 year normals (1981-2010); 800 m
Temperature	6.30 (3.62 – 9.15 °C)	Mean annual temperature of site	PRISM climate group; 30 year normals (1981-2010); 800 m
Elevation	1917 (1089 – 2721 m)	Elevation of site	National Elevation Dataset; 10m
Emergent Vegetation	0% - 27; <25% - 32; 25-50% - 10; >50% - 99	Percent shoreline covered with emergent vegetation	On site survey
Water type	Lake/pond - 44; stream - 68; beaver pond - 56	Aquatic habitat description at survey site	On site survey
Livestock impact	None - 83; low - 38; moderate - 26; high - 21	Impact of livestock around perimeter of site	On site survey

Table A2c: A list of covariates used to model detection at the eDNA sample level (p). Includes mean and range of covariate as well as description and source information.

Covariate	Mean (range)	Description	Source
Water temperature	18.2 (6.3 – 29.1 °C)	Measured water temperature from sample location	On site survey
pH	8.5 (6.8 – 10.6)	Measured pH from sample location	On site survey

Table A3: List of hypotheses at each scale for watershed occupancy (ψ), site occupancy (θ), and detection (p). All combinations were modeled for a total of 75 candidate models.

ψ (.)	θ (.)	p (.)
ψ (streams)	θ (elevation)	p (pH)
ψ (slope)	θ (livestock impact)	p (water temperature)
ψ (precipitation + temperature)	θ (precipitation + temperature)	
ψ (precipitation + temperature + streams)	θ (emergent vegetation + water type)	

Table A4: Coefficient estimates from the strongest supported candidate model for multi-scale occupancy of the Columbia spotted frog (*Rana luteiventris*) in the Great Basin, ψ (precipitation + temperature) θ (emergent vegetation + water type) p (water temperature). Lower and upper confidence intervals at 95%. Estimate in parentheses represents the range from the resampled datasets with false positives.

	Estimate	Standard Error	Lower limit of C.I.	Upper limit of C.I.
ψ				
Precipitation	0.91 (0.84 - 0.91)	0.36	0.21	1.61
Temperature	-1.31 (-1.33 - -1.16)	0.50	-2.28	-0.34
θ				
Emergent vegetation	1.10 (1.02 - 1.20)	0.25	0.60	1.59
Water type – Lake/pond	-0.19 (-0.31 - -0.1)	0.37	-0.92	0.55
Water type – Stream	0.63 (0.40 - 0.67)	0.38	-0.13	1.38
Water type – Beaver pond	0.57 (0.50 – 0.67)	0.35	-0.11	1.27
p				
Water temperature	0.11 (0.09 – 0.13)	0.04	0.03	0.20