Lois Webster Fund Black Swift Movement Ecology Report

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Introduction:

Animal movement occurs on a wide spectrum of spatiotemporal scales and are important for understanding population dynamics and communities (Hanski 1999). Understanding movement patterns is paramount for species conservation, especially for species in decline. Identifying home range size and movement pattern use will inform wildlife management. However, this information is lacking for many species due to low density and or their cryptic nature.

Movement patterns are linked to the amount of available resources and their distribution in space and time. Specifically resources influence foraging activity and distances traveled across the landscape (Charnov et al. 2016) and are heterogeneously distributed across space and time (Johnson et al. 1992). The distribution and dynamics of available resources are conditioned on the scale a particular organism interacts with the landscape (Wiens and Milne 1989). Thus animals alter their behavior to maximize resource use at different scales (Fauchald and Tveraa 2006).

Black Swifts are aerial insectivores that forage on aerial plankton while on the wing. It is thought that they forage long distances from the nest but the time spent and distance from the nest is unknown. Our objectives are to 1) determine foraging range, foraging duration and distance at breeding locations, 2) Identifying foraging areas, 3) determine whether Black Swifts perform "aerial roosting" on the wintering grounds, 4) determine more precise wintering area(s).

We use continuous-time Markov chain (CTMC) in discrete space within a generalized linear model (GLM) framework to relate environmental variables to Black Swift movement during the breeding season and use a utilization density surface to estimate home range and explore hot spots.

Our collaborators at Lund University are currently analyzing the wing activity device data to determine whether Black Swifts perform aerial roosting on their wintering grounds.

Methods:

Field Methods

We captured swifts at Box Canyon, Fulton and Zapata Falls during the third week of July to the last week of August using 38mm-mesh mist nets. We attached gps tags and wing activity devices using a backpack harness method. We marked each individual captured with a U.S. Geological Survey aluminum band. We also recorded standard morphometric measurements including wing and tail length, mass, brood patch, cloacal protuberance, and fat measurements as described in Pyle (1997).

We deployed 5 gps tags in 2017, and deployed 7 wing activity devices. In 2019 we deployed an additional 13 gps tags.

Movement Model

Here we use a continuous-time Markov chain (CTMC) to model the Black Swift breeding movement through discrete space (Hanks et al. 2015). This process links movement data to environmental covariates and allows for the response to potential drivers of movement.

We used raster grids with a resolution of 500 meters square for our covariates on the CTMC discrete space GLM model. The spatial raster covariates were; topographic wetness index, elevation, river length and distance from nest.

The utilization density was calculated from the CTMC discrete GLM model. Model coefficients can be used to get a rate matrix for the entire study area. The rate matrix is used to calculate the limiting distribution of the Markov Chain which is an estimate of the proportion of time Black Swifts spends in each area (raster cell) (Wilson et al. 2018).

We also identified hotspots using spatial clustering based on distance (Getis and Ord 1992).

Results:

We recovered 2 of 5 gps tags in 2018. The recovery rate for gps tags was 40% however there are an additional 13 tags deployed in 2019 which will likely increase the gps tag recovery rate. In 2019 we recovered 6 wing activity devices and didn't recover additional gps tags. The recovery rate for the wing activity devices is 86%.

Mean daily foraging distance was 175 km and mean height was 3,213 meters. Foraging duration lasted at least 12 hours with some uncertainty due to missing gps locations during evening times. Missing gps locations are likely due to the limitation of the solar powered battery to recharge during late evening or early morning hours or during circumstances that create less direct sun. Generally foraging started at sunrise and continued into the evening.

There was a strong effect of distance to nest, a gradient variable and for the location based environmental variables there was a strong effect for elevation and river length (Table 1) on foraging behavior.

Table 1. Coefficient estimates from CTMC discrete space GLM looking at the effect of environmental variables on Black Swift movement. Distance from nest = nestdist (gradient variable), autocovariate = crw, elevation = elev (gradient variable), elevation = elev.loc (location variable), river length = river.loc (location variable). Bold indicates significant effects ($p<0.05$).

	Estimate	*SE*
(Intercept)	-6.80	0.09
nestdist	**-0.12**	**0.02**
crw	**1.32**	**0.02**
elev	-0.10	0.10
elev.loc	**-2.57e-4**	**2.35e-05**
wet.loc	0.01	0.01
river.loc	**-0.24**	**0.06**

The utilization density distribution is large as well as the 50% use core area (Figure 1). Hotspots were located in close proximity to the nest (Figure 1).

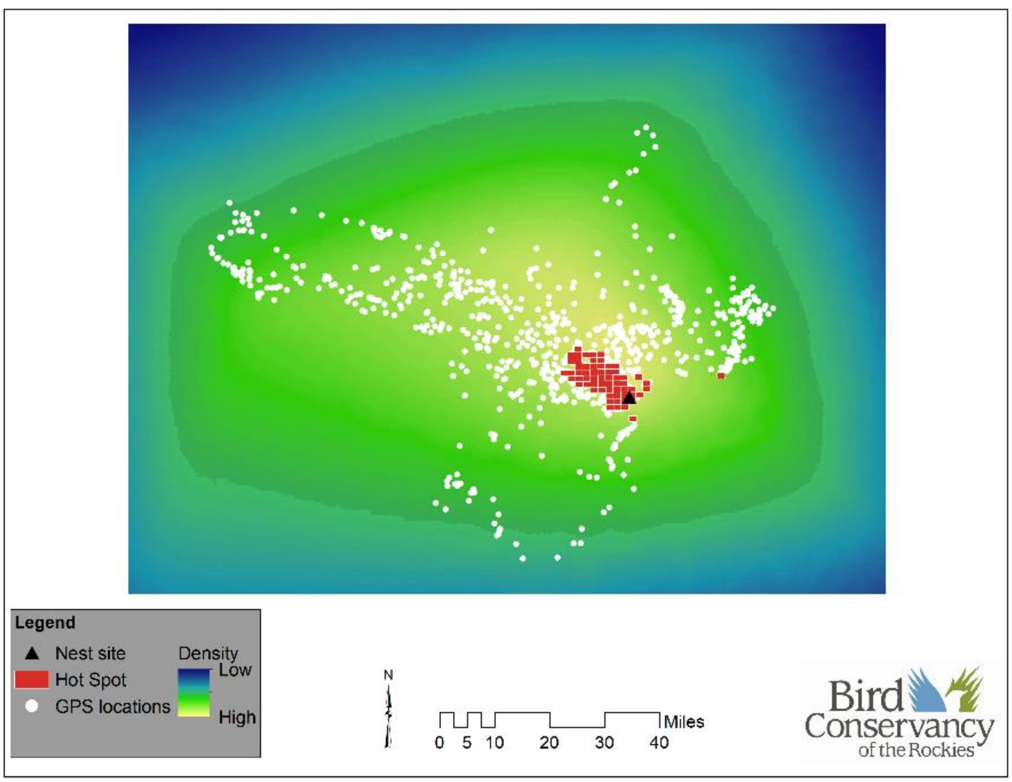

Figure 1. Black Swift utilization density distribution, gps locations, hotspots and core use area (shaded).

Discussion:

Continuous time discrete space movement models used here revealed for the first time how environmental covariates influence Black Swift foraging behavior and core use areas during the breeding season. Foraging duration increased with elevation and areas with rivers, likely related to higher insect abundance occurring near water and insect hatch date. Subalpine insect phenology during the month of August corresponds with snowmelt, which may explain foraging at higher elevations. The massive foraging flight distances may indicate insect availability is localized across the landscape and may also be related to shorter insect flight durations during late summer.

Black Swift foraging spatio-temporal patterns are related to insect availability across the landscape and may need to adapt to potentially declining prey availability. Reported global insect declines will impact aerial insectivor population demography. Unfortunately in North America, aerial insectivores including nightjars, swallows and swifts are already experiencing long-term population declines (Nebel et al. 2010, Smith et al. 2015), and these trends show a consistent pattern across North America. However it is unclear how big of a role insect declines and how the interaction of insect declines with other global patterns such as climate change may also be influencing aerial insectivore demography.

Understanding Black Swift spatial and temporal foraging patterns will help land managers develop conservation plans that incorporate space use and environmental relationships. The CTMC discrete space model estimates the transition rate of the movement process to each neighboring cell which can be viewed as available resources and defines preferential use of the resources in each cell. This process provides information about how animals are using the available habitat. Therefore, this method of obtaining utilization density distributions has similarities with resource selection and mechanistic home range modelling (Moorcroft, 2012), highlighting the difference between utilization densities obtained from kernel density estimation. The CTMC discrete modeling framework can incorporate multiple individuals to obtain inference at the population level. Population level inference will improve our understanding of foraging patterns across colonies.

We hope to recover more gps tags in 2020 to increase our sample size and strength of inference. Recovering more gps tags will also provide more precise migration and wintering location information. Understanding the extent of Black Swift flight activity during the wintering is currently being looked at by our collaborators at Lund University. This will have conservation implication for this species during their wintering period.

Conclusion

In August Black Swifts forage on average 175 km roundtrip each day at an average elevation of 3,213 meters. Foraging duration increased at higher elevations in areas with rivers or streams present. This is the first documentation of movement ecology for this species using fine scale gps data and will inform conservation plans for this species.

References:

Charnov E, Orians GH. Optimal foraging: some theoretical explorations. Seattle. 2006.

Fauchald P, Tveraa T. Hierarchical patch dynamics and animal movement pattern. Oecologia. 2006;149:383–95.

Getis, A. and J.K. Ord. 1992. The Analysis of Spatial Association by Use of Distance Statistics. *Geographical Analysis* 24(3).

Hanks, E. M.; Hooten, M. B. & Alldredge, M. W. Continuous-time Discrete-space Models for Animal Movement The Annals of Applied Statistics, 2015, 9, 145-165.

Hanski IA. Metapopulation ecology. Oxford: Oxford University Press; 1999.

Johnson A, Wiens J, Milne B, Crist T. Animal movements and population dynamics in heterogeneous landscapes. Landsc Ecol. 1992;7:63–75.

Moorcroft, P. (2012). Mechanistic approaches to understanding and predicting mammalian space use: Recent advances, future directions. Journal of Mammalogy, 93, 903–916.

Pyle, P. 1997. Identification Guide to North American Birds, Part I: Columbidae to Ploceidae. - Slate Creek Press. Bolinas, CA in press.

Smith, A. C., Hudson, M. A. R., Downes, C. M. and Francis, C. M. 2015. Change points in the population trends of aerial-insectivorous birds in North America: Synchronized in time across species and regions. - PLoS One 10(7).

Wiens J, Milne B. Scaling of “landscapes” in landscape ecology, or, landscape ecology from a beetle’s perspective. Landsc Ecol. 1989;3:87–96.

Wilson, K., E. M. Hanks, and D. S. Johnson. 2018. Estimating animal utilization densities using continuous-time Markov chain models. Methods in Ecology and Evolution 9:1232–1240.