Multi-Scale Occupancy Estimation Using NABat Data in Colorado: Effects of Noise, Clutter, and Weather

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Background

- The North American Bat Monitoring Program (NABat) is a continental scale effort to monitor bat populations.[1]
- In Colorado, researchers have deployed stationary acoustic detectors for NABat across the state since 2014.
- Multi-scale occupancy modeling allows us to estimate occupancy at two scales: the grid (Ψ) and detector (θ) level.[2]
- This study investigated how noise, along with other site and time covariates, affects the occurrence of four common Colorado bat species using data collected in 2016.

Hypotheses

- Noise will have a negative relationship with occupancy, with more pronounced effects at the local, detector (θ) scale.
- Noise effects will vary depending on species, with greater impacts expected for low-frequency, widespread (as opposed to urban-adapted) bats.

Top left: *Myotis lucifugus* (High frequency-urban adapted). Top right: *Eptesicus fuscus (*Low frequency, urban-adapted). Bottom left: *Myotis ciliolabrum* (High frequency, widespread). Bottom right: *Lasiurus cinereus* (Low frequency, widespread).
Photo sources: MYLU-Roger W. Barbour /www.discoverlife.org; EPFU and LACI- Dan Neubaum/ www.cnhp.colostate.edu/teams/zoology/cbwg; MYCI- Stan Tekiela Nature Smart Wildlife Images, https://www.flickr.com/photos/naturesmartimages/5466531162/in/photolist-AWubRS-9k4pgh

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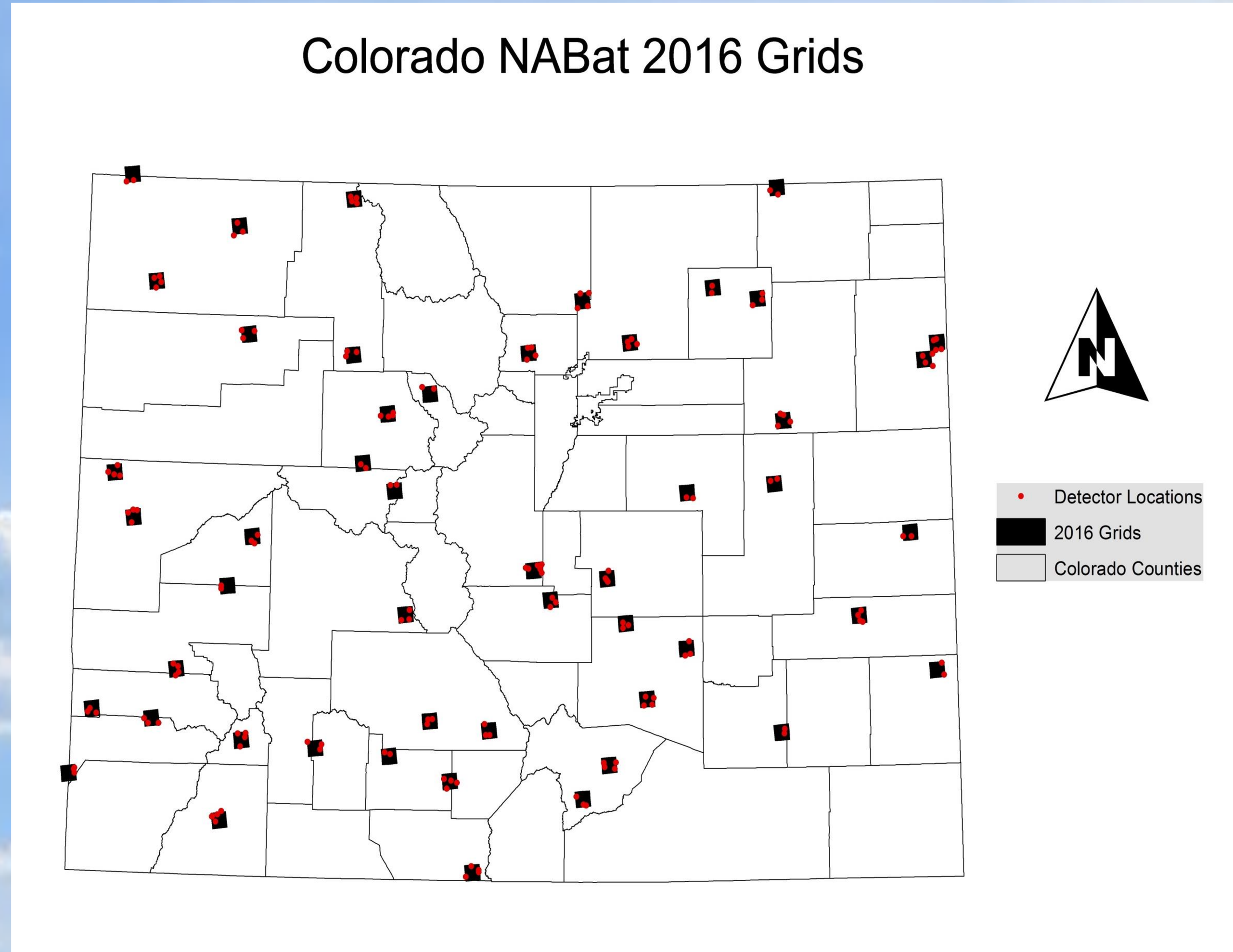

Methods

- 50 grids selected using the generalized random-tessellation stratified (GRTS) survey design algorithm.[3]
- 2-4 acoustic detectors placed in each grid for 4 nights during summer of 2016.
- Acoustic data processed using Sonobat 3.1 Great Basin.
- Calls identified to consensus were manually vetted for each species for each night of survey.
- "Noise" level defined as the difference between existing and natural sound pressure levels (decibels), based on GIS data provided by the NPS Natural Sounds and Night Skies Division.
- "Clutter" was classified as an estimate of obstacles in the flight environment.[4]
- Other covariates included elevation, land cover type, temperature, wind speed, and precipitation.
- Data analyzed for each species using multi-scale occupancy estimation in MARK v8.2. (K=4 detectors, L=4 nights)

Literature Cited

[1]Loeb, S.C.; Rodhouse, T.J.; Ellison, L.E.; Lausen, C.L. [and others]. 2015. A plan for the North American Bat Monitoring Program (NABat). Gen. Tech. Rep. SRS-208. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 100 p.
[2]Nichols, J.D., Bailey, L.L., O'Connell Jr., A.F., Talancy, N.W., Campbell Grant, E.H., Gilbert, A.T., Annand, E.M., Husband, T.P., Hines, J.E. 2008. Multi-scale occupancy estimation and modelling using multiple detection methods. *Journal of Applied Ecology* 45:1321-1329.
[3]Stevens, D.L. and Olsen, A.R. 2004. Spatially balanced sampling of natural resources. *Journal of the American Statistical Association*. 99: 262–278.
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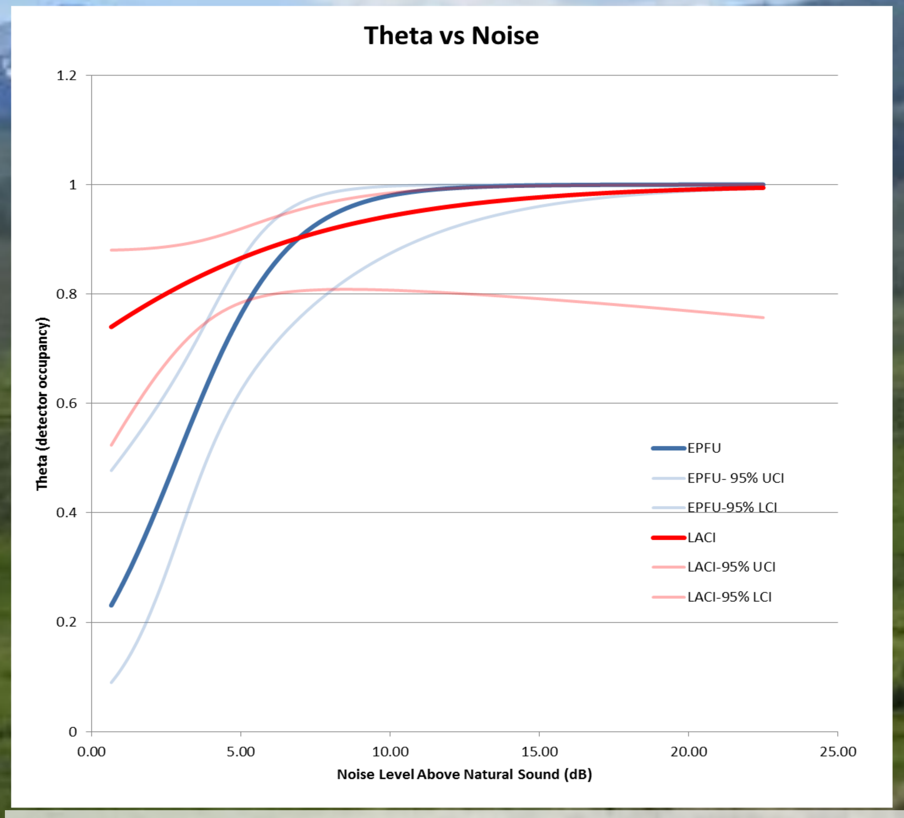
Results

- Occupancy at the detector (θ) level positively influenced by noise for *L. cinereus* (w_+=0.65), and *E. fuscus* (w_+=0.99).
- Clutter had a positive relationship with detection probability in the top models for *L. cinereus* (w_+=0.99), *E. fuscus* (w_+= 0.77), and *M. lucifugus* (w_+= 0.64).
- Noise was not supported as a covariate for occupancy at the grid (Ψ) level for any of the four species.
- Wind had a negative relationship with detection probability in the top models for *E. fuscus* (w_+= 0.99), , *M. lucifugus* (w_+= 0.42), , and *M. ciliolabrum* (w_+= 0.51).

Species	Model	AIC_c	Delta AIC_c	$AIC_{c\ Weight}$	No. Parameters
MYLU	psi(elevation)theta(.)p(clutter+wind)	595.4980	0.0000	0.17389	6
	psi(elevation+noise)theta(.)p(clutter+wind)	595.5608	0.0628	0.16851	7
	psi(elevation+noise)theta(.)p(clutter)	595.8552	0.3572	0.14545	6
	psi(elevation)theta(.)p(clutter)	595.9456	0.4476	0.13902	5
EPFU	psi(.)theta(noise)p(clutter+temp+wind)	559.7089	0.0000	0.27825	7
	psi(.)theta(noise)p(clutter+wind)	559.9814	0.2725	0.24280	6
MYCI	psi(elevation)theta(.)p(wind)	458.5739	0.0000	0.16975	5
	psi(.)theta(.)p(wind)	458.7027	0.1288	0.15916	4
	psi(elevation)theta(.)p(.)	459.6341	1.0602	0.09991	4
	psi(elevation)theta(noise)p(wind)	459.7761	1.2022	0.09306	6
	psi(.)theta(.)p(.)	459.9005	1.3266	0.08745	3
	psi(.)theta(noise)p(wind)	460.1999	1.6260	0.07529	5
LACI	psi(.)theta(noise)p(clutter)	674.2123	0.0000	0.28124	5
	psi(elevation)theta(noise)p(clutter)	675.0713	0.8590	0.18304	6
	psi(.)theta(.)p(clutter)	675.3860	1.1737	0.15639	4



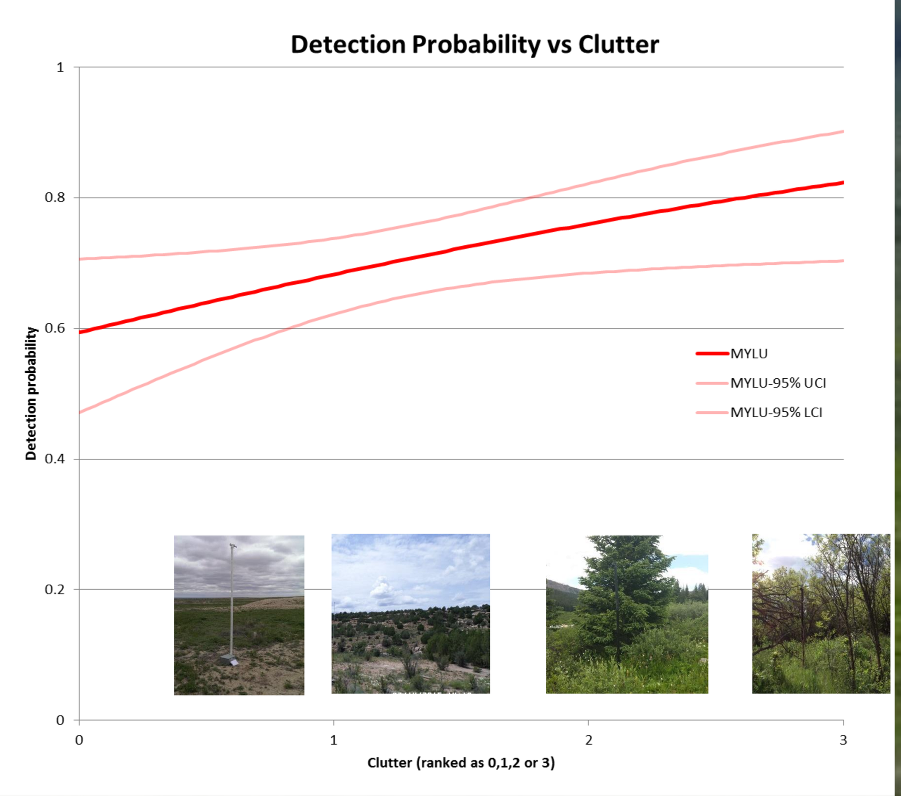


Figure 1. Theta (occupancy at detector scale) has a positive relationship with noise.
Figure 2: Detection probability has a positive relationship with clutter (examples of clutter ranking on x axis).

Conclusions

- The impacts of noise are more pronounced at small scales.
- Noise and small-scale occupancy are positively related for our two low-frequency bats- this could indicate that noise is an attractant or that sites with higher noise are correlated with another unconsidered covariate.
- Noise was not measured directly, the model simulated typical summer daytime noise levels-if measured nightly at the sites we might see different results.
- The positive relationship between detection probability and clutter could be attributed to the fact that cluttered environments could funnel bats into the small amounts of open space where we place detectors, leading to increased detections. In uncluttered open space, bats may not fly near enough to detectors to trigger recording.
- Similar to other studies, we find that higher wind speeds lead to less bat detections, especially for smaller species that maybe more affected by high wind speeds.