ESTIMATING THE IMPACT OF HOUSE SPARROWS ON EASTERN BLUEBIRD REPRODUCTIVE SUCCESS ACROSS AN URBAN GRADIENT

by

Stacey C. Pavlik

Submitted in Partial Fulfillment of the Requirements

for the Degree of

Masters of Science

in the

Biology

Program

YOUNGSTOWN STATE UNIVERSITY

December 2012

Estimating the impact of House Sparrows on Eastern Bluebird reproductive success across an urban gradient

Stacey C. Pavlik

I hereby release this thesis to the public. I understand that this thesis will be made available from the OhioLINK ETD Center and the Maag Library Circulation Desk for public access. I also authorize the University or other individuals to make copies of this thesis as needed for scholarly research.

Signature:

Stacey C. Pavlik, Student Date

Approvals:

Dr. Ian J. Renne, Thesis Advisor Date

Dr. Dawna L. Cerney, Committee Member Date

Dr. Thomas P. Diggins, Committee Member Date

Peter J. Kasvinsky, Dean of School of Graduate Studies and Research Date

ABSTRACT

Non-indigenous species are widely reported to compromise the population growth of native species, but quantitative estimates of this are often lacking. As a result, management recommendations for non-native species are frequently rooted in subjective speculation and thus have poor predictive power. The House Sparrow (HOSP) was introduced into New York, NY from Europe in 1851 and has since expanded its range to encompass all of North America, where it usurps nests of native cavity-nesting birds, frequently destroying eggs, and killing nestlings and adults. This two-year study investigated habitat effects as well as the impact and management of HOSPs on the reproductive success in Northeast Ohio of the Eastern Bluebird (EABL), a native species whose population is managed via artificial nest box placement and maintenance. To do so, I attempted to found rural and urban EABL populations to assess whether the expected high number of discarded HOSP nests from artificial nest boxes in urban areas was sufficient to facilitate EABL nesting success. I found EABL fledgling number was two-fold higher in rural compared to urban areas, but nesting success (at least one chick fledged per nest attempt) was marginally higher in the latter. Despite reduced EABL nesting success by HOSPs, this habitat difference appears to not be primarily driven by HOSP abundance and suggests nest predation rates on EABLs may be higher in rural areas. Point count estimates of HOSP abundance were positively correlated with the number of HOSP nests I discarded from nest boxes and negatively correlated with distance from buildings offering HOSPs a stable food source. These data, including the effects of House Wrens, were integrated in a GIS-based hazard model to predict EABL nesting success across an urban-rural landscape. Key factors affecting the founding and subsequent success of EABL populations across habitats will provide managers with science-based practices to best augment populations at local and regional scales.

Acknowledgements

I would like to first and foremost thank my immediate and extended family for all of their support and encouragement.

I also want to thank the Graduate School of Youngstown State University and the North American Bluebird Society for awarding grants to make this research possible.

Thank you Dr. Renne for your continued support and critical assessments of my research and writing. You have facilitated me to be a better scientist and researcher.

Many thanks to Dr. Diggins, Dr. Cerney, Professor Bethaney Kryzs, Sean Satterlee, Laura Kosierik, Heidi Hall, and Amanda Ruozzo for their help in the lab, writing, and data collection in the field! This research would not have been possible without all your assistance!

Table of Contents

List of Figures

Appendix

I. INTRODUCTION

Pimentel et al. (2005) estimate that non-native species, which spread and become dominant beyond points of introduction, collectively reduce the U.S. Gross Domestic Product by nearly $120 billion annually through direct costs associated with pesticide and herbicide applications, and indirect costs incurred via reduced agricultural and forestry productivity. Invasion by non-indigenous species is also an important factor contributing to the population decline of many native species (Williams 2003, Florey and Clay 2010, Relva et al., 2010), but quantitative estimates of their impact on the dynamics of native populations are frequently absent, particularly for bird species (Chace and Walsh 2006, but see Kight and Swaddle 2007, Chavez-Zichinelli et al. 2010). These qualitative approaches have intuitive management appeal but are weak scientifically in predicting their effects on native biota. By quantifying the impact and management of non-indigenous birds on other species, a plan of high predictive power can be developed to promote population growth of native avifauna (Pinkowski 1979). Moreover, a comprehensive understanding of the important drivers of population growth is necessary to augment existing populations and perhaps even found new populations of native species in areas otherwise unavailable because of non-native species competition.

The European House Sparrow (HOSP; *Passer domesticus* L.) was introduced into New York, New York in 1851 (Moulton et al. 2010) and has since expanded its range to encompass all of North America south of the Arctic Circle, including northern Mexico (Alderfer 2006). It is considered one of the world's worst avian introductions (Long 1981, Pimentel et al. 2005) and areas with high HOSP abundance correspond to lower avian species richness relative to non-invaded areas (Chace and Walsh 2006, MacGregor-Fors et al. 2010). It is now believed there are twice as many HOSPs than all other songbird species in the United States, making it the most successful bird in North American history (Eno 1996). Throughout its introduced range, it aggressively displaces many native cavity-nesting birds by usurping their nests, often destroying their eggs, and killing nestlings and adults in the process (Gowaty 1984, MacGregor-Fors, et al. 2010). One such species experiencing population declines from the HOSP is the Eastern Bluebird (EABL; *Sialia sialis* L.), a charismatic songbird native to eastern North America. Habitat destruction and invasion by HOSPs are two main drivers of EABL population declines over the last 60 years (Wallace 1959, Zeleny 1976, Lumsden 1989, LeClerc et al. 2005), with HOSPs contributing to 30% or more of EABL nest failures (Radunzel et al. 1997). Zeleny (1977) suggests competition and mortality from HOSPs and European Starlings (*Sturnus vulgaris* L.) have contributed to a 90% decline of EABLs between 1930 through 1970.

Throughout its range, various organizations actively manage EABL populations by placing artificial nest boxes in appropriate habitat (e.g., Ohio Bluebird Society, North American Bluebird Society), including areas formerly harboring but currently lacking an EABL population (Lloyd et al. 2009). Nest boxes undergo varying degrees of maintenance, which may include weekly checks from mid-March through August to determine whether EABLs are nesting, and if HOSPs have usurped a nest (Radunzel et al. 1997, Wells 2004). If the latter occurs, it is acceptable under the U.S. Migratory Bird Treaty Act and common procedure to discard HOSP nests, including all eggs and nestlings. However, due in part to negligence, many private land owners and public land managers fail to remove HOSP nests from nest boxes, which results in not only a decline in local EABL reproductive output but also exacerbates the problem by increasing the HOSP population (MacGregor-Fors et al. 2010).

Additional management issues include whether new EABL populations can be easily founded and if their success depends on landscape features. EABLs and many other passerines exhibit a high degree of nest site fidelity and many fledglings return to an area within 1.1 kilometers of their original nesting grounds (Pinkowski 1979, Greenwood and Harvey 1982, Ingold 1996, Stanbeck and Rockwell 2003). In addition, HOSP abundance tends to be highest in urbanized areas and may be positively associated with building density (Chace and Walsh 2006, Shaw et al. 2008, Chavez-Zichinelli et al. 2010). Attempting to found new EABL populations in urbanized areas may thus prove more difficult than in rural areas because of typically high HOSP abundance in urban areas and because EABLs usually abandon a nest box if a nesting attempt is unsuccessful (Gowaty and Plissner 1997). That said, HOSPs exhibit the same nesting behavior as EABLs and nesting pairs may be dissuaded from using artificial nest boxes if their nests are regularly removed (Chamberlain et al. 2007). Despite an expected higher degree of EABL nest box maintenance in urban areas, it may nonetheless be possible to successfully establish EABL populations in these or similar habitats (Cornell et al. 2011).

Actively managing EABL nest boxes includes regular disposal of HOSP nests, eggs, and, if necessary, nestlings to deter future nest building by HOSPs (Gowaty and Plissner 1997, Radunzel et al. 1997), but the effectiveness of this on EABL nesting and fledging success has not been assessed. Although the management value of nest box maintenance is unknown, information gathered is critical for managers to estimate HOSP impact on EABL reproduction in artificial nest boxes. Effectiveness of HOSP nest removal likely depends on local HOSP abundance, which may differ across habitats (Blair 1996) and be associated with building type and distance from building (Remacha and Delgado 2009). By correlating HOSP abundance with the incidence of re-nesting following HOSP nest removal, the effectiveness of this management strategy can be quantitatively addressed.

I sought to identify local and landscape variables that affect the likelihood of founding EABL populations and their subsequent reproductive success. These variables include nest box placement in different habitat types, and nest box distance from forest edge and building type. Distance from buildings is negatively correlated with use of nest boxes by HOSPs (Remacha and Delgado 2009) but building type has not been tested. Proximity to abundant food sources may be particularly important in nest site selection (Chamberlain et al. 2009) and anecdotal observations indicate buildings containing a food source may be as well. These findings suggest EABLs may experience low reproductive success near buildings with a consistent food source because of HOSP competition. Nest boxes near forest edges may also promote competition between EABLs and House Wrens (HOWR; *Troglodytes aedon* V.) because the latter prefer to nest within 10 m of woodlot edges (Parren 1991, Newhouse et al. 2008). Lastly, Tree Swallows (TRSW; *Tachycineta bicolor* V.) frequently occupy nest boxes but pairing nest boxes deters TRSW from nesting near each other, which leaves some nest boxes available for EABLs to nest (Prescott 1982, O'Halloran 1997). These variables were considered when determining nest box locations and installation.

In this study, I addressed if: 1) EABL fledgling and nesting success differed between rural and urban habitats, 2) HOSP re-nesting attempts following nest removal were associated with local HOSP abundance, 3) HOSP abundance was correlated with particular building types and if so, whether their abundance changed as a function of distance from building, 4) distance from active barns affected HOSP abundance and EABL nesting success, and 5) pairing of nest boxes affected percentage of TRSW nest attempts relative to single nest boxes. Using these data, I also developed a Geographic Information System (GIS)-based model for predicting high quality EABL habitat at the landscape level. This study is intended to present information which may reduce the need for maintenance as well as maximize efforts to increase EABL population establishment and subsequent success. Organizations such as the Ohio Bluebird Society and North American Bluebird Society show that nest box installation has increased EABL abundance in Eastern North America but active maintenance of nest boxes is important to EABL success and productivity, particularly in areas with high HOSP abundance.

II. METHODS

The study area includes Mahoning, Trumbull, and Columbiana counties in Northeast Ohio, where average precipitation is 97.8 cm (38.5 inches) annually, 26.7 cm (11.4 inches) of which normally falls between May and July. Weather is moderate with a mean temperature of 21.7 degrees Celsius (71 degrees Fahrenheit) during July and August (National Weather Service).

I selected four urban areas, three along the Mahoning River between Youngstown, Ohio and the Eastern Pennsylvania border and a fourth located on the campus of Youngstown State University (YSU). The first three are classified as urban industrial areas with many large buildings, some of which are abandoned, while the YSU site is more residential with high human traffic. With the possible exception of feeders at residential houses, these sites generally do not offer a stable food source for HOSPs. These areas were characterized by highly fragmented forest and at least 1 ha of open grassland or old field. The four rural areas included the Horseman's Park at Beaver Creek State Park (East Liverpool, Ohio), Mill Creek Sanctuary (Boardman, Ohio), Stone Gate Farms (Hanoverton, Ohio), and an old farm grassland habitat (New Middletown, Ohio). These sites lacked industrialization and were chosen based on their large grassland habitat and low human traffic. Some standing trees were found in these sites and EABLs prefer rural habitats containing trees for perching but avoid heavily wooded and populated areas to evade HOWRs and HOSPs (Zeleny 1985). Lastly, I used a rural nest box trail along a highway (Salem, Ohio) to determine if HOSP re-nesting attempts following nest removal was associated with local HOSP abundance.

Habitat Type Assessment

Forty-eight nest boxes were initially installed between April 15th and May 15th, 2011 at four rural and four urban sites in an attempt to found new EABL populations (n = 6 boxes per site). This time period is considered late because EABL pre-breeding scouting occurs in March (Ingold 1996) and most EABLs lay their first clutch before the end of April in northeast Ohio (Pinkowski 1977). Throughout the 2011 breeding season, TRSWs nested in many nest boxes. As a result, four additional nest boxes were added to each site in February 2012 to construct five pairs of nest boxes, spaced 50 m apart, along a 200 m transect. This resulted in 80 total nest boxes, 10 of which were in each of our four urban and four rural sites (Appendix B). Here, I define urban areas as those associated with high abundance of industrialized buildings and high human activity while rural areas lack these features. All selected sites were located at least 2 km from each other, which is outside the average natal dispersal of 1 km for EABLs (Plissner and Gowaty 1996).

Nest box placement and installation

Paired nest boxes were installed within 3 m of each other, as TRSWs typically do not nest near each other (Prescott 1982, O'Halloran 1997). In addition, Gowaty and Plissner (1995) noted that EABLs prefer paired nest boxes because they are more easily located by EABLs when scouting for nesting sites. By pairing nest boxes in year two, I was able to compare the percentage of TRSW nest attempts in single nest boxes during the first year and paired nest boxes in the second year. During the second year, I also sought to determine if nest box placement in relation to buildings with a stable food source affects EABL nesting success and whether HOSP abundance declines as a function of distance from these building types. To do so, I placed pairs of nest boxes at 50 m intervals from three active barns, conducted point counts at 0, 100 and 200 m from the barns, and recorded EABL nesting success and fledgling numbers for all boxes.

I used the Garden Nest Box (Model #:L560), which is a fully assembled cedar wood nest box with a 3.8 cm diameter entrance hole in the forward opening door and these are appropriate dimensions for EABL and other small cavity nesting species. A coat of polyurethane was applied to the outside of nest boxes to reduce weathering. Mounting bases were constructed from a 7.6 cm long x 7.6 cm wide x 0.3 cm high steel plate with 2 drilled holes on opposite corners (for attachment to bottom of nest box with 1.3 cm screws) and a 8.9 cm long x 1.3 cm diameter piece of hollow steel conduit was welded to the center of the plate. A 5.1 cm long mounting sleeve with a tightening screw on each end was used to attach the base construction to a 1.5 m long x 1.3 cm diameter piece of hollow steel conduit. The steel was painted with industrial enamel for protection from weather. A 1.5 m x 1.3 m diameter piece of rebar was driven into the ground to a 61-76 cm depth, the 1.5 m x 1.3 cm hollow conduit was slid over the rebar, and the mounting base was attached and tightened with the mounting sleeve.

Nest box checking and maintenance

All nest boxes were monitored weekly, which began between March 20 and April 10 and continued until August 31st. When approaching the nest box, the presence of any bird around the box, including its behavior (e.g., collecting nesting material, feeding and nurturing young, fledging attempts) was recorded. Most species nesting in boxes of this size fledge at approximately 14-21 days. If the estimated age of the chicks was 14 days or older, the nest box was not opened to avoid potential injury to the chicks. Instead, auditory observations and the presence of adults near the box were noted. Upon opening the nest box, the date of visit, species nest type and stage of completion, number of eggs, age and number of chicks (approximated from date of first egg laid), and number of chicks fledged were recorded (Appendix D). Once birds fledged the nest, the soiled nest was removed and the nest box was cleaned to allow subsequent nesting (Kibler 1969, Zimmerman 2004). When a HOSP nest was encountered, the nest and its contents were discarded and recorded. Each nest box was assigned its own set of letters and numbers for record keeping purposes.

Point Counts

To assess the effect of HOSP abundance on EABL nesting success, three equally spaced five-minute point counts at 100 m intervals were performed along the 200 m nest box transects and all relevant species were recorded within a 50 m radius of each point. EABL, HOSP, HOWR, TRSW, Black-capped Chickadee (*Poecile atricapillus* L.), and Tufted Titmouse (*Baeolophus bicolor* L.) are all known to nest in nest boxes this size and were recorded. Point counts were performed within two hours after sunrise between March 15th through May 31st in both years at all sites. This time span encompasses peak breeding periods for all species of interest (Pinkowski 1977) and offers the best opportunity to auditorily and visually estimate the abundance of species known to nest in small artificial nest boxes. Point count methods were modeled from Bried et al. (2011) and Dettmers et al. (1999), who suggest multiple 5-10 minute point counts per site at least four days apart.

To determine if building type and density correlated with HOSP abundance, eight replicates of five different building types were chosen to perform three equally spaced, five-minute point counts along 200 m transects (Appendix C). Building types included active barns, abandoned barns, residential, commercial, and urban industrial. I define active barns as structures in which livestock and food were kept for most of the year, particularly in the summer months during peak passerine breeding. Abandoned barns were those that showed no use over several years, did not contain a stable anthropogenic food source, and had dense vegetation around the structure. Residential locations included numerous non-vacant houses within ~30 m of each other and these were adjacent to large open fields. Commercial structures (e.g., restaurants, gas stations, convenience stores, etc.) were assumed to contain a stable food source desirable to HOSPs, and were adjacent to large open fields. Lastly, urban industrial structures were used exclusively for the manufacturing, retail, or storage of large equipment and presumably provide housing for cavity nesters. Point counts were taken in transects away from buildings toward the adjacent open fields. Various building types were selected to establish a ‘distance-from-building’ relationship for HOSPs and EABLs, with the expectation that buildings offering a relatively stable food source will harbor more HOSPs (e.g., active barns, residential and commercial).

Geographic Information System (GIS) Modeling

I created a site suitability model in GIS to represent good and poor areas for establishing EABL trails based on characteristics that contribute to high HOSP and HOWR abundance. An area of approximately 72 square kilometers in Northeast Ohio, which contained a mixture of urban, suburban, and rural features, was selected to include variables known to affect EABL reproductive success. Active barns, commercial and residential structures, forest, and shrubs were delineated at an average scale of 1:9,000. Using my data on the association of HOSP abundance with building type and distance from building, buffer zones of 200 m were established around all building types. In addition, 10 m buffer zones around forest and shrubs were created because HOWRs frequently colonize nest boxes at this distance (Parren 1991). Each land cover layer with buffer zones was converted into a raster layer, which included a matrix of pixels organized into a grid where each cell contained a value representing information. This permitted classification of good areas for EABLs (0; anything outside each buffer zone) or poor (1; anything that fell inside the buffers) for each land cover type. Raster math was used to consolidate the overlapping layers, resulting in a predictive model representing good and poor areas to attempt EABL nest box trail establishment.

Statistical Analysis

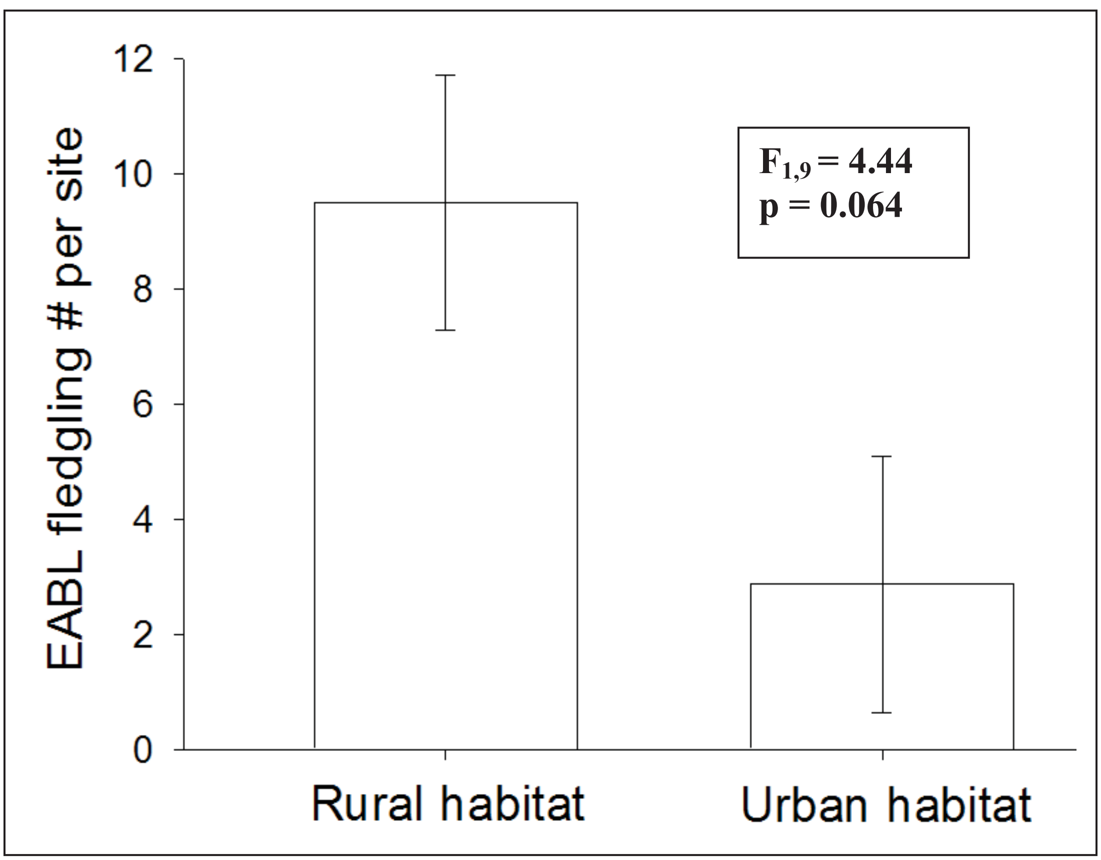
I used a repeated measure, one-way analysis of variance (ANOVA) to separate the effects of habitat type (rural and urban; between-subject effect) and year (2011 and 2012; within-subject effects) on EABL nesting and fledgling success. A nest is considered successful if at least one chick fledged. Fledgling success is the number of fledged young compared to number of hatched chicks (Sauer and Droege 1990). Each site contained five pairs of nest boxes and I used site as an experimental unit ($k = 4$ per habitat). Number of EABL chicks fledged was regressed against nest box distance from active barns to determine whether distance from active barn affected EABL nesting success. To test whether pairing of nest boxes reduced nesting by TRSWs, a one-way ANOVA was performed to compare percentage of TRSW nest attempts from single boxes in the first year and paired nest boxes in the second year. To determine whether the frequency with which HOSPs usurped artificial nest boxes depended on HOSP density, the number of

HOSP nests removed was regressed against HOSP abundance. Lastly, a two-way ANOVA was used to test whether HOSP abundance differed among building types (k = 5) and distance from building (k = 3; 0, 100, and 200 m away). Two building types had few HOSPs (i.e., inactive barns, industrial buildings), heterogeneity of variance could not be rectified via transformation and thus I tested if: 1) treatment means differed by distance for three building types and 2) treatment means for these three building types differed from the other two at each distance.

III. RESULTS

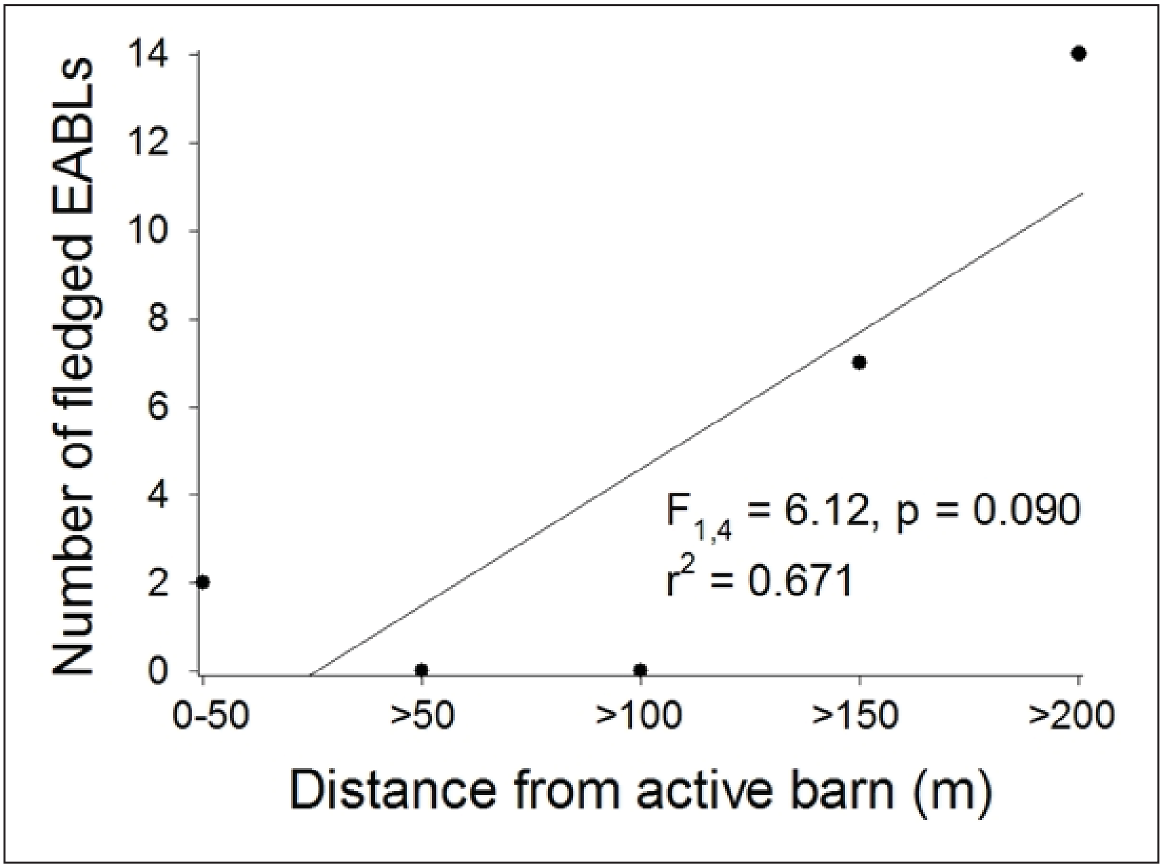
I found a marginally significant effect of habitat, with 230% higher fledgling number in rural relative to urban areas (Figure 1: $F_{1,9} = 4.44$, $p = 0.064$). Year and the year*habitat interaction ($F_{1,9} \leq 0.19$, $p = 0.67$) were not significant, but I note that fledglings were nearly three-fold more abundant in urban areas in year two relative to year one.

Figure 1: Number of EABL fledglings per site, with five pairs of nest boxes per site (k = 4 sites). Means ± 1 SE are shown.



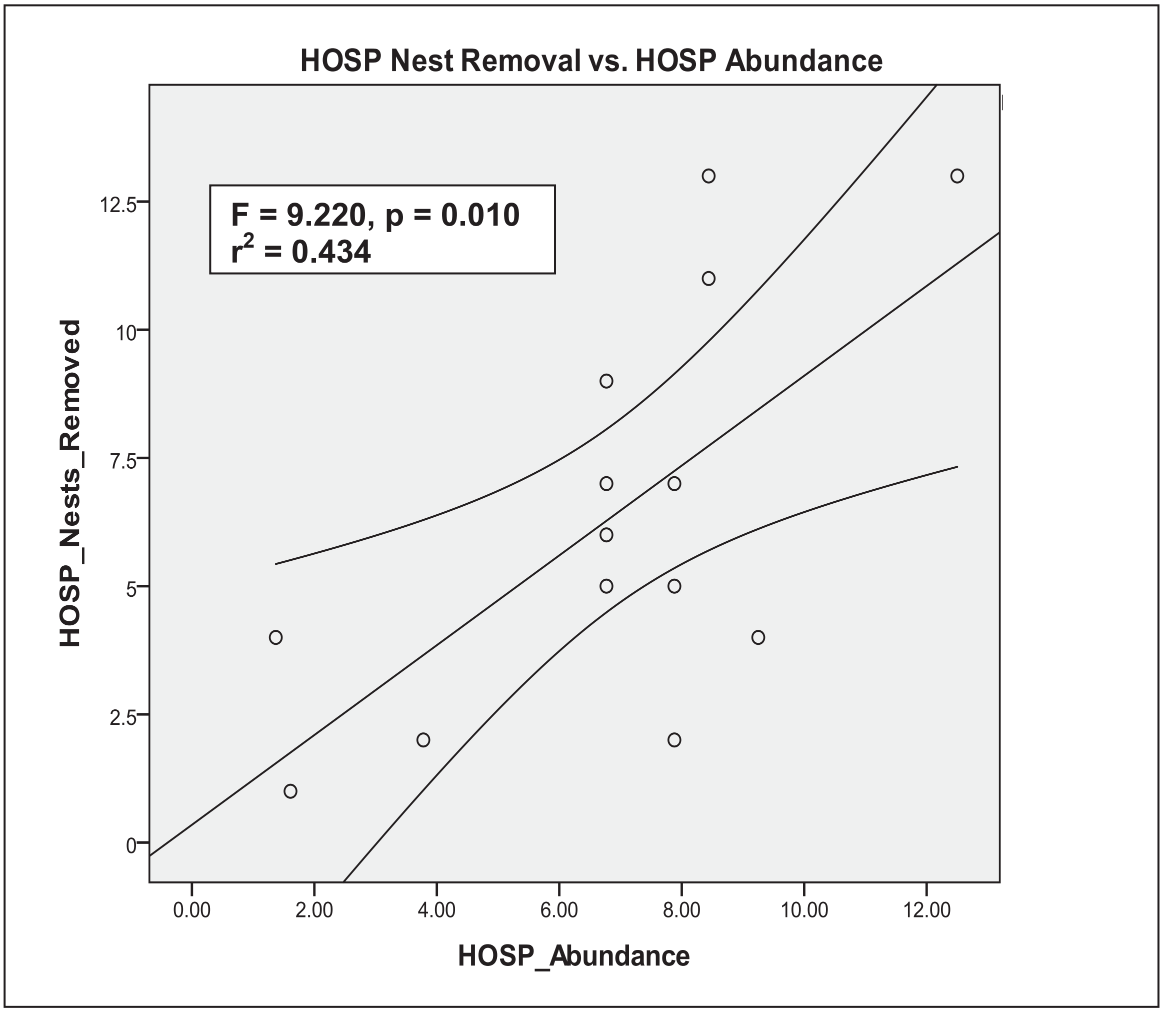
The number of fledged EABLs was positively correlated with distance from active barns, with 67.1% of the variation in fledgling success explained by distance of nest box from active barns (Figure 2: $F_{1,4} = 6.12$, $p = 0.090$). Although this relationship was marginally significant, 91% of fledglings emerged at distances of 150 meters or more from active barns.

Figure 2: The number of EABLs fledged at varying distances from an active barn.



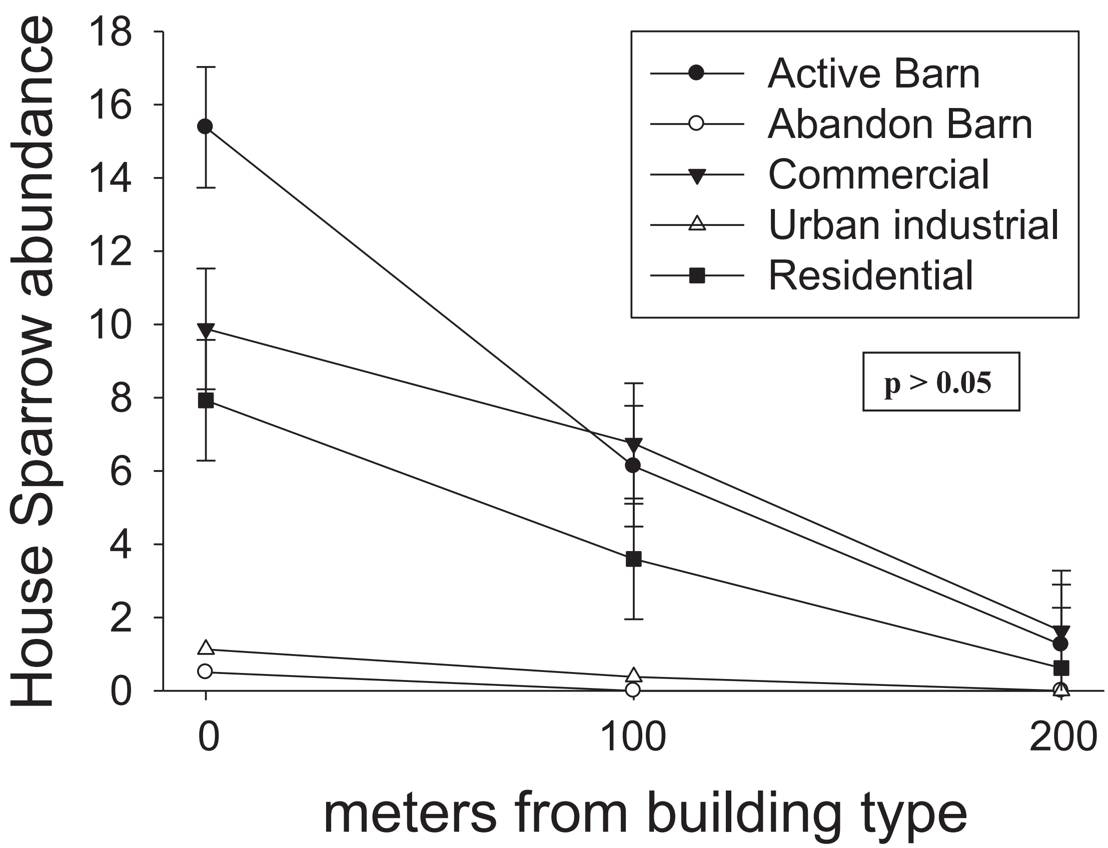
The number of HOSP nests removed from artificial nest boxes was positively correlated with local HOSP abundance (Figure 3; F = 9.2, p = 0.010, r^2 = 0.434). I found no difference in the percentage of TRSW nesting attempts among paired and unpaired nest boxes ($F_{1,14}$ = 0.043, p = 0.838, Levene's HOV: p = 0.022) but in no case did TRSWs simultaneously nest in a set of paired nest boxes.

Figure 3: Number of HOSP nests that were removed as a function of HOSP abundance. Shown are the 95% confidence intervals.



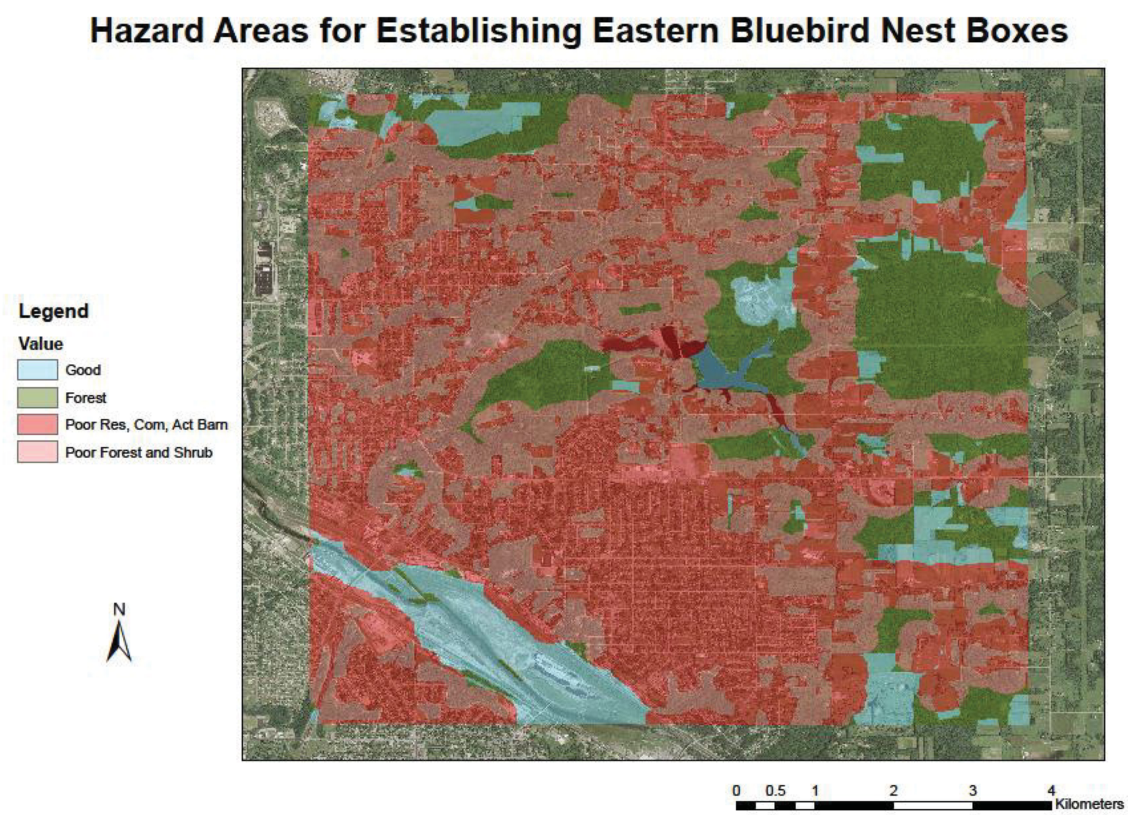
For active barns and commercial and residential buildings, only distance from building emerged as significant and HOSP abundance differed at all distances (Figure 4: Tukey-adjusted $p = 0.002$), but did not differ among building types ($p > 0.05$). At distances of 0 and 100 m, these three building types had HOSP abundances significantly higher than 0, indicating they differ from the same respective distance from abandoned barns and urban industrial buildings. HOSP abundance did not differ for any building type at 200 m.

Figure 4: House Sparrow abundance as a function of building type and distance from building. Data were collected during five minute point-counts, with eight replicates per treatment combination. Means ± 1 are shown.



Using criteria stated in the Methods, Figure 5 was created in ArcGIS ArcMap to predict good and poor areas for attempting to establish EABL populations. Blue areas represent good habitat for establishing EABL artificial nest box trails, green indicates forested areas, dark red represents residential, commercial, and active barn buildings including a 200 m buffer zone around them and pink represents a 10 m buffer zone around shrubs and forests.

Figure 5: ArcGIS map showing predictably good areas for EABL trail establishment (blue locations) and poor EABL habitat based on predicted HOSP and HOWR abundance. Green indicates forested areas, dark red represents residential, commercial, and active barn buildings including a 200 m buffer zone around them and pink represent shrubs and 10 m buffer zones around shrubs and forests.



IV. DISCUSSION:

Invasive species are a contributing factor to native species population decline (Williams, 2003) but quantitative estimates of their impact are lacking, especially for avian species (Chace and Walsh, 2006). As a result, management recommendations for non-native species are frequently rooted in subjective speculation and thus have poor predictive power. Here, I attempt to quantify the effects of the non-indigenous HOSP on EABLs, identify key habitat features affecting their reproductive output, and importantly, assess factors which may be critical to predicting whether particular areas are conducive to EABL population establishment.

To foster population growth, it is not only important to provide EABLs with cavities for nesting but also to place nest boxes in habitats conducive to reproductive success. EABLs prefer more rural habitats with open grasslands and old fields for nesting and foraging (Pinkowski 1979, Pinkowski 1997) and thus urban habitats may be considered inappropriate for EABLs. Although I found EABL fledgling success was higher in rural relative to urban areas, EABL fledgling number nearly tripled in urban habitats from year one to year two. This suggests some urban areas are conducive to EABL reproduction and population establishment. Given high nest site fidelity and ample opportunity to scout nest boxes, which was not available in year one, it will be interesting to observe whether this trend of increased EABL reproduction continues in urban areas.

In some locales, long-term data sets show repeated HOSP nest removal from particular nest boxes, suggesting nest box management is futile in these areas. However, it is common practice by EABL nest box trail managers to remove HOSP nests (Kibler 1969, Wells 2004, Zimmerman 2004). It is thus not only important to quantify the effectiveness of HOSP nest removal on EABL reproductive success, but also address whether this depends on local HOSP abundance. I used 16 nest boxes to address this relationship and found that HOSP re-nesting following nest removal was positively correlated with HOSP abundance. This suggests management efforts and resources will be wasted in attempting to establish EABL trails in areas with high HOSP densities, and that point counts of HOSPs during the breeding season may be used as a guide for nest box placement.

HOSPs are generally most abundant in urbanized areas where building density is high (Shaw et al, 2008), but building type may also affect their local abundance. For example, abandoned barns and urban industrial buildings may offer ample nesting sites but lack a stable food source compared to active barns, and commercial and residential buildings. As such, the latter building types may have the highest local HOSP abundance and if so, the important question is how far HOSPs will nest away from them. Point count data revealed a strong association of HOSPs with active barns and residential and commercial buildings, but not with inactive barns and industrial buildings. Importantly, HOSP abundance significantly declined from 0 to 100, and 100 to 200 m away from the building types that offered a stable food source. I also found a marginally significant but nonetheless strong relationship between EABL fledgling success and HOSP abundance. Coupling this with my findings above suggests managers could use distance from particular buildings, including point counts, to evaluate the likelihood of HOSPs usurping nest boxes.

HOSP abundance was low in nearly all rural and urban nest box sites during both years, indicating they are not the sole driver of EABL success at these locations. HOSP scarcity is likely due to the lack of a stable food source, which is associated with HOSP nest site selection (Chamberlain et al. 2009). Interestingly, despite rural habitats producing more EABL fledglings, nest box records suggest nest predation rates were higher in rural compared to urban areas in the second year of this study. This observation supports the predator refuge hypothesis, which proposes that some bird species may benefit from reduced nest predation rates in urban habitats (Stracey 2011).

Not only must EABLs evade HOSPs and predators, but they also compete for nest cavities with other species like TRSWs. By pairing nest boxes, managers may increase EABL nesting attempts without discouraging native TRSWs. No significant difference in TRSW nesting attempts was found between single and paired nest boxes but it is important to note that TRSW nests never appeared in both paired nest boxes simultaneously, supporting O'Halloran's (1997) premise for nest box pairing. EABL nesting attempts and nesting success increased in the second year with paired nest boxes but never exceeded 50% at any site, suggesting reduced TRSW competition from nest box pairing may nonetheless be useful. Additionally, first year nest boxes were established after EABL scouting began but this was not an issue in the second year (Ingold 1996). Subsequent nesting in the second year might also be attributed to nest site fidelity by the first year's brood, which EABLs are known to exhibit (Stanback and Rockwell 2003), and the availability of more nest boxes. Data compiled by managers who actively maintain EABL and Mountain Bluebird trails in the United States found similar results regarding pairing of nest boxes with no significant difference in reproductive output of either EABLs or TRSWs in paired verses single nest boxes (Eno, 1997).

Human-dominated landscapes are a mosaic of different land use histories and building types, all of which may affect EABL reproduction. Moreover, throughout the EABL range, many nest boxes are placed in sub-optimal habitat and thus management may not maximize EABL reproductive success (Cornell, 2011). Using data from Parren (1991) as well as data from the present study on building type and distance from building (Figure 4), I created a GIS-based map predicting areas conducive to EABL population establishment (Figure 5). In the future, I expect to test the accuracy of this model by placing nest boxes in areas with predicted low and high HOSP and HOWR abundance and measure EABL nesting and fledgling success. Additionally, these microsite variables could be measured at nest boxes with long-term data sets to develop a predictive model at the state-wide scale. If supported, this model has great potential for being a powerful conservation tool.

Although I found EABL fledgling success was higher in rural relative to urban areas, EABL fledgling numbers tripled in year two compared to year one in urban habitats, suggesting that some urban areas are conducive to EABL reproduction. HOSP re-nesting attempts following nest removal was positively correlated with HOSP abundance, suggesting areas with high HOSP abundance serve as poor sites for EABLs. HOSP abundance was strongly correlated with building types offering a stable food source, and declined as distance from these buildings increased. Since EABL nesting success depends on local HOSP abundance, the implementation of point counts is a potentially powerful and practical tool to identify good EABL nest box locations. Active management on nest box trails to reduce nesting by HOSPs is important to EABL conservation and pairing of nest boxes may increase nesting by EABL by reducing competition with TRSW. Incorporating this predictive model and point counts in areas potentially conducive to population establishment would make EABL conservation simpler and more effective by illustrating appropriate EABL habitat. It was Lawrence Zeleny's life goal to promote EABL population growth, he established the North American Bluebird Society (Sauer, 1990) and their continued support in research has served its mission of conservation well.

Citations:

Alderfer, J. 2006. Complete birds of North America. National Geographic Society. Washington, D.C. 20036.

Blair, R. B. 1996. Land use and avian species diversity along an urban gradient. Ecological Applications 6(2): 506-519.

Bried, Jason T., Langwig, K. E., Dewan, A. A., and Gifford, N. A. 2011. Habitat associations and survey effort for shrubland birds in an urban pine barrens preserve. Landscape and Urban Planning 90: 218-225.

Chace, J. F. and J. J. Walsh. 2006. Urban effects on native avifauna: a review. Landscape and Urban Planning 74: 46-69.

Chamberlain, D. E, M. P. Toms, R. Cleary-McHarg, and A. N. Banks. 2007. House sparrow (*Passer Domesticus*) habitat use in urbanized landscapes. Journal of Ornithology 148: 453-462.

Chamberlain, D. E., A. R. Cannon, M. P. Toms, D. I. Leech, B. J. Hatchwell, and K. J. Gaston. 2009. Avian productivity in urban landscapes: a review and meta-analysis. Ibis 151: 1-18.

Chavez-Zichinelli C. A., I. MacGregor-Fors, P. T. Rohana, R. Valdez, M. C. Romano, and J. E. Scondube. 2010. Stress responses of the House Sparrow (*Passer domesticus*) to different urban land uses. Landscape and Urban Planning 98: 183-189.

Cornell, K. L., C. R. Kight, R. B. Burdge, A. R. Gunderson, J. K. Hubbard, A. K. Jackson, J. E. LeClerc, M. L. Pitts, J. P. Swaddle, and D. A. Cristol. 2011. Reproductive success of Eastern Bluebirds (*Sialia sialis*) on suburban golf courses. The Auk 128(3): 577-586.

Dettmers, R., D. A. Buehler, J. G. Bartlett, and N. A. Klaus. 1999. Influence of point count length and repeated visits on habitat model performance. Journal of Wildlife Management 3(3): 815-823.

Eno, Steve. 1996. House Sparrows. Bluebirds across Nebraska.

Eno, Steve. 1997. To pair or not to pair. Bluebirds Across Nebraska.

Florey, L. and K. Clay. 2010. Non-native grass invasion alters native plant composition in experimental communities. Biological Invasions 12(5): 1285-1294.

Gowaty, P. A. 1984. House Sparrows kill Eastern Bluebirds. Journal of Field Ornithology 55: 378- 380.

Gowaty, P. A. and J. Plissner. 1995. Eastern Bluebirds are attracted to two-box sites. Wilson Bulletin 107(2): 289-295.

Gowaty, P. A. and J. Plissner. 1997. Breeding dispersal of Eastern Bluebirds depends on nesting success but not on removal of old nest: An experimental study. Journal of Field Ornithology 68(3): 323-502.

Greenwood, P. T. and P. H. Harvey. 1982. The natal and breeding dispersal of birds. Annual Review of Ecology and Systematics 13: 1-21.

Ingold, D. 1996. Between-year nest-site fidelity in Eastern Bluebirds in Ohio. Sialia 18: 43-47.

Isserman, A. M. 2005. In the national interest: defining rural and urban correctly in research and public policy. International Regional Science Review 28(4): 465-499.

Kibler, L. 1969. The establishment and maintenance of a bluebird nest-box project: A review and commentary. Bird Banding 40(2): 114-129.

Kight, C. R. and J. P. Swaddle. 2007. Associations of anthropogenic activity and disturbance with fitness metrics of Eastern Bluebirds (*Sialia sialis*). Biological Conservation 138: 189-197.

LeClerc, J., J. P. Che, J. P. Swaddle and D. A. Cristol. 2005. Reproductive success and developmental stability of Eastern Bluebirds (*Sialia sialis*) on golf courses: evidence that gold courses can be productive. Wildlife Conservation Bulletin 33: 483-493.

Lloyd, J. D., G. L. Slater and S. Snow. 2009. Demography of reintroduced Eastern Bluebirds and Brown-headed Nuthatches. Journal of Wildlife Management 73: 955-964.

Long, J. L. 1981. Introduced birds of the world: The worldwide history, distribution, and influence of birds introduced to new environments. Universe Books, New York.

Lumsden, H. G. 1989. Test of nest box preferences of Eastern Bluebirds, *Sialia sialis*, and Tree Swallows, *Tachycineta bicolor*. Canadian Field Naturalist 103: 595-597.

MacGregor-Fors, I., L. Morales-Perez, J. Quesada and J. E. Schondube. 2010. Relationship between the presence of House Sparrows (*Passer domesticus*) and neotropical bird community structure and diversity. Biological Invasions 12: 87-96.

Moulton, M. P., W. P. Cropper Jr., M. L. Avery, and L. E. Moulton. 2010. The earliest House Sparrow introductions in North America. Biological Invasions 12: 2955-2958.

Newhouse, M. J., P. P. Marra, and S. Johnson. 2008. Reproductive success of house wrens in suburban and rural landscapes. The Wilson Journal of Ornithology 120(1): 99-104.

O'Halloran, J. 1997. BRAW's 1996 season box-pairing update. Wisconsin Bluebird 12(1): 1-3.

Parren, Steven G. 1991. Evaluation of nest-box sites selected by Eastern Bluebirds, Tree Swallows, and House Wrens. Wildlife Society Bulletin 19: 270-277.

Pimentel, D., R. Zuniga, and D. Morrison. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52: 273-288.

Pinkowski, B. C. 1977. Breeding adaptations in the Eastern Bluebird. The Condor 79: 289-302.

Pinkowski, B. C. 1979. Annual productivity and its measurement in a multi-brooded passerine, the Eastern Bluebird. The Auk 96: 562-572.

Pinkowski, B. C. 1979. Nest site selection in Eastern Bluebirds. The Condor 81: 435-436.

Pinkowski, B. C. 1997. Foraging behavior of the Eastern Bluebird. The Wilson Bulletin 89(3): 404- 414.

Plissner, J. H., and P. A. Gowaty. 1996. Patterns of natal dispersal, turnover and dispersal costs in Eastern Bluebirds. Animal Behavior 51(6): 1307-1322.

Prescott, H. W. 1982. Using paired nesting boxes to reduce swallow-bluebird competition. Sialia 4: 3-7.

Radunzel, L. A., D. M. Muschitz, V. M. Bauldry and P. Arcese. 1997. A long-term study of the breeding success of Eastern Bluebirds by year and cavity type. Journal of Field Ornithology 68: 7-18.

Remacha, C. and J. A. Delgado. 2009. Spatial nest-box selection of cavity nesting birds species in response to proximity to recreational infrastructures. Landscape and Urban Planning 93: 46-53.

Relva, Maria A., M. A. Nunez, D. Simberloff. 2010. Introduced deer reduce native plant cover and facilitate invasion of non-native tree species: evidence for invasional meltdown. Biological Invasions 12(2): 303-311.

Sauer, J. R. and S. Droege. 1990. Recent population trends of the Eastern Bluebird. Wilson Bulletin 102(2): 239-252.

Shaw, L. M., D. Chamberlain and M. Evans. 2008. The House Sparrow (*Passer domesticus*) in urban areas: reviewing a possible link between post-decline distribution and human socioeconomic status. Journal of Ornithology 149: 293-299.

Stanback, M. T. and E. K. Rockwell. 2003. Nest-site fidelity in Eastern Bluebirds (*Sialia sialis*) depends on the quality of alternate cavities. The Auk 120(4): 1029-1032.

Stracey, Christine M. 2011. Resolving the urban nest predator paradox: the role of alternative foods for nest predators. Biological Conservation 144: 1545-1552.

Wallace, G. J. 1959. The plight of the bluebird in Michigan. The Wilson Bulletin 71: 192-193.

Wells, A. 2004. Impact of house sparrow and other invasive bird species being monitored by volunteers in Cornell Lab of Ornithology's birdhouse network. Cornell News.

Williams, B. K. 2003. Policy, research, and adaptive management in avian conservation. The Auk 120: 212-217.

Zeleny, L. 1976. The bluebird. Indiana University Press, Bloomington, Indiana.

Zeleny, L. 1977. Song of hope for the bluebird. National Geographic 151: 854-865.

Zeleny, L. 1985. The Importance of nesting box location. Sialia 7(1): 15-17.

Zimmerman, E. A. 2004. A dozen bluebirding myths. NABS Bluebird Journal 26(4): 8-9.

APPENDIX A

Thursday, September 08, 2011

Dr. Ian Renne
Biology Department
UNIVERSITY

Re: IACUC Protocol # 03-11
Title: Estimating impact and management of House Sparrows on Eastern Bluebird reproduction across an urban gradient.

Dear Dr. Renne:

The Institutional Animal Care and Use Committee of Youngstown State University has reviewed the aforementioned protocol you submitted for consideration and determined it should be unconditionally approved for the period of September 8, 2011 through its expiration date of September 8, 2014.

This protocol is approved for a period of three years; however, it must be updated yearly via the submission of an Annual Review-Request to Use Animals form. These Annual Review forms must be submitted to the IACUC at least thirty days ***prior*** to the protocol's yearly anniversary dates of September 8, 2012 and September 8, 2013. If you do not submit the forms in a timely fashion, this protocol will be immediately suspended. You must adhere to the procedures described in your approved request; any modification of your project must first be authorized by the Institutional Animal Care and Use Committee. Good luck with your research!

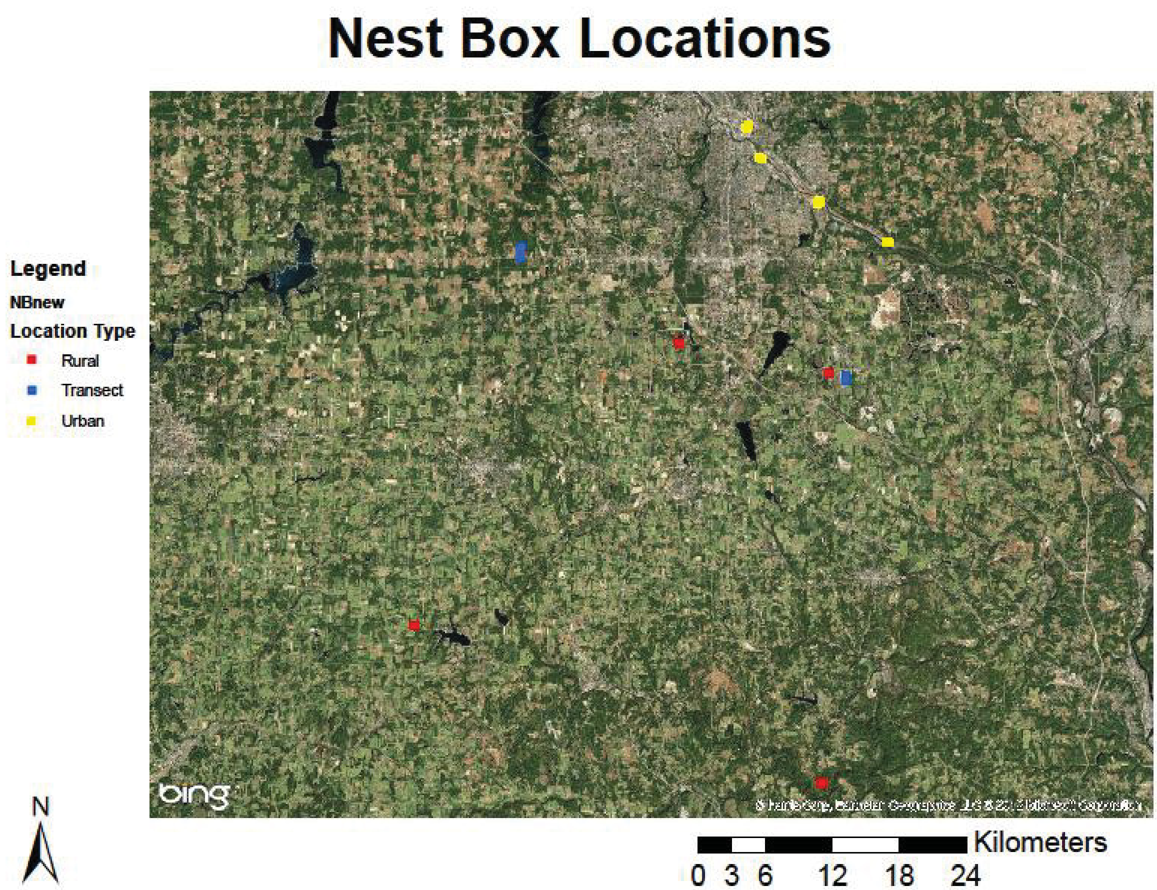
Sincerely,

Dr. Peter J. Kasvinsky
Associate Provost for Research
Dean School of Graduate Studies and Research

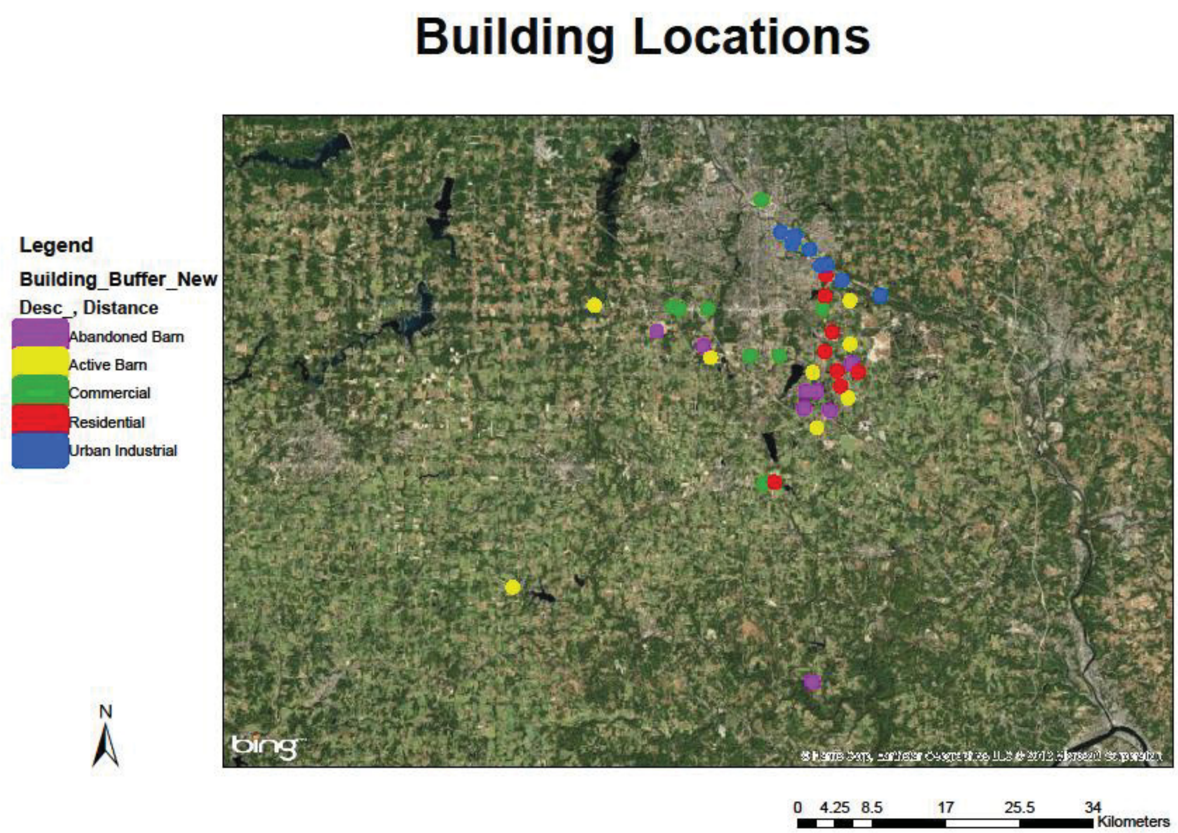
PJK:dka

C: Dr. Walter Horne, Consulting Veterinarian, NEOUCOM
Dr. Robert Leipheimer, Chair IACUC, Chair Biological Sciences
Dawn Amolsch, Animal Tech., Biological Sciences

APPENDIX B : Nest box locations, indicates nest box sites for rural (red), urban (yellow) and transect active barn sites (blue).



APPENDIX C: Location of the 40 buildings in which transect point counts were taken including abandoned barns (purple), active barns (yellow), commercial buildings (green), residential buildings (red), and urban industrial buildings (blue).



APPENDIX D: Sample of a nest box data sheet.

Bluebird Trail Nest Record for __________ Box # _________ Year ________

Date	Species	Empty Box	Partial	Complete	# Eggs	# Chicks	Age	# Fledged	Comments