UNGRATEFUL BIRDS:

Why don't American Kestrels use a lot of nest boxes we made for them?

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Small Packages of Fury

American Kestrels are one of the smallest raptors in North America[1]. Weighing no more than a stick of butter (90-160 grams), this feisty predator will consume anything that moves, hops, or slither, making them valuable as pest control especially around agricultural fields. Unfortunately, despite their label as common species[2], these birds face declining populations all across the US. Causes for this decline is unknown— there is speculation that this decline might be attributed to increases in predator population, pesticide use, and habitat loss.

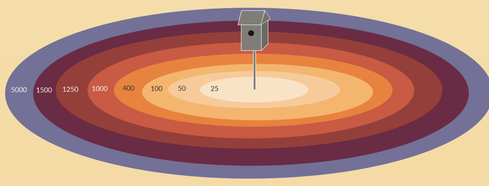
To combat this, many conservation programs across the US are erecting artificial nest boxes to increase local kestrel populations. However, many of them don't get used. Some nest boxes remain abandoned, while others are used initially and then fall sharply in use in subsequent years. And while kestrel populations are generally in decline, there are some regions that experience *increases* in population. So are we guessing wrong on habitat? This study investigates on what actually constitutes good habitat for the American Kestrel and how a breeding pair chooses a nest site. The results from this study will help inform program managers where to place future nest boxes to help increase these charismatic raptor species.

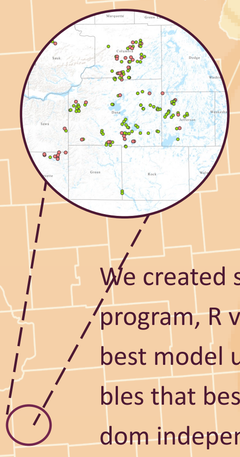
Methods

Recent research has move towards using a multi-scale approach, since animals, especially birds, may consider features in the landscape at coarser scales. For our study, we used several spatial scales to analyze nest site selection in American Kestrels. Since we don't know at what spatial levels American Kestrels use to evaluate nest sites, we chose range of scales

Using ArcMap ver. 10.5.1, we chose 3 major categories of scales and created 8 total circular buffers around the nest boxes (in meters radius):

1. **Nest Box Level** (25, 50, 100, 400 m)
2. **Area around Nest Box** (1000, 1250, 1500 m)
3. **Landscape Level** (5000 m)





We then selected various different factors based on kestrel literature and observations from nest box managers (listed below) and imported data into tables for each nest box at each spatial scale. We used pairwise scatterplots and Pearson's R to check for multi-collinearity. For our study, we used nest box data from Madison Audubon, which consists of 153 total nest boxes placed around Madison, WI and over 7 years of occupancy data.

We created stepwise logistic regressions using the generalized linear model (GLM) in the statistical program, R ver. 3.5.1. This function adds on variables to each subsequent model and evaluates the best model using AIC (Akaike Information Criterion) scores. We used the best model with the variables that best explain for variance in occupancy and added year and individual nest box ID as random independent factors to account for possible pairs that may return to nest boxes in consecutive years. We've split our results in nine total models, 8 with spatial dependent models for each scale and 1 for non-spatial scales.

Results & Conclusions

Based on the results, it is more beneficial to have nest boxes further away from dense human populations, closer to open habitat, further away from forest edge, and more surprisingly, closer to wetland areas and away from other nest boxes. Most variables that have a positive impact on occupancy are at the smaller spatial scales (100 - 1000) which we would associate with open features—shrub/scrub, hay/pasture, grassland, tend to have negative impacts are larger scales. This may be that the more suitable habitat at larger scales, the more likely you'll run into competition with other kestrels. At the largest scale, these variables become favorable again, which may be indicative of a quadratic relationship with spatial scales instead of a linear one. As for wetlands, it could be possible that these birds enjoy the amount of dragonflies and insects that hang around there.

Spatial Dependent Factors	25	50	100	400	1000	1250	1500	5000
Total Population	-1.73*	-1.67*	-1.47*	-1.09*	-1.54*	-1.51*	-1.40*	-2.9**
Open Water	-0.19			3.39	-0.67*	-1.88**	-2.49***	-1.2**
Woody Wetlands				3.99	-0.3	-1.17**	-1.28**	-1.2**
Cultivated Crop			8.2	20.4		-3.5*	-4.7**	
Deciduous Forest	-0.09	-0.21	4.9	11.3	-0.29	-2.5**	-3.1**	
Mixed Forest		0.18			-0.07			-0.57*
Shrub/Scrub	0.39	0.32	0.8*	1.5	-0.33	-0.6*	-0.77**	-0.82**
Emergent Wetlands		-1.2	0.89	5.8	0.08	-1.6*	-1.98**	0.69*
Urban Cover			2.38	9.7	-0.25	-1.9*	-2.3*	2.24**
Hay/Pasture			6.16	14.9	0.38*	-1.79*	2.43**	
Grassland			0.94*	1.88*	0.17			0.39
Evergreen Forest			0.32	1.13*	0.34		-0.3	0.65**
Habitat Perimeter: Area								0.721**

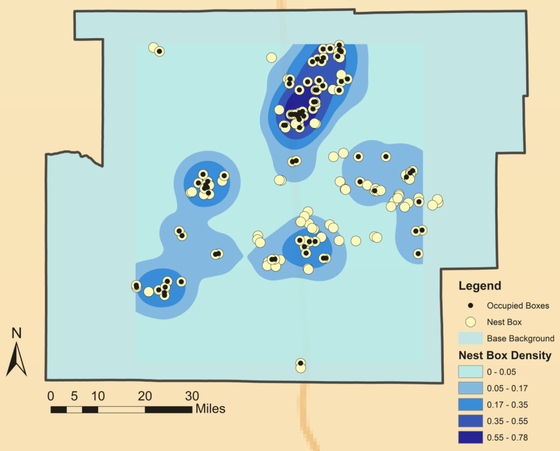
= significantly negative
= significantly positive
= insignificant
= not included high AIC

* = significance level

Non-Spatial Factors	Estimates	P-Value
Distance to Roads	0.049	
Distance to Forest	0.362	***
Distance to Wetlands	-0.59	**
Distance to Transmission	0.091	
Nearest Occupied Nestbox	-0.711	***

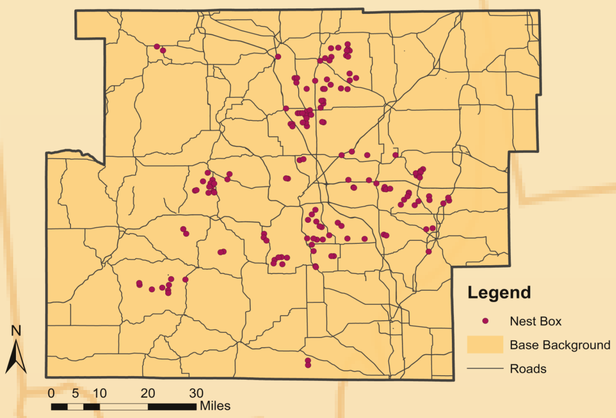
As part of a larger study, we will look into other state data and include a measure of openness using LiDAR data to investigate variables that impact occupancy at a larger regional scale. We will also need to split roads into different types as highways may have different impacts than country roads.

Nest Box Density



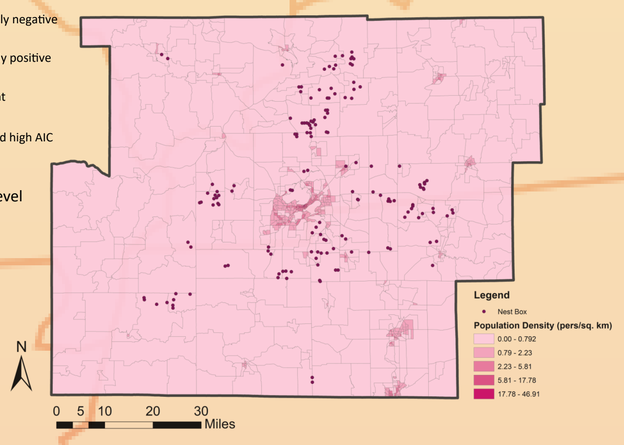
Kestrels tend to be territorial[2]. We've included the distance to nearest occupied nest box for each nest box as variable as a result. This map shows the cluster of nest boxes using Kernel Density.

Roads



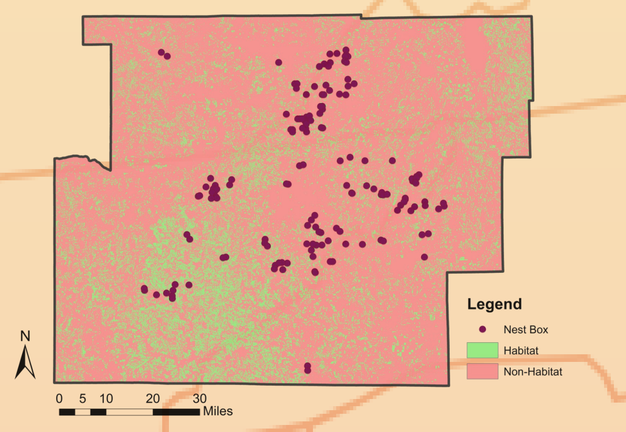
Roads can provide open spaces for hunting and foraging for kestrels along roadsides. There are also often power lines along roadsides for perching. They can also be a risk for kestrels with vehicular threats and accidents.

Population Density



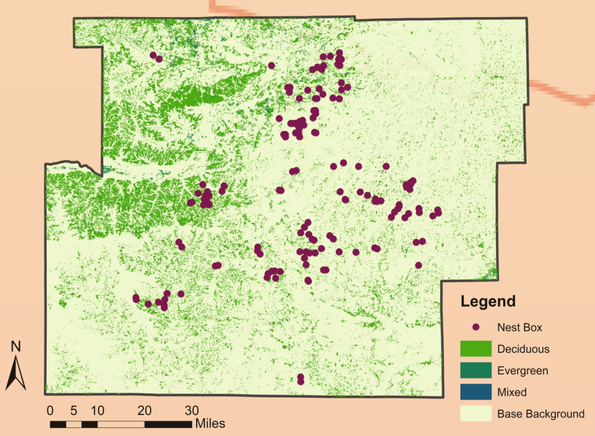
We've included population density as a measurement, using ACS 5-year census estimate data from 2012-2017. We created total population density by taking total population for each block group and dividing by the block group area. We clipped population to each spatial buffer for each nest box and multiplied density by the area of the nest box to get total population within the spatial buffer.

Habitat Fragmentation



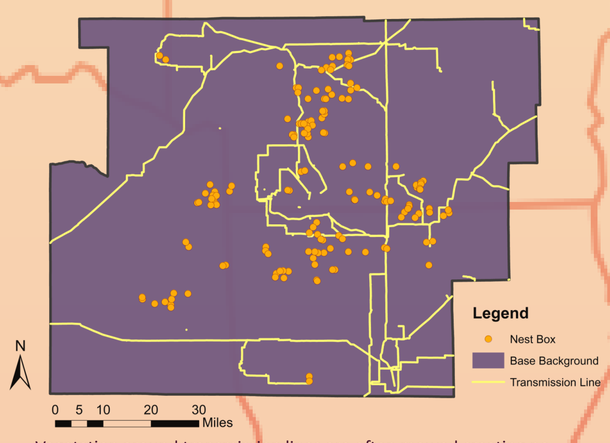
Habitat including anything that was of typical open low vegetated areas and non-habitat was everything else . We clipped each raster to each spatial buffer for each nest box and ran the samples through FRAGSTATS, a habitat fragmentation analysis program. Our measured parameters of habitat fragmentation included habitat patch perimeter to area ratio and median habitat patch size.

Forest



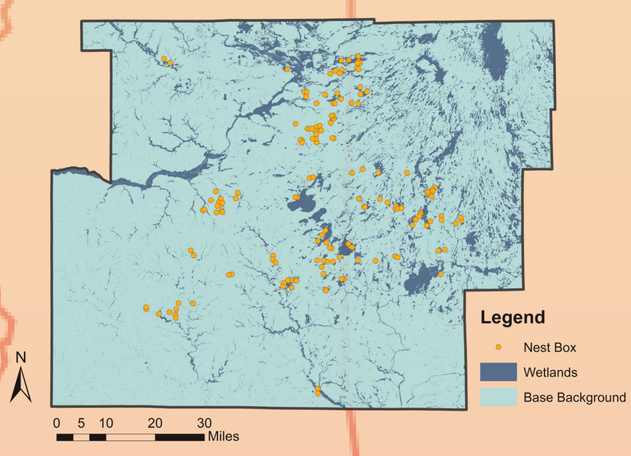
Forest cover consists of three types of forest—deciduous, evergreen, and mixed forest. We selected only forest cover from the NLCD data and vectorized the raster using ArcMap tool Raster to Vector. We calculated the distance to nearest forest edge using the Near tool in ArcMap for each nest box.

Transmission Lines



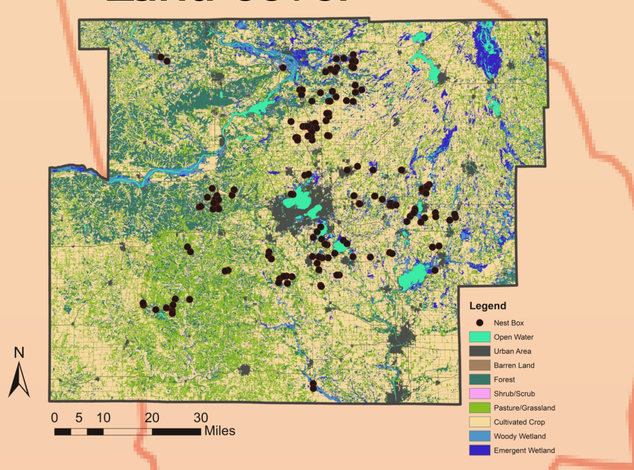
Vegetation around transmission lines are often mowed creating potential open habitat for kestrels. We took transmission line data and selected for only above ground transmission lines. We calculated the nearest distance to above ground transmission lines using the Near Tool in ArcMap.

Wetlands



Wetlands may provide open space and abundance of insects for kestrels to feed on. We've included data from the US National Hydrography dataset and selected for only non-forested wetlands. We calculated distance to nearest wetlands using the Near tool in ArcMap.

Land Cover



We used the National Land Cover Dataset (NLCD) to determine the impacts of various different land covers of occupancy at different spatial scales. We clipped the land cover data to each spatial scale and determined the total area of land cover within each nest box buffer.

Tufts

1. Smallwood, John A., Mark F. Causey, David H. Mossop, James R. Klucsarits, Bob Robertson, Sue Robertson, Joey Mason, et al. 2009. "Why Are American Kestrel (Falco Sparverius) Populations Declining in North America? Evidence from Nest-Box Programs."
2. Smallwood, J. A. and D. M. Bird (2002). American Kestrel (*Falco sparverius*), version 2.0. In The Birds of North America (A. F. Poole and F. B. Gill, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bna.602

Data Used: National Land Cover from Multi-Resolution Landcover Charateristics Consortium , US Homeland Infrastructure Foundation Level data for transmission lines, USGS National Hydrography Dataset for wetlands, US Census Bureau for roads, American Community Survey for population density, special thanks for Brand Smith of Madison Audubon for providing data.