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Dr. Julia Yoshida
Vice President
Chair, Blake Nuttall Committee
Nuttall Ornithological Club

Dear Dr. Yoshida and committee members,

Please find attached my report for my progress on the 2016 Charles Blake Fund Grant through the Nuttall Ornithological Club. Support of this project, entitled *Landscape effects on habitat use and singing behavior by edge-breeding bird species in Massachusetts*, has enabled me to complete data collection, finish vegetation analyses, and complete statistical analyses with student assistance. From this funding, I have used these data to prepare oral presentations at regional meetings and invited talks. I greatly appreciate this funding and anticipate submitting the results for publication over the course of the next year.

Thank you again for your consideration and funding. If you have additional questions, please feel free to contact me via email (greg.keller@gordon.edu) or phone (978-867-4852).

Sincerely,

Gregory S. Keller, Ph.D.
Professor of Conservation Biology
Gordon College

Title: Landscape effects on habitat use and singing behavior by edge-breeding bird species in Massachusetts

Abstract: Many Nearctic-Neotropic migrant songbirds are experiencing long-term population declines in North America due in part to habitat fragmentation on the breeding grounds. However, bird responses to landscape-level complexity in the form of natural heterogeneity compared to habitat fragmentation is not well established. In addition, little research has been conducted that links the landscape level and also habitat and vegetation levels to multiple bird responses, such as species richness, individual abundance, and behavior. To accomplish this goal, we surveyed specific migratory birds at three edge types (residential edge, agricultural edge, and natural edge) to determine abundance and richness of songbirds in forest-edge habitats. Focal species for this study were Eastern Kingbird (*Tyrannus tyrannus*), Great Crested Flycatcher (*Myiarchus crinitus*), Red-eyed Vireo (*Vireo olivaceus*), Warbling Vireo (*Vireo gilvus*), Gray Catbird (*Dumetella carolinensis*), Yellow Warbler (*Setophaga petechia*), Common Yellowthroat (*Geothlypis trichas*), and Baltimore Oriole (*Icterus galbula*). In addition, we compared singing behavior for Common Yellowthroat, Warbling Vireo, Baltimore Oriole, and Yellow Warbler to establish if this more subtle measure is affected by edge type. Finally, we compared bird and song measures to landscape-level fragmentation and heterogeneity metrics to determine the scales at which these species respond. Four species responded to habitat categories, all more abundant at natural edges with greater wetland cover. In addition, all species except Eastern Kingbird responded differentially to fragmentation and heterogeneity at the landscape scale. Song rates for Common Yellowthroat, Baltimore Oriole, and Warbling Vireo also responded to landscape variables, a scale that has not been considered previously in other research. Information from this study will be valuable to elucidate differences among species and habitats during the breeding season to help in overall conservation of important songbirds in New England.

Brief Review – Birds play integral roles in ecological systems as seed dispersers, pollinators, and predators (Holmes 1990; Greenberg et al. 2000). Nearctic-Neotropic migratory songbirds are a particularly influential group within the avian community; however, regional population declines have been reported for many of these species (Sauer et al. 2014), requiring significant conservation research to understand these patterns. A probable cause of these declines is habitat fragmentation, the process where remnant patches of natural habitat remain after agricultural development, sylvicultural harvest, and residential development. Although forest fragmentation is commonly viewed as detrimental to many bird populations (Lampila et al. 2005), little is known about how fragmentation compares to habitat heterogeneity in the form of natural openings.

Approximately 48% of forest remains in Massachusetts; however, this landscape is highly fragmented. Specifically, edges from fragmentation (interfaces between remnant forest and an opening) are a pervasive remnant and may influence the presence of specific bird species directly, due to differences in habitat requirements, or indirectly, through foraging or nesting patterns (Fonderflick et al. 2013). Edge creation results in an increase in species richness (Yahner 1995), as habitat generalists and edge specialists may be attracted to forest edges to exploit multiple resources (McCollin 1998). Although considerable research has been conducted on this edge effect, several important questions remain. What specific features of edges are important for these species? Also, what scales impact edge species and affect their presence, abundance, and behavior? What are the mechanisms of these impacts?

Objectives – Our objectives for this research were to: 1) compare relative abundance of focal migratory songbirds at sites that differ in edge type (residential, agricultural, and natural) in a range of landscape complexities during the breeding season in northeastern Massachusetts; 2) determine differences in song characteristics (rate, intensity, and frequency) as indices of breeding behavior for focal species in different edge types; and 3) determine the relative influence of landscape and site characteristics as they influence songbird abundance and song characteristics, with a specific comparison of fragmentation to heterogeneity in the landscape matrix. Focal species for this study were Eastern Kingbird (*Tyrannus tyrannus*), Great Crested Flycatcher (*Myiarchus crinitus*), Red-eyed Vireo (*Vireo olivaceus*), Warbling Vireo (*Vireo gilvus*), Gray Catbird (*Dumetella carolinensis*), Yellow Warbler (*Setophaga petechia*), Common Yellowthroat (*Geothlypis trichas*), and Baltimore Oriole (*Icterus galbula*). These focal species were selected because they are abundant in Massachusetts during the breeding season, they are either habitat generalists (e.g., Baltimore Oriole) or strict shrub-nesting edge specialists (e.g., Gray Catbird), they are relatively easy to identify by sight, song, and call, and they are typically conspicuous members of the avian community at edges. In addition, their population trends in New England are varied: severe decline (e.g., Eastern Kingbird, Common Yellowthroat); stable (e.g., Yellow Warbler, Great Crested Flycatcher); or increasing in abundance (e.g., Warbling Vireo) (Sauer et al. 2014). Therefore, species may respond differently to fragmentation because of these population trends.

Progress

Avian surveys – Three students, Ms. Cher Chow, Ms. Jonna Clark, and Ms. Zoe Davis joined me to assist in conducting avian surveys during the breeding season (25 May-7 July 2017) using 50-m fixed-radius 10-minute point counts at each site three times. This work in 2017 completes the field portion of this research project, with three field seasons completed.

Song rate – We recorded song rate for 38 birds during 2017, including 8 Baltimore Orioles, 12 Common Yellowthroats, 5 Warbling Vireos, and 12 Yellow Warblers. These additional observations, in addition to song-rate surveys from 2016, allow statistical comparisons among sites.

Landscape Analyses – To better understand landscape-scale variation, two students (Mr. Josh Spoonhour and Ms. Catherine Schweitzer) assisted me in using Geographical Information Systems (GIS) ArcGIS 10.4.1 software to analyze USGS color digital ortho quarterquad (DOQQ) images. We uploaded UTM XY coordinates for each site into the GIS and then bound each point with 200m, 500m, and 1000m radii to measure the sum area of forest and wetland cover and the sum length of human edge and wetland edge. We determined forest-patch size by measuring forest area that enclosed the survey point. From these landscape measures, we calculated a fragmentation index for each site. These local and landscape measures were then used to explain variation in habitat use.

Statistical Analyses – To meet Objective 1, dependent variables were abundance of focal species; independent variables were edge type, year, and variable interaction. To meet Objective 2, species were analyzed separately with MANOVA (and individual ANOVAs if statistically significant) to determine if song characteristics differed based on edge type. Finally, Objective 3 was met by condensing habitat variables and landscape variables using multivariate analyses to determine how avian measures are affected at both a local and landscape scale. Analyses were conducted with the software programs R and Minitab.

Results

We recorded a total of 366 individuals of the 8 focal species at 36 sites. The most abundant species were Gray Catbird (1.1 individuals/site), Common Yellowthroat (0.6 individuals/site), and Yellow Warbler (0.6 individuals/site). Abundance of four species (Common Yellowthroat, Yellow Warbler, Warbling Vireo, and Baltimore Oriole) differed by habitat type, all of which were more abundant at natural (i.e., wetland) edges compared to other habitats (Fig. 1). These results were particularly surprising for the Baltimore Oriole, which is considered a habitat generalist and not an edge specialist like the other species. Other species did not respond to habitat categories (Fig. 2), suggesting an equal value in fragmented edges (residential and pasture) compared to natural heterogeneity. In addition, we found interesting patterns in abundance at the landscape scale. Specifically, AICc analyses indicated that Great Crested Flycatcher, Warbling Vireo, Red-eyed Vireo, and Baltimore Oriole all responded positively to habitat heterogeneity measures but negatively to fragmentation measures. In contrast, other species showed more complex relationships depending upon spatial scale and require further analysis. For

example, Gray Catbird responded negatively to fine-scale fragmentation, positively to broad-scale fragmentation, but was not affected by heterogeneity at any scale.

Song rate for our focal species did not differ based on habitat category. However, we found interesting results at the landscape scale. Specifically, within a 500-m radius of our study sites, Common Yellowthroat sang more commonly in areas with greater wetland cover (Fig. 3), Baltimore Orioles sang more commonly in areas with more forest (data not shown), and Warbling Vireos sang more commonly in areas with greater fragmentation. We are quite excited about these results, since birds are responding behaviorally to differences at a very broad scale. These results, combined with abundance results, provide substantial findings for future publication.

Products

Having now completed data collected, I presented this work at the annual meeting of the Northeastern Naturalists and am preparing an invited presentation at the University of Iceland during winter 2018. In addition, I anticipate at least one major publication coming from this work (potentially two). I will begin preparing a manuscript on the main project for submission to the Wilson Journal of Ornithology or Condor. The Nuttall Ornithological Club will be mentioned prominently in the acknowledgement section of these papers.

Value – Results from this study will add to the important but limited body of literature on effects of landscape complexity (habitat fragmentation compared to natural heterogeneity) on edge-nesting migratory songbirds. With persistent development pressure in deciduous-forest habitats in the northeastern U.S., birds will continue to be influenced by human impacts. This study will consider bird responses at multiple scales (habitat and landscape) and at a variety of levels (richness, abundance, and behavior) in a group largely in decline and requiring more conservation attention. Flather and Sauer (1996) noted that Nearctic-Neotropic migrants are more sensitive to habitat fragmentation than other migratory guilds during the breeding season, suggesting that analysis of this group will provide considerable value to their conservation. Our results indicate that even the most subtle biological measures of singing behavior illustrate the persistent and pervasive impacts of habitat fragmentation on breeding songbirds. Understanding these pattern will significantly influence our understanding of population declines of these species breeding in New England as a result of human alteration of natural habitats. In this effort, we greatly appreciate the contribution of the Nuttall Society through the Charles Blake Fund Grant to our research.

References

Flather, C. H., and J. R. Sauer. 1996. Using landscape ecology to test hypotheses about large-scale abundance patterns in migratory birds. Ecology 77:28-35.

Fonderflick, J., A. Besnard, and J.-L. Martin. 2013. Species traits and the response of open-habitat species to forest edge in landscape mosaics. Oikos 122:42-51.

Greenberg, R., P. Bichier, A. C. Angon, C. MacVean, R. Perez, and E. Cano. 2000. The impact of avian insectivory on arthropods and leaf damage in some Guatemalan coffee plantations. Ecology 81:1750-1755.

Holmes, R. T. 1990. Ecological and evolutionary impacts of bird predation on forest insects: an overview. Studies in Avian Biology 13:6-13.

Lampila, P., M. Monkkonen, and A. Desrochers. 2005. Demographic responses by birds to forest fragmentation. Conservation Biology 19:1537-1546.

McCollin, D. 1998. Forest edges and habitat selection in birds: a functional approach. Ecography 21:247-260.

Sauer, J.R., J.E. Hines, J.E. Fallon, K.L. Pardieck, D.J. Ziolkowski, Jr., and W.A. Link. 2014. The North American Breeding Bird Survey, Results and Analysis 1966 - 2013. Version 01.30.2015 USGS Patuxent Wildlife Research Center, Laurel, MD.

Yahner, R.H. 1995. Forest fragmentation and avian populations in the northeast: Some regional landscape considerations. Northeast Wildlife 52:93–102.

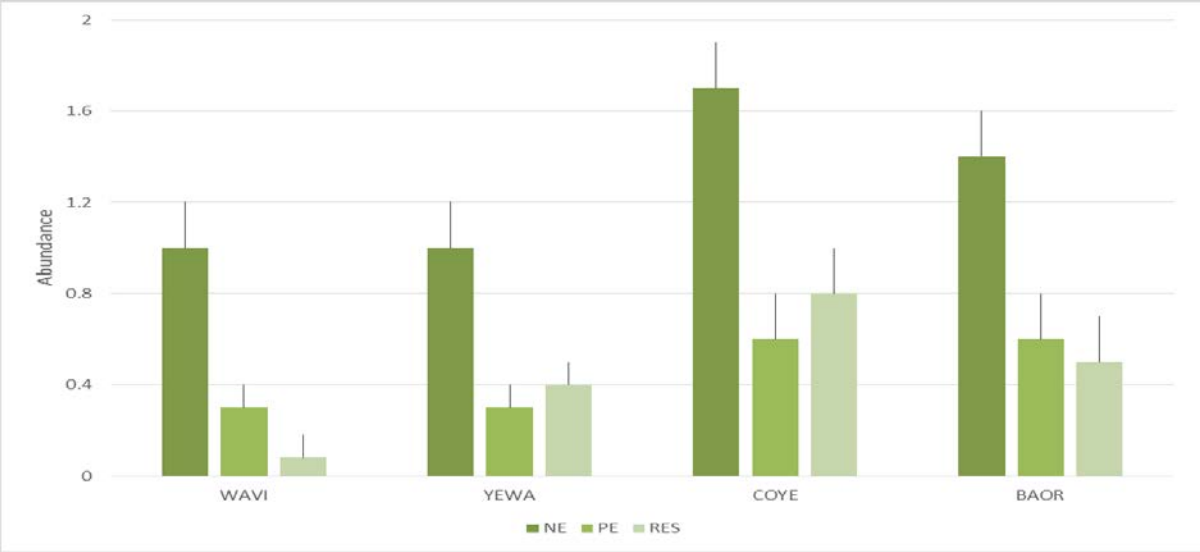

Figure 1. Average site abundance at natural edges (NE), pasture edges (PE), and residential edges (RES) for species with a significant habitat association, specifically all with greater abundance in natural edges, during 2015-2017 in northeastern Massachusetts. Species include Warbling Vireo (WAVI), Yellow Warbler (YEWA), Common Yellowthroat (COYE), and Baltimore Oriole (BAOR).

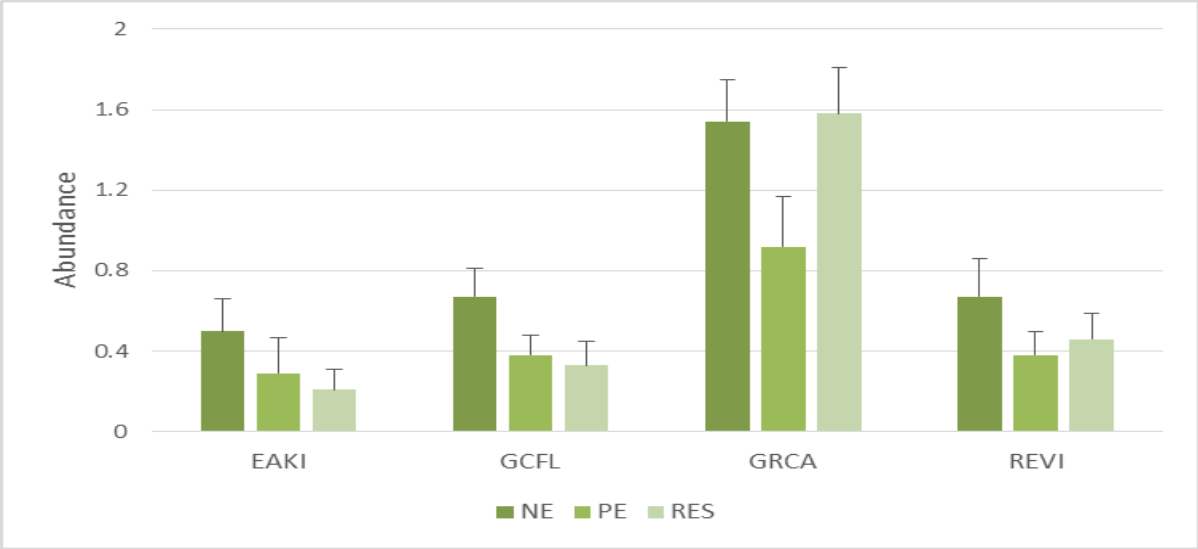

Figure 2. Average site abundance at natural edges (NE), pasture edges (PE), and residential edges (RES) for species with no significant habitat association during 2015-2017 in northeastern Massachusetts. Species include Eastern Kingbird (EAKI), Great Crested Flycatcher (GCFL), Gray Catbird (GRCA), and Red-eyed Vireo (REVI).

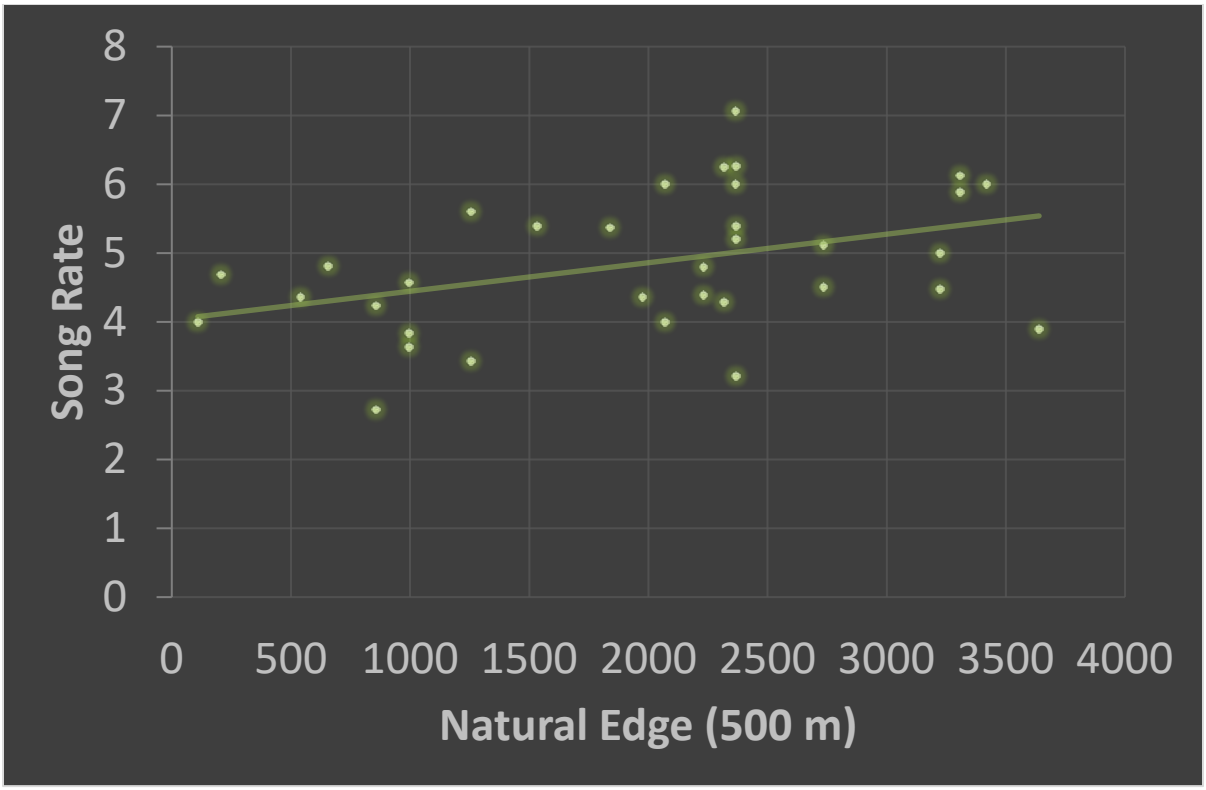

Figure 3. Positive significant landscape association based on AICc analysis between song rate and amount of natural edge within 500-m radius for Common Yellowthroats during summers 2015-2017 in northeastern Massachusetts.

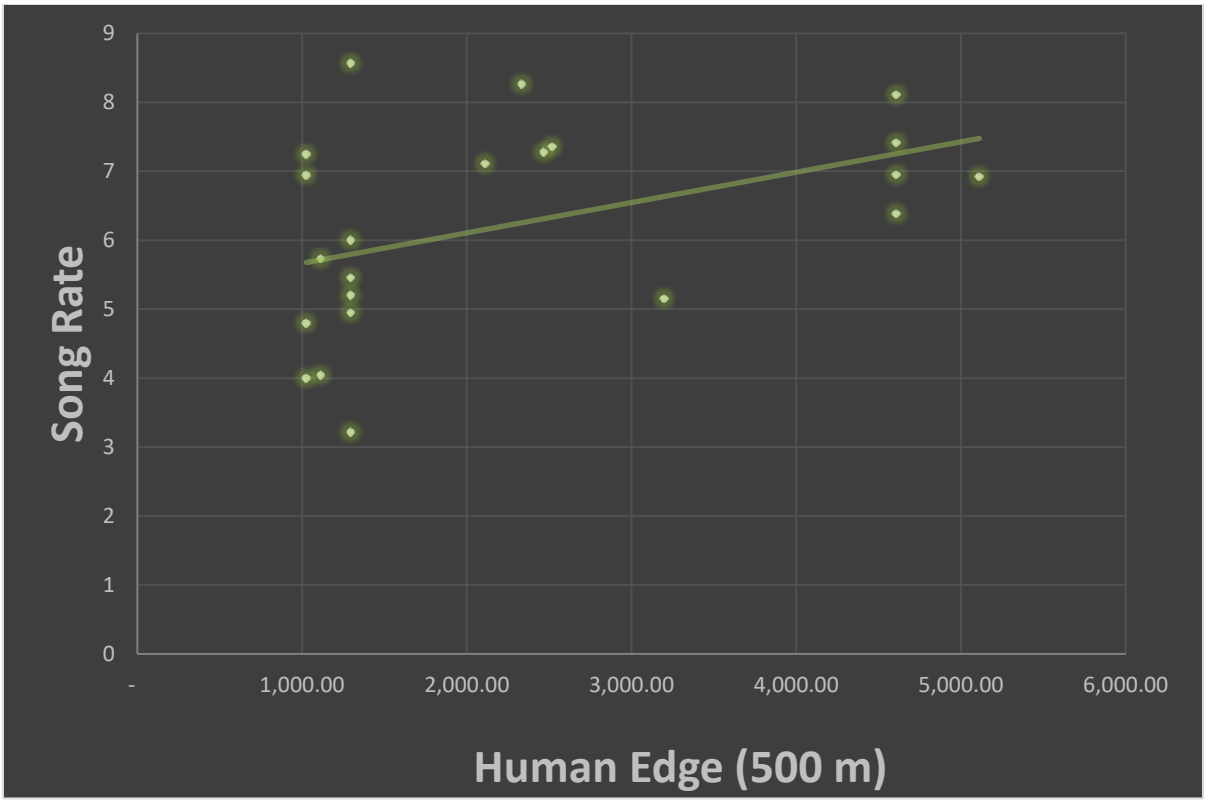

Figure 4. Positive significant landscape association between amount of human edge within 500 m of study sites and song rate for Warbling Vireo during 2015-2017 in northeastern Massachusetts.