Reshaping avian migration in the Anthropocene – continental scale attraction to artificial light at night revealed

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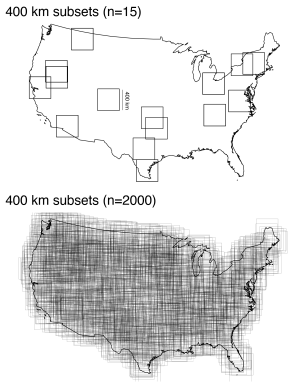
Summary: As billions of nocturnal avian migrants traverse North America, twice a year they must contend with ever-changing landscapes driven by natural and anthropogenic forces, including the rapid growth of artificial glow of the night sky. While airspaces facilitate migrant passage, terrestrial landscapes serve as essential areas to restore energy reserves and often act as refugia – making it critical to holistically identify stopover locations and understand drivers of use. Leveraging over 10 million remote sensing observations, we developed seasonal contiguous US layers of bird migrant stopover density. Across the US, in over 70% of our models we identify skyglow as a highly influential and consistently positive predictor of bird migration stopover density. This finding points to an expanding threat to avian migrants: peri-urban illuminated areas may act as ecological traps at macroscales, bringing migrants into dangerous, modified habitats.

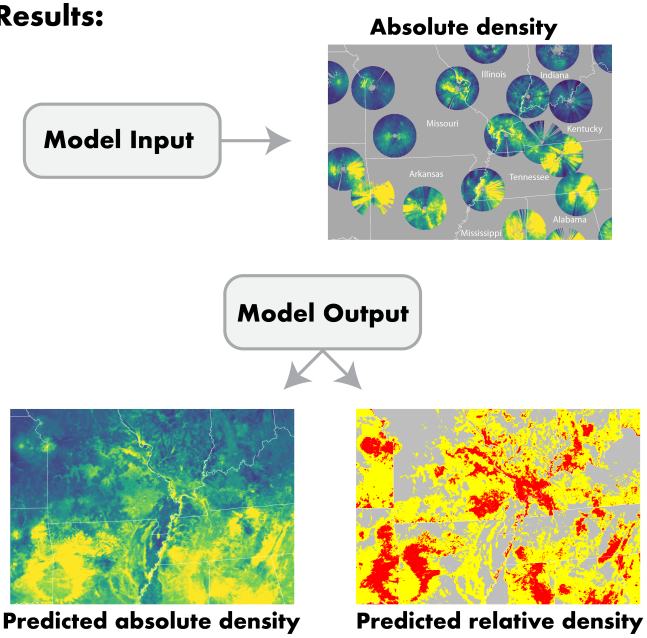
Methods:

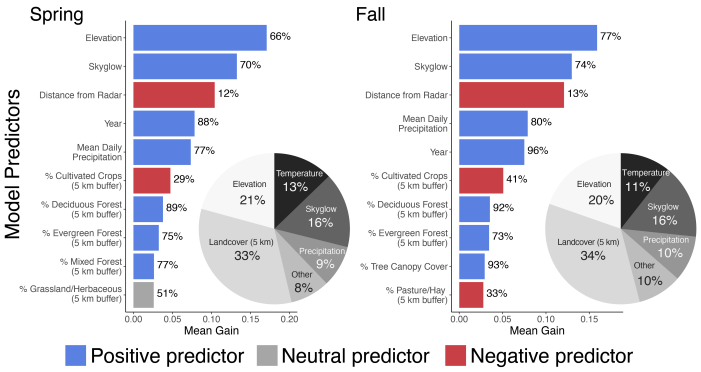
- The US NEXRAD network, is composed of 159 S-band (10 cm wavelength) radars, 143 which reside in the lower 48 states.
- Every 5-10 minutes, radars collect azimuthal scans, which we used to sample migrants as the departed from stopover habitats.
- We quantified migrant stopover density from radar reflectivity for 2016 to 2020 in spring (93 nights from March 15 to June 15) and fall (93 nights from August 15 to November 15).
- To understand the drivers of stopover densities, as estimated by radar, we assembled a broad suite of predictor variables, including the enhanced vegetation index (EVI), land cover classes and composition, percent canopy cover, percent impervious surface, accumulated nocturnal degree-days, precipitation, skyglow, elevation, distance to radar, and year. In all, we used 49 predictors, of which 48 were geospatial.



Schematic of spatial subsets used in boosted regression model training. In total, we assembled 2,500 unique models per season composed of 2,000 400 km subsets and 500 800 km subsets.

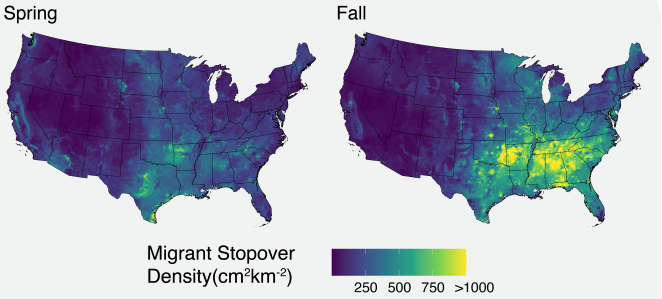
Results:



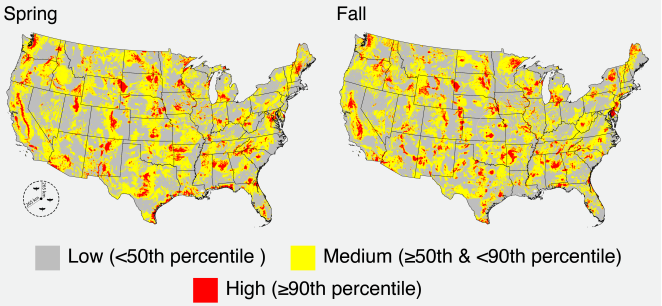


Top-10 seasonal variable importance plots ranked by mean gain. Blue bars show predictors that had a positive influence of migrant stopover density in >55% of models, red bars show predictors that had a negative influence on migrant stopover density in >55% of models, and gray show neutral predictors (between 45% and 55% positive). We show the percent of positive instances within models to the right of each bar.

Predicted absolute density



Predicted relative density



Red shades denote pixels above the 90th quantile of migrant stover density, yellow pixels between the 50th and 90th quantile of density, and gray showing pixels below the 50th quantile of density. Relative quantiles were identified using a circular focal window radius of 265 km, which relates to measured average nightly flight distances of tracked free-flying Swainson's (*Catharus ustulatus*) and hermit (*C. guttatus*) thrushes.

Discussion:

- With skyglow growing at nearly 10% per year in North America, and its broad and consistent importance in predicting migration stopover – broad-scale collaboration, advocacy, and development of lighting policies will be necessary to reverse the rise of this global pollutant.
- Our results yield a first continental scale perspective of this ecological threat, our understanding of light pollution and its impacts of avian migrants is far from complete – basic mechanisms of why migrants are attracted to lights remain at large.