# A COMPARISON OF AVIAN COMMUNITIES IN MANAGED EARLY SUCCESSIONAL EDGE HABITAT AND RESIDENTIAL EDGE HABITAT IN THE MIDDLE PATUXENT ENVIRONMENTAL AREA

By

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B.S. (Towson University) 2007

M.A. (University of Maryland Baltimore County) 2013

Independent Research Project

Submitted in partial satisfaction of the requirements

for the degree of

MASTER OF SCIENCE

in

ENVIRONMENTAL BIOLOGY

in the

GRADUATE SCHOOL

of

HOOD COLLEGE

November 2020

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## ABSTRACT

The Middle Patuxent Environmental Area (MPEA) is currently managed to maintain a variety of habitat types to support maximum biodiversity. The purpose of this project was to determine if the managed early successional habitat is effective in providing increased biodiversity for the avian community within the MPEA. Audio surveys were conducted in managed edge and residential edge habitats and the species presence/absence data were analyzed using generalized linear models to determine whether the community composition differs between the two edge habitats. Ten of the 18 most common species showed significant differences ($p<0.05$). Simple vegetation surveys were also conducted to further describe the two edge habitat types; differences in bird community composition may be due to vegetation differences, as managed edges were found to have denser understory ($p<0.05$). Surveys of other taxonomic groups, as well as a continuation of avian surveys in the future, are recommended.

## ACKNOWLEDGEMENTS AND SPONSORSHIP

I would like to thank Dr. Andrew Wilson for supervising this project, and for his guidance, patience, and support throughout the process. I would also like to thank Dr. Susan Carney for her encouragement throughout my time in the graduate program at Hood College. Finally, I would like to thank Cheryl Farfaras, Allen Dupre, and Jeff Claffy of the Middle Patuxent Environmental Area for their support and enthusiasm, and for all their hard work in maintaining a true natural gem in Howard County. I would also like to express my gratitude for the funding and supplies provided from the Hood College Graduate Research Fund and Gettysburg College.

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# INTRODUCTION

Many studies have investigated the impacts of human land use on wildlife, including the increased occurrence of edge as a result of the development of residential, commercial, and industrial areas (Giese et al. 2015). Increased fragmentation results in more habitat edge and a thorough understanding of edge effects is essential for management purposes (Ries et al. 2004). In this study, the effects of edge habitat created by management in a Maryland nature preserve were investigated in comparison to the effects of edge habitat created by residential areas. The avian communities were surveyed to determine whether the species present within the managed edge habitat differed from that of the residential edge habitat. Various sampling methods can be used to conduct bird surveys, including in-person point counts and use of autonomous recording units (ARUs) (Shonfield & Bayne 2017). For this study, ARUs were used to conduct auditory surveys to identify species present within each habitat, and the community composition of the two edge habitats were compared.

## Edge Effects

Increased land use by humans has resulted in greater fragmentation of habitats, leading to the presence of more edge habitat (Fletcher 2005). Various studies have investigated the effects of habitat edge on bird communities. Ries et al. (2004) define edges as “boundaries between distinct patch types”. Patches may be determined or defined based on vegetation structure or by land use classes. Early views of habitat edge embraced the potential for increased biodiversity along edges. A shift in the view of edges in the past few decades has occurred as studies focused on the negative impacts to habitat specialists with increased patchiness of habitats (Ries et al. 2004). Some evidence supports maintaining a mosaic landscape of habitats to support a diverse assemblage of bird species (Terraube et al. 2016). While several researchers argued that edge would result in negative outcomes for bird communities, the majority of studies have demonstrated either positive or neutral effects on bird abundance by species and richness/diversity over negative effects. Edges provide maximum access to different resources within two habitats that share an edge. However, one negative outcome of presence of edge habitat is the increased likelihood of nest predation and parasitism (Ries et al. 2004).

Ikin et al. (2014) examined edge effects between natural reserves and suburbs in Canberra, Australia. A Sorenson dissimilarity matrix was evaluated using the bird presence/absence data for each site surveyed. Birds were classified into foraging guilds, and species richness was determined for each guild. Suburbs were found to support species that fed on nectar, fruit, and seeds, while reserves supported arboreal insectivores. Overall, the bird community was found to differ significantly between the two habitat types, resulting in higher species richness when considering both communities as opposed to each in isolation (Ikin et al. 2014).

While a transition between habitats can be linked to the loss of species that depend on one habitat, edges can increase the overall biodiversity by supporting species that depend on each of the two habitats. Germaine et al. (1997) examined the bird community across edges of small forest openings in a hardwood forest habitat in Vermont. Bray-Curtis dissimilarity was calculated for different distances from the openings, and a species richness comparison was also completed. The overall species richness did not differ between forest and openings, however there was a turnover of species while moving from openings into the forest area, demonstrating an overall increase in biodiversity associated with the presence of forest openings (Germaine et al. 1997).

Multiple edges may also have an influence on community structure. Fletcher (2005) investigated whether multiple edges have an increased influence on bird populations compared to single-edge areas, with a focus specifically on the Bobolink (*Dolichonyx oryzivorus*) in Iowa. Surveys were conducted in areas with edges between grasslands and agricultural fields. Bobolinks had the greatest occurrence in interior habitats, and the lowest occurrence in double-edge plots (plots with two edges in close proximity to each other). The Bobolink's occurrence increased with distance from edge. Though only the Bobolink was studied, multiple habitat-dependent species may also exhibit similar trends, implying that not only the presence of edge but the number and proximity of edges should be considered in habitat management (Fletcher 2005).

The impact of edge effects may vary depending on the species. Fink et al. (2006) investigated the occurrence of eight species of birds in a forest interior habitat, glade habitat, and the forest-pasture edge in southern Missouri, USA. The species surveyed for were the Blue-winged Warbler (*Vermivora cyanoptera*), Northern Cardinal (*Cardinalis cardinalis*), Eastern Towhee (*Pipilo erythrophthalmus*), Prairie Warbler (*Setophaga discolor*), Field Sparrow (*Spizella pusilla*), White-eyed Vireo (*Vireo griseus*), Indigo Bunting (*Passerina cyanea*) and Yellow-breasted Chat (*Icteria virens*). While some species preferred interior habitat (Blue-winged Warbler; Eastern Towhee; Prairie Warbler; Yellow-breasted Chat), others were either more abundant or equally abundant in the edge habitat than interior (Field Sparrow; Northern Cardinal; Indigo Bunting) (Fink et al. 2006). Some species may also be dependent on different habitat types during different life stages. The Wood Thrush (*Hylocichla mustelina*) is often classified as a forest interior species, however the juveniles of this species tend to assemble in younger, more open forest stands with dense understory. The growing juveniles shift their preferred habitat back to mature forest closer to migration time. This shift may be linked to food availability, specifically the timing of fruits produced by plants (Vega Rivera et al. 1998).

The degree of edge effects may vary depending on the characteristics of habitats that exist on either side of the edge. Ries et al. (2004) investigated the effects of edge in relation to the similarities and differences between the adjacent habitats. When available resources differ greatly between the two habitats, edge provides maximum access to resources. For example, the Northern Bobwhite (*Colinus virginianus*) depends on four distinct habitat types, and therefore should be found in higher numbers in areas that contain a mosaic of all four preferred habitat types. Positive edge effects occur when adjacent habitats contain complementary resources instead of supplementary resources; when resources are concentrated at the edge; or when compared to edges between habitat and habitat of lower quality or non-habitat (such as residential areas) (Ries et al. 2004).

Though some habitat edge may be beneficial, edges associated with anthropogenic land use have been associated with negative edge effects. Edges between natural and developed areas are known to exhibit higher occurrences of nest predation and brood parasitism (Jones et al. 2000; Ries et al. 2004; King & Schlossberg 2014). Greater human presence is correlated with lower presence of sensitive species, though some species are positively associated with human disturbance; examples of such positively associated species include Brown-Headed Cowbird (*Molothrus ater*), Common Grackle (*Quiscalus quiscula*), European Starling (*Sturnus vulgaris*), House Sparrow (*Passer domesticus*), and Mourning Dove (*Zenaida macroura*) (Giese et al. 2015). Maintenance of early-successional habitat within forested areas can contribute to increased biodiversity by providing a more natural edge habitat (Germaine et al. 1997).

Maintaining Early Successional Habitat

The increasing evidence for the value of a mosaic landscape can inform plans to protect natural areas with the goal of maintaining high biodiversity. Terraube et al. (2016) argue that small-scale variation in habitat may provide increased biodiversity; insectivorous birds may be at an advantage in such habitats due to the increased insect biodiversity present at habitat edge. Bird species richness and total abundance have been shown to be higher at forest edges (Terraube et al. 2016).

In addition to proximity of broad habitat types, vegetation structure within those habitats is important for the establishment of bird populations. Several species are dependent directly on the presence of early successional plant species within forest areas. Many such bird species are highly abundant immediately following a disturbance and may find the habitat unsuitable after just a decade or less post-disturbance (King & Schlossberg 2014). Historic management of forest areas has reduced the occurrence of early successional habitat. A recent shift in best management practices now encourages allowing or creating small-scale disturbances to maintain early-successional areas within forest habitat (King & Schlossberg 2014; Farfaras et al. 2019). Early successional species are often designated species of conservation concern due to the decline in early successional habitat in the United States (King & Schlossberg 2014). Disturbances that can lead to the presence of early successional habitat can be anthropogenic or natural, though it has been shown that disturbances caused by industrial, agricultural, and commercial activities do not provide sufficient habitat for early successional species (King & Schlossberg 2014). Though management of early successional areas may appear to conflict with goals to maintain mature forest, maintaining a mosaic landscape has been shown to provide a net benefit for biodiversity. Early successional habitats can benefit forest species by providing habitat for juveniles that seek open habitat for food sources (Vega Rivera et al. 1998). It is recommended that 10% of forest habitat should be maintained as early successional habitat, not including areas that are in early successional stages as a result of past anthropogenic land use (King & Schlossberg 2014). The Middle Patuxent Environmental Area in Howard County, MD, the location of the project described in this report, is one example of a forested region that is currently being managed to include sections of early successional habitat (Farfaras et al. 2019).

Description of Research Area

Portions of Howard County, MD experienced an increase in forest fragmentation with the development of residential areas from 1950 to 1980 (Jones et al. 2000). The Middle Patuxent Environmental Area (MPEA) was established in 1996 and is managed by the Howard County Department of Recreation and Parks in partnership with the Middle Patuxent Environmental Foundation. The MPEA consists of 1021 acres of land and is managed with the purposes of natural resource conservation, environmental education, research, and passive recreation. The Howard County Bird Club has taken an active role in monitoring species within the park, and 150 species of birds have been documented in the MPEA (Howard County Department of Parks and Recreation 2019).

The MPEA contains mature second-growth upland forest and floodplain forest, with the Middle Patuxent River running through the property from north to south. The MPEA boundaries are adjacent to residential areas of Columbia, MD and Clarksville, MD. The area is currently being managed to provide a variety of habitats to support high levels of biodiversity (Middle Patuxent Environmental Foundation 2019).

Howard County Parks management staff has set back succession on portions of the MPEA (Figure 1). Habitat has been created and maintained as early successional areas within the park beginning in 1997 with the intention of supporting species that depend on such habitat (Farfaras et al. 2019). Farfaras et al. (2019) identify the target bird species list for the maintained early successional habitat to include the Yellow-breasted Chat (*Icteria virens*), Prairie Warbler (*Setophaga discolor*), Blue-winged Warbler (*Vermivora cyanoptera*), Field Sparrow (*Spizella pusilla*), Indigo Bunting (*Passerina cyanea*), and American Goldfinch (*Spinus tristis*). Edge habitat is present between the mature forest and the early successional managed areas. In addition, edge habitat exists between the protected area of mature forest and residential areas (Farfaras et al. 2019). Maintaining early successional habitat is intended to provide a variety of habitat types and increase overall biodiversity, however it has not yet been documented whether the management strategy is successful in achieving this outcome within the MPEA. This project serves to provide evidence of bird species present along the early successional area edge by conducting auditory surveys using autonomous recording units to determine effectiveness of the management plan.

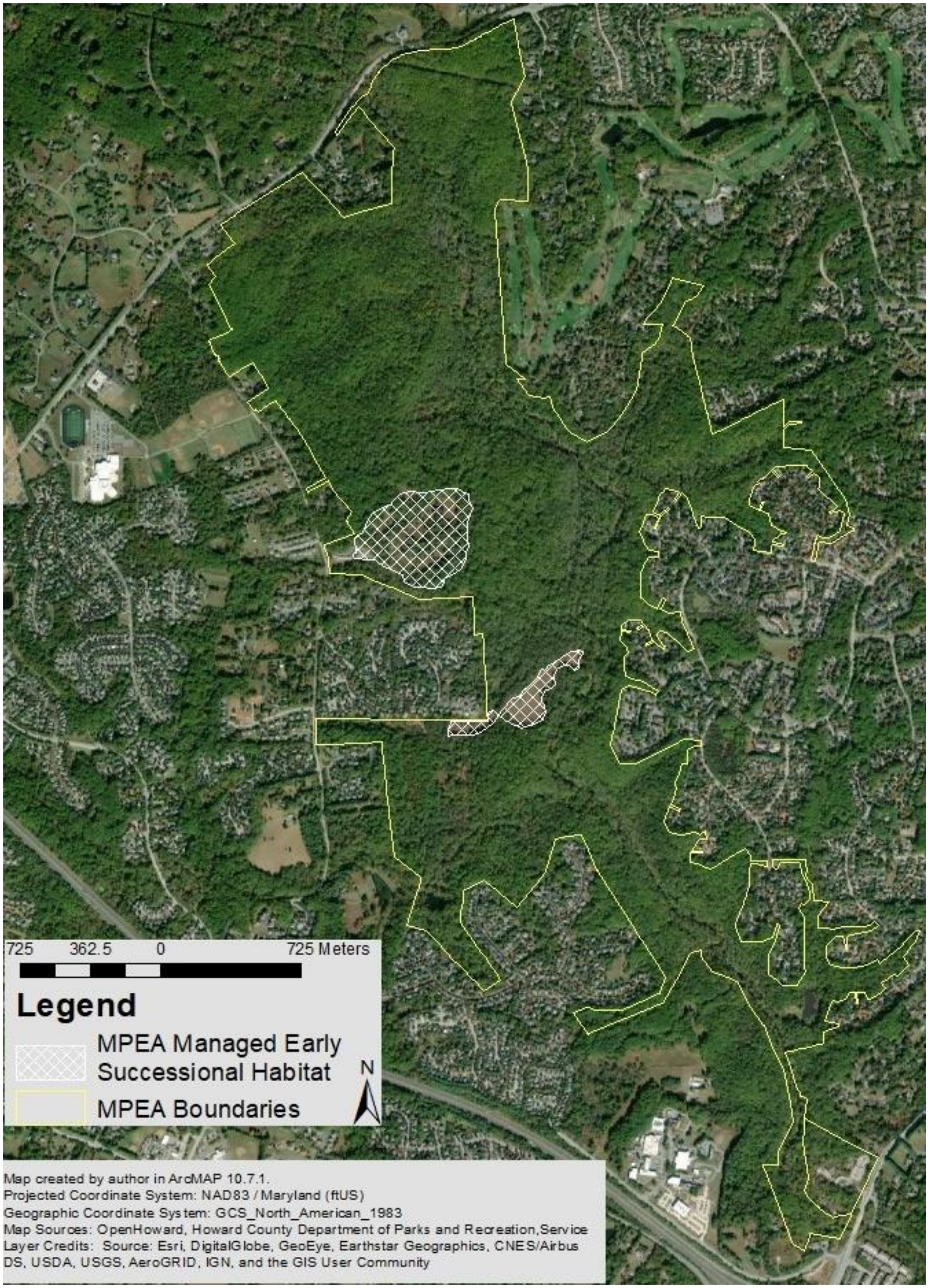


***Figure 1.*** *Map of the Middle Patuxent Environmental Area, with managed early successional habitat locations indicated by white cross hatching, and surrounding residential areas.*

## Autonomous Recording Units

Auditory point counts by a human observer have traditionally been used to survey bird communities, as many species are more readily detected by sound than by sight (Shonfield & Bayne 2017). Shonfield & Bayne (2017) note that the use of autonomous recording units (ARUs) has increased in recent years. The use of ARUs can have advantages over human observer point counts as recordings can be listened to multiple times and users have a permanent record of data. In addition, multiple people can listen to the same recordings for better accuracy with species identification. The disadvantages of using ARUs are that there is potential for data to be lost if the ARU fails. Also, they can be costly, and supporting evidence of visual observations is missed. Though they may not be the most ideal tool for abundance estimates, they can be very useful for collecting presence/absence data (Shonfield & Bayne 2017).

This study used the LabMaker AudioMoth ARU, recommended by Hill et al. (2018), a lightweight and inexpensive device measuring 58 x 48 x 18 mm and weighing only 80g when batteries are included. Hill et al. (2018) advocate that the AudioMoth ARU design is ideal for deployment in the field due to the small size and lightweight nature of the device. The portability of the AudioMoth allows for multiple devices to be easily carried and deployed by one person in the field. Recordings of 10 minute intervals such as those presented in the “Methods” section of this report can be easily accomplished with the energy requirements and data storage capacity of the AudioMoth ARUs (Hill et al. 2018).

## Purpose and Hypotheses

The purpose of this project was to compare the avian community composition of the managed early successional area and forest edge habitat (“managed”) to that of the adjacent residential areas and forest edge habitat ("residential"). The null and alternate hypotheses are as follows:

- Null hypothesis: The species richness and the specific species present/absent are the same in the managed edge habitat and the residential edge habitat.
- Alternate hypothesis: The specific species present/absent differ between the managed edge habitat and the residential edge habitat, and the species richness will be higher in the managed edge habitat compared to the residential edge habitat.

The higher species richness along the managed edge is expected as disturbances from anthropogenic land use are not sufficient to provide the necessary habitat for bird species that depend on early successional habitat (Ries et al. 2004; King & Schlossberg 2014).

Audio surveys were conducted to determine the presence/absence of bird species during the breeding season along the two edge habitats. Species richness was documented, and the detection probabilities for the most commonly detected species were compared between the different edge habitats to determine if the species composition varied.

## MATERIALS AND METHODS

Bird Species Sampling

Survey points were placed 200 m apart along each edge habitat (Jones et al. 2000). ArcMap 10.7.1 was used to outline the MPEA boundary as well as the boundaries to the early successional management areas; a buffer was created 50 m into the forest habitat from residential and managed boundaries (Figure 2). Potential sampling locations were placed along the 50 m buffer line. ARUs were placed 50 m from the forest edge so that they could adequately record bird vocalizations in the 100 m forest edge, but would have limited reach beyond that (A. Wilson, pers. comment). Nine points each were randomly selected from those that met the criteria of managed edge and residential edge, and were accessible, using Python in ArcMap for a total of 18 point locations. To ensure sufficient time to place ARUs, six points were sampled within one day (three residential and three managed) and all 18 points were sampled within one week.

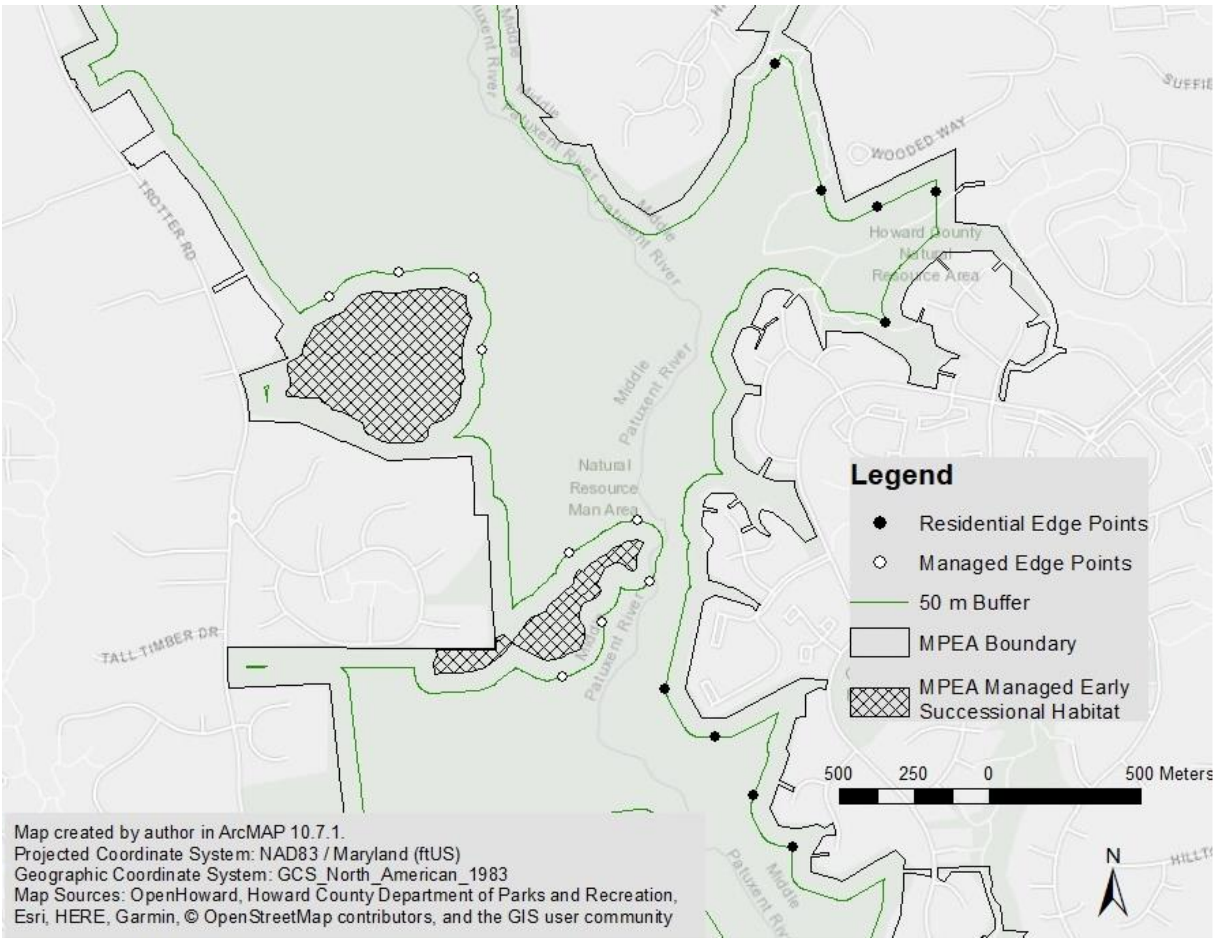


***Figure 2.*** *Location of sampling points used in surveys. Managed early successional edge sampling points marked in white and residential edge points marked in black.*

AudioMoth v1.1.0 autonomous recording devices from LabMaker were used to record bird presence data. Each device required 3 AA batteries and one micro SD card. Data were collected on two separate occasions during the 2020 breeding season, the first during the week of May 17, the second during the week of June 8. Mid-May through June is recommended for avian surveys as males will sing to establish territory and attract a mate at the start of the breeding season, and singing decreases after eggs are laid; the survey schedule was designed to capture early breeders as well as late-arriving migrants (Hamel et al. 1996). Dates of data collection were scheduled to each be at least 1 week apart and to occur on days with no precipitation and with low or no wind to maximize the probability of detection (Curson & Eberly 2018). The AudioMoth devices were

***Figure 3.*** *Audiomoth device deployed at a sample point in the managed edge habitat.*

programmed to record for three 10 minute periods, each one hour apart, beginning at 6:00 AM. Ideal sampling time occurs during the hours between 30 minutes prior to sunrise and four hours after sunrise, as birds are most active in vocalization at that time (Hamel et al. 1996). Devices were placed on trees/branches above head-height to avoid possible tampering by grazing animals (Hill et al. 2019). Each device was placed in a Ziploc bag for weatherproofing and secured to the tree/branch using zip ties (Figure 3) (Hill et al. 2018). ARUs were removed from the field in the late morning or early afternoon on the day of data collection.

***Figure 4.*** *Robel pole at a sample point in the residential edge habitat.*

<u>Vegetation Sampling</u>

Vegetation sampling was also conducted to describe possible differences in vegetation structure between the managed edge and the residential edge. All trees greater than 5 cm diameter at breast-height (DBH) were counted within a 10 m radius of the sampling point to provide descriptive data for tree stem density. To determine understory density, a modified Robel pole was used (Figure 4)

(Toledo et al. 2008). A white PVC pipe 2 m in length and 2.5 cm in diameter was marked with tape in 10 cm intervals to contain alternating white and black 10 cm sections. The pole was placed at the sampling point and viewed from each of the four cardinal directions at a distance of 4 m from the Robel pole and 1 m above the ground. The total number of 10 cm sections that were at least 25% obscured by understory vegetation were recorded, and the average number of sections for the four cardinal directions were calculated. Descriptive vegetation data were collected at each sampling point within one week of completion of auditory surveys.

Methods of Analysis

All audio recordings were reviewed using Audacity, a free open-source software, downloaded from www.audacityteam.org (Audacity Team 2020). Species were identified by sound as well as visual observation of the spectrogram of the audio file. Sections of each recording that contained more than one overlapping song or call, or songs that were less clear, were reviewed multiple times to ensure each species present was documented. All audible bird calls/songs clear to the reviewer were identified to the species level and documented in Microsoft Excel, organized by location, habitat type, date, and time. Songs that were challenging to identify to the reviewer were isolated when possible (if not overlapping other songs/calls) and reviewed using an online identification source, BirdNET (The Cornell Lab of Ornithology & Chemnitz University of Technology, 2019). Each 10-minute recording with a unique location, date, and time was considered to be a separate sampling event, and each species identified was listed once within the sampling event documentation. After completion of recording reviews, the Excel spreadsheet data were organized to show presence/absence data for each species during each sampling event, documented as "1" for species present, "0" for absent. The total number of detections for each species was calculated and all species showing greater than 30 total detections were further analyzed to determine detection probability within each edge type. For all species marked for further analysis, mean detection probability in each habitat was calculated and graphed in Excel for the May and June sampling periods. A comparison of overall detection probability was analyzed in R using the bglmer function in the blme package (Chung et al. 2013), a generalized mixed-effects model, with habitat type as the fixed effect and month and time as random effects. A mixed-effects model was selected to account for random variability potentially occurring due to month and time of each sampling event. Species richness for each sampling event was determined by totaling the number of species identified. Richness was also analyzed in R using the bglmer function in the blme package, with habitat type as the fixed effect and month and time as random effects. Vegetation data (tree stem density and understory density) were analyzed using a two-sample t-test in Microsoft Excel.

## RESULTS

Eighteen species had greater than 30 total detections (Table 1) and were analyzed to determine mean detection probabilities in managed and residential edge habitats (Figure 5). Ten of the 18 species analyzed were determined to have a statistically significant difference in detection probability between the two habitats (Table 2). An odds ratio greater than 1 demonstrated the species had a higher detection probability in the managed habitat, and an odds ratio lower than 1 demonstrated the species had a lower detection probability in the managed habitat compared to the residential habitat. A difference in detection probabilities between the two habitats was considered statistically significant for a species if the 95% confidence interval (CI) excluded 1 and the *p* value was $<0.05$. Though there were some differences in species composition between the two habitats, the overall species richness for sampling events did not significantly differ between the two habitat edge types (Table 3).

***Table 1.*** *Detection count (total, residential, and managed) for each species identified in survey recordings.*

| Species (Common Name) | Scientific Name | Detections (Total) | Detections (Residential) | Detections (Managed) |
|---|---|---|---|---|
| Mourning Dove | *Zenaida macroura* | 9 | 5 | 4 |
| Yellow-billed Cuckoo | *Coccyzus americanus* | 5 | 0 | 5 |
| Red-Shouldered Hawk | *Buteo lineatus* | 5 | 0 | 5 |
| Belted Kingfisher | *Megaceryle alcyon* | 1 | 0 | 1 |
| Red-bellied Woodpecker | *Melanerpes carolinus* | 77 | 40 | 37 |
| Downy Woodpecker | *Dryobates pubescens* | 33 | 16 | 17 |
| Hairy Woodpecker | *Dryobates villosus* | 2 | 2 | 0 |
| Pileated Woodpecker | *Dryocopus pileatus* | 24 | 14 | 10 |
| Northern Flicker | *Colaptes auratus* | 6 | 6 | 0 |
| Eastern Wood-Pewee | *Contopus virens* | 61 | 38 | 23 |
| Acadian Flycatcher | *Empidonax virescens* | 41 | 18 | 23 |
| Eastern Phoebe | *Sayornis phoebe* | 1 | 1 | 0 |
| Great Crested Flycatcher | *Myiarchus crinitus* | 7 | 5 | 2 |
| White-eyed Vireo | *Vireo griseus* | 3 | 1 | 2 |
| Yellow-throated Vireo | *Vireo flavifrons* | 6 | 2 | 4 |
| Red-eyed Vireo | *Vireo olivaceus* | 68 | 29 | 39 |
| Blue Jay | *Cyanocitta cristata* | 63 | 28 | 35 |
| American Crow | *Corvus brachyrhynchos* | 38 | 22 | 16 |
| Fish Crow | *Corvus ossifragus* | 13 | 7 | 6 |
| Carolina Chickadee | *Poecile carolinensis* | 30 | 16 | 14 |

***Table 1.*** *(continued.) Detection count (total, residential, and managed) for each species identified in survey recordings.*

| Species (Common Name) | Scientific Name | Detections (Total) | Detections (Residential) | Detections (Managed) |
|---|---|---|---|---|
| Tufted Titmouse | *Baeolophus bicolor* | 62 | 40 | 22 |
| White-breasted Nuthatch | *Sitta carolinensis* | 34 | 28 | 6 |
| Blue-gray Gnatcatcher | *Polioptila caerulea* | 14 | 4 | 10 |
| House Wren | *Troglodytes aedon* | 18 | 15 | 3 |
| Carolina Wren | *Thryothorus ludovicianus* | 94 | 44 | 50 |
| European Starling | *Sturnus vulgaris* | 1 | 0 | 1 |
| Gray Catbird | *Dumetella carolinensis* | 13 | 7 | 6 |
| Eastern Bluebird | *Sialia sialis* | 5 | 4 | 1 |
| Veery | *Catharus fuscescens* | 1 | 0 | 1 |
| Wood Thrush | *Hylocichla mustelina* | 74 | 45 | 29 |
| American Robin | *Turdus migratorius* | 20 | 18 | 2 |
| Cedar Waxwing | *Bombycilla cedrorum* | 44 | 16 | 28 |
| House Sparrow | *Passer domesticus* | 1 | 1 | 0 |
| House Finch | *Haemorhous mexicanus* | 3 | 2 | 1 |
| American Goldfinch | *Spinus tristis* | 12 | 6 | 6 |
| Chipping Sparrow | *Spizella passerina* | 10 | 9 | 1 |
| Field Sparrow | *Spizella pusilla* | 2 | 0 | 2 |
| Song Sparrow | *Melospiza melodia* | 1 | 0 | 1 |
| Eastern Towhee | *Pipilo erythrophthalmus* | 33 | 6 | 27 |

***Table 1.*** *(continued.) Detection count (total, residential, and managed) for each species identified in survey recordings.*

| Species (Common Name) | Scientific Name | Detections (Total) | Detections (Residential) | Detections (Managed) |
|---|---|---|---|---|
| Baltimore Oriole | *Icterus galbula* | 5 | 0 | 5 |
| Brown-headed Cowbird | *Molothrus ater* | 55 | 32 | 23 |
| Ovenbird | *Seiurus aurocapilla* | 40 | 37 | 3 |
| Louisiana Waterthrush | *Parkesia motacilla* | 6 | 2 | 4 |
| Northern Waterthrush | *Parkesia noveboracensis* | 1 | 0 | 1 |
| Tennessee Warbler | *Leiothlypis peregrina* | 4 | 2 | 2 |
| Common Yellowthroat | *Geothlypis trichas* | 37 | 0 | 37 |
| Hooded Warbler | *Setophaga citrina* | 3 | 3 | 0 |
| American Redstart | *Setophaga ruticilla* | 4 | 1 | 3 |
| Northern Parula | *Setophaga americana* | 12 | 0 | 12 |
| Blackpoll Warbler | *Setophaga striata* | 1 | 0 | 1 |
| Canada Warbler | *Cardellina canadensis* | 5 | 0 | 5 |
| Wilson's Warbler | *Cardellina pusilla* | 1 | 0 | 1 |
| Scarlet Tanager | *Piranga olivacea* | 35 | 8 | 27 |
| Northern Cardinal | *Cardinalis* | 100 | 47 | 53 |
| Indigo Bunting | *Passerina cyanea* | 21 | 0 | 21 |

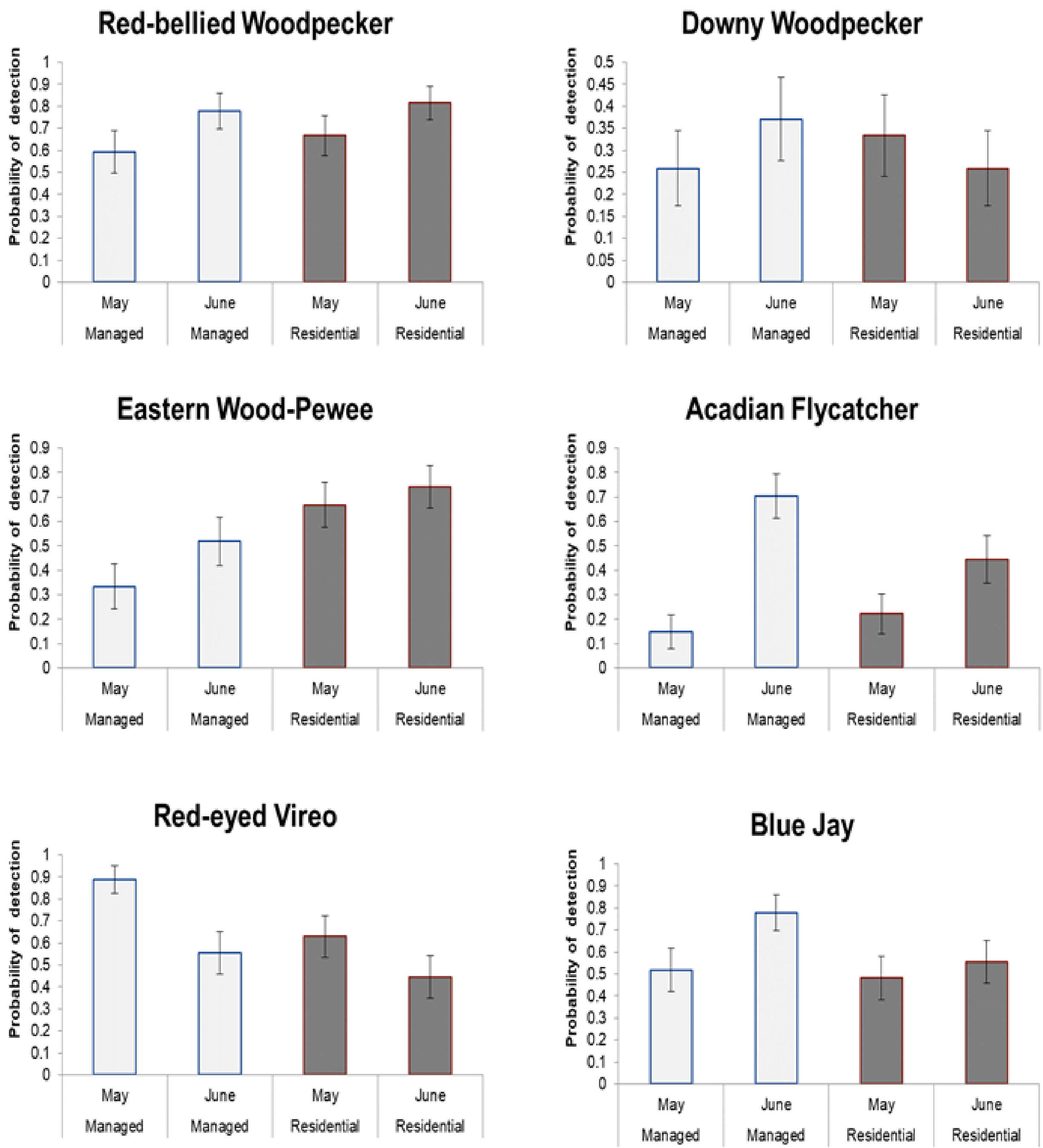


***Figure 5****. Mean detection probabilities with standard error bars for species with greater than 30 total detections during May and June sampling events in managed edge and residential edge.*

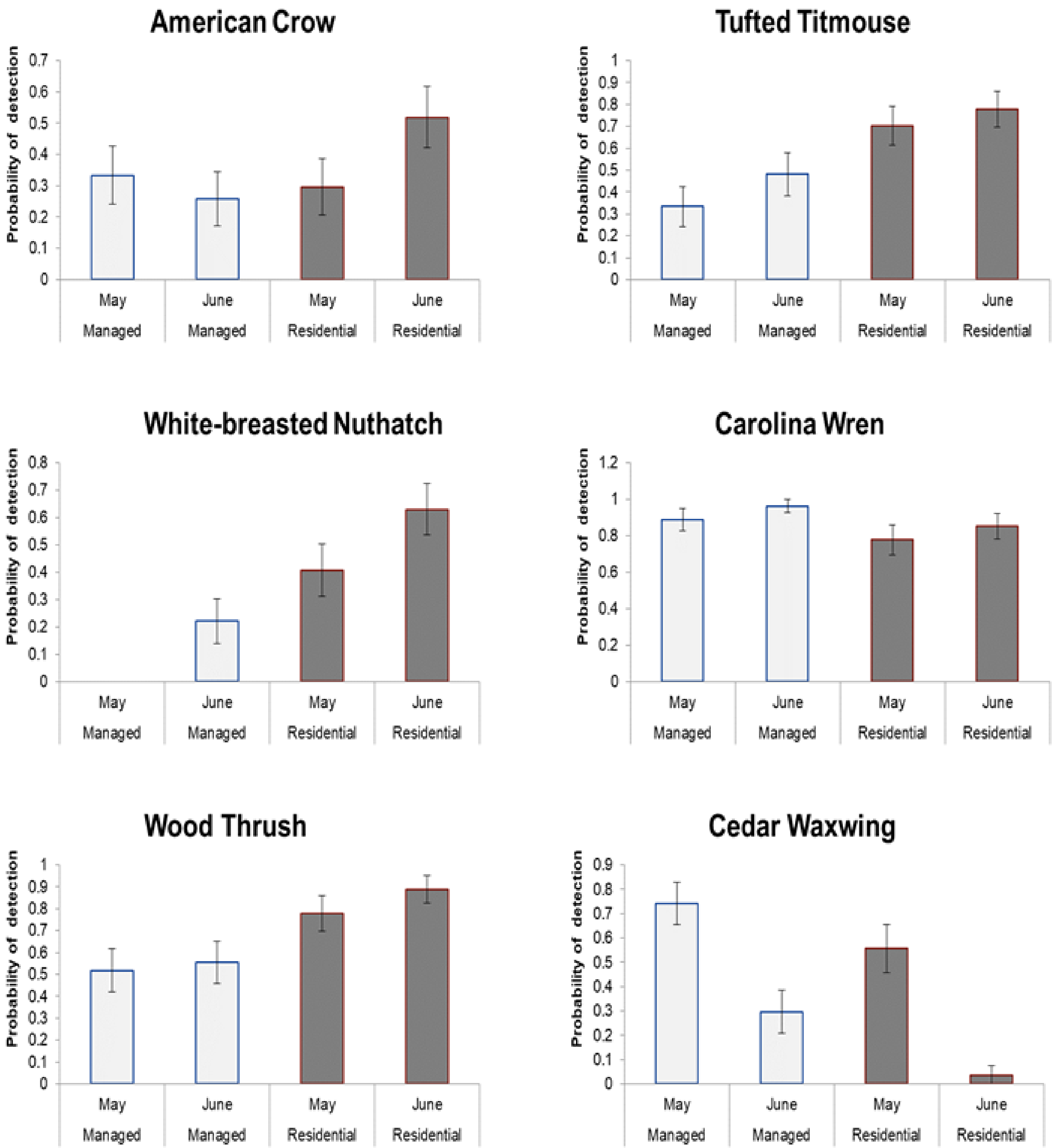


***Figure 5.*** *(continued) Mean detection probabilities with standard error bars for species with greater than 30 total detections during May and June sampling events in managed edge and residential edge.*

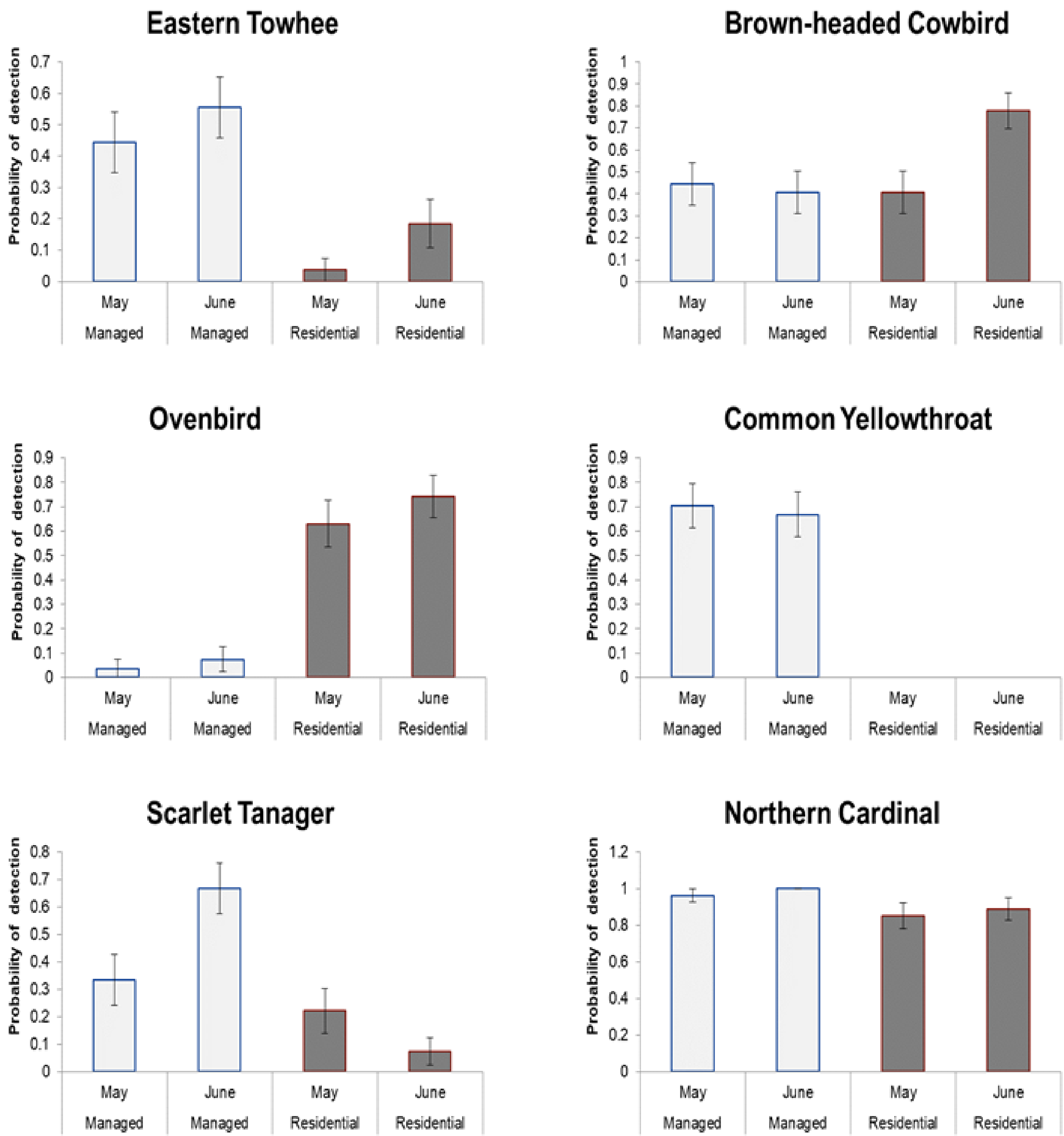


***Figure 5****. (continued) Mean detection probabilities with standard error bars for species with greater than 30 total detections during May and June sampling events in managed edge and residential edge.*

***Table 2.*** *Detection probability within residential and managed edge for species with greater than 30 total detections. Odds ratio considered significant for species with a p-value <0.05 and the 95% confidence intervals exclude 1.*

| Species | Mean Detection Probability | | Standard Error | | Odds Ratio | 95% Confidence Intervals | | *P* Value |
|---|---|---|---|---|---|---|---|---|
| | Residential Edge | Managed Edge | Residential Edge | Managed Edge | | Lower Limit | Upper Limit | |
| Red-bellied Woodpecker | 0.741 | 0.685 | 0.060 | 0.064 | 0.765 | 0.334 | 1.755 | 0.528 |
| Downy Woodpecker | 0.296 | 0.315 | 0.063 | 0.064 | 1.088 | 0.485 | 2.440 | 0.838 |
| Eastern Wood-Pewee | 0.704 | 0.426 | 0.063 | 0.068 | 0.320 | 0.145 | 0.704 | 0.005 |
| Acadian Flycatcher | 0.333 | 0.426 | 0.065 | 0.068 | 1.568 | 0.681 | 3.610 | 0.291 |
| Red-eyed Vireo | 0.537 | 0.722 | 0.068 | 0.062 | 2.341 | 1.027 | 5.334 | 0.043 |
| Blue Jay | 0.519 | 0.648 | 0.069 | 0.066 | 1.716 | 0.790 | 3.727 | 0.172 |
| American Crow | 0.407 | 0.296 | 0.067 | 0.063 | 0.619 | 0.281 | 1.361 | 0.233 |
| Tufted Titmouse | 0.741 | 0.407 | 0.060 | 0.067 | 0.250 | 0.112 | 0.558 | <0.001 |
| White-breasted Nuthatch | 0.519 | 0.111 | 0.069 | 0.043 | 0.112 | 0.041 | 0.307 | <0.001 |
| Carolina Wren | 0.815 | 0.926 | 0.053 | 0.036 | 2.705 | 0.829 | 8.832 | 0.099 |
| Wood Thrush | 0.833 | 0.537 | 0.051 | 0.068 | 0.244 | 0.102 | 0.583 | 0.002 |
| Cedar Waxwing | 0.296 | 0.519 | 0.063 | 0.069 | 3.325 | 1.330 | 8.312 | 0.010 |

***Table 2.*** *(continued.) Detection probability within residential and managed edge for species with greater than 30 total detections. Odds ratio considered significant for species with a p-value <0.05 and the 95% confidence intervals exclude 1.*

| Species | Mean Detection Probability | | Standard Error | | Odds Ratio | 95% Confidence Intervals | | *P* Value |
|---|---|---|---|---|---|---|---|---|
| | Residential Edge | Managed Edge | Residential Edge | Managed Edge | | Lower Limit | Upper Limit | |
| Eastern Towhee | 0.111 | 0.500 | 0.043 | 0.069 | 7.424 | 2.809 | 19.623 | <0.001 |
| Brown-headed Cowbird | 0.593 | 0.426 | 0.067 | 0.068 | 0.515 | 0.241 | 1.101 | 0.087 |
| Ovenbird | 0.685 | 0.056 | 0.064 | 0.032 | 0.034 | 0.010 | 0.110 | <0.001 |
| Common Yellowthroat | 0 | 0.685 | 0 | 0.064 | 131.691 | 17.201 | 1008.206 | <0.001 |
| Scarlet Tanager | 0.148 | 0.500 | 0.049 | 0.069 | 5.409 | 2.199 | 13.302 | <0.001 |
| Northern Cardinal | 0.870 | 0.981 | 0.046 | 0.019 | 6.322 | 1.025 | 39.007 | 0.047 |

***Table 3****. Analysis of species richness.*

| | Mean | | Standard Error | | Odds Ratio | 95% Confidence Intervals | | *P* Value |
|---|---|---|---|---|---|---|---|---|
| | Residential Edge | Managed Edge | Residential Edge | Managed Edge | | Lower Limit | Upper Limit | |
| Species Richness | 11.611 | 11.815 | 0.357 | 0.348 | 1.018 | 0.911 | 1.136 | 0.757 |

Species that had greater detection probability in the managed edge compared to the residential edge include the Red-eyed Vireo (95% CI 1.027 to 5.334; $p$ value = 0.043), Cedar Waxwing (95% CI 1.330 to 8.312; $p$ value = 0.010), Eastern Towhee (95% CI 2.809 to 19.623; $p$ value <0.001), Common Yellowthroat (95% CI 17.201 to 1008.206; $p$ value <0.001), Scarlet Tanager (95% CI 2.199 to 13.303; $p$ value <0.001), and Northern Cardinal (95% CI 1.025 to 39.007; $p$ value = .047). Species that had lower detection probability in the managed edge compared to the residential include the Eastern Wood-Pewee (95% CI 0.145 to 0.704; $p$ value = 0.005), Tufted Titmouse (95% CI 0.112 to 0.558; $p$ value < 0.001), Wood Thrush (95% CI 0.102 to 0.583; $p$ value = 0.002), and Ovenbird (95% CI 0.010 to 0.110; $p$ value < 0.001).

Species that did not show a difference in detection probability in the managed edge compared to the residential edge include the Red-bellied Woodpecker (95% CI 0.334 to 1.755; $p$ value = 0.528), Downy Woodpecker (95% CI 0.485 to 2.440; $p$ value = 0.838), Acadian Flycatcher (95% CI 0.681 to 3.610; $p$ value = 0.291), Blue Jay (95% CI 0.790 to 3.727; $p$ value = 0.172), American Crow (95% CI 0.281 to 1.361; $p$ value = 0.233), Carolina Wren (95% CI 0.829 to 8.832; $p$ value = 0.099), and Brown-headed Cowbird (95% CI 0.241 to 1.101; $p$ value = 0.087).

The vegetation structure varied for understory density but there was no difference in tree stem density between the two edge habitat types (Table 4). Mean understory density was found to be greater in managed edge habitat compared to residential edge habitat ($p$ value = 0.007).

***Table 4.*** *Vegetation survey data analysis for residential and managed edge habitats.*

| | Mean | | Standard Error | | T statistic | P value |
|---|---|---|---|---|---|---|
| | Residential | Managed | Residential | Managed | | |
| Tree Stem Density | 18.778 | 16.667 | 1.778 | 1.756 | -0.798 | 0.436 |
| Understory Density | 7.861 | 13.944 | 1.555 | 0.996 | 3.084 | 0.007 |

## DISCUSSION

The management of the early successional habitat in the Middle Patuxent Environmental Area (MPEA) has been successful in increasing the overall biodiversity of the area by providing edge habitat that differs from the edge created by residential areas. The species richness within each site did not differ between the two habitats, though the specific species present did show some variation.  Some overlap of the species present in the managed and residential edge habitats was found, however there were species that demonstrated a preference for the managed edge (Red-eyed Vireo, Cedar Waxwing, Eastern Towhee, Common Yellowthroat, Scarlet Tanager, Northern Cardinal) and species that demonstrated a preference for the residential edge (Eastern Wood-Pewee, Tufted Titmouse, Wood Thrush, Ovenbird), based on differing detection probabilities. The hypothesis that species richness would be greater in managed edge was not supported, however the hypothesis that species composition would differ was supported. The findings are consistent with that of Ikin et al. (2014), which found that although species richness may not differ between habitat types, the presence of multiple habitat types does increase the overall species richness of the larger area.

The presence of multiple habitat types allows for greater biodiversity due to the increased variety of resources provided by each distinct habitat type (Terraube et al. 2016). Providing diversity of habitats allows the MPEA to support a greater variety of avian species. The preference by some species for one edge habitat over the other may in part be explained by the difference in understory vegetation. Four of the six species (Red-eyed Vireo, Cedar Waxwing, Common Yellowthroat, and Scarlet Tanager) showing preference for managed edge over residential are categorized as forage gleaners by The Cornell Lab of Ornithology (2019) for their feeding behavior, relying on the presence of vegetation. Only one of the four species (Tufted Titmouse) showing preference for residential edge is categorized as a forage gleaner. Nesting behavior also influences habitat choice and may contribute to the link to edge preference based on vegetation understory. The Ovenbird, showing greater detection probability in residential edge habitat, is a ground-nesting species with a preference for open understory (The Cornell Lab of Ornithology 2019). The residential edge habitat exhibited significantly less understory density compared to the managed edge habitat. The Northern Cardinal was found to have greater detection probability in the managed edge, which exhibited greater understory density. The Northern Cardinal shows a preference for dense understory for nesting (The Cornell Lab of Ornithology 2019). The Eastern Towhee, another species with a greater detection probability in managed edge habitat, is also noted by The Cornell Lab of Ornithology (2019) to show preference for dense understory vegetation. Champlin et al. (2009) observed that some species of migratory songbirds show a preference for dense vegetation associated with early successional habitat regardless of the availability of food available and attributed the preference to the cover provided by the dense structure.

The Middle Patuxent Environmental Area management plan discusses the goal to increase overall biodiversity, and also identifies a list of specific species (Yellow-breasted Chat, Prairie Warbler, Blue-winged Warbler, Field Sparrow, Indigo Bunting, and American Goldfinch) as examples that may benefit from maintenance of early successional habitat (Farfaras et al. 2019). The survey conducted in this study did detect the presence of three of the six target species. The American Goldfinch was detected in six managed and six residential edge sampling events; the Indigo Bunting had 21 total detections, all in the managed edge; and the Field Sparrow had two total detections, both in the managed edge (Table 1). The remaining three example target species (Yellow-breasted Chat, Prairie Warbler, and Blue-winged Warbler) were not detected, however they are species that have generally been observed in the MPEA during April, early- to mid- May, late August, and September only; they may be detected briefly during migration but are likely not breeding in the area (eBird 2017). Though they may have been present during the May sampling events, the Blue-winged Warbler, Prairie Warbler, and Yellow-breasted Chat show preference for forest interior over edge habitat, which may also explain their absence during the surveys (Fink et al. 2006). Species that Fink et al. (2006) describe as showing strong preference for edge habitat over forest interior habitat include the Northern Cardinal, Field Sparrow, and Indigo Bunting, all of which were detected in this study. Few detections occurred for most of the species identified by Giese et al. (2015) to have a positive association with human disturbance. The species include the Brown-headed Cowbird, Common Grackle, European Starling, House Sparrow, and Mourning Dove (Giese et al. 2015). In this study, the Brown-headed Cowbird did meet the threshold of detections for further analysis, though no significant difference was found in preference for either edge habitat.

Recommendations for future research

The maintenance of a portion of the MPEA as early successional habitat is intended to increase overall biodiversity in the area; surveys to determine composition of communities in other taxonomic groups in addition to avian species should be conducted (Farfaras et al. 2019). Repeated surveys on avian communities should be conducted to determine any changes to the species present/absent in the habitats surveyed beyond 2020. The use of autonomous recorded devices (ARUs) in future surveys such as those used in this study is recommended, with modifications. The pairing of ARUs with in-person point counts may be considered. Klingbeil & Willig (2015) compare use of ARUs to point count methods and suggest that the two methods are comparable in overall survey success. Point count methods are more successful at identifying birds that vocalize less frequently, such as those in the woodpecker group, however ARUs are found to be more successful in detecting presence of passerines (Klingbeil & Willig 2015). In addition, the length of recordings could be reduced in future studies. This study protocol used three 10-minute recordings at each site during each sampling day. In this study, 50% of detections occurred within the first 90 seconds of the recordings, and 82% of detections occurred in the first 5 minutes of the recordings (Figure 6). Each 10-minute recording took a minimum of 30 minutes to review, due to the repeated reviewing of multiple sections that contained overlapping songs/calls or in the time to use the BirdNET site for confirmation of species identification. Shonfield & Bayne (2017) identify many advantages of the use of ARUs, including reduced observer interference during sampling, obtaining a permanent record of bird song, and the ability to listen multiple times, however they note that the significant amount of time needed to accurately review each recording is a disadvantage compared to point count methods. Continued use of ARUs is recommended, however to increase efficiency in reviewing the recordings, future studies may consider altering the protocol to include one recording at the start of each hour over a four hour period, and reducing the length of each from 10 to 5 minutes, as the majority of detections in this study did occur within the first 5 minutes of the recordings.

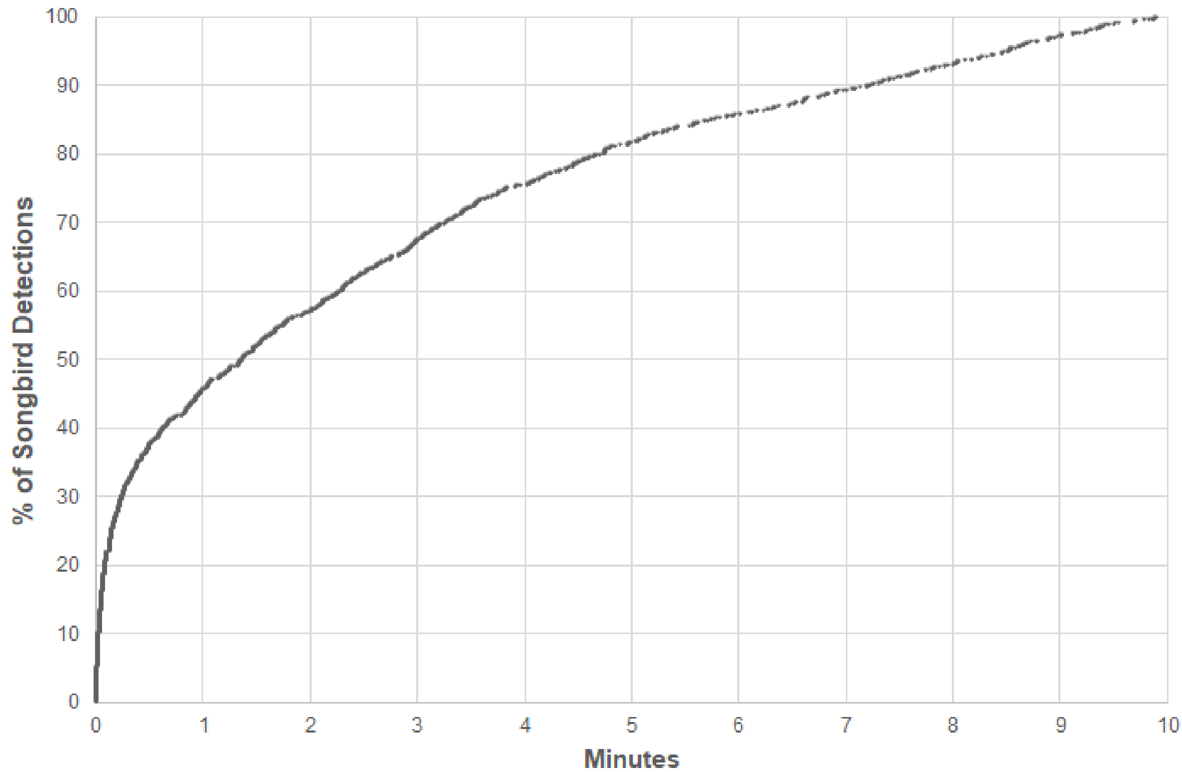


***Figure 6.*** *Total percentage of songbird detections for each sampling event accumulated over the 10-minute recording time period.*

In addition to conducting annual surveys to monitor long-term trends, surveys that include abundance estimates are recommended to provide further data for biodiversity index calculations, as the surveys described in this report focused on presence/absence data only. Abundance estimates could be determined by combining use of ARUs with in-person point count methods (Klingbeil & Willig 2015). The surveys described in this report were conducted early in the breeding season; further research on the success of nesting, as well as habitat use during different life stages beyond the breeding season, would provide more insight into potential differences between the two habitats and the success of the managed region. Species that were found to show a preference for residential edge over managed edge in this study may shift to showing preference for early-successional areas during the post-fledging period, including the Wood Thrush (Vega Rivera et al. 1998) and the Ovenbird (Streby et al. 2011). The results of the avian surveys described in this report provide evidence that the MPEA management strategies have been successful in increasing overall biodiversity, and the maintenance of early successional habitat within the area should continue; the recommendations provided in this section may be considered to collect further evidence of the benefits of current management practices.

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