# **Assessing the relationships between pollinator-friendly plantings and birds, bats and white-tailed deer on farms in the Coastal Plain of Virginia and Maryland.**

Earle Johnathan Berge

Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Master of Science

In

Fisheries and Wildlife Conservation

Sarah M. Karpanty

Megan O'Rourke

Dean Stauffer

Mark Ford

September 25, 2020

Blacksburg, Virginia

Keywords:

bats, birds, pollinator plot, farmscaping, landscape effects, white-tailed deer, wild turkey

© Earle J. Berge 2020

# **Assessing the relationships between pollinator-friendly plantings and birds, bats and white-tailed deer on farms in the Coastal Plain of Virginia and Maryland.**

Earle Jonathan Berge

## Academic Abstract

Pollinator-friendly wildflower and native grass plantings are increasingly incentivized by state and federal agencies to improve ecosystem services provided by pollinating insects on farmland. However, the potential ecosystem service benefits, or even disservices, of pollinator-friendly plantings relative to wildlife, such as resident, migratory, and nesting birds (e.g., wild turkey (*Meleagris gallopavo*)), resident and migratory bats, and white-tailed deer (*Odocoileus virginianus*) are of interest to both landowners and conservation managers. First, we studied bird species diversity, presence, density, and nesting on farms planted with and without pollinator-friendly plantings to evaluate the potential value of these plantings to bird-related values, such as cultural, recreational, and pest-regulating ecosystem services. Second, we quantified bat relative activity through recorded echolocation calls and explored how relative nightly activity varied across common cover types on a farm, by survey year, and by maternity (May-August) versus non-maternity season (September-April). Third, we determined whether white-tailed deer and wild turkey camera trap success and occupancy differed between farms with and without pollinator-friendly farmscaped plots, evaluated along with their relationships to percent cover of natural, developed, crop, and water habitats within 1 km of surveyed farms.

We conducted bird point counts across 20 farms on the Eastern Shore of Virginia and Maryland and the city of Virginia Beach, VA during the Spring and Fall of 2017 and 2018. We searched for bird nests in pollinator-friendly plots during the summers of 2017 and 2018. There were no differences in alpha diversity, defined as the number of species per farm per survey period, between control and pollinator farms in either Spring or Fall. We did find differences in species evenness on farms during Spring surveys, as measured by Simpson's index, with pollinator farms having a higher mean Simpson's index. When examining factors relating to presence/absence of our 15 modeled bird species out of 110 species detected on farms, landscape-level cover types were influential in 14 species and presence of pollinator plots was influential for 5 species. After stratification of density estimates by control and pollinator farm study sites, we found that during Spring surveys, the blue jay (*Cyanocitta cristata*) and Carolina wren (*Thryothorus ludovicianus*) had lower density on pollinator farms. In the Fall, the blue grosbeak (*Passerina caerulea*) had higher density on pollinator farms. We found nesting in the pollinator-friendly plots by red-winged blackbirds (*Agelaius phoeniceus*; n=7). These nests were placed in locations within the pollinator plots with higher forb coverage than random points in the same plots without nests.

We estimated the presence and relative activity of bats in 4 cover types, including forest trail, a forested pond edge, a crop field on forest edge, and a farmscaped wildflower plot, on the Eastern Shore Agricultural Research Extension Center in Painter, Virginia, from April 2017-November 2019 using acoustic detectors. Of total detections, 20.11% were identified as big brown bat (*Eptesicus fuscus*), 17.97% evening bat (*Nycticeius humeralis*), 15.35% silver-haired bat (*Lasionycteris noctivagans*), 7.11% eastern red bats (*Lasiurus borealis*), 3.66% hoary bats (*Lasiurus cinereus*), 3.1% little brown bat (*Myotis lucifugus*), and 1.38% tricolored bat

(*Perimyotis subflavus*). Relative activity measured by calls per night varied by cover type, with relative activity highest for all 7 species in the crop field-forest edge and water-forest edge cover types as compared to pollinator plot and forest trail cover types during the maternity season (May-August). All 7 bat species were recorded in the pollinator plot cover type; of the 8,877 calls in pollinator plots, 26.07% were silver-haired bat, 25.21% eastern red bats, 23.78% evening bat, 9.32% hoary bats, 9.11% little brown bat, 5.42% big brown bat, and 1.09% tricolored bat.

We used camera trap surveys to measure white-tailed deer and wild turkey occupancy across 20 farms on the Eastern Shore of Virginia and in the city of Virginia Beach, Virginia during the Spring and Fall of 2017 and 2018. Of all wild species photographed, white-tailed deer were most abundant (TS, # captures/100 nights) each survey season, however this varied season to season (Spring 2017 = 98.44 TS, Fall 2017 = 106.01 TS, Spring 2018 = 80.52 TS, Fall 2018 = 99.71 TS). Wild turkey total survey camera trap success was low compared to deer and other wildlife (4.51 TS), and also varied seasonally (Spring 2017 = 1.73 TS, Fall 2017 = 1.50 TS, Spring 2018 = 7.63 TS, Fall 2018 = 5.95 TS). White-tailed deer were detected at all survey locations at least once, and the occupancy of deer decreased as the percentage of developed land within 1km of a farm increased in each survey season. The factors relating to wild turkey occupancy varied by season. In Spring 2017, wild turkey occupancy increased as the percent of natural cover within 1 km of a farm increased. In Spring 2018, wild turkey occupancy decreased as the percent of developed land within 1 km increased. However, landscape variables did not influence wild turkey occupancy in the Fall seasons; rather in Fall 2018 we found that wild turkey occupancy decreased as camera trap success of farm machinery being used increased. Overall, wild turkey had a fairly low presence on all survey sites with an occupancy ranging from 0.18-0.53%, and no clear relationship to explain the change in survey season to season or year to year. Based on these results, pollinator plot presence or absence was not found to influence detection or occupancy of either of these target game species. Rather, other factors, mainly landscape-scale features, were found to have the largest influence on both species' occupancy and presence.

Our study is one of just a few in North America to demonstrate some potential benefits of pollinator-friendly plantings to multiple different wildlife species with cultural, recreational, and insect-regulating ecosystem service benefits to landowners. Generally, birds, bats, and our focal game species' presence relied on surrounding landscape variables and forest-edge configurations more than the presence of pollinator friendly plantings. This is probably in part due to the small size of our pollinator plots. We recommend that future work explore potentially increasing the size of pollinator plot plantings or placing pollinator plantings in locations on the landscape with the most surrounding natural area, and least development, to maximize the benefits of this resource to diverse wildlife species with home ranges that are often larger than any one farm.

**Assessing the relationships between pollinator-friendly plantings and birds, bats and white-tailed deer on farms in the Coastal Plain of Virginia and Maryland.**

Earle Jonathan Berge

## General Audience Abstract

Pollinator-friendly wildflower and native grass plantings are increasingly used by state and federal agencies to improve benefits from biodiversity such as increases in crop pollinating insects, but the potential benefits of such plantings for vertebrate wildlife are not well studied. We evaluated potential ecosystem services, or even disservices, of pollinator-friendly plantings related to vertebrate wildlife, such as resident, migratory, and nesting birds (e.g., wild turkey), resident and migratory bats, and white-tailed deer.

Bird point counts were conducted across 20 farms on the Eastern Shore of Virginia and Maryland and the city of Virginia Beach, VA during the Spring and Fall of 2017 and 2018, and we searched for bird nests in pollinator-friendly plots during the summers of 2017 and 2018. Over the entire project, we saw 110 different species; 96 were identified as insectivorous, indicating the potential for insect regulating services from birds. The total number of bird species observed on farms with pollinator plots were higher than farms without (100 > 90). After division of density estimates between control and pollinator farm study sites, we found that during Spring surveys, the Carolina wren had lower density on pollinator farms while in the Fall the blue grosbeak had higher density on pollinator farms. We found 7 nests of red-winged

blackbirds (n=7) in the pollinator-friendly plots and birds preferred nesting in locations within the pollinator plots with more dense flowering plants without woody stem coverage than random points without nests in the same plots.

We examined the presence and relative activity of bats in 4 cover types, including forest trail, a forested pond edge, a crop field on forest edge, and a farmscaped wildflower plot on one of our farm sites at the Eastern Shore Agricultural Research Extension Center in Painter, Virginia, from April 2017- November 2019 using acoustic detectors that record bat echolocation. All 7 bat species were recorded in the pollinator plot cover type and of total farm detections, 20.11% were identified as big brown bat, 17.97% evening bat, 15.35% silver-haired bat, 7.11% eastern red bats, 3.66% hoary bats, 3.1% little brown bat, and 1.38% tricolored bat. As expected, relative activity varied by cover type, with relative activity highest for all 7 species in the crop field-forest edge and water-forest edge cover types as compared to pollinator plot and forest trail cover types during the maternity season (May-August).

We used camera trap surveys to measure white-tailed deer and wild turkey camera trap success and occupancy across 20 farms on the Eastern Shore of Virginia and in the city of Virginia Beach, Virginia during the Spring and Fall of 2017 and 2018. Of all wild species photographed, white-tailed deer had the highest observations. Wild turkey detections were low compared to deer and other wildlife. White-tailed deer and wild turkey presence were not influenced by the presence of pollinator plots, but rather by other factors, mainly landscape features within 1 km. Our study is one of the first in North America to demonstrate some potential benefits of pollinator-friendly plantings to multiple different wildlife with cultural, recreational, and insect-regulating ecosystem service benefits to landowners. Generally, birds, bats, and our focal game specie’s presence relied on surrounding landscape variables and forest-edge configurations than the presence of pollinator friendly plantings. This is probably in part due to the small size of our pollinator plots. We recommend that future work explore potentially increasing the size of pollinator plot plantings or placing pollinator plantings in locations on the landscape with the most surrounding natural area, and least development, to maximize the benefits of this resource to diverse wildlife species with home ranges that are often larger than any one farm.

## Acknowledgements

Firstly, I would like to thank my friends and family who helped me strive for better and assisted me along the way to get where I am. I appreciate the love and support I had from my parents, brother, nieces, nephews, and other family who have taken interest in my project. I am extremely grateful to my partner, Rosemary Mallonée, for whom without their profound love and support, my mental sanity and the completion of my thesis would not have been possible to have.

To my advisor, Sarah Karpanty, I would like to express my deepest appreciation, not only for the opportunity but also the guidance and positive influence she has been on my past, current, and future career. Her belief in my work and in my abilities helped me through the most difficult learning I have taken time to pursue. I would like to extend my sincere thanks to my Committee members, Dean Stauffer, Mark Ford, and Megan O'Rourke. Dean Stauffer, with an office door always open for chats for stats help and encouragement. Mark Ford, with the necessary details to assist in proper measurement of bat activity. Megan O'Rourke, who arranged this interdisciplinary project and without it could not have been possible.

I would also like to extend my gratitude to my technicians, Cameron Robertson, Ally Moser Scott, and Amanda Crandall who conducted field work for partial summers and in many cases singlehandedly conducted field work on their own for months at a time. All of which have achieved better since and I hope to continue to achieve their goals. Thanks also goes to all the student employees who have greatly assisted me in the lab laboring meticulously over massive amounts of data processing. A special thanks to Emily Gardner, Joe Girgente, and Caleb Park who were able to start and finish my project with me.

I very much appreciate my lab mates, who have helped me along the way. Especially/particularly helpful to me during this time were Kat Black, Erin Leigh Heller, Brandon Semel, and Majango Wura who all assisted in moral support and in many cases technical support to help me along the way. Special thanks to students in other labs who have helped, particularly Elaine Barr, who without the kind help, I would not have been able to understand and process one of my chapters with ease and grace.

I also had great pleasure of working with the interdisciplinary team, mostly to Gina Angelella and Chris McCullough who working side by side on many of the same study plots to accomplish our research goals. An especially large thank you to the many landowners who have allowed my continued use of their property, to accomplish the data collection necessary, of which this project would not have been possible.

## Table of Contents

## List of Tables

## List of Figures

# Chapter 1: Introduction

Since the Green Revolution of the 1950s and 1960s, farmland production has greatly increased yield due to technological advancements in irrigation and the uses of herbicides and pesticides and fertilizers on increasingly larger and often monoculture crop systems (Wilson and Rigg 2003, Conway and Barbier 2013). In this transition to large-scale, high intensity farming practices, society has gained agricultural productivity often at the cost of on-farm ecological function and diversity (Tilman 1998, Dhaliwal et al. 2010, Horlings and Marsden 2011). The recent public focus on the decline of the non-native, but highly valued, honeybee (*Apis mellifera)* in North America has helped boost public support and funding for native pollinator conservation, Integrated Pest Management (IPM) approaches, and other sustainable agriculture techniques that aim to increase beneficial ecological diversity (Kevan et al. 1990, Kremen et al. 2002, Pimentel and Peshin 2014). Many types of activities exist to improve habitat quality of farms for native pollinators, and are collectively termed 'farmscaping,' defined broadly the process of altering the habitat structure and composition across farms for conservation purposes (Pavelis et al. 2011, Benson et al. 2016). Farmscaping practices may include, but are not limited to, adding a mix of cover types, planting shrub- or tree- dominated hedgerows along property boundaries, or the planting of native forb- and grass-dominated 'pollinator' plots or rows.

One increasingly common farmscaping technique is the planting of native, pollinator-friendly forbs and grasses (Shepherd et al. 2006, Shennan 2008, Alquezar and Machado 2015, Benson et al. 2016, Neumann 2016, Majewska et al. 2018). Pollinator plots or rows, studied in North American and European farming systems have been shown to reduce pest insect populations and to benefit the native insect pollinator community (Morandin and Kremen 2013, Benson et al. 2016, Bloom and Crowder 2016, O'Rourke et al. 2019). A review of the impacts of pollinator plots revealed that farmscaping practices in agricultural systems could result in increased pollinator presence, decreased parasitoid presence, reduced pesticide use, increased crop production, and increased species composition within the farming ecosystem (Shennan 2008). While many studies have shown benefits from the presence of native plants and edge habitats to many invertebrate pollinators (Aebischer 1991, Burel et al. 1998, Medan et al. 2011, Evans et al. 2016), studies are still lacking on the potential benefits of native pollinator-friendly forb and grass plantings effects for many vertebrates. Of the research conducted, findings suggest that vertebrate wildlife responses to farmscaping practices depend on the details of which practice is implemented. For example, white-tailed deer (*Odocoileus virginianus*), northern bobwhite (*Colinus virginianus*), and other vertebrates (bats, rabbit, squirrels, mice, birds) tend to use tree- or shrub-dominated hedgerows as cover and an increase of bird species richness has been shown with increases in shrub- or tree- densities along field edges in agricultural landscapes (Burel 1996, Davies and Pullin 2007, Boughey et al. 2011, Sisson et al. 2017).

In Virginia and Maryland, several groups such as the United States Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS), Virginia Department of Conservation & Recreation (VADCR), and Virginia Department of Transportation (VDOT) all have established pollinator friendly plantings for different uses, whether it be for visual, production, or ecological benefits (Vaughan and Skinner 2008, Ball 2015, VADCR and VADEQ 2019). My work seeks to increase understanding of the possible responses of vertebrate species to the establishment of pollinator plots. My target selected focal vertebrate species were chosen to represent potential provisioning (i.e., harvestable wild game; white-tailed deer and wild turkey), regulating (i.e., pest and disease reduction, insectivorous birds and bats), and cultural (i.e., aesthetics, spiritual inspiration, and consumptive and non-consumptive outdoor recreation, native birds) ecosystem services (Carpenter et al. 2009, Wilson et al. 2019). My overarching objective was to evaluate how these target vertebrate species responded to the presence of pollinator plots on farms in the Coastal Plain of Virginia and Maryland. I expected populations of each species to positively respond to the presence of pollinator plots and for farms with pollinator plots to exhibit more ecological diversity than farms without pollinator plots.

In my first chapter, "*Relationship of bird populations and community to pollinator-friendly plantings in the Coastal Plain of Virginia and Maryland*," I explored the potential benefits of pollinator plots in increasing the cultural, recreational, and pest-regulating ecosystems services of native birds in this study system, working on 10 farms with pollinator plantings and 10 farms without which served as control sites (Table 1.1). The concept of cultural ecosystem services is varied and complex, ranging from the spiritual values to the aesthetic impression and additional recreational opportunities a resource may provide (Whelan et al. 2008, Carpenter et al. 2009, Wenny et al. 2011). In my study, indices of overall bird species diversity were used as indicators of the potential aesthetic value of wildlife on farmscapes versus control farms. For example, previous studies have explored and quantified the positive feelings that birders gain while searching for migratory species as a cultural ecosystem service (Sekercioglu 2002, La Rouch 2003, Leonard 2006, Carver 2009). The Eastern Shore of Virginia currently heavily markets the ecotourism value of its natural areas for birdwatching, fishing and camping through its "You'll Love Our Nature" campaign (Eastern Shore of Virginia Tourism Commission 2020). On 'pick-your-own' farms in these areas, the presence of resident and migratory birds can both hold a cultural value to any birders as well as an economic value to small scale farmers who might bring in more business with the sightings of these birds (Burel and Baudry 1995, Roberts and Hall 2001, Belaire et al. 2015). Wildlife in agricultural settings, for example, the sights or sounds of the imperiled northern bobwhite, might provide unique value to birders and hunters, those who have historically heard them in greater numbers and view the decline negatively (Burger et al. 1999, Dailey 2002, Daley et al. 2004, Dailey and Braun 2012, Golden et al. 2013). Further, a less understood potential benefit of birds on farmscapes is pest reduction via insectivorous birds (Tscharntke 1992, Rosenheim 1998). Part of the uncertainty and complexity in understanding bird impacts is that some insectivorous birds consume both insect crop pests and the predatory insects of those crop pests as shown in exclusion studies removing predator birds on agroecosystems (Martin et al. 2013, Karp and Daily 2014, Railsback and Johnson 2014). However, a recent study in California showed that on organic row crop farms, elevated bird species richness across heterogeneous agroecosystems, such as hedgerows, could reduce insect pests during outbreak conditions when the numbers of predatory insects were low (Garfinkel and Johnson 2015). Therefore, I calculated species diversity, presence, and density of avifauna on farms with and without pollinator plots using point count surveys. In addition, I surveyed pollinator plots for possible nesting birds.

In my second chapter, "*Relative activity of native insectivorous bats in a farmscaped habitat on the Eastern Shore of Virginia,*" I determined the presence of native insectivorous bats in an agricultural setting. I used the presence and relative activity of native insectivorous bats as an indication of the potential pest-reduction potential by which pollinator-friendly plantings may provide if they increase bat diversity and relative activity. In Virginia, the State Wildlife Action Plan notes interest in insectivorous hoary bats (*Lasiurus cinereus*), silver-haired bats (*Lasionycteris noctivagans*), and eastern red bats (*Lasiurus borealis*) which occur in the coastal region where this study was located (VDWR 2015*a*). An increasing number of studies show neotropical bat species have been found to reduce plant damage and spread of disease caused by insects in several different ecosystems and farming landscapes (Williams-Guillén et al. 2008, Morrison and Lindell 2012). Although less frequent, studies of temperate bat species in agricultural landscapes have shown that bats may decrease pest insects on crop fields. However, a research need remains to fully understand the pest regulating potential of bats in agricultural settings in temperate regions (Russo et al. 2018). In the United States, insect-eating bats have been estimated to provide a pest regulating service worth more than $3.7 billion annually in agricultural landscapes (Boyles et al. 2011). Thus, I used acoustic detectors on a farmscape and calculated relative abundances of bat species across four main cover types present on farmscapes.

In my last chapter, "*Relationship of white-tailed deer and wild turkey to pollinator plot restoration and landscape features on small-scale farms on in the Coastal Plain of Virginia and Maryland,*" I explored the potential relationship of pollinator-friendly plantings and occupancy of white-tailed deer and wild turkey (*Meleagris gallopavo*), both of which provide provisioning ecosystem services. White-tailed deer bring in more than $500 million dollars annually from hunting in Virginia alone, but there is also the risk of ecosystem disservices such as conflicts from deer herbivory that result in millions of dollars in crop damage to agricultural businesses across Virginia each year (VDWR 2015*b*). Wild turkey populations are a highly desired hunting species on the Eastern Shore and have reached a stable population in the eastern U.S. after having been driven to near extinction by forest conversion to agricultural lands in the late 1800s and early 1900s (Dickson 1992, VDWR 2016). Both of these species are likely to be present and I have the opportunity to assess impacts on them from pollinator friendly plantings. I used camera traps on all of my survey sites to estimate the presence and abundance of different wildlife, with a focus on wild turkey and whitetail deer.

## Literature Cited


Aebischer, N. J. 1991. Twenty years of monitoring invertebrates and weeds in cereal fields in Sussex. The Ecology of Temperate Cereal Fields (eds L.G. Firbank, N. Carter, J.F. Darbyshire & G.R. Potts) 305–331. Blackwell Scientific Publishers, Oxford, UK.

Alquezar, R. D., and R. B. Machado. 2015. Comparisons between autonomous acoustic recordings and avian point counts in open woodland savanna. The Wilson Journal of Ornithology 127:712–723.

Ball, M. 2015. VDOT's pollinator habitat program moves toward statewide implementation. Informed Infrastructure. <https://informedinfrastructure.com/17439/vdots-pollinator-habitat-program-moves-toward-statewide-implementation/>. Accessed 3 Nov 2019.

Belaire, J. A., L. M. Westphal, C. J. Whelan, and E. S. Minor. 2015. Urban residents' perceptions of birds in the neighborhood: Biodiversity, cultural ecosystem services, and disservices. The Condor 117:192–202.

Benson, B., R. McDonald, N. C. Sugar Grove, and R. Morse. 2016. Farmscaping techniques for managing insect pests. Virginia Tech and Symbiont Biological Pest Management. <http://localfoodhub.org/wp-content/uploads/2012/07/5_farmscapingTechniquesForManagingInsectPests_VCE.pdf>. Accessed 3 Nov 2019.

Bloom, E. H., and D. W. Crowder. 2016. Biological control and pollination services on organic farms. Pages 27–46 in A. R. Horowitz and I. Ishaaya, editors. Advances in Insect Control and Resistance Management. Springer International Publishing, Switzerland.

Boughey, K. L., I. R. Lake, K. A. Haysom, and P. M. Dolman. 2011. Improving the biodiversity benefits of hedgerows: How physical characteristics and the proximity of foraging habitat affect the use of linear features by bats. Biological Conservation 144:1790–1798.

Boyles, J. G., P. M. Cryan, G. F. McCracken, and T. H. Kunz. 2011. Economic importance of bats in agriculture. Science 332:41–42.

Burel, F. 1996. Hedgerows and their role in agricultural landscapes. Critical Reviews in Plant Sciences 15:169–190.

Burel, F., and J. Baudry. 1995. Social, aesthetic and ecological aspects of hedgerows in rural landscapes as a framework for greenways. Landscape and Urban Planning 33:327–340.

Burel, F., J. Baudry, A. Butet, P. Clergeau, Y. Delettre, D. Le Coeur, F. Dubs, N. Morvan, G. Paillat, S. Petit, C. Thenail, E. Brunel, and J.-C. Lefeuvre. 1998. Comparative biodiversity along a gradient of agricultural landscapes. Acta Oecologica 19:47–60.

Burger, L. W., D. A. Miller, and R. I. Southwick. 1999. Economic impact of northern bobwhite hunting in the southeastern United States. Wildlife Society Bulletin 27:1010–1018.

Carpenter, S. R., H. A. Mooney, J. Agard, D. Capistrano, R. S. DeFries, S. Díaz, T. Dietz, A. K. Duraiappah, A. Oteng-Yeboah, H. M. Pereira, C. Perrings, W. V. Reid, J. Sarukhan, R. J. Scholes, and A. Whyte. 2009. Science for managing ecosystem services: beyond the millennium ecosystem assessment. Proceedings of the National Academy of Sciences 106:1305–1312.

Carver, E. 2009. Birding in the United States: A demographic and economic analysis: addendum to the 2006 national survey of fishing, hunting, and wildlife-associated recreation. US Fish and Wildlife Publications, Arlington, Virginia, USA.

Conway, G. R., and E. B. Barbier. 2013. After the green revolution: Sustainable agriculture for development. Earthscan, London, UK.

Dailey, T. V. 2002. Emerging trends in Midwest bobwhite culture. Proceedings of the National Quail Symposium 5:8–19.

Dailey, T. V., and C. E. Braun. 2012. Quail VII: Proceedings of the seventh national quail symposium. The University of Tennessee, National Bobwhite Conservation Initiative, Knoxville, USA.

Daley, S. S., D. T. Cobb, P. T. Bromley, and C. E. Sorenson. 2004. Landowner attitudes regarding wildlife management on private land in North Carolina. Wildlife Society Bulletin 32:209–219.

Davies, Z. G., and A. S. Pullin. 2007. Are hedgerows effective corridors between fragments of woodland habitat? An evidence-based approach. Landscape Ecology 22:333–351.

Dhaliwal, G. S., V. Jindal, and A. K. Dhawan. 2010. Insect pest problems and crop losses: changing trends. Indian Journal of Ecology 37:1–7.

Dickson, J. G. 1992. The wild turkey: Biology and management. Stackpole Books, Mechanicsburg, Pennsylvania, USA.

Eastern Shore of Virginia Tourism Commission. 2020. Media. Eastern Shore of Virginia Tourism. <https://visitesva.com/media/>. Accessed 26 Aug 2020.

Evans, T. R., M. J. Mahoney, E. D. Cashatt, J. Noordijk, G. De Snoo, and C. J. M. Musters. 2016. The impact of landscape complexity on invertebrate diversity in edges and fields in an agricultural area. Insects 7:7–23.

Garfinkel, M., and M. Johnson. 2015. Pest-removal services provided by birds on small organic farms in northern California. Agriculture, Ecosystems & Environment 211:24–31.

Golden, K. E., M. N. Peterson, C. S. DePerno, R. E. Bardon, and C. E. Moorman. 2013. Factors shaping private landowner engagement in wildlife management. Wildlife Society Bulletin 37:94–100.

Horlings, L. G., and T. K. Marsden. 2011. Towards the real green revolution? Exploring the conceptual dimensions of a new ecological modernisation of agriculture that could ‘feed the world.’ Global Environmental Change 21:441–452.

Karp, D. S., and G. C. Daily. 2014. Cascading effects of insectivorous birds and bats in tropical coffee plantations. Ecology 95:1065–1074.

Kevan, P. G., E. A. Clark, and V. G. Thomas. 1990. Insect pollinators and sustainable agriculture. American Journal of Alternative Agriculture 5:13–22.

Kremen, C., N. M. Williams, and R. W. Thorp. 2002. Crop pollination from native bees at risk from agricultural intensification. Proceedings of the National Academy of Sciences 99:16812–16816.

La Rouch, G. P. 2003. Birding in the United States: A demographic and economic analysis: addendum to the 2001 National survey of fishing, hunting and wildlife-associated recreation. Report 2001-1. U. S. Fish and Wildlife Service, Washington, D.C., USA.

Leonard, J. 2006. Wildlife watching in the United States: Economic impacts on national and state economies in 2006. Report 2006-1. U.S. Department of the Interior, Washington, D.C., USA.

Majewska, A. A., S. Sims, S. J. Wenger, A. K. Davis, and S. Altizer. 2018. Do characteristics of pollinator-friendly gardens predict the diversity, abundance, and reproduction of butterflies? Insect Conservation and Diversity 11:370–382.

Martin, E. A., B. Reineking, B. Seo, and I. Steffan-Dewenter. 2013. Natural enemy interactions constrain pest control in complex agricultural landscapes. Proceedings of the National Academy of Sciences 110:5534–5539.

Medan, D., J. P. Torretta, K. Hodara, E. B. de la Fuente, and N. H. Montaldo. 2011. Effects of agriculture expansion and intensification on the vertebrate and invertebrate diversity in the Pampas of Argentina. Biodiversity and Conservation 20:3077–3100.

Morandin, L. A., and C. Kremen. 2013. Hedgerow restoration promotes pollinator populations and exports native bees to adjacent fields. Ecological Applications 23:829–839.

Morrison, E. B., and C. A. Lindell. 2012. Birds and bats reduce insect biomass and leaf damage in tropical forest restoration sites. Ecological Applications 22:1526–1534.

Neumann, N. 2016. Designing and installing an agricultural hedgerow to restore native pollinator habitat. Thesis, University of Washington, Seattle, USA.

O'Rourke, M., C. Philips, and T. Kuhar. 2019. Improving pest management with farmscaping. Virginia Cooperative Extension, Virginia Tech, Blacksburg, USA.

Pavelis, G. A., D. Helms, and S. Stalcup. 2011. Soil and water conservation expenditures by USDA agencies, 1935–2010. Historical Insights: 10, U.S. Department of Agriculture - Natural Resources Conservation Service, Washington, D.C., USA.

Pimentel, D., and R. Peshin, editors. 2014. Integrated pest management: pesticide problems. Volume 3. Springer Science & Business Media, Dordrecht, London.

Railsback, S. F., and M. D. Johnson. 2014. Effects of land use on bird populations and pest control services on coffee farms. Proceedings of the National Academy of Sciences 111:6109–6114.

Roberts, L., and D. Hall. 2001. Rural tourism and recreation: Principles to practice. CABI Publishing, New York, New York, USA.

Rosenheim, J. A. 1998. Higher-order predators and the regulation of insect herbivore populations. Annual Review of Entomology 43:421–447.

Russo, D., L. Bosso, and L. Ancillotto. 2018. Novel perspectives on bat insectivory highlight the value of this ecosystem service in farmland: Research frontiers and management implications. Agriculture, Ecosystems & Environment 266:31–38.

Sekercioglu, C. H. 2002. Impacts of birdwatching on human and avian communities. Environmental Conservation 29:282–289.

Shennan, C. 2008. Biotic interactions, ecological knowledge and agriculture. Philosophical Transactions of the Royal Society B: Biological Sciences 363:717–739.

Shepherd, M., M. Vaughan, and S. H. Black. 2006. Pollinator-friendly parks. The Xerces Society for Invertebrate Conservation, Portland, Oregon, USA.

Sisson, D., H. Stribling, and S. Mitchell. 2017. Northern bobwhite population response to intensive modification of a farm landscape in middle Georgia (Poster Abstract). National Quail Symposium Proceedings 5:160.

Tilman, D. 1998. The greening of the green revolution. Nature 396:211–212.

Tscharntke, T. 1992. Cascade effects among four trophic levels: Bird predation on galls affects density-dependent parasitism. Ecology 73:1689–1698.

VADCR, and VADEQ. 2019. Virginia pollinator-smart business plan. Virginia Department of Conservation and Recreation, Virginia Department of Environmental Quality, Richmond, Virginia, USA. <https://www.dcr.virginia.gov/natural-heritage/document/solar-site-business-plan.pdf>. Accessed 3 Nov 2019.

Vaughan, M., and M. Skinner. 2008. Using farm bill programs for pollinator conservation. Technical Note No. 78, United States Department of Agriculture, Washington, D.C., USA.

VDWR. 2015a. Virginia’s 2015 state wildlife action plan. Virginia Department of Wildlife Resources, Henrico, Virginia, USA. <http://bewildvirginia.org/wildlife-action-plan/pdf/2015-Virginia-Wildlife-Action-Plan.pdf>. Accessed 30 Sep 2017.

VDWR. 2015b. Virginia deer management plan 2015-2024. Virginia Department of Wildlife Resources, Richmond, Virginia, USA. <https://dwr.virginia.gov/wp-content/uploads/virginia-deer-management-plan.pdf>. Accessed 6 Feb 2018.

VDWR. 2016. Record high wild turkey population likely to remain stable. Notes from the Field. Virginia Department of Wildlife Resources. <https://blog.wildlife.virginia.gov/2016/11/record-high-wild-turkey-population-likely-to-remain-stable/>. Accessed 12 Apr 2018.

Wenny, D. G., T. L. DeVault, M. D. Johnson, D. Kelly, C. H. Sekercioglu, D. F. Tomback, and C. J. Whelan. 2011. The need to quantify ecosystem services provided by birds. The Auk 128:1–14.

Whelan, C. J., D. G. Wenny, and R. J. Marquis. 2008. Ecosystem services provided by birds. Annals of the New York Academy of Sciences 1134:25–60.

Williams-Guillén, K., I. Perfecto, and J. Vandermeer. 2008. Bats limit insects in a neotropical agroforestry system. Science 320:70–70.

Wilson, G. A., and J. Rigg. 2003. ‘Post-productivist’ agricultural regimes and the South: discordant concepts? Progress in Human Geography 27:681–707.

Wilson, K. A., K. J. Davis, V. Matzek, and M. E. Kragt. 2019. Concern about threatened species and ecosystem disservices underpin public willingness to pay for ecological restoration. Restoration Ecology 27:513–519.

## Table

Table 1.1: Farm locations and type (Control with no pollinator plot or Treatment with pollinator plot) on the Eastern Shore of Virginia and Maryland and in the city of Virginia Beach, Virginia.

| Farm Treatment | Latitude and Longitude |
|---|---|
| Control | 36.627650°, -76.036733° |
| Control | 36.694082°, -76.023951° |
| Control | 36.893121°, -76.176165° |
| Control | 37.380042°, -75.982465° |
| Control | 37.397950°, -75.885538° |
| Control | 37.776111°, -75.642476° |
| Control | 37.810350°, -75.631517° |
| Control | 38.414251°, -75.802029° |
| Control | 38.307111°, -75.887891° |
| Control | 38.376274°, -75.655900° |
| Pollinator | 36.704733°, -75.991700° |
| Pollinator | 36.715735°, -76.015809° |
| Pollinator | 37.334838, -75.997241 |
| Pollinator | 37.391667°, -75.949667° |
| Pollinator | 37.588654°, -75.821345° |
| Pollinator | 37.648958°, -75.676925° |
| Pollinator | 37.712667°, -75.671459° |
| Pollinator | 38.213033°, -75.671183° |
| Pollinator | 38.330897°, -75.678645° |

| | |
|---|---|
| Pollinator | 38.454133°, -75.701134° |

# Chapter 2: Relationship of bird populations and community to pollinator-friendly plantings in the Coastal Plain of Virginia and Maryland.

Earle J. Berge[1]†, Sarah Karpanty[1], Megan O'Rourke[2], and Dean Stauffer[1].

[1]Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, Virginia 24061, USA

[2] United States Department of Agriculture National Institute of Food and Agriculture, Kansas City, Missouri 64133, USA

†E-mail: earleb@vt.edu

Target journal is Agriculture, Ecosystems and the Environment.

## Abstract

We estimated bird diversity, presence, density, and nesting on farms planted with and without pollinator-friendly plantings to evaluate the potential value of these farmscaping restoration activities to bird-related values, such as cultural, recreational, and insect-regulating ecosystem services. Bird point counts were conducted across 20 farms on the Eastern Shore of Virginia and Maryland and the city of Virginia Beach, VA, during the Spring and Fall of 2017 and 2018. We also searched for bird nests in pollinator-friendly plots during the summers of 2017 and 2018. We found no differences in alpha diversity, defined as species richness on a farm per survey season, between control and pollinator farms in either Spring or Fall. We did find that pollinator farms had higher indices of evenness than control farms, using both Pielou's evenness index and Simpson's index. When examining factors relating to the presence or absence of bird species on a farm, the most frequent influences were related to the percent cover within 1 km of a farm for 14 of 15 species modelled, with the exception being the eastern bluebird (*Sialia sialis*). The presence of pollinator plots was an influential factor in bird species presence or absence for 5 of 15 species. The percent cover of landscape features within 1 km around each farm also influenced bird density in 4 of 10 species in Spring surveys and 3 of 10 species in Fall surveys. After stratification of density estimates between control and pollinator farm study sites, we found that during Spring surveys, the blue jay (*Cyanocitta cristata*) and Carolina wren (*Thryothorus ludovicianus*) had lower density on pollinator farms whereas in the Fall the blue grosbeak (*Passerina caerulea*) had higher density on pollinator farms. We found red-winged blackbirds (*Agelaius phoeniceus*; n=7) nesting in the pollinator-friendly plots. This species preferred locations in the pollinator plots with higher forb coverage than random points in the same plots without nests. Our findings are one of the first in North America to demonstrate

potential benefits of pollinator-friendly plantings on bird species richness, presence and density as well as to support prior studies on the importance of natural cover in the surrounding landscapes on these same bird metrics. Future work should attempt to directly link these bird-related metrics on farms with pollinator plantings to metrics of the potential ecosystem-services, such as reduction in insect pests and social and financial benefits from bird-watching activities on farms.

## Introduction

Farmland yield has advanced greatly in recent decades due to the prevalence of high intensity, chemically-intensive monoculture crop systems on the landscape (Wilson and Rigg 2003, Conway and Barbier 2013). While benefiting food security objectives, high intensity farming practices have led to a decrease in plant and animal diversity and thus a corresponding reduction in ecosystem services such as regulation of pests and cultural value to birders (Tilman 1998, Dhaliwal et al. 2010, Horlings and Marsden 2011). Recognizing this loss, agencies such as the U.S. Department of Agriculture Natural Resource Conservation Service (USDA-NRCS) and various state agricultural and lands-based organizations have implemented policies to encourage biodiversity and ecosystem services through farmland alterations. These enhancements of farmland, defined here as 'farmscaping,' include altering the habitat structure on farms to benefit natural processes and native species, to enhance and bring back the diversity of ecosystem services that farmlands once provided (Pavelis et al. 2011, Benson et al. 2016). Farmscaping practices may include, but are not limited to, adding a mix of cover types, planting shrub- or tree-dominated hedgerows along property boundaries, or the planting of native forb- and native grass-dominated 'pollinator' plots or rows.

Wildlife responses to farmscaping practices are still relatively understudied compared to other benefits, such as pest reduction or pollination, and depend on the details of which practice is implemented. Wild Turkey (*Meleagris gallopavo*) and other vertebrates (bats, mice, rabbits, squirrels, deer) tend to use tree- or shrub-dominated hedgerows as cover with a concurring increase of bird species richness with increases in shrub- or tree-densities along field edges in agricultural landscapes (Burel 1996, Davies and Pullin 2007, Boughey et al. 2011). Pollinator plots or rows, studied in North American and European farming systems often have been shown to reduce pest insect populations and to benefit the native insect pollinator community (Morandin and Kremen 2013, Benson et al. 2016, Bloom and Crowder 2016, O'Rourke et al. 2019, Albrecht et al. 2020). A review of the impacts of farmscaping practices used in agricultural systems indicate that such practices can result in increased pollinator presence, decreased parasitoid presence, reduced pesticide use, increased crop production, and increased species diversity within the farming ecosystem (Shennan 2008).

Restoration of habitats that encourage the presence and abundance of resident and migratory insect-eating birds is one mechanism whereby farmscaping may augment pest control ecosystem services. However, studies on the pest control benefits of birds in farmscapes has sometimes been mixed as some insect-eating birds consume both insect crop pests and the predatory insects of those crop pests (Martin et al. 2013, Karp and Daily 2014, Railsback and Johnson 2014). However, research in California showed that on heterogeneous organic row crop farms with hedgerows, elevated bird species richness reduced insect pests during outbreak conditions when the numbers of predatory insects were low (Garfinkel and Johnson 2015).

In addition to the benefits that birds may provide for pest control in farmscapes, birds are also valued as a cultural ecosystem service by many people and contribute to ecotourism and agritourism campaigns. For example, the tourism board of the Eastern Shore of Virginia markets the ecotourism value of its natural areas for birdwatching, fishing, and camping through the "You'll Love Our Nature" campaign (Eastern Shore of Virginia Tourism Commission 2020). On 'pick-your-own' farms that encourage agritourism, the presence of resident and migratory birds can both hold a cultural value to birders as well as cultural and financial value to farmers who might bring in more business with the sightings of these birds (Burel and Baudry 1995, Roberts and Hall 2001, Belaire et al. 2015). Some bird species may hold both cultural values to birdwatchers and provisioning values for hunters. For example, the sights or sounds of the imperiled northern bobwhite (*Colinus virginianus*) and wild turkey might be valued by both birders and hunters (Burger et al. 1999, Dailey 2002, Daley et al. 2004, Dailey and Braun 2012, Golden et al. 2013) and thus farmscaping actions that increase their abundances would be particularly important to multiple stakeholder groups.

Studies documenting the impacts of farmscaping on bird populations and communities are still relatively rare despite the potential benefits of birds from farmscaping , including pest reduction, cultural, and provisioning ecosystem services (Smith et al. 2005). Specifically, the benefits of pollinator friendly plantings as a farmscaping practice in the Coastal Plain landscape of Virginia and Maryland are yet unstudied. In this region, several entities such as the USDA-NRCS, the Virginia Department of Conservation and Recreation (VA-DCR), and Virginia Department of Transportation (VDOT) have engaged in pollinator friendly plantings for different goals, whether it be for visual, production, or ecological benefits (Vaughan and Skinner 2008, Ball 2015, VADCR and VADEQ 2019).

Our objectives were to quantify species richness and diversity, factors relating to presence or absence, and density of birds on farms with and without pollinator plots on the Eastern Shore of Virginia and Maryland and in the city of Virginia Beach, VA. We also sought to determine if birds used these restored pollinator-friendly plots on farms as nesting habitat. We conducted point counts and nest searches for birds within the pollinator plots during the Spring (April-July) and Fall (August-October) of 2017 and 2018 and predicted that bird richness and diversity would be higher on farms with pollinator friendly plantings. We also predicted that landcover surrounding the farms would influence bird richness, diversity, presence, and density.

## Methods

### Study Area

A total of 20 farm study sites was selected for study in Spring of 2015 on the Eastern Shore of Virginia and Maryland (i.e. Delmarva Peninsula) and in the city of Virginia Beach, VA (Appendix A, Figure 2.1). Study sites were entirely located within the mid-Atlantic Coastal Plain denoted by primarily alluvial soils of sedimentary sand and clay with surrounding tidewater influences (McFarland and Bruce 2006). Landscape use of this area varies widely across the study area with a majority of larger cities in the northern reaches of Maryland and southern locations in the city of Virginia Beach, VA. The rest of the landscape is a mix of pine stands, poultry and crop farms, as well as natural parks and area preserves. Farmers were contacted for potential participation at farmer's markers and through conversations with local USDA-NRCS agents. Farms were selected based on landowner willingness to participate in the study whereby also ensuring variation in forest cover, crop lands, developed lands, and water features within a 1-km radius land cover analysis using data from the 2017 USDA Cropscape data layer (Appendix B; USDA National Agricultural Statistics Service Cropland Data Layer 2017). The cover classes of deciduous forest, evergreen forest, mixed forest, shrubland, woody wetland, and herbaceous wetland were collapsed into a category of natural cover. Cover classes of developed/open space, developed/low intensity, developed/medium intensity, developed/high intensity, and barren were collapsed into developed cover. Crop cover class was aggregated from all crop categories including a majority of corn, hay, wheat, soybeans, watermelon, sod, cotton, and sorghum. Water, which included saltwater or brackish bay, were combined into a water category. The percent area of the four cover classes (natural, developed, crop, and water) were calculated within a 1,000 m radius buffer surrounding each field site using ArcMap v10.5.1 (ESRI, Redlands, CA; Appendix B).

Each selected farm was located at least 2.5 km from any other farm used in the study. Farms included 5 sites in the city of Virginia Beach, VA; 4 sites in Northampton County, VA; 5 sites in Accomack County, VA; 5 sites in Wicomico County, MD; and 1 site in Somerset County, MD. Ten farm locations spread throughout the survey area had pollinator-targeted plantings; hereafter, 'pollinator' farms, which were planted and managed according to Angelella and O'Rourke 2017 and 10 farms did not receive the pollinator plantings, hereafter, 'control' farms (Figure 2.1, Appendix C). The size of pollinator friendly plantings ranged from 560 - 12,140 $m^2$, usually placed in large strips on field edge or blocks of land on the edge of cropland as allowed by landowners (Appendix A).

**Field Methods**

*Bird Surveys* – On each of the 20 farms, we placed 2-3, 50-meter radius point count locations with a distance of at least 100-meters between each point to avoid sampling overlap (Hamel et al. 1996). Point locations were placed depending on cover type and fell into four categories: forest-managed (FM), a location on forest edge adjacent to plowed fields, crops, or recently used fields; forest-unmanaged (FU) a location on forest edge adjacent to brush piles, fallow fields older than 2-years, or recently logged; pollinator-friendly native forb and grass plantings (PP), adjacent and encompassing a pollinator plot that researchers placed only on each pollinator farmscape; novel habitat (NH), where landscape features such as open fields of short weeds, repeatedly mown fields, and small stream flows caused alternative farmscapes features on control farms (Appendix A). All 10 pollinator farms included point counts in the FM, FU, and PP cover types. Six control farms included point counts in the FM, FU, and NH cover types. Two control farms had a FM and FU, but due to size restraints, did not include a NH cover type.

One control farm consisted of 3 FM points, and one control farm consisted of 3 FU points (Appendix A)

Point counts targeting Spring migration were completed between April 8th and June 5th, 2017 and 2018 and point counts targeting Fall migration were completed between August 26th and October 14th, 2017 and 2018. We did not conduct point counts when heavy rain and winds occurred in order to maximize detection of present species (Hamel et al. 1996). All point counts occurred between 10 minutes prior to sunrise to 3 hours after sunrise. At each point, the observer stood still for 2-minutes after arriving at a survey point. Then, a 5-minute point count was conducted with the observer noting all birds by sight and sound and recording observations within bands of 0-10m, 11-25m, 26-50m, and 51-100m buffers of the point location. Lastly, the surveyor would play northern bobwhite and wild turkey calls for 1-minute each using a small speaker with recordings taken from The Cornell Lab of Ornithology in order to encourage call backs to provide evidence of occupancy (Cornell Lab of Ornithology 2017). After recordings ceased, the observer conducted a second independent 5-minute point count using the same recording methods as the first.

*Nesting searches* - We searched all pollinator plots for nesting birds from June 4th to June 29th in 2017 and May 28th to July 8th in 2018. Before each field search, an observational period of the pollinator plot was conducted by an observer standing 15 m or more from the plot, lasting between 30- and 90-minutes (Ralph et al. 1993). During each observational period, surveyors would take notes on observations of territorial or nesting behavior by species within the pollinator plot and possible predators in the surrounding areas of the pollinator plot. When observers were certain that no predators were visible near the pollinator plot and no signs of nesting activity were observed, we carefully walked through each pollinator plot to flush any birds nesting that we may have missed based on visual observations (Winter et al. 2003). To aid in survey of each field, a 1.52 m long pole was used to trigger nesting bird flight before surveyors reached a possible nest as well as reduce the needed number of rows searched in each plot (Winter et al. 2003).

If a nest was located, surveyors would quickly take a photo of the nest/young and measure the height from ground to nest bowl before moving on in the survey. Fields without observed nesting behavior or nests were resurveyed every 7-10 days. If a field was found to have a nest or nesting behavior and unlocated nests, an observational period of 30-minutes was conducted every 3-4 days, taking note of other potential nest sites and possible predators. After every observational period, all located nests were re-examined and photographed for monitoring, continuing until fledging or failure of the nest.

After all nests in a plot failed or hatched, five random points without a nest present were also chosen within the pollinator plot by throwing a 0.25 $m^2$ square frame randomly 5 times into the pollinator plot. Then the height of vegetation and type of vegetation around nest sites, and those 5 random, unused sites within the same pollinator plot, were measured. We used a Robel pole (Robel et al. 1970) at the nest site after the nest failed or hatched or at random points, to measure vegetation height and height at which vegetation obstructed the Robel pole at 4 m in the four cardinal directions around the nest. The four values for each nest or random point were averaged for a measure of average vegetation height and visual obstruction. At each nest and random point, we then placed a 0.25 $m^2$ square frame and measured percent cover within of forb green vegetation, flowering heads, grass, dead vegetation, bare ground, and nest.

**Analytical Methods**

*Bird species richness and diversity metrics* - We calculated estimates of alpha (α) and beta (β) diversity for each farm site, and a gamma (γ) bird diversity across our all survey sites. We defined α diversity as total number of species within 50m of each survey point on each survey farm during all Spring and Fall survey periods (Whittaker 1972). An index of abundance was then calculated for each species on each farm by summing the total number of individuals of each species observed at each farm and then dividing by the survey effort and area surveyed at each farm to calculate individuals of a bird species per survey per hectare. Using this index of abundance, we defined β diversity using Pielou's evenness index (ranges from 0 to 1 with 0 being low evenness and 1 being high) to measure the level of equality in abundances by species for each survey farm during all survey periods (Pielou 1975). We defined γ diversity as the regional bird species richness by summing up the individual farm species richness estimates for all survey periods for all 20 farms, and then for pollinator and control farms (Lande 1996, Rundlöf et al. 2008). We also calculated Simpson's and Shannon's diversity indices to further compare diversity metrics across control and pollinator farms. Both indices were measured for each farm during all survey periods (Lande 1996, Bibi and Ali 2013). Calculations were done in R-Studio (Version 4.2.0) with the VEGAN package. Comparison of diversity metrics and indices between control and pollinator sites were conducted using two tailed t-tests in Microsoft Excel.

*Factors relating to bird species presence on a farm* - Presence or absence by bird species was determined within the 50m buffer of each sample point on each farm, by season (Fall and Spring) and year (2017 and 2018, Appendix D). We assessed factors relating to presence or absence of a bird species on a farm using mixed effects logistic regression, using R-studio (version 3.6.1) and package lme4 (Bates et al. 2020) for all bird species lumping within spring and within fall across years (i.e., Spring 2017 and 2018 lumped to Spring) excluding those present or absent on only 4 farms or less out of our total farm sites.

For each sample, covariates recorded included pollinator or control farm, year of survey, and percent land cover at a 1 km scale surrounding the farm, including developed, natural, cropland, and water. Non-discrete covariates were compared using a Pearson's correlation to determine possible redundancy in covariates, with a 60% correlation as the cutoff. For each species and season and year combination (Spring and Fall, 2017 and 2018), we ran all single covariate models. Models whose ΔAICc < 4.0 were considered competing (Arnold 2010*a*). When more than one single covariate model was competing, we also tested all model variations with up to 3 covariates to a model. We then evaluated goodness of fit for each model with the Hosmer-Lemeshow goodness of fit test.

*Factors relating to bird density on a farm* – We modeled bird population densities with Program Distance (version 7.3), with the multiple covariates distance sampling engine (MCDS). We treated each survey, including pre- and post-quail and turkey calls, at a point as a sample using all observations made within 100 m of the survey point to boost our observations and detection (Appendix E). We only estimated density for species with at least 100 observations within the seasons of both years combined to insure adequate sample size for post stratification, but did not considered species with flocks > 30 individuals for the purposes of subsetting species for analyses (Anderson et al. 1993). Truncation of our data was set at 100m and bins were predefined as 0-10m, 11-25m, 26-50m, and 51-100m. We determined key functions (uniform /simple polynomial/hazard rate) and adjustment expansions (cosine/half normal/hermite polynomial) by season for each species and ranked these detection functions using $AIC_c$. We then used the best key function model to evaluate the effects of covariates.

For each sample, covariates recorded included start time of survey since sunrise, temperature during survey, cloud cover at the start of survey, pollinator or control farm, type of land cover at each survey point (FM, FU, NH, and PP), observer, and percent land cover at a 1km scale including developed, natural, cropland, and water. Non-discrete covariates were compared with Pearson's correlation to determine possible redundancy of covariates, with a 60% correlation as the cutoff. For each species and season and year combination (Spring and Fall, 2017 and 2018), we ran single and double covariate models from measures mentioned above. Models with $\Delta$AICc < 4.0 were considered competing (Arnold 2010*a*). For each top model by season and year and species, we post-stratified the density estimated, weighted by survey effort, in control versus pollinator locations, to determine density of birds on control and pollinator farms.

*Use of pollinator plots for nesting* - We used a Wilcoxon rank sum test to determine the differences in the mean height of visual obstructions, vegetation height, and percent ground cover type at nest locations and random points without nests in each pollinator plot. Calculations were done in R-studio (version 3.6.1) with package stats.

## Results

*Bird species richness and diversity metrics* - We had 57 point locations in Spring 2017, 52 point locations in Fall 2017, 55 point locations in Spring 2018 and 55 point locations in Fall 2018 when counting all points sampled on the 20 farms. We conducted point count surveys 3 times in Spring 2017, 4 times in Fall 2017, 5 times in Spring 2018, and 4 times in Fall 2018 with two surveys (pre- and post- playback) during each visit. This totaled to 1748 samples, 892 during Spring surveys and 856 during Fall surveys.

Spring species richness per farm ($\alpha$ diversity) ranged from 16 – 46 bird species per farm ($\bar{x}$ = 36.15 species/farm, SE = 1.53); we found no difference in species richness between control and pollinator farms (two-tailed t-test: t = -0.42, df = 15, p = 0.68; control species/farm: $\bar{x}$ = 36.8, SE = 1.69, range 30-46; pollinator species/farm: $\bar{x}$ = 35.5, SE = 2.62, range 16-46; Figure 2.2). Similarly, Fall α diversity ranged from 19-39 bird species per farm ($\bar{x}$ = 31.95 species/farm, SE = 1.33); we found no difference between pollinator and control farms (two-tailed t-test: t = -0.65, df = 16, p=0.52; control species/farm: $\bar{x}$ = 32.9; SE = 2.15, range 22-39; pollinator species/farm: $\bar{x}$ = 31.1; SE = 1.70, range 19-39; Figure 2.2).

Pielou's evenness (J: β diversity) in the Spring ranged from 0.21-0.30 J (overall $\bar{x}$ = 0.25, SE = 0.004) across all farms with slightly higher evenness on pollinator farms than control farms (two-tailed t-test: t = 2.26, df = 18, p=0.04; control J: $\bar{x}$ = 0.24, SE = 0.01, range 0.21-0.26; pollinator J: $\bar{x}$ = 0.26, SE = 0.01, range 0.24-0.30; Figure 2.2).

Total γ richness across both seasons and years totaled 110 bird species (Spring γ richness = 96 bird species, Fall γ richness = 82 bird species; Figure 2.2). Total γ richness across both seasons and years was highest at pollinator farms (γ richness = 106 bird species) than at control farms (γ richness = 96 bird species). In addition, 15 birds were unique species only seen on pollinator farms, while 8 birds were unique species only seen on control farms.

We found no difference in Spring or Fall Shannon's diversity index (H) between control and pollinator farms (Figure 2.2). We did find that Simpsons diversity index (D) was higher on pollinator farms than control farms in the Spring, but not the Fall sampling seasons (Spring two-tailed t-test: t = 2.23, df = 15, p=0.04; control D: $\bar{x}$ = 0.87, SE = 0.02, range 0.75-0.93; pollinator D: $\bar{x}$ = 0.91, SE = 0.01, range 0.83-0.94; Figure 2.2).

*Factors relating to bird species presence on a farm* - Of the 110 species detected, excluding those present or absent on only 4 farms or less, 15 species were considered for further assessment; these included the America robin (*Turdus migratorius*), blue-gray gnatcatcher

(*Polioptila caerulea*), brown thrasher (*Toxostoma rufum*), common yellowthroat (*Geothlypis trichas*), downy woodpecker (*Picoides pubescens*), eastern bluebird (*Sialia sialis*), eastern wood pewee (*Contopus virens*), field sparrow (*Spizella pusilla*), gray catbird (*Dumetella carolinensis*), mourning dove (*Zenaida macroura*), northern mockingbird (*Mimus polyglottos*), pileated woodpecker (*Dryocopus pileatus*), red-eyed vireo (*Vireo olivaceus*), tree swallow (*Tachycineta bicolor*), and turkey vulture (*Cathartes aura*; Appendix D). No comparisons of covariates used exceeded our correlation threshold ($r < |0.6|$).

Most species modelled had competing models of the factors relating to presence or absence on studied farms, but we present the top model for Spring and Fall analyses (Table 2.1, Appendices F and G). The probability of presence or absence of bird species on farms varied by year for 8 of 15 species modelled; blue-gray gnatcatcher, common yellowthroat, downy woodpecker, eastern bluebird, northern mockingbird, red-eyed vireo, and tree swallow were all more likely to be present in 2018 than 2017 surveys whereas the pileated woodpecker was more likely to be present in 2017 than 2018 (Table 2.1).

Landscape covariates influenced the presence or absence of bird species on farms in Spring or Fall surveys for all species except eastern bluebird (Table 2.1). Mourning dove in the Spring ($\beta = 0.06$, 95% CI = 0.001 - 0.12) were positively related and eastern wood peewee in the Spring ($\beta = -0.07$, 95% CI = -0.13 - -0.01) were negatively related to the percent of natural landscape within 1 km (Table 2.1). Mourning dove in the Spring ($\beta = 0.08$, 95% CI = 0.002 – 0.16) were positively related to the percent of water landscape within 1km (Table 2.3). Field sparrow in the Spring ($\beta = 0.08$, 95% CI = 0.002 – 0.16) were positively related while turkey vulture ($\beta = -0.04$, 95% CI = -0.08 - -0.001) and blue-gray gnatcatcher ($\beta = -0.04$, 95% CI = -0.08 - -0.001) in the Fall were negatively related to the percent of crop landscape within 1km (Table 2.1).

The presence of a pollinator plot influenced the presence or absence of bird species for 5 of 15 species. Grey catbirds in the Spring ($\beta$ = -1.49, 95% CI = -2.90 - -0.08) and brown thrashers in the Fall ($\beta$ = -1.62, 95% CI = -3.17 - -0.07) were negatively related to the presence of pollinator plots on our farms compared to without (Table 2.1).

*Factors relating to bird density on a farm* - We obtained > 100 observations of only 10 of 113 bird species present in this subset on the 20 study farms: American crow (*Corvus brachyrhynchos*), American robin, blue grosbeak (*Passerina caerulea*), blue jay (*Cyanocitta cristata*), Carolina chickadee (*Poecile carolinensis*), Carolina wren (*Thryothorus ludovicianus*), chipping sparrow (*Spizella passerina*), field sparrow, northern cardinal (*Cardinalis cardinalis*), and tufted titmouse (*Baeolophus bicolor*; Appendix E).

We found that bird detectability was influenced by a variety of factors, as reflected in their presence in top or competing models, including land cover within 1km, pollinator plot presence, station type, whether the survey was before or after playback, observer, cloud cover, time since sunrise, and temperature (Tables 2.2 and 2.3, Appendices H and I). During Spring, a land cover predictor was present for 4 of 10 species. Only northern cardinal ($\beta$ = -0.002, SE = 0.001) and American robin ($\beta$ = -0.01, SE = 0.003) in the Fall were negatively related to the percent of crop landscape within 1km (Table 2.3). Carolina wren in the Spring ($\beta$ =-0.17, SE = 0.07) were negatively related and the blue grosbeak in the Fall ($\beta$ = 0.25, SE = 0.09) were negatively related to the presence of pollinator plots on our farms compared to without (Table 2.2 and 2.3).

The effect of farm type (i.e., pollinator versus control) was in the top model for two species during our Spring surveys (American Crow and Carolina Wren). After stratification of the Spring models, densities of blue jays and Carolina wrens were higher on control farms than on pollinator farms. In the Fall, blue grosbeaks had a higher density on pollinator farms than on control farms (Table 2.4, Figure 2.3).

*Use of pollinator plots for nesting* - During surveys of pollinator friendly plantings on pollinator farms (N = 10) in 2017 and 2018, 7 red-winged blackbird nests were found in pollinator plots on three farms (Table 2.5). No other bird nests, nor signs of bird nesting activity, were documented in 24-person days of search effort in 2017 and 41-person days of search effort in 2018. Presumed predation was the most common nest fate recorded (3/7 nests). Forbs made up a greater percentage of cover within 1 $m^2$ at nest locations ($\bar{x}$ = 86%, SE=6.78%) than at random locations ($\bar{x}$ = 58.8%, SE=3.22%) without nests (Wilcoxon test, $\chi 2$ =8.25, df = 1, p-value = 0.004, Figure 2.4). Additionally, percent leaf litter, which was correlated with percent forbs (Pearson's Correlation: -0.81), also made up a lower percentage of cover within 1 $m^2$ at nest locations ($\bar{x}$ = 3.60, SE = 1.86) than at random locations ($\bar{x}$ = 25.44, SE = 2.64) without nests (Wilcoxon test: $\chi^2$ =10.17, df = 1, p=0.001, Figure 2.4, Appendix J).

## Discussion

Farmscaping practices have the potential to turn small and large portions of cropland into areas that can support ecosystem services like pest reduction and cultural values due to increases in bird diversity, presence, and density. Currently, knowledge for pollinator friendly plantings have not been fully explored and we attempted to target and explain the relationship pollinator friendly plantings have on the diversity, presence, and density of bird species.

*Bird species richness and diversity metrics* - Current knowledge of bird diversity on farmscapes has shown that many farmland species are generalists that can use farmland edges and crops as a place to forage for insects as well as the developed land cover in the surrounding areas (Tscharntke et al. 2008, Sekercioglu 2012, Heath et al. 2017). The diversity of species identified on farms is generally much lower in comparison to natural areas, but heterogeneous habitats with a mix of low intensity agriculture and natural landscapes have been shown to support higher diversity because of the different cover types available in the landscape for specialists as well as generalist species (Kinross 2004, Jones et al. 2005, Tscharntke et al. 2008, Gove et al. 2013, Heath et al. 2017).

In Northampton County VA, there are records for 406 species of bird, 96 species are reportedly very rare for the area, leaving around 310 species of birds with a higher chance of being present on our farm study sites (ESVANWR 2012). We report recorded a total of 110 different species on farmscapes of the Coastal Plain of Virginia and Maryland. We documented 96 insectivorous bird species on our farms. As an overwhelming majority of birds observed on our study farms are insectivores, further study of the insect regulation benefits of native birds in these systems is warranted.

Alpha diversity did not differ between our control and pollinator farms were equivocal. However, examining multiple aspects of diversity we did find that β evenness and our γ richness showed differences between each. In general, our farm study sites were similar enough that it could be expected that α diversity measures were similar due to the small scale at which pollinator plantings presented on the landscape. However, Simpson's index in the Spring was higher on the pollinator farms rather than control farms (0.87 vs 0.91) which could explain differences pollinator plots are bringing to the farmscape. Our consideration of regional level species richness also suggest that farms with pollinator plots have higher species richness than control farms, and thus could offer benefits to species that require specialized habitat not available on farms without this resource.

*Factors relating to bird species presence on a farm* - It is currently accepted that a larger portion of landscape dominated by heterogeneous mixtures of crop land, grazing areas, wetlands, forests, and field margins are important for wildlife biodiversity (Penhollow and Stauffer 2000, Fahrig et al. 2011, Lee and Martin 2017) our work provided support for this in that landscape within 1 km of farms was included as a predictor in at least one top model for Spring or Fall (except for the eastern bluebird). Accordingly, the presence of some bird species was largely due to larger landscape cover type effects rather than small-scale changes resulting from pollinator friendly plantings. However, it is interesting to note that it is not always large-scale cover type changes that lead to increases in presence and biodiversity but the heterogeneity at the landscape scale that can increase the diversity and presence (Lee and Martin 2017). On farms, alternate features that represent habitat heterogeneity are equally as important to consider including heterogeneity of crops, edging, and diversity of farmscaping techniques in addition to their placement across a farm (Fahrig et al. 2011). Prior research has shown that even small scale increases in habitat heterogeneity can improve the suitability of a farm for wildlife (Garfinkel and Johnson 2015, Kross et al. 2016). Our findings of instances of influential impacts by pollinator-friendly plantings are in line with those previous studies. For example, we found that the eastern bluebird and eastern wood pewee were positively influenced by pollinator plot presence more than landscape level factors.

*Factors relating to bird density on a farm* - In agricultural areas, declines of avian diversity and density have been widely demonstrated (Gaston et al. 2003). Density of avian species on the agricultural landscape is frequently linked to large scale feature changes such as deforestation, loss of edges around field margins, intensification of crop production, and urbanization (Piha et al. 2007, Gavier-Pizarro et al. 2012, Evans et al. 2014). Thus, we might not see dramatic responses in bird density driven by a small pollinator plot, but we could see presence and diversity metrics be influenced by these small restoration plots. Our density estimates when stratified were not significantly different for a majority of the species we examined between farms with and without pollinator-friendly plantings. This is probably in major part to the small scale of the plantings in our study which is expected since the effective area for ecological effects is so small in each of our farmscapes (Allouche et al. 2012). Fall density analysis did show higher density of blue grosbeak on sites with pollinator friendly plantings (0.62 birds/ha > 0.21 birds/ha). For this particular species, specialized old-field fledgling habitat might be at a premium in current high intensity agriculture, which might add that fledglings and juveniles could be spending time on these farms feeding on insects increasing regulating services at the field level having created more effective area in our small plot size (McAtee 1911).

One issue we might be able to examine in the future is our analysis on species being restricted to only 10 out of 110 observed species on our study site farms. The main drawback of my analyses was in targeting individual species due to the lack of observations for more rare species and having to exclude them. Future research from our data sets will be processed into feeding or habitat response guilds to examine a wider scope of lumped species present on farms as seen in other agricultural studies (Knopf et al. 1988, Cederbaum et al. 2004).

*Use of pollinator plots for nesting* – We found red winged blackbirds using our pollinator plots for nesting and this finding has management implications for improving or inhibiting habitat for species such as the red-winged blackbird. Populations of red-winged blackbirds and other Ictarids are known to be declining in North America at an alarming rate although populations of red-winged blackbirds are still one of the most abundant bird species (Blackwell and Dolbeer 2001, Weatherhead 2005, Wells 2011). Although this might come as good news to corn farmers who have large loses to red-wing blackbird crop damage, there are still benefits red winged blackbirds can provide. Mainly, on farmlands where corn is not a predominant agricultural product, the red-wing blackbirds increased presence from nesting might increase pest reduction; which even on the corn ear worm, when managed properly, can assist in the pest regulating services on corn crops (Bollinger and Caslick 1985, Dolbeer 1990, Okurut-Akol et al. 1990). Thus, it is incredibly important for us to note that even a small pollinator plot might make a difference for future management and that fields used for nesting were those that were well established with higher cover of forbs. Future methods for actual planting of pollinator plots are likely a large influence in red wing blackbird nesting presence as well as possible links to nest predation, of which 2 of the failed nests seemed unlikely disturbed with missing eggs and likely predated by snakes (Best and Stauffer 1980).

## Acknowledgments

This research was supported by U.S. Department of Agriculture's Agroecosystem Management grant #11664133 and graduate teaching support to E. Berge from the Department of Fish and Wildlife Conservation at Virginia Tech. Thank you to all our gracious landowners that allowed us use of their property for study activities. We thank the research station staff at the Anheuser-Busch Costal Research Center for always having a place for us throughout the years to sleep and work. We also thank our field technicians: Cameron Robertson, Chris Rowe, Ally Moser-Scott, and Amanda Crandall, who worked tirelessly through completely packed survey seasons. Lastly, we want to thank our numerous lab staff who helped process data and spend time in the field on weekends, special thanks to Emily Gardner and Amie Scott.

## Literature Cited

Albrecht, M., D. Kleijn, N. M. Williams, M. Tschumi, B. R. Blaauw, R. Bommarco, A. J. Campbell, M. Dainese, F. A. Drummond, M. H. Entling, D. Ganser, G. A. de Groot, D. Goulson, H. Grab, H. Hamilton, F. Herzog, R. Isaacs, K. Jacot, P. Jeanneret, M. Jonsson, E. Knop, C. Kremen, D. A. Landis, G. M. Loeb, L. Marini, M. McKerchar, L. Morandin, S. C. Pfister, S. G. Potts, M. Rundlöf, H. Sardiñas, A. Sciligo, C. Thies, T. Tscharntke, E. Venturini, E. Veromann, I. M. G. Vollhardt, F. Wäckers, K. Ward, A. Wilby, M. Woltz, S. Wratten, and L. Sutter. 2020. The effectiveness of flower strips and hedgerows on pest control, pollination services and crop yield: a quantitative synthesis. Ecology Letters 23:1488–1498.

Allouche, O., M. Kalyuzhny, G. Moreno-Rueda, M. Pizarro, and R. Kadmon. 2012. Area-heterogeneity tradeoff and the diversity of ecological communities. Proceedings of the National Academy of Sciences of the United States of America 109:17495–17500.

Anderson, D. R., K. P. Burnham, and J. L. Laake. 1993. Distance sampling estimating abundance of biological populations. Chapman & Hall, London, UK.

Angelella, G., and M. O'Rourke. 2017. Pollinator habitat establishment after organic and no-till seedbed preparation methods. HortScience 52:1349–1355.

Arnold, T. W. 2010. Uninformative Parameters and Model Selection Using Akaike's Information Criterion. The Journal of Wildlife Management 74:1175–1178.

Ball, M. 2015. VDOT's pollinator habitat program moves toward statewide implementation. Informed Infrastructure. <https://informedinfrastructure.com/17439/vdots-pollinator-habitat-program-moves-toward-statewide-implementation/>. Accessed 3 Nov 2019.

Bates, D., M. Maechler, B. Bolker [aut, cre, S. Walker, R. H. B. Christensen, H. Singmann, B. Dai, F. Scheipl, G. Grothendieck, P. Green, and J. Fox. 2020. lme4: Linear mixed-effects models using "Eigen" and S4. <https://CRAN.R-project.org/package=lme4>. Accessed 7 Aug 2020.

Belaire, J. A., L. M. Westphal, C. J. Whelan, and E. S. Minor. 2015. Urban residents' perceptions of birds in the neighborhood: Biodiversity, cultural ecosystem services, and disservices. The Condor 117:192–202.

Benson, B., R. McDonald, N. C. Sugar Grove, and R. Morse. 2016. Farmscaping techniques for managing insect pests. Virginia Tech and Symbiont Biological Pest Management. <http://localfoodhub.org/wp-content/uploads/2012/07/5_farmscapingTechniques ForManagingInsectPests_VCE.pdf>. Accessed 3 Nov 2019.

Best, L. B., and F. Stauffer. 1980. Factors affecting nesting success in riparian bird communities. The Condor 82:149–158.

Bibi, F., and Z. Ali. 2013. Measurement of diversity indices of avian communities at Taunsa Barrage Wildlife Sanctuary, Pakistan. Journal of Animal and Plant Science 23:469–474.

Blackwell, B. F., and R. A. Dolbeer. 2001. Decline of the red-winged blackbird population in Ohio correlated to changes in agriculture (1965-1996). The Journal of Wildlife Management 65:661–667.

Bloom, E. H., and D. W. Crowder. 2016. Biological control and pollination services on organic farms. Pages 27–46 in A. R. Horowitz and I. Ishaaya, editors. Advances in Insect Control and Resistance Management. Springer International Publishing, Switzerland.

Bollinger, E. K., and J. W. Caslick. 1985. Red-winged blackbird predation on northern corn rootworm beetles in field corn. Journal of Applied Ecology 22:39–48.

Boughey, K. L., I. R. Lake, K. A. Haysom, and P. M. Dolman. 2011. Improving the biodiversity benefits of hedgerows: How physical characteristics and the proximity of foraging habitat affect the use of linear features by bats. Biological Conservation 144:1790–1798.

Burel, F. 1996. Hedgerows and their role in agricultural landscapes. Critical Reviews in Plant Sciences 15:169–190.

Burel, F., and J. Baudry. 1995. Social, aesthetic and ecological aspects of hedgerows in rural landscapes as a framework for greenways. Landscape and Urban Planning 33:327–340.

Burger, L. W., D. A. Miller, and R. I. Southwick. 1999. Economic impact of northern bobwhite hunting in the southeastern United States. Wildlife Society Bulletin 27:1010–1018.

Cederbaum, S. B., J. P. Carroll, and R. J. Cooper. 2004. Effects of alternative cotton agriculture on avian and arthropod populations. Conservation Biology 18:1272–1282.

Conway, G. R., and E. B. Barbier. 2013. After the green revolution: Sustainable agriculture for development. Earthscan, London, UK.

Cornell lab of ornithology. 2017. <https://www.allaboutbirds.org/guide/search>. Accessed 26 Apr 2017.

Dailey, T. V. 2002. Emerging trends in Midwest bobwhite culture. Proceedings of the National Quail Symposium 5:8–19.

Dailey, T. V., and C. E. Braun. 2012. Quail VII: Proceedings of the seventh national quail symposium. The University of Tennessee, National Bobwhite Conservation Initiative, Knoxville, USA.

Daley, S. S., D. T. Cobb, P. T. Bromley, and C. E. Sorenson. 2004. Landowner attitudes regarding wildlife management on private land in North Carolina. Wildlife Society Bulletin 32:209–219.

Davies, Z. G., and A. S. Pullin. 2007. Are hedgerows effective corridors between fragments of woodland habitat? An evidence-based approach. Landscape Ecology 22:333–351.

Dhaliwal, G. S., V. Jindal, and A. K. Dhawan. 2010. Insect pest problems and crop losses: changing trends. Indian Journal of Ecology 37:1–7.

Dolbeer, R. A. 1990. Ornithology and integrated pest management: Red-winged blackbirds *Agelaius phoeniceus* and corn. Ibis 132:309–322.

Eastern Shore of Virginia Tourism Commission. 2020. Media. Eastern Shore of Virginia Tourism. <https://visitesva.com/media/>. Accessed 26 Aug 2020.

ESVANWR. 2012. Birds, a guide to abundance and birding through the seasons on the Eastern Shore of Virginia. Eastern Shore of Virginia National Wildlife Refuge. <https://www.fws.gov/uploadedFiles/Region_5/NWRS/South_Zone/Chincoteague_Complex/Eastern_Shore_of_Virginia/PDFs/ESofVA%20Bird%20Brochure%201-19.12(1).pdf>. Accessed 30 Aug 2020.

Evans, K. O., L. W. Burger Jr., S. Riffell, and M. D. Smith. 2014. Assessing multiregion avian benefits from strategically targeted agricultural buffers. Conservation Biology 28:892–901.

Fahrig, L., J. Baudry, L. Brotons, F. G. Burel, T. O. Crist, R. J. Fuller, C. Sirami, G. M. Siriwardena, and J.-L. Martin. 2011. Functional landscape heterogeneity and animal biodiversity in agricultural landscapes. Ecology Letters 14:101–112.

Garfinkel, M., and M. Johnson. 2015. Pest-removal services provided by birds on small organic farms in northern California. Agriculture, Ecosystems & Environment 211:24–31.

Gaston, K. J., T. M. Blackburn, and K. K. Goldewijk. 2003. Habitat conversion and global avian biodiversity loss. Proceedings of the Royal Society of London. Series B: Biological Sciences 270:1293–1300.

Gavier-Pizarro, G. I., N. C. Calamari, J. J. Thompson, S. B. Canavelli, L. M. Solari, J. Decarre, A. P. Goijman, R. P. Suarez, J. N. Bernardos, and M. E. Zaccagnini. 2012. Expansion and intensification of row crop agriculture in the Pampas and Espinal of Argentina can reduce ecosystem service provision by changing avian density. Agriculture, Ecosystems & Environment 154:44–55.

Golden, K. E., M. N. Peterson, C. S. DePerno, R. E. Bardon, and C. E. Moorman. 2013. Factors shaping private landowner engagement in wildlife management. Wildlife Society Bulletin 37:94–100.

Gove, A. D., K. Hylander, S. Nemomissa, A. Shimelis, and W. Enkossa. 2013. Structurally complex farms support high avian functional diversity in tropical montane Ethiopia. Journal of Tropical Ecology 29:87–97.

Hamel, P. B., W. P. Smith, D. J. Twedt, J. R. Woehr, E. Morris, R. B. Hamilton, and R. J. Cooper. 1996. A land manager's guide to point counts of birds in the Southeast. US Dept of Agriculture, Forest Service, Southern Forest Experiment Station, New Orleans, Louisiana, USA.

Heath, S. K., C. U. Soykan, K. L. Velas, R. Kelsey, and S. M. Kross. 2017. A bustle in the hedgerow: Woody field margins boost on farm avian diversity and abundance in an intensive agricultural landscape. Biological Conservation 212:153–161.

Horlings, L. G., and T. K. Marsden. 2011. Towards the real green revolution? Exploring the conceptual dimensions of a new ecological modernisation of agriculture that could ‘feed the world.’ Global Environmental Change 21:441–452.

Jones, G. A., K. E. Sieving, and S. K. Jacobson. 2005. Avian diversity and functional insectivory on north-central Florida farmlands. Conservation Biology 19:1234–1245.

Karp, D. S., and G. C. Daily. 2014. Cascading effects of insectivorous birds and bats in tropical coffee plantations. Ecology 95:1065–1074.

Kinross, D. C. 2004. Avian use of farm habitats, including windbreaks, on the New South Wales Tablelands. Pacific Conservation Biology 10:180–192.

Knopf, F. L., J. A. Sedgwick, and R. W. Cannon. 1988. Guild structure of a riparian avifauna relative to seasonal cattle grazing. The Journal of Wildlife Management 52:280–290.

Kross, S. M., T. R. Kelsey, C. J. McColl, and J. M. Townsend. 2016. Field-scale habitat complexity enhances avian conservation and avian-mediated pest-control services in an intensive agricultural crop. Agriculture, Ecosystems & Environment 225:140–149.

Lande, R. 1996. Statistics and partitioning of species diversity, and similarity among multiple communities. Oikos 76:5–13.

Lee, M.-B., and J. A. Martin. 2017. Avian species and functional diversity in agricultural landscapes: Does landscape heterogeneity matter? PLoS ONE 12(1):e0170540.

Martin, E. A., B. Reineking, B. Seo, and I. Steffan-Dewenter. 2013. Natural enemy interactions constrain pest control in complex agricultural landscapes. Proceedings of the National Academy of Sciences 110:5534–5539.

McAtee, W. L. 1911. Our grosbeaks and their value to agriculture. Farmers’ Bulletin No. 456, U.S. Dept. of Agriculture, Washington, D.C., USA.

McCullough, C. T. 2020. The effects of wildflower plots and diverse landscapes on ecosystem services, bee communities, and on-farm tick abundance. Thesis, Virginia Tech, Blacksburg, USA.

McFarland, E. R., and T. S. Bruce. 2006. The Virginia coastal plain hydrogeologic framework. 1st ed. Professional paper 1731, U.S. Dept. of the Interior, U.S. Geological Survey, Reston, USA.

Morandin, L. A., and C. Kremen. 2013. Hedgerow restoration promotes pollinator populations and exports native bees to adjacent fields. Ecological Applications 23:829–839.

Okurut-Akol, F. H., R. A. Dolbeer, and P. P. Woronecki. 1990. Red-winged blackbird and starling feeding responses on corn earworm-infested corn. Proceedings of the Vertebrate Pest Conference 14. <https://escholarship.org/uc/item/11h7017j>. Accessed 4 Oct 2020.

O'Rourke, M., C. Philips, and T. Kuhar. 2019. Improving pest management with farmscaping. Virginia Cooperative Extension, Virginia Tech, Blacksburg, USA.

Pavelis, G. A., D. Helms, and S. Stalcup. 2011. Soil and water conservation expenditures by USDA agencies, 1935–2010. Historical Insights: 10, U.S. Department of Agriculture - Natural Resources Conservation Service, Washington, D.C., USA.

Penhollow, M. E., and F. Stauffer. 2000. Large-scale habitat relationships of neotropical migratory birds in Virginia. The Journal of Wildlife Management 64:362–373.

Pielou, E. C. 1975. Ecological diversity. Volume 8. John Wiley & Sons, New York, New York, USA.

Piha, M., J. Tiainen, J. Holopainen, and V. Vepsäläinen. 2007. Effects of land-use and landscape characteristics on avian diversity and abundance in a boreal agricultural landscape with organic and conventional farms. Biological Conservation 140:50–61.

Railsback, S. F., and M. D. Johnson. 2014. Effects of land use on bird populations and pest control services on coffee farms. Proceedings of the National Academy of Sciences 111:6109–6114.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. Handbook of field methods for monitoring landbirds. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, California, USA.

Ricotta, C. 2017. Of beta diversity, variance, evenness, and dissimilarity. Ecology and Evolution 7:4835–4843.

Robel, R. J., J. N. Briggs, A. D. Dayton, and L. C. Hulbert. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. Journal of Range Management 23:295–297.

Roberts, L., and D. Hall. 2001. Rural tourism and recreation: Principles to practice. CABI Publishing, New York, New York, USA.

Rundlöf, M., J. Bengtsson, and H. G. Smith. 2008. Local and landscape effects of organic farming on butterfly species richness and abundance. Journal of Applied Ecology 45:813–820.

Sekercioglu, C. H. 2012. Bird functional diversity and ecosystem services in tropical forests, agroforests and agricultural areas. Journal of Ornithology 153:153–161.

Shennan, C. 2008. Biotic interactions, ecological knowledge and agriculture. Philosophical Transactions of the Royal Society B: Biological Sciences 363:717–739.

Smith, M. D., P. J. Barbour, L. W. Burger, and S. J. Dinsmore. 2005. Density and diversity of overwintering birds in managed field borders in Mississippi. The Wilson Bulletin 117:258–269.

Tilman, D. 1998. The greening of the green revolution. Nature 396:211–212.

Tscharntke, T., C. H. Sekercioglu, T. V. Dietsch, N. S. Sodhi, P. Hoehn, and J. M. Tylianakis. 2008. Landscape constraints on functional diversity of birds and insects in tropical agroecosystems. Ecology 89:944–951.

USDA National Agricultural Statistics Service Cropland Data Layer. 2017. Published crop-specific data layer. USDA-NASS, Washington, D.C., USA.

VADCR, and VADEQ. 2019. Virginia pollinator-smart business plan. Virginia Department of Conservation and Recreation, Virginia Department of Environmental Quality, Richmond, Virginia, USA. <https://www.dcr.virginia.gov/natural-heritage/document/solar-site-business-plan.pdf>. Accessed 3 Nov 2019.

Vaughan, M., and M. Skinner. 2008. Using farm bill programs for pollinator conservation. Technical Note No. 78, United States Department of Agriculture, Washington, D.C., USA.

Weatherhead, P. J. 2005. Long-term decline in a red-winged blackbird population: ecological causes and sexual selection consequences. Proceedings of the Royal Society B: Biological Sciences 272:2313–2317.

Wells, J. V. 2011. Boreal birds of North America: A hemispheric view of their conservation links and significance. University of California Press, Oakland, USA.

Whittaker, R. H. 1972. Evolution and measurement of species diversity. Taxon 21:213–251.

Wilson, G. A., and J. Rigg. 2003. ‘Post-productivist’ agricultural regimes and the South: discordant concepts? Progress in Human Geography 27:681–707.

Winter, M., S. E. Hawks, J. A. Shaffer, and D. H. Johnson. 2003. Guidelines for finding nests of passerine birds in tallgrass prairie. The Prairie Naturalist 35:197–211.

# Tables

Table 2.1: Top-ranked models, model weight, beta-coefficients for variables present in models, and goodness of fit for each bird species from presence/absence binomial logistic regression analysis of point count data during Spring (April 8$^{th}$- June 5$^{th}$), and Fall (August 26$^{th}$-October 14$^{th}$) of 2017 and 2018 on 20 farms study sites across the Coastal Plain of Virginia and Maryland.

| Avian Code[1] | Season | Top Model Covariates[2] | Competing Models[3] (Delta <4) | (Intercept) 2017 or Control | β Coefficient (SE): Year (2018) | Pollinator | % of cover within 1 kilometer[4]: Developed | Natural | Cropland | Water | df | ΔAIC | $\bar{w}$ | Hosmer-Lemeshow statistic | p-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AMRO | Spring | % Developed in 1kmr | 4 | -0.42(0.77) | - | - | 0.21(0.12) | - | - | - | 3 | 0.00 | 0.51 | 7.62 | 0.47 |
| | Fall | % Water in 1kmr | 3 | 0.95(0.49) | - | - | - | - | - | -0.11(0.06) | 3 | 0.69 | 0.34 | 11.93 | 0.15 |
| BGGN | Spring | Year of Survey | 1 | -0.85(0.49) | 2.52(0.80) | - | - | - | - | - | 3 | 0.00 | 0.98 | 0.00 | 1.00 |
| | Fall | % Cropland in 1kmr | 24 | 0.82(0.93) | - | - | - | - | -0.04(0.02) | - | 3 | 0.09 | 0.09 | 13.18 | 0.11 |
| BRTH | Spring | Pollinator Plot Presence & % 'Natural' in 1kmr | 37 | -1.41(1.0) | - | -1.53(0.83) | - | 0.04(0.03) | - | - | 4 | 0.31 | 0.05 | 9.91 | 0.27 |
| | Fall | Pollinator Plot Presence | 12 | -0.12(0.49) | - | -1.62(0.79) | - | - | - | - | 3 | 0.00 | 0.22 | 0.00 | 1.00 |
| COYE | Spring | Pollinator Plot Presence & % Water in 1kmr | 27 | 0.95(0.64) | - | -1.44(0.85) | - | - | - | -0.05(0.04) | 4 | 0.33 | 0.08 | 10.31 | 0.24 |
| | Fall | Year of Survey | 12 | -0.96(0.53) | 1.06(0.70) | - | - | - | - | - | 3 | 0.00 | 0.13 | 0.00 | 1.00 |
| DOWO | Spring | Year of Survey & % 'Natural' in 1kmr | 4 | -2.63(1.50) | 1.77(0.97) | - | - | 0.05(0.03) | - | - | 4 | 0.00 | 0.38 | 5.86 | 0.66 |
| | Fall | Year of Survey & % Developed in 1kmr | 2 | -17.56(10.96) | 17.84(10.55) | - | 1.19(0.66) | - | - | - | 4 | 0.00 | 0.59 | 0.16 | 1.00 |
| EABL | Spring | Year of Survey & Pollinator Plot Presence | 26 | -3.06(1.46) | 1.51(1.01) | 2.01(1.29) | - | - | - | - | 4 | 0.00 | 0.10 | 8.22 | 0.41 |
| | Fall | Year of Survey | 1 | -9.34(3.14) | 18.43(5.25) | - | - | - | - | - | 3 | 0.00 | 0.97 | 0.16 | 1.00 |
| EAWP | Spring | % 'Natural' in 1kmr | 1 | 1.73(1.07) | - | - | - | -0.07(0.03) | - | - | 3 | 0.00 | 0.74 | 6.08 | 0.64 |
| | Fall | Pollinator Plot Presence | 30 | -2.67(1.47) | - | 1.84(1.42) | - | - | - | - | 3 | 0.00 | 0.08 | 6.07 | 0.64 |
| FISP | Spring | % Cropland in 1kmr | 1 | -2.93(1.63) | - | - | - | - | 0.08(0.04) | - | 3 | 0.00 | 0.83 | 6.28 | 0.62 |
| | Fall | NULL | 19 | -0.05(0.41) | - | - | - | - | - | - | 2 | 0.00 | 0.13 | 14.43 | 0.07 |
| GRCA | Spring | Pollinator Plot Presence | 6 | 0.11(0.46) | - | -1.49(0.72) | - | - | - | - | 3 | 0.00 | 0.30 | 0.00 | 1.00 |
| | Fall | % Water in 1kmr | 2 | 0.47(0.43) | - | - | - | - | - | 0.25(0.21) | 3 | 0.00 | 0.64 | 14.47 | 0.07 |

| Avian Code[1] | Season | Top Model Covariates[2] | Competing Models[3] (Delta <4) | (Intercept) 2017 or Control | β Coefficient (SE) Year (2018) | Pollinator | % of cover within 1 kilometer[4] Developed | Natural | Cropland | Water | df | ΔAIC | $\bar{w}$ | Hosmer-Lemeshow statistic | p-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MODO | Spring | % 'Natural' in 1kmr % Water in 1kmr | 12 | -2.99(1.26) | - | - | - | 0.06(0.03) | - | 0.08(0.04) | 4 | 0.00 | 0.16 | 6.53 | 0.59 |
| | Fall | % Water in 1kmr | 19 | 1.10(0.54) | - | - | - | - | - | -0.07(0.05) | 3 | 0.00 | 0.15 | 7.53 | 0.48 |
| NOMO | Spring | % Cropland in 1kmr % Water in 1kmr | 20 | 7.33(4.87) | - | - | - | - | -0.13(0.09) | -0.11(0.10) | 4 | 0.00 | 0.11 | 4.15 | 0.84 |
| | Fall | Year of Survey & % Water in 1kmr | 35 | 0.03(0.55) | 1.33(0.82) | - | - | - | - | 0.11(0.09) | 4 | 0.42 | 0.05 | 3.61 | 0.89 |
| PIWO | Spring | % Water in 1kmr | 19 | -0.98(0.42) | - | - | - | - | - | -0.06(0.06) | 3 | 0.91 | 0.08 | 6.97 | 0.54 |
| | Fall | Year of Survey | 1 | 9.19(3.15) | -19.84(5.79) | - | - | - | - | - | 3 | 0.00 | 0.99 | 0.12 | 1.00 |
| REVI | Spring | Year of Survey & % Water in 1kmr | 5 | -0.38(0.66) | 1.71(0.98) | - | - | - | - | -0.11(0.07) | 4 | 0.00 | 0.42 | 11.24 | 0.19 |
| | Fall | NULL | 17 | -0.98(0.51) | - | - | - | - | - | - | 2 | 1.00 | 0.08 | 7.66 | 0.47 |
| TRES | Spring | Year of Survey | 2 | -0.85(0.49) | 1.39(0.68) | - | - | - | - | - | 3 | 0.00 | 0.51 | 0.00 | 1.00 |
| | Fall | % Cropland in 1kmr | 5 | 1.92(1.53) | - | - | - | - | -0.07(0.04) | - | 3 | 0.00 | 0.44 | 4.73 | 0.79 |
| TUVU | Spring | % Water in 1kmr | 1 | 0.06(0.37) | - | - | - | - | - | -0.07(0.05) | 3 | 19.66 | 0.00 | 8.21 | 0.41 |
| | Fall | % Cropland in 1kmr | 31 | 0.81(0.93) | - | - | - | - | -0.04(0.02) | - | 3 | 0.00 | 0.08 | 9.28 | 0.32 |

[1]Avian codes represent, AMRO: America robin (*Turdus migratorius*), BGGN: blue-gray gnatcatcher (*Polioptila caerulea*), BRTH: brown thrasher (*Toxostoma rufum*), COYE: common yellowthroat (*Geothlypis trichas*), DOWO: downy woodpecker (*Picoides pubescens*), EABL: eastern bluebird (*Sialia sialis*), EAWP: eastern wood pewee (*Contopus virens*), FISP: field sparrow (*Spizella pusilla*), GRCA: gray catbird (*Dumetella carolinensis*), MODO: mourning dove (*Zenaida macroura*), NOMO: northern mockingbird (*Mimus polyglottos*), PIWO: pileated woodpecker (*Dryocopus pileatus*), REVI: red-eyed vireo (*Vireo olivaceus*), TRES: tree swallow (*Tachycineta bicolor*), and TUVU: turkey vulture (*Cathartes aura*)

[2]: Covariates used included pollinator or control farm, year of survey, and % land cover at a 1km scale including developed, natural,

cropland, and water

[3]: Top models and competing models can be found in Appendices 3&4

[4]: All landcover within 1 km covariates passed a Pearson's correlation test of 60% correlation

Table 2.2: Top models for density estimation from Program Distanceby species using bird species with > 100 observations for Spring surveys in 2017 and 2018 on 20 farms across the Coastal Plain of Virginia and Maryland.

| | | | β Coefficient (SE)[4] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Intercept | | | | | | | | | | | | Min | | | |
| Avian | Model | | Obs-EB or | Adjustment | Observer | | | Station | | | % of cover within 1 kilometer[5] | | | | from | | | |
| Code[1] | Def.[2] | Covariates[3] | Pollinator | Term | AC | CR | Control | FM | FU | NH | Natural | Crop | Devp. | Water | sunrise | Temp | ΔAIC | $W_i$ |
| AMCR | Haz-Cos | Obs/PP | 69.78 | | -0.16 | 0.55 | 0.01 | | | | | | | | | | 0.00 | 0.42 |
| | | | (133.6) | | (0.38) | (387.4) | (0.11) | | | | | | | | | | | |
| AMRO | HN-Cos | Obs/Station | 34.85 | | -0.55 | -0.23 | | 0.33 | 0.02 | 0.72 | | | | | | | 0.00 | 1.00 |
| | | | (1.49) | | (0.15) | (0.16) | | (0.13) | (0.13) | (0.26) | | | | | | | | |
| BLGR | HN-Cos | Station/Natural% | 15.73 | | | | | -0.12 | 0.19 | 0.62 | 0.008 | | | | | | 0.00 | 0.33 |
| | | | (1.32) | | | | | (0.14) | (0.17) | (0.29) | (0.004) | | | | | | | |
| BLJA | Haz-Cos | Station/Crops% | 27.20 | | | | | -0.14 | 0.43 | 1.55 | | -0.009 | | | | | 0.15 | 0.23 |
| | | | (3.93) | | | | | (0.40) | (0.42) | (0.79) | | (0.008) | | | | | | |
| CACH | HN-Cos | MinFrmSunR/Obs | 58.83 | | -0.84 | -0.67 | | | | | | | | | -0.003 | | 0.00 | 0.76 |
| | | | (5.52) | | (0.37) | (0.37) | | | | | | | | | (<0.001) | | | |
| CAWR | HN-Cos | Obs/PP | 26.00 | | -0.01 | 0.70 | -0.17 | | | | | | | | | | 0.00 | 0.69 |
| | | | (0.82) | | (0.11) | (0.12) | (0.07) | | | | | | | | | | | |
| CHSP | Haz-Cos | NoCov | 18.32 | 3.24 | | | | | | | | | | | | | 0.00 | 1.00 |
| | | | (1.06) | (0.14) | | | | | | | | | | | | | | |
| FISP | HN-Cos | MinFrmSunR/Developed% | 58.88 | | | | | | | | | | -0.03 | | -0.003 | | 0.00 | 0.15 |
| | | | (2.42) | | | | | | | | | | (0.02) | | (0.001) | | | |
| NOCA | HN-Cos | Temp/Station | 37.64 | | | | | -0.12 | -0.19 | 0.43 | | | | | | -0.01 | 0.00 | 0.96 |
| | | | (0.80) | | | | | (0.07) | (0.07) | (0.13) | | | | | | (0.004) | | |

| | | | β Coefficient (SE)[4] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Intercept | | | | | | | | | | | | Min | | | |
| Avian | Model | | Obs-EB or | Adjustment | Observer | | | Station | | | % of cover within 1 kilometer[5] | | | | from | | | |
| Code[1] | Def.[2] | Covariates[3] | Pollinator | Term | AC | CR | Control | FM | FU | NH | Natural | Crop | Devp. | Water | sunrise | Temp | ΔAIC | $W_i$ |
| TUTI | Haz-Cos | Temp/Water% | 65.67 | | | | | | | | | | | -0.002 | | -0.004 | 0.00 | 0.27 |
| | | | (6.58) | | | | | | | | | | | (0.002) | | (0.005) | | |

[1]Species codes represent, AMCR: American crow (*Corvus brachyrhynchos*), AMRO: American robin (*Turdus migratorius*), BLGR: blue grosbeak (*Passerina caerulea*), BLJA: blue jay (*Cyanocitta cristata*), CACH: Carolina chickadee (*Poecile carolinensis*), CAWR: Carolina wren (*Thryothorus ludovicianus*), CHSP: chipping sparrow (*Spizella passerina*), FISP: field sparrow (*Spizella pusilla*), NOCA: northern cardinal (*Cardinalis cardinalis*), and TUTI: tufted titmouse (*Baeolophus bicolor*)

[2]: Key functions hazard rate (HAZ), half normal (HN), simple polynomial (SP) and adjustment expansions cosine (COS)

[3]: Covariates used included start time of survey since sunrise, temperature during survey, pollinator or control farm, type of landcover at each survey point (FM, FU, NH, and PP), observer, and % landcover at a 1km scale including developed, natural, cropland, and water

[4]: Top models and competing models can be found in Appendices 5&6

[5]: All landcover within 1 km covariates passed a Pearson’s correlation test of 60% correlation

Table 2.3: Top models for density estimation from Program Distance for bird species with > 100 observations for Fall surveys in 2017 and 2018 on 20 farms across the Coastal Plain of Virginia and Maryland.

| | | | β Coefficient (SE)[4] | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Intercept) | | | | | | | | | | | | | |
| Avian | Model | | Obs-EB or | Adjustment | Observer | | | % of cover within 1 kilometer[5] | | | | | | Cloud | | |
| Code[1] | Def.[2] | Covariates[3] | Pollinator | Term | AC | AS | Control | Natural | Crop | Devp. | Water | Temp | playback | cover | ΔAIC | $W_i$ |
| AMCR | HN-SP | Playback/Water% | 74.34 | | | | | | | | 0.01 | | -0.02 | | 0.00 | 0.30 |
| | | | (12.10) | | | | | | | | (0.02) | | (0.07) | | | |
| AMRO | HN-Cos | CloudC/Crops% | 32.37 | | | | | | -0.01 | | | | | 0.003 | 0.00 | 0.17 |
| | | | (1.13) | | | | | | (0.003) | | | | | (0.002) | | |
| BLGR | Haz-Cos | Temp/PP | 42.94 | | | | 0.25 | | | | | -0.01 | | | 0.00 | 0.30 |
| | | | (2.76) | | | | (0.09) | | | | | (0.01) | | | | |
| BLJA | Haz-Cos | No Cov | 60.77 | 20.00 | | | | | | | | | | | 0.00 | 1.00 |
| | | | (6206.) | (<0.001) | | | | | | | | | | | | |
| CACH | Haz-Cos | Obs/PP | 43.73 | | -0.45 | -0.28 | -0.13 | | | | | | | | 0.00 | 0.29 |
| | | | (2.59) | | (0.22) | (0.22) | (0.08) | | | | | | | | | |
| CAWR | Haz-Cos | No Cov | 33.87 | 4.41 | | | | | | | | | | | 0.00 | 1.00 |
| | | | (1.09) | (0.22) | | | | | | | | | | | | |
| CHSP | Haz-Cos | No Cov | 27.49 | 8.27 | | | | | | | | | | | 0.00 | 0.20 |
| | | | (1.31) | (1.75) | | | | | | | | | | | | |
| FISP | Haz-Cos | No Cov | 24.83 | 4.33 | | | | | | | | | | | 0.00 | 1.00 |

| | | | β Coefficient (SE)[4] | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Intercept) | | | | | | | | | | | | | |
| Avian | Model | | Obs-EB or | Adjustment | Observer | | | % of cover within 1 kilometer[5] | | | | | | Cloud | | |
| Code[1] | Def.[2] | Covariates[3] | Pollinator | Term | AC | AS | Control | Natural | Crop | Devp. | Water | Temp | playback | cover | ΔAIC | $W_i$ |
| | | | (2.58) | (0.60) | | | | | | | | | | | | |
| NOCA | Haz-Cos | CloudC/Crops% | 30.08 | | | | | | -0.002 | | | | | -0.002 | 0.00 | 0.57 |
| | | | (0.59) | | | | | | (0.001) | | | | | (0.001) | | |
| TUTI | HN-SP | Obs/Natural% | <0.001 | | -74.64 | -74.80 | | 0.002 | | | | | | | 0.00 | 0.28 |
| | | | (<0.001) | | (<0.001) | (<0.001) | | (0.005) | | | | | | | | |

[1]: Species codes are found in Table 2.2

[2]: Key functions hazard rate (HAZ), half normal (HN), simple polynomial (SP) and adjustment expansions cosine (COS)

[3]: Covariates used included temperature during survey, cloud cover at the start of survey, pollinator or control farm, survey as before or after playback calls, observer, and % landcover at a 1km scale including developed, natural, cropland, and water

[4]: Top models and competing models can be found in Appendices 5&6

[5]: All landcover within 1 km covariates passed a Pearson's correlation test of 60% correlation

Table 2.4: Top models incorporating stratification of bird density by pollinator/control, as determined using program Distance Spring (April 8th- June 5th), and Fall (August 26th-October 14th) of 2017 and 2018. Data are from surveys on 20 farms study sites across the Coastal Plain of Virginia and Maryland stratifying by pollinator and control. Density is in birds/ha. N is the number of observations contributing to each density estimate.

| | Spring 2017&18 | | | | | | Pollinator Plot Control Landscape | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Overall | | | Pollinator | | | Control | | |
| Species Code[1] | Model | Top Model Covariates[2] | N | D[3] | SE | N | D[3] | SE | N | D[3] | SE |
| AMCR | Hazard-Cosine | Observer & Station Type | 253 | 0.18 | 0.02 | 130 | $^{N}$C | - | 123 | $^{N}$C | - |
| AMRO | Half.Normal-Cosine | Station Type & 1km Natural Land Cover | 294 | 0.79 | 0.18 | 96 | $^{N}$C | - | 198 | $^{N}$C | - |
| BLGR | Half.Normal-Cosine | | 157 | 0.55 | 0.09 | 84 | 0.58 | 0.15 | 73 | 0.59 | 0.14 |
| BLJA | Hazard-Cosine | Station Type & 1km Crop Land Cover | 146 | 0.36 | 0.06 | 67 | 0.13 | 0.03 | 79 | 0.38 | 0.09 |
| CACH | Half.Normal-Cosine | Observer & Minutes Since Sunrise | 217 | 0.77 | 0.12 | 114 | 0.74 | 0.17 | 103 | 0.84 | 0.19 |
| CAWR | Half.Normal-Cosine | Observer & Pollinator Plot Presence | 485 | 1.04 | 0.10 | 227 | 0.78 | 0.10 | 258 | 1.37 | 0.18 |
| CHSP | Hazard-Cosine | No Covariates | 805 | 4.02 | 0.54 | 452 | 4.00 | 0.79 | 353 | 4.04 | 0.72 |
| FISP | Half.Normal-Cosine | Minutes Since Sunrise & 1km Developed Land Cover | 205 | 0.28 | 0.05 | 85 | 0.26 | 0.06 | 120 | 0.35 | 0.10 |
| NOCA | Half.Normal-Cosine | Station Type & Temperature | 935 | 2.05 | 0.14 | 480 | 2.03 | 0.22 | 455 | 2.07 | 0.17 |
| TUTI | Hazard-Cosine | Temperature % 1km Water Land Cover | 230 | 0.20 | 0.03 | 139 | 0.24 | 0.04 | 91 | 0.16 | 0.03 |

| | Fall 2017&18 | | | | | | Pollinator Plot or Control Landscape | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Overall | | | Pollinator | | | Control | | |
| Species Code[1] | Model | Top Model Covariates[2] | N | D[3] | SE | N | D[3] | SE | N | D[3] | SE |
| AMCR | Half.Normal-Simple Polynomial | Before or After Playback & 1km Water Land Cover | 498 | 0.28 | 0.03 | 290 | 0.32 | 0.04 | 208 | 0.36 | 0.05 |
| AMRO | Half.Normal-Cosine | Cloud Cover & 1km Crop Land Cover | 107 | 0.26 | 0.06 | 51 | 0.23 | 0.08 | 56 | 0.32 | 0.10 |
| BLGR | Hazard-Cosine | Pollinator Plot Presence & Temperature | 201 | 0.41 | 0.08 | 130 | 0.61 | 0.16 | 71 | 0.21 | 0.06 |
| BLJA | Hazard-Cosine | No Covariates | 341 | 0.32 | 0.05 | 184 | 0.31 | 0.07 | 157 | 0.34 | 0.06 |
| CACH | Hazard-Cosine | Observer & Pollinator Plot Presence | 169 | 0.55 | 0.09 | 104 | 0.53 | 0.12 | 65 | 0.48 | 0.11 |
| CAWR | Hazard-Cosine | No Covariates | 1059 | 2.19 | 0.14 | 602 | 2.13 | 0.18 | 457 | 2.28 | 0.22 |
| CHSP | Hazard-Cosine | No Covariates | 149 | 0.60 | 0.13 | 98 | 0.66 | 0.18 | 51 | 0.58 | 0.22 |
| FISP | Hazard-Cosine | No Covariates | 113 | 0.42 | 0.13 | 61 | 0.44 | 0.16 | 52 | 0.39 | 0.20 |
| NOCA | Hazard-Cosine | Cloud Cover & 1km Crop Land Cover | 408 | 1.70 | 0.20 | 203 | 1.48 | 0.22 | 205 | 1.86 | 0.34 |
| TUTI | Half.Normal-Simple Polynomial | Observer & 1km Natural Land Cover | 139 | 0.37 | 0.07 | | $^{N}$C | - | | $^{N}$C | - |

[1]: Species codes are found in Table 2.2

[2]: Covariates used included start time of survey since sunrise, temperature during survey, cloud cover at the start of survey, pollinator or control farm, type of landcover at each survey point (FM, FU, NH, and PP), observer, survey as before or after playback calls, and % landcover at a 1km scale including developed, natural, cropland, and water

[3]: Density was estimated in birds per hectare

$^{N}$C: Model stratification did not converge and estimates were discarded

Table 2.5: Red-winged blackbird (*Agelaius phoeniceus*) nests found and monitored between June 4th and June 29th in 2017 and May 28th and July 8th in 2018 during nesting bird surveys of 10 pollinator plot pollinator farms on the Coastal Plain of Virginia and Maryland, and the city of Virginia Beach, VA.

| Nest ID | Discovery Date | Farm[1] | Initiation Date | # egg | Failure/Hatch Date | Fate | Fledge/End Date |
|---|---|---|---|---|---|---|---|
| 1 | June 4th 2017 | E | May 29th 2017* | 5 | June 8th 2017*¿ | Fledge | June 19th 2017 |
| 2 | June 4th 2017 | E | May 30th 2017* | 2 | June 9th 2017*¿ | Fledge | June 20th 2017 |
| 3 | May 17th 2018 | C | Unknown | 2 | N/A | Predation | May 20th 2018 |
| 4 | June 12th 2018 | E | June 7th 2018* | 4 | June 18th 2018 | Predation | June 22nd 2018 |
| 5 | June 19th 2018 | Q | June 6th 2018* | 4 | June 17th 2018* | Predation | June 28th 2018 |
| 6 | June 16th 2018 | C | June 16th 2018 | 3 | June 27th 2018 | Fledge | July 7th 2018 |
| 7 | June 14th 2018 | E | June 4th 2018* | 4 | June 15th 2018 | Fledge | June 25th 2018 |

1: Farm names, C: Copper Cricket, E: Virginia Tech Eastern Shore Agriculture Research and Extension Center, and Q: Sturgis.

*: Estimated value based on 11 day incubation and brooding period

¿: Nests changed status between June 7th and June 13th when weather negatively influenced timely surveys

## Figures

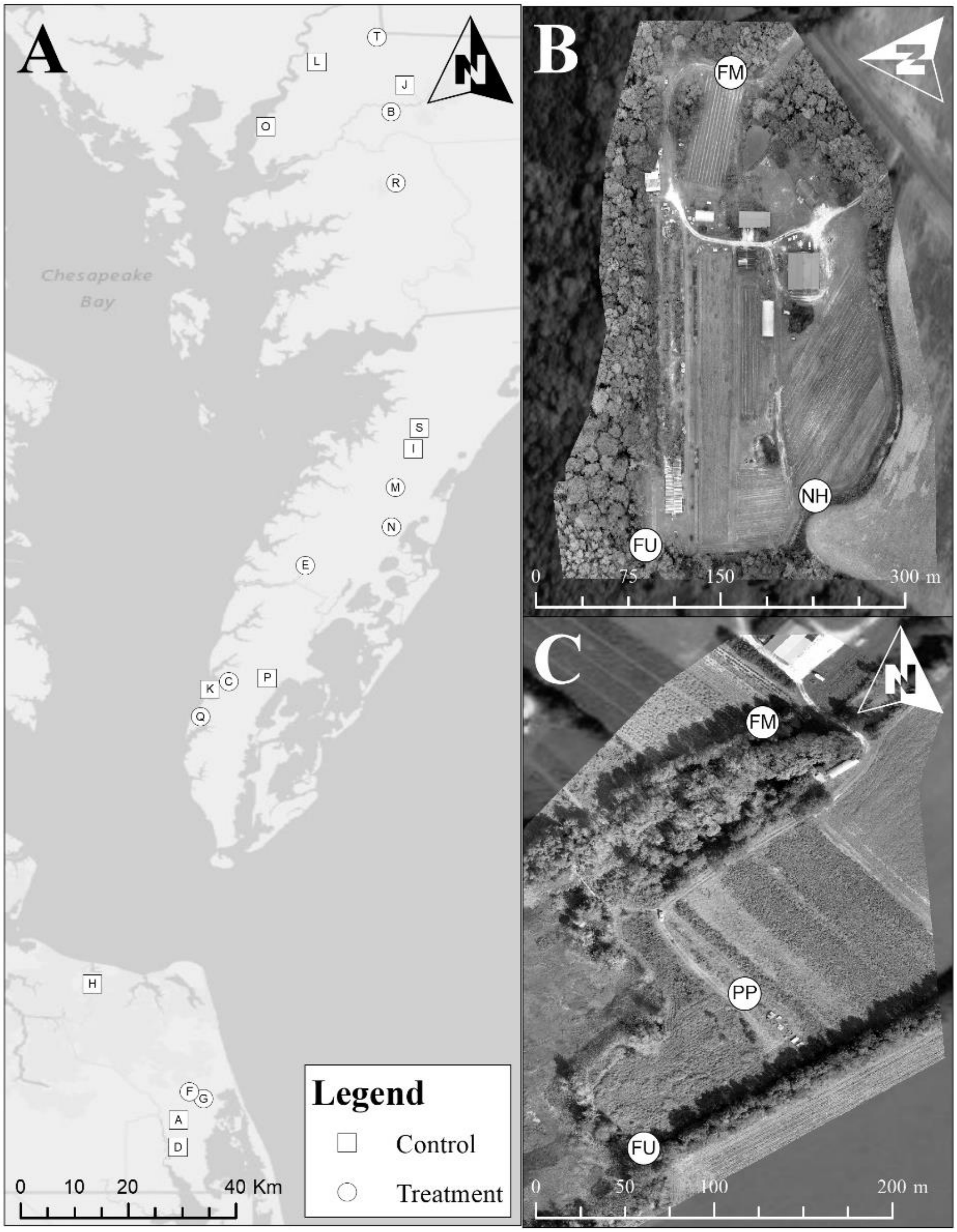


Figure 2.1: Plate A: Location of the 20 farm study sites on which bird point counts and nest searches were conducted in Virginia and Maryland in the Spring (April-July) and Fall (August-October) 2017-2018. Symbols represent 10 control (square, no farmscaped pollinator plot) and 10 pollinator (circle, received farmscaped pollinator plot) farms. Letters within symbols denote

farm locations, A: Brookdale, B: Calliope, C: Copper Cricket, D: Cullipher, E: Virginia Tech Eastern Shore Agricultural Research and Extension Center, F: Flanagan, G: Flip Flop, H: Virginia Tech Hampton Roads Agricultural Research and Extension Center , I: La Caridad, J: University of Maryland Lower Eastern Shore Research & Education Center - Extension, K: Mattawoman, L: Patty's Garden, M: Perennial, N: Pik Penny, O: Provident, P: Quail Cove, Q: Sturgis, R: University of Maryland Eastern Shore Somerset – Extension, S: Van Dessel, T: Wright.

Plate B: Example of the placement of point count survey locations on a control farm. Letters on location symbols for each camera station represent cover types: FM: forest-unmanaged, FU: forest-managed, NH: novelty habitat.

Place C: Example of the placement of point count survey locations on a pollinator farm. Letters on location symbols for each camera station represent cover types: FM: forest-unmanaged, FU: forest-managed, PP: pollinator plot.

Sources: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, AeroGRID, IGN, and the GIS User Community

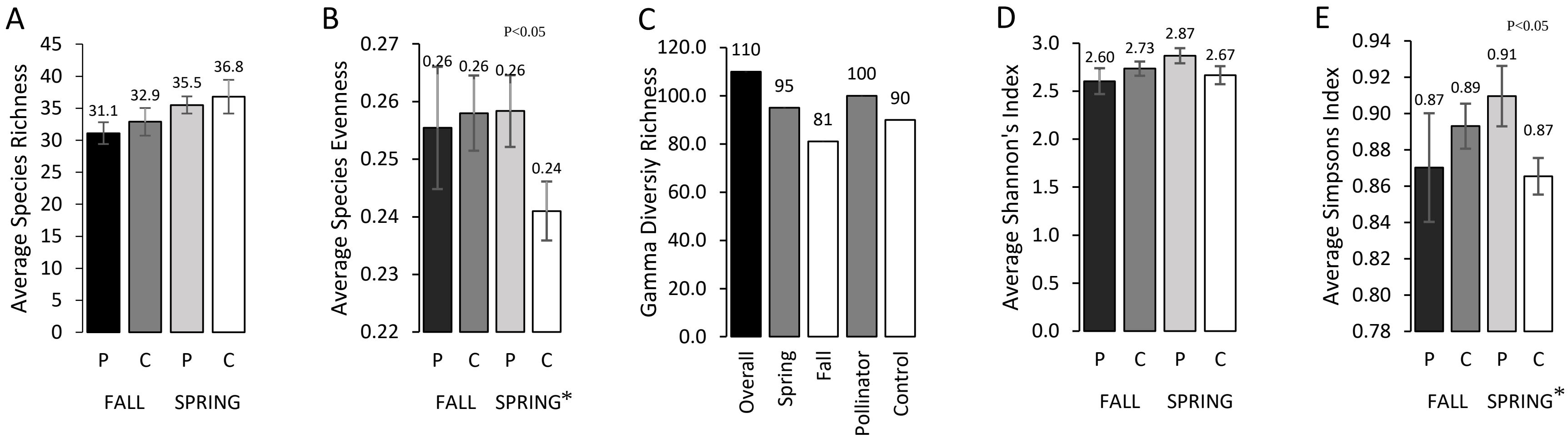


Figure 2.2: Alpha (average study site farm richness), beta (average study site farm Pielou's eveness), gamma (overall regional richness) diversity measures, as well as Shannon's and Simpsons dicersity indices for control farms without pollinator plots (C) and pollinator farms with pollinator plots (P) during Spring (April 8th- June 5th), and Fall (August 26th-October 14th) on 20 farms on the Eastern Shore of Virginia and Maryland and in the city of Virginia Beach, VA in 2017 and 2018. Ten farms were considered control farms without pollinator plots and 10 farms were considered pollinators with pollinator plots. Error bars represent the standard error of each data series. . Note that scale is different for each plate.

*: indicates significant difference between control and pollinator farms.

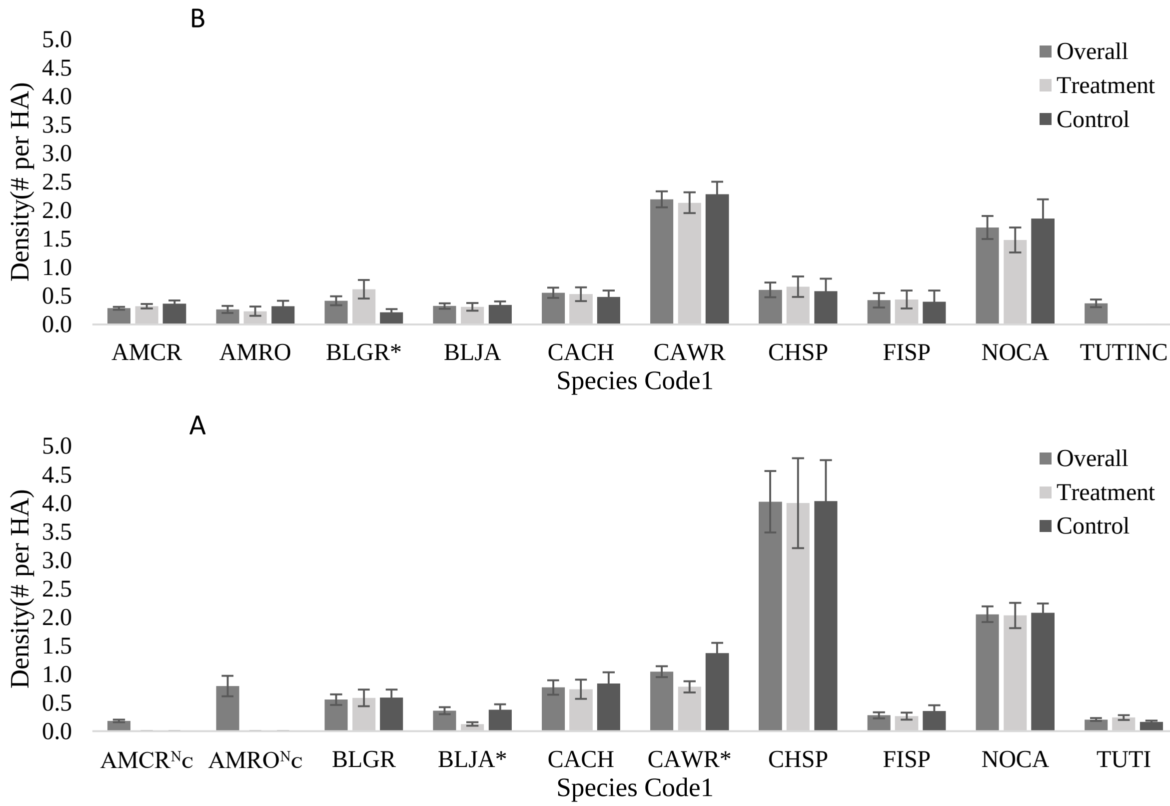


Figure 2.3: Bird species density (# individuals/hectare) in Spring (April 8th- June 5th, A) and Fall (August 26th-October 14th, B) overall (dark gray), on 10 pollinator farms with pollinator plots (light gray) and on 10 control farms without pollinator plots (black) on the Eastern Shore of Virginia and Maryland, and in the city of Virginia Beach, VA of 2017 and 2018 from top models determined by program Distance. Error bars represent the standard error of each data series.

$^{N}$c: indicates model non-converged when attempting stratification by control and pollinator farms

*: indicates significant difference between control and pollinator farms.

[1]: Species codes are found in Table 2.2

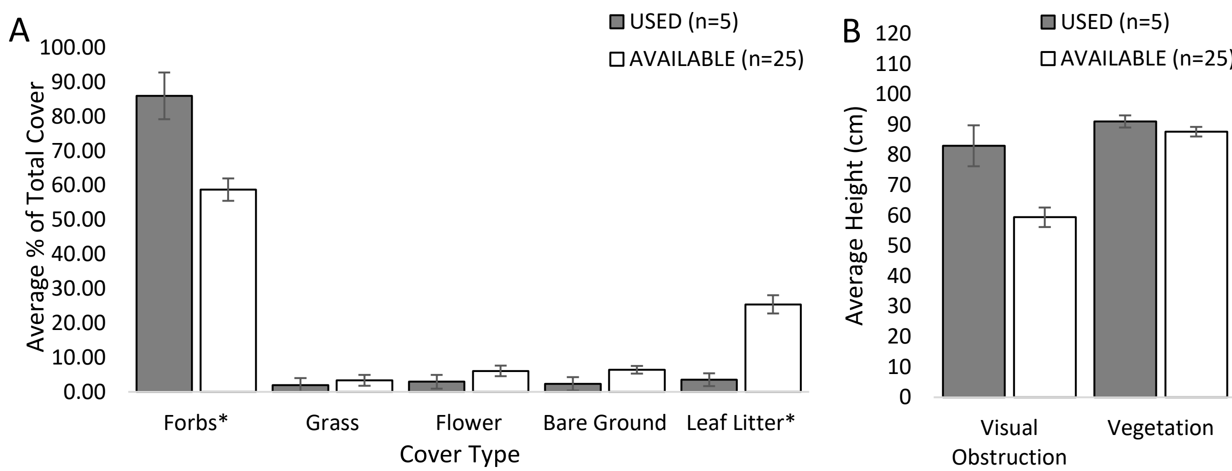


Figure 2.4: Percent cover (SE) within one-meter (A), height of visual obstruction and vegetation (SE; B) at nest sites used by red-winged blackbirds (*Agelaius phoeniceus*) and random but available sites within pollinator plots collected between June 4th and June 29th in 2017 and May 28th and July 8th in 2018 during monitoring of nests on 3 farms, C: Copper Cricket, E: Virginia Tech Eastern Shore Agriculture Research and Extension Center, and Q: Sturgis. Error bars represent a 95% confidence interval of standard error of each data series.

*: Kruskal-Wallis test on the use versus available characteristics were found significant for only percent cover of forbs ($\chi^2$ =8.25, df = 1, p=0.004) and leaf litter ($\chi^2$ =10.17, df = 1, p=0.001)

# Chapter 3: Relative activity of native insectivorous bats in a farmscaped habitat on the Eastern Shore of Virginia.

Earle J. Berge[1]†, Sarah Karpanty[1], Megan O'Rourke[2], Mark Ford[1], and Dean Stauffer[1].

[1]Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, Virginia 24061, USA

[2] United States Department of Agriculture National Institute of Food and Agriculture, Kansas City, Missouri 64133, USA

†E-mail: earleb@vt.edu

† Written for submission to Northeastern Naturalist

## Abstract

Pollinator-friendly wildflower plantings are increasingly incentivized by state and federal agencies in farm settings, but the potential benefits of such plantings for wildlife are not well known. As a group, migrant and resident bat species are of conservation concern to many of the same agencies that seek to incentivize pollinator-friendly wildflower habitat restoration. Thus, we estimated the presence and relative activity of bats with acoustic detectors in 4 cover types, including a wildflower plot intended to benefit pollinators, on the Eastern Shore Agricultural Research Extension Center in Painter, Virginia, from April 2017- November 2019. We documented which species used each cover type and calculated if bat nightly relative activity varied by year, season (maternity versus non-maternity season) and cover type (forest trail, crop field-forest edge, pollinator plot, forest-water edge) using a Kruskal-Wallis and a Dunn's *post-hoc* test. Of total detections, 20.11% were identified as big brown bat (*Eptesicus fuscus*), 17.97% evening bat (*Nycticeius humeralis*), 15.35% silver-haired bat (*Lasionycteris noctivagans*), 7.11% eastern red bat (*Lasiurus borealis*), 3.66% hoary bat (*Lasiurus cinereus*), 3.1% little brown bat (*Myotis lucifugus*), and 1.38% tricolored bat (*Perimyotis subflavus*). As expected, relative activity varied by cover type, with the average nightly call activity highest for all 7 species in the crop field-forest edge and water-forest edge cover types as compared to pollinator plot and forest trail cover types during the maternity season (May-August). All 7 bat species were recorded in the 8,877 calls detected in pollinator plots, 26.07% were silver-haired bat, 25.21% eastern red bats, 23.78% evening bat, 9.32% hoary bats, 9.11% little brown bat, 5.42% big brown bat, and 1.09% tricolored bat.

## Introduction

Agricultural yield has advanced greatly in recent decades due to the prevalence of high intensity, chemically-intensive monoculture crop systems on the landscape (Wilson and Rigg 2003, Conway and Barbier 2013). While benefiting food security objectives of society, high-intensity farming practices have led to a decrease in wild plant and animal diversity and a reduction in ecosystem services, such as non-chemical regulation of pests by native insectivores (Tilman 1998, Dhaliwal et al. 2010, Horlings and Marsden 2011). Recognizing this loss, organizations including, but not limited to, the U.S. Department of Agriculture's Natural Resource Conservation Service (USDA-NRCS) and various state agricultural and conservation-focused organizations have implemented policies to encourage farmland alterations. These alterations of farmland, defined here as 'farmscaping,' include altering the habitat structure on farms to benefit natural processes and native species, to enhance and bring back the diversity of ecosystem services that farmlands once provided (Pavelis et al. 2011, Benson et al. 2016). Farmscaping practices may include adding a mix of cover types, planting shrub- or tree-dominated hedgerows along property boundaries, or the planting of native forb- and native grass-dominated 'pollinator' plots or rows.

Wildlife responses to farmscaping practices are still relatively understudied compared to other benefits, such as pest regulation or pollination, and depend on the details of which practice is implemented. Pollinator plots or rows studied in North American and European farming systems have been shown to reduce pest insect populations and to benefit the native insect pollinator community, but we are unaware of studies of this farmscaping technique on wildlife generally or bats specifically other than insects (Morandin and Kremen 2013, Benson et al. 2016, Bloom and Crowder 2016, O'Rourke et al. 2019, Albrecht et al. 2020). A review of the impacts of pollinator plots revealed that farmscaping practices can result in increased pollinator presence, decreased parasitoid presence, reduced pesticide use, increased crop production, and increased species diversity within the farming ecosystem (Shennan 2008).

One way that the ecosystem service of pest control may be augmented by farmscaping is the restoration of cover types that encourage native insect-eating bats (Russo et al. 2018). Neotropical bat species are increase the pest-regulating ecosystem services that their foraging offers, resulting in reduction in both plant damage and the spread of disease caused by insects in several different ecosystems and farming landscapes (Williams-Guillén et al. 2008, Morrison and Lindell 2012). In the United States, insect-eating bats have been estimated to provide pest-reduction regulating services worth more than $3.7 billion annually in agricultural landscapes (Boyles et al. 2011). However, knowledge remains sparse on the potential value of farmscaping in general, and pollinator-friendly plantings specifically, for bats and ultimately their insect-reduction ecosystem services.

To our knowledge, vertebrate wildlife responses in general, and bats in particular, to pollinator-friendly plantings in the Coastal Plain landscape of Virginia are yet unstudied. In this region, several entities such as the USDA-NRCS, the Virginia Department of Conservation and Recreation (VA-DCR), and Virginia Department of Transportation (VDOT) have engaged in pollinator-friendly plantings for different goals, whether it be for visual, production, or ecological benefits (Vaughan and Skinner 2008, Ball 2015, VADCR and VADEQ 2019). Our objective was to address this knowledge gap by quantifying the presence and relative activity of native bats in a farm system on the Eastern Shore of Virginia that included a pollinator-friendly farmscaping plot. In Virginia, the State Wildlife Action Plan identifies a research need in general related to the coastal migration ecology of several insectivorous bats expected to be present around our farm study site, including 3 species ranked as moderate species of greatest conservation need (Tier IV, SGCN; hoary bats (*Lasiurus cinereus*), silver-haired bats (*Lasionycteris noctivagans*), and eastern red bats (*Lasiurus borealis*)) and one ranked as the highest (Tier I SGCN; little brown bat (*Myotis lucifugus*); VDWR 2015). We used zero-crossing acoustic detectors placed on a forest trail, a forested pond edge (water-forest edge), a crop field on forest edge (crop field-forest edge), and a farmscaped wildflower plot intended to attract native pollinators (pollinator plot). We examined how relative nightly activity varied across the year, and expected highest rates during the maternity (May-August) season as found in prior studies (Kuenzi and Morrison 2003, Johnson et al. 2011). We predicted that the relative activities of bats would be higher around pollinator plots than crop field-forest edges without these plantings. Based on prior literature, we expected the highest rates of bat activity around the forested trail and on water-forest edge sources due to the foraging opportunities along the forest trail and over the freshwater pond (Everette et al. 2001, Gehrt and Chelsvig 2008, Loeb and O'Keefe 2011).

## Methods

### Study Area

We surveyed bat echolocation calls at the Eastern Shore Agricultural Research Extension Center (ESAREC) on the Eastern Shore of Virginia in Painter, Virginia (Figure 3.1). This study site is located within the mid-Atlantic Coastal Plain, denoted by primarily alluvial soils of sedimentary sand and clay with surrounding tidewater influences (McFarland and Bruce 2006). A majority of the landscape is a mix of pine stands, poultry and crop farms, as well as natural parks and area preserves. The research center encompassed 89.03 ha of varied crop and natural, non-crop cover types. The natural landscape included a forested wetland area with wide trails (~2 m wide for fire prevention access) throughout and a large (~ 6.27 ha) freshwater pond into which the wetland drains. We identified four cover types in which to survey for bats on the ESAREC: forest trail, water-forest edge, crop field-forest edge, and a pollinator plot (Figure 3.1). The forest trail cover type was a 25 ha plot of forested land to the East of the agricultural research plots, mainly composed of coniferous trees and mixed hardwoods, along with several ~2 m wide trails throughout. The water-forest edge cover type included the freshwater pond surrounded by a forested wetland. The crop field-forest edge cover type was on the northern edge of the agricultural research station and contained a mix of fallow, tilled, and grass crops adjacent to a forest similar to the one described above but lacking wetland features. On the southern side of the agricultural research station was a 0.28 ha swath of pollinator-friendly plantings composed of native grasses and flowers as described in Angelella and O'Rourke 2017.

On the Eastern Shore of Virginia, 7 species of bat are known to occur as either year-round residents occur in seasonal migrants, including the big brown bat (*Eptesicus fuscus*) , hoary bat, silver-haired bat, eastern red bat, little brown bat, evening bat (*Nycticeius humeralis*), and the tricolored bat (*Perimyotis subflavus*; Linzey 1998, Johnson et al. 2011, Wolcott and Vulinec 2012, VDWR 2015). These 7 species of bats expected to be present on our farmscape included cavity, exfoliating bark, or foliage day-roosting habits (Linzey 1998). All 7 species are also insectivores, with some specialists on different arrays of species, mainly including beetles and moths (Linzey 1998).

**Field Methods**

We placed four zero-crossing acoustic detectors and SMM-U1 microphones on the ESAREC (Song Meter 4; Wildlife Acoustics, Maynard, MA), one in each of the four described cover types and spaced >100 meters apart to ensure sampling independence (Figure 3.1; Ford et al. 2005). Each acoustic detector was attached to a tree and the microphone was attached to the end of a standing 3.5m pole oriented towards a flyway or open area within the cover type (Muthersbaugh et al. 2019). Detectors were placed on April 27th, 2017 and were programmed to start to record one hour before sunset to one hour after sunrise each day through their takedown on November 1st, 2019. From setup to takedown, detectors were checked every 1-2 months to change batteries and SD cards.

**Analytical Methods**

*Call Identification* - We used program Kaleidoscope (5.1.9 Wildlife Acoustics, Inc.) with the approved programs outlined by the U.S. Fish and Wildlife Service (USFWS) version of Bats of North America (5.1.0 U.S. Fish and Wildlife) to identify zero-crossing echolocation recordings to species. We set signal parameters at 8-120kHz frequency range, 2-500 ms detection pulses, 500 ms maximum intersyllable gap, minimum 2 pulses, and enhanced with advanced signal processing (Muthersbaugh et al. 2019, USFWS 2019). Species calls used in analyses included 10 species, the 7 species known to be likely present in our survey area as listed above, as well as three additional species, southeastern myotis (*Myotis austroriparius*), northern long-eared bat (*Myotis septentrionalis*), and Indiana bat (*Myotis sodalis*); the final three were unlikely to be detected but were included because of the possibility of their presence (Linzey 1998). We identified all relevant detections to species or no identification within a maximum likelihood estimate $p < 0.05$ (Johnson and Gates 2008, Johnson et al. 2011, USFWS 2019).

*Effects on Nightly Activity* - We summarized the number of calls detected per night per bat species as an index of relative activity (Thomas and West 1989, Humes et al. 1999). The data were non-normally distributed and thus we used Kruskal Wallis test to evaluate the maternity season definition found in the literature by comparing our maternity (May-August) versus non-maternity (September-April) nightly relative activity datasets (Anthony et al. 1981, Nocera et al. 2019). For each species, we then tested for differences in nightly relative activity by maternity (May-August) season across years, and by cover types using untransformed data and the Kruskal-Wallis rank sum test, Dunn's *post-hoc* test, and a Bonferroni's correction in program R 3.6.1 (Packages: readr 1.3.1 & FSA 0.8.30; Kuenzi and Morrison 2003, Johnson et al. 2011).

## Results

We recorded 250,392 events within the four cover types over the survey period. Out of 916 possible survey nights for each detector, detectors recorded for 801 nights over the water-forest cover, 770 nights at the crop field-forest edge cover, 735 nights at the forest trail cover, and 634 nights at the pollinator plot cover. Of these total bat calls, 20.11% were identified as big brown bats, 17.97% evening bats, 15.35% silver-haired bats, 7.11% eastern red bats, 3.66% hoary bats, 3.1% little brown bats, and 1.38% tricolored bats. Southeastern myotis, northern long-eared bats, and Indiana bats were not reliably detected. Of all calls, 31.33% were not identified as one of these seven species categories. Of calls identified (171,951) to species, 69.12% were at the water-forest edge, 23.62% at the crop field-forest edge cover, 5.16% at the pollinator plot cover, and 2.1% at the forest trail. All seven species calls were identified at the four cover types on the farm. The pollinator plot had a total of 8877 call events, with 5.42% of calls at the pollinator plot coming from big brown bats, 25.21% eastern red bats, 9.32% hoary bats, 26.07% silver-haired bats, 9.11% little brown bats, 23.78% evening bats, and 1.09% tricolored bats.

*Year and Season Effects on Nightly Activity* – All bat species examined were active at the

ESAREC in April through August of each study year, but presence and nightly relative activity outside of the maternity season (May-August) was differed across the 7 detected species (Figure 3.2). For example, nightly relative activity of the big brown bat peaked later (July-August) than other species (April-May); this peak likely represents when young became volant in a given year (Figure 3.2). We did find that nightly relative activity distribution was significantly different and was higher during the maternity than non-maternity time period for all species (Table 3.1). We thus confined our analyses of nightly relative activity by cover type to the maternity season of May through August.

We found a differences in nightly relative activity among years during the maternity season for the eastern red bat and silver-haired bat but not for the big brown bat, hoary bat, little brown bat, evening bat, and tricolored bat. The eastern red bat had higher nightly relative activity in 2017 ($\bar{x}$ = 14.08, SE = 1.25) than in 2019 ($\bar{x}$ = 10.47, SE = 1.15; Dunn's post-hoc test: z=2.63, df = 1, p=0.03; Table 3.2) and there were no significant *post-hoc* comparisons for the silver-haired bat despite and overall significance finding of the year effect.

*Cover Type Effects on Nightly Activity* – Bat nightly relative activity varied among cover types within the maternity season for all 7 bat species detected (Table 3.3, Figure 3.3). For all 7 detected bat species, nightly relative activity was significantly higher in water-forest edge and crop field-forest edge cover types as compared to the forest trail and pollinator plot cover types (Table 3.4). Nightly relative activity during the maternity season for evening bats and hoary bats did not differ significantly between crop field-forest edge and water-forest edge cover types (Table 3.4). However, for the little brown bat, tri-colored bat, and eastern red bat, the crop field-forest edge cover did have significantly higher nightly relative activity during the maternity season than water-forest edge while nightly relative activity for silver-haired bats and big brown bats was higher in water-forest edge cover type than the crop field-forest edge (Table 3.4). Bat nightly relative activity during the maternity season was significantly higher in the pollinator plot than the forest trail cover type in all species except for the tricolored bat, which showed no difference between the two cover types (Table 3.4).

## Discussion

The VDWR has four bat SGCN that we were able to detect as present on the ESAREC. Three species (hoary bats, silver-haired bats, and eastern red bats) are of moderate conservation need (lowest: Tier IV SGCN) and the VDWR has identified strategies to benefit the population or at least have a reasonable chance at improving the conservation status. Under the 2015 state wildlife action plan, these three species were of interest due to the issues surrounding wind energy and bat mortality caused by wind turbine blades (VDWR 2015*a*). To improve the status of these three species, the VDWR identified a need to better understand the migration patterns of species using the coastal areas of Virginia to best plan possible avoidance and help mitigate conflict if wind energy is developed. Outside of these three species, the little brown bat is of interest because of declining populations due to White Nose Syndrome (WNS; Powers et al. 2015). Little brown bats are labeled as a critical (highest: Tier I) SGCN in Virginia, meaning the goal is to improve conservation status, with actions in progress to identify and protect fall swarm, roosts, and foraging areas (VDWR 2015*a*). Our research is thus important for conservation planning by VDWR as we documented use and relative activity by these bat species across the year in an agricultural setting which is an abundant yet understudied habitat type in Eastern Virginia. A prior study on seasonal activity patterns of bats on Assateague Island, Virginia recorded five species during their survey (big brown bat, eastern red bat, silver-haired bat, hoary bat, and the tricolored bat), similar to our study, and showed similar patterns in activity, mainly the mounting presence and nightly relative activity of bats in April, and declining nightly relative activity after August (Johnson et al. 2011). While nightly relative activity peaked in April through August, most bat species showed some level of nightly relative activity year-round in both the Johnson et al. (2011) study at Assateauge Island and in our study area on the ESAREC.

To our knowledge, this is the first study to have examined bat presence on intentionally-planted pollinator-friendly farmscapes in North America. One study in southwest United Kingdom explored bat occupancy and activity in four agri-environment schemes, including cover types similar to pollinator-friendly plantings. In that study, it was found that bat relative activity was influenced by the composition of the pollinator-friendly habitat, and varied by species of bat, some with preferential activity closer to wooded edges and others for dicot coverage and features related to what we call pollinator plots (McHugh et al. 2019). Studies in coastal areas similar to ours found bat species preferentially choose edge locations to be used for commuting when less complex habitat structure is present, as well as foraging opportunities such as flowering fields or open water where insect load is higher (Menzel et al. 2005*a*, Ford et al. 2006, Hein et al. 2009, Vindigni et al. 2009, Morris et al. 2010, McHugh et al. 2018, 2019). We found that bats were preferentially choosing the forest water edge and the forest field edge. Both of these areas are relatively structurally complex and cluttered cover types at the edges of two habitats, which are known to have higher activity for bats (Ford et al. 2006, Morris et al. 2010, Jantzen and Fenton 2013). We did detect all 7 species of bat at our pollinator plot, although the relative activity was lower than the forest-crop field and water-forest edge cover types. While the pollinator plot was located adjacent to a crop field, it was also bordered by a thin row of evergreen trees adjoining academic buildings and thus was comparable to an open foraging area rather than a crop field-forest edge or water-forest edge.

The bat species that we detected can generally be grouped into species that select more 'cluttered' habitat areas such as forests and species that select more open and less complex habitat, such as fields or open water for foraging. Of the 7 species that we detected, two (i.e., big brown bat and hoary bat ) are known to prefer open habitats (Menzel et al. 2005*b*) and in our study their nightly call rates were highest in the forest-water edge and forest-field edge cover types, and higher in the pollinator plot cover type than on the forest trail. The eastern red bat, evening bat, and tricolored bat are known to prefer cluttered habitat (Menzel et al. 2005*b*), but from our study their nightly call rates were highest in the forest-water edge and forest-field edge cover types than on the forest trail cover type. The relative call activity of the eastern red bat and the tricolored bat were higher on forest-field edge than the forest-water edge. This could be an indicator of edge preference for forested edge with less competition from open habitat species that would prefer foraging over water. The little brown bat has been shown to forage in both cluttered and open habitat types, depending on the size of bat and volancy periods (Kalcounis and Brigham 1995, Adams 1997, Brooks and Ford 2005). We suggest future studies determine whether a pollinator plot placed next to a more natural habitat edge, such as forest or water, may result in higher nightly relative activity of bats as compared to pollinator plots in open areas or integrated field margins.

## Acknowledgements

This research was supported by U.S. Department of Agriculture's Agroecosystem Management grant #11664133 and graduate teaching support to E. Berge from the Department of Fish and Wildlife Conservation at Virginia Tech. Thank you to staff at the Virginia Tech Eastern Shore Agricultural Research Extension Center for the warm welcomes and bright smiles. We want to thank Elaine Barr for helping with the analysis and data manipulation that started us off on the right path. We also thank our field technicians: Cameron Robertson, Chris Rowe, Ally Moser-Scott, Amanda Crandall, Joe Girgente, and Emily Gardner who worked tirelessly through completely packed survey seasons and long weekend trips.

## Literature Cited


Adams, R. A. 1997. Onset of volancy and foraging patterns of juvenile little brown bats, *Myotis lucifugus*. Journal of Mammalogy 78:239–246.

Albrecht, M., D. Kleijn, N. M. Williams, M. Tschumi, B. R. Blaauw, R. Bommarco, A. J. Campbell, M. Dainese, F. A. Drummond, M. H. Entling, D. Ganser, G. A. de Groot, D. Goulson, H. Grab, H. Hamilton, F. Herzog, R. Isaacs, K. Jacot, P. Jeanneret, M. Jonsson, E. Knop, C. Kremen, D. A. Landis, G. M. Loeb, L. Marini, M. McKerchar, L. Morandin, S. C. Pfister, S. G. Potts, M. Rundlöf, H. Sardiñas, A. Sciligo, C. Thies, T. Tscharntke, E. Venturini, E. Veromann, I. M. G. Vollhardt, F. Wäckers, K. Ward, A. Wilby, M. Woltz, S. Wratten, and L. Sutter. 2020. The effectiveness of flower strips and hedgerows on pest control, pollination services and crop yield: a quantitative synthesis. Ecology Letters 23:1488–1498.

Angelella, G., and M. O'Rourke. 2017. Pollinator habitat establishment after organic and no-till seedbed preparation methods. HortScience 52:1349–1355.

Anthony, E. L. P., M. H. Stack, and T. H. Kunz. 1981. Night roosting and the nocturnal time budget of the little brown bat, *Myotis lucifugus*: Effects of reproductive status, prey density, and environmental conditions. Oecologia 51:151–156.

Ball, M. 2015. VDOT's pollinator habitat program moves toward statewide implementation. Informed Infrastructure. <https://informedinfrastructure.com/17439/vdots-pollinator-habitat-program-moves-toward-statewide-implementation/>. Accessed 3 Nov 2019.

Benson, B., R. McDonald, N. C. Sugar Grove, and R. Morse. 2016. Farmscaping techniques for managing insect pests. Virginia Tech and Symbiont Biological Pest Management. <http://localfoodhub.org/wp-content/uploads/2012/07/5_farmscapingTechniques

ForManagingInsectPests_VCE.pdf>. Accessed 3 Nov 2019.

Bloom, E. H., and D. W. Crowder. 2016. Biological control and pollination services on organic farms. Pages 27–46 in A. R. Horowitz and I. Ishaaya, editors. Advances in Insect Control and Resistance Management. Springer International Publishing, Switzerland.

Boyles, J. G., P. M. Cryan, G. F. McCracken, and T. H. Kunz. 2011. Economic importance of bats in agriculture. Science 332:41–42.

Brooks, R. T., and W. M. Ford. 2005. Bat Activity in a forest landscape of central Massachusetts. Northeastern Naturalist 12:447–462.

Conway, G. R., and E. B. Barbier. 2013. After the green revolution: Sustainable agriculture for development. Earthscan, London, UK.

Dhaliwal, G. S., V. Jindal, and A. K. Dhawan. 2010. Insect pest problems and crop losses: changing trends. Indian Journal of Ecology 37:1–7.

Everette, A. L., T. J. O’Shea, L. E. Ellison, L. A. Stone, and J. L. McCance. 2001. Bat use of a high-plains urban wildlife refuge. Wildlife Society Bulletin (1973-2006) 29:967–973.

Ford, W. M., J. M. Menzel, M. A. Menzel, J. W. Edwards, and J. C. Kilgo. 2006. Presence and absence of bats across habitat scales in the upper Coastal Plain of South Carolina. The Journal of Wildlife Management 70:1200–1209.

Ford, W. M., M. A. Menzel, J. L. Rodrigue, J. M. Menzel, and J. B. Johnson. 2005. Relating bat species presence to simple habitat measures in a central Appalachian forest. Biological Conservation 126:528–539.

Gehrt, S. D., and J. E. Chelsvig. 2008. Bat activity in an urban landscape: Patterns at the landscape and microhabitat scale. Pages 437–453 in J. M. Marzluff, E. Shulenberger, W. Endlicher, M. Alberti, G. Bradley, C. Ryan, U. Simon, and C. ZumBrunnen, editors.

Urban Ecology: An International Perspective on the Interaction Between Humans and Nature. Springer US, Boston, MA.

Hein, C. D., S. B. Castleberry, and K. V. Miller. 2009. Site-occupancy of bats in relation to forested corridors. Forest Ecology and Management 257:1200–1207.

Horlings, L. G., and T. K. Marsden. 2011. Towards the real green revolution? Exploring the conceptual dimensions of a new ecological modernisation of agriculture that could 'feed the world.' Global Environmental Change 21:441–452.

Humes, M. L., J. P. Hayes, and M. W. Collopy. 1999. Bat activity in thinned, unthinned, and old-growth forests in western Oregon. The Journal of Wildlife Management 63:553–561.

Jantzen, M. K., and M. B. Fenton. 2013. The depth of edge influence among insectivorous bats at forest–field interfaces. Canadian Journal of Zoology 91:287–292.

Johnson, J. B., and J. E. Gates. 2008. Bats of Assateague Island National Seashore, Maryland. The American Midland Naturalist 160:160–170.

Johnson, J. B., J. E. Gates, and N. P. Zegre. 2011. Monitoring seasonal bat activity on a coastal barrier island in Maryland, USA. Environmental Monitoring and Assessment 173:685–699.

Kalcounis, M. C., and R. M. Brigham. 1995. Intraspecific variation in wing loading affects habitat use by little brown bats (*Myotis lucifugus*). Canadian Journal of Zoology 73:89–95.

Kuenzi, A., and M. Morrison. 2003. Temporal patterns of bat activity in southern Arizona. Journal of Wildlife Management 67:52–64.

Linzey, D. W. 1998. The mammals of Virginia. McDonald & Woodward Pub. Co., Blacksburg, USA.

Loeb, S. C., and J. M. O'Keefe. 2011. Bats and gaps: The role of early successional patches in the roosting and foraging ecology of bats. Pages 167–189 in C. Greenberg, B. Collins, and F. Thompson III, editors. Sustaining Young Forest Communities: Ecology and Management of early successional habitats in the central hardwood region, USA. Managing Forest Ecosystems, Springer Netherlands, Dordrecht.

McFarland, E. R., and T. S. Bruce. 2006. The Virginia coastal plain hydrogeologic framework. 1st ed. Professional paper 1731, U.S. Dept. of the Interior, U.S. Geological Survey, Reston, USA.

McHugh, N. M., B. L. Bown, A. S. Forbes, J. A. Hemsley, and J. M. Holland. 2018. Use of agri-environment scheme habitats by pipistrelle bats on arable farmland. Aspects of Applied Biology 139:1–8.

McHugh, N. M., B. L. Bown, J. A. Hemsley, and J. M. Holland. 2019. Relationships between agri-environment scheme habitat characteristics and insectivorous bats on arable farmland. Basic and Applied Ecology 40:55–66.

Menzel, J. M., M. A. Menzel, J. C. Kilgo, W. M. Ford, and J. W. Edwards. 2005a. Bat response to Carolina bays and wetland restoration in the southeastern U.S. Coastal Plain. Wetlands 25:542–550.

Menzel, J. M., M. A. Menzel, J. C. Kilgo, W. M. Ford, J. W. Edwards, and G. F. McCracken. 2005b. Effect of habitat and foraging height on bat activity in the Coastal Plain of South Carolina. The Journal of Wildlife Management 69:235–245.

Morandin, L. A., and C. Kremen. 2013. Hedgerow restoration promotes pollinator populations and exports native bees to adjacent fields. Ecological Applications 23:829–839.

Morris, A. D., D. A. Miller, and M. C. Kalcounis-Rueppell. 2010. Use of forest edges by bats in a managed pine forest landscape. Journal of Wildlife Management 74:26–34.

Morrison, E. B., and C. A. Lindell. 2012. Birds and bats reduce insect biomass and leaf damage in tropical forest restoration sites. Ecological Applications 22:1526–1534.

Muthersbaugh, M. S., W. M. Ford, K. E. Powers, and A. Silvis. 2019. Activity patterns of bats during the fall and spring along ridgelines in the central Appalachians. Journal of Fish and Wildlife Management 10:180–195.

Nocera, T., W. M. Ford, A. Silvis, and C. A. Dobony. 2019. Patterns of acoustical activity of bats prior to and 10 years after WNS on Fort Drum Army Installation, New York. Global Ecology and Conservation 18:e00633.

O'Rourke, M., C. Philips, and T. Kuhar. 2019. Improving pest management with farmscaping. Virginia Cooperative Extension, Virginia Tech, Blacksburg, USA.

Pavelis, G. A., D. Helms, and S. Stalcup. 2011. Soil and water conservation expenditures by USDA agencies, 1935–2010. Historical Insights: 10, U.S. Department of Agriculture - Natural Resources Conservation Service, Washington, D.C., USA.

Powers, K. E., R. J. Reynolds, W. Orndorff, W. M. Ford, and C. S. Hobson. 2015. Post-white-nose syndrome trends in Virginia's cave bats, 2008-2013. Journal of Ecology and the Natural Environment 7:113–123.

Russo, D., L. Bosso, and L. Ancillotto. 2018. Novel perspectives on bat insectivory highlight the value of this ecosystem service in farmland: Research frontiers and management implications. Agriculture, Ecosystems & Environment 266:31–38.

Shennan, C. 2008. Biotic interactions, ecological knowledge and agriculture. Philosophical Transactions of the Royal Society B: Biological Sciences 363:717–739.

Thomas, D. W., and S. West D. 1989. Sampling methods for bats. General Technical Report

PNW-GTR-243, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon, USA.

Tilman, D. 1998. The greening of the green revolution. Nature 396:211–212.

USFWS, U. S. F. & W. S. 2019. USFWS: Indiana bat summer survey guidance - Automated acoustic bat ID software programs. <https://www.fws.gov/midwest/endangered/mammals/inba/surveys/inbaAcousticSoftware.html>. Accessed 19 Jun 2020.

VADCR, and VADEQ. 2019. Virginia pollinator-smart business plan. Virginia Department of Conservation and Recreation, Virginia Department of Environmental Quality, Richmond, Virginia, USA. <https://www.dcr.virginia.gov/natural-heritage/document/solar-site-business-plan.pdf>. Accessed 3 Nov 2019.

Vaughan, M., and M. Skinner. 2008. Using farm bill programs for pollinator conservation. Technical Note No. 78, United States Department of Agriculture, Washington, D.C., USA.

VDWR. 2015. Virginia's 2015 state wildlife action plan. Virginia Department of Wildlife Resources, Henrico, Virginia, USA. <http://bewildvirginia.org/wildlife-action-plan/pdf/2015-Virginia-Wildlife-Action-Plan.pdf>. Accessed 30 Sep 2017.

Vindigni, M. A., A. D. Morris, D. A. Miller, and M. C. Kalcounis-Rueppell. 2009. Use of modified water sources by bats in a managed pine landscape. Forest Ecology and Management 258:2056–2061.

Williams-Guillén, K., I. Perfecto, and J. Vandermeer. 2008. Bats limit insects in a neotropical agroforestry system. Science 320:70–70.

Wilson, G. A., and J. Rigg. 2003. 'Post-productivist' agricultural regimes and the South: discordant concepts? Progress in Human Geography 27:681–707.

Wolcott, K. A., and K. Vulinec. 2012. Bat activity at woodland/farmland interfaces in central Delaware. Northeastern Naturalist 19:87–98.

## Tables

Table 3.1: Mean and standard error of calls/night of bat species at the Eastern Shore Agricultural Research Extension Center in Painter, Virginia between the maternity period (May-August) and non-maternity period (September-April) in 2017-2019. Results of the Wilcoxon Rank Sum Test for relative call activity (calls/night) by maternity versus non-maternity season for each bat species.

| Species | Mean (SE) calls/night maternity season | Mean (SE) calls/night non-maternity season | Chi-square | df | p-value |
|---|---|---|---|---|---|
| Big Brown Bat (*Eptesicus fuscus*) | 31.26(5.29) | 5.77(1.29) | 702.55 | 1 | <0.001 |
| Eastern Red Bat (*Lasiurus borealis*) | 12.55(0.71) | 0.84(0.15) | 798.11 | 1 | < 0.001 |
| Hoary Bat (*Lasiurus cinereus*) | 5.68(0.62) | 1.06(0.41) | 334.18 | 1 | < 0.001 |
| Silver-haired Bat (*Lasionycteris noctivagans*) | 18.54(2.22) | 8.68(1.62) | 435.85 | 1 | < 0.001 |
| Little Brown Bat (*Myotis lucifugus*) | 4.82(0.32) | 0.88(0.11) | 445.83 | 1 | < 0.001 |
| Evening Bat (*Nycticeius humeralis*) | 31.26(2.26) | 2.48(0.38) | 674.3 | 1 | < 0.001 |

| Species | Mean (SE) calls/night maternity season | Mean (SE) calls/night non-maternity season | Chi-square | df | p-value |
|---|---|---|---|---|---|
| Tricolored Bat (*Perimyotis subflavus*) | 2.14(0.48) | 0.39(0.05) | 125.12 | 1 | $< 0.001$ |

Table 3.2: Mean and standard error of calls/night of bat species at the Eastern Shore Agricultural Research Extension Center in Painter, Virginia during the maternity season (May-August) by year. Results of the Kruskal-Wallis Rank Sum Test for relative call activity (calls/night) during the maternity season (May-August) by year for each bat species.

| Species | Mean (SE) calls/night 2017 | Mean (SE) calls/night 2018 | Mean (SE) calls/night 2019 | Chi-square | df | p-value |
|---|---|---|---|---|---|---|
| Big Brown Bat (*Eptesicus fuscus*) | 18.91(5.34) | 42.05(12.55) | 31.24(7.20) | 1.26 | 2 | 0.53 |
| Eastern Red Bat (*Lasiurus borealis*) | 14.08(0.94) | 13.31(1.29) | 10.47(1.15) | **7.77** | **2** | **0.02** |
| Hoary Bat (*Lasiurus cinereus*) | 4.93(0.98) | 5.67(1.17) | 6.34(0.98) | 0.01 | 2 | 1 |
| Silver-haired Bat (*Lasionycteris noctivagans*) | 8.15(3.65) | 18.36(3.23) | 27.71(5.40) | 7.26 | 2 | 0.03[1] |
| Little Brown Bat (*Myotis lucifugus*) | 4.56(0.44) | 4.63(0.49) | 5.24(0.70) | 3.1 | 2 | 0.22 |
| Evening Bat (*Nycticeius humeralis*) | 26.68(2.89) | 31.52(3.51) | 34.96(4.60) | 1.99 | 2 | 0.37 |
| Tricolored Bat (*Perimyotis subflavus*) | 0.97(0.59) | 1.85(0.32) | 3.43(1.32) | 0.59 | 2 | 0.75 |

[1]: Further Dunn's *post hoc* test revealed no significance between years

Table 3.3: Mean and standard error of calls/night throughout the maternity season by cover type at the Eastern Shore Agricultural Research Extension Center in Painter, Virginia in 2017-2019 throughout the maternity period (May-August). Results of the Kruskal-Wallis Rank Sum Test for relative call activity (calls/night) of bat species by cover type. Relative call activity showed significant variation by cover type (crop field-forest edge, forest trail, water-forest edge, and pollinator plot) for all bat species.

| | Mean (Standard Error) of Calls/Night | | | | | | |
|---|---|---|---|---|---|---|---|
| Species | Crop Field-Forest Edge | Forest Trail | Water-Forest Edge | Pollinator Plot | Chi-square | df | p-value |
| Big Brown Bat (*Eptesicus fuscus*) | 12.62(1.68) | 1.98(0.34) | 99.55(18.89) | 1.57(0.12) | 336.06 | 3 | < 0.001 |
| Eastern Red Bat (*Lasiurus borealis*) | 25.45(1.80) | 1.38(0.31) | 14.33(1.22) | 8.01(1.60) | 382.89 | 3 | < 0.001 |
| Hoary Bat (*Lasiurus cinereus*) | 7.33(1.49) | 0.82(0.19) | 11.19(1.64) | 2.45(0.61) | 148.90 | 3 | < 0.001 |
| Evening Bat (*Nycticeius humeralis*) | 35.56(2.62) | 0.20(0.05) | 74.78(7.24) | 7.52(1.40) | 606.11 | 3 | < 0.001 |
| Little Brown Bat | 9.11(0.76) | 2.11(0.50) | 5.31(0.72) | 2.16(0.33) | 240.57 | 3 | < 0.001 |

| Species | Mean (Standard Error) of Calls/Night: Crop Field-Forest Edge | Forest Trail | Water-Forest Edge | Pollinator Plot | Chi-square | df | p-value |
|---|---|---|---|---|---|---|---|
| (*Myotis lucifugus*) | | | | | | | |
| Tricolored Bat (*Perimyotis subflavus*) | 3.23(0.35) | 0.09(0.03) | 4.57(1.71) | 0.14(0.04) | 285.97 | 3 | < 0.001 |
| Silver-haired Bat (*Lasionycteris noctivagans*) | 12.47(1.88) | 1.04(0.17) | 49.52(7.62) | 7.39(1.55) | 326.97 | 3 | < 0.001 |

Table 3.4: Results of Dunn's *post hoc* test for relative call activity (calls/night) of bat species at the Eastern Shore Agricultural Research Extension Center in Painter, Virginia throughout the maternity period (May-August) by cover type in 2017-2019. For all 7 detected bat species, relative call activity was significantly higher in water-forest edge and crop field-forest edge cover types as compared to the forest trail and pollinator plot cover type.

| Species | Comparison | Z | p.adj |
|---|---|---|---|
| *Eptesicus fuscus*, Big Brown Bat | Crop Field-Forest Edge vs. Forest Trail | 13.01 | <0.001 |
| | Crop Field-Forest Edge vs. Pollinator Plot | 8.58 | <0.001 |
| | Crop Field-Forest Edge vs. Water-Forest Edge | -3.01 | <0.001 |
| | Forest Trail vs. Pollinator Plot | -3.61 | <0.001 |
| | Forest Trail vs. Water-Forest Edge | -16.16 | <0.001 |
| | Pollinator Plot vs. Water-Forest Edge | -11.47 | <0.001 |
| *Lasiurus borealis*, Eastern Red Bat | Crop Field-Forest Edge vs. Forest Trail | 18.58 | <0.001 |
| | Crop Field-Forest Edge vs. Pollinator Plot | 10.37 | <0.001 |
| | Crop Field-Forest Edge vs. Water-Forest Edge | 5.09 | <0.001 |
| | Forest Trail vs. Pollinator Plot | -7.03 | <0.001 |
| | Forest Trail vs. Water-Forest Edge | -13.68 | <0.001 |
| | Pollinator Plot vs. Water-Forest Edge | -5.70 | <0.001 |
| *Lasiurus cinereus*, Hoary Bat | Crop Field-Forest Edge vs. Forest Trail | 9.61 | <0.001 |
| | Crop Field-Forest Edge vs. Pollinator Plot | 5.42 | <0.001 |
| | Crop Field-Forest Edge vs. Water-Forest Edge | -0.98 | 1.00 |
| | Forest Trail vs. Pollinator Plot | -3.58 | <0.001 |
| | Forest Trail vs. Water-Forest Edge | -10.69 | <0.001 |
| | Pollinator Plot vs. Water-Forest Edge | -6.38 | <0.001 |
| *Nycticeius humeralis*, Evening Bat | Crop Field-Forest Edge vs. Forest Trail | 20.57 | <0.001 |
| | Crop Field-Forest Edge vs. Pollinator Plot | 10.40 | <0.001 |
| | Crop Field-Forest Edge vs. Water-Forest Edge | -0.45 | 1.00 |
| | Forest Trail vs. Pollinator Plot | -8.87 | <0.001 |
| | Forest Trail vs. Water-Forest Edge | -21.23 | <0.001 |

| Species | Comparison | Z | p.adj |
|---|---|---|---|
| | Pollinator Plot vs. Water-Forest Edge | -10.92 | <0.001 |
| *Myotis lucifugus*, Little Brown Bat | Crop Field-Forest Edge vs. Forest Trail | 14.84 | <0.001 |
| | Crop Field-Forest Edge vs. Pollinator Plot | 10.46 | <0.001 |
| | Crop Field-Forest Edge vs. Water-Forest Edge | 6.77 | <0.001 |
| | Forest Trail vs. Pollinator Plot | -3.44 | <0.001 |
| | Forest Trail vs. Water-Forest Edge | -8.22 | <0.001 |
| | Pollinator Plot vs. Water-Forest Edge | -4.22 | <0.001 |
| *Perimyotis subflavus*, Tricolored Bat | Crop Field-Forest Edge vs. Forest Trail | 14.80 | <0.001 |
| | Crop Field-Forest Edge vs. Pollinator Plot | 13.19 | <0.001 |
| | Crop Field-Forest Edge vs. Water-Forest Edge | 6.00 | <0.001 |
| | Forest Trail vs. Pollinator Plot | -0.67 | 1.00 |
| | Forest Trail vs. Water-Forest Edge | -8.95 | <0.001 |
| | Pollinator Plot vs. Water-Forest Edge | -7.70 | <0.001 |
| *Lasionycteris noctivagans*, Silver-haired Bat | Crop Field-Forest Edge vs. Forest Trail | 12.58 | <0.001 |
| | Crop Field-Forest Edge vs. Pollinator Plot | 4.36 | <0.001 |
| | Crop Field-Forest Edge vs. Water-Forest Edge | -4.67 | <0.001 |
| | Forest Trail vs. Pollinator Plot | -7.43 | <0.001 |
| | Forest Trail vs. Water-Forest Edge | -17.38 | <0.001 |
| | Pollinator Plot vs. Water-Forest Edge | -8.77 | <0.001 |

## Figures


Figure 3.1: Location of bat acoustic surveys and cover types used in this study. On the left, the Eastern Shore of Virginia with the location of the Eastern Shore Agricultural Research Extension Center (ESAREC) shown as a dot. On the right, the ESAREC with four cover type point locations (crop field-forest edge, forest trail, water-forest edge, and pollinator plot) labeled and a 500-meter buffer placed around the survey points for scale. Background imagery from ArcMap World Imagery – Attribution: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, AeroGRID, IGN, and the GIS User Community.

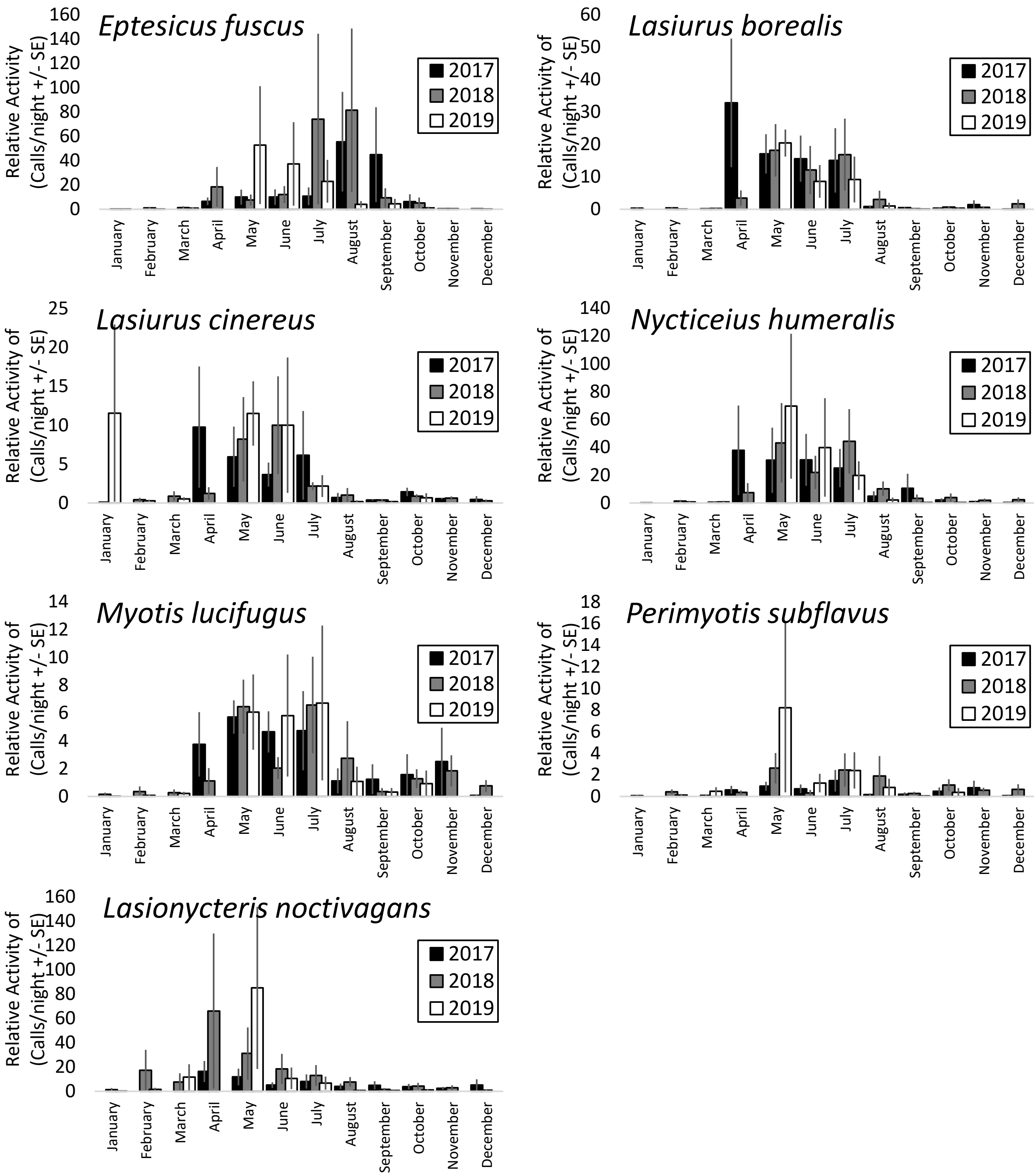


Figure 3.2: Bar graphs of the monthly average relative call rate (mean ± SE calls/night by month) of bat species at the Eastern Shore Agricultural Research Extension Center in Painter, Virginia averaged across the detectors at the four cover types throughout the year. Scale of each plate varies by species and SE is calculated for each month-long period of each year.

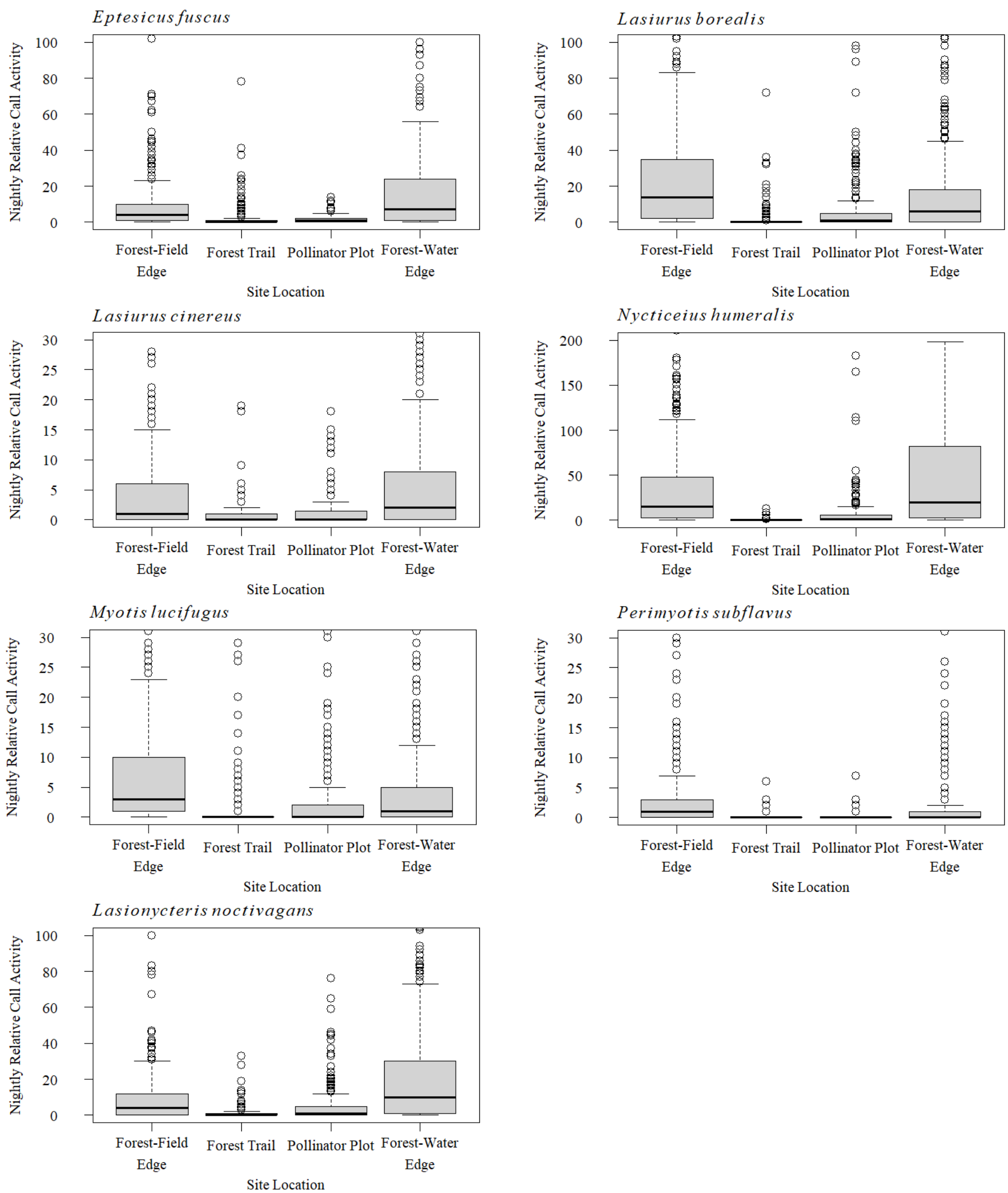


Figure 3.3: Box and whisker plots of relative call activity (calls/night) of bat species at the Eastern Shore Agricultural Research Extension Center in Painter, Virginia throughout the maternity period (May-August) by cover type. Scale of each plate varies by species. Plots

represent the median, upper and lower quantile, minimum and maximum values, and the outliers based on these shapes.

# Chapter 4: Relationship of white-tailed deer and wild turkey to pollinator plot restoration and landscape features on small-scale farms on in the Coastal Plain of Virginia and Maryland

Earle J. Berge[1]†, Sarah Karpanty[1], Megan O'Rourke[2], Dean Stauffer[1], and Mark Ford[1]

[1]Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, Virginia 24061, USA

[2] United States Department of Agriculture National Institute of Food and Agriculture, Kansas City, Missouri 64133, USA

†E-mail: earleb@vt.edu

† Written for submission to Journal of Fish and Wildlife Management

## Abstract

Wildflower and native grass plantings are a widely used method to improve ecosystem or even services provided by pollinating insects on farmland. However, the potential ecosystem service benefits, disservices, of pollinator friendly plantings related to larger vertebrates, such as white-tailed deer (*Odocoileus virginianus*) and wild turkey (*Meleagris gallopavo*) have not been studied. We assessed whether white-tailed deer and wild turkey camera trap success and occupancy differed between farms with and without pollinator-friendly farmscaped plots, and also evaluated the impacts of a farm's surrounding landcover on these same metrics. We used camera trap surveys to measure white-tailed deer and wild turkey camera trap success and occupancy across 20 farms on the Eastern Shore of Virginia and in the city of Virginia Beach, Virginia during the Spring and Fall of 2017 and 2018. Of all wild species photographed, white-tailed deer had the highest total camera trap success (TS, # captures/100 nights) each survey season (Spring 2017 = 98.44 TS, Fall 2017 = 106.01 TS, Spring 2018 = 80.52 TS, Fall 2018 = 99.71 TS). Wild turkey total survey camera trap success was low compared to deer and other wildlife (4.51 TS), and also varied seasonally (Spring 2017 = 1.73 TS, Fall 2017 = 1.50 TS, Spring 2018 = 7.63 TS, Fall 2018 = 5.95 TS). White-tailed deer were detected at all survey locations at least once, and in each survey season the occupancy of deer decreased as the percentage of developed land within 1km around a farm increased. The factors relating to wild turkey occupancy varied by season. In Spring 2017, wild turkey occupancy increased as the percent of natural cover within 1 km of a farm increased and similarly, in Spring 2018, wild turkey occupancy decreased as the percent of developed land within 1 km increased. However, landscape variables did not influence wild turkey occupancy in the Fall seasons, but rather in Fall 2018, we found that wild turkey occupancy decreased as camera trap success of farm machinery

in use increased. Overall, wild turkey had a fairly low capture rate on all survey sites and a probability of occupancy ranging from 0.18-0.53. Based on these results, pollinator plot presence or absence was not found to influence detection or occupancy of either of our target species. Rather, other factors, mainly landscape-scale features, were found to have the largest influence on both species' occupancy and presence. We conclude that though pollinator friendly plantings may provide some aspect of wild turkey or white-tailed deer habitat requirements, the scale at which they are placed in this study might be too small to sufficiently influence occupancy or presence of these species in our study system due to their life history traits and limited resources pollinator plots provide.

## Introduction

Farmland yield has advanced greatly in recent decades due to the prevalence chemically-intensive monoculture crop systems (Wilson and Rigg 2003, Conway and Barbier 2013). While benefiting food security objectives, high intensity farming practices have led to a decrease in ecological plant and animal diversity and reductions in ecosystem services such as pest regulation and the provisioning and cultural ecosystem services provided by game animals (Tilman 1998, Dhaliwal et al. 2010, Horlings and Marsden 2011).

Recognizing this loss, agencies such as the U.S. Department of Agriculture Natural Resource Conservation Service (USDA-NRCS) and various state agricultural and lands-based conservation organizations have been enacting policies to encourage farmland alterations that can support ecosystem services. These alterations of farmland, defined here as ‘farmscaping,’ include the altering the habitat structure on farms to benefit natural processes and native species, to enhance and bring back the many ecosystem services that farmlands once provided in addition to continued food production for the growing human population (Pavelis et al. 2011, Benson et al. 2016). Farmscaping practices may include, but are not limited to, adding a mix of cover types, planting shrub- or tree-dominated hedgerows along property boundaries, or the planting of native grass- and forb-dominated ‘pollinator’ plots or rows.

Wildlife responses to farmscaping practices are still relatively understudied compared to other benefits, such as pest reduction or pollination by insects, and depend on the details of which practice is implemented. Wild turkey (*Meleagris gallopavo*), white-tailed deer (*Odocoileus virginianus*), and other vertebrates (birds, mice, squirrels, rabbits, bats) tend to use tree- or shrub-dominated hedgerows as cover with a concurring increase of bird species richness with increases in shrub- or tree-densities along field edges in agricultural landscapes (Burel

1996, Davies and Pullin 2007, Boughey et al. 2011). Pollinator plots or rows, studied in North American and European farming systems often have been shown to reduce pest insect populations and to benefit the native insect pollinator community (Morandin and Kremen 2013, Benson et al. 2016, Bloom and Crowder 2016, O'Rourke et al. 2019, Albrecht et al. 2020), and thus may indirectly benefit birds or mammals that consume native insects.

Specific vertebrate wildlife responses to pollinator-friendly plantings in the Coastal Plain landscape of Virginia and Maryland are, to our knowledge, unstudied. In this region, several entities such as the USDA-NRCS, Virginia Department of Conservation & Recreation (VA-DCR), Maryland Department of Natural Resources (MA-DNR), and Virginia Department of Transportation (VDOT) have been planting pollinator friendly plantings for different uses, whether it be for their visual, production, or ecological benefits (Vaughan and Skinner 2008, Ball 2015, MDA 2016, VADCR and VADEQ 2019). Despite these investments, it is not yet understood how pollinator friendly plantings may influence the presence and occupancy of larger fauna of interest to many farmers for provisioning and cultural ecosystem service values, such as white-tailed deer and wild turkey. Some prior work on the responses of white-tailed deer and wild turkey to farmscaping techniques focused on hedgerow habitat and vertebrate pest management techniques (Macdonald and Feber 2015, Vispo et al. 2015), but to our knowledge there have been no studies focused on the relation of pollinator plots to white-tailed deer and wild turkey despite their recreational and harvest values. For example, the hunting of white-tailed deer is estimated to bring in more than $500 million/year in Virginia and $178 million/year from supplies, equipment and travel related to deer hunts in Maryland (VDWR 2015*b*, Eyler et al. 2019). In contrast to the benefits of deer for provisioning and recreational value in agricultural settings, it is also important to recognize that deer herbivory results in millions of dollars in crop damage to agricultural businesses across Virginia each year (VDWR 2015*b*). Thus farmers may be interested in the potential benefits of farmscaping for deer with respect to hunting, but concerned as well about potential ecosystem disservices related to crop herbivory. Similar to deer, wild turkey are recreationally valuable both in terms of harvest and recreational value for bird-watchers. Wild turkey populations in the eastern U.S. and within Virginia and Maryland have been increasing since the 1970s, stabilized in the1990s, and now both states have a stable and valued harvest program in place (Dickson 1992, VDWR 2016, Long 2019).

Our objective was to assess the relationship of pollinator plot farmscaping practices to white-tailed deer and wild turkey relative to other available cover types in the Coastal Plain habitats of Virginia and Maryland. We quantified white-tailed deer and wild turkey camera trap success and occupancy on farmlands participating in an USDA-NRCS sponsored pollinator plot planting. Using these metrics, we wanted to evaluate whether the presence of pollinator friendly plantings might increase presence and occupancy while also increasing potential provisioning ecosystem services of these farms related to deer and turkey as compared to farms without pollinator plantings. We predicted that farms with pollinator friendly plantings would have higher camera trap success and relative occupancy of both white-tailed deer and wild turkey than farms without pollinator plantings. We also documented landscape level cover types within 1 km of each farm and predicted that farms with more natural areas and less development within 1 km would have higher camera trap success and occupancy for both white-tailed deer and wild turkey and that landscape variables would be as influential to the presence of a pollinator planting on a farm.

## Methods

### Study Area

A total of 20 farm study sites was selected for study in the Spring of 2015 on the Eastern Shore of Virginia and Maryland (i.e. Delmarva Peninsula) and in the city of Virginia Beach, VA (Figure 4.1, Appendix K). Study sites were entirely located within the mid-Atlantic Coastal Plain denoted by primarily alluvial soils of sedimentary sand and clay with surrounding tidewater influences (McFarland and Bruce 2006). Landscape use of this area varies widely across the study area with a majority of larger cities in the northern reaches of Maryland and southern locations in the city of Virginia Beach, VA. The rest of the landscape is a mix of pine stands, poultry and crop farms, as well as natural parks and area preserves. Farmers were contacted for potential participation at farmer's markets across the Delmarva Peninsula and in the city of Virginia Beach, VA and through conversations with local USDA-NRCS agents. Farms included 5 sites in the city of Virginia Beach, VA; 4 sites in Northampton County, VA; 5 sites in Accomack County, VA; 5 sites in Wicomico County, MD; and 1 site in Somerset County, MD. Farms were selected based on landowner willingness to participate in the study while also ensuring we sampled variation in forest cover, crop lands, developed lands, and water features within a 1-km radius land cover analysis using data from the 2017 USDA Cropscape data layer (Appendix L; USDA National Agricultural Statistics Service Cropland Data Layer 2017). The cover classes of deciduous forest, evergreen forest, mixed forest, shrubland, woody wetland, and herbaceous wetland were collapsed into a category of natural cover. Cover classes of developed/open space, developed/low intensity, developed/medium intensity, developed/high intensity, and barren were collapsed into developed cover. Crop cover class was aggregated from all crop categories including a majority of corn, hay, wheat, soybeans, watermelon, sod, cotton, and sorghum. Water, which included saltwater or brackish bay, were combined into a water category. The percent area of the four cover classes (natural, developed, crop, and water) were calculated within a 1,000 m radius buffer surrounding each field site using ArcMap v10.5.1 (ESRI, Redlands, CA; Appendix L).

Each selected farm was located at least 2.5 km from any other farm used in the study. Farms included 5 sites in the city of Virginia Beach, VA; 4 sites in Northampton County, VA; 5 sites in Accomack County, VA; 5 sites in Wicomico County, MD; and 1 site in Somerset County, MD. Ten farm locations spread throughout the survey area had pollinator-targeted plantings; hereafter, 'pollinator' farms, which were planted and managed according to Angelella and O'Rourke 2017 and 10 farms did not receive the pollinator plantings, hereafter, 'control' farms (Figure 4.1, Appendix M). The size of pollinator friendly plantings ranged from 560 - 12,140 $m^2$, usually placed in large strips on field edge or blocks of land on the edge of cropland as allowed by landowners (Appendix K).

**Field Methods**

Camera trap surveys were conducted from May 13$^{th}$-June 29$^{th}$ 2017 (Spring 2017), August 16$^{th}$-October 15$^{th}$ 2017 (Fall 2018), April 20$^{th}$-June 24$^{th}$ 2018 (Spring 2018), and August 18$^{th}$-October 27$^{th}$ 2018 (Fall 2018). On each of the 20 farms, we placed 2-3 camera stations with a distance of at least 100m between each camera location (Figure 4.1). We placed cameras in 4 cover types on each farm: forest-managed (FM), a location on forest edge adjacent to plowed fields, crops, or recently cropped fields; forest-unmanaged (FU), a location on forest edge adjacent to brush piles, fallow fields older than 2-years, or recently logged forest; pollinator plot (PP), adjacent and encompassing a pollinator friendly planting that researchers placed only on each pollinator farm (see Appendix M); and novel habitat (NH), where landscape features such as open fields of short weeds, repeatedly mown fields, and small stream flows caused alternative farmscape features on control farms. Six control farms survey points included FM, FU, and NH cover types. Two control farms had FM and FU cover types, but due to size restraints did not include a NH cover type. One control farm consisted of 3 FM cover type points, and one other control farm of 3 FU cover type points (Appendix K).

Each sampling station consisted of a single camera trap (Moultrie M40i and D-80 White Flash, EBSCO Industries, Calera, AL) on a post or available tree at least 0.5 m high aimed to capture our target species (white-tailed deer and wild turkey) on available wildlife trails. Upon triggering the infrared camera, a set of 3 burst photos would be taken with a 30 second delay in-between each trigger. We grouped all photos of a species within 30 minutes of each other at a camera as a single capture event and recorded the maximum number of individuals captured of a given species within a single photo during that 30-minute capture event. During deployment, researchers checked camera traps every two weeks to exchange memory cards, change batteries, and clear overgrown vegetation, excluding crops, near the camera.

**Analytical Methods**

*Camera Trap Success* – We excluded species with less than 10 capture events from any analyses. We quantified camera trap success for each species by survey season (Spring and Fall 2017 and 2018) as the total number of capture events divided by the total survey nights and multiplied by 100, resulting in camera trap success per 100 trap nights (Kelly and Holub 2008).

Human presence was classified into two different categories. In the first human category, human presence with machinery (e.g. cars, mowers, tillers, trailers) were grouped together as “machines” due to probable disturbance in the form of noise and movement. Other human presence (e.g. pedestrians, dog walkers, researchers or manual laborers all possibly using, wheelbarrows, hand tools, and bicycles) were grouped into a strictly “human” category.

*Occupancy* - We used Program Presence 2.12.39 and a single season, single species framework to estimate occupancy (ψ, the probability that a site is occupied by a given species) and detection probability (p, the probability of capturing a given species during a given survey, provided it is present) without collapsing data and using each day as a survey period (MacKenzie et al. 2002). We compared the null model and survey-specific detection models to determine if detection probability was best modeled as a constant, or varying by day. Once the top detection model was selected, we calculated the effects of covariates on occupancy. Covariates included pollinator/control farm, human camera trap success per 100 trap nights, machine camera trap success per 100 trap nights, percent cover within 1 km of a farm (developed, natural, crop, water), and point type (FM, FU, PP, NH). We used Akaike’s Information Criterion to select the top model and considered those within 4 ΔAIC as competing models (Lukacs et al. 2007, Arnold 2010*b*).

## Results

*Camera trap success* – The cameras operated for a total of 11,067 trap nights: 2,330 in Spring 2017; 2,546 in Fall 2017, 3,113 in Spring 2018, and 3,078 in Fall 2018. Over the course of the 2 years, 4 seasons of surveys, white-tailed deer were captured on every farm except for farm H and were also captured on our pollinator cover type point at each of the 10 pollinator farms. Over the 2 years and 4 seasons of surveys, wild turkeys were captured on 15 of 20 farms and were captured in the cameras at pollinator cover points 5 of 10 pollinator.

The 6 most frequently detected wild animals were white-tailed deer (98.44 TS), non-domestic birds (61.20 TS), raccoons (*Procyon lotor*, 27.97 TS), red foxes (*Vulpes*, 25.46 TS), Eastern cottontail (*Sylvilagus floridanus*, 10.21 TS), and Eastern gray squirrel (*Sciurus carolinensis*, 9.86 TS, Table 4.1). Of all wild animals detected on the cameras, white-tailed deer had the highest total camera trap success each survey season (80.52 - 106.24 TS; Table 4.1). In contrast, wild turkeys were comparably rare on the cameras in both years and all seasons of the study (1.50 - 7.63 TS; Table 4.1).

White-tailed deer camera trap success was lower on pollinator farms than control farms every season (Table 4.2). Camera trap success per 100 trap nights was also lower at pollinator cover type on farms than both forest-managed and forest-unmanaged cover type while varying with novelty habitat (Table 4.2). Wild turkey camera trap success per 100 trap nights on pollinator farms was higher than control farms in Spring and Fall of 2017 and 2018 Fall, while lower in 2018 Spring (Table 4.2). Camera trap success per 100 trap nights was also lower at pollinator cover type on farms than both forest-managed and forest-unmanaged cover type while varying at novelty habitat for wild turkey (Table 4.2).

Domestic animals captured included cats (*Felis catus*, 7.72 TS), dogs (*Canis lupus familiaris*, 11.27 TS) and 'domestic farm animals,' including horses (*Equus caballus*), ducks (*Anas spp*.), turkeys (*Meleagris gallopavo f. domestica*), chickens (*Gallus gallus domesticus*), and Guinea hens (*Numida meleagris f. domestica*, 10.09 TS). Both machines (54.64 - 117.25 TS) and humans (31.22 - 45.69 TS) were among the most frequently detected events on the cameras in all seasons and both years (Table 4.1).

*White-tailed Deer Occupancy* - White-tailed deer detection was best modelled as a constant in all survey seasons and both years (Table 4.3, Appendix N). In all four survey periods, the amount of land that was developed within 1 km of a farm was the best predictor of white-tailed deer occupancy, with decreasing occupancy with increasing development (Table 4.4,

Figure 4.2). In Spring 2018, white-tailed deer occupancy was also positively related to the amount of natural area within 1 km of a farm as indicated in a competing model. The presence of a pollinator plot on a farm was not a predictor of white-tailed deer occupancy in any survey period, nor did occupancy vary by the type of point on a farm that was sampled (Table 4.3). Occupancy of deer at cameras across farms and survey periods was consistently high, ranging from 0.87-0.91 (Table 4.4).

*Wild Turkey Occupancy* - Wild turkey detection was best modeled as a constant and wild turkey occupancy was influenced by multiple competing covariates in each season (Table 4.5, Appendix O). In Spring 2017, wild turkey occupancy was positively related to the percent of natural landcover within 1km (Table 4.5, Figure 4.3). In Fall 2017, all modeled covariates (humans; water, developed, crop, natural cover types; presence of pollinator plot; machine; point cover type; farm identity) were present in competing models and no single model had a weight of more than 0.20 (Table 4.5, Appendix O). The presence of a pollinator was in the competing model set for Fall 2017, but not for any other season or year sampled (Appendix O). In Spring 2018, wild turkey occupancy was negatively related to the amount of land cover within 1 km that was developed (Table 4.5, Figure 4.3). In Fall 2018, wild turkey occupancy was negatively related to the trap success of machines captured on the cameras (Table 4.6, Figure 4.3). Overall, wild turkey occupancy was low across farm study sites, with occupancy higher in Spring 2018 than Spring 2017 (0.53 versus 0.18, respectively) and steady between Fall 2017 and Fall 2018 (0.22 versus 0.23, respectively, Table 4.6).

## Discussion

We did not find evidence that the presence of pollinator plantings on a farm influenced the occupancy or detection of our target species of white-tailed deer and wild turkey on our farm study sites in the Coastal Plain of Virginia and Maryland, but rather that the percent of land in natural cover or development strongly influenced the occupancy of both species. We also found that the presence of humans using machines in the farm setting was negatively related to the probability of occupancy of wild turkey. While the landscape-level variables and presence of humans using machines were the driving factors of occupancy on our farm study sites, we did find both species present on pollinator plots. Thus, the pollinator plots do not appear to be avoided by these species, but rather they were not determined to be the driving force behind occupancy rates in this system.

Further, we found lower camera trap success of deer on farms with pollinator plots as compared to farms without, and generally lower camera trap success in the actual pollinator plots as compared to other cover types on a given farm. This study does not suggest that the planting of pollinator plots was serving as an attractant to deer activity or presence, and thus not expected given these data to increase deer herbivory, although further study on that topic is recommended given its importance. Food plots are a similar management technique to pollinator friendly plantings used to assist deer populations with food sources in resource poor areas or to supplement higher quality food sources (Vanderhoof and Jacobson 1993, Stephens 2005). Food plots consist of varying herbaceous cover including corn, beans, and clover in large areas where resources can be targeted easily. One possible influence of our study sites stems from the surrounding natural and agricultural landscapes that provide a resource rich environment for white-tailed deer (Castleberry et al. 1999, Adams 2003, Miller 2012). Because of this, we believe there may be an influence of not only size of our plots not providing a large enough resource, if browse was occurring, but additionally, the surrounding area provided higher quality browse on corn and soybean specific farms and natural forage available in the surrounding landscape (Wentworth et al. 1992, Rouleau et al. 2002, Walter et al. 2009).

Several studies on white-tailed deer describe home ranges varying from 386ha to as small as 70ha, depending on resources available and hunting pressure in the area (Eyler 2005, Rhoads et al. 2010, Karns et al. 2011, 2012). Within a home range, deer select for diverse cover, including hardwoods and multiple stages of successional habitat in which to rear young and sustain diverse diet through all seasonal changes (Felix et al. 2004, Stewart et al. 2011, VDWR 2015*b*). Farmland, where crops can be foraged abundantly will at least satisfy partial food requirements of deer regularly (Stewart et al. 2011, VDWR 2015*b*). Given that crops do not always provide a diverse diet or cover types, additional farmscaped features may be important for sustaining deer presence on a farm. It is likely deer are influenced also by the presence of natural landscape features at a larger scale surrounding farms (Finder et al. 1999, Adams 2003, Long et al. 2005), as we found in this study that developed land a general converse to natural landcover was influencing occupancy. For these reasons, we suspect that pollinator plots do have the potential to increase foraging opportunities and young-rearing areas for white-tailed deer, but that features on the landscape scale drive patterns of occupancy and density.

Wild turkey home ranges have been shown to vary from 777-3367 ha in Virginia, with size increasing during years of low acorn production (VDWR 2013). Within their home range, wild turkeys select for both early successional cover for polt rearing as well as forest, fields and cropland for foraging by adults (Gustafson et al. 1994, Glennon and Porter 1999, Miller et al. 1999, VDWR 2013, Little et al. 2016). Wild turkeys will select for the edges of natural and agricultural habitat in order to glean seed crops as well as insects on vegetation when mast production is low or other food sources are low (Gustafson et al. 1994, VDWR 2013). Many of our farm study sites did provide open areas and foraging opportunities of both crops, as well as additional foraging opportunities for insects from pollinator plots, but the largest driver of wild turkey presence from the literature is the availability of early successional habitats for brood rearing in addition to stands that provide some form of hard or soft mast (Smith and Teitelbaum 1986, Miller et al. 1999, Ludwig 2012). While our results did vary by season, it is not surprising that the amount of natural cover within 1 km was positively related, and percent of developed cover negatively related, to deer occupancy in 2 out of 4 study seasons. Future analyses could look more closely at the amount of early successional habitat available on and around a farm as a driver of wild turkey occupancy, and if pollinator plantings could mimic features of early successional forest and field metrics, then they might be more heavily used by both deer and turkey.

Private landowners and farmers voluntarily engage in farmscaping programs, many of which include hedgerow management techniques, seasonal grasses, pollinator plots, as well as many other techniques that change farmscapes. Landowners offering their time, energy, and marginal areas of their farms hope to gain benefits related to their farmscaping practice and the ecosystem services included or presumed to be gained. Though pollinator friendly plantings may provide some aspect of white-tailed deer or wild turkey habitat requirements, the scale at which they are placed in this study might be too small, relative to the home range requirements of these two species, to have influenced presence and relative abundance. However, it was encouraging to not observe any potential dramatic increases in deer relative abundance or occupancy on pollinator farms that could be viewed as negative by participating farmers concerned about deer herbivory. Future research should focus on placement of pollinator plots in conjunction with the most available natural cover in the surrounding landscape-level and determine the potential for the plant species used in pollinator plots to more closely resemble early successional field-forest edge than simply a field-like structure as done under current protocols.

## Acknowledgments

This research was supported by U.S. Department of Agriculture's Agroecosystem Management grant #11664133 and graduate teaching support to E. Berge from the Department of Fish and Wildlife Conservation at Virginia Tech. Thank you to all our gracious landowners that allowed us use of their property for study activities. We thank the research station staff at the Anheuser-Busch Costal Research Center for always having a place for us throughout the years to sleep and work. We also thank our field technicians: Cameron Robertson, Chris Rowe, Ally Moser-Scott, and Amanda Crandall, who worked tirelessly through completely packed survey seasons. Lastly, we want to thank our numerous lab staff who helped process data and spend time in the field on weekends especially Shannon Flanagan, Courtney Linkous, Joe Girgente, Caleb Park, and Emily Gardner.

## Literature Cited


Adams, K. 2003. Fine-scale habitat use related to crop depredation by female white-tailed deer in an agricultural landscape. Thesis, University of Tennessee - Knoxville, USA.

Albrecht, M., D. Kleijn, N. M. Williams, M. Tschumi, B. R. Blaauw, R. Bommarco, A. J. Campbell, M. Dainese, F. A. Drummond, M. H. Entling, D. Ganser, G. A. de Groot, D. Goulson, H. Grab, H. Hamilton, F. Herzog, R. Isaacs, K. Jacot, P. Jeanneret, M. Jonsson, E. Knop, C. Kremen, D. A. Landis, G. M. Loeb, L. Marini, M. McKerchar, L. Morandin, S. C. Pfister, S. G. Potts, M. Rundlöf, H. Sardiñas, A. Sciligo, C. Thies, T. Tscharntke, E. Venturini, E. Veromann, I. M. G. Vollhardt, F. Wäckers, K. Ward, A. Wilby, M. Woltz, S. Wratten, and L. Sutter. 2020. The effectiveness of flower strips and hedgerows on pest control, pollination services and crop yield: a quantitative synthesis. Ecology Letters 23:1488–1498.

Angelella, G., and M. O'Rourke. 2017. Pollinator habitat establishment after organic and no-till seedbed preparation methods. HortScience 52:1349–1355.

Arnold, T. W. 2010. Uninformative parameters and model selection using Akaike's Information Criterion. The Journal of Wildlife Management 74:1175–1178.

Ball, M. 2015. VDOT's pollinator habitat program moves toward statewide implementation. Informed Infrastructure. <https://informedinfrastructure.com/17439/vdots-pollinator-habitat-program-moves-toward-statewide-implementation/>. Accessed 3 Nov 2019.

Benson, B., R. McDonald, N. C. Sugar Grove, and R. Morse. 2016. Farmscaping techniques for managing insect pests. Virginia Tech and Symbiont Biological Pest Management. <http://localfoodhub.org/wp-content/uploads/2012/07/5_farmscapingTechniquesForManagingInsectPests_VCE.pdf>. Accessed 3 Nov 2019.

Bloom, E. H., and D. W. Crowder. 2016. Biological control and pollination services on organic farms. Pages 27–46 in A. R. Horowitz and I. Ishaaya, editors. Advances in Insect Control and Resistance Management. Springer International Publishing, Switzerland.

Boughey, K. L., I. R. Lake, K. A. Haysom, and P. M. Dolman. 2011. Improving the biodiversity benefits of hedgerows: How physical characteristics and the proximity of foraging habitat affect the use of linear features by bats. Biological Conservation 144:1790–1798.

Burel, F. 1996. Hedgerows and their role in agricultural landscapes. Critical Reviews in Plant Sciences 15:169–190.

Castleberry, S. B., W. M. Ford, K. V. Miller, and W. P. Smith. 1999. White-tailed deer browse preferences in a southern bottomland hardwood forest. Southern Journal of Applied Forestry 23:78–82.

Conway, G. R., and E. B. Barbier. 2013. After the green revolution: Sustainable agriculture for development. Earthscan, London, UK.

Davies, Z. G., and A. S. Pullin. 2007. Are hedgerows effective corridors between fragments of woodland habitat? An evidence-based approach. Landscape Ecology 22:333–351.

Dhaliwal, G. S., V. Jindal, and A. K. Dhawan. 2010. Insect pest problems and crop losses: changing trends. Indian Journal of Ecology 37:1–7.

Dickson, J. G. 1992. The wild turkey: Biology and management. Stackpole Books, Mechanicsburg, Pennsylvania, USA.

Eyler, B., G. Timko, and L. O’Brien. 2019. Maryland annual deer report 2018-2019. Maryland Department of Agriculture, Wildlife & Heritage Service, Annapolis, USA.

Eyler, T. B. 2005. Habitat use and movements of sympatric sika deer (*Cervus nippon*) and white-tailed deer (*Odocoileus virginianus*) in Dorchester County, Maryland. Thesis, University of Maryland Eastern Shore, Princess Anne, USA.

Felix, A. B., H. Campa III, K. F. Millenbah, S. R. Winterstein, and W. E. Moritz. 2004. Development of landscape-scale habitat-potential models for forest wildlife planning and management. Wildlife Society Bulletin 32:795–806.

Finder, R. A., J. L. Roseberry, and A. Woolf. 1999. Site and landscape conditions at white-tailed deer/vehicle collision locations in Illinois. Landscape and Urban Planning 44:77–85.

Glennon, M. J., and W. F. Porter. 1999. Using satellite imagery to assess landscape-scale habitat for wild turkeys. Wildlife Society Bulletin 27:646–653.

Gustafson, E. J., G. R. Parker, and S. E. Backs. 1994. Evaluating spatial pattern of wildlife habitat: A case study of the wild turkey (*Meleagris gallopavo*). The American Midland Naturalist 131:24–33.

Horlings, L. G., and T. K. Marsden. 2011. Towards the real green revolution? Exploring the conceptual dimensions of a new ecological modernisation of agriculture that could 'feed the world.' Global Environmental Change 21:441–452.

Karns, G. R., R. A. Lancia, C. S. DePerno, and M. C. Conner. 2011. Investigation of adult male white-tailed deer excursions outside their home range. Southeastern Naturalist 10:39–52.

Karns, G. R., R. A. Lancia, C. S. DePerno, and M. C. Conner. 2012. Impact of hunting pressure on adult male white-tailed deer behavior. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 66:120–125.

Kelly, M. J., and E. L. Holub. 2008. Camera trapping of carnivores: Trap success among camera types and across species, and habitat selection by species, on salt pond mountain, Giles County, Virginia. Northeastern Naturalist 15:249–262.

Little, A. R., M. J. Chamberlain, L. M. Conner, and R. J. Warren. 2016. Habitat selection of wild turkeys in burned longleaf pine savannas. The Journal of Wildlife Management 80:1280–1289.

Long, B. 2019. Wild turkey 2018-2019 annual report. Maryland Department of Agriculture, Wildlife & Heritage Service, Annapolis, USA.

Long, E. S., D. R. Diefenbach, C. S. Rosenberry, B. D. Wallingford, and M. D. Grund. 2005. Forest cover influences dispersal distance of white-tailed deer. Journal of Mammalogy 86:623–629.

Ludwig, E. 2012. Reproductive ecology of eastern wild turkey hens in Sussex County Delaware. Thesis, University of Delaware, Newark, USA.

Lukacs, P. M., W. L. Thompson, W. L. Kendall, W. R. Gould, P. F. Doherty, K. P. Burnham, and D. R. Anderson. 2007. Concerns regarding a call for pluralism of information theory and hypothesis testing. Journal of Applied Ecology 44:456–460.

Macdonald, D. W., and R. Feber. 2015. Wildlife conservation on farmland: Managing for nature on lowland farms. Oxford University Press, Oxford, UK.

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83:2248–2255.

McCullough, C. T. 2020. The effects of wildflower plots and diverse landscapes on ecosystem services, bee communities, and on-farm tick abundance. Thesis, Virginia Tech, Blacksburg, USA.

McFarland, E. R., and T. S. Bruce. 2006. The Virginia coastal plain hydrogeologic framework. 1st ed. Professional paper 1731, U.S. Dept. of the Interior, U.S. Geological Survey, Reston, USA.

MDA. 2016. The Maryland pollinator protection plan. Maryland Department of Agriculture. <https://mda.maryland.gov/plants-pests/Documents/MP3-Pollinator-Plan.pdf>. Accessed 20 Aug 2020.

Miller, D. A., G. A. Hurst, and B. D. Leopold. 1999. Habitat use of eastern wild turkeys in central Mississippi. The Journal of Wildlife Management 63:210–222.

Miller, M. 2012. Resource selection and survival of female white-tailed deer in an agricultural landscape. Thesis, University of Delaware, Newark, USA.

Morandin, L. A., and C. Kremen. 2013. Hedgerow restoration promotes pollinator populations and exports native bees to adjacent fields. Ecological Applications 23:829–839.

O’Rourke, M., C. Philips, and T. Kuhar. 2019. Improving pest management with farmscaping. Virginia Cooperative Extension, Virginia Tech, Blacksburg, USA.

Pavelis, G. A., D. Helms, and S. Stalcup. 2011. Soil and water conservation expenditures by USDA agencies, 1935–2010. Historical Insights: 10, U.S. Department of Agriculture - Natural Resources Conservation Service, Washington, D.C., USA.

Rhoads, C. L., J. L. Bowman, and B. Eyler. 2010. Home range and movement rates of female exurban white-tailed deer. The Journal of Wildlife Management 74:987–994.

Rouleau, I., M. CrÊte, and J.-P. Ouellet. 2002. Contrasting the summer ecology of white-tailed deer inhabiting a forested and an agricultural landscape. Écoscience 9:459–469.

Smith, W. P., and R. D. Teitelbaum. 1986. Habitat use by eastern wild turkey hens in southeastern Louisiana. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 40:405–415.

Stephens, O. L. 2005. Forage production, use by white-tailed deer, and seasonal crude protein level of three cool season forages in Georgia. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 59:66–78.

Stewart, K. M., R. T. Bowyer, and P. J. Weisberg. 2011. Spatial use of landscapes. Pages 181–219 in. Biology and Management of White-tailed Deer. CRC Press, Boca Raton, Florida, USA.

Tilman, D. 1998. The greening of the green revolution. Nature 396:211–212.

USDA National Agricultural Statistics Service Cropland Data Layer. 2017. Published crop-specific data layer. USDA-NASS, Washington, D.C., USA.

VADCR, and VADEQ. 2019. Virginia pollinator-smart business plan. Virginia Department of Conservation and Recreation, Virginia Department of Environmental Quality, Richmond, Virginia, USA. <https://www.dcr.virginia.gov/natural-heritage/document/solar-site-business-plan.pdf>. Accessed 3 Nov 2019.

Vanderhoof, R. E., and H. A. Jacobson. 1993. Food plots and deer home range movements in the southern Coastal Plain. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 47:33–42.

Vaughan, M., and M. Skinner. 2008. Using farm bill programs for pollinator conservation. Technical Note No. 78, United States Department of Agriculture, Washington, D.C., USA.

VDWR. 2013. Virginia wild turkey management plan. Virginia Department of Wildlife Resources, Richmond, Virginia, USA. <https://dwr.virginia.gov/wp-content/uploads/turkey-management-plan.pdf>. Accessed 26 Apr 2020.

VDWR. 2015. Virginia deer management plan 2015-2024. Virginia Department of Wildlife Resources, Richmond, Virginia, USA. <https://dwr.virginia.gov/wp-content/uploads/virginia-deer-management-plan.pdf>. Accessed 6 Feb 2018.

VDWR. 2016. Record high wild turkey population likely to remain stable. Notes from the Field. Virginia Department of Wildlife Resources. <https://blog.wildlife.virginia.gov/2016/11/record-high-wild-turkey-population-likely-to-remain-stable/>. Accessed 12 Apr 2018.

Vispo, C., C. Knab-Vispo, and A. Duhon. 2015. Accidental harvest: The farmscape ecology of Columbia county, NY. <https://hvfarmscape.org/sites/default/files/vispo_knab-vispo_and_duhon_for_web.pdf>. Accessed 18 Apr 2020.

Walter, W. D., K. C. VerCauteren, H. Campa, W. R. Clark, J. W. Fischer, S. E. Hygnstrom, N. E. Mathews, C. K. Nielsen, E. M. Schauber, T. R. Van Deelen, and S. R. Winterstein. 2009. Regional assessment on influence of landscape configuration and connectivity on range size of white-tailed deer. Landscape Ecology 24:1405–1420.

Wentworth, J. M., A. S. Johnson, P. E. Hale, and K. E. Kammermeyer. 1992. Relationships of acorn abundance and deer herd characteristics in the southern Appalachians. Southern Journal of Applied Forestry 16:5–8.

Wilson, G. A., and J. Rigg. 2003. ‘Post-productivist’ agricultural regimes and the South: discordant concepts? Progress in Human Geography 27:681–707.

## Tables

Table 4.1: Camera trap success (# capture events /total survey nights x 100) of all events detected on farms study sites Eastern Shore of Virginia and Maryland (Delmarva Peninsula) and in the city of Virginia Beach, VA. in Spring and Fall 2017 and 2018.

| | Camera trap Success Per 100 Trap Nights | | | | |
|---|---|---|---|---|---|
| | Total Trap | 2017 | | 2018 | |
| Common name (scientific name) | Success | Spring | Fall | Spring | Fall |
| Total Event | 423.23 | 523.04 | 342.05 | 416.97 | 420.90 |
| White-tailed Deer (*Odocoileus virginianus*) | 98.44 | 106.01 | 80.52 | 99.71 | 106.24 |
| Machine[1] | 77.44 | 117.25 | 85.08 | 63.89 | 54.64 |
| Non-domestic Bird[2] | 61.20 | 83.39 | 33.94 | 50.98 | 77.44 |
| Human (*Homo sapiens*)[3] | 37.86 | 45.69 | 31.94 | 43.39 | 31.22 |
| Raccoon (*Procyon lotor*) | 27.97 | 40.51 | 17.59 | 33.20 | 21.75 |
| Red Fox (*Vulpes vulpes*) | 25.46 | 30.55 | 30.52 | 20.79 | 22.12 |
| Unknown | 24.59 | 24.57 | 21.59 | 29.93 | 21.69 |
| Domestic Dog (*Canis lupus familiaris*) | 11.27 | 10.96 | 8.40 | 12.13 | 13.00 |
| Eastern Cottontail (*Sylvilagus floridanus*) | 10.21 | 20.89 | 3.39 | 10.24 | 7.74 |
| Domestic Farm Animal[4] | 10.09 | 1.17 | 0.99 | 1.36 | 33.29 |
| Eastern Grey Squirrel (*Sciurus carolinensis*) | 9.86 | 18.02 | 8.95 | 5.91 | 8.44 |
| Gray Fox (*Urocyon cinereoargenteus*) | 8.52 | 7.84 | 9.32 | 12.79 | 4.01 |
| Domestic Cat (*Felis catus*) | 7.72 | 10.29 | 5.01 | 10.71 | 4.96 |
| Opossum (*Didelphidae*) | 5.76 | 6.54 | 3.95 | 7.43 | 5.00 |

| | Camera trap Success Per 100 Trap Nights | | | | |
|---|---|---|---|---|---|
| | Total Trap | 2017 | | 2018 | |
| Common name (scientific name) | Success | Spring | Fall | Spring | Fall |
| Wild Turkey (*Meleagris gallopavo*) | 4.51 | 1.73 | 1.50 | 7.63 | 5.95 |
| Groundhog (*Marmota monax*) | 1.81 | 3.25 | 0.91 | 1.91 | 1.38 |
| Coyote (*Canis latrans*) | 1.28 | 1.00 | 0.51 | 1.75 | 1.64 |
| Bobcat (*Lynx rufus*) | 0.26 | 0.30 | 0.36 | 0.19 | 0.20 |
| Eastern Striped Skunk (*Mephitis mephitis*) | 0.12 | 0.04 | 0.00 | 0.06 | 0.33 |

[1]: Machine was classified by human presence with machinery, like cars, mowers, tillers, trailers.

[2]: Non-domestic birds included incidental captures of songbirds and other large birds like hawks and vultures, but excluded wild turkey captures.

[3]: Human presence included pedestrians, researchers, dog walkers, or manual laborers all possibly using, wheelbarrows, hand tools, and bicycles.

[4]: Domestic farm animal included horses, ducks, turkey, chickens, and Guinea hens.

Table 4.2: Camera trap success (# capture events /total survey nights x 100) of white-tailed deer (*Odocoileus virginianus*) and wild turkey (*Meleagris gallopavo*) events detected by cover type points (pollinator plot, forest-managed, forest-unmanaged, and novelty habitat) and pollinator versus control farm study sites on the Eastern Shore of Virginia and Maryland (Delmarva Peninsula) and in the city of Virginia Beach, VA. in Spring and Fall of 2017 and 2018.

| | | Camera trap Success Per 100 Trap Nights | | | |
|---|---|---|---|---|---|
| | | 2017 | | 2018 | |
| | Cover Type Points | Spring | Fall | Spring | Fall |
| White-tailed Deer | Pollinator Plot | 67.33 | 43.95 | 64.33 | 78.80 |
| | Forest-managed | 108.25 | 120.80 | 85.51 | 146.41 |
| | Forest-unmanaged | 115.62 | 64.94 | 131.30 | 88.42 |
| | Novelty Habitat | 133.17 | 35.22 | 100.74 | 79.00 |
| Wild Turkey | Pollinator Plot | 1.01 | 1.12 | 4.62 | 0.55 |
| | Forest-managed | 1.94 | 1.01 | 8.70 | 8.99 |
| | Forest-unmanaged | 2.15 | 2.65 | 9.83 | 7.27 |
| | Novelty Habitat | 0.51 | <0.001 | 0.37 | <0.001 |

| | | Camera trap Success Per 100 Trap Nights | | | |
|---|---|---|---|---|---|
| | | 2017 | | 2018 | |
| | Farms | Spring | Fall | Spring | Fall |
| White-tailed Deer | Pollinator | 90.53 | 57.80 | 85.35 | 102.66 |
| | Control | 122.25 | 110.47 | 117.93 | 110.39 |
| Wild Turkey | Pollinator | 2.21 | 2.22 | 7.05 | 8.99 |

| | Camera trap Success Per 100 Trap Nights | | | |
|---|---|---|---|---|
| | 2017 | | 2018 | |
| Farms | Spring | Fall | Spring | Fall |
| Control | 1.24 | 0.55 | 8.36 | 2.42 |

Table 4.3: Top, competing (delta AIC < 4) and global model of white-tailed deer (*Odocoileus virginianus*) occupancy during each season for Spring 2017 (May 13th-June 29th), Fall 2017 (August 16th-October 15th), Spring 2018 (April 20th-June 24th), and Fall 2018 (August 18th-October 27th) across the Eastern Shore of Virginia and Maryland (Delmarva Peninsula) and in the city of Virginia Beach, VA.

| | | | | | | Beta Coefficients (Standard Error) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Season | Model[a] | AIC | ΔAIC | W[b] | Intercept | % area Developed within 1 km | % area Natural within 1 km | p[c] | K[d] |
| 2017 | Spring | ψ(kmDvlp[e]) p(.) | 2962.14 | 0.00 | 0.89 | 4.00 (0.92) | -8.87 (0.05) | - | 0.06 (0.04) | 3 |
| | | ψ(Global[f]) p(.) | 2998.21 | 36.07 | 0.00 | - | - | - | - | 30 |
| | Fall | ψ(kmDvlp[e]) p(.) | 3016.84 | 0.00 | 0.996 | 4.34 (1.27) | -19.57 (0.09) | | -0.51 (0.04) | 3 |
| | | ψ(Global[f]) p(.) | 3043.79 | 26.95 | 0.00 | - | - | - | - | 28 |
| 2018 | Spring | ψ(kmDvlp[e]) p(.) | 3924.50 | 0.00 | 0.81 | 3.31 (0.71) | -6.99 (0.03) | | -0.09 (0.04) | 3 |
| | | ψ(kmNtrl[g]) p(.) | 3927.81 | 3.31 | 0.16 | -1.44 (1.34) | - | 0.12 (0.05) | -0.09 (0.04) | 3 |
| | | ψ(Global[f]) p(.) | 3951.54 | 27.04 | 0.00 | - | - | - | - | 29 |
| | Fall | ψ(kmDvlp[e]) p(.) | 3785.30 | 0.00 | 0.89 | 3.03 (0.65) | -6.99 (0.03) | - | -0.08 (0.04) | 3 |

| Year | Season | Model[a] | AIC | ΔAIC | W[b] | Beta Coefficients (Standard Error) | | | | K[d] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Intercept | % area Developed within 1 km | % area Natural within 1 km | p[c] | |
| | | ψ(Global[f]) p(.) | 3807.78 | 22.48 | 0.00 | - | - | - | - | 29 |

[a] ψ (Occupancy covariate); p (detection probability)

[b] Model Weight

[c] Beta coefficients and standard error associated with detection estimate

[d] Number of parameters

[e] Percent of developed cover type within 1km of each farm

[f] Global model with farm, pollinator/control, human camera trap success per 100 trap nights, machine camera trap success per 100 trap nights, 1km cover type (Developed, Natural, and Crop), and point type (forest-managed, forest-unmanaged, pollinator plot).

[g] Percent of natural cover type within 1km of each farm

Table 4.4: Occupancy ($\psi$) and detection (p) rates of white-tailed deer (*Odocoileus virginianus*) and their associated detection probabilities during each season for Spring 2017 (May 13$^{th}$-June 29$^{th}$), Fall 2017 (August 16$^{th}$-October 15$^{th}$), Spring 2018 (April 20$^{th}$-June 24$^{th}$), and Fall 2018 (August 18$^{th}$-October 27$^{th}$) at 20 farm study sites across the Eastern Shore of Virginia and Maryland (Delmarva Peninsula) and in the city of Virginia Beach, VA.

| Year | Season | Model[a] | $\psi$ (SE)[b] | p (SE)[c] |
|---|---|---|---|---|
| 2017 | Spring | $\psi$(kmDvlp[d]) p(.) | 0.91 (0.04) | 0.52 (0.01) |
| | Fall | $\psi$(kmDvlp[d]) p(.) | 0.87 (0.05) | 0.38 (0.01) |
| 2018 | Spring | $\psi$(kmDvlp[d]) p(.) | 0.89 (0.04) | 0.48 (0.01) |
| | Fall | $\psi$(kmDvlp[d]) p(.) | 0.87 (0.05) | 0.48 (0.01) |

[a] $\psi$ = Occupancy covariate; p = detection probability.

[b] Occupancy with associated standard error

[c] Detection probability with associated standard error

[d] Percent of developed cover type within 1km of each farm

Table 4.5: Top and the global model of wild turkey (*Meleagris gallopavo*) occupancy during each season for Spring 2017 (May 13th-June 29th), Fall 2017 (August 16th-October 15th), Spring 2018 (April 20th-June 24th), and Fall 2018 (August 18th-October 27th) at 20 farm study sites across the Eastern Shore of Virginia and Maryland (Delmarva Peninsula) and in the city of Virginia Beach, VA.

| Year | Season | Model[a] | AIC | ΔAIC | w[b] | Beta Coefficients (Standard Error) | | | | | | | | | | | | K[d] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Intercept (Control or Novelty Habitat) | % area Natural within 1 km | % area Developed within 1 km | % area Water within 1 km | Human TS/100 trap nights | % area Crop within 1 km | Pollinator | Machine TS/100 trap nights | FM | FU | PP | p[c] | |
| 2017 | Spring | ψ(kmNtrl[e]) p(.) | 275.62 | 0.00 | 0.71 | -4.82 | 0.08 | - | - | - | - | - | - | - | - | - | -2.41 | 3 |
| | | | | | | (1.18) | (0.02) | | | | | | | | | | (0.19) | |
| | | ψ(kmBkgd[f]),p(.) | 278.12 | 2.5 | 0.20 | -0.98 | - | - | -0.51 | - | - | - | - | - | - | - | -2.42 | 3 |
| | | | | | | (0.40) | | | (0.43) | | | | | | | | (0.19) | |
| | | ψ(Global[g]) p(.) | 304.44 | 28.82 | 0.00 | - | - | - | - | - | - | - | - | - | - | - | - | 30 |
| | Fall | ψ(.) p(.) | 266.34 | 0.00 | 0.17 | -1.28 | - | - | - | - | - | - | - | - | - | - | -3.04 | 2 |
| | | | | | | (0.37) | | | | | | | | | | | (0.23) | |
| | | ψ(Human[h]),p(.) | 266.38 | 0.04 | 0.17 | -0.91 | - | - | - | -0.02 | - | - | - | - | - | - | -3.04 | 3 |
| | | | | | | (0.49) | | | | (0.02) | | | | | | | (0.23) | |
| | | ψ(kmBkgd[f]),p(.) | 266.55 | 0.21 | 0.15 | -1.03 | - | - | -0.06 | - | - | - | - | - | - | - | -3.04 | 3 |
| | | | | | | (0.41) | | | (0.06) | | | | | | | | (0.23) | |
| | | ψ(kmDvlp[i]),p(.) | 266.88 | 0.54 | 0.13 | -0.88 | - | -0.04 | - | - | - | - | - | - | - | - | -3.04 | 3 |

| Year | Season | Model[a] | AIC | ΔAIC | w[b] | Beta Coefficients (Standard Error) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Intercept (Control or Novelty Habitat) | % area Natural within 1 km | % area Developed within 1 km | % area Water within 1 km | Human TS/100 trap nights | % area Crop within 1 km | Pollinator | Machine TS/100 trap nights | FM | FU | PP | p[c] | K[d] |
| | | | | | | (0.56) | | (0.06) | | | | | | | | | (0.23) | |
| | | ψ(kmCrop[j]),p(.) | 267.02 | 0.68 | 0.12 | -2.39 | - | - | - | - | 0.02 | - | - | - | - | - | -3.03 | 3 |
| | | | | | | (0.98) | | | | | (0.02) | | | | | | (0.23) | |
| | | ψ(kmNtrl[e]),p(.) | 267.70 | 1.36 | 0.08 | -2.02 | 0.02 (0.02) | - | - | - | - | - | - | - | - | - | -3.04 | 3 |
| | | | | | | (0.95) | | | | | | | | | | | (0.23) | |
| | | ψ(PPorNot[k]),p(.) | 268.30 | 1.96 | 0.06 | -1.36 | - | - | - | - | - | 0.14 | - | - | - | - | -3.04 | 3 |
| | | | | | | (0.57) | | | | | | (0.74) | | | | | (0.23) | |
| | | ψ(Machine[l]),p(.) | 268.33 | 1.99 | 0.06 | -1.26 | - | - | - | - | - | - | -<0.001 | - | - | - | -3.04 | 3 |
| | | | | | | (0.38) | | | | | | | (0.003) | | | | (0.23) | |
| | | *ψ(Points[m]),p(.) | 268.33 | 1.99 | 0.06 | -32.60 | - | - | - | - | - | - | - | 31.93 | 31.19 | 30.59 | -3.04 | 5 |
| | | | | | | (2.69) | | | | | | | | (2.69) | (2.76) | (2.92) | (0.23) | |
| | | ψ(Global[g]) p(.) | 304.91 | 38.57 | 0.00 | - | - | - | - | - | - | - | - | - | - | - | - | 28 |
| 2018 | Spring | ψ(kmDvlp[i]) p(.) | 1219.27 | 0.00 | 0.40 | 0.88 | - | -0.08 | - | - | - | - | - | - | - | - | -2.14 | 20 |
| | | | | | | (0.51) | | (0.06) | | | | | | | | | (0.08) | |
| | | ψ (Human[h])p(.) | 1221 | 1.73 | 0.17 | 0.58 | - | - | - | -0.01 | - | - | - | - | - | - | -2.15 | 3 |
| | | | | | | (0.36) | | | | (0.01) | | | | | | | (0.08) | |

| Year | Season | Model[a] | AIC | ΔAIC | w[b] | Intercept (Control or Novelty Habitat) | % area Natural within 1 km | % area Developed within 1 km | % area Water within 1 km | Human TS/100 trap nights | % area Crop within 1 km | Pollinator | Machine TS/100 trap nights | FM | FU | PP | p[c] | K[d] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Beta Coefficients (Standard Error) | | | | | | | | | | | | |
| | | ψ (kmNtrl[e])p(.) | 1221.39 | 2.12 | 0.14 | -1.42 | 0.04 | - | - | - | - | - | - | - | - | - | -2.14 | 3 |
| | | | | | | (0.75) | (0.02) | | | | | | | | | | (0.08) | |
| | | ψ(Global[g]) p(.) | 1222.22 | 2.95 | 0.09 | - | - | - | - | - | - | - | - | - | - | - | - | 29 |
| | | ψ(kmBkgd[f])p(.) | 1223.07 | 3.8 | 0.06 | 0.36 | - | - | -0.04 | - | - | - | - | - | - | - | -2.15 | 3 |
| | | | | | | (0.31) | | | (0.03) | | | | | | | | (0.08) | |
| | Fall | ψ(Machine[l]) p(.) | 410.86 | 0.00 | 0.72 | -0.41 | - | - | - | - | - | - | -0.06 | - | - | - | -2.55 | 3 |
| | | | | | | (0.43) | | | | | | | (0.03) | | | | (0.15) | |
| | | ψ(Global[g]) p(.) | 415.86 | 4.22 | 0.09 | - | - | - | - | - | - | - | - | - | - | - | - | 29 |

[a] ψ = Occupancy covariate; p = detection probability.

[b] Model Weight

[c] Beta coefficients and standard error associated with detection estimate

[d] Number of parameters

[e] Percent of natural cover type within 1km of each farm

[f] Percent of water cover type within 1km of each farm

[g] Global model with farm, pollinator/control, human camera trap success per 100 trap nights, machine camera trap success per 100 trap nights, 1km cover type (Developed, Natural, and Crop), and point type (forest-managed, forest-unmanaged, pollinator plot).

[h] Camera trap success per 100 nights for that survey season of strictly human disturbance.

[i] Percent of developed cover type within 1km of each farm

[j] Percent of crop cover type within 1km of each farm

[k] Control or pollinator

[l] Camera trap success per 100 nights for that survey season of human disturbance classified as machines.

[m] Covariates included each point type (forest-managed - FM, forest-unmanaged - FU, pollinator plot - PP, and novelty habitat - NH)

Table 4.6: Occupancy ($\psi$) and detection (p) rates of wild turkey (*Meleagris gallopavo*) during each season for Spring 2017 (May 13th-June 29th), Fall 2017 (August 16th-October 15th), Spring 2018 (April 20th-June 24th), and Fall 2018 (August 18th-October 27th) at 20 farm study sites on the Eastern Shore of Virginia and Maryland (Delmarva Peninsula) and in the city of Virginia Beach, VA.

| Year | Season | Model[a] | $\psi$ (SE)[b] | p (SE)[c] |
|---|---|---|---|---|
| 2017 | Spring | $\psi$(kmNtrl[d]) p(.) | 0.18 (0.05) | 0.08 (0.02) |
| | Fall | $\psi$(.) p(.) | 0.22 (0.05) | 0.46 (0.01) |
| 2018 | Spring | $\psi$(kmDvlp[e]) p(.) | 0.53 (0.07) | 0.12 (0.01) |
| | Fall | $\psi$(Machine[f]) p(.) | 0.23 (0.06) | 0.07 (0.01) |

[a] $\psi$ = Occupancy covariate; p = detection probability.

[b] Occupancy with associated standard error

[c] Detection probability with associated standard error

[d] Percent of natural cover type within 1km of each farm

[e] Percent of developed cover type within 1km of each farm

[f] Camera trap success per 100 nights for that survey season of human disturbance classified as machines.

# Figures

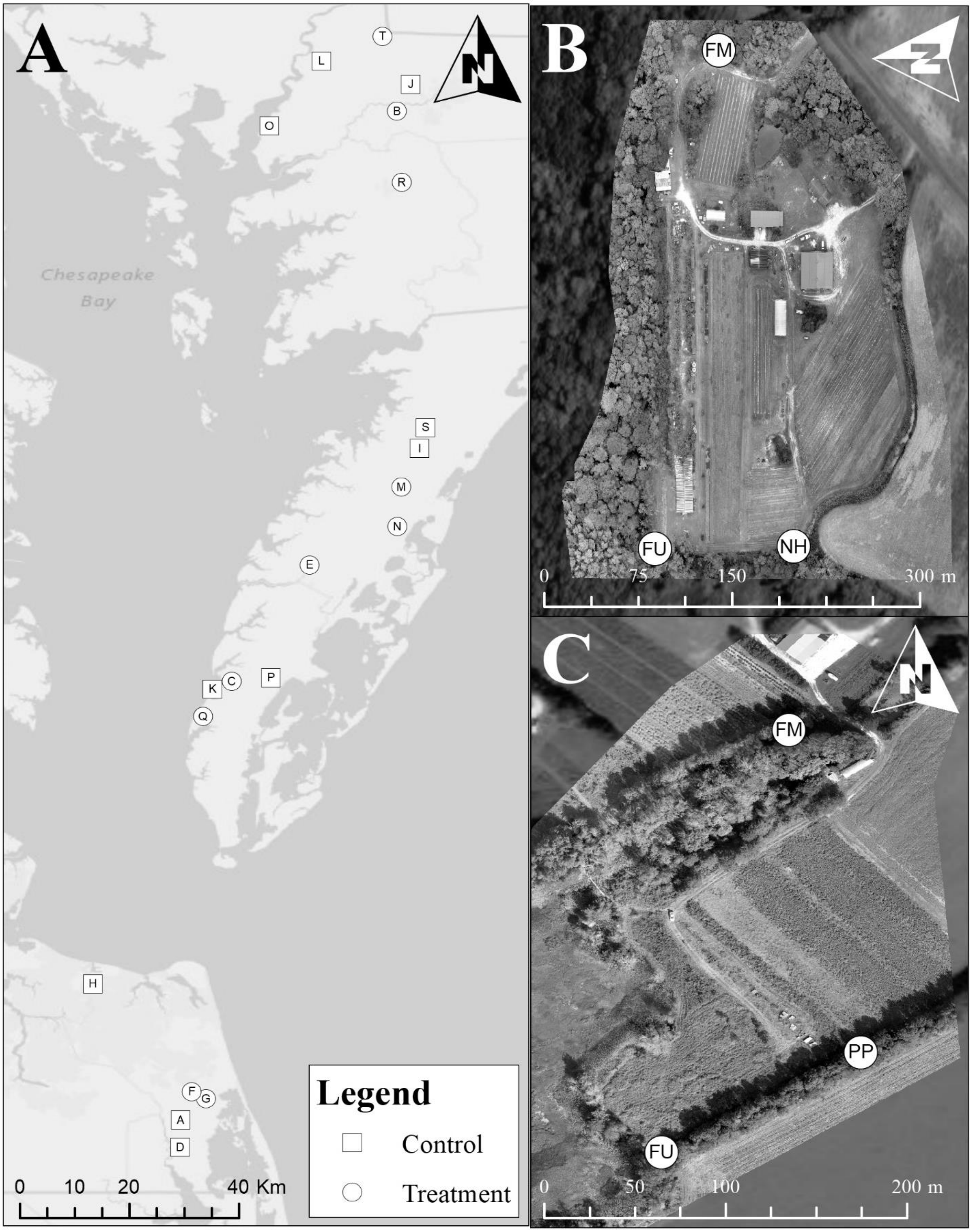
A
Chesapeake
Bay
T
L
J
B
O
R
S
I
M
N
E
C
K
P
Q
H
F
G
A
D
0 10 20 40 Km
Legend
Control
Treatment
B
FM
FU
NH
0 75 150 300 m
C
FM
PP
FU
0 50 100 200 m

Figure 4.1: Plate A: Location of the 20 farm sites on which project activities were conducted in Virginia and Maryland in 2016-2018. Symbols represent 10 control (square, no farmscaped pollinator plot) and 10 pollinator (circle, received farmscaped pollinator plot) farms. Letters within symbols denote farm locations, A: Brookdale, B: Calliope, C: Copper Cricket, D: Cullipher, E: Virginia Tech Eastern Shore Agricultural Research and Extension Center, F: Flanagan, G: Flip Flop, H: Virginia Tech Hampton Roads Agricultural Research and Extension Center , I: La Caridad, J: University of Maryland Lower Eastern Shore Research & Education Center - Extension, K: Mattawoman, L: Patty's Garden, M: Perennial, N: Pik Penny, O: Provident, P: Quail Cove, Q: Sturgis, R: University of Maryland Eastern Shore Somerset – Extension, S: Van Dessel, T: Wright.

Plate B: Example of the placement of camera traps on a control farm. Letters on location symbols for each camera station represent cover types: FM: forest-unmanaged, FU: forest-managed, NH: novelty habitat.

Place C: Example of the placement of camera traps on a pollinator farm. Letters on location symbols for each camera station represent cover types: FM: forest-unmanaged, FU: forest-managed, PP: pollinator plot.

Sources: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, AeroGRID, IGN, and the GIS User Community

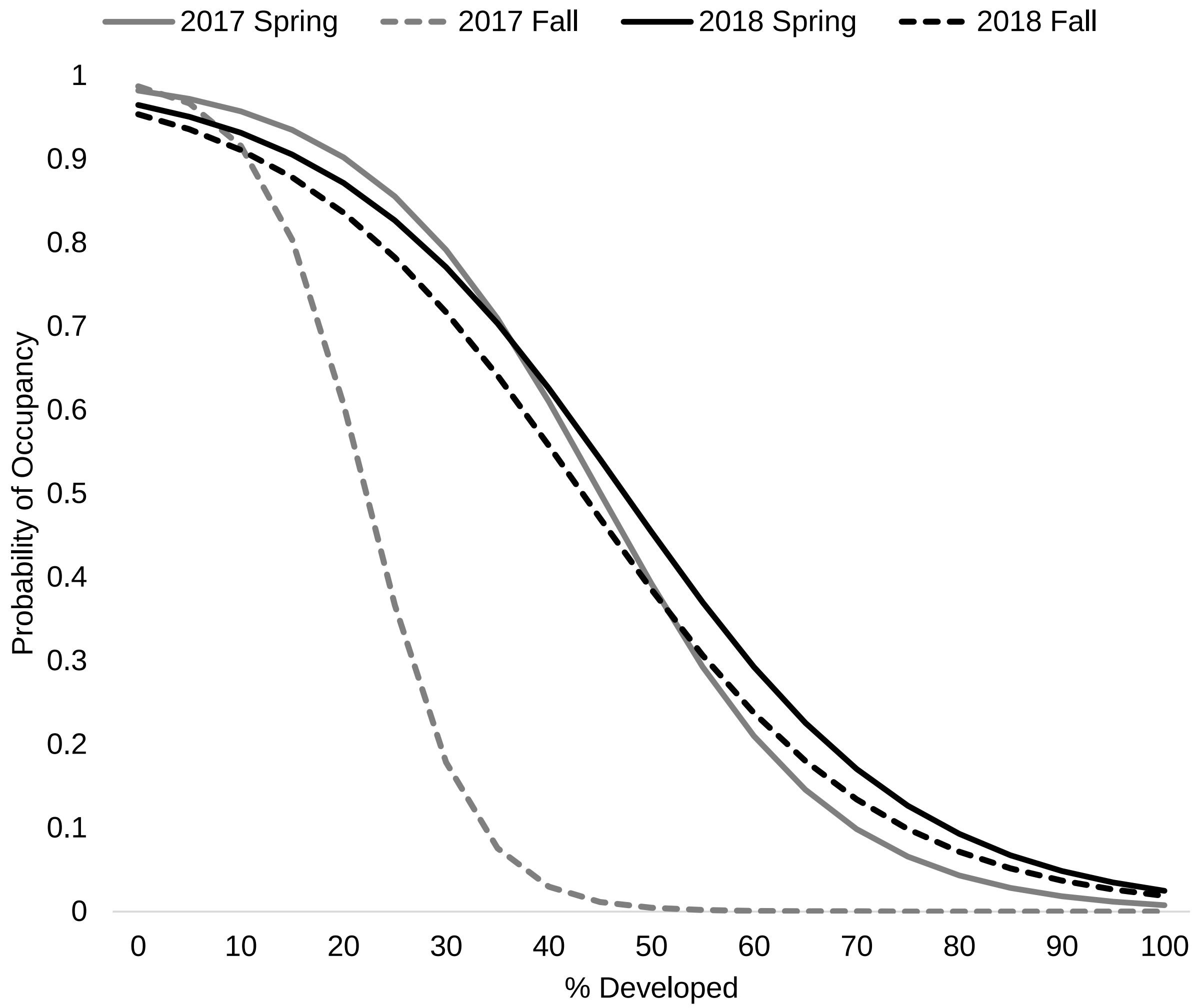


Figure 4.2: White-tailed deer (*Odocoileus virginianus*) occupancy compared to the percentage of developed cover in a 1 km radius around each farm study site for each survey season of Spring 2017 (May 13th-June 29th), Fall 2017 (August 16th-October 15th), Spring 2018 (April 20th-June 24th), and Fall 2018 (August 18th-October 27th) across the Eastern Shore of Virginia and Maryland (i.e. Delmarva Peninsula) and in the city of Virginia Beach, VA. As the percentage of developed land within a 1km radius increases, the probability of occupancy decreased in each season and year combination.

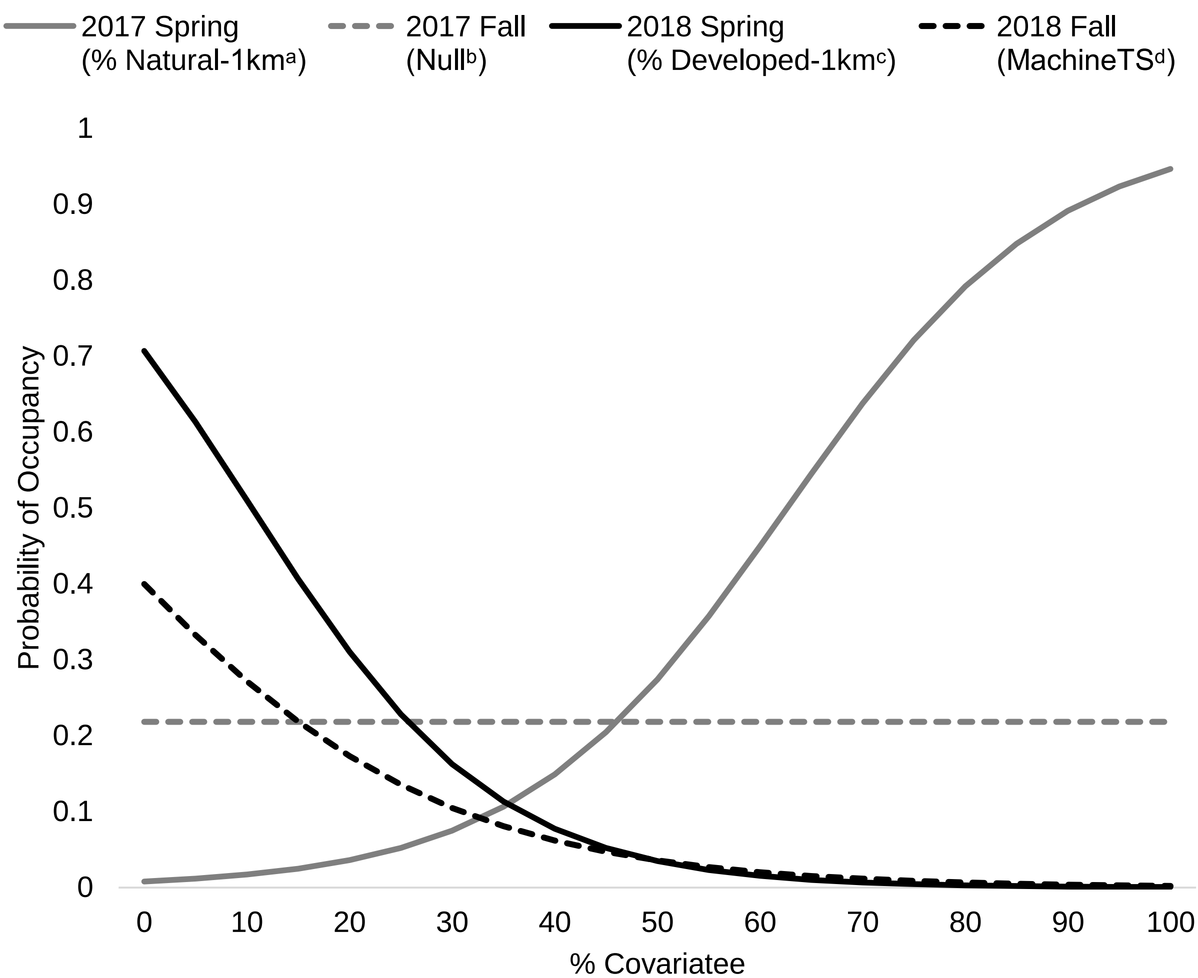


Figure 4.3: Wild turkey (*Meleagris gallopavo*) probability of occupancy as compared to the percent of natural cover within 1 km (Spring 2017), percent developed area within 1 km (Spring 2018) and range of camera trap success of humans using machines (Fall 2018) standardized for 1-100 from top model for each survey season of Spring 2017 (May 13th-June 29th), Fall 2017 (August 16th-October 15th), Spring 2018 (April 20th-June 24th), and Fall 2018 (August 18th-October 27th) at 20 farm study sites across the Eastern Shore of Virginia and Maryland (i.e. Delmarva Peninsula) and in the city of Virginia Beach, VA.

[a] Model effect of the percent of natural cover type within 1km of each farm.

[b] No model effect was present on top model, thus base occupancy was used.

[c] Model effect of the percent of developed cover type within 1km of each farm.

[d] Model effect of the camera trap success per 100 nights for that survey season of human disturbance classified as machines, max TS calculated as 500 events per 100 trap nights.

[e] Each covariate was factored to be put on a 100 percent scale.

# Chapter 5: Conclusion

While many studies have shown that the presence of native plants and edge habitats benefit invertebrate non-pollinators and pollinators (Aebischer 1991, Burel et al. 1998, Medan et al. 2011, Evans et al. 2016), studies are still lacking on the potential benefits of native pollinator-friendly forb and grass plantings for vertebrates. To address this research gap, my thesis evaluated the potential benefits of pollinator plots to birds and mammals using a framework of cultural, regulating, and provisioning ecosystem services in each of three chapters, described briefly below.

- Chapter 1: My objectives were to quantify species richness and diversity, factors relating to presence or absence, and density of birds on farms with and without pollinator plots, using concepts of cultural and regulating ecosystem services as a rationale for the importance of these species on farms. I also sought to determine if birds used these restored pollinator-friendly plots on farms as nesting habitat and details on nest site selection within these plots. I conducted point counts of birds during the Spring (April-July) and Fall (August-October) of 2017 and 2018 across different farm cover types on the Eastern Shore of Virginia and Maryland and in the city of Virginia Beach, VA. I also surveyed and monitored bird nesting during the summer maternity season (May-July) in my pollinator plots in both 2017 and 2018.
- Chapter 2: My objective was to determine which bats are present on farmland of the Eastern Shore of Virginia and how their relative activity was influenced by cover type on farmland. I used the concept of regulating ecosystem services in this chapter to emphasize the values of bats on farmland habitats. I placed four zero-crossing acoustic detectors at the Eastern Shore Agricultural Research Extension Center, one in each of

four cover types (crop field-forest, water-forest, forest trail, and pollinator plot), and recorded bat nightly call activity between April 2017 and October 2019. I sought to determine bat species relative activity differences across years and cover type locations within the maternity (May-August) season of each year.

- Chapter 3: My objective was to determine the relative influences of the presence of pollinator friendly plantings and  cover types in the surrounding landscape, and other covariates, on the presence, camera trap success, and occupancy of white-tailed deer (*Odocoileus virginianus*) and wild turkey (*Meleagris gallopavo*). Both of these species provide valuable cultural and provisioning ecosystem services on farmlands. I used camera traps on all of my farm study sites during the Spring (April-July) and Fall (August-October) of 2017 and 2018 to calculate the presence and abundance of different wildlife, with a focus on wild turkey and white-tailed deer. I quantified white-tailed deer and wild turkey camera trap success and occupancy on farmlands with and without pollinator plots. I also explored effects on presence and occupancy of landscape level cover types within 1 km of each farm for both white-tailed deer and wild turkey.

The research provided will be beneficial to organizations that advance farmland-based conservation practices such as pollinator plots and other pollinator friendly management techniques. From here, I summarize my key research findings, management implications, and future research needs.

## KEY RESEARCH FINDINGS

Chapter 1: “Relationship of bird populations and community to pollinator-friendly plantings in the Coastal Plain of Virginia and Maryland."

- *Bird species richness and diversity metrics*
    - A total of 110 species of birds was observed on my 20 study farms.
    - Some diversity metrics varied between control and pollinator farms in part due to the wide presence of common farm birds, influencing my measures of diversity and diversity indices.
        - The average species richness per farm per survey, or alpha diversity, was not different between control farms without pollinator plots and farms with pollinator plots for both survey seasons
        - Regional species richness, or gamma diversity, was higher on pollinator farms ($\gamma$ richness = 106 bird species) than control farms ($\gamma$ richness = 96 bird species).
        - Simpsons index in Spring was higher on pollinator farms ($\bar{x} = 0.91$, SE = 0.01, range 0.83-0.94) than on control farms ($\bar{x} = 0.87$, SE = 0.02, range 0.75-0.93) without pollinator plots.
- *Factors relating to bird species presence on a farm*
    - Only the America robin, blue-gray gnatcatcher, brown thrasher, common yellowthroat, downy woodpecker, eastern bluebird, eastern wood pewee, field sparrow, gray catbird, mourning dove, northern mockingbird, pileated woodpecker, red-eyed vireo, tree swallow and turkey vulture were present or absent on enough farms (>4) to be analyzed. Thus, most species (N= 98) were rarely recorded.
    - The landscape cover within 1 km of a farm, year of the study, and presence of

pollinator plots were the most influential factors of presence or absence of bird species from a study farm.

        - Landscape covariates influenced the presence or absence of bird species on farms in at least Spring or Fall surveys for all species analyzed (14/15), except eastern bluebird.
        - The probability of presence or absence of bird species on farms varied by year for 8 of 15 species top models.
        - Presence of pollinator plots was positively associated with the presence of eastern bluebirds in the Spring and eastern wood peewees in the Fall.
        - The brown thrasher was negatively associated with pollinator plots in both Spring and Fall survey seasons.

- *Factors relating to bird density on a farm*
    - Land cover within 1 km of a study farm was the most common influential factor in density for 10 species that I modelled: American crow, American robin, blue grosbeak, blue jay, Carolina chickadee, Carolina wren, chipping sparrow, field sparrow, northern cardinal, and tufted titmouse. Again, most species (N=103) had < 100 total individuals observed over the study and were not included in density analyses.
        - Densities of blue jays and Carolina wrens were higher on control farms than on pollinator farms without pollinator plots in Spring.
        - Densities of blue grosbeaks were higher on pollinator farms than on control farms without pollinator plots in Fall.
- *Use of pollinator plots for nesting*

- Only one species of bird, the red-winged blackbird, was found nesting in the pollinator plots, despite 24-person days of search effort in 2017 and 41-person days of search effort in 2018.
    - The percentage of forb cover was higher within 1 $m^2$ of nest locations (86%, SE=6.78%) than at random points (58.8%, SE=3.22%) without nests in the pollinator plots.
    - I found no differences in average vegetation height, visual obstruction, flowering heads, grass, dead vegetation, and bare ground variables measured between nest locations and random points without nests in the pollinator plots.

Chapter 2: "Relative activity of native insectivorous bats in a farmscaped habitats on the Eastern Shore of Virginia."

- I identified calls of seven species (big brown bat, evening bat, silver-haired bat, eastern red bats, hoary bats, little brown bat, and tricolored bat) across the 4 cover types.
- All 7 bat species were detected in the pollinator plot cover type.
- *Cover Type Effects on Nightly Activity*
    - Relative activity during the maternity season was highest in crop field-forest edge and water forest edge compared to forest trail and pollinator plot cover types for all 7 bat species.
    - Relative activity during the maternity season was higher in pollinator plots than forest trail for all bats except for the tricolored bat.

Chapter 3: "Relationship of white-tailed deer and wild turkey to pollinator plot restoration and landscape features on small-scale farms on in the Coastal Plain of Virginia and Maryland."

- *Camera trap success*
    - Of all wild animals detected on the cameras, white-tailed deer had the highest total camera trap success (TS: # captures/100 nights) each survey season
    - Wild turkeys were rare on the cameras in both years and all seasons of the study
    - The 4 most frequently detected wild animals were
        - white-tailed deer (Overall 98.44 TS)
        - non-domestic birds (61.20 TS), such as European starlings, common grackles, raptors, and vultures.
        - raccoons (27.97 TS)
        - red foxes (25.46 TS)
- *Occupancy*
    - White-tailed deer occupancy (range = 0.87 - 0.91) was negatively related to the % developed land within 1 km of a farm during all seasons of the study
    - Wild turkey occupancy (range = 0.18 - 0.53) was relatively low and not consistently explained by any single covariate across seasons and years of the study.
    - There is some indication that wild turkey occupancy was positively related to the % landscape in natural habitat within 1 km of a farm (Spring 2017) or negatively to % developed cover within 1 km of a farm (Spring 2018) and camera trap

success of humans using machines (Fall 2018)

MANAGEMENT IMPLICATIONS

- *Pollinator friendly plantings and bird richness, diversity, density, and nesting*
    - I documented 113 species of birds present on in-production farmland in Virginia Beach and the Eastern Shore of Virginia and Maryland.
    - Farms with pollinator plots had overall higher species richness than farms without pollinator plots.
    - My finding of red-winged blackbirds nesting in pollinator plots is the first known observation of the benefits of these pollinator plantings for native nesting birds. This observation could indicate the potential value of these restoration areas for native birds and deserves future study
    - The cover types within 1-km of a farm were important drivers of bird presence and density, thus I recommend that managers should plan to place pollinator plots on farms with the highest percentage of natural cover and lowest percentage of developed cover in the surrounding landscapes when resources limit the area and locations of such restoration efforts.
- *Relative activity of native insectivorous bats*
    - The VDWR has identified four bat species of greatest conservation need (SGCN) which I was able to detect as present on the Eastern Shore Agricultural Research and Extension Center.
        - Three species (hoary bats, silver-haired bats, and eastern red bats) are of moderate conservation need (lowest: Tier IV SGCN) in which long term

planning to stabilize the population is in progress and ranked ‘a’ in which VDWR has identified strategies to benefit the population or at least have a reasonable chance at improving the conservation status.

- Under the 2015 management plan, these three species were of interest due to the issues surrounding wind energy and bat mortality caused by wind energy development. To improve the status of these three species, the VDWR identified that the migration patterns of species using the coastal areas of Virginia are of importance to avoid and help mitigate conflict if wind energy is developed in the area.
- For these three bat species, nightly activity was significantly higher in water-forest edge and crop field-forest edge cover types as compared to the forest trail and pollinator plot cover types.
- Nightly activity was highest during what we defined as the maternity season (April – August) but they were still detected throughout the year.

▪ Little brown bats are labeled as a critical (highest: Tier I) SGCN, meaning the goal is to improve conservation status; with actions in progress to identify and protect fall swarm, roosts, and foraging areas (VDWR 2015*a*).

- My research is important for conservation planning by VDWR as I documented use and relative activity by these bat species across the year in an agricultural setting which is an abundant landscape yet understudied habitat type in eastern Virginia.

      - For the little brown bat, nightly activity was significantly higher in water-forest edge and crop field-forest edge cover types as compared to the forest trail and pollinator plot cover types.
      - Nightly activity was highest during what we defined as the maternity season (April – August) but they were still detected throughout the year.

  - Our findings suggest on-farm management consider benefits to native bat species
    - Maintaining areas of water and forest-field edge habitats should be considered useful for promoting bat diversity and activity.
    - Management of farmland has a huge potential to provide for bat species at both pollinator plots and in surrounding landscapes.
    - We show general patterns and periods such as the volancy of young during several years of data which can aid in understanding of bat migration and activity levels throughout the year.
      - This can aid the designation of possible future wind turbine curtailment during the maternity season.

- *Deer and turkey camera trap success and occupancy and pollinator-friendly plantings*
  - When addressing provisioning questions managers may have about pollinator friendly plantings, I show it is important to consider large scale landscape effects over pollinator friendly plantings.
    - Pollinator planting relationships were likely masked by the small scale size of plots, and managers may want to consider larger feature changes

with more heterogeneous cover types placed when interested in white-tailed deer and wild turkey.

FUTURE RESEARCH NEEDS

While my work makes important contributions towards understanding the benefits of pollinator plots to wildlife, there are further research questions that arise from my study. I sorted these questions and needs between landscape level effects, edge influences, and other vertebrate responses.

Landscape effects:

- Does distance of farm from wildlife management areas change diversity, presence, or density?
- Does the size of pollinator friendly plantings influence:
    - Diversity, presence, density, and nesting potential?
    - Bat presence and relative activity?
    - Presence of white-tailed deer and wild turkey?
- Is there an influence in the surrounding landscape of early successional habitat and timber stands as a driver of wild turkey and white-tailed deer occupancy?
    - If so, could researchers also influence the pollinator friendly planting to resemble a mix closer to early successional habitat or feather the edge of pollinator plots with forest and crop to achieve better results?

Edge influences:

- The specific value of edge was a potential factor that I did not fully examine, but could do in follow-up analyses as I have data from each farm from drone aerial surveys completed in 2017 and 2018 with the potential to calculate distance to edge and amount of edge on my farm study areas at a small scale. I recommend these analyses in order to determine if the amount of forested edge on farmland influences presence and density of the wildlife species I studied.
- I also recommend that future work examines how the presence and activity of bat species change when pollinator plots are placed on different types of edges or not at all on farmscapes? Edges might include:
    - Development including buildings
    - Adjacent to forested areas
    - Brush piles and areas where farm equipment are stored
    - Near water features
- Configuration of pollinator plots in shape, length, and distance within crop fields to compare edge versus open plot establishment on vertebrates are necessary study designs for future research. Creating rows through agricultural fields may provide a corridor for wildlife.
    - Placing plots in the center of fields may assist vertebrate influences in many ways.
        - Birds in center plots may have less competition with edge conspecifics.
        - Plot establishment might be influenced by deer browse and thus field centrality might influence amount of browse.
    - Longer rows along edges may influence possible edge effects.

Other vertebrate responses:

- I only examined a small portion of vertebrate wildlife present on farmscapes and how they interact with farms. Future studies and interactions might include:
    - White-tailed deer herbivory on pollinator friendly plantings as well as on crops within the farmland with and without pollinator plots.
    - White-tail deer and wild turkey were known to have bedded in my pollinator plots, but a majority of behavior sightings were on the largest of plots.
        - Do white-tail deer, wild turkey, or other species use pollinator plots for bedding and cover?
        - What time frames are we most likely to find use as cover, and does the management of plots such as seed mix composition, plot size, or mowing of field to assist in plots seeding in subsequent years influence these uses?
    - Nest predation was presumed by snakes, and several woodland box turtles (*Terrapene carolina carolina*) were found within pollinator plots during nesting searches. Large portions of farmland that are not managed or sprayed might house a variety of snakes, turtles, or possibly frog species.
        - Would the presence of reptiles and amphibians on farms be influenced by pollinator friendly plantings?
        - Is there an influence from snakes on the predation and productivity potential pollinator plots can provide to avian species?
        - Are box turtles using pollinator plots for foraging insects?
    - Other vertebrate species such as red foxes, gray foxes, groundhogs, raccoons and opossums were present on observations from camera trapping.

        - Are these species influenced by the presence, size, and management around pollinator plots or against farms without pollinator plots?
    - Small mammals, such as meadow voles and least shrews, may use pollinator plots and should be considered in future studies.
- In both presence/absence and density analyses, I only examined a portion of the species present on my farms due to sample size constraints.
    - Future work should include analyses of guilds and ordination of species to examine a greater number of rare species and their interactions with farms and pollinator plots.
    - Future work should explore multivariate statistics such as ordination by farm type and landscape cover to see if there are patterns in these majority of species.
- Future bat analyses should include using our entire volume of yearly data and plotting nightly variation across a year for better visualization and interpretation of the seasonal activity with influences incorporated from temperature and wind speed.
    - This would give more details and more specific dates into maternity season activity changed and when volant young drop and are presumed active are each of our cover types.
    - Comparisons of these data to other areas in the Coastal Plain, Piedmont, and Appalachian regions will allow managers to fully understand the benefits of different ecoregions to bat species of concern.
- We used a novel estimate of farm activity by using the trap success of machines per survey site for some of our analyses, where there are several other factors of farm intensity to consider.

    - Does the type of machinery affect wildlife relationships with farmland?
    - More importantly, does the farm production intensity and crop type influence pollinator plot relationships for high intensity monoculture crop fields vs small scale hand-picked diverse crop fields?
- I used presence, relative activity, and abundance as indices of potential ecosystem services. A next step should be to quantify the actual ecosystem service values. A few potential examples follow below.
    - Does insect bio-load influence presence of bats over pollinator plots, and how can pollinator plots be managed to encourage possible insect-bat foraging with possible influences from insect prey presence in a measure of regulation services?
    - Does the presence of red-winged blackbirds and regulation of insect prey behaviors correlate with a precipitation of insect pests on crops?
    - Does the presence of a pollinator plot influence the potential area use of a farm by white-tail deer and wild turkey browse and gleaning of crops?

## Literature Cited

Aebischer, N. J. 1991. Twenty years of monitoring invertebrates and weeds in cereal fields in Sussex. The Ecology of Temperate Cereal Fields (eds L.G. Firbank, N. Carter, J.F. Darbyshire & G.R. Potts) 305–331. Blackwell Scientific Publishers, Oxford, UK.

Burel, F., J. Baudry, A. Butet, P. Clergeau, Y. Delettre, D. Le Coeur, F. Dubs, N. Morvan, G. Paillat, S. Petit, C. Thenail, E. Brunel, and J.-C. Lefeuvre. 1998. Comparative biodiversity along a gradient of agricultural landscapes. Acta Oecologica 19:47–60.

Evans, T. R., M. J. Mahoney, E. D. Cashatt, J. Noordijk, G. De Snoo, and C. J. M. Musters. 2016. The impact of landscape complexity on invertebrate diversity in edges and fields in an agricultural area. Insects 7:7–23.

Medan, D., J. P. Torretta, K. Hodara, E. B. de la Fuente, and N. H. Montaldo. 2011. Effects of agriculture expansion and intensification on the vertebrate and invertebrate diversity in the Pampas of Argentina. Biodiversity and Conservation 20:3077–3100.

VDWR. 2015. Virginia's 2015 state wildlife action plan. Virginia Department of Wildlife Resources, Henrico, Virginia, USA. <http://bewildvirginia.org/wildlife-action-plan/pdf/2015-Virginia-Wildlife-Action-Plan.pdf>. Accessed 30 Sep 2017.

# Appendix

Appendix A: Study farms with associated survey points on each site during bird studies during Spring (April 8th- June 5th), and Fall (August 26th-October 14th) of 2017 and 2018 on the Eastern Shore of Virginia and Maryland, and in the city of Virginia Beach, VA. Some changes occurred across seasons: two farms opted out of 2017 Fall survey season, and only one came back to the study; three farms had multiple of the same cover type including farms I, K, and P. Each survey location had three survey points except for farm Q in 2017 during Spring, O and farm J with two locations.

| | Pollinator Plot | | | Point Type[2] | | | |
|---|---|---|---|---|---|---|---|
| Farm[1] | Area ($m^2$) | Year | Season | FU | FM | NH | PP |
| A | | 2017 | Spring | 1 | 1 | 1 | - |
| | | | Fall | - | - | - | - |
| | | 2018 | Spring | - | - | - | - |
| | | | Fall | - | - | - | - |
| B | 948.49 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| C | 1112.17 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| D | | 2017 | Spring | 1 | 1 | 1 | - |

| Pollinator Plot | | | | Point Type[2] | | | |
|---|---|---|---|---|---|---|---|
| Farm[1] | Area ($m^2$) | Year | Season | FU | FM | NH | PP |
| | | | Fall | 1 | 1 | 1 | - |
| | | 2018 | Spring | 1 | 1 | 1 | - |
| | | | Fall | 1 | 1 | 1 | - |
| E | 3372.42 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| F | 2139.52 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| G | 1649.36 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| H | | 2017 | Spring | 1 | 1 | 1 | - |
| | | | Fall | 1 | 1 | 1 | - |
| | | 2018 | Spring | 1 | 1 | 1 | - |
| | | | Fall | 1 | 1 | 1 | - |
| I | | 2017 | Spring | 3 | - | - | - |
| | | | Fall | - | - | - | - |

| | Pollinator Plot | | | Point Type[2] | | | |
|---|---|---|---|---|---|---|---|
| Farm[1] | Area ($m^2$) | Year | Season | FU | FM | NH | PP |
| | | 2018 | Spring | 3 | - | - | - |
| | | | Fall | 3 | - | - | - |
| J | | 2017 | Spring | 1 | 1 | - | - |
| | | | Fall | 1 | 1 | - | - |
| | | 2018 | Spring | 1 | 1 | - | - |
| | | | Fall | 1 | 1 | - | - |
| K | | 2017 | Spring | 1 | 1 | 1 | - |
| | | | Fall | 1 | 1 | 1 | - |
| | | 2018 | Spring | 2 | - | 1 | - |
| | | | Fall | 2 | - | 1 | - |
| L | | 2017 | Spring | 1 | 1 | 1 | - |
| | | | Fall | 1 | 1 | 1 | - |
| | | 2018 | Spring | 1 | 1 | 1 | - |
| | | | Fall | 1 | 1 | 1 | - |
| M | 2274.03 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| N | 709.94 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |

| | Pollinator Plot | | | Point Type[2] | | | |
|---|---|---|---|---|---|---|---|
| Farm[1] | Area ($m^2$) | Year | Season | FU | FM | NH | PP |
| | | | Fall | 1 | 1 | - | 1 |
| O | | 2017 | Spring | 1 | 1 | - | - |
| | | | Fall | 1 | 1 | - | - |
| | | 2018 | Spring | 1 | 1 | - | - |
| | | | Fall | 1 | 1 | - | - |
| P | | 2017 | Spring | - | 3 | - | - |
| | | | Fall | - | 3 | - | - |
| | | 2018 | Spring | - | 3 | - | - |
| | | | Fall | - | 3 | - | - |
| Q | 10779.7 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| R | 2191.81 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| S | | 2017 | Spring | 1 | 1 | 1 | - |
| | | | Fall | 1 | 1 | 1 | - |
| | | 2018 | Spring | 1 | 1 | 1 | - |
| | | | Fall | 1 | 1 | 1 | - |

| | Pollinator Plot | | | Point Type[2] | | | |
|---|---|---|---|---|---|---|---|
| Farm[1] | Area ($m^2$) | Year | Season | FU | FM | NH | PP |
| T | 2533.9 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |

[1]: Farm locations, A: Brookdale, B: Calliope, C: Copper Cricket, D: Cullipher, E: Virginia Tech Eastern Shore Agricultural Research and Extension Center, F: Flanagan, G: Flip Flop, H: Virginia Tech Hampton Roads Agricultural Research and Extension Center , I: La Caridad, J: University of Maryland Lower Eastern Shore Research & Education Center - Extension, K: Mattawoman, L: Patty's Garden, M: Perennial, N: Pik Penny, O: Provident, P: Quail Cove, Q: Sturgis, R: University of Maryland Eastern Shore Somerset – Extension, S: Van Dessel, T: Wright.

[2]: Point types, FU: Forest Unmanaged, FM: Forest Managed, NH: Novelty Habitat, PP: Pollinator Plot.

Appendix B: Cover types by farm for each survey location on the Eastern Shore of Virginia and Maryland, and in the city of Virginia Beach, VA from the 2017 USDA Cropscape data layer (USDA National Agricultural Statistics Service Cropland Data Layer 2017). The cover classes of deciduous forest, evergreen forest, mixed forest, shrubland, woody wetland, and herbaceous wetland were collapsed into natural. Cover classes of developed/open space, developed/low intensity, developed/medium intensity, developed/high intensity, and barren were collapsed into developed. Crop cover class was aggregated from all crop categories including a majority of corn, hay, wheat, soybeans, watermelon, sod, cotton, and sorghum. Water and background cover were included together into a water category.

| | % of 1-Kilometer Radius in Each Cover type Around Each Study Farm[2] | | | |
|---|---|---|---|---|
| Farm[1] | Water | Crop | Natural | Developed |
| A | 0.03 | 58.8 | 34.55 | 6.62 |
| B | 0.95 | 33 | 57.65 | 8.4 |
| C | 27.16 | 43.73 | 26.84 | 2.27 |
| D | 0.06 | 63.13 | 29.79 | 7.02 |
| E | 1.12 | 53.69 | 40.72 | 4.48 |
| F | 0.14 | 42.29 | 41.69 | 15.88 |
| G | 0.11 | 52.75 | 42.72 | 4.42 |
| H | 3.47 | 0.03 | 10.48 | 86.02 |
| I | 0.06 | 62.03 | 29.68 | 8.23 |
| J | 0.09 | 73.17 | 14.19 | 12.56 |
| K | 49.35 | 22.86 | 24.69 | 3.1 |
| L | 0.11 | 25.89 | 69.17 | 4.82 |

| | % of 1-Kilometer Radius in Each Cover type Around Each Study Farm[2] | | | |
|---|---|---|---|---|
| Farm[1] | Water | Crop | Natural | Developed |
| M | 0.03 | 34.89 | 49.97 | 15.11 |
| N | 4.67 | 36.04 | 54.53 | 4.76 |
| O | 17.41 | 25.36 | 35.69 | 21.54 |
| P | 0 | 58.32 | 38.18 | 3.5 |
| Q | 10.06 | 53.28 | 36.03 | 0.63 |
| R | 0 | 31.16 | 59.89 | 8.95 |
| S | 0 | 60.83 | 32.72 | 6.45 |
| T | 1.52 | 67.95 | 21.01 | 9.52 |

[1]: Letters denote farm, A: Brookdale, B: Calliope, C: Copper Cricket, D: Cullipher, E: Virginia Tech Eastern Shore Agricultural Research and Extension Center, F: Flanagan, G: Flip Flop, H: Virginia Tech Hampton Roads Agricultural Research and Extension Center , I: La Caridad, J: University of Maryland Lower Eastern Shore Research & Education Center - Extension, K: Mattawoman, L: Patty's Garden, M: Perennial, N: Pik Penny, O: Provident, P: Quail Cove, Q: Sturgis, R: University of Maryland Eastern Shore Somerset – Extension, S: Van Dessel, T: Wright.

[2]: All landcover within 1 km covariates passed a Pearson’s correlation test of 60% correlation

Appendix C: List of plant species used in each wildflower mix. Information and table obtained (McCullough 2020)

**A.** Grass and forb mix for well-drained soils (N = 7)

| Common Name | Scientific Name | Seeding Rate (weight of pure live seed per acre) |
|---|---|---|
| Little Bluestem (G) | *Schizachyrium scoparium* | 0.75 pound |
| Splitbeard Bluestem (G) | *Andropogon ternarius* | 0.75 pound |
| Narrowleaf Mountain Mint (P) | *Pycnanthemum tenuifolium* | 1.5 ounce |
| Plains Coreopsis (A) | *Coreopsis tinctoria* | 1.5 ounce |
| Partridge Pea (A) | *Chamaecrista fasciculata* | 2.0 pounds |
| Black-eyed Susan (B) | *Rudbeckia hirta* | 3 ounces |
| Bergamot, Spotted (P) | *Monarda fistulosa* | 1.5 ounce |
| Lanceleaf Coreopsis (P) | *Coreopsis lanceolata* | 15 ounces |
| Maximilian Sunflower (P) | *Helianthus maximilianii* | 1 pound |
| Indian Blanket (A) | *Gaillardia pulchella* | 13.5 ounces |
| Purple Coneflower (P) | *Echinacea purpurea* | 1.8 pound |

**B.** Grass and forb mix for poorly-drained soils (N = 2)

| Common Name | Scientific Name | Seeding Rate (weight of pure live seed per acre) |
|---|---|---|
| Beaked Panicum (G) | *Panicum anceps* | 0.37 pound |
| Redtop Panicum (G) | *Panicum rigidulum* | 0.30 pound |
| Aster, Purple-stemmed (P) | *Symphyotrichum puniceum var. puniceum* | 4.5 ounces |

| | | |
|---|---|---|
| Sneezeweed, Common (P) | *Helenium autumnale* | 3 ounces |
| Coreopsis, Plains (A) | *Coreopsis tinctoria* | 1.5 ounce |
| Goldenrod, Wrinkleleaf (P) | *Solidago rugosa* | 3 ounces |
| Joe Pye Weed, Spotted (P) | *Eupatoriadelphus fistulosus* | 3 ounces |
| Partridge Pea (A) | *Chamaecrista fasciculata* | 2.0 pounds |
| Rattlesnake Master (P) | *Eryngium yuccifolium* | 12 ounces |
| Rosemallow (P) | *Hibiscus moscheutos* | 3 ounces |
| Narrowleaf Sunflower (P) | *Helianthus angustifolius* | 6 ounces |

**C.** Forb mix for 2015 well-drained field

| Common Name | Scientific Name |
|---|---|
| Showy evening primrose (P)* | *Oenothera speciosa* |
| Indian Blanket (A) | *Gaillardia pulchella* |
| Maximilian Sunflower (P) | *Helianthus maximiliani* |
| Black-eyed Susan (B) | *Rudbeckia hirta* |
| Partridge Pea (A) | *Chamaecrista fasciculate* |
| Plains Coreopsis (A) | *Coreopsis tinctoria* |
| Lanceleaf Coreopsis (P) | *Coreopsis lanceolate* |
| Spotted Beebalm (P)* | *Monarda punctate* |
| Tickseed Sunflower (A)* | *Bidens aristosa* |

G = grass,

A = annual

B = biennial

P = perennial

* not in well-drained mix of table A

Appendix D: Recorded presence (★, in at least one survey) or absence (-, in all surveys) of all birds seen or heard during bird point counts in Spring (April 8th- June 5th), and Fall (August 26th- October 14th) of 2017 and 2018 on 20 farms study sites across the Coastal Plain of Virginia and Maryland.

| Farm[1] | | A | D | H | I | J | K | L | O | P | S | B | C | E | F | G | M | N | Q | R | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollinator or Control[2] | | C | C | C | C | C | C | C | C | C | C | P | P | P | P | P | P | P | P | P | P |
| Species[3] | Diet[4] | | | | | | | | | | | | | | | | | | | | |
| American Crow (*Corvus brachyrhynchos*) | 8 (2, 7, 1, 4, 10, 3) | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| American Goldfinch (*Spinus tristis*) | 1, 10, 2 | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| American Kestrel (*Falco sparverius*) | 3 | - | ★ | - | - | - | - | - | - | - | - | - | - | - | - | ★ | - | - | ★ | - | - |
| American Redstart (*Setophaga ruticilla*) | 2 | - | - | - | ★ | - | ★ | ★ | - | ★ | ★ | ★ | ★ | ★ | - | - | ★ | - | ★ | ★ | ★ |
| American Robin (*Turdus migratorius*) | 2, 4, 9 | ★ | ★ | ★ | ★ | ★ | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| Bald Eagle (*Haliaeetus leucocephalus*) | 3, 5, 7 | - | - | - | - | - | - | - | - | - | ★ | - | - | ★ | - | - | - | - | ★ | ★ | |
| Baltimore Oriole (*Icterus galbula*) | 2, 6 | - | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - | - | - | - |
| Barn Swallow | 2 | ★ | ★ | ★ | - | ★ | ★ | - | ★ | ★ | - | - | ★ | ★ | ★ | ★ | ★ | - | ★ | - | ★ |

| Farm[1] | | A | D | H | I | J | K | L | O | P | S | B | C | E | F | G | M | N | Q | R | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollinator or Control[2] | | C | C | C | C | C | C | C | C | C | C | P | P | P | P | P | P | P | P | P | P |
| Species[3] | Diet[4] | | | | | | | | | | | | | | | | | | | | |
| (*Hirundo rustica*) | | | | | | | | | | | | | | | | | | | | | |
| Black-and-white Warbler | 2, 4 | - | - | - | ★ | - | - | ★ | - | - | - | - | - | ★ | - | - | - | - | ★ | - | - |
| (*Mniotilta varia*) | | | | | | | | | | | | | | | | | | | | | |
| Black-crowned Night Heron | 3 | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - | - | - | - | - | - | - |
| (*Nycticorax nycticorax*) | | | | | | | | | | | | | | | | | | | | | |
| Belted Kingfisher | 5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | ★ | - | - | - | ★ | - |
| (*Megaceryle alcyon*) | | | | | | | | | | | | | | | | | | | | | |
| Blue-grey Gnatcatcher | 2 | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | - |
| (*Polioptila caerulea*) | | | | | | | | | | | | | | | | | | | | | |
| Brown-headed Cowbird | 2, 4, 1 | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| (*Molothrus ater*) | | | | | | | | | | | | | | | | | | | | | |
| Brown-headed Nuthatch | 2, 1 | - | - | - | - | - | - | - | - | - | - | - | ★ | - | - | ★ | - | - | - | - | ★ |
| (*Sitta pusilla*) | | | | | | | | | | | | | | | | | | | | | |
| Blue-headed Vireo | 2, 4, 1 | - | ★ | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - | - | ★ | - | - |
| (*Vireo solitarius*) | | | | | | | | | | | | | | | | | | | | | |
| Blue Grosbeak | 2, 4, 1 | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| (*Passerina caerulea*) | | | | | | | | | | | | | | | | | | | | | |
| Blue Jay | 8 (2, 1, 7, | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| (*Cyanocitta cristata*) | 4, 3) | | | | | | | | | | | | | | | | | | | | |

| Farm[1] | | A | D | H | I | J | K | L | O | P | S | B | C | E | F | G | M | N | Q | R | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollinator or Control[2] | | C | C | C | C | C | C | C | C | C | C | P | P | P | P | P | P | P | P | P | P |
| Species[3] | Diet[4] | | | | | | | | | | | | | | | | | | | | |
| Black Vulture (*Coragyps atratus*) | 7 | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | ★ | - | - | - | - |
| Bobolink (*Dolichonyx oryzivorus*) | 2, 4, 1 | - | - | - | - | - | ★ | - | - | ★ | - | - | ★ | - | ★ | - | - | - | - | - | - |
| Brown Thrasher (*Toxostoma rufum*) | 2, 4 | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | - | - | ★ | ★ | - | ★ | ★ | ★ | - |
| Black Throated Blue Warbler (*Setophaga caerulescens*) | 2, 4 | - | - | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - | - | - |
| Carolina Chickadee (*Poecile carolinensis*) | 2, 4, 1 | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| Canada Goose (*Branta canadensis*) | 10 | - | - | ★ | - | ★ | ★ | ★ | - | ★ | ★ | ★ | ★ | ★ | - | ★ | - | ★ | ★ | ★ | ★ |
| Carolina Wren (*Thryothorus ludovicianus*) | 2, 4, 1 | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| Cedar Waxwing (*Bombycilla cedrorum*) | 4 | - | ★ | ★ | ★ | - | ★ | - | - | ★ | - | ★ | - | ★ | - | - | - | - | - | - | - |
| Chipping Sparrow (*Spizella passerina*) | 1, 2 | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| Chimney Swift | 2 | ★ | ★ | ★ | - | - | - | - | ★ | - | ★ | ★ | - | ★ | - | - | ★ | - | - | - | - |

| Farm[1] | | A | D | H | I | J | K | L | O | P | S | B | C | E | F | G | M | N | Q | R | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollinator or Control[2] | | C | C | C | C | C | C | C | C | C | C | P | P | P | P | P | P | P | P | P | P |
| Species[3] | Diet[4] | | | | | | | | | | | | | | | | | | | | |
| (*Chaetura pelagica*) | | | | | | | | | | | | | | | | | | | | | |
| Common Grackle | 2, 4, 1, 3 | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| (*Quiscalus quiscula*) | | | | | | | | | | | | | | | | | | | | | |
| Common Yellowthroat | 2 | - | ★ | ★ | ★ | ★ | ★ | ★ | - | ★ | ★ | ★ | ★ | ★ | ★ | - | ★ | ★ | ★ | ★ | - |
| (*Geothlypis trichas*) | | | | | | | | | | | | | | | | | | | | | |
| Dickcissle | 2, 4, 1 | - | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - | - | - | - |
| (*Spiza americana*) | | | | | | | | | | | | | | | | | | | | | |
| Downy Woodpecker | 2, 1 | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | - | ★ | ★ | - | ★ | - | ★ | ★ | ★ | ★ | ★ | ★ |
| (*Picoides pubescens*) | | | | | | | | | | | | | | | | | | | | | |
| Eastern Bluebird | 2, 4 | - | ★ | ★ | - | ★ | ★ | ★ | - | - | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | - | ★ | - |
| (*Sialia sialis*) | | | | | | | | | | | | | | | | | | | | | |
| Eastern Kingbird | 2, 4 | - | - | - | - | - | ★ | ★ | - | - | ★ | - | ★ | ★ | - | - | - | ★ | - | - | ★ |
| (*Tyrannus tyrannus*) | | | | | | | | | | | | | | | | | | | | | |
| Eastern Meadowlark | 2, 4, 1 | - | ★ | - | - | - | ★ | - | - | - | - | - | ★ | ★ | ★ | ★ | - | - | ★ | - | - |
| (*Sturnella magna*) | | | | | | | | | | | | | | | | | | | | | |
| Eastern Phoebe | 2, 4 | - | - | ★ | - | - | - | ★ | - | - | - | - | - | - | - | - | ★ | ★ | ★ | ★ | ★ |
| (*Sayornis phoebe*) | | | | | | | | | | | | | | | | | | | | | |
| Eastern Screech Owl | 3, 2, 5 | - | - | - | - | - | - | ★ | - | - | - | ★ | - | - | - | ★ | - | - | - | - | - |
| (*Megascops asio*) | | | | | | | | | | | | | | | | | | | | | |

| Farm[1] | | A | D | H | I | J | K | L | O | P | S | B | C | E | F | G | M | N | Q | R | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollinator or Control[2] | | C | C | C | C | C | C | C | C | C | C | P | P | P | P | P | P | P | P | P | P |
| Species[3] | Diet[4] | | | | | | | | | | | | | | | | | | | | |
| Eastern Towhee (*Pipilo erythrophthalmus*) | 1, 2 | - | - | ★ | ★ | ★ | - | ★ | ★ | ★ | - | - | ★ | - | ★ | ★ | - | - | - | ★ | - |
| Eastern Wood Pewee (*Contopus virens*) | 2, 4 | ★ | ★ | ★ | - | ★ | ★ | ★ | - | - | - | ★ | ★ | ★ | ★ | ★ | - | ★ | - | - | ★ |
| European Starling* (*Sturnus vulgaris*) | 2, 4, 1, 6 | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| Field Sparrow (*Spizella pusilla*) | 1, 2 | ★ | ★ | - | ★ | ★ | - | ★ | - | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| Great Blue Heron (*Ardea herodias*) | 3 | - | - | - | - | - | ★ | - | - | - | - | - | - | - | - | ★ | - | ★ | - | - | - |
| Great Crested Flycatcher (*Myiarchus crinitus*) | 2, 4 | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | - | - | ★ | ★ | - |
| Great Horned Owl (*Bubo virginianus*) | 3, 2, 5 | - | ★ | - | - | - | - | ★ | - | - | - | ★ | - | - | - | - | - | - | - | - | - |
| Gray Catbird (*Dumetella carolinensis*) | 2, 4 | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| Green Heron (*Dumetella carolinensis*) | 3 | - | - | - | - | - | ★ | - | - | - | - | - | - | ★ | - | ★ | - | ★ | - | - | - |
| Grasshopper Sparrow | 1, 2 | - | - | - | ★ | - | ★ | ★ | - | ★ | ★ | - | ★ | ★ | ★ | - | ★ | - | ★ | ★ | - |

| Farm[1] | | A | D | H | I | J | K | L | O | P | S | B | C | E | F | G | M | N | Q | R | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollinator or Control[2] | | C | C | C | C | C | C | C | C | C | C | P | P | P | P | P | P | P | P | P | P |
| Species[3] | Diet[4] | | | | | | | | | | | | | | | | | | | | |
| (*Ammodramus savannarum*) | | | | | | | | | | | | | | | | | | | | | |
| Hairy Woodpecker | 2, 1 | - | - | - | - | - | - | ★ | - | - | ★ | - | - | - | - | ★ | - | - | ★ | ★ | ★ |
| (*Leuconotopicus villosus*) | | | | | | | | | | | | | | | | | | | | | |
| Herring Gull | 8 (3, 5, 2, | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | ★ | - | - | - |
| (*Larus argentatus*) | 7, 1, 4) | | | | | | | | | | | | | | | | | | | | |
| Hermit Thrush | 2, 4 | - | - | - | - | ★ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| (*Catharus guttatus*) | | | | | | | | | | | | | | | | | | | | | |
| House Finch | 1, 10, 2 | - | - | ★ | - | - | - | - | - | - | - | ★ | - | - | ★ | - | - | - | - | - | - |
| (*Haemorhous mexicanus*) | | | | | | | | | | | | | | | | | | | | | |
| Horned Lark | 1, 2 | - | ★ | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - | - | - | - | - |
| (*Eremophila alpestris*) | | | | | | | | | | | | | | | | | | | | | |
| House Sparrow* | 1, 2 | - | - | - | - | - | - | - | - | - | - | - | - | ★ | - | - | ★ | - | - | - | - |
| (*Passer domesticus*) | | | | | | | | | | | | | | | | | | | | | |
| House Wren | 2 | - | - | ★ | - | ★ | - | ★ | - | - | - | ★ | - | - | ★ | - | - | - | - | - | - |
| (*Troglodytes aedon*) | | | | | | | | | | | | | | | | | | | | | |
| Indigo Bunting | 2, 1 | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| (*Passerina cyanea*) | | | | | | | | | | | | | | | | | | | | | |
| Kentucky Warbler | 2 | - | ★ | - | - | - | - | - | - | - | ★ | ★ | - | - | - | - | - | - | - | - | - |
| (*Geothlypis formosa*) | | | | | | | | | | | | | | | | | | | | | |

| Farm[1] | | A | D | H | I | J | K | L | O | P | S | B | C | E | F | G | M | N | Q | R | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollinator or Control[2] | | C | C | C | C | C | C | C | C | C | C | P | P | P | P | P | P | P | P | P | P |
| Species[3] | Diet[4] | | | | | | | | | | | | | | | | | | | | |
| Killdeer (*Charadrius vociferus*) | 8 (2, 9, 4, 11, 12) | ★ | ★ | ★ | - | - | ★ | - | ★ | ★ | - | - | - | ★ | ★ | ★ | ★ | ★ | - | ★ | ★ |
| Laughing Gull (*Leucophaeus atricilla*) | 8 (3, 5, 2, 7, 1, 4) | - | - | - | - | - | ★ | - | - | ★ | ★ | ★ | - | - | - | - | ★ | ★ | - | - | - |
| Marsh Wren (*Cistothorus palustris*) | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | ★ | - | - | - |
| Mourning Dove (*Zenaida macroura*) | 1, 4 | - | ★ | ★ | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| Nashville Warbler (*Leiothlypis ruficapilla*) | 2, 4 | - | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - | - | - | - |
| Nelson's Sparrow (*Ammodramus nelsoni*) | 1, 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - |
| Northern Bobwhite (*Colinus virginianus*) | 10, 1, 2 | ★ | ★ | - | - | - | - | - | - | ★ | - | - | ★ | - | - | - | - | - | - | - | - |
| Northern Cardinal (*Cardinalis cardinalis*) | 2, 4, 1 | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| Northern Flicker (*Colaptes auratus*) | 2, 4, 1 | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| Northern Mockingbird | 2, 4 | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |

| Farm[1] | | A | D | H | I | J | K | L | O | P | S | B | C | E | F | G | M | N | Q | R | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollinator or Control[2] | | C | C | C | C | C | C | C | C | C | C | P | P | P | P | P | P | P | P | P | P |
| Species[3] | Diet[4] | | | | | | | | | | | | | | | | | | | | |
| (*Mimus polyglottos*) | | | | | | | | | | | | | | | | | | | | | |
| Northern Parula | 2, 4 | - | - | ★ | - | - | - | - | ★ | - | - | ★ | - | - | - | - | - | - | ★ | - | ★ |
| (*Setophaga americana*) | | | | | | | | | | | | | | | | | | | | | |
| Northern Waterthrush | 2, 4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | ★ |
| (*Parkesia noveboracensis*) | | | | | | | | | | | | | | | | | | | | | |
| Orchard Oriole | 2, 6 | - | - | - | - | - | ★ | ★ | - | - | ★ | - | - | - | - | - | ★ | ★ | ★ | ★ | ★ |
| (*Icterus spurius*) | | | | | | | | | | | | | | | | | | | | | |
| Osprey | 5 | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - | - | - | ★ | - | - |
| (*Pandion haliaetus*) | | | | | | | | | | | | | | | | | | | | | |
| Ovenbird | 2, 4 | - | ★ | - | ★ | ★ | - | ★ | - | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| (*Seiurus aurocapilla*) | | | | | | | | | | | | | | | | | | | | | |
| Palm Warbler | 2, 4 | - | ★ | - | - | ★ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| (*Setophaga palmarum*) | | | | | | | | | | | | | | | | | | | | | |
| Pine Siskin | 1, 10, 2 | - | - | - | - | - | - | - | ★ | - | - | - | - | ★ | - | - | - | - | - | - | - |
| (*Spinus pinus*) | | | | | | | | | | | | | | | | | | | | | |
| Pine Warbler | 2, 4 | - | ★ | ★ | ★ | - | - | - | - | - | - | ★ | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| (*Setophaga pinus*) | | | | | | | | | | | | | | | | | | | | | |
| Pileated Woodpecker | 2 | - | ★ | - | ★ | ★ | ★ | ★ | ★ | - | ★ | ★ | - | ★ | ★ | ★ | ★ | - | - | ★ | ★ |
| (*Dryocopus pileatus*) | | | | | | | | | | | | | | | | | | | | | |

| Farm[1] | | A | D | H | I | J | K | L | O | P | S | B | C | E | F | G | M | N | Q | R | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollinator or Control[2] | | C | C | C | C | C | C | C | C | C | C | P | P | P | P | P | P | P | P | P | P |
| Species[3] | Diet[4] | | | | | | | | | | | | | | | | | | | | |
| Prairie Warbler (*Setophaga discolor*) | 2, 4 | - | - | ★ | ★ | ★ | - | ★ | - | - | ★ | - | - | ★ | - | - | - | - | - | - | ★ |
| Prothonotary Warbler (*Protonotaria citrea*) | 2, 4 | - | - | ★ | - | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - |
| Purple Martin (*Progne subis*) | 2 | - | - | ★ | - | - | - | ★ | ★ | - | - | - | - | ★ | ★ | ★ | ★ | - | - | - | - |
| Rose-breasted Grosebeak (*Pheucticus ludovicianus*) | 2, 4, 1 | - | ★ | - | - | - | ★ | - | - | - | - | - | - | ★ | - | - | - | - | - | ★ | ★ |
| Red-breasted Nuthatch (*Sitta canadensis*) | 2, 1 | - | - | - | - | - | - | - | - | - | - | ★ | ★ | - | - | - | - | - | - | - | ★ |
| Red-bellied Woodpecker (*Melanerpes carolinus*) | 2, 1 | ★ | ★ | ★ | ★ | ★ | ★ | ★ | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| Ruby-crowned Kinglet (*Regulus calendula*) | 2 | - | - | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - | - | - |
| Red-eyed Vireo (*Vireo olivaceus*) | 2, 4 | - | - | ★ | ★ | ★ | ★ | ★ | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | - | ★ | ★ |
| Red-headed Woodpecker (*Melanerpes erythrocephalus*) | 2, 1 | - | ★ | - | - | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - |
| Rock Pigeon* | 1, 4 | - | - | - | - | - | ★ | ★ | - | - | - | - | - | - | ★ | ★ | ★ | ★ | - | - | - |

| Farm[1] | | A | D | H | I | J | K | L | O | P | S | B | C | E | F | G | M | N | Q | R | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollinator or Control[2] | | C | C | C | C | C | C | C | C | C | C | P | P | P | P | P | P | P | P | P | P |
| Species[3] | Diet[4] | | | | | | | | | | | | | | | | | | | | |
| (*Columba livia*) | | | | | | | | | | | | | | | | | | | | | |
| Red-shouldered Hawk | 3 | - | ★ | - | - | - | - | ★ | - | - | - | ★ | - | - | ★ | ★ | - | - | - | ★ | - |
| (*Buteo lineatus*) | | | | | | | | | | | | | | | | | | | | | |
| Red-tailed Hawk | 3 | - | ★ | ★ | - | ★ | - | - | - | - | - | - | - | ★ | ★ | ★ | - | - | ★ | - | ★ |
| (*Buteo jamaicensis*) | | | | | | | | | | | | | | | | | | | | | |
| Ruby-throated Hummingbird | 6 | - | ★ | ★ | - | - | - | - | ★ | ★ | ★ | ★ | ★ | - | ★ | - | ★ | ★ | ★ | ★ | ★ |
| (*Archilochus colubris*) | | | | | | | | | | | | | | | | | | | | | |
| Red-winged Blackbird | 2, 4, 1 | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| (*Agelaius phoeniceus*) | | | | | | | | | | | | | | | | | | | | | |
| Scarlet Tanager | 2, 4 | - | - | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - | - | - |
| (*Piranga olivacea*) | | | | | | | | | | | | | | | | | | | | | |
| Semipalmated Plover | 8 (2, 9, 4, | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - | - | - | - | - |
| (*Charadrius semipalmatus*) | 11, 12) | | | | | | | | | | | | | | | | | | | | |
| Snow Goose | 10 | - | - | - | - | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - |
| (*Chen caerulescens*) | | | | | | | | | | | | | | | | | | | | | |
| Song Sparrow | 1, 2 | ★ | ★ | ★ | ★ | ★ | - | ★ | ★ | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | - | ★ | ★ |
| (*Melospiza melodia*) | | | | | | | | | | | | | | | | | | | | | |
| Summer Tanager | 2, 4 | ★ | - | - | ★ | - | - | ★ | - | ★ | ★ | ★ | ★ | ★ | ★ | - | ★ | ★ | - | - | ★ |
| (*Piranga rubra*) | | | | | | | | | | | | | | | | | | | | | |

| Farm[1] | | A | D | H | I | J | K | L | O | P | S | B | C | E | F | G | M | N | Q | R | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollinator or Control[2] | | C | C | C | C | C | C | C | C | C | C | P | P | P | P | P | P | P | P | P | P |
| Species[3] | Diet[4] | | | | | | | | | | | | | | | | | | | | |
| Swamp Sparrow (*Melospiza georgiana*) | 1, 2 | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - | - | - | ★ | - | - | - |
| Tree Swallow (*Tachycineta bicolor*) | 2 | ★ | ★ | ★ | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | - | ★ | - | - |
| Tufted Titmouse (*Baeolophus bicolor*) | 2, 4, 1 | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| Turkey Vulture (*Cathartes aura*) | 7 | - | - | ★ | ★ | ★ | ★ | ★ | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | - | ★ | ★ |
| Unknown Flycatcher (*Tyrannidae spp.*) | NA | - | - | - | - | - | - | ★ | - | ★ | - | - | ★ | - | - | - | - | ★ | - | - | - |
| Unknown Gull (*Laridae spp.*) | NA | - | - | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - | ★ | - | - | - |
| Unknown Hawk (*Accipitridae spp.*) | NA | - | - | - | - | - | - | ★ | - | - | - | - | - | - | ★ | - | - | - | - | - | - |
| Unknown | NA | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| Unknown Sparrow (*Passeridae spp.*) | NA | - | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| Unknown Swallow | NA | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - | - | - | - | - | - |

| Farm[1] | | A | D | H | I | J | K | L | O | P | S | B | C | E | F | G | M | N | Q | R | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollinator or Control[2] | | C | C | C | C | C | C | C | C | C | C | P | P | P | P | P | P | P | P | P | P |
| Species[3] | Diet[4] | | | | | | | | | | | | | | | | | | | | |
| (*Hirundinidae spp.*) | | | | | | | | | | | | | | | | | | | | | |
| Unknown Warbler | NA | - | - | - | - | ★ | ★ | ★ | ★ | ★ | - | - | - | - | - | ★ | ★ | ★ | ★ | ★ | - |
| (*Parulidae spp.*) | | | | | | | | | | | | | | | | | | | | | |
| Unknown Woodpecker | NA | - | ★ | - | - | - | ★ | ★ | - | - | ★ | ★ | - | - | - | ★ | ★ | ★ | ★ | ★ | ★ |
| (*Picidae spp.*) | | | | | | | | | | | | | | | | | | | | | |
| Warbling Vireo | 2, 4, 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | ★ | - | - |
| (*Vireo gilvus*) | | | | | | | | | | | | | | | | | | | | | |
| White-breasted Nuthatch | 2, 1 | - | - | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | ★ | - | - |
| (*Sitta carolinensis*) | | | | | | | | | | | | | | | | | | | | | |
| White-eyed Vireo | 2, 4, 1 | - | ★ | - | ★ | - | ★ | ★ | ★ | - | ★ | ★ | - | ★ | - | ★ | ★ | ★ | ★ | ★ | - |
| (*Vireo griseus*) | | | | | | | | | | | | | | | | | | | | | |
| Worm-eating Warbler | 2, 4 | - | - | - | - | - | - | ★ | - | ★ | ★ | - | - | - | - | - | - | - | - | - | - |
| (*Helmitheros vermivorum*) | | | | | | | | | | | | | | | | | | | | | |
| White Ibis | 8 (2, 9, 11, | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - | ★ | - | - | - |
| (*Eudocimus albus*) | 12, 1, 4, 5) | | | | | | | | | | | | | | | | | | | | |
| Willow Flycatcher | 2, 4 | - | - | - | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - | - |
| (*Empidonax traillii*) | | | | | | | | | | | | | | | | | | | | | |
| Wild Turkey | 10, 2 | - | - | - | ★ | - | ★ | - | - | - | - | - | - | - | - | - | - | - | ★ | ★ | - |
| (*Meleagris gallopavo*) | | | | | | | | | | | | | | | | | | | | | |

| Farm[1] | | A | D | H | I | J | K | L | O | P | S | B | C | E | F | G | M | N | Q | R | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollinator or Control[2] | | C | C | C | C | C | C | C | C | C | C | P | P | P | P | P | P | P | P | P | P |
| Species[3] | Diet[4] | | | | | | | | | | | | | | | | | | | | |
| Wood Duck (*Aix sponsa*) | 10, 1, 2, 11 | - | ★ | - | - | - | - | ★ | - | - | - | - | - | - | - | - | - | - | ★ | - | - |
| Wood Thrush (*Hylocichla mustelina*) | 2, 4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | ★ |
| White-throated Sparrow (*Zonotrichia albicollis*) | 1, 2 | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |
| Yellow-breasted Chat (*Icteria virens*) | 2 | - | ★ | - | - | ★ | ★ | - | - | - | ★ | - | - | - | - | - | - | ★ | - | - | - |
| Yellow-billed Cuckoo (*Coccyzus americanus*) | 2 | - | - | - | ★ | - | ★ | ★ | - | - | ★ | ★ | - | ★ | ★ | - | ★ | - | ★ | ★ | ★ |
| Yellow-bellied Sapsucker (*Sphyrapicus varius*) | 2 | - | - | - | - | - | - | ★ | - | - | - | ★ | - | - | - | - | - | - | - | ★ | - |
| Yellow Warbler (*Setophaga petechia*) | 2, 4 | - | - | - | - | - | - | - | - | - | ★ | - | - | - | - | - | - | - | ★ | - | - |
| Yellow-rumped Warbler (*Setophaga coronata*) | 2, 4 | ★ | ★ | - | - | ★ | ★ | ★ | ★ | ★ | - | ★ | - | - | ★ | - | - | ★ | ★ | ★ | ★ |
| Yellow-throated Warbler (*Setophaga dominica*) | 2, 4 | - | - | - | ★ | - | ★ | - | - | - | - | ★ | ★ | ★ | - | - | ★ | - | ★ | ★ | - |

[1]: Letters denote farm locations, A: Brookdale, B: Calliope, C: Copper Cricket, D: Cullipher, E: Virginia Tech Eastern Shore Agricultural Research and Extension Center, F: Flanagan, G: Flip

Flop, H: Virginia Tech Hampton Roads Agricultural Research and Extension Center , I: La Caridad, J: University of Maryland Lower Eastern Shore Research & Education Center - Extension, K: Mattawoman, L: Patty's Garden, M: Perennial, N: Pik Penny, O: Provident, P: Quail Cove, Q: Sturgis, R: University of Maryland Eastern Shore Somerset – Extension, S: Van Dessel, T: Wright.

[2]: Denotes control farms (C) without pollinator plot and pollinator farms (P) with pollinator plot.

[3]: A species not native to the United States is denoted by *. Status gathered from Sibley (2017).

[4]: Numbers denote diet classifications, 1: Granivore, 2: Insectivore, 3: Carnivore, 4: Frugivore, 5: Piscivore, 6: Nectarivore, 7: Scavenger, 8: Omnivore, 9: Vermivore, 10: Herbivore, 11: Molluscivore, 12: Crustaceovore. Diet information gathered from Sibley et al. (2001).

Appendix E: Avian observations made from bird point count data during Spring (April 8th- June 5th), and Fall (August 26th-October 14th) of 2017 and 2018 on 20 farms study sites collapsed between control versus pollinator and our point cover types (forest-managed, forest-unmanaged, novelty habitat, and pollinator plot) across the Coastal Plain of Virginia and Maryland by season and year.

| | | Count at Control or Pollinator[1] Farm | | | | | | | | Count at Cover type Point[2] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | | | | 2018 | | | | 2017 | | | | | | | | 2018 | | | | | | | |
| | | Spring | | Fall | | Spring | | Fall | | Spring | | | | Fall | | | | Spring | | | | Fall | | | |
| Species[3] | Diet[4] | C[1] | P | C | P | C | P | C | P | FM[2] | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP |
| American Crow (*Corvus brachyrhynchos*) | 8 (2, 7, 1, 4, 10, 3) | 5 | 14 | 61 | 87 | 55 | 49 | 31 | 18 | 3 | 10 | - | 6 | 72 | 52 | 2 | 22 | 40 | 54 | 1 | 9 | 24 | 16 | 5 | 4 |
| American Goldfinch (*Spinus tristis*) | 1, 10, 2 | 8 | 1 | 55 | 114 | 21 | 54 | 9 | 118 | 3 | 4 | 1 | 1 | 44 | 19 | 24 | 82 | 11 | 30 | 8 | 26 | 22 | 31 | 1 | 73 |
| American Kestrel (*Falco sparverius*) | 3 | - | 1 | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| American Redstart (*Setophaga ruticilla*) | 2 | - | 3 | 4 | 4 | - | - | 17 | 22 | 3 | - | - | - | 2 | 4 | 2 | - | - | - | - | - | 12 | 13 | 3 | 11 |
| American Robin (*Turdus migratorius*) | 2, 4, 9 | 33 | 19 | 26 | 24 | 122 | 55 | 19 | 16 | 21 | 15 | 3 | 13 | 11 | 18 | 13 | 8 | 55 | 85 | 10 | 27 | 13 | 14 | 2 | 6 |
| Bald Eagle (*Haliaeetus leucocephalus*) | 3, 5, 7 | - | - | - | 1 | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| Baltimore Oriole (*Icterus galbula*) | 2, 6 | - | - | 4 | - | - | - | - | - | - | - | - | - | - | - | 4 | - | - | - | - | - | - | - | - | - |
| Barn Swallow (*Hirundo rustica*) | 2 | 6 | 3 | - | - | 20 | 28 | 3 | 6 | 4 | 1 | 4 | - | - | - | - | - | 16 | 15 | 1 | 16 | 5 | 2 | - | 2 |
| Black-and-white Warbler (*Mniotilta varia*) | 2, 4 | - | - | 8 | 3 | - | - | 2 | - | - | - | - | - | 2 | 8 | - | 1 | - | - | - | - | - | 2 | - | - |
| Black-crowned Night Heron (*Nycticorax nycticorax*) | 3 | 2 | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Belted Kingfisher (*Megaceryle alcyon*) | 5 | - | - | - | 2 | - | - | - | 1 | - | - | - | - | 1 | 1 | - | - | - | - | - | - | 1 | - | - | - |

| | | Count at Control or Pollinator[1] Farm | | | | | | | | Count at Cover type Point[2] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | | | | 2018 | | | | 2017 | | | | | | | | 2018 | | | | | | | |
| | | Spring | | Fall | | Spring | | Fall | | Spring | | | | Fall | | | | Spring | | | | Fall | | | |
| Species[3] | Diet[4] | C[1] | P | C | P | C | P | C | P | FM[2] | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP |
| Blue-grey Gnatcatcher (*Polioptila caerulea*) | 2 | 5 | 7 | 7 | 10 | 76 | 123 | 5 | 3 | 4 | 8 | - | - | 3 | 11 | 1 | 2 | 39 | 97 | 17 | 46 | 5 | 3 | - | - |
| Brown-headed Cowbird (*Molothrus ater*) | 2, 4, 1 | 15 | 3 | 7 | 40 | 123 | 67 | 791 | 65 | 9 | 6 | 2 | 1 | 40 | 3 | 4 | - | 107 | 46 | 15 | 22 | 707 | 22 | 87 | 40 |
| Brown-headed Nuthatch (*Sitta pusilla*) | 2, 1 | - | - | - | - | - | 5 | - | - | - | - | - | - | - | - | - | - | 1 | 4 | - | - | - | - | - | - |
| Blue-headed Vireo (*Vireo solitarius*) | 2, 4, 1 | - | - | - | - | 3 | - | 5 | 1 | - | - | - | - | - | - | - | - | - | 3 | - | - | 5 | 1 | - | - |
| Blue Grosbeak (*Passerina caerulea*) | 2, 4, 1 | 18 | 26 | 10 | 40 | 45 | 52 | 51 | 82 | 14 | 15 | 1 | 14 | 18 | 7 | 9 | 16 | 42 | 22 | 7 | 26 | 34 | 38 | 22 | 39 |
| Blue Jay (*Cyanocitta cristata*) | 8 (2, 1, 7, 4, 3) | 11 | 8 | 60 | 55 | 35 | 36 | 40 | 61 | 8 | 7 | 1 | 3 | 38 | 43 | 13 | 21 | 22 | 36 | 3 | 10 | 44 | 37 | 4 | 16 |
| Black Vulture (*Coragyps atratus*) | 7 | - | - | - | - | 4 | 8 | - | - | - | - | - | - | - | - | - | - | 12 | - | - | - | - | - | - | - |
| Bobolink (*Dolichonyx oryzivorus*) | 2, 4, 1 | - | - | 30 | 160 | - | - | 30 | 15 | - | - | - | - | - | - | 30 | 160 | - | - | - | - | 30 | - | - | 15 |
| Brown Thrasher (*Toxostoma rufum*) | 2, 4 | 8 | 1 | 9 | - | 22 | 2 | 8 | 5 | 2 | 6 | 1 | - | 5 | 2 | 2 | - | 14 | 6 | 3 | 1 | 6 | 2 | 3 | 2 |
| Black Throated Blue Warbler (*Setophaga caerulescens*) | 2, 4 | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - |
| Carolina Chickadee (*Poecile carolinensis*) | 2, 4, 1 | 30 | 33 | 37 | 46 | 60 | 69 | 25 | 51 | 27 | 25 | 5 | 6 | 39 | 28 | 5 | 11 | 36 | 66 | 1 | 26 | 23 | 38 | 3 | 12 |
| Canada Goose (*Branta canadensis*) | 10 | - | - | 1 | 2 | 13 | 157 | 102 | - | - | - | - | - | - | 2 | - | 1 | 5 | 71 | 10 | 84 | 21 | - | 81 | - |
| Carolina Wren (*Thryothorus ludovicianus*) | 2, 4, 1 | 67 | 75 | 191 | 293 | 126 | 79 | 188 | 215 | 46 | 55 | 13 | 28 | 190 | 182 | 37 | 75 | 76 | 79 | 20 | 30 | 134 | 156 | 38 | 75 |
| Cedar Waxwing (*Bombycilla cedrorum*) | 4 | - | - | 17 | - | 14 | 13 | - | - | - | - | - | - | - | - | 17 | - | 2 | 12 | - | 13 | - | - | - | - |
| Chipping Sparrow (*Spizella passerina*) | 1, 2 | 55 | 51 | 8 | 34 | 247 | 349 | 42 | 64 | 54 | 29 | 5 | 18 | 10 | 7 | 3 | 22 | 205 | 204 | 35 | 152 | 39 | 18 | 16 | 33 |
| Chimney Swift | 2 | 3 | - | 1 | 2 | 9 | 14 | 4 | 41 | 1 | - | 2 | - | 1 | - | - | 2 | 13 | 1 | 2 | 7 | 29 | 16 | - | - |

| | | Count at Control or Pollinator[1] Farm | | | | | | | | Count at Cover type Point[2] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | | | | 2018 | | | | 2017 | | | | | | | | 2018 | | | | | | | |
| | | Spring | | Fall | | Spring | | Fall | | Spring | | | | Fall | | | | Spring | | | | Fall | | | |
| Species[3] | Diet[4] | C[1] | P | C | P | C | P | C | P | FM[2] | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP |
| (*Chaetura pelagica*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Common Grackle | 2, 4, 1, | 76 | 64 | 46 | 2 | 461 | 364 | 251 | 60 | 58 | 26 | 6 | 50 | - | 5 | 41 | 2 | 326 | 257 | 89 | 153 | 4 | 54 | 246 | 7 |
| (*Quiscalus quiscula*) | 3 | | | | | | | | | | | | | | | | | | | | | | | | |
| Common Yellowthroat | 2 | 11 | 10 | 5 | 6 | 27 | 20 | 23 | 15 | 5 | 7 | 6 | 3 | - | 6 | 2 | 3 | 9 | 17 | 13 | 8 | 3 | 28 | 1 | 6 |
| (*Geothlypis trichas*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dickcissle | 2, 4, 1 | 1 | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| (*Spiza americana*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Downy Woodpecker | 2, 1 | 2 | 11 | 6 | 6 | 13 | 26 | 7 | 19 | 3 | 7 | 2 | 1 | 6 | 4 | - | 2 | 11 | 21 | - | 7 | 8 | 8 | - | 10 |
| (*Picoides pubescens*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Eastern Bluebird | 2, 4 | 1 | 3 | 17 | 16 | 3 | 13 | 53 | 25 | 1 | - | - | 3 | 10 | - | 14 | 9 | 3 | 4 | 3 | 6 | 47 | 12 | 8 | 11 |
| (*Sialia sialis*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Eastern Kingbird | 2, 4 | - | 5 | 6 | - | 3 | 5 | 1 | 1 | 2 | 3 | - | - | 1 | 5 | - | - | 3 | - | 3 | 2 | - | 2 | - | - |
| (*Tyrannus tyrannus*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Eastern Meadowlark | 2, 4, 1 | 7 | 3 | - | - | 27 | 7 | 2 | - | 7 | - | 1 | 2 | - | - | - | - | 11 | 6 | 12 | 5 | 2 | - | - | - |
| (*Sturnella magna*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Eastern Phoebe | 2, 4 | - | - | 2 | 5 | - | - | 1 | 2 | - | - | - | - | 1 | 3 | - | 3 | - | - | - | - | 1 | 2 | - | - |
| (*Sayornis phoebe*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Eastern Towhee | 1, 2 | 5 | 6 | - | - | 4 | - | - | - | 6 | 3 | 2 | - | - | - | - | - | 1 | 2 | 1 | - | - | - | - | - |
| (*Pipilo erythrophthalmus*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Eastern Wood Pewee | 2, 4 | - | - | 3 | 7 | 4 | 3 | 5 | 6 | - | - | - | - | 6 | 4 | - | - | 1 | 4 | 1 | 1 | 8 | - | 1 | 2 |
| (*Contopus virens*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Eastern Screech Owl | 8 (3, 2, | - | - | 1 | 2 | - | - | - | - | - | - | - | - | 1 | 1 | - | 1 | - | - | - | - | - | - | - | - |
| (*Megascops asio*) | 5) | | | | | | | | | | | | | | | | | | | | | | | | |
| European Starling* | 2, 4, 1, | 92 | 29 | 28 | 38 | 44 | 237 | 104 | 385 | 24 | 26 | 57 | 14 | 1 | 28 | - | 37 | 28 | 132 | 14 | 107 | 200 | 138 | 11 | 140 |
| (*Sturnus vulgaris*) | 6 | | | | | | | | | | | | | | | | | | | | | | | | |
| Field Sparrow | 1, 2 | 16 | 12 | 10 | 43 | 59 | 36 | 35 | 15 | 4 | 11 | 10 | 3 | 10 | 15 | 6 | 22 | 17 | 52 | 9 | 17 | 7 | 18 | 13 | 12 |
| (*Spizella pusilla*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Great Blue Heron | 3 | - | - | 1 | 5 | - | - | - | 1 | - | - | - | - | 2 | 4 | - | - | - | - | - | - | - | - | - | 1 |
| (*Ardea herodias*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Great Crested Flycatcher | 2, 4 | 4 | 7 | 4 | 1 | 39 | 42 | 5 | 3 | 4 | 7 | - | - | 5 | - | - | - | 27 | 43 | 5 | 6 | 2 | 2 | 2 | 2 |
| (*Myiarchus crinitus*) | | | | | | | | | | | | | | | | | | | | | | | | | |

| | | Count at Control or Pollinator[1] Farm | | | | | | | | Count at Cover type Point[2] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | | | | 2018 | | | | 2017 | | | | | | | | 2018 | | | | | | | |
| | | Spring | | Fall | | Spring | | Fall | | Spring | | | | Fall | | | | Spring | | | | Fall | | | |
| Species[3] | Diet[4] | C[1] | P | C | P | C | P | C | P | FM[2] | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP |
| Great Horned Owl (*Bubo virginianus*) | 8 (3, 2, 5) | - | - | 1 | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| Gray Catbird (*Dumetella carolinensis*) | 2, 4 | 4 | 2 | 17 | 23 | 22 | 4 | 43 | 28 | 2 | 2 | 2 | - | 15 | 13 | 5 | 7 | 6 | 12 | 6 | 2 | 22 | 31 | 11 | 7 |
| Green Heron (*Dumetella carolinensis*) | 3 | - | 2 | - | - | 2 | - | - | - | - | 2 | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - |
| Grasshopper Sparrow (*Ammodramus savannarum*) | 1, 2 | 26 | 17 | - | - | 84 | 102 | 4 | 41 | 29 | 2 | 2 | 10 | - | - | - | - | 73 | 70 | 10 | 33 | 5 | 2 | 2 | 36 |
| Hairy Woodpecker (*Leuconotopicus villosus*) | 2, 1 | - | - | 2 | 6 | - | - | 1 | - | - | - | - | - | 7 | - | 1 | - | - | - | - | - | - | - | 1 | - |
| Herring Gull (*Larus argentatus*) | 8 (3, 2, 5, 7, 1, 4) | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - |
| Hermit Thrush (*Catharus guttatus*) | 2, 4 | 1 | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| House Finch (*Haemorhous mexicanus*) | 1, 10, 2 | - | - | - | - | 1 | 1 | 2 | 2 | - | - | - | - | - | - | - | - | 1 | 1 | - | - | 4 | - | - | - |
| Horned Lark (*Eremophila alpestris*) | 1, 2 | - | - | - | - | 12 | - | - | - | - | - | - | - | - | - | - | - | 12 | - | - | - | - | - | - | - |
| House Sparrow* (*Passer domesticus*) | 1, 2 | - | - | - | 32 | - | 15 | - | - | - | - | - | - | 31 | 1 | - | - | 1 | - | - | 14 | - | - | - | - |
| House Wren (*Troglodytes aedon*) | 2 | 1 | - | 3 | 1 | - | - | 1 | - | - | 1 | - | - | - | 2 | 1 | 1 | - | - | - | - | 1 | - | - | - |
| Indigo Bunting (*Passerina cyanea*) | 2, 1 | 1 | 11 | - | - | 89 | 127 | 20 | 40 | 7 | 2 | - | 3 | - | - | - | - | 74 | 92 | 17 | 33 | 22 | 20 | 8 | 10 |
| Kentucky Warbler (*Geothlypis formosa*) | 2 | - | - | 2 | 1 | - | - | - | 2 | - | - | - | - | - | 1 | 1 | 1 | - | - | - | - | - | 2 | - | - |
| Killdeer (*Charadrius vociferus*) | 8 (2, 9, 4, 11, 12) | 3 | 4 | 19 | 8 | - | 1 | 2 | 2 | 3 | - | - | 4 | 19 | 1 | 4 | 3 | 1 | - | - | - | 2 | 2 | - | - |
| Laughing Gull | 8 (3, 5, | 3 | 1 | - | 2 | 220 | 393 | - | - | 3 | 1 | - | - | - | - | - | 2 | 222 | 190 | - | 201 | - | - | - | - |

| | | Count at Control or Pollinator[1] Farm | | | | | | | | Count at Cover type Point[2] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | | | | 2018 | | | | 2017 | | | | | | | | 2018 | | | | | | | |
| | | Spring | | Fall | | Spring | | Fall | | Spring | | | | Fall | | | | Spring | | | | Fall | | | |
| Species[3] | Diet[4] | C[1] | P | C | P | C | P | C | P | FM[2] | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP |
| (*Leucophaeus atricilla*) | 2, 7, 1, 4) | | | | | | | | | | | | | | | | | | | | | | | | |
| Marsh Wren (*Cistothorus palustris*) | 2 | - | - | - | - | - | 2 | - | 2 | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | 2 |
| Mourning Dove (*Zenaida macroura*) | 1, 4 | 2 | 5 | 50 | 12 | 18 | 9 | 39 | 55 | 1 | 2 | - | 4 | 13 | 37 | 1 | 11 | 18 | 1 | 1 | 7 | 40 | 18 | 33 | 3 |
| Nashville Warbler (*Leiothlypis ruficapilla*) | 2, 4 | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - |
| Nelson's Sparrow (*Ammodramus nelsoni*) | 1, 2 | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - |
| Northern Bobwhite (*Colinus virginianus*) | 10, 1, 2 | 1 | - | 1 | 1 | 5 | - | - | - | 1 | - | - | - | 2 | - | - | - | - | 4 | 1 | - | - | - | - | - |
| Northern Cardinal (*Cardinalis cardinalis*) | 2, 4, 1 | 79 | 71 | 78 | 98 | 262 | 301 | 116 | 99 | 51 | 66 | 11 | 22 | 64 | 74 | 11 | 27 | 210 | 233 | 36 | 84 | 74 | 98 | 24 | 19 |
| Northern Flicker (*Colaptes auratus*) | 2, 4, 1 | - | 4 | 24 | 24 | 7 | 5 | 39 | 31 | - | 4 | - | - | 15 | 19 | 8 | 6 | 5 | 7 | - | - | 27 | 20 | 11 | 12 |
| Northern Mockingbird (*Mimus polyglottos*) | 2, 4 | 5 | 6 | 10 | 6 | 28 | 16 | 48 | 45 | 7 | 2 | - | 2 | 8 | 6 | - | 2 | 15 | 20 | 3 | 6 | 37 | 43 | 7 | 6 |
| Northern Parula (*Setophaga americana*) | 2, 4 | - | - | - | - | 1 | 2 | 1 | 7 | - | - | - | - | - | - | - | - | 1 | 1 | - | 1 | 5 | 3 | - | - |
| Northern Waterthrush (*Parkesia noveboracensis*) | 2, 4 | - | - | - | 1 | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| Orchard Oriole (*Icterus spurius*) | 2, 6 | - | 1 | - | - | 11 | 18 | - | - | - | 1 | - | - | - | - | - | - | 11 | 5 | 7 | 6 | - | - | - | - |
| Osprey (*Pandion haliaetus*) | 5 | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - |
| Ovenbird (*Seiurus aurocapilla*) | 2, 4 | 4 | 11 | 1 | - | 17 | 10 | - | - | 7 | 6 | - | 2 | - | 1 | - | - | 9 | 18 | - | - | - | - | - | - |
| Palm Warbler (*Setophaga palmarum*) | 2, 4 | - | - | - | - | 1 | - | 6 | - | - | - | - | - | - | - | - | - | 1 | - | - | - | 6 | - | - | - |
| Pine Siskin | 1, 10, 2 | - | - | - | - | 2 | 1 | - | - | - | - | - | - | - | - | - | - | 2 | - | - | 1 | - | - | - | - |

| | | Count at Control or Pollinator[1] Farm | | | | | | | | Count at Cover type Point[2] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | | | | 2018 | | | | 2017 | | | | | | | | 2018 | | | | | | | |
| | | Spring | | Fall | | Spring | | Fall | | Spring | | | | Fall | | | | Spring | | | | Fall | | | |
| Species[3] | Diet[4] | C[1] | P | C | P | C | P | C | P | FM[2] | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP |
| (*Spinus pinus*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pine Warbler | 2, 4 | - | 2 | 5 | 54 | 1 | 6 | 6 | 1 | - | 2 | - | - | 13 | 7 | - | 39 | 1 | 6 | - | - | 4 | 2 | - | 1 |
| (*Setophaga pinus*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pileated Woodpecker | 2 | 2 | 1 | 3 | 10 | 2 | 1 | 7 | 1 | 1 | 1 | 1 | - | 3 | 6 | - | 4 | 1 | 1 | - | 1 | 3 | 3 | 2 | - |
| (*Dryocopus pileatus*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Prairie Warbler | 2, 4 | - | - | - | - | 9 | 2 | 4 | 2 | - | - | - | - | - | - | - | - | 4 | 7 | - | - | 5 | 1 | - | - |
| (*Setophaga discolor*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Prothonotary Warbler | 2, 4 | - | - | - | - | - | 5 | - | - | - | - | - | - | - | - | - | - | - | 5 | - | - | - | - | - | - |
| (*Protonotaria citrea*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Purple Martin | 2 | - | - | - | - | 3 | 5 | 1 | 38 | - | - | - | - | - | - | - | - | 3 | 1 | 1 | 3 | 17 | 9 | 1 | 12 |
| (*Progne subis*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rose-breasted Grosebeak | 2, 4, 1 | 1 | - | - | - | - | - | 3 | 5 | - | - | 1 | - | - | - | - | - | - | - | - | - | 6 | 1 | - | 1 |
| (*Pheucticus ludovicianus*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Red-breasted Nuthatch | 2, 1 | - | - | - | - | - | - | - | 3 | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | - | 1 |
| (*Sitta canadensis*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Red-bellied Woodpecker | 2, 1 | 17 | 13 | 2 | 3 | 28 | 29 | 11 | 17 | 6 | 17 | 5 | 2 | - | 4 | - | 1 | 15 | 24 | 5 | 13 | 10 | 10 | 1 | 7 |
| (*Melanerpes carolinus*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ruby-crowned Kinglet | 2 | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - |
| (*Regulus calendula*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Red-eyed Vireo | 2, 4 | 6 | 2 | 4 | 1 | 16 | 29 | 6 | 9 | 2 | 5 | 1 | - | 3 | 1 | 1 | - | 29 | 13 | - | 3 | 3 | 8 | - | 4 |
| (*Vireo olivaceus*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Red-headed Woodpecker | 2, 1 | - | - | - | - | 1 | 5 | - | 4 | - | - | - | - | - | - | - | - | - | 6 | - | - | - | 4 | - | - |
| (*Melanerpes erythrocephalus*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rock Pigeon* | 1, 4 | - | - | - | - | - | - | 1 | 3 | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | 1 | 1 |
| (*Columba livia*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Red-shouldered Hawk | 3 | - | - | - | 3 | - | 2 | - | 1 | - | - | - | - | 2 | - | - | 1 | 1 | 1 | - | - | 1 | - | - | - |
| (*Buteo lineatus*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Red-tailed Hawk | 3 | - | 2 | 1 | 2 | - | 5 | - | 1 | 2 | - | - | - | - | 1 | 1 | 1 | 2 | 2 | - | 1 | - | 1 | - | - |
| (*Buteo jamaicensis*) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ruby-throated Hummingbird | 6 | 1 | 3 | 1 | 14 | 2 | 4 | 6 | 7 | 2 | 2 | - | - | 3 | 4 | 1 | 7 | 1 | 4 | - | 1 | 6 | 2 | 3 | 2 |
| (*Archilochus colubris*) | | | | | | | | | | | | | | | | | | | | | | | | | |

| | | Count at Control or Pollinator[1] Farm | | | | | | | | Count at Cover type Point[2] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | | | | 2018 | | | | 2017 | | | | | | | | 2018 | | | | | | | |
| | | Spring | | Fall | | Spring | | Fall | | Spring | | | | Fall | | | | Spring | | | | Fall | | | |
| Species[3] | Diet[4] | C[1] | P | C | P | C | P | C | P | FM[2] | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP |
| Red-winged Blackbird (*Agelaius phoeniceus*) | 2, 4, 1 | 47 | 11 | 2 | - | 149 | 206 | 2 | 2 | 35 | 9 | 9 | 5 | - | - | 2 | - | 127 | 117 | 39 | 72 | - | 2 | 2 | - |
| Scarlet Tanager (*Piranga olivacea*) | 2, 4 | - | 1 | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Semipalmated Plover (*Charadrius semipalmatus*) | 8 (2, 9, 4, 11, 12) | - | - | - | - | 8 | - | - | - | - | - | - | - | - | - | - | - | 8 | - | - | - | - | - | - | - |
| Snow Goose (*Chen caerulescens*) | 10 | - | - | - | - | - | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | 7 | - | - | - | - |
| Song Sparrow (*Melospiza melodia*) | 1, 2 | 6 | 1 | - | 2 | 35 | 27 | 18 | 15 | 3 | 4 | - | - | 2 | - | - | - | 21 | 12 | 11 | 18 | 12 | 19 | 2 | - |
| Summer Tanager (*Piranga rubra*) | 2, 4 | 1 | 1 | 3 | 5 | 4 | 12 | 1 | 9 | 2 | - | - | - | 4 | 1 | 1 | 2 | 4 | 10 | 1 | 1 | 3 | 5 | - | 2 |
| Swamp Sparrow (*Melospiza georgiana*) | 1, 2 | 1 | - | - | 1 | 6 | - | - | - | - | 1 | - | - | - | 1 | - | - | - | - | 6 | - | - | - | - | - |
| Tree Swallow (*Tachycineta bicolor*) | 2 | 35 | 40 | 31 | 96 | 153 | 114 | 16 | 21 | 28 | 1 | 31 | 15 | 54 | 52 | 13 | 8 | 190 | 56 | 3 | 18 | 7 | 26 | - | 4 |
| Tufted Titmouse (*Baeolophus bicolor*) | 2, 4, 1 | 5 | 25 | 21 | 53 | 46 | 59 | 5 | 40 | 15 | 11 | - | 4 | 25 | 28 | 8 | 13 | 40 | 45 | 4 | 16 | 13 | 25 | 2 | 5 |
| Turkey Vulture (*Cathartes aura*) | 7 | 1 | 2 | - | 6 | 25 | 39 | 4 | 13 | 3 | - | - | - | - | 6 | - | - | 33 | 21 | 1 | 9 | 6 | 4 | - | 7 |
| Unknown Hawk (*Accipitridae spp.*) | NA | - | 2 | 1 | 1 | - | - | - | - | 2 | - | - | - | - | 1 | 1 | - | - | - | - | - | - | - | - | - |
| Unknown Flycatcher (*Tyrannidae spp.*) | NA | - | - | 2 | 1 | - | - | - | 1 | - | - | - | - | 2 | - | 1 | - | - | - | - | - | - | 1 | - | - |
| Unknown Gull (*Laridae spp.*) | NA | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - |
| Unknown spp. | NA | 33 | 37 | 39 | 59 | 34 | 46 | 41 | 46 | 23 | 25 | 8 | 14 | 32 | 38 | 9 | 19 | 22 | 34 | 8 | 16 | 28 | 29 | 16 | 14 |
| Unknown Sparrow (*Passeridae spp.*) | NA | 10 | 5 | 85 | 79 | 13 | 31 | 1 | 2 | - | 11 | - | 4 | 53 | 50 | 28 | 33 | 10 | 18 | - | 16 | - | 2 | 1 | - |

| | | Count at Control or Pollinator[1] Farm | | | | | | | | Count at Cover type Point[2] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | | | | 2018 | | | | 2017 | | | | | | | | 2018 | | | | | | | |
| | | Spring | | Fall | | Spring | | Fall | | Spring | | | | Fall | | | | Spring | | | | Fall | | | |
| Species[3] | Diet[4] | C[1] | P | C | P | C | P | C | P | FM[2] | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP |
| Unknown Swallow (*Hirundinidae spp.*) | NA | - | - | 1 | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - |
| Unknown Warbler (*Parulidae spp.*) | NA | 5 | - | 4 | 10 | 2 | 1 | - | - | 3 | - | 2 | - | - | 6 | 2 | 6 | - | 1 | 2 | - | - | - | - | - |
| Unknown Woodpecker (*Picidae spp.*) | NA | 1 | - | 3 | 3 | - | 2 | - | - | - | 1 | - | - | 1 | 1 | 1 | 3 | - | 2 | - | - | - | - | - | - |
| Warbling Vireo (*Vireo gilvus*) | 2, 4, 1 | - | - | - | - | - | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - |
| White-breasted Nuthatch (*Sitta carolinensis*) | 2, 1 | - | - | - | 3 | - | - | - | - | - | - | - | - | 2 | - | - | 1 | - | - | - | - | - | - | - | - |
| White-eyed Vireo (*Vireo griseus*) | 2, 4, 1 | 6 | 3 | - | 9 | 26 | 18 | 11 | 17 | 2 | 5 | 2 | - | - | 6 | - | 3 | 16 | 18 | 6 | 4 | 1 | 13 | 7 | 7 |
| Worm-eating Warbler (*Helmitheros vermivorum*) | 2, 4 | - | - | - | - | 7 | - | - | - | - | - | - | - | - | - | - | - | 7 | - | - | - | - | - | - | - |
| White Ibis (*Eudocimus albus*) | 8 (2, 9, 11, 12, 1, 4, 5) | - | - | - | - | 3 | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | - | - | - |
| Willow Flycatcher (*Empidonax traillii*) | 2, 4 | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - |
| Wild Turkey (*Meleagris gallopavo*) | 10, 2 | - | 1 | - | 1 | 1 | 5 | 1 | - | - | 1 | - | - | - | - | - | 1 | - | 6 | - | - | - | 1 | - | - |
| Wood Duck (*Aix sponsa*) | 10, 1, 2, 11 | 3 | - | - | - | - | 1 | - | - | - | - | 3 | - | - | - | - | - | - | 1 | - | - | - | - | - | - |
| Wood Thrush (*Hylocichla mustelina*) | 2, 4 | - | 2 | - | - | - | 7 | - | - | 1 | - | - | 1 | - | - | - | - | 4 | - | - | 3 | - | - | - | - |
| White-throated Sparrow (*Zonotrichia albicollis*) | 1, 2 | 29 | 50 | - | - | 129 | 245 | 11 | 3 | 41 | 29 | 6 | 3 | - | - | - | - | 161 | 144 | 15 | 54 | - | 3 | 11 | - |
| Yellow-breasted Chat (*Icteria virens*) | 2 | 3 | - | - | - | 2 | 3 | - | - | 1 | 1 | 1 | - | - | - | - | - | 1 | 2 | - | 2 | - | - | - | - |
| Yellow-billed Cuckoo (*Coccyzus americanus*) | 2 | - | - | - | 2 | 10 | 8 | 1 | 2 | - | - | - | - | - | 2 | - | - | 3 | 9 | 4 | 2 | 1 | 2 | - | - |

| | | Count at Control or Pollinator[1] Farm | | | | | | | | Count at Cover type Point[2] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | | | | 2018 | | | | 2017 | | | | | | | | 2018 | | | | | | | |
| | | Spring | | Fall | | Spring | | Fall | | Spring | | | | Fall | | | | Spring | | | | Fall | | | |
| Species[3] | Diet[4] | C[1] | P | C | P | C | P | C | P | FM[2] | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP | FM | FU | NH | PP |
| Yellow-bellied Sapsucker (*Sphyrapicus varius*) | 2 | - | 1 | - | - | 1 | - | - | - | 1 | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - |
| Yellow Warbler (*Setophaga petechia*) | 2, 4 | - | - | - | - | 4 | 2 | - | - | - | - | - | - | - | - | - | - | 2 | - | 4 | - | - | - | - | - |
| Yellow-rumped Warbler (*Setophaga coronata*) | 2, 4 | 21 | 9 | - | - | 52 | 156 | - | - | 14 | 7 | 7 | 2 | - | - | - | - | 67 | 114 | 2 | 25 | - | - | - | - |
| Yellow-throated Warbler (*Setophaga dominica*) | 2, 4 | 4 | - | - | - | 2 | 18 | - | - | - | 4 | - | - | - | - | - | - | 5 | 4 | - | 11 | - | - | - | - |

[1]: Denotes control farms (C), without pollinator plot, and pollinator farms (P) with pollinator plot.

[2]: Point types, FU: Forest Unmanaged, FM: Forest Managed, NH: Novelty Habitat, PP: Pollinator Plot.

[3]: A species not native to the United States is denoted by *. Status gathered from Sibley (2017).

[5]: Numbers denote diet classifications, 1: Granivore, 2: Insectivore, 3: Carnivore, 4: Frugivore, 5: Piscivore, 6: Nectarivore, 7: Scavenger, 8: Omnivore, 9: Vermivore, 10: Herbivore, 11: Molluscivore, 12: Crustaceovore. Diet information gathered from Sibley et al. (2001).

Appendix F: Top and competing models ( ΔAIC<4) for each analyzed bird species from presence/absence binomial logistic regression analysis of bird point count data during Spring (April 8th- June 5th) of 2017 and 2018 on 20 farms study sites across the Coastal Plain of Virginia and Maryland.

| | | (Intercept) | β Coefficient (SE)[2] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avian | | 2017 or | | | % of cover within 1 kilometer | | | | | | | | Hosmer-Lemeshow | |
| Code[1] | Top Model Covariates[2] | Control | Year (2018) | Pollinator | Developed | Natural | Cropland | Water | df | AICc | ΔAIC | $w_i$ | statistic | p-value |
| AMRO | **% Developed in 1km** | **-0.42(0.77)** | **-** | **-** | **0.21(0.12)** | **-** | **-** | **-** | **3** | **44.86** | **0** | **0.51** | **7.62** | **0.47** |
| | % Developed in 1km & % Water in 1km | -0.01(0.88) | - | - | 0.17(0.12) | - | - | -0.02(0.03) | 4 | 46.66 | 1.80 | 0.21 | 5.32 | 0.72 |
| | % Water in 1km | 1.36(0.44) | - | - | - | - | - | -0.04(0.03) | 3 | 48.71 | 3.85 | 0.07 | 5.60 | 0.69 |
| | NULL | 1.06(0.37) | - | - | - | - | - | - | 2 | 48.74 | 3.88 | 0.07 | 15.69 | 0.05 |
| BGGN | **Year of Survey** | **-0.84(0.49)** | **2.52(0.80)** | **-** | **-** | **-** | **-** | **-** | **3** | **47.69** | **0** | **0.98** | **0** | **1** |
| BRTH | NULL | -0.62(0.39) | - | - | - | - | - | - | 2 | 55.16 | 0 | 0.06 | 16.38 | 0.04 |
| | Year of Survey | -1.23(0.64) | 1.11(0.78) | - | - | - | - | - | 3 | 55.20 | 0.05 | 0.06 | 16.80 | 0.03 |
| | Pollinator Plot Presence | -0.11(0.48) | - | -1.01(0.73) | - | - | - | - | 3 | 55.45 | 0.30 | 0.05 | NC | - |
| | **Pollinator Plot Presence & % Natural in 1km** | **-1.41(1.00)** | **-** | **-1.53(0.83)** | **-** | **0.04(0.03)** | **-** | **-** | **4** | **55.47** | **0.31** | **0.05** | **9.91** | **0.27** |
| | Year of Survey & Pollinator Plot Presence | -0.67(0.66) | 1.16(0.78) | -1.16(0.82) | - | - | - | - | 4 | 55.47 | 0.31 | 0.05 | 6.68 | 0.57 |
| | Year of Survey & Pollinator Plot Presence & % Natural in 1km | -2.15(1.29) | 1.21(0.80) | -1.74(1.00) | - | 0.05(0.03) | - | - | 5 | 55.48 | 0.32 | 0.05 | 6.01 | 0.65 |
| | Pollinator Plot Presence & % Developed in 1km & % Natural in 1km | -2.49(1.32) | - | -1.57(0.90) | 0.03(0.02) | 0.06(0.03) | - | - | 5 | 56.04 | 0.88 | 0.04 | 7.14 | 0.52 |
| | % Water in 1km | -0.42(0.41) | - | - | - | - | - | -0.04(0.04) | 3 | 56.25 | 1.09 | 0.03 | 12.47 | 0.13 |
| | Pollinator Plot Presence & % Crop in 1km & % Water in 1km | 1.87(1.30) | - | -1.24(0.75) | - | - | -0.03(0.02) | -0.06(0.04) | 5 | 56.29 | 1.14 | 0.03 | 5.78 | 0.67 |
| | Pollinator Plot Presence & % Water in 1km | 0.15(0.51) | - | -1.10(0.74) | - | - | - | -0.04(0.04) | 4 | 56.30 | 1.14 | 0.03 | 12.67 | 0.12 |
| | Year of Survey & Pollinator Plot Presence & % Water in 1km | -0.39(0.66) | 1.21(0.80) | -1.27(0.83) | - | - | - | -0.05(0.04) | 5 | 56.31 | 1.15 | 0.03 | 14.36 | 0.07 |
| | Year of Survey & % Water in 1km | -1.02(0.64) | 1.14(0.79) | - | - | - | - | -0.04(0.05) | 4 | 56.35 | 1.19 | 0.03 | 10.88 | 0.21 |
| | % Crop in 1km | 0.26(0.93) | - | - | - | - | -0.02(0.02) | - | 3 | 56.48 | 1.33 | 0.03 | 7.09 | 0.53 |
| | % Developed in 1km | -0.85(0.48) | - | - | 0.02(0.02) | - | - | - | 3 | 56.50 | 1.34 | 0.03 | 12.95 | 0.11 |
| | % Crop in 1km & % Water in 1km | 1.01(1.07) | - | - | - | - | -0.03(0.02) | -0.06(0.04) | 4 | 56.56 | 1.41 | 0.03 | 8.26 | 0.41 |

| Avian Code[1] | Top Model Covariates[2] | (Intercept) 2017 or Control | β Coefficient (SE)[2] Year (2018) | Pollinator | % of cover within 1 kilometer Developed | Natural | Cropland | Water | df | AICc | ΔAIC | $w_i$ | Hosmer-Lemeshow statistic | p-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year of Survey & % Developed in 1km | -1.49(0.01) | 1.12(0.01) | - | 0.02(0.01) | - | - | - | 4 | 56.67 | 1.52 | 0.03 | 12.47 | 0.13 |
| | Year of Survey & % Crop in 1km | -0.28(1.08) | 1.10(0.77) | - | - | - | -0.02(0.02) | - | 4 | 56.71 | 1.55 | 0.03 | 7.61 | 0.47 |
| | % Natural in 1km | -1.37(1.03) | - | - | - | 0.02(0.02) | - | - | 3 | 56.81 | 1.65 | 0.02 | 5.51 | 0.70 |
| | Year of Survey & % Crop in 1km & % Water in 1km | 0.54(1.19) | 1.15(0.79) | - | - | - | -0.03(0.02) | -0.06(0.05) | 5 | 56.81 | 1.66 | 0.02 | 15.95 | 0.04 |
| | Pollinator Plot Presence & % Crop in 1km | 0.72(0.98) | - | -1.00(0.73) | - | - | -0.02(0.02) | - | 4 | 56.95 | 1.79 | 0.02 | 5.11 | 0.75 |
| | % Developed in 1km & % Natural in 1km | -2.39(1.31) | - | - | 0.03(0.02) | 0.04(0.03) | - | - | 4 | 56.97 | 1.82 | 0.02 | 11.74 | 0.16 |
| | Year of Survey & % Natural in 1km | -2.05(1.25) | 1.10(0.77) | - | - | 0.02(0.03) | - | - | 4 | 57.00 | 1.84 | 0.02 | 9.01 | 0.34 |
| | Year of Survey & Pollinator Plot Presence & % Crop in 1km | 0.23(1.11) | 1.16(0.79) | -1.15(0.82) | - | - | -0.02(0.02) | - | 5 | 57.13 | 1.98 | 0.02 | 6.71 | 0.57 |
| | Pollinator Plot Presence & % Natural in 1km & % Water in 1km | -1.02(1.06) | - | -1.56(0.84) | - | 0.04(0.03) | - | -0.03(0.04) | 5 | 57.18 | 2.02 | 0.02 | 4.99 | 0.76 |
| | Year of Survey & % Developed in 1km & % Natural in 1km | -3.17(1.59) | 1.13(0.78) | - | 0.04(0.03) | 0.04(0.03) | - | - | 5 | 57.29 | 2.13 | 0.02 | 10.51 | 0.23 |
| | Pollinator Plot Presence & % Developed in 1km | -0.33(0.60) | - | -0.89(0.74) | 0.01(0.02) | - | - | - | 4 | 57.48 | 2.32 | 0.02 | 9.60 | 0.29 |
| | Pollinator Plot Presence & % Natural in 1km & % Crop in 1km | -0.69(1.37) | - | -1.53(0.86) | - | 0.04(0.03) | -0.01(0.02) | - | 5 | 57.58 | 2.43 | 0.02 | 14.48 | 0.07 |
| | Year of Survey & Pollinator Plot Presence & % Developed in 1km | -0.91(0.76) | -1.1(0.78) | -1.02(0.83) | 0.01(0.02) | - | - | - | 5 | 57.66 | 2.50 | 0.02 | 7.63 | 0.47 |
| | % Developed in 1km & % Water in 1km | -0.64(0.49) | - | - | 0.02(0.02) | - | - | -0.04(0.04) | 4 | 57.87 | 2.71 | 0.01 | 7.56 | 0.48 |
| | Year of Survey & % Developed in 1km & % Water in 1km | -1.27(0.01) | 1.15(0.01) | - | 0.02(0.01) | - | - | -0.04(0.01) | 5 | 58.11 | 2.95 | 0.01 | 7.45 | 0.49 |
| | % Natural in 1km & % Water in 1km | -0.96(1.08) | - | - | - | 0.01(0.03) | - | -0.03(0.04) | 4 | 58.42 | 3.26 | 0.01 | 3.79 | 0.88 |
| | % Natural in 1km & % Crop in 1km | -0.43(1.41) | - | - | - | 0.02(0.02) | -0.02(0.02) | - | 4 | 58.56 | 3.41 | 0.01 | 5.25 | 0.73 |
| | Pollinator Plot Presence & % Developed in 1km & % Water in 1km | -0.03(0.61) | - | -1.00(0.75) | 0.01(0.02) | - | - | -0.04(0.04) | 5 | 58.63 | 3.47 | 0.01 | 12.93 | 0.11 |
| | Year of Survey & % Natural in 1km & % Water in 1km | -1.61(0.01) | 1.14(0.01) | - | - | 0.01(0.01) | - | -0.04(0.01) | 5 | 58.68 | 3.52 | 0.01 | 6.96 | 0.54 |
| | % Developed in 1km & % Crop in 1km | -0.21(1.31) | - | - | 0.01(0.03) | - | -0.01(0.02) | - | 4 | 58.72 | 3.56 | 0.01 | 13.43 | 0.10 |
| | Year of Survey & % Natural in 1km & % Crop in 1km | -1.04(1.62) | 1.10(0.78) | - | - | 0.02(0.03) | -0.02(0.02) | - | 5 | 58.94 | 3.78 | 0.01 | 9.63 | 0.29 |
| | Year of Survey & % Developed in 1km & % Crop in 1km | -0.81(1.50) | 1.11(0.78) | - | 0.01(0.03) | - | -0.01(0.03) | - | 5 | 59.07 | 3.92 | 0.01 | 8.51 | 0.39 |
| COYE | Pollinator Plot Presence | 0.6(0.58) | - | -1.31(0.85) | - | - | - | - | 3 | 57.23 | 0 | 0.09 | NC | - |
| | **Pollinator Plot Presence & % Water in 1km** | **0.95(0.64)** | **-** | **-1.44(0.85)** | **-** | **-** | **-** | **-0.05(0.03)** | **4** | **57.55** | **0.33** | **0.08** | **10.31** | **0.24** |
| | NULL | -0.07(0.42) | - | - | - | - | - | - | 2 | 57.61 | 0.38 | 0.07 | NC | - |

| | | (Intercept) | β Coefficient (SE)[2] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avian | | 2017 or | | | % of cover within 1 kilometer | | | | | | | | Hosmer-Lemeshow | |
| Code[1] | Top Model Covariates[2] | Control | Year (2018) | Pollinator | Developed | Natural | Cropland | Water | df | AICc | ΔAIC | $w_i$ | statistic | p-value |
| | Year of Survey & Pollinator Plot Presence | 0.19(0.69) | 0.97(0.79) | -1.45(0.94) | - | - | - | - | 4 | 58.06 | 0.83 | 0.06 | 12.93 | 0.11 |
| | Year of Survey & Pollinator Plot Presence & % Water in 1km | 0.56(0.72) | 1(0.79) | -1.59(0.94) | - | - | - | -0.05(0.04) | 5 | 58.42 | 1.20 | 0.05 | 13.18 | 0.11 |
| | Year of Survey | -0.53(0.61) | 0.93(0.8) | - | - | - | - | - | 3 | 58.43 | 1.20 | 0.05 | 13.52 | 0.10 |
| | Pollinator Plot Presence & % Crop in 1km | -0.41(1.06) | - | -1.33(0.84) | - | - | 0.02(0.02) | - | 4 | 58.51 | 1.29 | 0.05 | 7.59 | 0.47 |
| | % Water in 1km | 0.16(0.41) | - | - | - | - | - | -0.04(0.01) | 3 | 58.53 | 1.30 | 0.05 | 12.10 | 0.15 |
| | % Crop in 1km | -1.08(1.11) | - | - | - | - | 0.02(0.02) | - | 3 | 58.94 | 1.71 | 0.04 | 10.97 | 0.20 |
| | Year of Survey & Pollinator Plot Presence & % Crop in 1km | -0.94(1.22) | 0.99(0.79) | -1.47(0.92) | - | - | 0.03(0.02) | - | 5 | 59.41 | 2.18 | 0.03 | 12.00 | 0.15 |
| | Pollinator Plot Presence & % Developed in 1km | 0.79(0.7) | - | -1.41(0.88) | -0.01(0.02) | - | - | - | 4 | 59.44 | 2.21 | 0.03 | 8.99 | 0.34 |
| | Pollinator Plot Presence & % Natural in 1km | 0.12(1.07) | - | -1.49(0.93) | - | 0.02(0.03) | - | - | 4 | 59.44 | 2.22 | 0.03 | 10.86 | 0.21 |
| | Year of Survey & % Water in 1km | -0.28(0.6) | 0.93(0.79) | - | - | - | - | -0.04(0.04) | 4 | 59.46 | 2.23 | 0.03 | 7.76 | 0.46 |
| | Pollinator Plot Presence & % Developed in 1km & % Water in 1km | 1.25(0.78) | - | -1.59(0.88) | -0.02(0.02) | - | - | -0.05(0.03) | 5 | 59.62 | 2.39 | 0.03 | 10.06 | 0.26 |
| | Pollinator Plot Presence & % Crop in 1km & % Water in 1km | 0.28(1.18) | - | -1.42(0.84) | - | - | 0.01(0.02) | -0.04(0.04) | 5 | 59.78 | 2.56 | 0.03 | 8.84 | 0.36 |
| | Year of Survey & % Crop in 1km | -1.65(1.31) | 0.94(0.79) | - | - | - | 0.03(0.03) | - | 4 | 59.85 | 2.62 | 0.02 | 9.73 | 0.28 |
| | % Natural in 1km | 0.09(1.13) | - | - | - | 0(0.03) | - | - | 3 | 59.93 | 2.71 | 0.02 | 12.54 | 0.13 |
| | % Developed in 1km | -0.05(0.5) | - | - | 0(0.02) | - | - | - | 3 | 59.95 | 2.73 | 0.02 | 12.56 | 0.13 |
| | Pollinator Plot Presence & % Natural in 1km & % Water in 1km | 0.77(1.15) | - | -1.49(0.91) | - | 0.01(0.03) | - | -0.05(0.04) | 5 | 60.16 | 2.93 | 0.02 | 10.15 | 0.25 |
| | Year of Survey & Pollinator Plot Presence & % Developed in 1km | 0.41(0.79) | 0.97(0.79) | -1.56(0.97) | -0.01(0.02) | - | - | - | 5 | 60.40 | 3.17 | 0.02 | 12.31 | 0.14 |
| | Year of Survey & Pollinator Plot Presence & % Natural in 1km | -0.34(1.21) | 0.97(0.79) | -1.64(1.03) | - | 0.02(0.03) | - | - | 5 | 60.41 | 3.18 | 0.02 | 9.42 | 0.31 |
| | Pollinator Plot Presence & % Natural in 1km & % Crop in 1km | -1.34(1.6) | - | -1.57(0.91) | - | 0.02(0.03) | 0.03(0.02) | - | 5 | 60.49 | 3.26 | 0.02 | 10.05 | 0.26 |
| | % Crop in 1km & % Water in 1km | -0.55(1.19) | - | - | - | - | 0.02(0.02) | -0.03(0.04) | 4 | 60.60 | 3.37 | 0.02 | 11.48 | 0.18 |
| | Year of Survey & % Natural in 1km | -0.35(1.27) | 0.93(0.8) | - | - | 0(0.03) | - | - | 4 | 60.89 | 3.66 | 0.01 | 14.06 | 0.08 |
| | Year of Survey & % Developed in 1km | -0.51(0.67) | 0.93(0.8) | - | 0(0.02) | - | - | - | 4 | 60.91 | 3.68 | 0.01 | 16.20 | 0.04 |
| | % Developed in 1km & % Crop in 1km | -1.74(1.56) | - | - | 0.02(-) | - | 0.03(0.03) | - | 4 | 61.03 | 3.80 | 0.01 | 9.46 | 0.31 |
| | Pollinator Plot Presence & % Developed in 1km & % Crop in 1km | -0.6(1.56) | - | -1.29(-) | 0(0.03) | - | 0.03(0.03) | - | 5 | 61.13 | 3.90 | 0.01 | 7.00 | 0.54 |
| DOWO | **Year of Survey & % Natural in 1km** | **-2.63(1.5)** | **1.77(0.97)** | **-** | **-** | **0.05(0.03)** | **-** | **-** | **4** | **55.23** | **0** | **0.38** | **5.86** | **0.66** |

| Avian Code[1] | Top Model Covariates[2] | (Intercept) 2017 or Control | β Coefficient (SE)[2] Year (2018) | Pollinator | % of cover within 1 kilometer: Developed | Natural | Cropland | Water | df | AICc | ΔAIC | $w_i$ | Hosmer-Lemeshow statistic | p-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year of Survey | -0.77(0.62) | 1.76(0.98) | - | - | - | - | - | 3 | 55.69 | 0.46 | 0.31 | 17.89 | 0.02 |
| | % Natural in 1km | -1.38(0.94) | - | - | - | 0.04(0.02) | - | - | 3 | 57.81 | 2.58 | 0.11 | 13.49 | 0.10 |
| | NULL | 0.05(0.33) | - | - | - | - | - | - | 2 | 58.35 | 3.11 | 0.08 | 13.12 | 0.11 |
| EABL | **Year of Survey & Pollinator Plot Presence** | -3.06(1.46) | 1.51(1.01) | 2.01(1.29) | - | - | - | - | **4** | **49.99** | **0** | **0.10** | **8.22** | **0.41** |
| | Pollinator Plot Presence | -1.94(0.9) | - | 1.7(1.03) | - | - | - | - | 3 | 50.37 | 0.38 | 0.08 | Nc | - |
| | Year of Survey | -2.06(1.1) | 1.54(1.03) | - | - | - | - | - | 3 | 50.94 | 0.96 | 0.06 | Nc | - |
| | Year of Survey & Pollinator Plot Presence & % Developed in 1km | -3.71(1.75) | 1.53(1.03) | 2.41(1.41) | 0.03(0.03) | - | - | - | 5 | 51.21 | 1.22 | 0.05 | 5.89 | 0.66 |
| | Pollinator Plot Presence & % Developed in 1km | -2.48(1.11) | - | 2.03(1.1) | 0.03(0.02) | - | - | - | 4 | 51.44 | 1.45 | 0.05 | 12.68 | 0.12 |
| | Year of Survey & Pollinator Plot Presence & % Water in 1km | -2.71(1.36) | 1.52(1.01) | 1.95(1.26) | - | - | - | -0.06(0.07) | 5 | 51.46 | 1.47 | 0.05 | 8.68 | 0.37 |
| | NULL | -1.06(0.59) | - | - | - | - | - | - | 2 | 51.58 | 1.59 | 0.04 | 5.73 | 0.68 |
| | Pollinator Plot Presence & % Water in 1km | -1.66(0.86) | - | 1.66(1.02) | - | - | - | -0.05(0.06) | 4 | 51.73 | 1.74 | 0.04 | 11.00 | 0.20 |
| | Year of Survey & Pollinator Plot Presence & % Crop in 1km | -1.97(1.69) | 1.54(1.04) | 2.12(1.34) | - | - | -0.03(0.03) | - | 5 | 51.84 | 1.85 | 0.04 | 3.06 | 0.93 |
| | Pollinator Plot Presence & % Crop in 1km | -1(1.27) | - | 1.79(1.06) | - | - | -0.02(0.03) | - | 4 | 52.07 | 2.08 | 0.03 | 8.50 | 0.39 |
| | Year of Survey & % Water in 1km | -1.72(1.01) | 1.55(1.02) | - | - | - | - | -0.06(0.06) | 4 | 52.19 | 2.20 | 0.03 | 11.75 | 0.16 |
| | Year of Survey & % Natural in 1km | -3.45(2.11) | 1.55(1.03) | - | - | 0.04(0.04) | - | - | 4 | 52.47 | 2.48 | 0.03 | 11.81 | 0.16 |
| | Year of Survey & Pollinator Plot Presence & % Natural in 1km | -3.51(2.03) | 1.52(1.02) | 1.86(1.32) | - | 0.01(0.04) | - | - | 5 | 52.50 | 2.51 | 0.03 | 10.65 | 0.22 |
| | % Water in 1km | -0.78(0.57) | - | - | - | - | - | -0.05(0.05) | 3 | 52.73 | 2.74 | 0.02 | 9.98 | 0.27 |
| | Pollinator Plot Presence & % Natural in 1km | -2.3(1.43) | - | 1.58(1.06) | - | 0.01(0.03) | - | - | 4 | 52.74 | 2.75 | 0.02 | 9.89 | 0.27 |
| | Year of Survey & % Crop in 1km | -1.04(1.62) | 1.57(1.05) | - | - | - | -0.02(0.04) | - | 4 | 52.87 | 2.88 | 0.02 | 11.07 | 0.20 |
| | % Natural in 1km | -2.21(1.47) | - | - | - | 0.03(0.03) | - | - | 3 | 52.96 | 2.97 | 0.02 | 8.93 | 0.35 |
| | Pollinator Plot Presence & % Crop in 1km & % Water in 1km | -0.34(1.31) | - | 1.7(1.04) | - | - | -0.03(0.03) | -0.06(0.06) | 5 | 53.04 | 3.05 | 0.02 | 5.94 | 0.65 |
| | Year of Survey & % Developed in 1km | -2.29(1.25) | 1.55(1.04) | - | 0.02(0.03) | - | - | - | 4 | 53.10 | 3.11 | 0.02 | 11.67 | 0.17 |
| | Pollinator Plot Presence & % Developed in 1km & % Water in 1km | -2.18(1.08) | - | 1.98(1.1) | 0.03(0.02) | - | - | -0.05(0.06) | 5 | 53.15 | 3.16 | 0.02 | 11.48 | 0.18 |
| | Pollinator Plot Presence & % Developed in 1km & % Natural in 1km | -3.61(1.94) | - | 1.85(1.12) | 0.04(0.03) | 0.03(0.03) | - | - | 5 | 53.35 | 3.36 | 0.02 | 6.96 | 0.54 |
| | % Crop in 1km | -0.22(1.24) | - | - | - | - | -0.02(0.03) | - | 3 | 53.38 | 3.39 | 0.02 | 9.82 | 0.28 |

| Avian | | (Intercept) | β Coefficient (SE)[2] | | | | | | | | | | Hosmer-Lemeshow | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2017 or | | | % of cover within 1 kilometer | | | | | | | | | |
| Code[1] | Top Model Covariates[2] | Control | Year (2018) | Pollinator | Developed | Natural | Cropland | Water | df | AICc | ΔAIC | $w_i$ | statistic | p-value |
| | Year of Survey & % Crop in 1km & % Water in 1km | -0.1(1.62) | 1.57(1.05) | - | - | - | -0.04(0.03) | -0.08(0.06) | 5 | 53.59 | 3.60 | 0.02 | 11.64 | 0.17 |
| | % Developed in 1km | -1.24(0.71) | - | - | 0.01(0.03) | - | - | - | 3 | 53.61 | 3.62 | 0.02 | 9.59 | 0.30 |
| | Year of Survey & % Developed in 1km & % Natural in 1km | -4.83(2.9) | 1.6(1.07) | - | 0.04(0.04) | 0.06(0.05) | - | - | 5 | 53.81 | 3.82 | 0.01 | 10.05 | 0.26 |
| | % Crop in 1km & % Water in 1km | 0.58(1.3) | - | - | - | - | -0.03(0.03) | -0.06(0.05) | 4 | 53.97 | 3.98 | 0.01 | 9.23 | 0.32 |
| EAWP | **% Natural in 1km** | **1.73(1.07)** | **-** | **-** | **-** | **-0.07(0.03)** | **-** | **-** | **3** | **49.56** | **0** | **0.74** | **6.08** | **0.64** |
| FISP | **% Crop in 1km** | **-2.93(1.63)** | **-** | **-** | **-** | **-** | **0.08(0.04)** | **-** | **3** | **49.34** | **0** | **0.83** | **6.28** | **0.62** |
| GRCA | **Pollinator Plot Presence** | **0.11(0.46)** | **-** | **-1.49(0.72)** | **-** | **-** | **-** | **-** | **3** | **52.99** | **0** | **0.30** | **0** | **1** |
| | Pollinator Plot Presence & % Developed in 1km | -0.26(0.57) | - | -1.31(0.74) | 0.02(0.03) | - | - | - | 4 | 54.19 | 1.20 | 0.17 | 6.82 | 0.56 |
| | Pollinator Plot Presence & % Crop in 1km | 0.88(0.98) | - | -1.5(0.73) | - | - | -0.02(0.02) | - | 4 | 54.63 | 1.64 | 0.13 | 11.50 | 0.18 |
| | % Developed in 1km | -0.99(0.5) | - | - | 0.03(0.03) | - | - | - | 3 | 55.01 | 2.02 | 0.11 | 12.60 | 0.13 |
| | NULL | -0.62(0.39) | - | - | - | - | - | - | 2 | 55.16 | 2.17 | 0.10 | 16.40 | 0.04 |
| | % Crop in 1km | 0.19(0.94) | - | - | - | - | -0.02(0.02) | - | 3 | 56.64 | 3.66 | 0.05 | 16.30 | 0.04 |
| MODO | **% Natural in 1km & % Water in 1km** | **-2.99(1.26)** | **-** | **-** | **-** | **0.06(0.03)** | **-** | **0.08(0.04)** | **4** | **53.70** | **0** | **0.16** | **6.53** | **0.59** |
| | % Developed in 1km & % Crop in 1km | 3.7(1.51) | - | - | -0.06(0.03) | - | -0.07(0.03) | - | 4 | 53.91 | 0.20 | 0.14 | 7.08 | 0.53 |
| | Year of Survey & % Natural in 1km & % Water in 1km | -3.33(1.35) | 0.61(0.74) | - | - | 0.06(0.03) | - | 0.08(0.04) | 5 | 55.64 | 1.94 | 0.06 | 10.39 | 0.24 |
| | Year of Survey & % Developed in 1km & % Crop in 1km | 3.44(1.53) | 0.61(0.74) | - | -0.06(0.03) | - | -0.07(0.03) | - | 5 | 55.85 | 2.15 | 0.05 | 7.02 | 0.53 |
| | Pollinator Plot Presence & % Natural in 1km & % Water in 1km | -3.03(1.26) | - | 0.43(0.78) | - | 0.06(0.03) | - | 0.08(0.04) | 5 | 56.05 | 2.35 | 0.05 | 3.16 | 0.92 |
| | % Developed in 1km & % Natural in 1km & % Crop in 1km | 5.24(3.73) | - | - | -0.08(0.04) | -0.02(0.04) | -0.08(0.04) | - | 5 | 56.31 | 2.61 | 0.04 | 3.81 | 0.87 |
| | % Developed in 1km & % Crop in 1km & % Water in 1km | 3.25(1.73) | - | - | -0.06(0.03) | - | -0.06(0.03) | 0.02(0.04) | 5 | 56.31 | 2.61 | 0.04 | 3.81 | 0.87 |
| | % Natural in 1km & % Crop in 1km & % Water in 1km | -2.63(2.22) | - | - | - | 0.06(0.03) | 0(0.03) | 0.08(0.04) | 5 | 56.31 | 2.61 | 0.04 | 3.81 | 0.87 |
| | % Developed in 1km & % Natural in 1km & % Water in 1km | -3.13(1.48) | - | - | 0(0.03) | 0.06(0.03) | - | 0.08(0.04) | 5 | 56.31 | 2.61 | 0.04 | 3.81 | 0.87 |
| | Pollinator Plot Presence & % Developed in 1km & % Crop in 1km | 3.33(1.64) | - | 0.36(0.77) | -0.06(0.03) | - | -0.07(0.03) | - | 5 | 56.34 | 2.63 | 0.04 | 9.64 | 0.29 |
| | % Water in 1km | -0.46(0.37) | - | - | - | - | - | 0.06(0.04) | 3 | 57.16 | 3.46 | 0.03 | 2.48 | 0.96 |
| | % Natural in 1km | -1.65(0.96) | - | - | - | 0.04(0.02) | - | - | 3 | 57.43 | 3.73 | 0.02 | 7.01 | 0.54 |
| NOMO | **% Crop in 1km & % Water in 1km** | **7.33(4.87)** | **-** | **-** | **-** | **-** | **-0.13(0.09)** | **-0.11(0.09)** | **4** | **50.76** | **0** | **0.11** | **4.15** | **0.84** |

| | | (Intercept) | | | β Coefficient (SE)[2] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avian | | 2017 or | | | % of cover within 1 kilometer | | | | | | | | Hosmer-Lemeshow | |
| Code[1] | Top Model Covariates[2] | Control | Year (2018) | Pollinator | Developed | Natural | Cropland | Water | df | AICc | ΔAIC | $w_i$ | statistic | p-value |
| | % Developed in 1km & % Natural in 1km | -5.02(3.79) | - | - | 0.13(0.14) | 0.12(0.09) | - | - | 4 | 50.79 | 0.03 | 0.11 | 4.16 | 0.84 |
| | % Crop in 1km | 5.07(3.59) | - | - | - | - | -0.09(0.07) | - | 3 | 50.81 | 0.05 | 0.11 | 4.18 | 0.84 |
| | NULL | 0.87(0.93) | - | - | - | - | - | - | 2 | 52.29 | 1.53 | 0.05 | 4.71 | 0.79 |
| | % Natural in 1km & % Crop in 1km | 2.53(3.98) | - | - | - | 0.06(0.07) | -0.08(0.07) | - | 4 | 52.43 | 1.67 | 0.05 | 3.80 | 0.88 |
| | % Developed in 1km | -0.33(1.42) | - | - | 0.12(0.16) | - | - | - | 3 | 52.48 | 1.72 | 0.05 | 4.91 | 0.77 |
| | % Natural in 1km | -2.08(2.57) | - | - | - | 0.08(0.07) | - | - | 3 | 52.73 | 1.97 | 0.04 | 4.23 | 0.84 |
| | % Developed in 1km & % Crop in 1km | 3.48(3.53) | - | - | 0.09(0.16) | - | -0.07(0.06) | - | 4 | 52.84 | 2.08 | 0.04 | 4.68 | 0.79 |
| | Year of Survey & % Crop in 1km | 5.14(3.62) | -0.14(0.97) | - | - | - | -0.09(0.07) | - | 4 | 53.28 | 2.52 | 0.03 | 4.20 | 0.84 |
| | Pollinator Plot Presence & % Developed in 1km & % Natural in 1km | -5.06(3.83) | - | -0.67(1.8) | 0.13(0.14) | 0.13(0.1) | - | - | 5 | 53.29 | 2.53 | 0.03 | 4.06 | 0.85 |
| | Pollinator Plot Presence & % Crop in 1km | 5.11(3.74) | - | -0.05(1.64) | - | - | -0.09(0.07) | - | 4 | 53.30 | 2.54 | 0.03 | 4.18 | 0.84 |
| | Year of Survey & % Crop in 1km & % Water in 1km | 7.39(4.88) | -0.14(0.98) | - | - | - | -0.13(0.09) | -0.11(0.09) | 5 | 53.38 | 2.62 | 0.03 | 4.17 | 0.84 |
| | % Developed in 1km & % Natural in 1km & % Water in 1km | -5.28(4.08) | - | - | 0.14(0.15) | 0.12(0.09) | - | 0.01(0.07) | 5 | 53.39 | 2.63 | 0.03 | 4.20 | 0.84 |
| | % Developed in 1km & % Natural in 1km & % Crop in 1km | -3.83(6.59) | - | - | 0.12(0.15) | 0.11(0.1) | -0.01(0.07) | - | 5 | 53.39 | 2.63 | 0.03 | 4.20 | 0.84 |
| | % Developed in 1km & % Crop in 1km & % Water in 1km | 7.06(5.54) | - | - | 0.01(0.14) | - | -0.12(0.09) | -0.11(0.1) | 5 | 53.39 | 2.63 | 0.03 | 4.20 | 0.84 |
| | Year of Survey & % Developed in 1km & % Natural in 1km | -4.95(3.81) | -0.14(0.98) | - | 0.13(0.14) | 0.12(0.09) | - | - | 5 | 53.41 | 2.65 | 0.03 | 4.17 | 0.84 |
| | % Water in 1km | 1.12(1.07) | - | - | - | - | - | -0.05(0.08) | 3 | 54.19 | 3.43 | 0.02 | 4.63 | 0.80 |
| | Year of Survey | 0.92(1.03) | -0.1(0.93) | - | - | - | - | - | 3 | 54.63 | 3.87 | 0.02 | NC | - |
| | Pollinator Plot Presence | 0.82(1.24) | - | 0.09(1.61) | - | - | - | - | 3 | 54.64 | 3.88 | 0.02 | NC | - |
| | % Developed in 1km & % Water in 1km | -0.04(1.51) | - | - | 0.11(0.16) | - | - | -0.03(0.07) | 4 | 54.75 | 3.99 | 0.01 | 4.85 | 0.77 |
| PIWO | NULL | -1.2(0.38) | - | - | - | - | - | - | 2 | 46.47 | 0 | 0.12 | NC | - |
| | **% Water in 1km** | **-0.98(0.42)** | **-** | **-** | **-** | **-** | **-** | **-0.06(0.06)** | **3** | **47.38** | **0.91** | **0.08** | **6.97** | **0.54** |
| | % Crop in 1km | -2.41(1.21) | - | - | - | - | 0.03(0.02) | - | 3 | 47.49 | 1.02 | 0.07 | 8.92 | 0.35 |
| | Year of Survey | -0.85(0.49) | -0.83(0.8) | - | - | - | - | - | 3 | 47.69 | 1.23 | 0.07 | 0 | 1 |
| | % Developed in 1km | -1.04(0.47) | - | - | -0.02(0.03) | - | - | - | 3 | 48.49 | 2.02 | 0.04 | 9.67 | 0.29 |
| | Pollinator Plot Presence | -1.03(0.52) | - | -0.36(0.76) | - | - | - | - | 3 | 48.60 | 2.13 | 0.04 | 13.61 | 0.09 |

| Avian Code[1] | Top Model Covariates[2] | (Intercept) 2017 or Control | β Coefficient (SE)[2] Year (2018) | Pollinator | % of cover within 1 kilometer Developed | Natural | Cropland | Water | df | AICc | ΔAIC | $w_i$ | Hosmer-Lemeshow statistic | p-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year of Survey & % Water in 1km | -0.62(0.52) | -0.84(0.81) | - | - | - | - | -0.06(0.06) | 4 | 48.75 | 2.28 | 0.04 | 8.13 | 0.42 |
| | % Natural in 1km | -1.31(1.03) | - | - | - | 0(0.03) | - | - | 3 | 48.81 | 2.34 | 0.04 | 3.38 | 0.91 |
| | Year of Survey & % Crop in 1km | -2.07(1.25) | -0.84(0.81) | - | - | - | 0.03(0.02) | - | 4 | 48.86 | 2.39 | 0.04 | 14.46 | 0.07 |
| | % Crop in 1km & % Water in 1km | -1.89(1.29) | - | - | - | - | 0.02(0.02) | -0.04(0.06) | 4 | 49.24 | 2.77 | 0.03 | 4.64 | 0.80 |
| | % Developed in 1km & % Water in 1km | -0.79(0.52) | - | - | -0.02(0.03) | - | - | -0.05(0.06) | 4 | 49.43 | 2.96 | 0.03 | 6.02 | 0.65 |
| | % Natural in 1km & % Crop in 1km | -3.88(2.95) | - | - | - | 0.02(0.04) | 0.04(0.03) | - | 4 | 49.54 | 3.07 | 0.03 | 5.64 | 0.69 |
| | Pollinator Plot Presence & % Water in 1km | -0.78(0.55) | - | -0.41(0.78) | - | - | - | -0.05(0.06) | 4 | 49.59 | 3.12 | 0.03 | 3.11 | 0.93 |
| | Pollinator Plot Presence & % Crop in 1km | -2.2(1.28) | - | -0.31(0.78) | - | - | 0.02(0.02) | - | 4 | 49.82 | 3.35 | 0.02 | 8.98 | 0.34 |
| | % Natural in 1km & % Water in 1km | -0.8(1.08) | - | - | - | 0(0.03) | - | -0.06(0.06) | 4 | 49.84 | 3.37 | 0.02 | 2.58 | 0.96 |
| | Year of Survey & % Developed in 1km | -0.68(0.57) | -0.83(0.8) | - | -0.02(0.03) | - | - | - | 4 | 49.85 | 3.38 | 0.02 | 7.90 | 0.44 |
| | % Developed in 1km & % Crop in 1km | -2.41(1.51) | - | - | 0(0.03) | - | 0.03(0.03) | - | 4 | 49.98 | 3.51 | 0.02 | 8.92 | 0.35 |
| | Year of Survey & Pollinator Plot Presence | -0.68(0.61) | -0.82(0.8) | -0.35(0.78) | - | - | - | - | 4 | 49.99 | 3.52 | 0.02 | 0.13 | 1.00 |
| | Year of Survey & % Natural in 1km | -0.97(1.09) | -0.83(0.8) | - | - | 0(0.03) | - | - | 4 | 50.17 | 3.70 | 0.02 | 5.50 | 0.70 |
| REVI | **Year of Survey & % Water in 1km** | **-0.38(0.66)** | **1.71(0.98)** | **-** | **-** | **-** | **-** | **-0.11(0.07)** | **4** | **53.60** | **0** | **0.42** | **11.24** | **0.19** |
| | % Water in 1km | 0.36(0.43) | - | - | - | - | - | -0.09(0.06) | 3 | 55.34 | 1.75 | 0.17 | NC | - |
| | Year of Survey | -0.93(0.74) | 1.71(0.99) | - | - | - | - | - | 3 | 55.84 | 2.25 | 0.14 | 12.45 | 0.13 |
| | Year of Survey & % Natural in 1km | -2.36(1.73) | 1.71(1) | - | - | 0.04(0.04) | - | - | 4 | 57.18 | 3.58 | 0.07 | 10.75 | 0.22 |
| | % Natural in 1km & % Water in 1km | -0.21(1.1) | - | - | - | 0.01(0.03) | - | -0.09(0.06) | 4 | 57.53 | 3.93 | 0.06 | 13.54 | 0.09 |
| TRES | **Year of Survey** | **-0.85(0.49)** | **1.39(0.68)** | **-** | **-** | **-** | **-** | **-** | **3** | **56.13** | **0** | **0.51** | **0** | **1** |
| | NULL | -0.15(0.32) | - | - | - | - | - | - | 2 | 58.17 | 2.04 | 0.18 | NC | - |
| TUVU | Year of Survey | -10.81(3.50) | 21(5.64) | - | - | - | - | - | 3 | 36.81 | 0 | 1 | NC | - |
| | **% Water in 1km** | **0.06(0.37)** | **-** | **-** | **-** | **-** | **-** | **-0.07(0.05)** | **3** | **56.47** | **19.66** | **0** | **8.21** | **0.41** |

[1]: Species codes are found in Table 2.1

[2]: Covariates used included pollinator or control farm, year of survey, and % land cover at a 1km scale including developed, natural,

cropland, and water

[N]C: indicates model non-convergence

Appendix G: The top models from ΔAIC<4 for each species from presence/absence binomial logistic regression analysis of bird point count data during Fall (August 26th-October 14th) of 2017 and 2018 on 20 farms study sites across the Coastal Plain of Virginia and Maryland.

| Avian Code[1] | Top Model Covariates[2] | (Intercept) 2017 or Control | β Coefficient (SE)[2] Year (2018) | Pollinator | % of cover within 1 kilometer: Developed | Natural | Cropland | Water | df | AICc | ΔAIC | $w_i$ | Hosmer-Lemeshow statistic | p-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AMRO | % Developed in 1km & % Water in 1km | 0.15(0.69) | - | - | 0.08(0.07) | - | - | -0.11(0.06) | 4 | 48.60 | 0 | 0.48 | 12.48 | 0.13 |
| | **% Water in 1km** | **0.95(0.49)** | **-** | **-** | **-** | **-** | **-** | **-0.11(0.06)** | **3** | **49.29** | **0.69** | **0.34** | **11.93** | **0.15** |
| | % Developed in 1km | -0.47(0.68) | - | - | 0.1(0.08) | - | - | - | 3 | 52.38 | 3.78 | 0.07 | 12.06 | 0.15 |
| BGGN | Pollinator Plot Presence & % Crop in 1km | 1.33(1.04) | - | -1.22(0.77) | - | - | -0.03(0.02) | - | 4 | 49.83 | 0 | 0.09 | 12.11 | 0.15 |
| | **% Crop in 1km** | **0.82(0.93)** | **-** | **-** | **-** | **-** | **-0.04(0.02)** | **-** | **3** | **49.92** | **0.09** | **0.09** | **13.18** | **0.11** |
| | Pollinator Plot Presence | -0.12(0.5) | - | -1.29(0.8) | - | - | - | - | 3 | 50.25 | 0.42 | 0.07 | NC | - |
| | Pollinator Plot Presence & % Developed in 1km & % Crop in 1km | 2.87(1.7) | - | -1.57(0.85) | -0.03(0.03) | - | -0.06(0.03) | - | 5 | 50.81 | 0.98 | 0.06 | 9.32 | 0.32 |
| | NULL | -0.78(0.41) | - | - | - | - | - | - | 2 | 50.91 | 1.08 | 0.05 | 9.35 | 0.31 |
| | Pollinator Plot Presence & % Natural in 1km | -1.09(0.99) | - | -1.66(0.85) | - | 0.03(0.03) | - | - | 4 | 51.39 | 1.56 | 0.04 | 4.37 | 0.82 |
| | Pollinator Plot Presence & % Water in 1km | -0.38(0.54) | - | -1.18(0.75) | - | - | - | 0.03(0.03) | 4 | 51.48 | 1.65 | 0.04 | 6.81 | 0.56 |
| | % Water in 1km | -1(0.47) | - | - | - | - | - | 0.04(0.03) | 3 | 51.50 | 1.68 | 0.04 | 12.26 | 0.14 |
| | Pollinator Plot Presence & % Natural in 1km & % Crop in 1km | 0.38(1.42) | - | -1.58(0.91) | - | 0.03(0.03) | -0.03(0.02) | - | 5 | 51.72 | 1.89 | 0.04 | 6.82 | 0.56 |
| | % Crop in 1km & % Water in 1km | 0.43(1.03) | - | - | - | - | -0.03(0.02) | 0.02(0.03) | 4 | 51.78 | 1.95 | 0.03 | 9.95 | 0.27 |
| | % Developed in 1km & % Crop in 1km | 1.6(1.37) | - | - | -0.02(0.02) | - | -0.05(0.03) | - | 4 | 51.79 | 1.97 | 0.03 | 8.07 | 0.43 |
| | Pollinator Plot Presence & % Natural in 1km & % Water in 1km | -1.82(1.17) | - | -1.63(0.86) | - | 0.04(0.03) | - | 0.05(0.03) | 5 | 51.86 | 2.03 | 0.03 | 1.91 | 0.98 |
| | Pollinator Plot Presence & % Crop in 1km & % Water in 1km | 0.99(1.17) | - | -1.16(0.78) | - | - | -0.03(0.02) | 0.02(0.03) | 5 | 52.18 | 2.36 | 0.03 | 12.16 | 0.14 |
| | % Natural in 1km & % Crop in 1km | 0.68(1.39) | - | - | - | 0(0.02) | -0.04(0.02) | - | 4 | 52.43 | 2.60 | 0.02 | 10.40 | 0.24 |
| | Year of Survey & % Crop in 1km | 0.84(1) | -0.05(0.74) | - | - | - | -0.04(0.02) | - | 4 | 52.44 | 2.61 | 0.02 | 10.90 | 0.21 |
| | Year of Survey & Pollinator Plot Presence & % Crop in 1km | 1.37(1.11) | -0.09(0.77) | -1.23(0.77) | - | - | -0.03(0.02) | - | 5 | 52.50 | 2.67 | 0.02 | 7.50 | 0.48 |
| | Year of Survey & Pollinator Plot Presence | -0.05(0.63) | -0.13(0.74) | -1.29(0.81) | - | - | - | - | 4 | 52.74 | 2.91 | 0.02 | 10.78 | 0.21 |

| Avian Code[1] | Top Model Covariates[2] | (Intercept) 2017 or Control | β Coefficient (SE)[2] Year (2018) | Pollinator | % of cover within 1 kilometer Developed | Natural | Cropland | Water | df | AICc | ΔAIC | $w_i$ | Hosmer-Lemeshow statistic | p-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pollinator Plot Presence & % Developed in 1km | -0.13(0.6) | - | -1.28(0.83) | 0(0.02) | - | - | - | 4 | 52.77 | 2.94 | 0.02 | 16.70 | 0.03 |
| | % Developed in 1km | -0.89(0.49) | - | - | 0.01(0.02) | - | - | - | 3 | 53.03 | 3.20 | 0.02 | 14.76 | 0.06 |
| | % Natural in 1km | -1.14(1.03) | - | - | - | 0.01(0.02) | - | - | 3 | 53.12 | 3.29 | 0.02 | 10.31 | 0.24 |
| | % Natural in 1km & % Water in 1km | -1.93(1.18) | - | - | - | 0.02(0.03) | - | 0.05(0.03) | 4 | 53.22 | 3.40 | 0.02 | 9.73 | 0.28 |
| | Year of Survey | -0.73(0.55) | -0.09(0.72) | - | - | - | - | - | 3 | 53.26 | 3.43 | 0.02 | [N]C | - |
| | % Developed in 1km & % Water in 1km | -1.16(0.54) | - | - | 0.01(0.02) | - | - | 0.04(0.03) | 4 | 53.57 | 3.74 | 0.01 | 15.44 | 0.05 |
| | Pollinator Plot Presence & % Developed in 1km & % Natural in 1km | -1.52(1.26) | - | -1.65(0.87) | 0.01(0.02) | 0.04(0.03) | - | - | 5 | 53.75 | 3.92 | 0.01 | 8.84 | 0.36 |
| BRTH | **Pollinator Plot Presence** | **-0.12(0.49)** | **-** | **-1.62(0.79)** | **-** | **-** | **-** | **-** | **3** | **47.14** | **0** | **0.22** | **0.00** | **1** |
| | Year of Survey & Pollinator Plot Presence | -0.53(0.66) | 0.76(0.79) | -1.64(0.81) | - | - | - | - | 4 | 48.71 | 1.57 | 0.10 | 1.04 | 1.00 |
| | Pollinator Plot Presence & % Crop in 1km | 0.5(0.96) | - | -1.59(0.8) | - | - | -0.01(0.02) | - | 4 | 49.09 | 1.94 | 0.08 | 7.65 | 0.47 |
| | NULL | -0.92(0.45) | - | - | - | - | - | - | 2 | 49.31 | 2.16 | 0.07 | [N]C | - |
| | Pollinator Plot Presence & % Water in 1km | -0.24(0.54) | - | -1.57(0.8) | - | - | - | 0.01(0.03) | 4 | 49.39 | 2.25 | 0.07 | 7.40 | 0.49 |
| | Pollinator Plot Presence & % Developed in 1km | -0.19(0.59) | - | -1.58(0.82) | 0(0.02) | - | - | - | 4 | 49.62 | 2.48 | 0.06 | 8.01 | 0.43 |
| | Year of Survey | -1.39(0.72) | 0.79(0.8) | - | - | - | - | - | 3 | 50.64 | 3.50 | 0.04 | 5.37 | 0.72 |
| | Year of Survey & Pollinator Plot Presence & % Crop in 1km | 0.13(1.04) | 0.8(0.8) | -1.61(0.81) | - | - | -0.02(0.02) | - | 5 | 50.74 | 3.59 | 0.04 | 10.15 | 0.25 |
| | % Crop in 1km | -0.1(0.96) | - | - | - | - | -0.02(0.02) | - | 3 | 50.86 | 3.72 | 0.03 | 7.81 | 0.45 |
| | % Water in 1km | -1.07(0.52) | - | - | - | - | - | 0.02(0.03) | 3 | 51.03 | 3.88 | 0.03 | 11.94 | 0.15 |
| | Year of Survey & Pollinator Plot Presence & % Water in 1km | -0.67(0.71) | 0.78(0.8) | -1.59(0.81) | - | - | - | 0.02(0.03) | 5 | 51.09 | 3.94 | 0.03 | 9.05 | 0.34 |
| | % Developed in 1km | -1.1(0.54) | - | - | 0.01(0.02) | - | - | - | 3 | 51.13 | 3.98 | 0.03 | 13.65 | 0.09 |
| COYE | **Year of Survey** | **-0.96(0.53)** | **1.06(0.7)** | **-** | **-** | **-** | **-** | **-** | **3** | **54.28** | **0** | **0.13** | **0.00** | **1** |
| | NULL | -0.38(0.33) | - | - | - | - | - | - | 2 | 54.31 | 0.03 | 0.13 | [N]C | - |
| | Pollinator Plot Presence | -0.12(0.49) | - | -0.5(0.68) | - | - | - | - | 3 | 56.13 | 1.85 | 0.05 | 0.00 | 1 |
| | % Natural in 1km | 0.15(0.89) | - | - | - | -0.01(0.02) | - | - | 3 | 56.28 | 1.99 | 0.05 | 5.70 | 0.68 |
| | Year of Survey & Pollinator Plot Presence | -0.69(0.63) | 1.06(0.7) | -0.5(0.7) | - | - | - | - | 4 | 56.28 | 2.00 | 0.05 | 0.39 | 1.00 |
| | Year of Survey & % Natural in 1km | -0.41(0.99) | 1.07(0.7) | - | - | -0.01(0.02) | - | - | 4 | 56.40 | 2.12 | 0.05 | 4.72 | 0.79 |

| Avian Code[1] | Top Model Covariates[2] | (Intercept) 2017 or Control | β Coefficient (SE)[2] Year (2018) | Pollinator | % of cover within 1 kilometer: Developed | Natural | Cropland | Water | df | AICc | ΔAIC | $w_i$ | Hosmer-Lemeshow statistic | p-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % Crop in 1km | -0.67(0.88) | - | - | - | - | 0.01(0.02) | - | 3 | 56.56 | 2.28 | 0.04 | 8.22 | 0.41 |
| | % Developed in 1km | -0.42(0.4) | - | - | 0(0.02) | - | - | - | 3 | 56.67 | 2.38 | 0.04 | 7.42 | 0.49 |
| | % Water in 1km | -0.39(0.38) | - | - | - | - | - | 0(0.03) | 3 | 56.69 | 2.40 | 0.04 | 4.67 | 0.79 |
| | Year of Survey & % Crop in 1km | -1.22(0.99) | 1.06(0.7) | - | - | - | 0.01(0.02) | - | 4 | 56.70 | 2.42 | 0.04 | 5.37 | 0.72 |
| | Year of Survey & % Developed in 1km | -0.99(0.58) | 1.06(0.7) | - | 0(0.02) | - | - | - | 4 | 56.78 | 2.50 | 0.04 | 9.80 | 0.28 |
| | Year of Survey & % Water in 1km | -0.97(0.56) | 1.06(0.7) | - | - | - | - | 0(0.03) | 4 | 56.80 | 2.52 | 0.04 | 7.88 | 0.44 |
| DOWO | **Year of Survey & % Developed in 1km** | **-17.56(10.96)** | **17.84(10.55)** | **-** | **1.19(0.66)** | **-** | **-** | **-** | **4** | **44.19** | **0** | **0.59** | **0.16** | **1** |
| | Year of Survey & % Water in 1km | 10.47(4.1) | 13.77(4.17) | - | - | - | - | -1.3(0.44) | 4 | 45.61 | 1.43 | 0.29 | 0.09 | 1.00 |
| EABL | **Year of Survey** | **-9.34(3.14)** | **18.43(5.25)** | **-** | **-** | **-** | **-** | **-** | **3** | **45.12** | **0** | **0.97** | **0.16** | **1** |
| EAWP | **Pollinator Plot Presence** | **-2.67(1.47)** | **-** | **1.84(1.42)** | **-** | **-** | **-** | **-** | **3** | **44.25** | **0** | **0.08** | **6.07** | **0.64** |
| | NULL | -1.53(0.79) | - | - | - | - | - | - | 2 | 44.53 | 0.28 | 0.07 | NC | - |
| | Year of Survey & Pollinator Plot Presence | -2.58(1.9) | -1.52(1.23) | 2.32(1.95) | - | - | - | - | 4 | 44.66 | 0.41 | 0.07 | NC | - |
| | Year of Survey | -1.12(0.94) | -1.37(1.08) | - | - | - | - | - | 3 | 44.87 | 0.62 | 0.06 | 13.66 | 0.09 |
| | % Natural in 1km | -3.39(1.97) | - | - | - | 0.05(0.04) | - | - | 3 | 44.89 | 0.64 | 0.06 | 5.71 | 0.68 |
| | Year of Survey & % Natural in 1km | -3.33(2.45) | -1.41(1.12) | - | - | 0.06(0.05) | - | - | 4 | 45.36 | 1.11 | 0.05 | 5.10 | 0.75 |
| | Pollinator Plot Presence & % Natural in 1km | -4.06(2.3) | - | 1.57(1.37) | - | 0.04(0.04) | - | - | 4 | 45.62 | 1.36 | 0.04 | 6.09 | 0.64 |
| | % Developed in 1km | -0.97(0.89) | - | - | -0.05(0.08) | - | - | - | 3 | 45.75 | 1.50 | 0.04 | 9.38 | 0.31 |
| | Year of Survey & Pollinator Plot Presence & % Natural in 1km | -4.16(2.82) | -1.51(1.2) | 1.92(1.74) | - | 0.05(0.05) | - | - | 5 | 46.20 | 1.95 | 0.03 | 5.34 | 0.72 |
| | Pollinator Plot Presence & % Developed in 1km | -2.07(1.48) | - | 1.61(1.35) | -0.05(0.09) | - | - | - | 4 | 46.22 | 1.97 | 0.03 | 7.13 | 0.52 |
| | Year of Survey & % Developed in 1km | -0.46(1.08) | -1.37(1.07) | - | -0.06(0.1) | - | - | - | 4 | 46.23 | 1.98 | 0.03 | 7.02 | 0.53 |
| | % Water in 1km | -1.36(0.78) | - | - | - | - | - | -0.03(0.05) | 3 | 46.59 | 2.34 | 0.03 | NC | - |
| | Pollinator Plot Presence & % Water in 1km | -2.5(1.44) | - | 1.78(1.39) | - | - | - | -0.02(0.06) | 4 | 46.60 | 2.35 | 0.03 | 7.08 | 0.53 |
| | Pollinator Plot Presence & % Crop in 1km | -2.46(1.92) | - | 1.87(1.44) | - | - | -0.01(0.03) | - | 4 | 46.75 | 2.50 | 0.02 | 6.44 | 0.60 |
| | Year of Survey & Pollinator Plot Presence & % Developed in 1km | -1.81(1.85) | -1.48(1.18) | 1.98(1.78) | -0.05(0.11) | - | - | - | 5 | 46.82 | 2.57 | 0.02 | 4.35 | 0.82 |
| | % Crop in 1km | -1.56(1.52) | - | - | - | - | 0(0.03) | - | 3 | 46.90 | 2.65 | 0.02 | 8.63 | 0.37 |

| | | (Intercept) | β Coefficient (SE)[2] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avian | | 2017 or | | | % of cover within 1 kilometer | | | | | | | | Hosmer-Lemeshow | |
| Code[1] | Top Model Covariates[2] | Control | Year (2018) | Pollinator | Developed | Natural | Cropland | Water | df | AICc | ΔAIC | $w_i$ | statistic | p-value |
| | % Developed in 1km & % Natural in 1km | -2.68(2) | - | - | -0.05(0.09) | 0.04(0.04) | - | - | 4 | 46.91 | 2.66 | 0.02 | 8.29 | 0.41 |
| | % Natural in 1km & % Crop in 1km | -5.08(3.85) | - | - | - | 0.06(0.05) | 0.03(0.04) | - | 4 | 46.98 | 2.73 | 0.02 | 6.08 | 0.64 |
| | Year of Survey & % Water in 1km | -0.9(0.94) | -1.37(1.07) | - | - | - | - | -0.03(0.06) | 4 | 47.07 | 2.82 | 0.02 | 6.74 | 0.56 |
| | Year of Survey & Pollinator Plot Presence & % Water in 1km | -2.34(1.84) | -1.51(1.21) | 2.22(1.89) | - | - | - | -0.03(0.07) | 5 | 47.17 | 2.92 | 0.02 | 4.91 | 0.77 |
| | Year of Survey & Pollinator Plot Presence & % Crop in 1km | -2.35(2.43) | -1.52(1.22) | 2.35(1.96) | - | - | -0.01(0.04) | - | 5 | 47.32 | 3.07 | 0.02 | 8.34 | 0.40 |
| | % Natural in 1km & % Water in 1km | -3.28(2.1) | - | - | - | 0.05(0.04) | - | -0.01(0.05) | 4 | 47.39 | 3.14 | 0.02 | 5.72 | 0.68 |
| | Year of Survey & % Crop in 1km | -1.19(1.8) | -1.37(1.08) | - | - | - | 0(0.04) | - | 4 | 47.39 | 3.14 | 0.02 | 6.63 | 0.58 |
| | Year of Survey & % Developed in 1km & % Natural in 1km | -2.46(2.4) | -1.39(1.1) | - | -0.05(0.11) | 0.05(0.05) | - | - | 5 | 47.56 | 3.31 | 0.02 | 10.09 | 0.26 |
| | Year of Survey & % Natural in 1km & % Crop in 1km | -5.21(4.45) | -1.39(1.1) | - | - | 0.07(0.06) | 0.03(0.05) | - | 5 | 47.61 | 3.36 | 0.02 | 5.53 | 0.70 |
| | % Developed in 1km & % Water in 1km | -0.65(1) | - | - | -0.07(0.1) | - | - | -0.03(0.05) | 4 | 47.73 | 3.48 | 0.01 | 9.76 | 0.28 |
| | % Developed in 1km & % Crop in 1km | -0.05(1.89) | - | - | -0.06(0.08) | - | -0.02(0.04) | - | 4 | 47.98 | 3.73 | 0.01 | 9.02 | 0.34 |
| | Pollinator Plot Presence & % Developed in 1km & % Natural in 1km | -3.44(2.36) | - | 1.46(1.33) | -0.04(0.1) | 0.04(0.04) | - | - | 5 | 47.99 | 3.74 | 0.01 | 6.41 | 0.60 |
| | Year of Survey & % Natural in 1km & % Water in 1km | -3.18(2.59) | -1.41(1.12) | - | - | 0.06(0.05) | - | -0.01(0.06) | 5 | 48.03 | 3.78 | 0.01 | 5.15 | 0.74 |
| | Pollinator Plot Presence & % Natural in 1km & % Crop in 1km | -5.55(4.56) | - | 1.45(1.33) | - | 0.05(0.05) | 0.02(0.05) | - | 5 | 48.08 | 3.83 | 0.01 | 6.30 | 0.61 |
| FISP | **NULL** | **-0.05(0.41)** | **-** | **-** | **-** | **-** | **-** | **-** | **2** | **55.13** | **0** | **0.13** | **14.43** | **0.07** |
| | % Developed in 1km | 0.4(0.55) | - | - | -0.04(0.04) | - | - | - | 3 | 55.32 | 0.18 | 0.12 | [N]C | - |
| | % Natural in 1km & % Crop in 1km | -4.21(2.86) | - | - | - | 0.05(0.04) | 0.05(0.04) | - | 4 | 55.80 | 0.67 | 0.09 | 11.84 | 0.16 |
| | % Crop in 1km | -1.31(1.16) | - | - | - | - | 0.03(0.02) | - | 3 | 55.93 | 0.80 | 0.08 | 10.65 | 0.22 |
| | % Natural in 1km | -1.13(1.1) | - | - | - | 0.03(0.03) | - | - | 3 | 56.33 | 1.20 | 0.07 | 9.54 | 0.30 |
| | Pollinator Plot Presence | -0.39(0.6) | - | 0.62(0.81) | - | - | - | - | 3 | 56.90 | 1.77 | 0.05 | 10.84 | 0.21 |
| | Year of Survey | -0.25(0.55) | 0.37(0.72) | - | - | - | - | - | 3 | 57.24 | 2.11 | 0.04 | 4.73 | 0.79 |
| | % Developed in 1km & % Natural in 1km | -0.3(1.28) | - | - | -0.04(0.04) | 0.02(0.03) | - | - | 4 | 57.47 | 2.34 | 0.04 | 6.73 | 0.57 |
| | % Developed in 1km & % Crop in 1km | -0.38(1.45) | - | - | -0.04(0.04) | - | 0.02(0.03) | - | 4 | 57.50 | 2.37 | 0.04 | 13.68 | 0.09 |
| | Year of Survey & % Developed in 1km | 0.21(0.66) | 0.38(0.73) | - | -0.04(0.04) | - | - | - | 4 | 57.57 | 2.44 | 0.04 | 10.25 | 0.25 |
| | Pollinator Plot Presence & % Developed in 1km | 0.18(0.74) | - | 0.36(0.81) | -0.04(0.04) | - | - | - | 4 | 57.65 | 2.51 | 0.04 | 17.19 | 0.03 |

| Avian Code[1] | Top Model Covariates[2] | (Intercept) 2017 or Control | β Coefficient (SE)[2] Year (2018) | Pollinator | % of cover within 1 kilometer Developed | Natural | Cropland | Water | df | AICc | ΔAIC | $w_i$ | Hosmer-Lemeshow statistic | p-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pollinator Plot Presence & % Crop in 1km | -1.62(1.29) | - | 0.6(0.82) | - | - | 0.03(0.02) | - | 4 | 57.90 | 2.77 | 0.03 | 10.40 | 0.24 |
| | Year of Survey & % Crop in 1km | -1.49(1.24) | 0.36(0.73) | - | - | - | 0.03(0.02) | - | 4 | 58.21 | 3.08 | 0.03 | 11.23 | 0.19 |
| | Year of Survey & % Natural in 1km & % Crop in 1km | -4.43(2.93) | 0.38(0.74) | - | - | 0.05(0.04) | 0.05(0.04) | - | 5 | 58.22 | 3.09 | 0.03 | 9.31 | 0.32 |
| | Pollinator Plot Presence & % Natural in 1km & % Crop in 1km | -4.22(2.89) | - | 0.19(0.84) | - | 0.05(0.04) | 0.05(0.04) | - | 5 | 58.43 | 3.30 | 0.02 | 9.99 | 0.27 |
| | % Developed in 1km & % Natural in 1km & % Crop in 1km | -4.06(3.63) | - | - | 0(0.06) | 0.05(0.04) | 0.05(0.04) | - | 5 | 58.48 | 3.35 | 0.02 | 9.74 | 0.28 |
| | Year of Survey & % Natural in 1km | -1.35(1.2) | 0.39(0.72) | - | - | 0.03(0.03) | - | - | 4 | 58.56 | 3.43 | 0.02 | 13.48 | 0.10 |
| | Pollinator Plot Presence & % Natural in 1km | -1.16(1.1) | - | 0.35(0.85) | - | 0.02(0.03) | - | - | 4 | 58.68 | 3.55 | 0.02 | 10.61 | 0.22 |
| GRCA | **% Water in 1km** | **0.47(0.43)** | **-** | **-** | **-** | **-** | **-** | **0.25(0.21)** | **3** | **44.29** | **0** | **0.64** | **14.47** | **0.07** |
| | NULL | 0.99(0.37) | - | - | - | - | - | - | 2 | 47.53 | 3.24 | 0.13 | 4.37 | 0.82 |
| MODO | **% Water in 1km** | **1.1(0.54)** | **-** | **-** | **-** | **-** | **-** | **-0.07(0.04)** | **3** | **50.39** | **0** | **0.15** | **7.53** | **0.48** |
| | % Developed in 1km & % Water in 1km | 0.68(0.64) | - | - | 0.04(0.05) | - | - | -0.06(0.04) | 4 | 51.63 | 1.24 | 0.08 | 7.10 | 0.53 |
| | NULL | 0.75(0.5) | - | - | - | - | - | - | 2 | 51.65 | 1.26 | 0.08 | 10.16 | 0.25 |
| | % Natural in 1km & % Water in 1km | 2.11(1.42) | - | - | - | -0.02(0.03) | - | -0.08(0.05) | 4 | 52.17 | 1.78 | 0.06 | 10.05 | 0.26 |
| | % Developed in 1km | 0.2(0.67) | - | - | 0.05(0.06) | - | - | - | 3 | 52.20 | 1.81 | 0.06 | 11.39 | 0.18 |
| | % Crop in 1km & % Water in 1km | 1.48(1.33) | - | - | - | - | -0.01(0.03) | -0.07(0.05) | 4 | 52.80 | 2.42 | 0.04 | 7.63 | 0.47 |
| | Year of Survey & % Water in 1km | 1.2(0.68) | -0.2(0.77) | - | - | - | - | -0.07(0.04) | 4 | 52.85 | 2.46 | 0.04 | 6.51 | 0.59 |
| | Pollinator Plot Presence & % Water in 1km | 1.2(0.72) | - | -0.19(0.84) | - | - | - | -0.07(0.04) | 4 | 52.86 | 2.47 | 0.04 | 5.67 | 0.68 |
| | % Developed in 1km & % Crop in 1km | -1.55(1.63) | - | - | 0.07(0.06) | - | 0.04(0.03) | - | 4 | 53.25 | 2.86 | 0.03 | 5.94 | 0.65 |
| | % Crop in 1km | 0.39(1.17) | - | - | - | - | 0.01(0.02) | - | 3 | 53.92 | 3.53 | 0.02 | 11.72 | 0.16 |
| | Year of Survey | 0.83(0.64) | -0.16(0.77) | - | - | - | - | - | 3 | 53.98 | 3.59 | 0.02 | 11.72 | 0.16 |
| | % Natural in 1km | 0.97(1.26) | - | - | - | -0.01(0.03) | - | - | 3 | 53.99 | 3.60 | 0.02 | 11.49 | 0.18 |
| | Pollinator Plot Presence | 0.72(0.68) | - | 0.05(0.9) | - | - | - | - | 3 | 54.02 | 3.63 | 0.02 | 11.68 | 0.17 |
| | % Developed in 1km & % Natural in 1km & % Crop in 1km | -5.58(4.16) | - | - | 0.1(0.07) | 0.05(0.05) | 0.07(0.05) | - | 5 | 54.11 | 3.72 | 0.02 | 9.05 | 0.34 |
| | % Developed in 1km & % Crop in 1km & % Water in 1km | -0.11(1.83) | - | - | 0.05(0.05) | - | 0.01(0.03) | -0.05(0.05) | 5 | 54.11 | 3.72 | 0.02 | 9.05 | 0.34 |
| | % Developed in 1km & % Natural in 1km & % Water in 1km | 1.33(1.61) | - | - | 0.03(0.05) | -0.01(0.03) | - | -0.07(0.05) | 5 | 54.11 | 3.72 | 0.02 | 9.05 | 0.34 |

| | | (Intercept) | β Coefficient (SE)[2] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avian | | 2017 or | | | % of cover within 1 kilometer | | | | | | | | Hosmer-Lemeshow | |
| Code[1] | Top Model Covariates[2] | Control | Year (2018) | Pollinator | Developed | Natural | Cropland | Water | df | AICc | ΔAIC | $w_i$ | statistic | p-value |
| | % Natural in 1km & % Crop in 1km & % Water in 1km | 4.61(4.4) | - | - | - | -0.05(0.05) | -0.03(0.05) | -0.1(0.07) | 5 | 54.11 | 3.72 | 0.02 | 9.05 | 0.34 |
| | Year of Survey & % Developed in 1km & % Water in 1km | 0.78(0.76) | -0.2(0.78) | - | 0.04(0.05) | - | - | -0.06(0.04) | 5 | 54.25 | 3.86 | 0.02 | 6.85 | 0.55 |
| | Pollinator Plot Presence & % Developed in 1km & % Water in 1km | 0.63(0.86) | - | 0.07(0.87) | 0.04(0.05) | - | - | -0.06(0.04) | 5 | 54.30 | 3.92 | 0.02 | 8.29 | 0.41 |
| NOMO | Year of Survey & % Natural in 1km & % Crop in 1km | 10.87(7.5) | 1.46(0.86) | - | - | -0.11(0.08) | -0.13(0.09) | - | 5 | 46.04 | 0 | 0.07 | 5.69 | 0.68 |
| | **Year of Survey & % Water in 1km** | **0.03(0.55)** | **1.33(0.82)** | **-** | **-** | **-** | **-** | **0.11(0.09)** | **4** | **46.46** | **0.42** | **0.05** | **3.61** | **0.89** |
| | % Natural in 1km & % Crop in 1km | 10.65(7.11) | - | - | - | -0.1(0.08) | -0.12(0.08) | - | 4 | 46.47 | 0.43 | 0.05 | 4.28 | 0.83 |
| | Year of Survey & % Developed in 1km & % Water in 1km | -0.95(1.02) | 1.42(0.85) | - | 0.11(0.1) | - | - | 0.12(0.1) | 5 | 46.51 | 0.47 | 0.05 | 8.01 | 0.43 |
| | Year of Survey & % Crop in 1km | 2.34(1.29) | 1.38(0.84) | - | - | - | -0.04(0.03) | - | 4 | 46.67 | 0.62 | 0.05 | 7.22 | 0.51 |
| | % Water in 1km | 0.64(0.41) | - | - | - | - | - | 0.1(0.09) | 3 | 46.76 | 0.72 | 0.05 | 7.03 | 0.53 |
| | % Developed in 1km & % Water in 1km | -0.22(0.88) | - | - | 0.1(0.1) | - | - | 0.11(0.09) | 4 | 46.83 | 0.79 | 0.04 | 4.52 | 0.81 |
| | % Crop in 1km | 2.74(1.24) | - | - | - | - | -0.04(0.02) | - | 3 | 47.09 | 1.04 | 0.04 | 8.61 | 0.38 |
| | Pollinator Plot Presence & % Natural in 1km & % Crop in 1km | 15.67(9.85) | - | -1.31(1) | - | -0.14(0.1) | -0.17(0.11) | - | 5 | 47.27 | 1.23 | 0.04 | 3.29 | 0.92 |
| | Year of Survey | 0.45(0.48) | 1.22(0.79) | - | - | - | - | - | 3 | 47.36 | 1.31 | 0.03 | 0.00 | 1 |
| | Year of Survey & % Crop in 1km & % Water in 1km | 1.5(1.36) | 1.44(0.86) | - | - | - | -0.03(0.03) | 0.09(0.09) | 5 | 47.51 | 1.47 | 0.03 | 2.84 | 0.94 |
| | NULL | 0.99(0.37) | - | - | - | - | - | - | 2 | 47.53 | 1.49 | 0.03 | 14.47 | 0.07 |
| | Year of Survey & Pollinator Plot Presence & % Crop in 1km | 3.49(1.85) | 1.39(0.85) | -1.17(0.92) | - | - | -0.05(0.03) | - | 5 | 47.56 | 1.52 | 0.03 | 8.57 | 0.38 |
| | Pollinator Plot Presence & % Crop in 1km | 3.89(1.79) | - | -1.14(0.89) | - | - | -0.05(0.03) | - | 4 | 47.77 | 1.72 | 0.03 | 8.76 | 0.36 |
| | Year of Survey & Pollinator Plot Presence & % Water in 1km | 0.57(0.75) | 1.35(0.84) | -0.96(0.86) | - | - | - | 0.12(0.1) | 5 | 47.83 | 1.79 | 0.03 | 5.35 | 0.72 |
| | % Crop in 1km & % Water in 1km | 1.97(1.3) | - | - | - | - | -0.03(0.02) | 0.08(0.08) | 4 | 47.91 | 1.87 | 0.03 | 3.67 | 0.89 |
| | Pollinator Plot Presence & % Water in 1km | 1.18(0.66) | - | -0.93(0.82) | - | - | - | 0.11(0.1) | 4 | 47.94 | 1.89 | 0.03 | 8.78 | 0.36 |
| | Year of Survey & % Developed in 1km | -0.08(0.71) | 1.27(0.81) | - | 0.06(0.07) | - | - | - | 4 | 48.07 | 2.02 | 0.02 | 10.99 | 0.20 |
| | % Developed in 1km | 0.51(0.6) | - | - | 0.05(0.06) | - | - | - | 3 | 48.19 | 2.15 | 0.02 | 5.76 | 0.67 |
| | Pollinator Plot Presence & % Developed in 1km & % Water in 1km | 0.14(1.01) | - | -0.96(0.92) | 0.12(0.11) | - | - | 0.15(0.13) | 5 | 48.33 | 2.29 | 0.02 | 2.36 | 0.97 |
| | Year of Survey & Pollinator Plot Presence | 1.01(0.71) | 1.24(0.81) | -0.95(0.82) | - | - | - | - | 4 | 48.46 | 2.41 | 0.02 | 18.31 | 0.02 |
| | Pollinator Plot Presence | 1.54(0.64) | - | -0.92(0.79) | - | - | - | - | 3 | 48.47 | 2.42 | 0.02 | 0.00 | 1 |

| Avian Code[1] | Top Model Covariates[2] | (Intercept) 2017 or Control | β Coefficient (SE)[2] Year (2018) | Pollinator | % of cover within 1 kilometer: Developed | Natural | Cropland | Water | df | AICc | ΔAIC | $w_i$ | Hosmer-Lemeshow statistic | p-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pollinator Plot Presence & % Crop in 1km & % Water in 1km | 3.36(1.96) | - | -1.28(0.96) | - | - | -0.04(0.03) | 0.1(0.1) | 5 | 48.55 | 2.51 | 0.02 | 7.47 | 0.49 |
| | Year of Survey & % Developed in 1km & % Crop in 1km | 1.72(1.54) | 1.37(0.84) | - | 0.05(0.08) | - | -0.04(0.03) | - | 5 | 48.82 | 2.77 | 0.02 | 3.96 | 0.86 |
| | % Developed in 1km & % Crop in 1km | 2.14(1.48) | - | - | 0.05(0.08) | - | -0.03(0.03) | - | 4 | 49.06 | 3.01 | 0.01 | 6.53 | 0.59 |
| | Year of Survey & % Natural in 1km & % Water in 1km | 0.01(1.17) | 1.33(0.82) | - | - | 0(0.03) | - | 0.11(0.09) | 5 | 49.15 | 3.10 | 0.01 | 3.61 | 0.89 |
| | % Developed in 1km & % Natural in 1km & % Water in 1km | -1.01(1.59) | - | - | 0.11(0.1) | 0.02(0.03) | - | 0.12(0.09) | 5 | 49.15 | 3.11 | 0.01 | 4.20 | 0.84 |
| | % Developed in 1km & % Crop in 1km & % Water in 1km | 0.66(1.72) | - | - | 0.1(0.1) | - | -0.02(0.03) | 0.1(0.09) | 5 | 49.15 | 3.11 | 0.01 | 4.20 | 0.84 |
| | % Natural in 1km & % Crop in 1km & % Water in 1km | 10.21(9.49) | - | - | - | -0.1(0.1) | -0.11(0.1) | 0.01(0.11) | 5 | 49.15 | 3.11 | 0.01 | 4.20 | 0.84 |
| | % Developed in 1km & % Natural in 1km & % Crop in 1km | 11.01(8.95) | - | - | -0.01(0.11) | -0.1(0.09) | -0.12(0.09) | - | 5 | 49.15 | 3.11 | 0.01 | 4.20 | 0.84 |
| | % Natural in 1km & % Water in 1km | 0.67(1.06) | - | - | - | 0(0.02) | - | 0.1(0.09) | 4 | 49.28 | 3.24 | 0.01 | 5.36 | 0.72 |
| | Year of Survey & % Natural in 1km | 0.9(1.08) | 1.22(0.8) | - | - | -0.01(0.02) | - | - | 4 | 49.67 | 3.62 | 0.01 | 7.12 | 0.52 |
| | % Natural in 1km | 1.43(1.01) | - | - | - | -0.01(0.02) | - | - | 3 | 49.69 | 3.64 | 0.01 | 11.49 | 0.18 |
| | Pollinator Plot Presence & % Developed in 1km | 1(0.83) | - | -0.74(0.8) | 0.05(0.07) | - | - | - | 4 | 49.83 | 3.79 | 0.01 | 5.03 | 0.75 |
| | Year of Survey & Pollinator Plot Presence & % Developed in 1km | 0.41(0.91) | 1.28(0.82) | -0.75(0.83) | 0.05(0.07) | - | - | - | 5 | 49.90 | 3.86 | 0.01 | 7.80 | 0.45 |
| PIWO | **Year of Survey** | **9.19(3.15)** | **-19.84(5.79)** | **-** | **-** | **-** | **-** | **-** | **3** | **39.44** | **0** | **0.99** | **0.12** | **1** |
| REVI | Year of Survey | -2.01(0.98) | 1.59(1) | - | - | - | - | - | 3 | 48.07 | 0 | 0.13 | $^{N}$C | - |
| | **NULL** | **-0.98(0.5)** | **-** | **-** | **-** | **-** | **-** | **-** | **2** | **49.07** | **1.00** | **0.08** | **7.66** | **0.47** |
| | Year of Survey & % Developed in 1km | -1.47(1.02) | 1.61(1) | - | -0.06(0.07) | - | - | - | 4 | 49.08 | 1.01 | 0.08 | 5.79 | 0.67 |
| | Year of Survey & % Natural in 1km | -3.27(1.88) | 1.62(1.01) | - | - | 0.03(0.04) | - | - | 4 | 49.64 | 1.57 | 0.06 | 9.01 | 0.34 |
| | Year of Survey & Pollinator Plot Presence | -2.49(1.3) | 1.63(1.02) | 0.81(1.08) | - | - | - | - | 4 | 49.97 | 1.89 | 0.05 | $^{N}$C | - |
| | % Developed in 1km | -0.51(0.64) | - | - | -0.05(0.06) | - | - | - | 3 | 49.98 | 1.90 | 0.05 | 12.13 | 0.15 |
| | Year of Survey & % Crop in 1km | -2.43(1.68) | 1.59(1) | - | - | - | 0.01(0.03) | - | 4 | 50.49 | 2.42 | 0.04 | 14.41 | 0.07 |
| | Year of Survey & % Water in 1km | -1.97(1) | 1.59(0.99) | - | - | - | - | -0.01(0.04) | 4 | 50.57 | 2.50 | 0.04 | 14.69 | 0.07 |
| | % Natural in 1km | -1.96(1.28) | - | - | - | 0.03(0.03) | - | - | 3 | 50.59 | 2.52 | 0.04 | 8.24 | 0.41 |
| | Pollinator Plot Presence | -1.32(0.74) | - | 0.61(0.87) | - | - | - | - | 3 | 50.93 | 2.86 | 0.03 | $^{N}$C | - |
| | % Crop in 1km | -1.37(1.23) | - | - | - | - | 0.01(0.02) | - | 3 | 51.31 | 3.24 | 0.03 | 13.41 | 0.10 |

| Avian Code[1] | Top Model Covariates[2] | (Intercept) 2017 or Control | β Coefficient (SE)[2] Year (2018) | Pollinator | % of cover within 1 kilometer: Developed | Natural | Cropland | Water | df | AICc | ΔAIC | $w_i$ | Hosmer-Lemeshow statistic | p-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year of Survey & % Developed in 1km & % Natural in 1km | -2.39(1.91) | 1.63(1.01) | - | -0.05(0.08) | 0.02(0.04) | - | - | 5 | 51.36 | 3.29 | 0.03 | 7.99 | 0.43 |
| | % Water in 1km | -0.94(0.54) | - | - | - | - | - | -0.01(0.03) | 3 | 51.41 | 3.33 | 0.02 | 13.63 | 0.09 |
| | Year of Survey & Pollinator Plot Presence & % Developed in 1km | -1.84(1.31) | 1.64(1.02) | 0.56(1.06) | -0.05(0.07) | - | - | - | 5 | 51.47 | 3.40 | 0.02 | 5.38 | 0.72 |
| | Year of Survey & % Developed in 1km & % Water in 1km | -1.33(1.08) | 1.61(1) | - | -0.06(0.08) | - | - | -0.01(0.04) | 5 | 51.65 | 3.57 | 0.02 | 7.03 | 0.53 |
| | Year of Survey & % Developed in 1km & % Crop in 1km | -0.96(1.88) | 1.62(1.01) | - | -0.06(0.07) | - | -0.01(0.03) | - | 5 | 51.68 | 3.60 | 0.02 | 5.90 | 0.66 |
| | Year of Survey & % Natural in 1km & % Crop in 1km | -4.59(3.07) | 1.62(1.01) | - | - | 0.04(0.04) | 0.02(0.03) | - | 5 | 51.87 | 3.79 | 0.02 | 11.54 | 0.17 |
| TRES | **% Crop in 1km** | **1.92(1.53)** | **-** | **-** | **-** | **-** | **-0.07(0.04)** | **-** | **3** | **47.77** | **0** | **0.44** | **4.73** | **0.79** |
| | % Crop in 1km & % Water in 1km | 1.38(1.61) | - | - | - | - | -0.06(0.04) | 0.04(0.05) | 4 | 49.67 | 1.91 | 0.17 | 4.63 | 0.80 |
| | NULL | -0.99(0.72) | - | - | - | - | - | - | 2 | 50.33 | 2.57 | 0.12 | NC | - |
| | % Water in 1km | -1.35(0.83) | - | - | - | - | - | 0.07(0.06) | 3 | 50.72 | 2.96 | 0.10 | 7.73 | 0.46 |
| TUVU | **% Crop in 1km** | **0.81(0.93)** | **-** | **-** | **-** | **-** | **-0.04(0.02)** | **-** | **3** | **49.93** | **0** | **0.08** | **9.28** | **0.32** |
| | Pollinator Plot Presence & % Crop in 1km | 0.47(0.97) | - | 1.15(0.85) | - | - | -0.05(0.02) | - | 4 | 50.41 | 0.48 | 0.06 | 4.52 | 0.81 |
| | Year of Survey & % Crop in 1km | 0.34(1.01) | 1.08(0.78) | - | - | - | -0.04(0.02) | - | 4 | 50.42 | 0.50 | 0.06 | 6.55 | 0.59 |
| | Year of Survey & Pollinator Plot Presence & % Crop in 1km | -0.08(1.07) | 1.17(0.8) | 1.25(0.88) | - | - | -0.05(0.03) | - | 5 | 50.86 | 0.93 | 0.05 | 8.07 | 0.43 |
| | NULL | -0.73(0.38) | - | - | - | - | - | - | 2 | 50.98 | 1.05 | 0.05 | NC | - |
| | % Water in 1km | -1.02(0.41) | - | - | - | - | - | 0.04(0.03) | 3 | 51.00 | 1.07 | 0.05 | 8.11 | 0.42 |
| | Pollinator Plot Presence & % Crop in 1km & % Water in 1km | -0.2(1.1) | - | 1.46(0.96) | - | - | -0.04(0.03) | 0.04(0.03) | 5 | 51.34 | 1.41 | 0.04 | 5.74 | 0.68 |
| | % Crop in 1km & % Water in 1km | 0.34(1.03) | - | - | - | - | -0.03(0.02) | 0.03(0.03) | 4 | 51.44 | 1.52 | 0.04 | 6.15 | 0.63 |
| | % Developed in 1km & % Crop in 1km | 1.73(1.38) | - | - | -0.02(0.02) | - | -0.05(0.03) | - | 4 | 51.57 | 1.64 | 0.04 | 3.60 | 0.89 |
| | Pollinator Plot Presence & % Water in 1km | -1.72(0.71) | - | 1.08(0.81) | - | - | - | 0.05(0.03) | 4 | 51.59 | 1.67 | 0.03 | 9.52 | 0.30 |
| | Year of Survey | -1.31(0.66) | 0.97(0.78) | - | - | - | - | - | 3 | 51.62 | 1.70 | 0.03 | NC | - |
| | Year of Survey & % Water in 1km | -1.62(0.65) | 1.03(0.77) | - | - | - | - | 0.05(0.03) | 4 | 51.64 | 1.71 | 0.03 | 8.47 | 0.39 |
| | Year of Survey & % Crop in 1km & % Water in 1km | -0.19(1.13) | 1.13(0.8) | - | - | - | -0.03(0.02) | 0.03(0.03) | 5 | 52.02 | 2.10 | 0.03 | 7.69 | 0.46 |
| | Year of Survey & % Developed in 1km & % Crop in 1km | 1.32(1.44) | 1.12(0.79) | - | -0.02(0.02) | - | -0.06(0.03) | - | 5 | 52.15 | 2.22 | 0.03 | 4.40 | 0.82 |
| | Year of Survey & Pollinator Plot Presence & % Water in 1km | -2.43(0.93) | 1.12(0.8) | 1.17(0.83) | - | - | - | 0.05(0.03) | 5 | 52.16 | 2.24 | 0.03 | 4.32 | 0.83 |

| Avian Code[1] | Top Model Covariates[2] | (Intercept) 2017 or Control | β Coefficient (SE)[2] Year (2018) | Pollinator | % of cover within 1 kilometer Developed | Natural | Cropland | Water | df | AICc | ΔAIC | $w_i$ | Hosmer-Lemeshow statistic | p-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pollinator Plot Presence | -1.18(0.57) | - | 0.77(0.73) | - | - | - | - | 3 | 52.20 | 2.27 | 0.03 | 8.85 | 0.35 |
| | % Natural in 1km & % Crop in 1km | 0.7(1.39) | - | - | - | 0(0.02) | -0.04(0.02) | - | 4 | 52.44 | 2.51 | 0.02 | 6.99 | 0.54 |
| | % Natural in 1km & % Water in 1km | -2.03(1.2) | - | - | - | 0.02(0.03) | - | 0.05(0.03) | 4 | 52.63 | 2.71 | 0.02 | 10.64 | 0.22 |
| | Pollinator Plot Presence & % Developed in 1km & % Crop in 1km | 1.21(1.48) | - | 1.06(0.88) | -0.02(0.02) | - | -0.06(0.03) | - | 5 | 52.66 | 2.74 | 0.02 | 8.62 | 0.38 |
| | Pollinator Plot Presence & % Developed in 1km & % Water in 1km | -2.41(1.03) | - | 1.53(0.97) | 0.03(0.02) | - | - | 0.06(0.03) | 5 | 52.84 | 2.91 | 0.02 | 6.43 | 0.60 |
| | Pollinator Plot Presence & % Natural in 1km & % Crop in 1km | 0.96(1.44) | - | 1.33(0.94) | - | -0.01(0.03) | -0.05(0.03) | - | 5 | 52.86 | 2.93 | 0.02 | 4.30 | 0.83 |
| | Year of Survey & Pollinator Plot Presence | -1.82(0.89) | 1.02(0.79) | 0.87(0.81) | - | - | - | - | 4 | 52.87 | 2.94 | 0.02 | NC | - |
| | Year of Survey & % Natural in 1km & % Crop in 1km | 0.21(1.47) | 1.08(0.78) | - | - | 0(0.02) | -0.04(0.02) | - | 5 | 53.09 | 3.17 | 0.02 | 6.44 | 0.60 |
| | % Developed in 1km & % Water in 1km | -1.18(0.49) | - | - | 0.01(0.02) | - | - | 0.04(0.03) | 4 | 53.17 | 3.24 | 0.02 | 8.24 | 0.41 |
| | % Developed in 1km | -0.83(0.42) | - | - | 0.01(0.02) | - | - | - | 3 | 53.18 | 3.26 | 0.02 | 5.75 | 0.67 |
| | % Natural in 1km | -1.08(0.95) | - | - | - | 0.01(0.02) | - | - | 3 | 53.20 | 3.27 | 0.02 | 4.07 | 0.85 |
| | Year of Survey & % Natural in 1km & % Water in 1km | -2.74(1.37) | 1.07(0.78) | - | - | 0.03(0.03) | - | 0.06(0.03) | 5 | 53.33 | 3.40 | 0.01 | 10.45 | 0.23 |
| | % Developed in 1km & % Natural in 1km & % Water in 1km | -3.22(1.63) | - | - | 0.03(0.02) | 0.04(0.03) | - | 0.07(0.03) | 5 | 53.79 | 3.86 | 0.01 | 4.44 | 0.82 |
| | % Natural in 1km & % Crop in 1km & % Water in 1km | -0.41(1.63) | - | - | - | 0.02(0.03) | -0.03(0.02) | 0.04(0.03) | 5 | 53.79 | 3.86 | 0.01 | 4.44 | 0.82 |
| | % Developed in 1km & % Crop in 1km & % Water in 1km | 1.1(1.66) | - | - | -0.02(0.03) | - | -0.04(0.03) | 0.02(0.03) | 5 | 53.79 | 3.86 | 0.01 | 4.44 | 0.82 |
| | % Developed in 1km & % Natural in 1km & % Crop in 1km | 3.32(2.82) | - | - | -0.04(0.03) | -0.02(0.03) | -0.07(0.03) | - | 5 | 53.79 | 3.86 | 0.01 | 4.44 | 0.82 |

[1]: Species codes are found in Table 2.1

[2]: Covariates used included pollinator or control farm, year of survey, and % land cover at a 1km scale including developed, natural, cropland, and Water

NC: indicates model non-convergence under Hosmer-Lemshow goodness of fit test

Appendix H: Top and competing (ΔAIC<4 ) models of bird density by species using bird point count data during Spring (April 8th- June 5th) of 2017 and 2018 surveys on 20 farms study sites across the Coastal Plain of Virginia and Maryland.

| Species Code[1] | Model Def. [2] | Covariates[3] | # obs | # params | ΔAIC | AIC | $W_i$ | EDR[34] | D[45] | D LCL | D UCL | D CV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AMCR | **Haz-Cos** | **Obs/PP** | **253** | **5** | **0.00** | **448.52** | **0.42** | **71.06** | **0.18** | **0.14** | **0.23** | **0.12** |
| | Haz-Cos | Obs/Developed% | 253 | 5 | 0.45 | 448.97 | 0.34 | 71.39 | 0.18 | 0.14 | 0.22 | 0.12 |
| | Haz-Cos | Obs/Water% | 253 | 5 | 1.14 | 449.66 | 0.24 | 71.65 | 0.18 | 0.14 | 0.22 | 0.12 |
| AMRO | **HN-Cos** | **Obs/Station** | **294** | **6** | **0.00** | **693.89** | **1.00** | **36.42** | **0.79** | **0.50** | **1.24** | **0.23** |
| BLGR | **HN-Cos** | **Station/Natural%** | **157** | **5** | **0.00** | **361.71** | **0.33** | **31.81** | **0.55** | **0.40** | **0.77** | **0.17** |
| | HN-Cos | Station | 157 | 4 | 2.08 | 363.79 | 0.12 | 32.38 | 0.53 | 0.39 | 0.74 | 0.17 |
| | HN-Cos | Station/Crops% | 157 | 5 | 2.55 | 364.25 | 0.09 | 32.16 | 0.54 | 0.39 | 0.75 | 0.17 |
| | HN-Cos | CloudC/Station | 157 | 5 | 2.68 | 364.39 | 0.09 | 32.22 | 0.54 | 0.39 | 0.75 | 0.17 |
| | HN-Cos | Station/Water% | 157 | 5 | 3.60 | 365.30 | 0.05 | 32.34 | 0.54 | 0.39 | 0.74 | 0.17 |
| | HN-Cos | Playback/Station | 157 | 5 | 3.78 | 365.49 | 0.05 | 32.35 | 0.54 | 0.39 | 0.74 | 0.17 |
| | HN-Cos | PP/Station | 157 | 5 | 3.87 | 365.58 | 0.05 | 32.34 | 0.54 | 0.39 | 0.74 | 0.17 |
| | HN-Cos | MinFrmSunR/Station | 157 | 5 | 3.91 | 365.62 | 0.05 | 32.39 | 0.53 | 0.38 | 0.74 | 0.17 |
| | HN-Cos | Temp/Station | 157 | 5 | 4.00 | 365.70 | 0.04 | 32.37 | 0.53 | 0.39 | 0.74 | 0.17 |
| BLJA | Haz-Cos | Station/Water% | 146 | 6 | 0.00 | 366.38 | 0.24 | 48.88 | 0.22 | 0.16 | 0.30 | 0.16 |
| | **Haz-Cos** | **Station/Crops%** | **146** | **6** | **0.15** | **366.53** | **0.23** | **38.09** | **0.36** | **0.25** | **0.51** | **0.18** |
| | Haz-Cos | MinFrmSunR/Station | 146 | 6 | 1.04 | 367.42 | 0.14 | 33.70 | 0.46 | 0.32 | 0.66 | 0.18 |
| | Haz-Cos | PP/Station | 146 | 6 | 1.11 | 367.49 | 0.14 | 34.38 | 0.44 | 0.30 | 0.64 | 0.19 |
| | Haz-Cos | Temp/Station | 146 | 6 | 1.28 | 367.66 | 0.13 | 36.56 | 0.39 | 0.27 | 0.56 | 0.18 |
| | Haz-Cos | Obs/Station | 146 | 7 | 3.75 | 370.13 | 0.04 | 49.94 | 0.21 | 0.15 | 0.29 | 0.17 |
| CACH | **HN-Cos** | **MinFrmSunR/Obs** | **217** | **4** | **0.00** | **512.81** | **0.76** | **31.78** | **0.77** | **0.56** | **1.06** | **0.16** |
| | HN-Cos | Obs/Temp | 217 | 4 | 2.57 | 515.37 | 0.21 | 31.92 | 0.76 | 0.55 | 1.05 | 0.16 |
| CAWR | **HN-Cos** | **Obs/PP** | **485** | **4** | **0.00** | **1019.04** | **0.69** | **40.71** | **1.04** | **0.87** | **1.26** | **0.09** |
| CHSP | **Haz-Cos** | **NoCov** | **805** | **2** | **0.00** | **2006.55** | **1.00** | **26.72** | **4.02** | **3.09** | **5.24** | **0.13** |
| FISP | **HN-Cos** | **MinFrmSunR/Developed%** | **205** | **3** | **0.00** | **472.88** | **0.15** | **51.07** | **0.28** | **0.19** | **0.41** | **0.19** |
| | HN-Cos | MinFrmSunR/Natural% | 205 | 3 | 0.30 | 473.18 | 0.13 | 51.20 | 0.28 | 0.19 | 0.41 | 0.19 |
| | HN-Cos | MinFrmSunR/Water% | 205 | 3 | 0.86 | 473.74 | 0.10 | 51.23 | 0.28 | 0.19 | 0.41 | 0.19 |
| | HN-Cos | MinFrmSunR/CloudC | 205 | 3 | 1.12 | 474.00 | 0.08 | 51.24 | 0.28 | 0.19 | 0.41 | 0.19 |
| | HN-Cos | MinFrmSunR | 205 | 2 | 1.38 | 474.27 | 0.07 | 51.49 | 0.28 | 0.19 | 0.40 | 0.19 |
| | HN-Cos | Playback/MinFrmSunR | 205 | 3 | 1.42 | 474.30 | 0.07 | 51.30 | 0.28 | 0.19 | 0.40 | 0.19 |

| Species Code[1] | Model Def. [2] | Covariates[3] | # obs | # params | ΔAIC | AIC | $W_i$ | EDR[34] | D[45] | D LCL | D UCL | D CV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HN-Cos | MinFrmSunR/Station | 205 | 5 | 1.47 | 474.35 | 0.07 | 50.98 | 0.28 | 0.19 | 0.41 | 0.19 |
| | HN-Cos | CloudC/Developed% | 205 | 3 | 1.85 | 474.73 | 0.06 | 51.33 | 0.28 | 0.19 | 0.40 | 0.19 |
| | HN-Cos | MinFrmSunR/Crops% | 205 | 3 | 2.16 | 475.05 | 0.05 | 51.41 | 0.28 | 0.19 | 0.40 | 0.19 |
| | HN-Cos | MinFrmSunR/Temp | 205 | 3 | 2.56 | 475.44 | 0.04 | 51.37 | 0.28 | 0.19 | 0.40 | 0.19 |
| | HN-Cos | Temp/Developed% | 205 | 3 | 2.93 | 475.81 | 0.03 | 51.38 | 0.28 | 0.19 | 0.40 | 0.19 |
| | HN-Cos | MinFrmSunR/PP | 205 | 3 | 3.37 | 476.26 | 0.03 | 51.48 | 0.28 | 0.19 | 0.40 | 0.19 |
| | HN-Cos | Station/Natural% | 205 | 5 | 3.70 | 476.59 | 0.02 | 51.25 | 0.28 | 0.19 | 0.41 | 0.19 |
| NOCA | **HN-Cos** | **Temp/Station** | **935** | **5** | **0.00** | **2235.40** | **0.96** | **40.33** | **2.05** | **1.79** | **2.35** | **0.07** |
| TUTI | **Haz-Cos** | **Temp/Water%** | **230** | **4** | **0.00** | **487.54** | **0.27** | **63.41** | **0.20** | **0.16** | **0.26** | **0.12** |
| | Haz-Cos | Temp/Station | 230 | 6 | 1.26 | 488.80 | 0.14 | 63.48 | 0.20 | 0.16 | 0.26 | 0.12 |
| | Haz-Cos | Playback/Temp | 230 | 4 | 1.76 | 489.30 | 0.11 | 62.66 | 0.21 | 0.16 | 0.27 | 0.12 |
| | Haz-Cos | Temp/CloudC | 230 | 4 | 2.35 | 489.89 | 0.08 | 63.84 | 0.20 | 0.16 | 0.26 | 0.12 |
| | Haz-Cos | Obs/Natural% | 230 | 6 | 2.43 | 489.97 | 0.08 | 69.34 | 0.17 | 0.13 | 0.22 | 0.12 |
| | Haz-Cos | MinFrmSunR/Temp | 230 | 4 | 2.47 | 490.01 | 0.08 | 63.28 | 0.20 | 0.16 | 0.26 | 0.12 |
| | Haz-Cos | Temp/Developed% | 230 | 4 | 2.95 | 490.49 | 0.06 | 63.12 | 0.21 | 0.16 | 0.26 | 0.12 |
| | Haz-Cos | Obs/Station | 230 | 8 | 3.10 | 490.65 | 0.06 | 69.30 | 0.17 | 0.13 | 0.22 | 0.12 |
| | Haz-Cos | Temp/Natural% | 230 | 4 | 3.83 | 491.38 | 0.04 | 63.98 | 0.20 | 0.16 | 0.26 | 0.12 |

[1]: Species codes are found in Table 2.2

[2]: Key functions hazard rate (HAZ), half normal (HN), simple polynomial (SP) and adjustment expansions cosine (COS)

[3]: Covariates used included start time of survey since sunrise, temperature during survey, cloud cover at the start of survey, pollinator or control farm, type of landcover at each survey point (FM, FU, NH, and PP), observer, and % landcover at a 1km scale including developed, natural, cropland, and Water

[4]: Effective distance radius

[5]: Density was estimated in birds per hectare

* Model stratification did not converge and estimates were discarded

Appendix I: Top and competing models (ΔAIC<4 ) of bird density by species of bird using point count data collected during Fall (August 26th-October 14th) of 2017 and 2018 surveys on 20 farms study sites across the Coastal Plain of Virginia and Maryland.

| Species Code[1] | Model Def.[2] | Covariates[3] | # obs | # params | ΔAIC | AIC | Wi | EDR[4] | D[5] | D LCL | D UCL | D CV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AMCR | **HN-SP** | **Playback/Water%** | **498** | **4** | **0.00** | **852.79** | **0.30** | **81.21** | **0.28** | **0.23** | **0.34** | **0.09** |
| | HN-SP | Water%/Developed% | 498 | 3 | 0.80 | 853.59 | 0.20 | 74.31 | 0.34 | 0.28 | 0.41 | 0.10 |
| | HN-SP | Water%/Natural% | 498 | 3 | 0.87 | 853.66 | 0.19 | 74.43 | 0.33 | 0.28 | 0.40 | 0.10 |
| | HN-SP | Water% | 498 | 2 | 3.03 | 855.82 | 0.07 | 74.39 | 0.33 | 0.28 | 0.40 | 0.10 |
| | HN-SP | Station/Water% | 498 | 5 | 3.16 | 855.95 | 0.06 | 73.86 | 0.34 | 0.28 | 0.41 | 0.10 |
| | HN-SP | MinFrmSunR/Water% | 498 | 3 | 3.26 | 856.05 | 0.06 | 74.25 | 0.34 | 0.28 | 0.41 | 0.10 |
| AMRO | **HN-Cos** | **CloudC/Crops%** | **107** | **3** | **0.00** | **238.08** | **0.17** | **39.00** | **0.26** | **0.17** | **0.41** | **0.23** |
| | HN-Cos | Crops% | 107 | 2 | 1.33 | 239.41 | 0.09 | 39.43 | 0.26 | 0.16 | 0.40 | 0.23 |
| | HN-Cos | Playback/Crops% | 107 | 3 | 2.48 | 240.56 | 0.05 | 39.30 | 0.26 | 0.16 | 0.40 | 0.23 |
| | HN-Cos | PP/Crops% | 107 | 3 | 2.87 | 240.95 | 0.04 | 39.32 | 0.26 | 0.16 | 0.40 | 0.23 |
| | HN-Cos | Station/Crops% | 107 | 5 | 2.98 | 241.06 | 0.04 | 38.74 | 0.27 | 0.17 | 0.42 | 0.23 |
| | HN-Cos | Natural%/Developed% | 107 | 3 | 3.16 | 241.24 | 0.03 | 39.37 | 0.26 | 0.16 | 0.40 | 0.23 |
| | HN-Cos | Crops%/Natural% | 107 | 3 | 3.18 | 241.26 | 0.03 | 39.36 | 0.26 | 0.16 | 0.40 | 0.23 |
| | HN-Cos | Crops%/Developed% | 107 | 3 | 3.20 | 241.28 | 0.03 | 39.37 | 0.26 | 0.16 | 0.40 | 0.23 |
| | HN-Cos | Temp/Crops% | 107 | 3 | 3.22 | 241.30 | 0.03 | 39.39 | 0.26 | 0.16 | 0.40 | 0.23 |
| | HN-Cos | Water%/Crops% | 107 | 3 | 3.23 | 241.31 | 0.03 | 39.42 | 0.26 | 0.16 | 0.40 | 0.23 |
| | HN-Cos | MinFrmSunR/Crops% | 107 | 3 | 3.25 | 241.33 | 0.03 | 39.39 | 0.26 | 0.16 | 0.40 | 0.23 |
| | HN-Cos | CloudC/Developed% | 107 | 3 | 3.35 | 241.43 | 0.03 | 39.54 | 0.25 | 0.16 | 0.40 | 0.23 |
| | HN-Cos | Station/Developed% | 107 | 5 | 3.41 | 241.49 | 0.03 | 38.92 | 0.26 | 0.17 | 0.41 | 0.23 |
| | HN-Cos | Station | 107 | 4 | 3.43 | 241.51 | 0.03 | 39.15 | 0.26 | 0.17 | 0.41 | 0.23 |
| | HN-Cos | CloudC | 107 | 2 | 3.89 | 241.97 | 0.02 | 39.89 | 0.25 | 0.16 | 0.39 | 0.23 |
| BLGR | **Haz-Cos** | **Temp/PP** | **201** | **4** | **0.00** | **390.93** | **0.30** | **42.69** | **0.41** | **0.28** | **0.60** | **0.19** |
| | Haz-Cos | PP | 201 | 3 | 1.14 | 392.07 | 0.17 | 42.11 | 0.42 | 0.29 | 0.62 | 0.19 |
| | Haz-Cos | CloudC/PP | 201 | 4 | 1.90 | 392.82 | 0.12 | 41.65 | 0.43 | 0.30 | 0.63 | 0.19 |
| | Haz-Cos | PP/Water% | 201 | 4 | 2.04 | 392.96 | 0.11 | 42.02 | 0.42 | 0.29 | 0.62 | 0.19 |
| | Haz-Cos | PP/Developed% | 201 | 4 | 2.48 | 393.41 | 0.09 | 42.11 | 0.42 | 0.29 | 0.62 | 0.19 |
| | Haz-Cos | PP/Crops% | 201 | 4 | 3.12 | 394.04 | 0.06 | 41.84 | 0.43 | 0.29 | 0.62 | 0.19 |
| | Haz-Cos | Obs/PP | 201 | 5 | 3.16 | 394.09 | 0.06 | 42.16 | 0.42 | 0.29 | 0.61 | 0.19 |
| | Haz-Cos | PP/Natural% | 201 | 4 | 3.47 | 394.39 | 0.05 | 42.03 | 0.42 | 0.29 | 0.62 | 0.19 |

| Species Code[1] | Model Def.[2] | Covariates[3] | # obs | # params | ΔAIC | AIC | Wi | EDR[4] | D[5] | D LCL | D UCL | D CV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Haz-Cos | PP/Station | 201 | 6 | 3.82 | 394.75 | 0.04 | 41.82 | 0.43 | 0.29 | 0.62 | 0.19 |
| BLJA | **Haz-Cos** | **No Cov** | **341** | **2** | **0.00** | **726.70** | **1.00** | **62.82** | **0.32** | **0.24** | **0.43** | **0.14** |
| CACH | **Haz-Cos** | **Obs/PP** | **169** | **5** | **0.00** | **355.06** | **0.29** | **33.78** | **0.55** | **0.40** | **0.76** | **0.16** |
| | Haz-Cos | CloudC/Natural% | 169 | 4 | 1.45 | 356.51 | 0.14 | 34.49 | 0.53 | 0.38 | 0.73 | 0.16 |
| | Haz-Cos | CloudC/PP | 169 | 4 | 1.50 | 356.56 | 0.14 | 34.13 | 0.54 | 0.39 | 0.74 | 0.16 |
| | Haz-Cos | MinFrmSunR/Obs | 169 | 5 | 3.45 | 358.51 | 0.05 | 33.19 | 0.57 | 0.41 | 0.79 | 0.16 |
| | Haz-Cos | CloudC | 169 | 3 | 3.96 | 359.02 | 0.04 | 34.78 | 0.52 | 0.38 | 0.72 | 0.16 |
| CAWR | **Haz-Cos** | **No Cov** | **1059** | **2** | **0.00** | **2438.35** | **1.00** | **42.38** | **2.19** | **1.94** | **2.48** | **0.06** |
| CHSP | **Haz-Cos** | **No Cov** | **149** | **2** | **0.00** | **266.24** | **0.20** | **30.29** | **0.60** | **0.40** | **0.92** | **0.21** |
| | Haz-Cos | Water% | 149 | 3 | 2.59 | 270.65 | 0.05 | 27.96 | 0.71 | 0.46 | 1.09 | 0.22 |
| | Haz-Cos | PP | 149 | 3 | 3.84 | 271.90 | 0.03 | 28.41 | 0.69 | 0.45 | 1.06 | 0.22 |
| | Haz-Cos | Natural% | 149 | 3 | 3.94 | 272.00 | 0.03 | 28.51 | 0.68 | 0.44 | 1.05 | 0.22 |
| | Haz-Cos | Playback | 149 | 3 | 3.95 | 272.01 | 0.03 | 28.57 | 0.68 | 0.44 | 1.04 | 0.22 |
| | Haz-Cos | Temp | 149 | 3 | 3.99 | 272.05 | 0.03 | 28.47 | 0.68 | 0.44 | 1.05 | 0.22 |
| FISP | **Haz-Cos** | **No Cov** | **113** | **2** | **0.00** | **253.40** | **1.00** | **31.58** | **0.42** | **0.23** | **0.76** | **0.31** |
| NOCA | **Haz-Cos** | **NOCACloudC/Crops%** | **408** | **4** | **0.00** | **845.70** | **0.57** | **29.90** | **1.70** | **1.34** | **2.15** | **0.12** |
| | Haz-Cos | NOCANo Cov | 408 | 2 | 0.53 | 846.23 | 0.43 | 28.54 | 1.86 | 1.44 | 2.40 | 0.13 |
| TUTI | **HN-SP** | **Obs/Natural%** | **139** | **4** | **0.00** | **306.08** | **0.28** | **37.46** | **0.37** | **0.26** | **0.53** | **0.19** |
| | HN-SP | Obs/Station | 139 | 6 | 1.37 | 307.44 | 0.14 | 37.19 | 0.37 | 0.26 | 0.54 | 0.19 |
| | HN-SP | PP | 139 | 2 | 2.77 | 308.85 | 0.07 | 37.88 | 0.36 | 0.25 | 0.52 | 0.18 |
| | HN-SP | MinFrmSunR/PP | 139 | 3 | 3.07 | 309.14 | 0.06 | 37.72 | 0.36 | 0.25 | 0.52 | 0.19 |
| | HN-SP | Playback/Water% | 139 | 4 | 3.53 | 309.60 | 0.05 | 53.36 | 0.18 | 0.13 | 0.26 | 0.18 |
| | HN-SP | PP/Crops% | 139 | 3 | 3.56 | 309.63 | 0.05 | 37.65 | 0.36 | 0.25 | 0.53 | 0.19 |
| | HN-SP | PP/Natural% | 139 | 3 | 3.75 | 309.83 | 0.04 | 37.66 | 0.36 | 0.25 | 0.53 | 0.19 |

[1]: Species codes are found in Table 2.2

[2]: Key functions hazard rate (HAZ), half normal (HN), simple polynomial (SP) and adjustment expansions cosine (COS)

[3]: Covariates used included start time of survey since sunrise, temperature during survey, cloud cover at the start of survey, pollinator or control farm, type of landcover at each survey point (FM, FU, NH, and PP), observer, and % landcover at a 1km scale including developed, natural, cropland, and water

[4]: Effective distance radius

[5]: Density was estimated in birds per hectare

* Model stratification did not converge and estimates were discarded

Appendix J: Mean (SE) values of vegetation variables taken after a nesting success or failure during monitoring of red-winged blackbird (*Agelaius phoeniceus*) nests on ten survey farms with pollinator plots on the Coastal Plain of Virginia and Maryland between June 4th and June 29th 2017 and May 28th and July 8th 2018. Forb green vegetation, grass, flowering heads, bare ground, and dead vegetation are taken from 1 $m^2$ vegetation surveys and vegetation obstruction and height was collected from Robel pole measurements.

| | USED (SE) (n=5) | AVAILABLE (SE) (n=25) |
|---|---|---|
| Forbs | 86% (6.78%) | 58.8% (3.22%) |
| Grass | 2% (2%) | 3.4% (1.57%) |
| Flower | 3% (2%) | 6.12% (1.5%) |
| Bare Ground | 2.4% (1.94%) | 6.42% (1.11%) |
| Dead Vegetation | 3.6% (1.86%) | 25.44% (2.64%) |
| Vegetation Height | 91cm (10.26cm) | 87.64cm (3.69cm) |
| Visual Obstruction | 83cm (9.1cm) | 59.4cm (4.41cm) |

Appendix K: Each farm study site with associated survey points on each cover type during all four separate survey seasons in 2017-18 Spring and Fall across the Eastern Shore of Virginia and Maryland (Delmarva Peninsula) and in the city of Virginia Beach, VA. Two farms, A: Brookdale and I: La Caridad, opted out of 2017 Fall survey season, and only one (I) came back to the study in 2018. Three farms had multiple sample points of the same cover type including I: La Caridad, K: Mattawoman, and P: Quail Cove. Each farm study site had three survey points except for Q: Sturgis in 2017 during Spring, O: Provident with two locations, and J: LSREC with two locations.

| | Plot Area | | | Point Type[2] | | | |
|---|---|---|---|---|---|---|---|
| Farm[1] | ($m^2$) | Year | Season | FU | FM | NH | PP |
| A | - | 2017 | Spring | 1 | 2 | - | - |
| | | | Fall | - | - | - | - |
| | | 2018 | Spring | - | - | - | - |
| | | | Fall | - | - | - | - |
| B | 948.49 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| C | 1112.17 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| D | - | 2017 | Spring | 1 | 1 | 1 | - |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Fall | 1 | 1 | 1 | - |
| | | 2018 | Spring | 1 | 1 | 1 | - |
| | | | Fall | 1 | 1 | 1 | - |
| E | 3372.42 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| F | 2139.52 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| G | 1649.36 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| H | - | 2017 | Spring | 1 | 1 | 1 | - |
| | | | Fall | 1 | 1 | 1 | - |
| | | 2018 | Spring | 1 | 1 | 1 | - |
| | | | Fall | 1 | 1 | 1 | - |
| I | - | 2017 | Spring | 3 | - | - | - |
| | | | Fall | - | - | - | - |
| | | 2018 | Spring | 3 | - | - | - |
| | | | Fall | 3 | - | - | - |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| J | - | 2017 | Spring | 1 | 1 | - | - |
| | | | Fall | 1 | 1 | - | - |
| | | 2018 | Spring | 1 | 1 | - | - |
| | | | Fall | 1 | 1 | - | - |
| K | - | 2017 | Spring | 1 | 1 | 1 | - |
| | | | Fall | 1 | 1 | 1 | - |
| | | 2018 | Spring | 2 | - | 1 | - |
| | | | Fall | 2 | - | 1 | - |
| L | - | 2017 | Spring | 1 | 1 | 1 | - |
| | | | Fall | 1 | 1 | 1 | - |
| | | 2018 | Spring | 1 | 1 | 1 | - |
| | | | Fall | 1 | 1 | 1 | - |
| M | 2274.03 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| N | 709.94 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| O | - | 2017 | Spring | 1 | 1 | - | - |
| | | | Fall | 1 | 1 | - | - |
| | | 2018 | Spring | 1 | 1 | - | - |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Fall | 1 | 1 | - | - |
| P | - | 2017 | Spring | - | 3 | - | - |
| | | | Fall | - | 3 | - | - |
| | | 2018 | Spring | - | 3 | - | - |
| | | | Fall | - | 3 | - | - |
| Q | 10779.7 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| R | 2191.81 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| S | - | 2017 | Spring | 1 | 1 | 1 | - |
| | | | Fall | 1 | 1 | 1 | - |
| | | 2018 | Spring | 1 | 1 | 1 | - |
| | | | Fall | 1 | 1 | 1 | - |
| T | 2533.9 | 2017 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |
| | | 2018 | Spring | 1 | 1 | - | 1 |
| | | | Fall | 1 | 1 | - | 1 |

[1]: Farm locations, A: Brookdale, B: Calliope, C: Copper Cricket, D: Cullipher, E: Virginia Tech Eastern Shore Agricultural Research and Extension Center, F: Flanagan, G: Flip Flop, H:

Virginia Tech Hampton Roads Agricultural Research and Extension Center , I: La Caridad, J: University of Maryland Lower Eastern Shore Research & Education Center - Extension, K: Mattawoman, L: Patty's Garden, M: Perennial, N: Pik Penny, O: Provident, P: Quail Cove, Q: Sturgis, R: University of Maryland Eastern Shore Somerset – Extension, S: Van Dessel, T: Wright.

[2]: Point types, FU: Forest Unmanaged, FM: Forest Managed, NH: Novelty Habitat, PP: Pollinator Plot.

Appendix L: Covariate values by farm for each survey location. Covariates include the percent of 4 cover types within a 1-km radius land cover analysis on each farm study site using data from the 2017 USDA Cropscape data layer and the human and machine camera trap success for each survey season for Spring 2017 (May 13th-June 29th), Fall 2017 (August 16th-October 15th), Spring 2018 (April 20th-June 24th), and Fall 2018 (August 18th-October 27th) across the Eastern Shore of Virginia and Maryland (i.e. Delmarva Peninsula) and in the city of Virginia Beach, VA.

| | % of 1 Kilometer Radius by Cover type | | | | | Human[3] Camera trap Success Per 100 Trap Nights | | | | Machine[4] Camera trap Success Per 100 Trap Nights | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2017 | | 2018 | | 2017 | | 2018 | |
| Farm[1] | Water | Crop | Natural | Developed | Point Cover type[2] | Spring | Fall | Spring | Fall | Spring | Fall | Spring | Fall |
| A | 0.03 | 58.8 | 34.55 | 6.62 | FU | 35.9 | - | - | - | 48.72 | - | - | - |
| | | | | | FM1 | 23.81 | - | - | - | 52.38 | - | - | - |
| | | | | | FM2 | 26.83 | - | - | - | 129.27 | - | - | - |
| B | 0.95 | 33 | 57.65 | 8.4 | FU | 7.32 | 12.5 | 6.25 | 8.7 | 0 | 0 | 0 | 1.45 |
| | | | | | PP | 9.76 | 5.26 | 37.5 | 27.69 | 0 | 0 | 26.56 | 18.46 |
| | | | | | FM | 68.29 | 75 | 76.56 | 100 | 519.51 | 557.14 | 501.56 | 736.67 |
| C | 27.16 | 43.73 | 26.84 | 2.27 | FM | 3.7 | 2.5 | 6.35 | 6.67 | 25.93 | 0 | 17.46 | 0 |
| | | | | | PP | 202.44 | 231.37 | 67.8 | 194.12 | 73.17 | 43.14 | 89.83 | 11.76 |
| | | | | | FU | 14.81 | 11.76 | 223.73 | 39.22 | 66.67 | 50.98 | 79.66 | 80.39 |
| D | 0.06 | 63.13 | 29.79 | 7.02 | FU | 7.14 | 3.39 | 11.11 | 3.45 | 0 | 0 | 2.78 | 0 |
| | | | | | NH | 10 | 3.39 | 12 | 10 | 0 | 0 | 0 | 2.5 |
| | | | | | FM | 61.9 | 106.78 | 41.46 | 126.09 | 376.19 | 438.98 | 402.44 | 413.04 |
| E | 1.12 | 53.69 | 40.72 | 4.48 | FU | 23.81 | 21.15 | 31.91 | 9.38 | 4.76 | 9.62 | 6.38 | 1.56 |
| | | | | | FM | 11.63 | 6.06 | 12.82 | 5.56 | 0 | 6.06 | 66.67 | 20.37 |
| | | | | | PP | 63.41 | 11.54 | 44.68 | 13.46 | 17.07 | 32.69 | 63.83 | 30.77 |

| | | | | | | Human[3] Camera trap Success Per 100 Trap Nights | | | | Machine[4] Camera trap Success Per 100 Trap Nights | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % of 1 Kilometer Radius by Cover type | | | | | 2017 | | 2018 | | 2017 | | 2018 | |
| Farm[1] | Water | Crop | Natural | Developed | Point Cover type[2] | Spring | Fall | Spring | Fall | Spring | Fall | Spring | Fall |
| F | 0.14 | 42.29 | 41.69 | 15.88 | FU | 9.68 | 12.07 | 12.5 | 16.13 | 16.13 | 0 | 0 | 3.23 |
| | | | | | PP | 38.89 | 29.17 | 64.44 | 32.79 | 22.22 | 4.17 | 20 | 6.56 |
| | | | | | FM | 7.32 | 17.24 | 12.5 | 13.46 | 9.76 | 39.66 | 7.81 | 7.69 |
| G | 0.11 | 52.75 | 42.72 | 4.42 | FU | 9.52 | 6.78 | 7.81 | 7.46 | 0 | 0 | 1.56 | 0 |
| | | | | | FM | 75 | 16.28 | 42.19 | 8.96 | 21.43 | 13.95 | 25 | 2.99 |
| | | | | | PP | 42.86 | 14.29 | 53.85 | 16.42 | 45.24 | 14.29 | 121.15 | 23.88 |
| H | 3.47 | 0.03 | 10.48 | 86.02 | FU | 9.52 | 6.38 | 14.29 | 7.94 | 0 | 0 | 0 | 4.76 |
| | | | | | NH | 97.62 | 82.35 | 62.5 | 58.82 | 128.57 | 29.41 | 46.88 | 25 |
| | | | | | FM | 119.05 | 84.75 | 87.69 | 89.71 | 97.62 | 152.54 | 72.31 | 41.18 |
| I | 0.06 | 62.03 | 29.68 | 8.23 | FU3 | 6.90 | - | 7.94 | 9.68 | 0 | - | 0 | 0 |
| | | | | | FU1 | 9.52 | - | 6.35 | 15.09 | 0 | - | 0 | 0 |
| | | | | | FU2 | 14.29 | - | 22.22 | 25.37 | 4.76 | - | 4.76 | 1.49 |
| J | 0.09 | 73.17 | 14.19 | 12.56 | FU | 16.67 | 3.64 | 6.25 | 8.7 | 52.38 | 76.36 | 51.56 | 49.28 |
| | | | | | FM | 39.02 | 10.91 | 31.58 | 13.04 | 195.12 | 85.45 | 131.58 | 88.41 |
| K | 49.35 | 22.86 | 24.69 | 3.1 | NH | 6.98 | 8.16 | 55.38 | 5.56 | 79.07 | 8.16 | 87.69 | 22.22 |
| | | | | | FU | 38.1 | 8.16 | 16.92 | 11.43 | 1104.76 | 79.59 | 115.38 | 28.57 |
| | | | | | FM | 30.95 | 26.09 | 27.69 | 19.44 | 330.95 | 91.3 | 116.92 | 33.33 |
| L | 0.11 | 25.89 | 69.17 | 4.82 | FM | 17.07 | 5.45 | 8.33 | 5.88 | 121.95 | 9.09 | 4.17 | 20.59 |
| | | | | | NH | 36.59 | 14.71 | 119.61 | 11.76 | 270.73 | 155.88 | 280.39 | 77.94 |
| | | | | | FU | 29.27 | 12.12 | 20.63 | 11.11 | 234.15 | 81.82 | 49.21 | 111.11 |
| M | 0.03 | 34.89 | 49.97 | 15.11 | FU | 4.76 | 6.38 | 7.94 | 10 | 7.14 | 0 | 3.17 | 0 |
| | | | | | PP | 74.36 | 23.08 | 45.9 | 22.86 | 46.15 | 12.82 | 22.95 | 5.71 |
| | | | | | FM | 367.5 | 348 | 507.55 | 314.93 | 485 | 376 | 428.30 | 417.91 |

| | % of 1 Kilometer Radius by Cover type | | | | | Human[3] Camera trap Success Per 100 Trap Nights | | | | Machine[4] Camera trap Success Per 100 Trap Nights | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2017 | | 2018 | | 2017 | | 2018 | |
| Farm[1] | Water | Crop | Natural | Developed | Point Cover type[2] | Spring | Fall | Spring | Fall | Spring | Fall | Spring | Fall |
| N | 4.67 | 36.04 | 54.53 | 4.76 | FU | 6.98 | 15.09 | 9.62 | 8 | 0 | 0 | 3.85 | 0 |
| | | | | | PP | 11.63 | 13.16 | 19.35 | 4.55 | 18.6 | 42.11 | 33.87 | 1.52 |
| | | | | | FM | 390.7 | 166.04 | 246.15 | 80.3 | 93.02 | 15.09 | 61.54 | 9.09 |
| O | 17.41 | 25.36 | 35.69 | 21.54 | FU | 9.76 | 4 | 6.82 | 4.41 | 0 | 0 | 0 | 0 |
| | | | | | FM | 403.45 | 96 | 229.41 | 173.68 | 51.72 | 6 | 85.29 | 44.74 |
| P | 0 | 58.32 | 38.18 | 3.5 | FM3 | 7.14 | 2.78 | 9.68 | 6.06 | 0 | 0 | 0 | 0 |
| | | | | | FM2 | 19.05 | 29.41 | 30.65 | 56.82 | 23.81 | 47.06 | 150 | 215.91 |
| | | | | | FM1 | 40.48 | 7.84 | 14.29 | 15.22 | 1635.71 | 766.67 | 26.98 | 484.78 |
| Q | 10.06 | 53.28 | 36.03 | 0.63 | PP | 11.11 | 12.5 | 18.46 | 16.92 | 11.11 | 10.71 | 6.15 | 1.54 |
| | | | | | FU | 4.65 | 17.78 | 11.67 | 19.7 | 4.65 | 6.67 | 13.33 | 4.55 |
| | | | | | FM | 4.65 | 5.36 | 12.73 | 4.62 | 13.95 | 35.71 | 129.09 | 203.08 |
| R | 0 | 31.16 | 59.89 | 8.95 | FU | 5.00 | 12.28 | 10.77 | 8.06 | 2.5 | 1.75 | 23.08 | 0 |
| | | | | | PP | 23.68 | 10.53 | 21.54 | 8.82 | 47.37 | 21.05 | 20 | 8.82 |
| | | | | | FM | 7.5 | 78.57 | 65 | 21.82 | 27.5 | 914.29 | 70 | 40 |
| S | 0 | 60.83 | 32.72 | 6.45 | NH | 9.52 | 9.26 | 12.7 | 10.45 | 7.14 | 0 | 22.22 | 5.97 |
| | | | | | FU | 11.9 | 18 | 18.6 | 86 | 28.57 | 20 | 27.91 | 28 |
| | | | | | FM | 14.29 | 7.41 | 8.62 | 14.29 | 9.52 | 3.7 | 0 | 38.78 |
| T | 1.52 | 67.95 | 21.01 | 9.52 | FU | 12.2 | 8.7 | 6.45 | 13.16 | 0 | 0 | 24.19 | 5.26 |
| | | | | | PP | 29.27 | 9.09 | 18.75 | 17.31 | 7.32 | 0 | 12.5 | 5.77 |
| | | | | | FM | 17.07 | 25.45 | 13.56 | 23.08 | 4.88 | 20 | 22.03 | 5.77 |

[1]: Farm locations, A: Brookdale, B: Calliope, C: Copper Cricket, D: Cullipher, E: Virginia Tech Eastern Shore Agricultural Research and Extension Center, F: Flanagan, G: Flip Flop, H: Virginia Tech Hampton Roads Agricultural Research and Extension Center , I: La Caridad, J:

University of Maryland Lower Eastern Shore Research & Education Center - Extension, K: Mattawoman, L: Patty's Garden, M: Perennial, N: Pik Penny, O: Provident, P: Quail Cove, Q: Sturgis, R: University of Maryland Eastern Shore Somerset – Extension, S: Van Dessel, T: Wright.

[2]: Point types, FU: Forest Unmanaged, FM: Forest Managed, NH: Novelty Habitat, PP: Pollinator Plot.

[3]: Human camera trap events in calculations of camera trap success included pedestrians, dog walkers, researchers or manual laborers all possibly using wheelbarrows, hand tools, and bicycles.

[4]: Machine camera trap events in calculations of camera trap success included human presence with machinery, like cars, mowers, tillers, trailers.

Appendix M: List of plant species used in each wildflower mix. Taken from dissertation of project partner Christopher T. McCullough (McCullough 2020). Pollinator plots planted included farm study sites on the Eastern Shore of Virginia and Maryland (i.e. Delmarva Peninsula) and in the city of Virginia Beach, VA (Table 4.1, Figure 4.1). Farms included 3 sites in the city of Virginia Beach, VA; 2 sites in Northampton, VA; 2 sites in Accomack, VA; and 3 sites in Wicomico, MD.

**A.** Grass and forb mix for well-drained soils (N = 7). Used on farms; C: Copper Cricket, E: ESAREC, F: Flanagan, M: Perennial, N: Pik Penny, R: UMES, and T: Wright.

| Common Name | Scientific Name | Seeding Rate (weight of pure live seed per acre) |
|---|---|---|
| Little Bluestem (G) | *Schizachyrium scoparium* | 0.75 pound |
| Splitbeard Bluestem (G) | *Andropogon ternarius* | 0.75 pound |
| Narrowleaf Mountain Mint (P) | *Pycnanthemum tenuifolium* | 1.5 ounce |
| Plains Coreopsis (A) | *Coreopsis tinctoria* | 1.5 ounce |
| Partridge Pea (A) | *Chamaecrista fasciculata* | 2.0 pounds |
| Black-eyed Susan (B) | *Rudbeckia hirta* | 3 ounces |
| Bergamot, Spotted (P) | *Monarda fistulosa* | 1.5 ounce |
| Lanceleaf Coreopsis (P) | *Coreopsis lanceolata* | 15 ounces |
| Maximilian Sunflower (P) | *Helianthus maximilianii* | 1 pound |
| Indian Blanket (A) | *Gaillardia pulchella* | 13.5 ounces |
| Purple Coneflower (P) | *Echinacea purpurea* | 1.8 pound |

**B.** Grass and forb mix for poorly-drained soils (N = 2). Used on farms; B: Calliope and G: Flip

Flop.

| Common Name | Scientific Name | Seeding Rate (weight of pure live seed per acre) |
|---|---|---|
| Beaked Panicum (G) | *Panicum anceps* | 0.37 pound |
| Redtop Panicum (G) | *Panicum rigidulum* | 0.30 pound |
| Aster, Purple-stemmed (P) | *Symphyotrichum puniceum var. puniceum* | 4.5 ounces |
| Sneezeweed, Common (P) | *Helenium autumnale* | 3 ounces |
| Coreopsis, Plains (A) | *Coreopsis tinctoria* | 1.5 ounce |
| Goldenrod, Wrinkleleaf (P) | *Solidago rugosa* | 3 ounces |
| Joe Pye Weed, Spotted (P) | *Eupatoriadelphus fistulosus* | 3 ounces |
| Partridge Pea (A) | *Chamaecrista fasciculata* | 2.0 pounds |
| Rattlesnake Master (P) | *Eryngium yuccifolium* | 12 ounces |
| Rosemallow (P) | *Hibiscus moscheutos* | 3 ounces |
| Narrowleaf Sunflower (P) | *Helianthus angustifolius* | 6 ounces |

**C.** Forb mix for 2015 well-drained field. Used on farm Q: Sturgis.

| Common Name | Scientific Name |
|---|---|
| Showy evening primrose (P)* | *Oenothera speciosa* |
| Indian Blanket (A) | *Gaillardia pulchella* |
| Maximilian Sunflower (P) | *Helianthus maximiliani* |
| Black-eyed Susan (B) | *Rudbeckia hirta* |

| | |
|---|---|
| Partridge Pea (A) | *Chamaecrista fasciculate* |
| Plains Coreopsis (A) | *Coreopsis tinctoria* |
| Lanceleaf Coreopsis (P) | *Coreopsis lanceolate* |
| Spotted Beebalm (P)* | *Monarda punctate* |
| Tickseed Sunflower (A)* | *Bidens aristosa* |

G = grass,

A = annual

B = biennial

P = perennial

* not in well-drained mix found in table A

Appendix N: White-tailed deer (*Odocoileus virginianus*) occupancy models for Spring 2017 (May 13th-June 29th), Fall 2017 (August 16th-October 15th), Spring 2018 (April 20th-June 24th), and Fall 2018 (August 18th-October 27th) at 20 farm study sites across the Eastern Shore of Virginia and Maryland (i.e. Delmarva Peninsula) and in the city of Virginia Beach, VA. ‘*’ denotes a likely model non-convergence.

| Year | Season | Model | AIC | ΔAIC | AIC wgt | Model Likelihood | no.Par. | -2*LogLike |
|---|---|---|---|---|---|---|---|---|
| **2017** | **Spring** | **ψ(kmDvlp[a]),p(.)** | **2962.14** | **0** | **0.89** | **1** | **3** | **2956.14** |
| | | ψ(kmNtrl[b]),p(.) | 2966.53 | 4.39 | 0.1 | 0.11 | 3 | 2960.53 |
| | | *ψ(kmCrop[c]),p(.) | 2971.52 | 9.38 | 0.01 | 0.01 | 3 | 2965.52 |
| | | 1 group, Constant P | 2976.28 | 14.14 | 0.001 | 0.001 | 2 | 2972.28 |
| | | ψ(kmBkgd[d]),p(.) | 2977.73 | 15.59 | <0.001 | <0.001 | 3 | 2971.73 |
| | | ψ(Machine[e]),p(.) | 2977.87 | 15.73 | <0.001 | <0.001 | 3 | 2971.87 |
| | | ψ(PPorNot[f]),p(.) | 2977.98 | 15.84 | <0.001 | <0.001 | 3 | 2971.98 |
| | | ψ(Human[g]),p(.) | 2978.22 | 16.08 | <0.001 | <0.001 | 3 | 2972.22 |
| | | ψPoints[h]),p(.) | 2981.06 | 18.92 | <0.001 | <0.001 | 5 | 2971.06 |
| | | *ψ(Farm[i]),p(.) | 2987.85 | 25.71 | 0 | 0 | 21 | 2945.85 |
| | | *1 group, Survey-specific P | 2996.55 | 34.41 | 0 | 0 | 49 | 2898.55 |
| | | *ψ(Global[j]),p(.) | 2998.21 | 36.07 | 0 | 0 | 30 | 2938.21 |
| | Fall | **ψ(kmDvlp[a]),p(.)** | **3016.84** | **0** | **0.99** | **1** | **3** | **3010.84** |
| | | ψ(Human[g]),p(.) | 3029.06 | 12.22 | 0.002 | 0.002 | 3 | 3023.06 |
| | | *ψ(kmNtrl[b]),p(.) | 3031.5 | 14.66 | 0.001 | 0.001 | 3 | 3025.5 |
| | | 1 group, Constant P | 3032.88 | 16.04 | <0.001 | <0.001 | 2 | 3028.88 |
| | | ψ(kmBkgd[d]),p(.) | 3032.95 | 16.11 | <0.001 | <0.001 | 3 | 3026.95 |
| | | ψ(Machine[e]),p(.) | 3034.14 | 17.3 | <0.001 | <0.001 | 3 | 3028.14 |
| | | ψ(PPorNot[f]),p(.) | 3034.16 | 17.32 | <0.001 | <0.001 | 3 | 3028.16 |
| | | ψ(Farm[I]),p(.) | 3037.25 | 20.41 | 0 | 0 | 19 | 2999.25 |
| | | ψ(Points[h]),p(.) | 3037.32 | 20.48 | 0 | 0 | 5 | 3027.32 |

| Year | Season | Model | AIC | ΔAIC | AIC wgt | Model Likelihood | no.Par. | -2*LogLike |
|---|---|---|---|---|---|---|---|---|
| | | *ψ(Global[j]),p(.) | 3043.79 | 26.95 | 0 | 0 | 28 | 2987.79 |
| | | *1 group, Survey-specific P | 3066.04 | 49.2 | 0 | 0 | 62 | 2942.04 |
| | | *ψ(kmCrop[c]),p(.) | 3126.31 | 109.47 | 0 | 0 | 3 | 3120.31 |
| 2018 | Spring | **ψ(kmDvlp[a]),p(.)** | **3924.5** | **0** | **0.81** | **1** | **3** | **3918.5** |
| | | ψ(kmNtrl[b]),p(.) | 3927.81 | 3.31 | 0.16 | 0.19 | 3 | 3921.81 |
| | | *ψ(kmCrop[c]),p(.) | 3931.46 | 6.96 | 0.03 | 0.03 | 3 | 3925.46 |
| | | 1 group, Constant P | 3935.45 | 10.95 | 0.003 | 0.004 | 2 | 3931.45 |
| | | ψ(PPorNot[f]),p(.) | 3936.22 | 11.72 | 0.002 | 0.003 | 3 | 3930.22 |
| | | ψ(Human[g]),p(.) | 3936.83 | 12.33 | 0.002 | 0.002 | 3 | 3930.83 |
| | | ψ(Machine[e]),p(.) | 3937.36 | 12.86 | 0.001 | 0.002 | 3 | 3931.36 |
| | | ψ(kmBkgd[d]),p(.) | 3937.45 | 12.95 | 0.001 | 0.002 | 3 | 3931.45 |
| | | ψ(Points[h]),p(.) | 3937.72 | 13.22 | 0.001 | 0.002 | 5 | 3927.72 |
| | | *ψ(Farm[i]),p(.) | 3945 | 20.5 | 0 | 0 | 20 | 3905 |
| | | *ψ(Global[j]),p(.) | 3951.54 | 27.04 | 0 | 0 | 29 | 3893.54 |
| | | *1 group, Survey-specific P | 4005.8 | 81.3 | 0 | 0 | 67 | 3871.8 |
| | Fall | **ψ(kmDvlp[a]),p(.)** | **3785.3** | **0** | **0.89** | **1** | **3** | **3779.3** |
| | | ψ(kmCrop[c]),p(.) | 3790.32 | 5.02 | 0.07 | 0.08 | 3 | 3784.32 |
| | | ψ(kmNtrl[b]),p(.) | 3793.23 | 7.93 | 0.02 | 0.02 | 3 | 3787.23 |
| | | ψ(Points[h]),p(.) | 3794.12 | 8.82 | 0.01 | 0.01 | 5 | 3784.12 |
| | | 1 group, Constant P | 3795.71 | 10.41 | 0.005 | 0.01 | 2 | 3791.71 |
| | | ψ(Machine[e]),p(.) | 3796.52 | 11.22 | 0.003 | 0.004 | 3 | 3790.52 |
| | | ψ(Human[g]),p(.) | 3796.58 | 11.28 | 0.003 | 0.004 | 3 | 3790.58 |
| | | *ψ(PPorNot[f]),p(.) | 3797.68 | 12.38 | 0.002 | 0.002 | 3 | 3791.68 |
| | | ψ(kmBkgd[d]),p(.) | 3797.69 | 12.39 | 0.002 | 0.002 | 3 | 3791.69 |
| | | *ψ(Farm[i]),p(.) | 3805.05 | 19.75 | 0 | <0.001 | 20 | 3765.05 |
| | | *ψ(Global[j]),p(.) | 3807.78 | 22.48 | 0 | 0 | 29 | 3749.78 |
| | | *1 group, Survey-specific P | 3827.53 | 42.23 | 0 | 0 | 72 | 3683.53 |

[a] Percent of developed cover type within 1km of each farm

[b] Percent of natural cover type within 1km of each farm

[c] Percent of crop cover type within 1km of each farm

[d] Percent of water cover type within 1km of each farm

[e] Camera trap success per 100 nights for that survey season of human disturbance classified as machines.

[f] Control or pollinator farm

[g] Camera trap success per 100 nights for that survey season of strictly human presence either all possibly using, wheelbarrows, hand tools, and bicycles

[h] Covariates included each point type (forest-managed, forest-unmanaged, pollinator plot, and novelty habitat)

[i] Covariates included each farm as a parameter to consider individual farm.

[j] Global model with farm, pollinator/control, human camera trap success per 100 trap nights, machine camera trap success per 100 trap nights, 1km cover type (Developed, Natural, and Crop), and point type (forest-managed, forest-unmanaged, pollinator plot).

Appendix O: Wild turkey (*Meleagris gallopavo*) occupancy models for Spring 2017 (May 13th-June 29th), Fall 2017 (August 16th-October 15th), Spring 2018 (April 20th-June 24th), and Fall 2018 (August 18th-October 27th) at 20 farm study sites across the Eastern Shore of Virginia and Maryland. '*' denotes a likely model non-convergence.

| Year | Season | Model | AIC | ΔAIC | AIC wgt | Model Likelihood | no.Par. | -2*LogLike |
|---|---|---|---|---|---|---|---|---|
| **2017** | **Spring** | **ψ(kmNtrl[a]),p(.)** | **275.62** | **0** | **0.71** | **1** | **3** | **269.62** |
| | | ψ(kmBkgd[b]),p(.) | 278.12 | 2.5 | 0.20 | 0.29 | 3 | 272.12 |
| | | ψ(Human[c]),p(.) | 282.49 | 6.87 | 0.02 | 0.03 | 3 | 276.49 |
| | | 1 group, Constant P | 282.58 | 6.96 | 0.02 | 0.03 | 2 | 278.58 |
| | | ψ(kmDvlp[d]),p(.) | 284.02 | 8.4 | 0.01 | 0.02 | 3 | 278.02 |
| | | ψ(kmCrop[e]),p(.) | 284.05 | 8.43 | 0.01 | 0.02 | 3 | 278.05 |
| | | ψ(Machine[f]),p(.) | 284.52 | 8.9 | 0.01 | 0.01 | 3 | 278.52 |
| | | ψ(PPorNot[g]),p(.) | 284.57 | 8.95 | 0.01 | 0.01 | 3 | 278.57 |
| | | *ψ(Points[h]),p(.) | 288.25 | 12.63 | 0.001 | 0.002 | 5 | 278.25 |
| | | *ψ(Farm[i]),p(.) | 290.41 | 14.79 | <0.001 | <0.001 | 21 | 248.41 |
| | | *ψ(Global[j]),p(.) | 304.44 | 28.82 | 0 | 0 | 30 | 244.44 |
| | | *1 group, Survey-specific P | 316.27 | 40.65 | 0 | 0 | 49 | 218.27 |
| | Fall | 1 group, Constant P | 266.34 | **0** | 0.17 | 1 | 2 | 262.34 |
| | | ψ(Human[c]),p(.) | 266.38 | **0.04** | 0.16 | 0.98 | 3 | 260.38 |
| | | ψ(kmBkgd[b]),p(.) | 266.55 | **0.21** | 0.15 | 0.90 | 3 | 260.55 |
| | | ψ(kmDvlp[d]),p(.) | 266.88 | **0.54** | 0.13 | 0.76 | 3 | 260.88 |
| | | ψ(kmCrop[e]),p(.) | 267.02 | **0.68** | 0.12 | 0.71 | 3 | 261.02 |
| | | ψ(kmNtrl[a]),p(.) | 267.7 | **1.36** | 0.08 | 0.51 | 3 | 261.7 |
| | | ψ(PPorNot[g]),p(.) | 268.3 | **1.96** | 0.06 | 0.38 | 3 | 262.3 |
| | | ψ(Machine[f]),p(.) | 268.33 | **1.99** | 0.06 | 0.37 | 3 | 262.33 |
| | | *ψ(Points[h]),p(.) | 268.33 | **1.99** | 0.06 | 0.37 | 5 | 258.33 |
| | | *ψ(Farm[i]),p(.) | 272.63 | 6.29 | 0.01 | 0.04 | 19 | 234.63 |

| Year | Season | Model | AIC | ΔAIC | AIC wgt | Model Likelihood | no.Par. | -2*LogLike |
|---|---|---|---|---|---|---|---|---|
| | | ψ(Global[j]),p(.) | 304.91 | 38.57 | 0 | 0 | 28 | 248.91 |
| | | *1 group, Survey-specific P | 317.81 | 51.47 | 0 | 0 | 62 | 193.81 |
| 2018 | Spring | *ψ(Farm[i]),p(.)[X] | 1207.17 | 0 | 0.99 | 1 | 20 | 1167.17 |
| | | **ψ(kmDvlp[d]),p(.)** | **1219.27** | **12.1** | **0.002** | **0.002** | **3** | **1213.27** |
| | | ψ(Human[c]),p(.) | 1221 | 13.83 | 0.001 | 0.001 | 3 | 1215 |
| | | ψ(kmNtrl[a]),p(.) | 1221.39 | 14.22 | 0.001 | 0.001 | 3 | 1215.39 |
| | | *ψ(Global[j]),p(.) | 1222.22 | 15.05 | 0.001 | 0.001 | 29 | 1164.22 |
| | | ψ(kmBkgd[b]),p(.) | 1223.07 | 15.9 | <0.001 | <0.001 | 3 | 1217.07 |
| | | ψ(kmCrop[e]),p(.) | 1223.28 | 16.11 | <0.001 | <0.001 | 3 | 1217.28 |
| | | 1 group, Constant P | 1223.99 | 16.82 | <0.001 | <0.001 | 2 | 1219.99 |
| | | ψ(Machine[f]),p(.) | 1225.42 | 18.25 | <0.001 | <0.001 | 3 | 1219.42 |
| | | ψ(PPorNot[g]),p(.) | 1225.75 | 18.58 | <0.001 | <0.001 | 3 | 1219.75 |
| | | ψ(Points[h]),p(.) | 1227.29 | 20.12 | 0 | 0 | 5 | 1217.29 |
| | | 1 group, Survey-specific P | 1262.42 | 55.25 | 0 | 0 | 67 | 1128.42 |
| | Fall | **ψ(Machine[f]),p(.)** | **410.86** | **0** | **0.72** | **1** | **3** | **404.86** |
| | | *ψ(Global[j]),p(.) | 415.08 | 4.22 | 0.09 | 0.12 | 29 | 357.08 |
| | | ψ(kmCrop[e]),p(.) | 415.12 | 4.26 | 0.09 | 0.12 | 3 | 409.12 |
| | | *ψ(Points[h]),p(.) | 416.8 | 5.94 | 0.04 | 0.05 | 5 | 406.8 |
| | | 1 group, Constant P | 418.07 | 7.21 | 0.02 | 0.03 | 2 | 414.07 |
| | | ψ(kmDvlp[d]),p(.) | 418.93 | 8.07 | 0.01 | 0.02 | 3 | 412.93 |
| | | ψ(Human[c]),p(.) | 419.01 | 8.15 | 0.01 | 0.02 | 3 | 413.01 |
| | | ψ(PPorNot[g]),p(.) | 419.1 | 8.24 | 0.01 | 0.02 | 3 | 413.1 |
| | | *ψ(Farm[i]),p(.) | 419.73 | 8.87 | 0.02 | 0.01 | 20 | 379.73 |
| | | ψ(kmNtrl[a]),p(.) | 419.9 | 9.04 | 0.02 | 0.01 | 3 | 413.9 |
| | | *1 group, Survey-specific P | 459.78 | 48.92 | 0 | 0 | 72 | 315.78 |
| | | *ψ(kmBkgd[b]),p(.) | 515.97 | 105.11 | 0 | 0 | 3 | 509.97 |

[a] Percent of natural cover type within 1km of each farm

[b] Percent of water cover type within 1km of each farm

[c] Camera trap success per 100 nights for that survey season of strictly human presence either all possibly using, wheelbarrows, hand tools, and bicycles

[d] Percent of developed cover type within 1km of each farm

[e] Percent of crop cover type within 1km of each farm

[f] Camera trap success per 100 nights for that survey season of human disturbance classified as machines.

[g] Control or pollinator

[h] Covariates included each point type (forest-managed, forest-unmanaged, pollinator plot, and novelty habitat)

[i] Covariates included each farm as a parameter to consider individual farm.

[j] Global model with farm, pollinator/control, human camera trap success per 100 trap nights, machine camera trap success per 100 trap nights, 1km cover type (Developed, Natural, and Crop), and point type (forest-managed, forest-unmanaged, pollinator plot).