



Bird Community Monitoring at George Washington Carver National Monument, Missouri

Status Report 2008–2020

Natural Resource Report NPS/HTLN/NRR—2021/2318



ON THE COVER

Carver home at George Washington Carver National Monument
Photography by NPS, Heartland Inventory and Monitoring Network

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Executive Summary

Breeding bird surveys were initiated on George Washington Carver National Monument, Missouri, in 2008 to assess temporal changes in the species composition and abundance of birds on the park and to improve our understanding of relationships between breeding birds and their habitat and the effects of management actions, such as invasive plant species control and tree thinning, on bird populations. Birds were sampled using point counts with 70 variable circular plots located on a systematic grid of 100 x 100-m cells (originating from a random start point). All birds seen or heard on a plot during a 5-min sampling period were recorded.

In the 13 years since initiating our breeding bird surveys on the park, birds were surveyed on as many of the 70 variable circular plots as possible each year, resulting in 520 cumulative plot visits. Surveys have yielded records for 100 different species of birds. Ninety-seven of the species recorded are classified as permanent or summer residents to the area, two are classified as transients in the area, and one as a winter resident to the area. Six breeding species recorded are considered species of conservation concern for the Central Hardwoods Bird Conservation Region, the bird conservation region in which George Washington Carver National Monument is located. Of the 97 breeding species recorded, ten species in grassland habitat and six in woodland habitat occurred in numbers large enough to calculate annual abundances with some degree of confidence. Trends in abundance were classified as uncertain for most species, which means that there were no significant increases or decreases but it is not certain that trends were < 5% per year. The Northern Cardinal (*Cardinalis cardinalis*) in woodland habitat was stable. The Eastern Meadowlark (*Sturnella magna*) in grassland habitat was in moderate decline, and the Northern Bobwhite (*Colinus virginianus*) in grassland habitat was in steep decline.

Comparing population trends (i.e., changes in population size over time) on the park with regional trends for the Central Hardwoods Bird Conservation Region suggests that the bird community at George Washington Carver National Monument is faring similarly to that of the region as a whole. Trends in the park's populations of Field Sparrow (*Spizella pusilla*) and Indigo Bunting (*Passerina cyanea*) in grassland habitat and Carolina Wren (*Thryothorus ludovicianus*) in woodland habitat were uncertain, whereas they declined significantly in the larger region, which could be a result of management on George Washington Carver National Monument. Red-bellied Woodpecker (*Melanerpes carolinus*) population trends were uncertain in grassland habitat on the park, but increased significantly in the region. The Red-bellied Woodpecker utilizes trees for foraging, which are sparse in the grassland habitat on the park. Declining diversity and richness values suggest that park habitat is declining in its ability to meet the requirements of many of the park's breeding bird species. This decline in species richness could reflect habitat management practices, but it could also reflect the influences of larger-scale factors such as weather or climatic conditions on vegetation. Therefore, continued monitoring of birds and their habitats on George Washington Carver National Monument as management and weather and climatic conditions change is essential for park management.

Acknowledgments

We would like to thank the staff of George Washington Carver National Monument, Missouri, for allowing us access to the park during our site visit. We would also like to thank our volunteers who assisted with bird surveys on the park: Larry T. and JoAnn M. Carnagey, Phyllis Chancellor, David R. Hennes, Lawrence V. Herbert, Audrey M. Menninga, B. Mullins, Rachelle M. Pollock, Lydia E. and Jeanne E. O'Donnell, Holly V. Simmons, Caleb L. Thyer, and Jeff M. Williams.

Introduction

Birds are an important component of park ecosystems. Their high body temperature, rapid metabolism, and high ecological position in most food webs make them good indicators of the effects of local and regional changes in ecosystems. Management activities aimed at preserving habitat for bird populations (e.g., habitat for neotropical migrants) can have the added benefit of preserving entire ecosystems and their attendant ecosystem services (Karr 1991; Maurer 1993). Birds also have a tremendous following among the public, and many parks provide information on the status and trends of birds through their interpretive programs.

George Washington Carver National Monument, Missouri, is located in the western edge of the Ozark Highland section of the Central Hardwoods Bird Conservation Region (Figure 1). This section, commonly referred to as oak savanna, historically consisted of the transition zone between the northern and western tallgrass prairie and southern and eastern pine-hardwood forest. The Central Hardwoods Bird Conservation Region is one of 67 regions identified in the North American Bird Conservation Initiative (NABCI). Started in 1999, the NABCI is a coalition of government agencies and private organizations in the United States working to ensure the

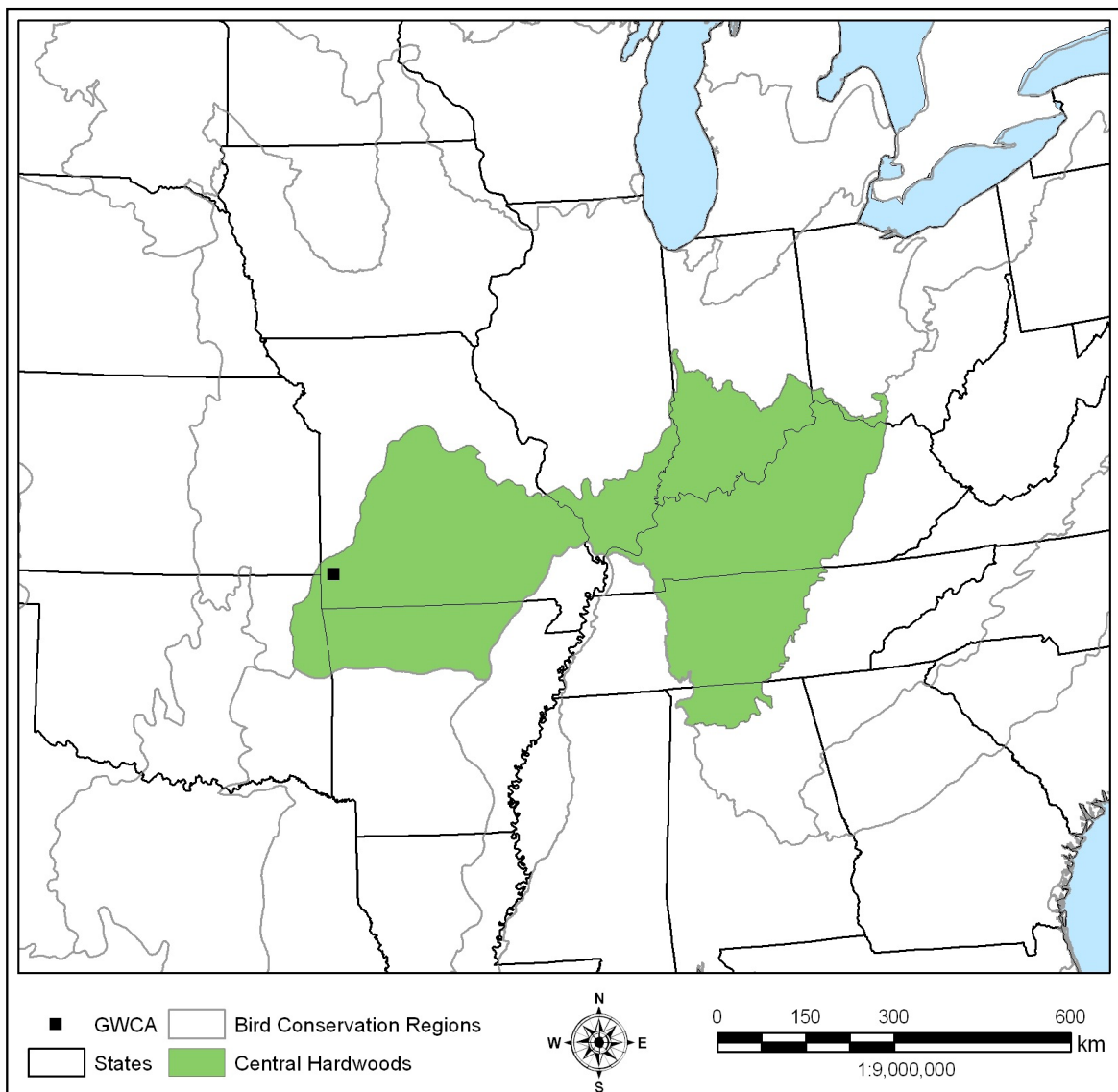


Figure 1. Location of George Washington Carver National Monument within the Central Hardwoods Bird Conservation Region.

long-term health of North America's native bird populations (NABCI 2020).

The rolling topography of the area in and around George Washington Carver National Monument is less dissected than other portions of the Ozark Highlands but more dissected than the Osage Plains further north and west (Fitzgerald and Pashley 2000). This landscape contains a rich mix of forested plant communities and grasslands. Approximately 111 species of breeding birds can be found in the area (Robbins and Easterla 1992). Widespread habitat loss to agriculture and urban and industrial development threaten the integrity of the area for birds.

Data collected during the U.S. Geological Survey's annual North American Breeding Bird Surveys (BBS) between 2005 and 2015 indicate that a number of potential breeding species occurring at George Washington Carver National Monument show evidence of population decline (Sauer et al. 2017). In fact, 28% of the recorded species have populations reported to be in decline, with species such as the Barn Swallow (*Hirundo rustica*), Belted Kingfisher (*Megaceryle alcyon*), Carolina Wren (*Thryothorus*

ludovicianus), Cedar Waxwing (*Bombycilla cedrorum*), Chimney Swift (*Chaetura pelagica*), Eastern Bluebird (*Sialia sialis*), Grasshopper Sparrow (*Ammodramus savannarum*), House Sparrow (*Passer domesticus*), Loggerhead Shrike (*Lanius ludovicianus*), and Northern Bobwhite (*Colinus virginianus*) declining at alarming rates.

We use long-term trends in the composition and abundance of bird populations as indicators of ecosystem integrity at George Washington Carver National Monument. Ecosystem integrity is defined as the system's capability to support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitats of the region (Karr and Dudley 1981). Because birds serve as good indicators of changes in ecosystems (Cairns et al. 2004; Mallory et al. 2006; Wood et al. 2006), bird monitoring can help us evaluate the effectiveness of management actions to restore and maintain the cultural landscape at George Washington Carver National Monument.



Loggerhead shrike (*Lanius ludovicianus*) is a year-round resident at George Washington Carver National Monument and is a species of conservation concern in the Central Hardwoods Bird Conservation Region. Photo by the Southeast Coast Network/NPS.

Objectives

There are two primary objectives for monitoring breeding birds at George Washington Carver National Monument:

- Identify significant temporal changes in the species composition and abundance of bird communities that occur on George Washington Carver National Monument during the breeding season.
- Improve our understanding of relationships between breeding birds and their habitat and the

effects of management actions (such as riparian stand thinning or prescribed fire) on bird populations by examining potential correlations between changes in specific habitat variables (e.g., vegetation structure and ground cover) and changes in bird community composition and abundance.

This report summarizes species composition and population trends for birds recorded during 13 years of monitoring (2008–2020).

Methods

Site Selection

Permanent monitoring locations or plots were selected by overlaying a systematic grid of 100 x 100-m cells (originating from a random start point). The orientation of the grid was rotated 45 degrees to prevent monitoring sites from being influenced by man-made features (roads, fences, etc.) located along cardinal directions. We established 70 permanent plots: 18 are located in woodland habitat and 52 are in grassland/open habitat (Figure 2). Monitoring occurred on various numbers of sites annually depending on weather conditions and volunteer availability (Table 1 and Appendix A). In years when 24 or fewer plots were sampled, plots sampled were from the same cohort. This cohort of plots was used in calculating bird species trends.

During bird surveys in 2008 and 2012, monitoring plots were located using navigation waypoints (Peitz 2009) in a Trimble Geo XT GNSS unit and temporarily marked with 36-inch pin flags to aid in relocating the plots for habitat assessment, eliminating the need for permanent plot markers. We collected pin flags from each plot once the habitat work was completed.

Habitat assessment crews worked independent of the birder in 2016 and 2020, and monitoring plots were located using a GNSS unit and not marked with pin flags. In years when habitat assessments were not conducted (2009–2011, 2013–2015, and 2017–2019) bird survey monitoring plots were located using a GNSS unit and plots were not marked with pin flags.

Bird Surveys

Bird surveys followed methods outlined in the bird monitoring protocol by Peitz et al. (2008) and summarized in this report. Variable circular plot counts, a point count methodology that incorporates a measure of detectability into population estimates, were used to survey birds present (Fancy 1997). All birds seen or heard at plots during 5-min sampling periods were recorded along with their corresponding distance from the observer. For most species, we recorded each individual bird as a separate observation. For species that usually occur in clusters or flocks, the units recorded were cluster or flock size and not the individual bird. During analysis, each individual in a cluster or flock was treated as a separate observation.

Table 1. Number of plots sampled and sampling dates for breeding bird surveys conducted at George Washington Carver National Monument by year. Also listed are the observers who conducted the surveys and whether or not habitat data were collected during the survey year. See Appendices B through E for the number of grassland and woodland plots sampled in each year.

Year	Sampling Dates	Number of Plots Sampled	Observer(s)	Habitat Data Collected
2008	May 27–May 29	70	D.G. Peitz*	Yes
2009	June 2–June 7	24	L.T. and J.M. Carnagey, D.R. Henness, L.V. Herbert, and L.E. O'Donnell	No
2010	June 6–June 12	24	L.T. and J.M. Carnagey, D.R. Henness, and L.V. Herbert	No
2011	May 22–June 3	23	L.E. and J.E. O'Donnell, D.R. Henness, and L.V. Herbert	No
2012	June 4–June 6	70	D.G. Peitz*	Yes
2013	June 19–June 25	24	D.R. Henness and L.E. O'Donnell	No
2014	June 11–June 14	20	D.R. Henness, L.E. O'Donnell, and P. Chancellor	No
2015	June 3–June 11	66	D.R. Henness, A.M. Menninga, L.E. O'Donnell, R.M. Pollock, C.L. Thyer, and J.M. Williams	No
2016	May 24–June 9	70	D.G. Peitz*, H.V. Simmons, and L.E. O'Donnell	Yes
2017	June 6–June 9	24	D.R. Henness and L.E. O'Donnell	No
2018	June 9–June 15	23	D.R. Henness and L.E. O'Donnell	No
2019	June 8	12	D.R. Henness and L.E. O'Donnell	No
2020	June 11–June 12	70	D.G. Peitz*	Yes

*Heartland I&M Network staff.

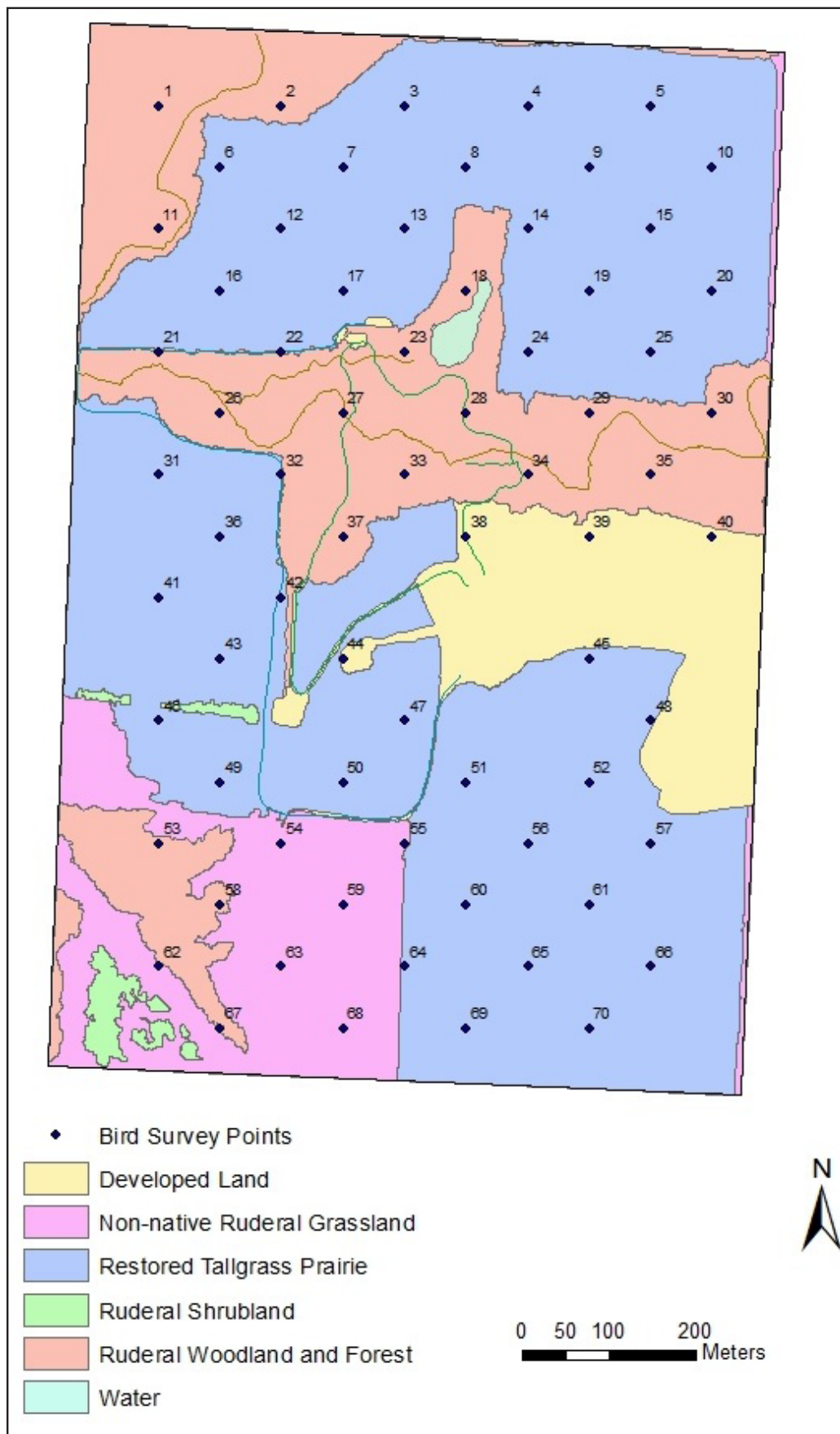


Figure 2. Bird plot locations on George Washington Carver National Monument. Vegetation mapping and classification provided by Diamond et al. (2013).



Habitats at George Washington Carver National Monument include woodlands, streams, and prairie. NPS

After completing a count at a plot and filling out the data sheet, the observer navigated to the next plot using a GNSS unit. While traveling between plots, the observer was vigilant for the presence of species not recorded during timed surveys. These species help formulate a more complete species list for the park by identifying species missed during timed surveys. However, these observations were not included in any analysis as they did not directly relate to any individual plot. We sampled most birds from when it was light enough to observe birds in the morning to approximately four hours after sunrise. An exception to this was in 2020 when time and travel considerations dictated that we continue to sample beyond the daily sample window to get surveys completed, and cool temperatures kept birds active.

Variable circular plot counts were conducted in an attempt to get an instantaneous count of all birds present. The observer recorded birds flushed from a plot when approached and the counts were started as soon as the observer reached plot center. We recorded all birds seen or heard, including flyovers,

along with distance from the observer when possible. For this report, all birds seen or heard during the 5-min survey are included.

Habitat Assessment

The collection of habitat data followed methods outlined in the bird monitoring protocol by Peitz et al. (2008) and summarized in this report. Habitat data were collected in 2008, 2012, 2016, and 2020. During years when habitat assessments were made, plots were visited in generally the same order used to survey for birds to avoid disturbing birds on a plot prior to sampling. Once the habitat crew arrived at a plot, they set up a 5-m radius subplot and completed all habitat measures for this subplot, a nested 1.78-m radius sample plot, and a larger 50-m radius plot.

Slope, slope variability, aspect, aspect variability, and topographic position of each 50-m radius plot were recorded during the first visit to a plot and not remeasured in subsequent years. The amount of various vegetation types (lawn, field/prairie, shrub, woodland) and road and water cover on each 50-m

plot were recorded. As 5-m subplots were sampled, horizontal vegetation cover was estimated in 0.25-m intervals from 0.0 to 2.0 m above ground surface using a 0.15-cm-wide cover board. Area of the cover board obscured by vegetation was estimated at a distance of 15 m north of plot center. Using a graduated measuring rod, vertical vegetation structure was measured in 1-m increments up to 7.5 m in height at four locations around the perimeter of the subplot. Locations were in the four cardinal directions. Vertical structure was recorded for deciduous, coniferous, and herbaceous vegetation. Trees were tallied on subplots by species and diameter size class (<1.0 cm, 1.1–2.5 cm, 2.6–8.0 cm, 8.1–15.0 cm, 15.1–23.0 cm, 23.1–38.0 cm, or >38.0 cm). Lastly, at a 1.78-m sample plot nested within the subplot, ground and foliar cover were estimated. Ground cover classes included deciduous and grass litter, bare soil, rock, woody debris (>2.5 cm in diameter), and unvegetated. Foliar cover was estimated for six plant guilds, including warm and cool-season grasses, forbs, moss and lichens, shrubs and vines, tree seedlings, and total foliar cover (<1.5 m tall).

Data Analysis

Prior to summary analysis, the residency status (permanent resident, summer resident, transient, winter resident) of each bird species recorded was determined. Identifying the residency of each species helps to exclude transient and winter residents from analysis of breeding birds within George Washington Carver National Monument. Proportion of plots occupied by each bird species was calculated (total number of plots occupied by a species/number of plots surveyed) and reported by habitat type (grassland or woodland) in Appendix B through E. For species with greater than 60 observations recorded, Distance software (Distance 6.0 Release 2) was used to determine the habitat-wide abundance of each species (Buckland et al. 2001). A central part of the analysis in Distance is the modeling of a detection function to account for individuals present but not observed before calculating species abundance. Four candidate functions plus series expansion—Half-normal + Cosine, Uniform + Cosine, Half-normal + Hemite polynomial, and Hazard-rate + Simple polynomial—were considered in determining the detection function of each species, and the most robust models were selected by Distance based on the lowest Akaike Information Criteria (AIC) values.

In grassland habitat the Hazard-rate + Simple polynomial function was selected for eight species: Brown-headed Cowbird (*Molothrus ater*), Dickcissel (*Spiza americana*), Eastern Meadowlark (*Sturnella magna*), Field Sparrow (*Spizella pusilla*), Indigo Bunting (*Passerina cyanea*), Northern Bobwhite (*Colinus virginianus*), Northern Cardinal (*Cardinalis cardinalis*), and Red-bellied Woodpecker (*Melanerpes carolinus*). The Uniform + Cosine function was chosen for Tufted Titmouse (*Baeolophus bicolor*), and the Half-normal + Cosine function was chosen for Common Yellowthroat (*Geothlypis trichas*). Abundances for these species are reported in Appendix B. In woodland habitat the Hazard-rate + Simple polynomial function was chosen for six species: Carolina Wren (*Thryothorus ludovicianus*), Indigo Bunting (*Passerina cyanea*), Northern Cardinal (*Cardinalis cardinalis*), Red-billed Woodpecker (*Melanerpes carolinus*), Tufted Titmouse (*Baeolophus bicolor*), and Yellow-billed Cuckoo (*Coccyzus americanus*). Abundances for these species are reported in Appendix D.

For species with fewer than 60 observations, habitat-wide abundance was calculated by first deriving a species density from observations recorded within a 50-m radius (0.79 ha) around each plot center and then calculating abundance based on average plot densities. Habitat-wide abundances for species with less than 60 observations are reported in Appendix C (grassland) and Appendix E (woodland).

For species with adequate abundance (those with greater than 60 observations and sampled in the cohort of 24 plots monitored in most years), trends were calculated by regressing abundance against survey years in the statistical software TRIM Version 3.54 (Pannekoek and Van Strien 2005) and reported in Appendix F. TRIM is a program developed for the analysis of count data obtained from the monitoring of wildlife populations. It analyzes time series of counts using Poisson regression and produces estimates of yearly indices and trends. We employed a linear trend model with changepoints selected by a stepwise procedure. Serial correlation in count data among years and overdispersion are taken into account with this software. In years when data were not collected from a plot, abundance values were extrapolated from years when data were collected.

For this report, we also obtained Central Hardwoods Bird Conservation Region breeding bird trends for the period from 2005 through 2015 from the

Breeding Bird Survey (BBS) website of the USGS Patuxent Wildlife Research Center (Appendix G; Sauer et al. 2017). It is possible to determine trends for many bird species and many regions of interest for periods ranging from 1966 to 2015 by using the [interactive calculator available at https://www.mbr-pwrc.usgs.gov/bbs/trend/tf15.html](https://www.mbr-pwrc.usgs.gov/bbs/trend/tf15.html). However, we chose the last 11-year period of available data to maximize the accuracy of regional trend results without going too far beyond the sampling period at George Washington Carver National Monument.

We compared regional trends with those calculated using TRIM for the habitats of George Washington Carver National Monument. Regional trends with a confidence interval that straddled zero were classified as uncertain for comparison with results from George Washington Carver National Monument. It should be noted that trends determined by the BBS were calculated using a different methodology; due to limitations in the BBS field data collections, hierarchical modeling was used to produce an annual index

of abundance, and trends were then estimated as constant annual rates based only on the first and last years of the intervals selected. Since all but the first and last year indices are ignored in this approach, trends based on BBS data tend to display variability when compared among different broadly overlapping intervals, and interpretation of BBS results should be made with caution.

Trends in the diversity, richness, and species distribution evenness of the breeding bird community in grassland and woodland habitats on the park were assessed by regressing each metric against survey years in the add-in statistical software of Microsoft Excel and then graphing the results. Prior to trend analysis, bird community diversity values were calculated annually using the Shannon Diversity Index:

$$H' = -\sum(n_i/N)\ln(n_i/N)$$

where n_i/N is the proportion of the total number of individuals in a population consisting of the i^{th} species (Shannon 1949). Species richness values were



Indigo Bunting (*Passerina cyanea*) populations are in decline in the Central Hardwoods Bird Conservation Region, the region in which George Washington Carver National Monument is located. NPS

determined as the total number of bird taxa recorded annually. Species distribution evenness values were calculated using Pielou (J'):

$$J' = H' / H_{max}$$

where H' is the Shannon Diversity Index and H_{max} is the maximum possible diversity for a given number of species if all species are present in equal numbers ($\ln(\text{annual species richness})$). J' is a measure of how evenly individuals are distributed within a community when compared to the equal distribution and maximum diversity a community can have (Pielou 1969).

Because not all species occurring in an area may actually be observed in a survey (i.e., rare species may be missed), recorded species richness is often an underestimate. Statistical species richness estimators utilize the information in species distribution and abundance patterns to produce an estimate of true species richness. Species richness estimators are also useful in comparing surveys with unequal sampling effort (e.g., different numbers of plots) since more species are usually discovered with greater sampling effort. However, different species richness estimators will produce varying estimates and no single estimator is consistently superior to others. Nonparametric statistical estimators have generally performed better than parametric types (Walther and Moore 2005). Reese et al. (2014) recently reviewed nonparametric species richness estimators and found that two coverage-based estimators, the Abundance Coverage-based Estimator (ACE) and Incidence Coverage-based Estimator (ICE), provided less biased and more accurate estimates than many of the others. Thus, we employed these two species richness estimators and report estimated species richness along with observed species richness. The software application EstimateS (Colwell 2013) was used to calculate the ACE and ICE estimators.

Location and permanent abiotic measures on each plot were reported by Peitz (2009). Annual averages ($\pm$ std dev) for semi-permanent plot data, including road and water cover, were calculated from plot estimates (Appendix H for grassland; Appendix I for woodland). Averages ($\pm$ std dev) for horizontal vegetation cover between 0–0.25, 0.25–0.5, 0.5–0.75, 0.75–1.0, 1.0–1.25, 1.25–1.5, 1.5–1.75, and 1.75–2.0 m were calculated. Average ($\pm$ std dev) annual vertical structure diversity was estimated as well. Vertical structural diversity was calculated as

$$\text{Vertical Structure Diversity Index} = \frac{((\sum p_i / 8) + a) \cdot 100}{2}$$

where p_i is the observed frequency for vegetation in the i^{th} interval touching a measuring rod out of twelve measuring events, and a is the percent of intervals with recorded vegetation in eight height increments. Vertical structure diversity values are weighted equally to represent both the vertical height of vegetation and how dense the vegetation is within each height increment.

Within each plot, ground cover, including deciduous and grass litter, bare soil, rock, woody debris (> 2.5 cm DBH), and unvegetated, were averaged ($\pm$ std dev) across plots (Appendix H for grassland; Appendix I for woodland). Foliar cover by guild—warm and cool-season grasses, forbs, mosses and lichens, shrubs and vines, tree seedlings, and total foliar cover (< 1.5 m tall)—were averaged ($\pm$ std dev) across plots as well. Trees were identified to family and size class before summing stems per hectare for the park (Appendix J).

Results

Bird Surveys

Between 2008 and 2020, 12 to 70 plots on George Washington Carver National Monument were surveyed annually for breeding birds (Table 1). Over the 13 years, there were 520 plot surveys and 100 different bird species were recorded, 97 of which are species with the potential to breed within the park (Table 2; Robbins and Easterla 1992).

Three breeding species were only observed outside 5-min survey periods: Henslow's Sparrow

(*Ammodramus henslowii*), Wood Duck (*Aix sponsa*), and Yellow-throated Warbler (*Setophaga dominica*). Six of the breeding species recorded are species of regional concern for the Central Hardwoods Bird Conservation Region (USFWS 2008): Bell's Vireo (*Vireo bellii*), Cerulean Warbler (*Setophaga cerulea*), Henslow's Sparrow, Kentucky Warbler (*Geothlypis formosa*), Loggerhead Shrike (*Lanius ludovicianus*), and Red-headed Woodpecker (*Melanerpes erythrocephalus*).

Table 2. Bird species recorded during breeding bird surveys at George Washington Carver National Monument from 2008 through 2020. The American Ornithologists' Union Code (AOU code) and residency status of each species is given. Species names are valid and verified names taken from the Integrated Taxonomic Information System web site (ITIS 2020).

Common Name	Scientific Name	AOU Code	Residency ^A
Acadian Flycatcher	<i>Empidonax virescens</i>	ACFL	SR
American Coot	<i>Fulica americana</i>	AMCO	SR
American Crow	<i>Corvus brachyrhynchos</i>	AMCR	R
American Goldfinch	<i>Spinus tristis</i>	AMGO	R
American Kestrel	<i>Falco sparverius</i>	MAKE	R
American Redstart	<i>Setophaga ruticilla</i>	AMRE	SR
American Robin	<i>Turdus migratorius</i>	AMRO	R
American Woodcock	<i>Scolopax minor</i>	AMWO	R
Baltimore Oriole	<i>Icterus galbula</i>	BAOR	SR
Bank Swallow	<i>Riparia riparia</i>	BANS	SR
Barn Swallow	<i>Hirundo rustica</i>	BARS	SR
Barred Owl	<i>Strix varia</i>	BDOW	R
Bell's Vireo^B	<i>Vireo bellii</i>	BEVI	SR
Belted Kingfisher	<i>Megasceryle alcyon</i>	BEKI	R
Blue-gray Gnatcatcher	<i>Poliophtila caerulea</i>	BGGN	SR
Blue Grosbeak	<i>Passerina caerulea</i>	BLGR	SR
Blue Jay	<i>Cyanocitta cristata</i>	BLJA	R
Brown-headed Cowbird	<i>Molothrus ater</i>	BHCO	R
Brown Thrasher	<i>Toxostoma rufum</i>	BRTH	SR
Canada Goose	<i>Branta canadensis</i>	CAGO	R
Carolina Chickadee	<i>Poecile carolinensis</i>	CACH	R
Carolina Wren	<i>Thryothorus ludovicianus</i>	CARW	R
Cedar Waxwing	<i>Bombycilla cedrorum</i>	CEDW	R
Cerulean Warbler^B	<i>Setophaga cerulea</i>	CEWA	SR
Chimney Swift	<i>Chaetura pelagica</i>	CHSW	SR

^A Residency: R = year-round resident; SR = summer resident; T = transient; WR = winter resident; according to Robbins and Easterla (1992).

^B Species of regional concern for the Central Hardwoods Bird Conservation Region (USFWS 2008; also in bold).

^C Species only recorded between point transects or other times outside of 5-min survey periods.

Table 2 (continued). Bird species recorded during breeding bird surveys at George Washington Carver National Monument from 2008 through 2020. The American Ornithologists' Union Code (AOU code) and residency status of each species is given. Species names are valid and verified names taken from the Integrated Taxonomic Information System web site (ITIS 2020).

Common Name	Scientific Name	AOU Code	Residency ^A
Chipping Sparrow	<i>Spizella passerina</i>	CHSP	SR
Cliff Swallow	<i>Petrochelidon pyrrhonota</i>	CLSW	SR
Common Grackle	<i>Quiscalus quiscula</i>	COGR	R
Common Nighthawk	<i>Chordeiles minor</i>	CONI	SR
Common Yellowthroat	<i>Geothlypis trichas</i>	COYE	SR
Cooper's Hawk	<i>Accipiter cooperi</i>	COHA	SR
Dickcissel	<i>Spiza americana</i>	DICK	SR
Downy Woodpecker	<i>Picoides pubescens</i>	DOWO	R
Eastern Bluebird	<i>Sialia sialis</i>	EABL	R
Eastern Kingbird	<i>Tyrannus tyrannus</i>	EAKI	SR
Eastern Meadowlark	<i>Sturnella magna</i>	EAME	R
Eastern Phoebe	<i>Sayornis phoebe</i>	EAPH	R
Eastern Towhee	<i>Pipilo erythrophthalmus</i>	EATO	R
Eastern Wood-pewee	<i>Contopus virens</i>	EAWP	SR
European Starling	<i>Sturnus vulgaris</i>	EUST	R
Field Sparrow	<i>Spizella pusilla</i>	FISP	R
Fish Crow	<i>Corvus ossifragus</i>	FICR	R
Grasshopper Sparrow	<i>Ammodramus savannarum</i>	GRSP	SR
Gray Catbird	<i>Dumetella carolinensis</i>	GRCA	SR
Great Blue Heron	<i>Ardea herodias</i>	GBHE	R
Great Crested Flycatcher	<i>Myiarchus crinitus</i>	GCFL	SR
Great Egret	<i>Ardea albus</i>	GREG	SR
Green Heron	<i>Butorides virescens</i>	GRHE	SR
Great Horned Owl	<i>Bubo virginianus</i>	GHOW	R
Hairy Woodpecker	<i>Picoides villosus</i>	HAWO	R
Henslow's Sparrow^{B, C}	<i>Ammodramus henslowii</i>	HESP	SR
House Finch	<i>Haemorhous mexicanus</i>	HOFI	R
House Sparrow	<i>Passer domesticus</i>	HOSP	R
House Wren	<i>Troglodytes aedon</i>	HOWR	SR
Indigo Bunting	<i>Passerina cyanea</i>	INBU	SR
Kentucky Warbler^B	<i>Geothlypis formosa</i>	KEWA	SR
Killdeer	<i>Charadrius vociferus</i>	KILL	R
Lark Sparrow	<i>Chondestes grammacus</i>	LASP	SR
Loggerhead Shrike^B	<i>Lanius ludovicianus</i>	LOSH	R
Louisiana Waterthrush	<i>Parkesia motacilla</i>	LOWA	SR
Mourning Dove	<i>Zenaidura macroura</i>	MODO	R
Northern Bobwhite	<i>Colinus virginianus</i>	NOBO	R
Northern Cardinal	<i>Cardinalis cardinalis</i>	NOCA	R

^A Residency: R = year-round resident; SR = summer resident; T = transient; WR = winter resident; according to Robbins and Easterla (1992).

^B Species of regional concern for the Central Hardwoods Bird Conservation Region (USFWS 2008; also in bold).

^C Species only recorded between point transects or other times outside of 5-min survey periods.

Table 2 (continued). Bird species recorded during breeding bird surveys at George Washington Carver National Monument from 2008 through 2020. The American Ornithologists' Union Code (AOU code) and residency status of each species is given. Species names are valid and verified names taken from the Integrated Taxonomic Information System web site (ITIS 2020).

Common Name	Scientific Name	AOU Code	Residency ^A
Northern Flicker	<i>Colaptes auratus</i>	YSFL	R
Northern Harrier	<i>Circus cyaneus</i>	NOHA	SR
Northern Mockingbird	<i>Minus polyglottos</i>	NOMO	R
Northern Parula	<i>Setophaga americana</i>	NOPA	SR
Orchard Oriole	<i>Icterus spurius</i>	OROR	SR
Ovenbird	<i>Seiurus aurocapilla</i>	OVEN	SR
Peregrine Falcon^B	<i>Falco peregrinus</i>	PEFA	WR
Pileated Woodpecker	<i>Dryocopus pileatus</i>	PIWO	R
Prothonotary Warbler	<i>Protonotaria citrea</i>	PROW	SR
Purple Martin	<i>Progne subis</i>	PUMA	SR
Red-bellied Woodpecker	<i>Melanerpes carolinus</i>	RBWO	R
Red-eyed Vireo	<i>Vireo olivaceus</i>	REVI	SR
Red-headed Woodpecker^B	<i>Melanerpes erythrocephalus</i>	RHWO	R
Red-shouldered Hawk	<i>Buteo lineatus</i>	RSHA	R
Red-tailed Hawk	<i>Buteo jamaicensis</i>	RTHA	R
Red-winged Blackbird	<i>Agelaius phoeniceus</i>	RWBL	R
Rock Dove	<i>Columba livia</i>	RODO	R
Rose-breasted Grosbeak	<i>Pheucticus ludovicianus</i>	RBGR	SR
Ruby-throated Hummingbird	<i>Archilochus colubris</i>	RTHU	SR
Scissor-tailed Flycatcher	<i>Tyrannus forficatus</i>	STFL	SR
Sharp-shinned Hawk	<i>Accipiter striatus</i>	SSHA	SR
Song Sparrow	<i>Melospiza melodia</i>	SOSP	R
Summer Tanager	<i>Piranga rubra</i>	SUTA	SR
Swainson's Thrush	<i>Catharus ustulatus</i>	SWTH	T
Tufted Titmouse	<i>Baeolophus bicolor</i>	ETTI	R
Turkey Vulture	<i>Cathartes aura</i>	TUVU	R
Warbling Vireo	<i>Vireo gilvus</i>	WAVI	SR
White-breasted Nuthatch	<i>Sitta carolinensis</i>	WBNU	R
White-eyed Vireo	<i>Vireo griseus</i>	WEVI	SR
Wild Turkey	<i>Meleagris gallopavo</i>	WITU	R
Wood Duck ^C	<i>Aix sponsa</i>	WODU	SR
Yellow-bellied Flycatcher	<i>Empidonax flaviventris</i>	YBFL	T
Yellow-billed Cuckoo	<i>Coccyzus americanus</i>	YBCU	SR
Yellow-breasted Chat	<i>Icteria virens</i>	YBCH	SR
Yellow-throated Vireo	<i>Vireo flavifrons</i>	YTVI	SR
Yellow-throated Warbler ^C	<i>Setophaga dominica</i>	YTWA	SR
Yellow Warbler	<i>Setophaga petechia</i>	YWAR	SR

^A Residency: R = year-round resident; SR = summer resident; T = transient; WR = winter resident; according to Robbins and Easterla (1992).

^B Species of regional concern for the Central Hardwoods Bird Conservation Region (USFWS 2008; also in bold).

^C Species only recorded between point transects or other times outside of 5-min survey periods.

Ten breeding species in grassland and six in woodland habitats were observed during the survey period in large enough numbers to calculate annual abundances with some degree of confidence (Appendix B and Appendix D, respectively). Of these sixteen species, only the Eastern Meadowlark (*Sturnella magna*) and Northern Bobwhite (*Colinus virginianus*) showed significant directional trends in abundance (Figure 3a and Appendix F). In grassland habitat, Eastern Meadowlark showed a moderate decline and Northern Bobwhite showed a steep decline. Northern Cardinal (*Cardinalis cardinalis*) in woodland habitat had a stable trend in abundance (Figure 3b and Appendix F). With a single exception, all other species in both the grassland and woodland habitats had uncertain population trends over the 13 monitoring years. An uncertain trend means that

there were no significant increases or decreases but it is not certain that trends were < 5% per year (see Appendix F). A trend could not be determined for the Tufted Titmouse in either grassland or woodland habitat.

Region-wide, the populations of Brown-headed Cowbird (*Molothrus ater*), Eastern Meadowlark, Field Sparrow (*Spizella pusilla*), and Northern Bobwhite recorded in grassland habitat; Carolina Wren (*Thryothorus ludovicianus*) in woodland habitat; and Indigo Bunting (*Passerina cyanea*) in both habitats are in decline (Figures 3a and 3b and Appendix G). Population trends of Common Yellowthroat (*Geothlypis trichas*) and Dickcissel (*Spiza americana*) in grassland habitat; Yellow-billed Cuckoo (*Coccyzus americanus*) in woodland habitat;

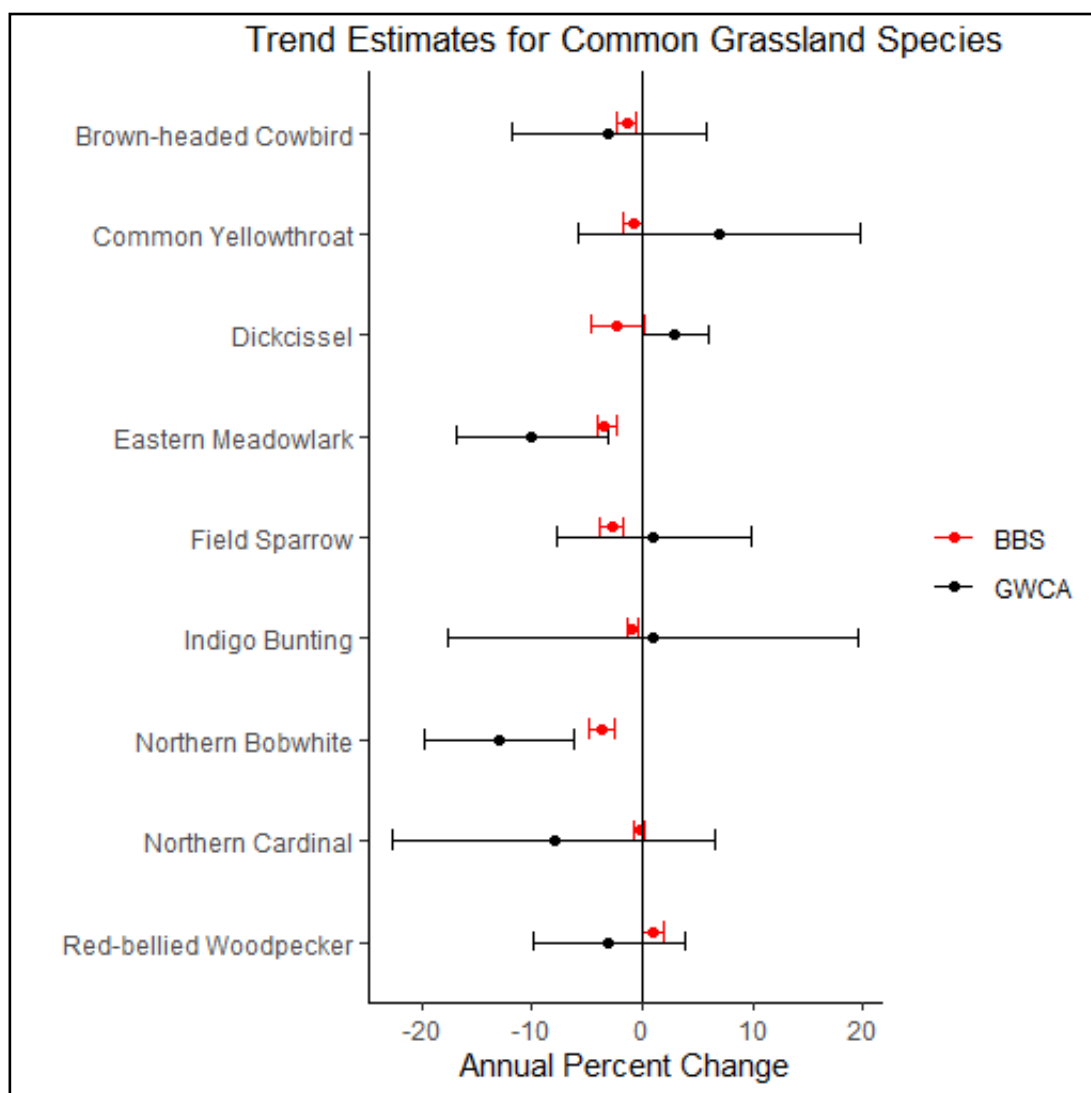


Figure 3a. Comparison of grassland bird population trends from George Washington Carver National Monument (2008–2020) with trends in the larger Central Hardwoods Bird Conservation Region (2005–2015). Error bars represent 95% confidence intervals.

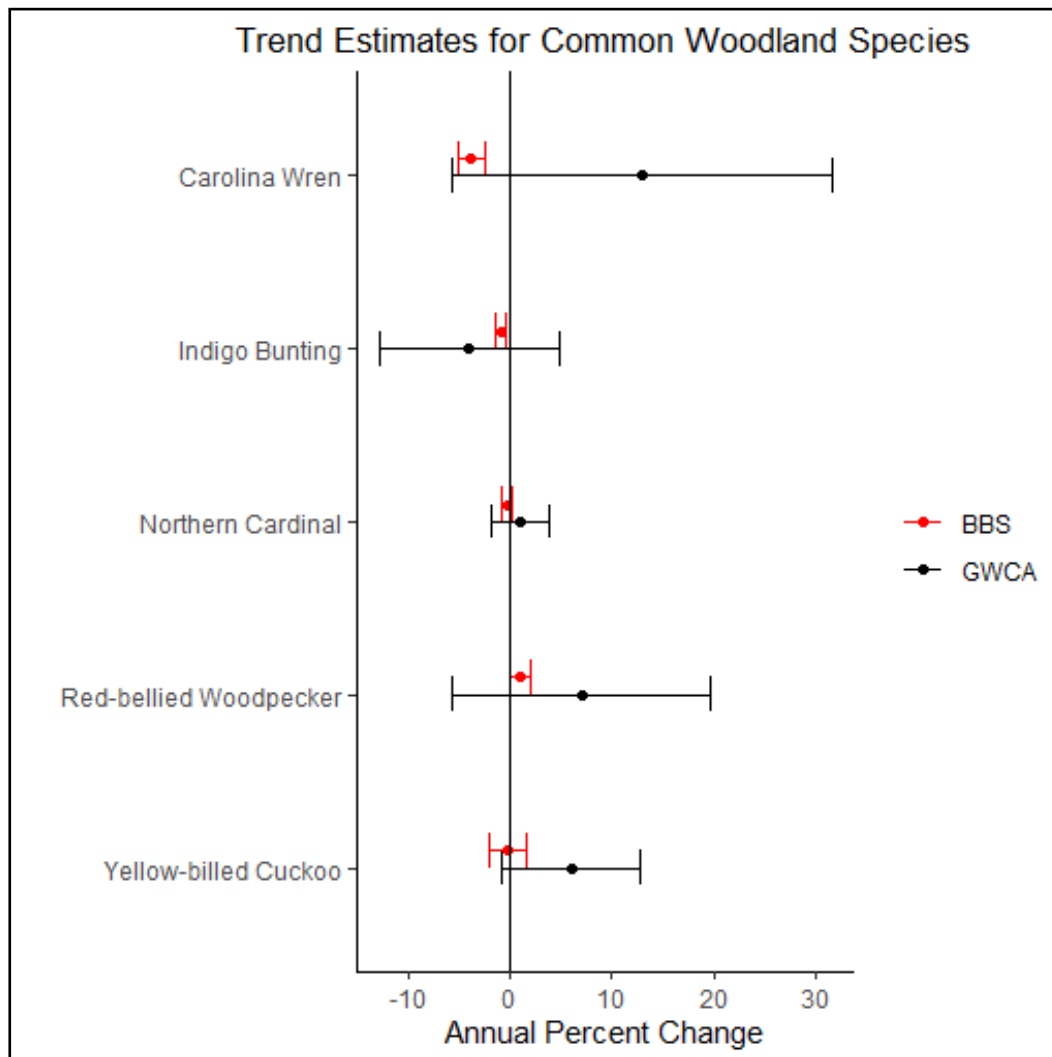


Figure 3b. Comparison of woodland bird population trends from George Washington Carver National Monument (2008–2020 with those of the larger Central Hardwoods Bird Conservation Region (2005–2015). Error bars represent 95% confidence intervals.

and Northern Cardinal in both habitats are stable. Red-bellied Woodpecker (*Melanerpes carolinus*) and Tufted Titmouse (*Baeolophus bicolor*), recorded in both habitat types, are increasing region-wide.

Bird diversity declined moderately ($P = 0.10$) and species richness declined significantly ($P = 0.05$) in the breeding bird community in grassland habitat on the park since 2008 (Figures 4a). However, the evenness in distribution of individuals across species remained the same ($P = 0.58$). Similar to the grassland habitat, bird diversity ($P = 0.07$) and species richness ($P = 0.02$) in the breeding bird community in woodland habitat declined (moderately and significantly, respectively; Figures 4b), and evenness values remained the same ($P = 0.27$).

For the grassland breeding bird community on George Washington Carver National Monument, species richness averaged 37 species annually. Average estimated annual species richness was 47 by the ACE estimator and 50 by the ICE estimator for this habitat. For the woodland breeding bird community, richness averaged 29 species annually. Average estimated annual species richness was 43 by the ACE estimator and 51 by the ICE estimator for this habitat. These results should be interpreted with caution as interannual variability in the number of plots sampled may be influencing changes in these metrics.

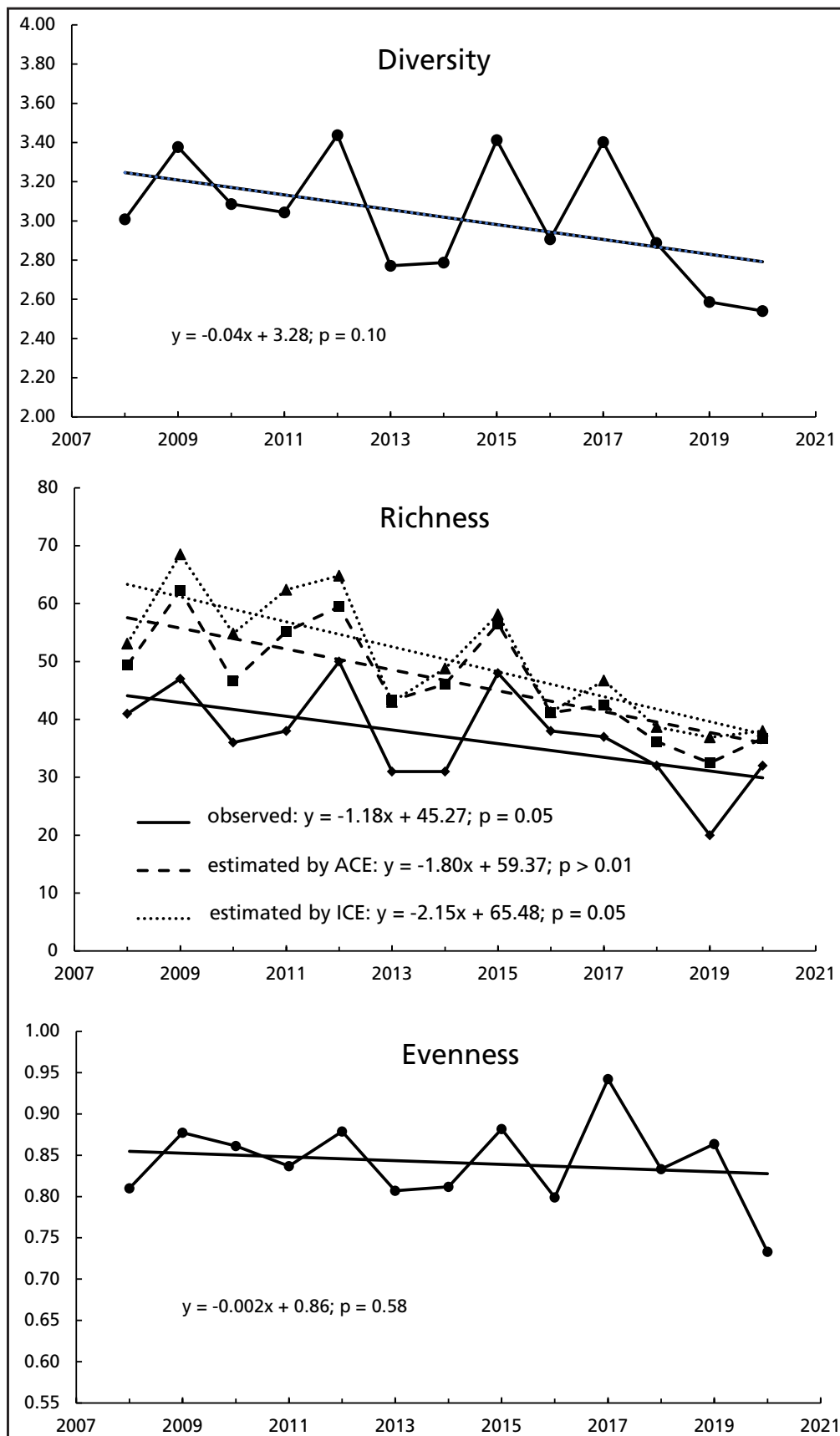


Figure 4a. Trends in grassland bird community diversity, richness, and species distribution evenness on George Washington Carver National Monument from 2008 through 2020.

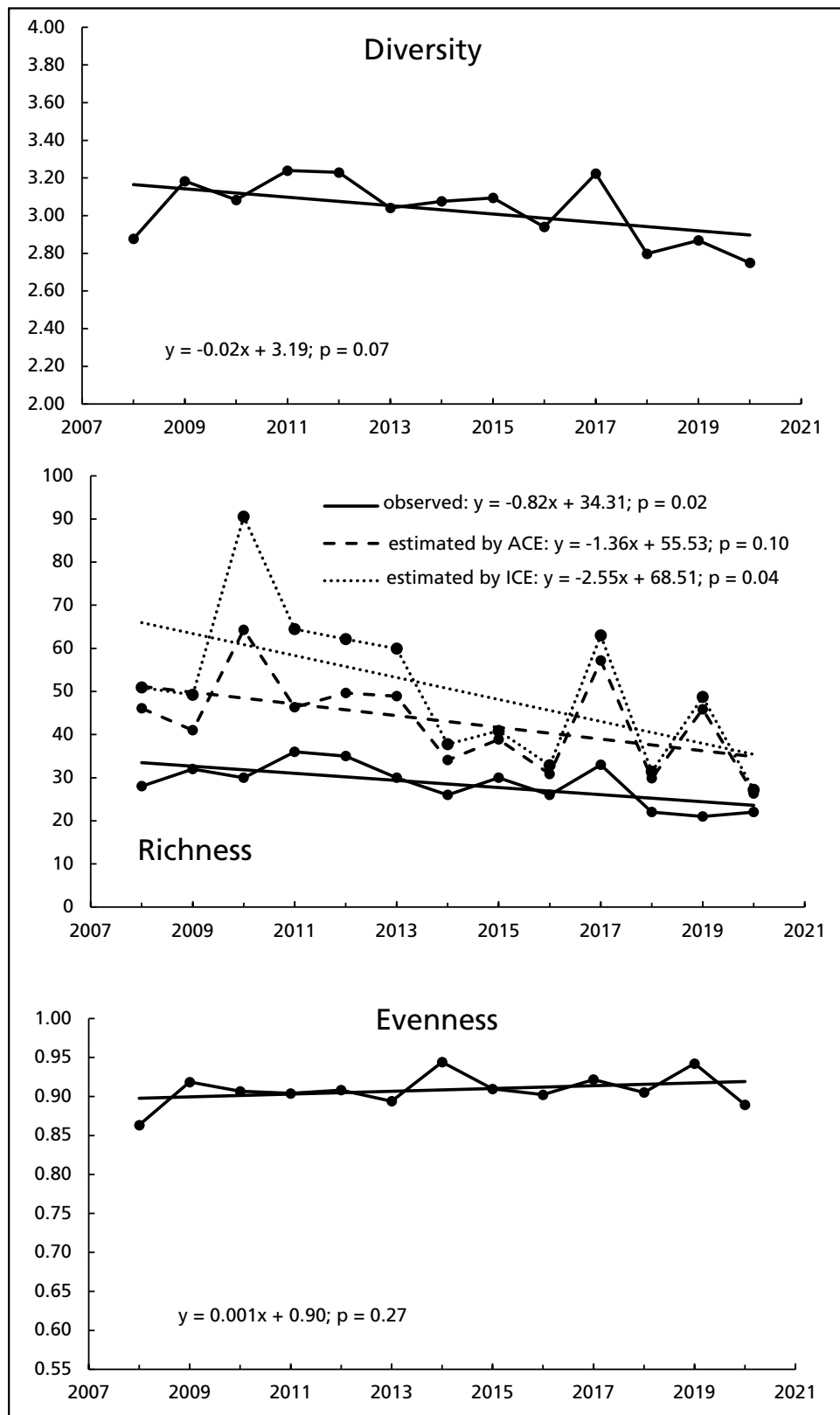


Figure 4b. Trends in woodland bird community diversity, richness, and species distribution evenness on George Washington Carver National Monument from 2008 through 2020.

Habitat Assessment

When sampled, habitats on the grassland plots at George Washington Carver National Monument consisted primarily of the old field/prairie type (89%), with lesser amounts of other types present (Appendix H). Canopy cover averaged 4 to 6% on grassland plots, with cover provided entirely by hardwood trees. Basal area of hardwood trees on grassland plots averaged between 0.63 and 0.96 m²/ha, and canopy height averaged from 0.21 to 2.10 m. Hardwood tree species from nine different families contributed to the canopy cover and basal area of grassland plots (Appendix J), with the largest trees occurring in the Moraceae family. Habitats on woodland plots consisted primarily of the woodland (68–75%) and lawn (9–10%) types, with lesser amounts of other types present (Appendix I).

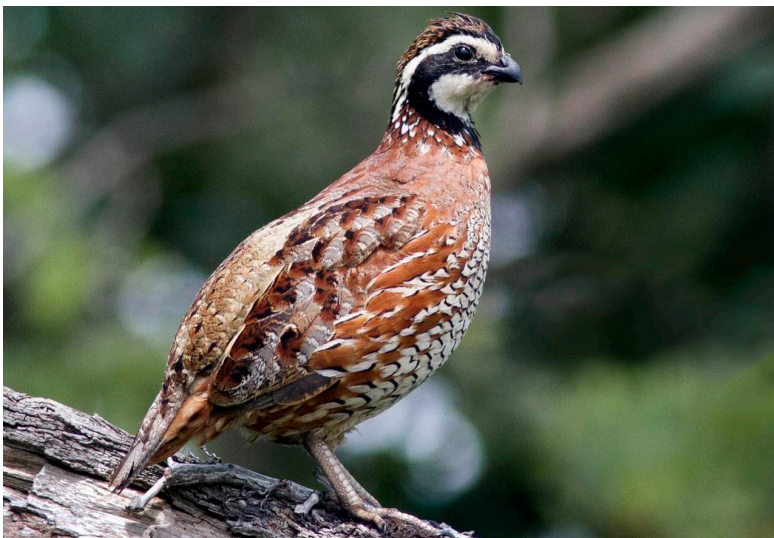
Canopy cover averaged 85 to 94% on woodland plots, with cover also provided entirely by hardwood trees. Basal area of hardwood trees on woodland plots averaged between 18.75 and 26.25 m²/ha, and canopy height averaged 15.33 to 19.93 m. Interestingly, conifers did add a small amount to the woodland plot total basal area (0–0.14 m²/ha), with conifers only 0.24 to 0.61 m tall. Hardwood tree species from 17 different families contributed to the canopy cover and basal area (Appendix J) of woodland plots. However, most of the largest trees occurred in the Cannabaceae, Fagaceae, Juglandaceae, Moraceae, Platanaceae, and Salicaceae families. Conifer trees (Juniperaceae family) were not observed within 5-m subplots where tree species were recorded.

Across all grassland plots, the densest vegetation measures at the time of assessment (mid-May to

mid-June) occurred in horizontal profile heights below 0.50 m, when sampled (Appendix H). However, vegetation was measured in all height classes to 2.0 m. Across all woodland plots, the densest vegetation measures occurred in horizontal profile heights below 1.0 m (Appendix I). Similar to grassland plots, vegetation was measured in all height classes to 2.0 m. Average vertical structure diversity estimated across years ranged from 13 to 15% for grassland plots, and 39 to 50% for woodland plots.

When sampled, grassland plots were primarily unvegetated (63–88%) at ground level with bare soil (3–54%) exposed (Appendix H). Grass litter (18–37%) dominated areas with cover, followed by deciduous litter (<1–3%), woody debris (<1–2%), and rock (<1%). Woodland plots were also primarily unvegetated (79–83%) at ground level, with bare soil (27–50%) exposed (Appendix I). Deciduous litter (8–28%), conifer litter (<1%), grass litter (5–17%), woody debris (4–22%), and rock (4–7%) were present, but in lesser amounts on woodland plots.

When sampled, foliar cover on grassland plots was dominated by warm-season (6–43%) and cool-season grasses (6–31%), followed by forbs (13–26%), woody shrubs and vines (4–16%), tree seedlings (<1–3%), and mosses and lichens (<1%; Appendix H). Foliar cover on woodland plots was dominated by cool-season grasses (4–44%), forbs (8–31%), and woody shrubs and vines (16–29%), followed by moss and lichens (0–7%), tree seedlings (<1–2%), and warm-season grasses (0–2%; Appendix I). Total foliar coverage averaged 36 to 83% across grassland plots and 27 to 82% on woodland plots.



Northern Bobwhite (*Colinus virginianus*) require clump grasses, bare soil, and forbs to survive. At George Washington Carver National Monument, this species has experienced a steep decline as woody shrubs and trees are increasing in the grassland. Photo: MaCaulay Library, CLO, Linda Chittum.

Discussion

Ninety-seven bird species that are permanent or summer residents to the area (Robbins and Easterla 1992) have value in characterizing the breeding bird community and habitat on which they rely at George Washington Carver National Monument. The six breeding species of concern for the Central Hardwoods Bird Conservation Region should be given additional consideration in the management of natural resources on the park: Bell's Vireo (*Vireo bellii*), Cerulean Warbler (*Setophaga cerulea*), Henslow's Sparrow (*Ammodramus henslowii*), Kentucky Warbler (*Geothlypis formosa*), Loggerhead Shrike (*Lanius ludovicianus*), and Red-headed Woodpecker (*Melanerpes erythrocephalus*). However, all six species were recorded in low numbers or as incidental observations making it difficult to assess the impacts of managing for their requirements (Table 2; Appendix C and E). If it is not feasible to manage habitat for these species directly, then habitat should at least be managed in a way that does not conflict with their habitat preferences (see the [Central Hardwoods Joint Venture website at https://www.chjv.org](https://www.chjv.org) for individual species habitat requirements and management recommendations). For example, removal of riparian woodland habitat would be detrimental to the Cerulean and Kentucky warblers (Stokes and Stokes 1996).

Other species that are in decline region wide, such as the Carolina Wren (*Thryothorus ludovicianus*) and Indigo Bunting (*Passerina cyanea*), have improved reproductive success when shrub cover is dense and mid-canopy trees are present, and population changes in either of these two species could indicate changes in the understory and midstory of the woodlands. The fact that both the Carolina Wren and Indigo Bunting have uncertain population trends on the park could be the result of management efforts to control invasive woody plants in the woodlands understory and woody encroachment from riparian areas into the grasslands.

Grassland dominates the bird habitat at George Washington Carver National Monument by nearly 3:1 over woodlands. However, within the Ozark Highland's portion of the Central Hardwoods Bird Conservation Region this mix is approximately 1:1, with woodland having a slightly greater presence (NPS 2012). Of the breeding birds recorded, 36 are

eastern forest species and nine are grassland species (Rosenberg et.al. 2019). The remaining resident species are more habitat generalist or edge species favored by the mix and positioning of habitats on the park. The habitat diversity (structural composition) seen on the park is especially important for the species of regional concern, as their microhabitat requirements vary (Pashley and Barrow 1993). For example, Red-headed Woodpeckers prefer farmlands, open woodlands, orchards, and urban/suburban forest; Kentucky Warblers prefer moist deciduous bottomlands and ravines; and Cerulean Warbler prefer mature trees near swampy areas and streams, but most other species of regional concern require thick shrubby or old field habitat (Stokes and Stokes 1996).

Habitat availability and quality dictate bird population trends within a region. However, when suitable habitat that is large enough to meet a bird's requirements is found locally, then population trends in that area may differ from that of the region. The opposite may be true as well. Two grassland species—Eastern Meadowlark (*Sturnella magna*) and Northern Bobwhite (*Colinus virginianus*)—observed in numbers adequate to calculate annual abundances have alarming trends on George Washington Carver National Monument. The Eastern Meadowlark's moderate decline and Northern Bobwhite's steep decline (Figure 3A, Appendix F) suggest current management actions are not satisfying their requirements for clump grasses, bare soil, and forbs—a grazed old-field appearance (Stokes and Stokes 1996). Our habitat data suggest that woody shrubs, vines, and tree seedlings are increasing in the grassland habitat. This increasing woody component to the landscape may be providing perches for avian predators (Svedarsky et.al. 2003), which could negatively influence meadowlark and quail numbers. The stable Northern Cardinal (*Cardinalis cardinalis*) populations in woodlands suggest management in this habitat is having little if any influence on their numbers. The uncertain population trend of most species suggests their populations are changing little, if any.

The bird community (Figures 3a and 3b) at George Washington Carver National Monument is faring similarly to that of the overall Central Hardwoods

Bird Conservation Region. Trends in the park's populations of Field Sparrow (*Spizella pusilla*) and Indigo Bunting in grassland habitat and Carolina Wren in woodland habitat were uncertain, whereas they declined significantly in the larger region, which could be a result of management on George Washington Carver National Monument. Trends in the park's population of Red-bellied Woodpecker (*Melanerpes carolinus*; a woodland species) are uncertain in grassland habitat compared to significant increases in the region, as would be expected. All other species population trends were uncertain. Efforts to manage habitat on the park to be tallgrass prairie-open woodlands (i.e. oak savanna) would meet the grassland requirements of many species, including the Dickcissel (*Spiza Americana*), Grasshopper Sparrow (*Ammodramus savannarum*), Eastern Meadowlark and Northern Bobwhite. The latter two species are in decline on the park. Management efforts would also create sparse open woodland habitat preferred by species such as Loggerheaded Shrike and Red-headed Woodpecker, two species that are declining at alarming rates region wide (Stokes and Stokes 1996).

Over the 13 years of bird monitoring on George Washington Carver National Monument, the declining diversity and richness values in both grassland and woodland habitats suggest that the ability of park habitat to meet most species' requirements has declined (Figures 4a and 4b). Species richness declined from 45 to 30 breeding species annually in grassland habitat and 34 to 20 species annually in woodland habitat. While changes in population sizes, especially of common and widely distributed species, may be utilized to assess changing habitat conditions, weather and climate also play a role in determining habitat and should always be considered. Therefore, continued monitoring of birds on George Washington Carver National Monument as management and weather and climatic conditions change is essential for park natural resource decision-making.

Literature Cited

- Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press. 432 pp.
- Cairns Jr., J., P. V. McCormick and B. R. Niederlehner. 2004. A proposed framework for developing indicators of ecosystem health. *Hydrobiologia* 263:1–44.
- Central Hardwoods Joint Venture (CHJV). 2020. CHJV bird habitat management recommendations <https://www.chjv.org/> (accessed 6 November 2020).
- Colwell, R. K. 2013. EstimateS: Statistical estimation of species richness and shared species from samples. Version 9. User's Guide and application published at <http://purl.oclc.org/estimates>.
- Diamond, D. D., L. F. Elliott, M. D. DeBacker, K. M. James, D. L. Pursell, and A. Struckhoff. 2013. Vegetation mapping and classification of George Washington Carver National Monument. Natural Resource Report NPS/GWCA/NRR—2013/648. National Park Service, Fort Collins, Colorado.
- Fancy, S. G. 1997. A new approach for analyzing bird densities from variable circular plot counts. *Pacific Science* 51:107–114.
- Fitzgerald, J. A., and D. N. Pashley. 2000. Partners in Flight bird conservation plan for the Ozarks/Ouachita (Physiographic Area 19). Cornell Lab of Ornithology, Ithaca, New York.
- Gregory R. D., J. Reif, L. Fornasari, I. J. Burfield, P. Chylarecki, A. Van Strien, P. Vorisek, F. D. R. Jiguet, A. W. Gmelig Meyling. 2007. Population trends of widespread woodland birds in Europe. *Ibis* 149:78–97.
- Integrated Taxonomic Information System (ITIS). 2020. USGS plant name verification web site. Available at <http://www.itis.usda.gov/> (accessed 23 July 2020).
- Karr, J. R. 1991. Biological integrity: a long-neglected aspect of water resource management. *Ecological Applications* 1:66–84.
- Karr, J. R., and D. R. Dudley. 1981. Ecological perspective on water quality goals. *Environmental Management* 5:55–68.
- Link, W. A., and J. R. Sauer. 1998. Estimating population change from count data: application to the North American breeding bird survey. *Ecological Applications* 8:258–268.
- Mallory, M. L., H. G. Gilchrist, B. M. Braune and A. J. Gaston. 2006. Marine birds as indicators of arctic marine ecosystem health: linking the northern ecosystem initiative to long-term studies. *Environmental Monitoring and Assessment* 113:31–48.
- Maurer, B. A. 1993. Biological diversity, ecological integrity, and neotropical migrants: New perspectives for wildlife managers. Pages 24–31 in D. M. Finch and P. W. Stangel, eds. Status and management of neotropical migratory birds. U.S. Forest Service General Technical Report RM-229.
- National Park Service (NPS). 2012. NPScape GIS data store web site. Available at http://science.nature.nps.gov/im/monitor/npscape/gis_data.cfm (accessed 8 November 2012).
- North American Bird Conservation Initiative (NABCI). 2020. North American bird conservation initiative. Available at <https://nabci-us.org/resources/bird-conservationregions-map/> (accessed 25 June 2020).
- Pannekoek J., and A. J. Van Strien. 2005. TRIM 3 manual (Trends and Indices for Monitoring data). Statistics Netherlands, Voorburg, The Netherlands.
- Pashley, D. N., and W. C. Barrow. 1993. Effects of land use practices on neotropical migratory birds in bottomland hardwood forests. Pages 315–320 in D.M. Finch and P.W. Stangel, eds. Status and management of neotropical migratory birds. U.S. Forest Service General Technical Report RM-229.

- Peitz, D. G. 2009. Bird monitoring at George Washington Carver National Monument, Missouri: 2008 status report. Natural Resource Technical Report NPS/HTLN/NRTR—2009/193. National Park Service, Fort Collins, Colorado.
- Peitz, D. G., G. A. Rowell, J. L. Haack, K. M. James, L. W. Morrison, and M. D. Debacker. 2008. Breeding bird monitoring protocol for the Heartland Network Inventory and Monitoring Program. Natural Resource Report NPS/HTLN/NRR-2008/044. National Park Service, Fort Collins, Colorado.
- Pielou, E. C. 1969. An introduction to mathematical ecology. John Wiley and Sons, New York, New York. 286pp.
- Reese, G. C., K. R. Wilson, and C. H. Flather. 2014. Performance of species richness estimators across assemblage types and survey parameters. *Global Ecology and Biogeography*, 23: 585–594.
- Robbins, M. B., and D. A. Easterla. 1992. Birds of Missouri: their distribution and abundance. University of Missouri Press, Columbia, Missouri.
- Rosenberg, K. V., A. M. Dokter, P. J. Blancher, J. R. Sauer, A. C. Smith, P. A. Smith, J. C. Stanton, A. Panjabi, L. Helft, M. Parr, and P. P. Marra. 2019. Decline of the North American avifauna. *Science* 366(6461): 120–124. DOI: 10.1126/science.aaw1313.
- Sauer, J. R., D. K. Niven, J. E. Hines, D. J. Ziolkowski, Jr, K. L. Pardieck, J. E. Fallon, and W. A. Link. 2017. The North American breeding bird survey, results and analysis 1966 - 2015. Version 2.07.2017 USGS Patuxent Wildlife Research Center, Laurel, Maryland.
- Shannon, C. E. 1949. The mathematical theory of communication. University of Illinois Press, Urbana, Illinois. 177 pp.
- Stokes, D. W., and L. Q. Stokes. 1996. Stokes field guide to birds: eastern region. Little, Brown and Company, New York, New York.
- Svedarsky, W. D., J. E. Toepfer, R. L. Westemeier, and R. J. Robel. 2003. Effects of management practices on grassland birds: Greater Prairie-Chicken. Northern Prairie Wildlife Research Center, Jamestown, ND. Northern Prairie Wildlife Research Center Online. Available at <http://www.npwrc.usgs.gov/resource/literatr/grasbird/gpch/gpch.htm> (Version 28 May 2004).
- U.S. Fish and Wildlife Service (USFWS). 2008. Birds of conservation concern 2008. United States Department of Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia. 85 pp. [Online version available at <http://www.fws.gov/migratorybirds/>].
- Van Strien, A. J., J. Pannekoek, and D. W. Gibbons. 2001. Indexing European bird population trends using results of national monitoring schemes: a trial of a new method. *Bird Study* 48:200–213.
- Walther, B. A., and J. L. Moore. 2005. The concepts of bias, precision and accuracy, and their use in testing the performance of species richness estimators, with a literature review of estimator performance. *Ecography* 28:815–829.
- Wood, J. K., N. Nur, C. A. Howell, and G. R. Geupel. 2006. Overview of Cosumnes riparian bird study and recommendations for monitoring and management. A Report to the California Bay-Delta Authority Ecosystem Restoration Program. Petaluma, California. 18pp.

Appendix A. Plots Sampled

Table A1. Plots sampled on George Washington Carver National Monument between 2008 and 2020 and gross habitat type. “Yes” indicates plot was sampled in that year; “No” indicates it was not.

Plot	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Plot Type
GWCA1*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Woodland
GWCA2	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Woodland
GWCA3	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA4*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Grassland
GWCA5	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA6	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA7*	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Grassland
GWCA8	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA9	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA10*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Grassland
GWCA11*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Woodland
GWCA12	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA13*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Grassland
GWCA14	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA15	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA16	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA17	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA18	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Woodland
GWCA19*	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Grassland
GWCA20	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA21	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA22*	Yes	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Grassland
GWCA23	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Woodland
GWCA24	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA25	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA26	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Woodland
GWCA27	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	Woodland

* Plots included in analysis of individual bird species trends (also in bold).

Table A1 (continued). Plots sampled on George Washington Carver National Monument between 2008 and 2020 and gross habitat type. “Yes” indicates plot was sampled in that year; “No” indicates it was not.

Plot	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Plot Type
GWCA28*	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Woodland
GWCA29	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Woodland
GWCA30*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Woodland
GWCA31*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Grassland
GWCA32	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes	Grassland
GWCA33	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Woodland
GWCA34*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Woodland
GWCA35	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Woodland
GWCA36	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA37*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Woodland
GWCA38	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA39	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Woodland
GWCA40*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Woodland
GWCA41	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA42	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA43*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Grassland
GWCA44	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA45*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Grassland
GWCA46	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA47	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA48	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA49*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Grassland
GWCA50	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA51	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA52*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Grassland
GWCA53	Yes	Yes	No	Yes	Yes	No	No	No	Yes	Yes	No	No	Yes	Woodland
GWCA54	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA55*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Grassland
GWCA56	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland

* Plots included in analysis of individual bird species trends (also in bold).

Table A1 (continued). Plots sampled on George Washington Carver National Monument between 2008 and 2020 and gross habitat type. “Yes” indicates plot was sampled in that year; “No” indicates it was not.

Plot	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Plot Type
GWCA57	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA58*	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Woodland
GWCA59	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA60	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA61*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Grassland
GWCA62	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA63	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA64*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Grassland
GWCA65	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA66	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA67*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Grassland
GWCA68	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA69	Yes	No	No	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Grassland
GWCA70*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Grassland

* Plots included in analysis of individual bird species trends (also in bold).

Appendix B. Proportion of Grassland Plots Occupied and Abundance (Corrected for Undetected Individuals)

Table B1. Annual proportion of grassland plots occupied by each breeding bird species and estimated abundance (determined using Distance software; shown in parentheses) of each species at George Washington Carver National Monument during the 2008 to 2020 spring bird surveys (n = number of plots sampled). Note that the proportion of plots occupied includes flyovers, whereas estimated abundance using Distance does not. “–” denotes when an annual abundance value could not be calculated because the species was present but distance measures from observers could not be determined.

Common Name	Proportion of Plots Occupied (Abundance)												
	2008 n=52	2009 n=16	2010 n=16	2011 n=14	2012 n=52	2013 n=15	2014 n=13	2015 n=49	2016 n=52	2017 n=16	2018 n=14	2019 n=8	2020 n=52
Brown-headed Cowbird	0.38 (13)	0.25 (13)	0.50 (15)	0.43 (15)	0.23 (3)	0.40 (5)	0.31 (8)	0.29 (9)	0.19 (8)	0.25 (6)	0.21 (10)	0.13 (13)	0 (0)
Common Yellowthroat	0.06 (1)	0.06 (2)	0.38 (7)	0.07 (3)	0.13 (2)	0.07 (4)	0.08 (1)	0.10 (2)	0.10 (2)	0.19 (4)	0.29 (6)	0.13 (2)	0.19 (4)
Dickcissel	0.52 (61)	0.75 (89)	0.94 (120)	0.79 (101)	0.85 (102)	0.93 (152)	0.92 (187)	0.82 (109)	0.71 (98)	0.94 (165)	0.93 (170)	0.63 (89)	0.75 (78)
Eastern Meadowlark	0.15 (5)	0.31 (12)	0.38 (16)	0.57 (14)	0.08 (2)	0.53 (17)	0 (0)	0.18 (5)	0.23 (9)	0.25 (9)	0.14 (5)	0 (0)	0.04 (2)
Field Sparrow	0.17 (2)	0.25 (3)	0.31 (5)	0.14 (1)	0.10 (1)	0.53 (9)	0.54 (9)	0.37 (5)	0.23 (4)	0.19 (3)	0.43 (6)	0.75 (10)	0.12 (2)
Indigo Bunting	0.19 (15)	0.25 (29)	0.31 (24)	0.07 (6)	0.17 (19)	0.20 (15)	0.23 (24)	0.14 (11)	0.17 (13)	0.31 (29)	0.43 (33)	0.13 (10)	0.08 (6)
Northern Bobwhite	0.17 (3)	0.38 (8)	0.38 (7)	0.43 (7)	0.06 (2)	0.13 (2)	0.08 (2)	0.49 (7)	0.06 (–)	0.19 (3)	0.14 (2)	0 (0)	0 (0)
Northern Cardinal	0.15 (13)	0.31 (49)	0.63 (53)	0.64 (56)	0.21 (16)	0.27 (24)	0.31 (23)	0.29 (25)	0.21 (20)	0.50 (38)	0.21 (17)	0.38 (30)	0.10 (7)
Red-bellied Woodpecker	0.12 (1)	0.19 (3)	0.31 (2)	0.50 (4)	0.08 (1)	0.27 (2)	0.31 (3)	0.20 (2)	0.06 (–)	0.31 (2)	0.14 (2)	0.38 (3)	0.06 (1)
Tufted titmouse	0.06 (1)	0.13 (3)	0.31 (4)	0.43 (5)	0.08 (1)	0.20 (2)	0.08 (2)	0.12 (2)	0.08 (1)	0.50 (6)	0.36 (7)	0.25 (4)	0.15 (2)

Appendix C. Proportion of Grassland Plots Occupied and Abundance (Not Corrected for Undetected Individuals)

Table C1. Annual proportion of grassland plots occupied by each breeding bird species and estimated abundance (determined using birds within 50 m of plot center; shown in parentheses) of each species at George Washington Carver National Monument during the 2008 to 2020 spring bird surveys (n = number of plots sampled). Note that the proportion of plots occupied includes flyovers, whereas estimated abundance does not. “–” denotes when an annual abundance value could not be calculated because the species was present but outside of 50 m from the plot center.

Common Name	Proportion of Plots Occupied (Abundance)												
	2008 n=52	2009 n=16	2010 n=16	2011 n=14	2012 n=52	2013 n=15	2014 n=13	2015 n=49	2016 n=52	2017 n=16	2018 n=14	2019 n=8	2020 n=52
American Coot	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (–)	0 (0)	0 (0)	0 (0)
American Crow	0.06 (–)	0.38 (–)	0.38 (–)	0.07 (–)	0.10 (–)	0 (0)	0.23 (–)	0.20 (2)	0.08 (–)	0.25 (–)	0.21 (–)	0.25 (–)	0.02 (–)
American Goldfinch	0.08 (11)	0.13 (10)	0.06 (–)	0.36 (6)	0.10 (–)	0.07 (–)	0.15 (–)	0.10 (–)	0.15 (8)	0.19 (–)	0.21 (23)	0 (0)	0.10 (2)
American Kestrel	0 (0)	0.06 (–)	0.06 (–)	0 (0)	0.02 (–)	0 (0)	0.08 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
American Robin	0.08 (2)	0.13 (5)	0.31 (–)	0.07 (6)	0.02 (2)	0.07 (–)	0.15 (–)	0.08 (–)	0.02 (–)	0.19 (–)	0 (–)	0.13 (–)	0.04 (2)
Baltimore Oriole	0 (0)	0.06 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0.08 (–)	0.04 (–)	0 (0)	0 (0)	0.07 (–)	0 (0)	0 (0)
Bank Swallow	0 (0)	0.06 (15)	0 (0)	0 (0)	0.02 (–)	0 (0)	0.08 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Barn Swallow	0.13 (–)	0.13 (10)	0 (0)	0.14 (–)	0.04 (–)	0.20 (–)	0 (0)	0.18 (2)	0.10 (–)	0.13 (–)	0.21 (–)	0 (0)	0.06 (–)
Barred Owl	0 (0)	0.06 (–)	0 (0)	0 (0)	0.02 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.02 (–)
Bell's Vireo*	0 (0)	0.19 (20)	0.06 (5)	0 (0)	0 (0)	0 (0)	0.15 (13)	0.02 (2)	0.04 (3)	0 (0)	0.07 (–)	0 (0)	0 (0)
Belted Kingfisher	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.02 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Blue-gray Gnatcatcher	0.04 (5)	0.06 (–)	0 (0)	0 (0)	0.04 (2)	0 (0)	0 (0)	0.04 (2)	0 (0)	0.06 (5)	0 (0)	0 (0)	0.02 (–)
Blue Grosbeak	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.08 (5)	0 (0)	0.07 (12)	0 (0)	0 (0)
Blue Jay	0.06 (–)	0.19 (–)	0.06 (–)	0.36 (–)	0.04 (–)	0.13 (–)	0.08 (–)	0.04 (2)	0.06 (–)	0.06 (–)	0.29 (–)	0 (0)	0.06 (2)
Brown Thrasher	0.10 (6)	0.06 (5)	0.06 (5)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0.02 (–)	0 (0)	0.07 (6)	0 (0)	0 (0)
Canada Goose	0 (0)	0 (0)	0.06 (–)	0.07 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Carolina Chickadee	0.02 (–)	0 (0)	0 (0)	0.14 (6)	0.04 (6)	0.13 (–)	0 (0)	0.04 (–)	0.02 (–)	0.06 (–)	0 (0)	0.13 (10)	0 (0)
Carolina Wren	0.17 (5)	0.31 (10)	0.44 (10)	0 (0)	0 (0)	0.07 (–)	0.38 (–)	0.06 (–)	0.10 (5)	0.31 (10)	0.14 (–)	0.25 (10)	0.04 (–)
Cedar Waxwing	0 (0)	0 (0)	0 (0)	0 (0)	0.02 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cerulean Warbler*	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.02 (–)	0 (0)	0 (0)	0 (0)	0 (0)
Chimney Swift	0 (0)	0 (0)	0 (0)	0 (0)	0.02 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Chipping Sparrow	0.04 (–)	0.06 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

*Species of conservation concern for the Central Hardwoods Bird Conservation Region (USFWS 2008; also in bold).

Table C1 (continued). Annual proportion of grassland plots occupied by each breeding bird species and estimated abundance (determined using birds within 50 m of plot center; shown in parentheses) of each species at George Washington Carver National Monument during the 2008 to 2020 spring bird surveys (n = number of plots sampled). Note that the proportion of plots occupied includes flyovers, whereas estimated abundance does not. “–” denotes when an annual abundance value could not be calculated because the species was present but outside of 50 m from the plot center.

Common Name	Proportion of Plots Occupied (Abundance)												
	2008 n=52	2009 n=16	2010 n=16	2011 n=14	2012 n=52	2013 n=15	2014 n=13	2015 n=49	2016 n=52	2017 n=16	2018 n=14	2019 n=8	2020 n=52
Cliff Swallow	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Common Grackle	0 (0)	0.13 (–)	0 (0)	0.07 (–)	0.04 (–)	0.27 (–)	0.31 (–)	0.14 (–)	0.15 (6)	0 (0)	0.07 (–)	0 (0)	0.02 (–)
Common Nighthawk	0.02 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0 (0)	0 (0)	0 (0)
Cooper’s Hawk	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.02 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Downy Woodpecker	0 (0)	0.06 (–)	0 (0)	0 (0)	0.04 (3)	0 (0)	0 (0)	0.04 (2)	0.02 (–)	0 (0)	0 (0)	0 (0)	0 (0)
Eastern Bluebird	0.02 (3)	0.19 (–)	0.31 (–)	0.36 (12)	0.08 (3)	0.20 (5)	0.38 (–)	0.06 (–)	0.06 (5)	0.06 (–)	0.29 (–)	0 (0)	0 (0)
Eastern Kingbird	0.08 (3)	0.13 (–)	0.13 (5)	0 (0)	0.06 (–)	0.07 (–)	0.08 (–)	0.14 (8)	0.06 (6)	0.13 (5)	0 (0)	0.13 (–)	0.02 (–)
Eastern Phoebe	0.02 (–)	0.13 (5)	0.06 (–)	0.14 (–)	0.04 (–)	0 (0)	0 (0)	0.08 (2)	0.04 (3)	0.13 (5)	0 (0)	0 (0)	0.02 (2)
Eastern Towhee	0 (0)	0 (0)	0 (0)	0 (0)	0.02 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Eastern Wood-pewee	0.06 (–)	0 (0)	0.06 (5)	0.07 (–)	0.12 (2)	0.27 (–)	0.08 (–)	0.06 (3)	0 (0)	0.13 (15)	0.14 (–)	0.13 (–)	0.06 (–)
European Starling	0 (0)	0.06 (–)	0.25 (–)	0.07 (–)	0.04 (–)	0.20 (–)	0 (0)	0.02 (–)	0 (0)	0.06 (10)	0 (0)	0 (0)	0 (0)
Fish Crow	0 (0)	0.06 (–)	0 (0)	0 (0)	0.02 (–)	0.07 (–)	0 (0)	0.02 (–)	0 (0)	0 (0)	0 (0)	0.13 (–)	0 (0)
Grasshopper Sparrow	0.27 (17)	0 (0)	0 (0)	0 (0)	0.17 (9)	0 (0)	0 (0)	0 (0)	0.10 (8)	0 (0)	0 (0)	0 (0)	0.08 (8)
Gray Catbird	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.02 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0.02 (2)
Great Blue Heron	0 (0)	0.06 (–)	0.06 (–)	0 (0)	0.02 (–)	0 (0)	0 (0)	0.08 (–)	0 (0)	0 (0)	0 (0)	0.13 (–)	0 (0)
Great Crested Flycatcher	0.02 (–)	0 (0)	0.06 (–)	0.07 (–)	0.02 (2)	0 (0)	0.08 (–)	0 (0)	0.04 (2)	0 (0)	0 (0)	0 (0)	0.10 (2)
Great Egret	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.07 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
House Finch	0 (0)	0 (0)	0.06 (5)	0 (0)	0.02 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
House Sparrow	0.02 (–)	0.06 (–)	0 (0)	0.07 (–)	0 (0)	0.07 (–)	0 (0)	0.02 (–)	0 (0)	0.06 (10)	0 (0)	0 (0)	0 (0)
House Wren	0 (0)	0.06 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Kentucky Warbler*	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.08 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Killdeer	0 (0)	0 (0)	0 (0)	0.07 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lark Sparrow	0.04 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Loggerhead Shrike*	0 (0)	0 (0)	0 (0)	0 (0)	0.02 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mourning Dove	0 (0)	0.44 (26)	0.31 (5)	0.14 (–)	0 (0)	0.07 (–)	0.08 (–)	0.06 (–)	0.04 (–)	0.25 (–)	0.14 (–)	0.25 (–)	0 (0)
Northern Flicker	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0.06 (–)	0 (0)	0 (0)	0 (0)

*Species of conservation concern for the Central Hardwoods Bird Conservation Region (USFWS 2008; also in bold).

Table C1 (continued). Annual proportion of grassland plots occupied by each breeding bird species and estimated abundance (determined using birds within 50 m of plot center; shown in parentheses) of each species at George Washington Carver National Monument during the 2008 to 2020 spring bird surveys (n = number of plots sampled). Note that the proportion of plots occupied includes flyovers, whereas estimated abundance does not. “–” denotes when an annual abundance value could not be calculated because the species was present but outside of 50 m from the plot center.

Common Name	Proportion of Plots Occupied (Abundance)												
	2008 n=52	2009 n=16	2010 n=16	2011 n=14	2012 n=52	2013 n=15	2014 n=13	2015 n=49	2016 n=52	2017 n=16	2018 n=14	2019 n=8	2020 n=52
Northern Harrier	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.02 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Northern Mockingbird	0.04 (5)	0.19 (5)	0.06 (–)	0.29 (–)	0.06 (–)	0.13 (–)	0.23 (6)	0.10 (2)	0.04 (2)	0.25 (–)	0.14 (–)	0 (0)	0.02 (–)
Northern Parula	0.06 (2)	0 (0)	0 (0)	0 (0)	0.10 (–)	0.07 (–)	0 (0)	0 (0)	0.10 (2)	0.13 (–)	0 (0)	0 (0)	0.08 (–)
Orchard Oriole	0 (0)	0 (0)	0 (0)	0 (0)	0.02 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ovenbird	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)
Pileated Woodpecker	0.04 (–)	0.06 (–)	0.06 (–)	0.14 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (–)	0.13 (–)	0.07 (–)	0 (0)	0 (0)
Purple Martin	0.02 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Red-eyed Vireo	0 (0)	0 (0)	0 (0)	0.07 (–)	0 (0)	0 (0)	0 (0)	0.02 (–)	0.02 (–)	0 (0)	0 (0)	0.13 (–)	0 (0)
Red-headed Woodpecker*	0 (0)	0.19 (5)	0 (0)	0 (0)	0 (0)	0 (0)	0.15 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Red-shouldered Hawk	0.02 (–)	0.13 (–)	0 (0)	0.07 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.07 (–)	0 (0)
Red-tailed Hawk	0.02 (–)	0.06 (–)	0 (0)	0 (0)	0.02 (–)	0 (0)	0 (0)	0.08 (–)	0 (0)	0.06 (–)	0.07 (–)	0 (0)	0.06 (–)
Red-winged Blackbird	0 (0)	0.19 (10)	0.19 (–)	0.43 (–)	0.02 (–)	0 (0)	0 (0)	0.10 (3)	0 (0)	0.13 (–)	0.07 (–)	0 (0)	0.08 (3)
Rock Dove	0 (0)	0 (0)	0 (0)	0.07 (–)	0 (0)	0 (0)	0 (0)	0.02 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Rose-breasted Grosbeak	0 (0)	0 (0)	0 (0)	0 (0)	0.02 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ruby-throated Hummingbird	0.02 (–)	0 (0)	0 (0)	0.14 (6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Scissor-tailed Flycatcher	0 (0)	0.06 (10)	0.06 (–)	0.07 (–)	0.10 (3)	0.07 (–)	0 (0)	0.12 (3)	0 (0)	0.13 (–)	0.14 (–)	0 (0)	0 (0)
Song Sparrow	0.02 (2)	0 (0)	0.06 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Summer Tanager	0.04 (2)	0 (0)	0 (0)	0 (0)	0.06 (2)	0.07 (–)	0 (0)	0 (0)	0.08 (3)	0.06 (–)	0 (0)	0 (0)	0.02 (–)
Turkey Vulture	0.02 (–)	0.25 (–)	0.06 (–)	0.43 (–)	0.04 (–)	0.13 (–)	0.08 (–)	0.20 (–)	0.06 (–)	0.13 (–)	0.07 (–)	0 (0)	0.08 (–)
Warbling Vireo	0 (0)	0 (0)	0.06 (–)	0.07 (–)	0.04 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
White-breasted Nuthatch	0 (0)	0.06 (10)	0 (0)	0.07 (–)	0.04 (–)	0 (0)	0.15 (6)	0 (0)	0 (0)	0.06 (5)	0 (0)	0 (0)	0 (0)
White-eyed Vireo	0 (0)	0 (0)	0 (0)	0 (0)	0.02 (–)	0 (0)	0 (0)	0 (0)	0.04 (3)	0 (0)	0 (0)	0 (0)	0 (0)
Wild Turkey	0 (0)	0.06 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Yellow-billed Cuckoo	0.08 (2)	0.06 (5)	0.19 (5)	0.07 (–)	0.10 (2)	0.33 (–)	0.08 (–)	0.06 (2)	0.06 (–)	0.06 (5)	0.29 (–)	0.38 (20)	0.10 (–)
Yellow-breasted Chat	0.02 (2)	0.06 (5)	0 (0)	0 (0)	0.06 (2)	0 (0)	0.08 (–)	0.02 (–)	0 (0)	0 (0)	0.14 (–)	0.13 (–)	0.04 (2)

*Species of conservation concern for the Central Hardwoods Bird Conservation Region (USFWS 2008; also in bold).

Appendix D. Proportion of Woodland Plots Occupied and Abundance (Corrected for Undetected Individuals)

Table D1. Annual proportion of woodland plots occupied by each breeding bird species and estimated abundance (determined using Distance software; shown in parentheses) of each species at George Washington Carver National Monument during the 2008 to 2020 spring bird surveys (n = number of plots sampled). Note that the proportion of plots occupied includes flyovers, whereas estimated abundance using Distance does not.

Common Name	Proportion of Plots Occupied (Abundance)												
	2008 n=18	2009 n=8	2010 n=8	2011 n=9	2012 n=18	2013 n=9	2014 n=7	2015 n=17	2016 n=18	2017 n=8	2018 n=9	2019 n=4	2020 n=18
Carolina Wren	0.39 (14)	0.38 (12)	0.50 (12)	0 (0)	0.06 (2)	0.56 (16)	0.43 (14)	0.35 (12)	0.28 (9)	0.50 (24)	0.78 (33)	0.75 (18)	0.33 (12)
Indigo Bunting	0.50 (43)	0.38 (33)	0.25 (20)	0.44 (35)	0.39 (26)	0.44 (47)	0.43 (23)	0.18 (7)	0.11 (6)	0.25 (13)	0.44 (29)	0 (0)	0.28 (29)
Northern Cardinal	0.50 (26)	0.88 (56)	0.75 (38)	0.89 (41)	0.50 (31)	0.89 (56)	0.57 (38)	0.76 (40)	0.67 (38)	0.75 (42)	0.89 (41)	0.75 (34)	0.67 (34)
Red-bellied Woodpecker	0.11 (3)	0.38 (9)	0.88 (22)	0.33 (11)	0.11 (5)	0.44 (17)	0.29 (18)	0.47 (22)	0.17 (4)	0.63 (28)	0.56 (14)	0.75 (37)	0.28 (8)
Tufted titmouse	0.06 (1)	0.25 (10)	0.38 (7)	0.78 (15)	0.33 (8)	0.44 (17)	0.29 (8)	0.53 (16)	0.33 (10)	0.50 (10)	0.44 (13)	0.50 (10)	0.33 (6)
Yellow-billed Cuckoo	0.17 (4)	0.13 (6)	0.63 (14)	0.33 (15)	0.28 (8)	0.22 (10)	0.43 (16)	0.35 (14)	0.06 (1)	0.50 (14)	0.44 (20)	0.75 (22)	0.44 (11)

Appendix E. Proportion of Woodland Plots Occupied and Abundance (Not Corrected for Undetected Individuals)

Table E1. Annual proportion of woodland plots occupied by each breeding bird species and estimated abundance (determined using birds within 50 m of plot center; shown in parentheses) of each species at George Washington Carver National Monument during the 2008 to 2020 spring bird surveys (n = number of plots sampled). Note that the proportion of plots occupied includes flyovers, whereas estimated abundance does not. “–” denotes when an annual abundance value could not be calculated because the species was present but outside of 50 m from the plot center.

Common Name	Proportion of Plots Occupied (Abundance)												
	2008 n=18	2009 n=8	2010 n=8	2011 n=9	2012 n=18	2013 n=9	2014 n=7	2015 n=17	2016 n=18	2017 n=8	2018 n=9	2019 n=4	2020 n=18
Acadian Flycatcher	0 (0)	0.13 (4)	0 (0)	0.22 (6)	0 (0)	0.11 (3)	0 (0)	0 (0)	0.17 (6)	0.13 (4)	0.11 (3)	0.25 (7)	0 (0)
American Crow	0.06 (–)	0.13 (–)	0.13 (–)	0.11 (–)	0.06 (2)	0.11 (–)	0 (0)	0.24 (–)	0.06 (3)	0.25 (4)	0.11 (–)	0.25 (–)	0 (0)
American Goldfinch	0 (0)	0 (0)	0 (0)	0.78 (16)	0.11 (2)	0 (0)	0.14 (–)	0.06 (–)	0 (0)	0.25 (4)	0.11 (–)	0.50 (–)	0.06 (2)
American Redstart	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (2)
American Robin	0.11 (2)	0.13 (11)	0.25 (7)	0.22 (6)	0.17 (5)	0.33 (19)	0.14 (4)	0.29 (7)	0.17 (2)	0.38 (7)	0.11 (–)	0 (0)	0.17 (3)
American Woodcock	0.06 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Baltimore Oriole	0 (0)	0 (0)	0 (0)	0.11 (3)	0.06 (–)	0 (0)	0.14 (4)	0 (0)	0 (0)	0 (0)	0.11 (3)	0 (0)	0 (0)
Barn Swallow	0 (0)	0 (0)	0 (0)	0.11 (–)	0.06 (–)	0 (0)	0 (0)	0 (0)	0.06 (–)	0 (0)	0 (0)	0 (0)	0 (0)
Barred Owl	0 (0)	0 (0)	0.13 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Bell's Vireo*	0 (0)	0.13 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0.14 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Blue-gray Gnatcatcher	0.33 (14)	0.38 (14)	0.25 (4)	0 (0)	0.28 (8)	0.22 (10)	0.29 (8)	0.35 (8)	0.17 (5)	0.38 (14)	0.22 (10)	0.25 (7)	0.22 (6)
Blue Jay	0.11 (3)	0.38 (4)	0 (0)	0.11 (6)	0.06 (2)	0.22 (–)	0 (0)	0.06 (–)	0.11 (3)	0 (0)	0.44 (6)	0.25 (–)	0.22 (3)
Brown-headed Cowbird	0.06 (2)	0.25 (–)	0.13 (–)	0.11 (–)	0 (0)	0.44 (–)	0.71 (–)	0.24 (–)	0 (0)	0.25 (–)	0.11 (–)	0.25 (–)	0 (0)
Brown Thrasher	0 (0)	0.13 (3)	0 (0)	0.11 (6)	0 (0)	0.11 (3)	0 (0)	0 (0)	0 (0)	0.13 (4)	0 (0)	0 (0)	0 (0)
Carolina Chickadee	0.06 (2)	0.13 (4)	0.13 (4)	0.11 (3)	0.39 (11)	0.11 (–)	0.29 (16)	0.35 (14)	0.17 (8)	0.13 (4)	0 (0)	0.25 (7)	0 (0)
Cedar Waxwing	0 (0)	0 (0)	0.13 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Chimney Swift	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (–)	0 (0)	0.29 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Chipping Sparrow	0 (0)	0 (0)	0.13 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cliff Swallow	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Common Grackle	0 (0)	0.25 (–)	0.13 (–)	0 (0)	0.06 (3)	0 (0)	0 (0)	0.12 (2)	0.11 (3)	0 (0)	0 (0)	0 (0)	0 (0)
Common Nighthawk	0 (0)	0.13 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Common Yellowthroat	0.06 (2)	0 (0)	0 (0)	0.22 (3)	0.17 (5)	0.11 (–)	0.14 (–)	0.06 (–)	0.17 (5)	0.13 (–)	0.22 (–)	0.25 (7)	0 (0)

*Species of conservation concern for the Central Hardwoods Bird Conservation Region (USFWS 2008; also in bold).

Table E1 (continued). Annual proportion of woodland plots occupied by each breeding bird species and estimated abundance (determined using birds within 50 m of plot center; shown in parentheses) of each species at George Washington Carver National Monument during the 2008 to 2020 spring bird surveys (n = number of plots sampled). Note that the proportion of plots occupied includes flyovers, whereas estimated abundance does not. “–” denotes when an annual abundance value could not be calculated because the species was present but outside of 50 m from the plot center.

Common Name	Proportion of Plots Occupied (Abundance)												
	2008 n=18	2009 n=8	2010 n=8	2011 n=9	2012 n=18	2013 n=9	2014 n=7	2015 n=17	2016 n=18	2017 n=8	2018 n=9	2019 n=4	2020 n=18
Dickcissel	0 (0)	0 (0)	0 (0)	0.33 (10)	0.11 (3)	0.11 (–)	0.29 (–)	0.35 (2)	0.06 (–)	0.13 (7)	0.33 (6)	0.25 (–)	0 (0)
Downy Woodpecker	0.11 (3)	0.25 (14)	0 (0)	0.22 (3)	0.06 (2)	0.11 (–)	0.14 (4)	0 (0)	0.06 (3)	0 (0)	0 (0)	0 (0)	0.17 (2)
Eastern Bluebird	0.11 (5)	0.13 (11)	0 (0)	0 (0)	0.11 (–)	0.11 (–)	0.14 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Eastern Kingbird	0 (0)	0 (0)	0 (0)	0.11 (3)	0 (0)	0 (0)	0 (0)	0.06 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Eastern Meadowlark	0 (0)	0.13 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Eastern Phoebe	0 (0)	0.25 (4)	0.13 (7)	0.33 (3)	0.06 (3)	0 (0)	0 (0)	0.24 (5)	0 (0)	0.13 (7)	0.11 (–)	0 (0)	0 (0)
Eastern Towhee	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (2)	0.11 (–)	0 (0)	0.06 (–)	0 (0)	0.13 (4)	0 (0)	0 (0)	0 (0)
Eastern Wood-pewee	0.22 (5)	0.38 (7)	0.38 (7)	0.44 (10)	0 (0)	0.11 (3)	0.29 (4)	0.18 (3)	0.22 (2)	0.25 (4)	0.44 (10)	0 (0)	0.17 (5)
Field Sparrow	0.06 (2)	0 (0)	0.13 (–)	0.22 (–)	0.11 (2)	0.22 (–)	0 (0)	0.29 (4)	0.11 (–)	0.25 (4)	0.11 (–)	0.25 (7)	0 (0)
Fish Crow	0 (0)	0.13 (4)	0 (0)	0.11 (–)	0 (0)	0.11 (–)	0.14 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gray Catbird	0 (0)	0 (0)	0.13 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.25 (7)	0 (0)
Great Blue Heron	0 (0)	0 (0)	0 (0)	0.11 (–)	0.06 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Great Crested Flycatcher	0.06 (2)	0.25 (7)	0.13 (–)	0.11 (3)	0.11 (3)	0.22 (10)	0 (0)	0 (0)	0.28 (5)	0.13 (4)	0 (0)	0.50 (7)	0.17 (3)
Green Heron	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Great Horned Owl	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.13 (–)	0 (0)	0 (0)	0 (0)
Hairy Woodpecker	0 (0)	0 (0)	0.13 (–)	0 (0)	0.06 (2)	0 (0)	0 (0)	0 (0)	0.06 (2)	0 (0)	0 (0)	0 (0)	0.06 (2)
House Finch	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (–)
House Wren	0 (0)	0 (0)	0.13 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.13 (4)	0 (0)	0 (0)	0.06 (3)
Kentucky Warbler*	0.17 (3)	0 (0)	0.13 (4)	0.22 (3)	0 (0)	0.11 (3)	0.14 (–)	0 (0)	0 (0)	0.13 (4)	0 (0)	0 (0)	0 (0)
Killdeer	0.06 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Louisiana Waterthrush	0 (0)	0 (0)	0 (0)	0.11 (3)	0.06 (2)	0.11 (–)	0 (0)	0.06 (2)	0 (0)	0.13 (4)	0 (0)	0 (0)	0 (0)
Mourning Dove	0 (0)	0.25 (25)	0.13 (–)	0.11 (–)	0 (0)	0.11 (–)	0.29 (–)	0.18 (–)	0 (0)	0 (0)	0.22 (–)	0 (0)	0 (0)
Northern Bobwhite	0.06 (2)	0.25 (14)	0.13 (–)	0.22 (–)	0.11 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0.13 (–)	0.11 (–)	0 (0)	0 (0)
Northern Flicker	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.14 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Northern Mockingbird	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

*Species of conservation concern for the Central Hardwoods Bird Conservation Region (USFWS 2008; also in bold).

Table E1 (continued). Annual proportion of woodland plots occupied by each breeding bird species and estimated abundance (determined using birds within 50 m of plot center; shown in parentheses) of each species at George Washington Carver National Monument during the 2008 to 2020 spring bird surveys (n = number of plots sampled). Note that the proportion of plots occupied includes flyovers, whereas estimated abundance does not. “–” denotes when an annual abundance value could not be calculated because the species was present but outside of 50 m from the plot center.

Common Name	Proportion of Plots Occupied (Abundance)												
	2008 n=18	2009 n=8	2010 n=8	2011 n=9	2012 n=18	2013 n=9	2014 n=7	2015 n=17	2016 n=18	2017 n=8	2018 n=9	2019 n=4	2020 n=18
Northern Parula	0.28 (10)	0.13 (4)	0.13 (–)	0.22 (6)	0.22 (5)	0.67 (16)	0.29 (12)	0.06 (2)	0.11 (5)	0.38 (11)	0.33 (3)	0 (0)	0.06 (2)
Pileated Woodpecker	0.11 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.13 (4)	0 (0)	0.25 (–)	0 (0)
Prothonotary Warbler	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.13 (4)	0 (0)	0 (0)	0 (0)
Red-eyed Vireo	0.06 (2)	0.25 (7)	0.13 (4)	0.33 (10)	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (3)	0.13 (4)	0 (0)	0 (0)	0.06 (–)
Red-headed Woodpecker*	0 (0)	0.13 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Red-shouldered Hawk	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Red-winged Blackbird	0 (0)	0.13 (–)	0 (0)	0.11 (–)	0 (0)	0 (0)	0 (0)	0.06 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ruby-throated Hummingbird	0.06 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (3)	0 (0)	0 (0)	0 (0)	0.13 (4)	0 (0)	0 (0)	0 (0)
Sharp-shinned Hawk	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (2)
Song Sparrow	0 (0)	0.13 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Summer Tanager	0.06 (2)	0 (0)	0 (0)	0.11 (3)	0.17 (2)	0.11 (3)	0.14 (4)	0.06 (2)	0 (0)	0 (0)	0 (0)	0.25 (7)	0 (0)
Turkey Vulture	0 (0)	0.25 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (–)	0 (0)	0 (0)	0.25 (–)	0 (0)
Warbling Vireo	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (2)
White-breasted Nuthatch	0 (0)	0 (0)	0.13 (–)	0.22 (10)	0.06 (–)	0.11 (–)	0.14 (4)	0.18 (3)	0.17 (5)	0.13 (4)	0 (0)	0 (0)	0.11 (3)
White-eyed Vireo	0 (0)	0 (0)	0 (0)	0 (0)	0.22 (8)	0 (0)	0 (0)	0 (0)	0.06 (2)	0.13 (4)	0 (0)	0 (0)	0 (0)
Wild Turkey	0 (0)	0 (0)	0.13 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.25 (–)	0 (0)
Yellow-breasted Chat	0.06 (2)	0 (0)	0 (0)	0.11 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Yellow-throated Vireo	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Yellow Warbler	0 (0)	0 (0)	0.13 (4)	0.11 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

*Species of conservation concern for the Central Hardwoods Bird Conservation Region (USFWS 2008; also in bold).

Appendix F. George Washington Carver National Monument Trends

Table F1. Trends, annual change in abundance (individuals), of breeding birds recorded on George Washington Carver National Monument from 2008 through 2020. “–” denotes when an annual trend value could not be calculated resulting in an undetermined trend classification.

Habitat	Bird Common Name	Trend ^A	SE of Slope	Trend Classification ^B
Grassland	Brown-headed Cowbird	0.97	0.05	Uncertain
	Common Yellowthroat	1.07	0.07	Uncertain
	Dickcissel	1.03	0.02	Uncertain
	Eastern Meadowlark	0.90	0.04	Moderate decline
	Field Sparrow	1.01	0.05	Uncertain
	Indigo Bunting	1.01	0.10	Uncertain
	Northern Bobwhite	0.87	0.04	Steep decline
	Northern Cardinal	0.92	0.08	Uncertain
	Red-bellied Woodpecker	0.97	0.04	Uncertain
	Tufted titmouse	–	–	Undetermined
Woodland	Carolina Wren	1.13	0.10	Uncertain
	Indigo Bunting	0.96	0.05	Uncertain
	Northern Cardinal	1.01	0.02	Stable
	Red-bellied Woodpecker	1.07	0.07	Uncertain
	Tufted titmouse	–	–	Undetermined
	Yellow-billed Cuckoo	1.06	0.04	Uncertain

^A Trends were determined using the statistical software TRIM Version 3.54 (2006).

^B Trend classification types depend on statistical significance and magnitude (Pannekoek and Van Strien 2005; Van Strien et al. 2001) and follow Gregory et. al. (2007). The multiplicative overall slope estimate in TRIM was converted into one of the following categories depending on the overall slope as well as its 95% confidence interval (= slope $\pm$ 1.96 times the standard error of the slope). Strong increase—increases significantly more than 5% per year. Criterion: lower limit of confidence interval > 1.05. Moderate increase—significant increase but not significantly more than 5% per year. Criterion: 1.00 < lower limit of confidence interval < 1.05. Stable—no significant increase or decline, and it is certain that trends are less than 5% per year. Criterion: confidence interval encloses 1.00 but lower limit > 0.95 and upper limit < 1.05. Uncertain—no significant increase or decline but not certain that trends are less than 5% per year. Criterion: confidence interval encloses 1.00 but lower limit < 0.95 or upper limit > 1.05. Moderate decline—significant decline, but not significantly more than 5% per year. Criterion: 0.95 < upper limit of confidence interval < 1.00. Steep decline—decline significantly more than 5% per year. Criterion: upper limit of confidence interval < 0.95.

Appendix G. Regional Trends

Table G1. Central Hardwoods Bird Conservation Region trends for breeding birds recorded on George Washington Carver National Monument for years 2005 through 2015. Regional trend data were obtained from breeding bird surveys (BBS; Sauer et al. 2017). Trend is defined as an interval-specific geometric mean of proportional changes in population size (Link and Sauer 1998), expressed as a percentage.

Common Name	Annual Percent Change in Population Size	95% Confidence Interval	
		Lower	Upper
Acadian Flycatcher	1.66	7810.79	2.74
American Crow	-0.43	-1.23	0.39
American Goldfinch	-0.70	-2.11	0.63
American Kestrel	-0.99	-3.36	1.31
American Robin	-1.01	-1.88	-0.12
American Woodcock	1.24	-8.85	12.39
Baltimore Oriole	0.23	-1.99	2.25
Bank Swallow	9.08	-5.51	27.01
Barn Swallow	-2.37	-3.35	-1.32
Barred Owl	3.47	-0.96	7.95
Bell's Vireo^A	7.84	1.97	15.42
Belted Kingfisher	-3.39	-6.32	-0.33
Blue-gray Gnatcatcher	-0.86	-2.15	0.28
Blue Grosbeak	2.44	1.21	3.70
Blue Jay	-1.38	-2.17	-0.54
Brown-headed Cowbird	-1.41	-2.36	-0.55
Brown Thrasher	-0.90	-1.79	0.06
Canada Goose	15.45	5.93	23.40
Carolina Chickadee	-1.33	-2.73	0.04
Carolina Wren	-3.80	-5.07	-2.51
Cedar Waxwing	-6.18	-9.96	-2.49
Cerulean Warbler^A	-1.64	-4.28	1.24
Chimney Swift	-3.10	-4.33	-1.72
Chipping Sparrow	0.76	-0.28	1.75
Cliff Swallow	20.60	14.34	26.01
Common Grackle	-3.78	-4.87	-2.85
Common Nighthawk	-0.49	-4.01	3.73
Common Yellowthroat	-0.84	-1.68	0.01
Cooper's Hawk	3.71	0.81	6.08
Dickcissel	-2.29	-4.73	0.26
Downy Woodpecker	0.09	-1.50	1.73
Eastern Bluebird	-5.40	-6.95	-3.84
Eastern Kingbird	-1.21	-2.13	-0.29
Eastern Meadowlark	-3.53	-4.16	-2.36
Eastern Phoebe	-1.11	-2.38	0.11

^A Species of conservation concern for the Central Hardwoods Bird Conservation Region (USFWS 2008; also in bold).

^B Species recorded between point transects or other times outside of 5-min survey periods.

Table G1 (continued). Central Hardwoods Bird Conservation Region trends for breeding birds recorded on George Washington Carver National Monument for years 2005 through 2015. Regional trend data were obtained from breeding bird surveys (BBS; Sauer et al. 2017). Trend is defined as an interval-specific geometric mean of proportional changes in population size (Link and Sauer 1998), expressed as a percentage.

Common Name	Annual Percent Change in Population Size	95% Confidence Interval	
		Lower	Upper
Eastern Towhee	-1.17	-2.21	-0.09
Eastern Wood-pewee	-0.50	-1.35	0.37
European Starling	-0.18	-1.54	0.96
Field Sparrow	-2.77	-3.78	-1.77
Fish Crow	6.95	-1.52	13.53
Grasshopper Sparrow	-4.72	-7.42	-2.23
Gray Catbird	-2.21	-3.50	-0.87
Great Blue Heron	3.47	1.31	5.57
Great Crested Flycatcher	-0.29	-1.35	0.78
Great Egret	4.64	-8.98	15.53
Green Heron	-1.99	-3.09	-0.74
Hairy Woodpecker	1.30	-0.50	3.29
Henslow's Sparrow^{A,B}	3.05	-4.54	8.25
House Finch	2.15	-1.81	6.75
House Sparrow	-4.81	-6.04	-3.57
House Wren	0.97	-1.18	3.10
Indigo Bunting	-0.91	-1.41	-0.43
Kentucky Warbler^A	-0.16	-1.57	1.24
Killdeer	-1.14	-2.63	0.31
Lark Sparrow	3.05	-3.47	13.52
Loggerhead Shrike^A	-6.76	-9.04	-4.59
Louisiana Waterthrush	3.33	1.40	6.00
Mourning Dove	0.56	-0.22	1.39
Northern Bobwhite	-3.68	-4.87	-2.46
Northern Cardinal	-0.24	-0.73	0.26
Northern Flicker	-2.64	-4.32	-1.01
Northern Harrier	0.73	-16.64	12.18
Northern Mockingbird	0.90	-0.13	1.97
Northern Parula	3.35	2.06	4.45
Orchard Oriole	-0.97	-2.08	0.23
Pileated Woodpecker	0.78	-0.56	2.10
Purple Martin	0.94	-1.14	2.71
Red-bellied Woodpecker	0.99	0.01	1.97
Red-eyed Vireo	0.07	-0.89	1.03
Red-headed Woodpecker^A	0.36	-1.93	2.77
Red-shouldered Hawk	4.24	1.35	6.77
Red-tailed Hawk	0.82	-1.21	2.56

^A Species of conservation concern for the Central Hardwoods Bird Conservation Region (USFWS 2008; also in bold).

^B Species recorded between point transects or other times outside of 5-min survey periods.

Table G1 (continued). Central Hardwoods Bird Conservation Region trends for breeding birds recorded on George Washington Carver National Monument for years 2005 through 2015. Regional trend data were obtained from breeding bird surveys (BBS; Sauer et al. 2017). Trend is defined as an interval-specific geometric mean of proportional changes in population size (Link and Sauer 1998), expressed as a percentage.

Common Name	Annual Percent Change in Population Size	95% Confidence Interval	
		Lower	Upper
Red-winged Blackbird	-1.83	-2.85	-0.77
Rock Dove	-0.76	-3.17	2.08
Rose-breasted Grosbeak	1.63	-7.07	8.90
Ruby-throated Hummingbird	0.91	-1.17	2.84
Scissor-tailed Flycatcher	7.54	3.87	11.17
Song Sparrow	0.15	-1.32	1.66
Summer Tanager	0.75	-0.20	1.74
Tufted titmouse	2.19	1.08	3.32
Turkey Vulture	4.31	2.56	6.14
Warbling Vireo	-0.15	-1.86	1.48
White-breasted Nuthatch	-0.88	-2.92	1.07
White-eyed Vireo	0.49	-0.63	1.63
Wild Turkey	7.29	1.50	12.93
Wood Duck ^B	1.19	-3.45	5.72
Yellow-billed Cuckoo	-0.23	-1.99	1.58
Yellow-breasted Chat	-.086	-1.87	0.11
Yellow-throated Vireo	1.63	0.39	2.96
Yellow-throated Warbler ^B	3.05	1.48	4.59
Yellow Warbler	-2.02	-4.99	0.94

^A Species of conservation concern for the Central Hardwoods Bird Conservation Region (USFWS 2008; also in bold).

^B Species recorded between point transects or other times outside of 5-min survey periods.

Appendix H. Habitat Parameters in Grassland Areas

Tables H1 through H3 show the averages for habitat parameters in three different sized plots in the grassland areas at George Washington Carver National Monument from 2008 through 2020.

Table H1. Average ($\pm$ std dev) percent cover of each habitat type in 50-m plots in the grassland areas at George Washington Carver National Monument, Missouri, during the bird breeding seasons from 2008 to 2020. Total percent coverages across habitat types may not sum to 100% as values are averaged over mid-point values of cover classes (i.e. class 1 = 0.5%, class 2 = 3.0%, class 3 = 15.0%, class 4 = 37.5%, class 5 = 62.5%, class 6 = 85.0%, and class 7 = 97.5%).

Habitat Parameter	2008	2012	2016	2020
Old Field/Prairie (%)	88.61 ($\pm$ 19.81)	88.56 ($\pm$ 15.93)	89.13 ($\pm$ 19.91)	89.23 ($\pm$ 15.49)
Lawn (%)	2.50 ($\pm$ 10.33)	1.78 ($\pm$ 9.07)	1.56 ($\pm$ 8.87)	2.75 ($\pm$ 12.25)
Parking Lot (%)	0.01 ($\pm$ 0.07)	0	0.07 ($\pm$ 0.42)	0.01 ($\pm$ 0.07)
Pasture Road (%)	2.20 ($\pm$ 5.15)	0.54 ($\pm$ 1.14)	1.10 ($\pm$ 3.03)	1.67 ($\pm$ 4.46)
Paved Road (%)	0	0.06 ($\pm$ 0.42)	0.35 ($\pm$ 2.11)	0.02 ($\pm$ 0.10)
Shrub (%)	0	0.84 ($\pm$ 5.22)	2.28 ($\pm$ 13.63)	0.29 ($\pm$ 2.08)
Stream (%)	0.75 ($\pm$ 2.96)	0.06 ($\pm$ 0.42)	0.18 ($\pm$ 0.71)	0.12 ($\pm$ 0.58)
Trail (%)	0.35 ($\pm$ 2.11)	0.12 ($\pm$ 0.58)	0.17 ($\pm$ 0.71)	0.40 ($\pm$ 2.14)
Woodland (%)	3.91 ($\pm$ 11.58)	2.25 ($\pm$ 7.71)	4.04 ($\pm$ 10.55)	2.97 ($\pm$ 9.12)

Table H2. Average ($\pm$ std dev) canopy cover, canopy height, basal area, percent cover of vegetation at various horizontal height increments to 2.0 m, and vertical structure diversity in 5-m subplots in the grassland areas at George Washington Carver National Monument during the bird breeding seasons from 2008 to 2020. For percent cover data, total percent coverages may not sum to 100% as values are averaged over mid-point values of cover classes (i.e. class 1 = 0.5%, class 2 = 3.0%, class 3 = 15.0%, class 4 = 37.5%, class 5 = 62.5%, class 6 = 85.0%, and class 7 = 97.5%).

Habitat Parameter	Subcategory	2008	2012	2016	2020
Canopy Cover	Hardwood (%)	5.79 ($\pm$ 17.83)	4.06 ($\pm$ 12.48)	6.00 ($\pm$ 18.24)	4.88 ($\pm$ 13.53)
	Total cover (%)	5.79 ($\pm$ 17.83)	4.06 ($\pm$ 12.48)	6.00 ($\pm$ 18.24)	4.88 ($\pm$ 13.53)
Canopy Height	Hardwood (m)	1.73 ($\pm$ 4.60)	2.10 ($\pm$ 5.27)	1.35 ($\pm$ 4.22)	0.21 ($\pm$ 1.18)
Basal Area	Hardwood (m ² /ha)	0.63 ($\pm$ 1.97)	0.87 ($\pm$ 3.70)	0.96 ($\pm$ 3.51)	0.63 ($\pm$ 1.78)
	Total (m ² /ha)	0.63 ($\pm$ 1.97)	0.87 ($\pm$ 3.70)	0.96 ($\pm$ 3.51)	0.63 ($\pm$ 1.78)
Horizontal Vegetation Profile—measured at 15 m north of plot center (percent cover at different height increments)	0.00–0.25 m (%)	93.13 ($\pm$ 14.86)	93.81 ($\pm$ 18.64)	95.68 ($\pm$ 13.10)	95.45 ($\pm$ 23.34)
	0.25–0.50 m (%)	62.89 ($\pm$ 36.47)	95.63 ($\pm$ 13.52)	92.79 ($\pm$ 14.68)	91.46 ($\pm$ 22.69)
	0.50–0.75 m (%)	13.16 ($\pm$ 27.43)	89.18 ($\pm$ 21.30)	34.63 ($\pm$ 32.12)	49.12 ($\pm$ 38.69)
	0.75–1.00 m (%)	8.58 ($\pm$ 24.86)	32.47 ($\pm$ 39.51)	17.14 ($\pm$ 24.60)	28.26 ($\pm$ 33.65)
	1.00–1.25 m (%)	3.96 ($\pm$ 16.58)	12.27 ($\pm$ 29.46)	11.14 ($\pm$ 24.06)	11.57 ($\pm$ 25.69)
	1.25–1.50 m (%)	4.95 ($\pm$ 20.60)	1.89 ($\pm$ 13.52)	6.82 ($\pm$ 23.33)	5.53 ($\pm$ 20.67)
	1.50–1.75 m (%)	4.47 ($\pm$ 19.49)	1.88 ($\pm$ 13.52)	5.74 ($\pm$ 22.93)	3.88 ($\pm$ 18.92)
	1.75–2.00 m (%)	5.38 ($\pm$ 22.02)	1.88 ($\pm$ 13.52)	4.57 ($\pm$ 19.48)	3.81 ($\pm$ 18.93)
Vertical Structure Diversity (%)	n/a	12.61 ($\pm$ 10.46)	14.66 ($\pm$ 10.09)	13.54 ($\pm$ 9.67)	12.56 ($\pm$ 6.64)

Table H3. Average percent of soil substrate cover and plant guild cover ($\pm$ std dev) in 1.78-m sample plots in the grassland areas at George Washington Carver National Monument during the bird breeding seasons from 2008 to 2020. Total percent coverages may not necessarily sum to 100% as values are averaged over mid-point values of cover classes (i.e. class 1 = 0.5%, class 2 = 3.0%, class 3 = 15.0%, class 4 = 37.5%, class 5 = 62.5%, class 6 = 85.0%, and class 7 = 97.5%).

Habitat Parameter	2008	2012	2016	2020
Deciduous Litter (%)	1.47 ($\pm$ 5.53)	0.30 ($\pm$ 0.46)	1.13 ($\pm$ 5.55)	3.05 ($\pm$ 7.79)
Grass Litter (%)	31.49 ($\pm$ 31.03)	25.24 ($\pm$ 27.53)	17.96 ($\pm$ 19.17)	36.98 ($\pm$ 36.35)
Bare Soil (%)	54.07 ($\pm$ 30.94)	44.43 ($\pm$ 22.43)	3.39 ($\pm$ 6.13)	41.94 ($\pm$ 33.89)
Rock (%)	0.62 ($\pm$ 2.15)	0	0.13 ($\pm$ 0.44)	0.02 ($\pm$ 0.10)
Woody Debris (%)	0.16 ($\pm$ 0.59)	0.01 ($\pm$ 0.07)	0.84 ($\pm$ 2.95)	1.75 ($\pm$ 5.86)
Unvegetated (%)	87.88 ($\pm$ 5.32)	63.41 ($\pm$ 14.37)	77.40 ($\pm$ 17.58)	80.63 ($\pm$ 11.87)
Warm-season Grass (%)	6.44 ($\pm$ 10.34)	10.89 ($\pm$ 13.39)	42.59 ($\pm$ 32.11)	28.35 ($\pm$ 25.74)
Cool-season Grass (%)	8.86 ($\pm$ 12.49)	6.36 ($\pm$ 7.49)	23.25 ($\pm$ 28.07)	31.04 ($\pm$ 27.67)
Forb (%)	13.25 ($\pm$ 14.56)	13.45 ($\pm$ 9.81)	12.65 ($\pm$ 13.21)	26.38 ($\pm$ 20.49)
Moss and Lichen (%)	0.28 ($\pm$ 0.46)	0	0.01 ($\pm$ 0.07)	0.36 ($\pm$ 2.11)
Woody Shrub and Vine (%)	3.68 ($\pm$ 7.88)	9.38 ($\pm$ 13.58)	10.77 ($\pm$ 15.31)	16.29 ($\pm$ 15.07)
Tree Seedling (%)	0.06 ($\pm$ 0.42)	0.01 ($\pm$ 0.07)	0.82 ($\pm$ 2.28)	2.70 ($\pm$ 7.65)
Total Foliar (%)	36.40 ($\pm$ 15.54)	43.17 ($\pm$ 17.93)	82.03 ($\pm$ 16.58)	83.09 ($\pm$ 20.26)

Appendix I. Habitat Parameters in Woodland Areas

Tables I1 through I3 show the averages for habitat parameters in three different sized plots in the woodland areas at George Washington Carver National Monument from 2008 through 2020.

Table I1. Average ($\pm$ std dev) percent cover of each habitat type in 50-m plots in the woodland areas at George Washington Carver National Monument during the bird breeding seasons from 2008 to 2020. Total percent coverages across habitat types may not sum to 100% as values are averaged over mid-point values of cover classes (i.e. class 1 = 0.5%, class 2 = 3.0%, class 3 = 15.0%, class 4 = 37.5%, class 5 = 62.5%, class 6 = 85.0%, and class 7 = 97.5%).

Habitat Parameter	2008	2012	2016	2020
Old Field/Prairie (%)	9.28 ($\pm$ 14.08)	7.22 ($\pm$ 16.84)	16.72 ($\pm$ 22.67)	8.97 ($\pm$ 16.74)
Lawn (%)	9.22 ($\pm$ 24.05)	10.30 ($\pm$ 27.41)	8.61 ($\pm$ 20.19)	9.08 ($\pm$ 26.50)
Parking Lot (%)	0.83 ($\pm$ 3.54)	0.16 ($\pm$ 0.71)	0.83 ($\pm$ 3.54)	0
Pasture Road (%)	0.19 ($\pm$ 0.71)	0.03 ($\pm$ 0.12)	2.19 ($\pm$ 4.79)	0.03 ($\pm$ 0.12)
Paved Road (%)	0.17 ($\pm$ 0.71)	0	1.00 ($\pm$ 3.56)	0.03 ($\pm$ 0.12)
Pond (%)	2.11 ($\pm$ 8.83)	0.17 ($\pm$ 0.71)	0.83 ($\pm$ 3.54)	2.08 ($\pm$ 8.84)
Shrub (%)	1.00 ($\pm$ 3.56)	0	0	0
Stream (%)	5.33 ($\pm$ 7.10)	1.33 ($\pm$ 3.60)	1.67 ($\pm$ 3.60)	2.08 ($\pm$ 4.79)
Trail (%)	2.86 ($\pm$ 5.67)	2.03 ($\pm$ 4.82)	0.33 ($\pm$ 0.97)	5.75 ($\pm$ 20.10)
Woodland (%)	73.61 ($\pm$ 26.42)	75.42 ($\pm$ 31.38)	74.31 ($\pm$ 24.45)	68.08 ($\pm$ 46.83)

Table I2. Average ($\pm$ std dev) canopy cover, canopy height, basal area, percent cover of vegetation at various horizontal height increments to 2.0 m, and vertical structure diversity in 5-m subplots in the woodland areas at George Washington Carver National Monument during the bird breeding seasons from 2008 to 2020. For percent cover data, total percent coverages may not sum to 100% as values are averaged over mid-point values of cover classes (i.e. class 1 = 0.5%, class 2 = 3.0%, class 3 = 15.0%, class 4 = 37.5%, class 5 = 62.5%, class 6 = 85.0%, and class 7 = 97.5%).

Habitat Parameter	Subcategory	2008	2012	2016	2020
Canopy Cover	Hardwood (%)	85.31 ($\pm$ 21.79)	94.19 ($\pm$ 12.27)	91.59 ($\pm$ 9.67)	90.96 ($\pm$ 6.63)
	Total cover (%)	85.31 ($\pm$ 21.79)	94.19 ($\pm$ 12.27)	91.59 ($\pm$ 9.67)	90.96 ($\pm$ 6.63)
Canopy Height	Hardwood (m)	18.63 ($\pm$ 6.17)	18.89 ($\pm$ 3.42)	19.93 ($\pm$ 5.68)	15.33 ($\pm$ 5.90)
	Conifer (m)	0	0.26 ($\pm$ 1.11)	0.24 ($\pm$ 1.00)	0.61 ($\pm$ 1.24)
Basal Area	Hardwood (m ² /ha)	18.75 ($\pm$ 9.71)	26.25 ($\pm$ 10.92)	19.86 ($\pm$ 8.51)	21.39 ($\pm$ 8.32)
	Conifer (m ² /ha)	0	0.14 ($\pm$ 0.59)	0.14 ($\pm$ 0.59)	0
	Total (m ² /ha)	18.75 ($\pm$ 9.71)	26.39 ($\pm$ 10.82)	20.00 ($\pm$ 8.66)	21.39 ($\pm$ 8.32)
Horizontal Vegetation Profile—measured at 15 m north of plot center (percent cover at different height increments)	0.00 – 0.25 m (%)	87.67 ($\pm$ 28.69)	88.92 ($\pm$ 25.67)	96.11 ($\pm$ 4.04)	92.22 ($\pm$ 19.50)
	0.25 – 0.50 m (%)	84.72 ($\pm$ 31.90)	88.06 ($\pm$ 26.19)	91.39 ($\pm$ 23.00)	87.53 ($\pm$ 29.13)
	0.50 – 0.75 m (%)	62.14 ($\pm$ 42.17)	80.17 ($\pm$ 32.69)	64.19 ($\pm$ 31.92)	70.17 ($\pm$ 34.45)
	0.75 – 1.00 m (%)	59.67 ($\pm$ 42.81)	63.50 ($\pm$ 38.69)	42.06 ($\pm$ 38.20)	54.89 ($\pm$ 40.83)
	1.00 – 1.25 m (%)	45.67 ($\pm$ 42.42)	66.69 ($\pm$ 41.32)	34.00 ($\pm$ 35.89)	42.14 ($\pm$ 43.05)
	1.25 – 1.50 m (%)	43.56 ($\pm$ 45.19)	43.36 ($\pm$ 41.71)	19.31 ($\pm$ 30.91)	37.44 ($\pm$ 41.80)
	1.50 – 1.75 m (%)	42.42 ($\pm$ 45.33)	49.92 ($\pm$ 42.34)	19.28 ($\pm$ 28.83)	37.56 ($\pm$ 37.01)
Vertical Structure Diversity (%)	1.75 – 2.00 m (%)	38.50 ($\pm$ 45.82)	50.92 ($\pm$ 45.48)	23.14 ($\pm$ 33.44)	40.25 ($\pm$ 40.75)
	n/a	38.80 ($\pm$ 18.57)	49.70 ($\pm$ 14.32)	43.58 ($\pm$ 14.02)	40.06 ($\pm$ 17.04)

Table I3. Average percent of soil substrate cover and plant guild cover ($\pm$ std dev) in 1.78-m sample plots at George Washington Carver National Monument during the bird breeding seasons from 2008 to 2020. Total percent coverages may not necessarily sum to 100% as values are averaged over mid-point values of cover classes (i.e. class 1 = 0.5%, class 2 = 3.0%, class 3 = 15.0%, class 4 = 37.5%, class 5 = 62.5%, class 6 = 85.0%, and class 7 = 97.5%).

Habitat Parameter	2008	2012	2016	2020
Deciduous Litter (%)	18.14 ($\pm$ 26.06)	8.22 ($\pm$ 22.51)	8.81 ($\pm$ 11.83)	27.56 ($\pm$ 18.11)
Conifer Litter (%)	0.03 ($\pm$ 0.12)	0	0.03 ($\pm$ 0.12)	0.08 ($\pm$ 0.19)
Grass Litter (%)	15.39 ($\pm$ 20.73)	14.06 ($\pm$ 28.41)	5.28 ($\pm$ 9.17)	17.17 ($\pm$ 21.08)
Bare Soil (%)	49.92 ($\pm$ 32.40)	37.39 ($\pm$ 25.20)	26.56 ($\pm$ 23.65)	38.92 ($\pm$ 24.71)
Rock (%)	6.47 ($\pm$ 22.99)	5.56 ($\pm$ 20.14)	6.86 ($\pm$ 20.07)	3.81 ($\pm$ 14.68)
Woody Debris (%)	3.86 ($\pm$ 5.27)	21.83 ($\pm$ 31.38)	5.58 ($\pm$ 6.12)	9.36 ($\pm$ 6.54)
Unvegetated (%)	82.64 ($\pm$ 10.09)	79.31 ($\pm$ 20.97)	81.39 ($\pm$ 24.77)	78.75 ($\pm$ 10.37)
Warm-season Grass (%)	0.03 ($\pm$ 0.12)	0.14 ($\pm$ 0.23)	1.67 ($\pm$ 4.85)	0
Cool-season Grass (%)	12.83 ($\pm$ 15.67)	4.31 ($\pm$ 14.56)	25.06 ($\pm$ 29.44)	44.06 ($\pm$ 26.25)
Forb (%)	17.94 ($\pm$ 19.49)	8.44 ($\pm$ 6.81)	12.83 ($\pm$ 10.67)	31.14 ($\pm$ 20.31)
Moss and Lichen (%)	3.67 ($\pm$ 5.36)	0	4.36 ($\pm$ 9.50)	7.47 ($\pm$ 9.67)
Woody Shrub and Vine (%)	19.83 ($\pm$ 21.00)	18.50 ($\pm$ 25.94)	16.39 ($\pm$ 17.00)	29.47 ($\pm$ 22.20)
Tree Seedling (%)	0.58 ($\pm$ 1.13)	0.42 ($\pm$ 0.19)	1.97 ($\pm$ 3.52)	2.22 ($\pm$ 3.44)
Total Foliar (%)	53.36 ($\pm$ 22.93)	26.67 ($\pm$ 29.70)	64.44 ($\pm$ 26.35)	82.08 ($\pm$ 16.09)

Appendix J. Trees Found on George Washington Carver National Monument

Tables J1 and J2 show stems per hectare for trees in George Washington Carver National Monument in grassland and woodland areas, respectively.

Table J1. Stems per hectare for trees found in the grassland areas at George Washington Carver National Monument by size class during the 2008 to 2020 bird breeding seasons. Tree stems per hectare are reported by family.

Stem Size Class	Family	2008	2012	2016	2020
< 1.0 cm	Cannabaceae	0	0	2	0
	Fagaceae	0	0	5	0
	Juglandaceae	0	0	2	0
	Moraceae	0	0	2	0
	Oleaceae	0	0	274	0
	Rosaceae	5	0	71	0
	Snag	0	64	0	0
	Ulmaceae	0	0	5	0
1.1–2.5 cm	Juglandaceae	2	0	0	5
	Snag	0	10	0	0
	Ulmaceae	2	0	0	12
2.6–8.0 cm	Fabaceae	0	0	2	2
	Fagaceae	2	0	2	0
	Juglandaceae	0	2	0	0
	Moraceae	0	0	2	2
	Rosaceae	2	0	0	0
	Ulmaceae	2	2	0	0
8.1–15.0 cm	Fabaceae	12	0	0	2
	Fagaceae	0	2	0	0
	Moraceae	2	0	0	2
	Oleaceae	0	2	0	0
	Salicaceae	0	2	0	0
	Snag	0	2	2	0
	Ulmaceae	0	0	2	2
15.1–23.0 cm	Cannabaceae	0	0	2	0
	Fagaceae	0	0	2	0
	Oleaceae	2	0	0	0
	Salicaceae	0	5	0	0
	Snag	0	0	2	0
	Ulmaceae	0	0	0	2
23.1–38.0 cm	Moraceae	0	0	2	0
> 38.0 cm	None	0	0	0	0

Table J2. Stems per hectare for trees found in the woodland areas at George Washington Carver National Monument by size class during the 2008 to 2020 bird breeding seasons. Tree stems per hectare are reported by family.

Stem Size Class	Family	2008	2012	2016	2020
< 1.0 cm	Cannabaceae	21	92	28	99
	Cornaceae	7	0	0	0
	Cupressaceae	0	7	7	0
	Fabaceae	28	92	7	0
	Fagaceae	0	0	0	7
	Juglandaceae	0	7	7	0
	Oleaceae	0	7	14	21
	Rosaceae	7	14	7	0
	Sapindaceae	0	0	7	0
	Snag	0	0	0	28
	Ulmaceae	21	14	14	21
1.1–2.5 cm	Cannabaceae	7	78	78	141
	Cupressaceae	7	7	0	14
	Fabaceae	21	7	0	0
	Juglandaceae	21	14	28	7
	Moraceae	21	7	0	0
	Oleaceae	14	0	7	0
	Rosaceae	50	14	7	0
	Snag	14	71	14	78
	Ulmaceae	64	7	35	85
2.6–8.0 cm	Adoxaceae	7	0	7	7
	Cannabaceae	226	276	226	212
	Cupressaceae	0	14	7	35
	Fabaceae	35	57	57	7
	Fagaceae	0	0	0	35
	Juglandaceae	42	28	14	0
	Moraceae	42	64	57	64
	Oleaceae	28	7	14	42
	Rosaceae	28	127	21	7
	Sapindaceae	0	0	7	0
	Sapotaceae	0	0	0	7
	Snag	78	92	14	71
	Ulmaceae	205	191	120	156
8.1–15.0 cm	Betulaceae	0	7	0	0
	Cannabaceae	57	85	42	71
	Cupressaceae	0	0	7	0
	Ebenaceae	0	0	0	7
	Fabaceae	21	7	0	7
	Juglandaceae	14	14	14	14
	Moraceae	42	28	50	57
	Oleaceae	0	7	21	14

Table J2 (continued). Stems per hectare for trees found in the woodland areas at George Washington Carver National Monument by size class during the 2008 to 2020 bird breeding seasons. Tree stems per hectare are reported by family.

Stem Size Class	Family	2008	2012	2016	2020
8.1–15.0 cm (continued)	Rosaceae	0	28	0	0
	Sapindaceae	0	0	7	0
	Snag	14	0	42	21
	Ulmaceae	99	71	92	106
15.1–23.0 cm	Cannabaceae	21	50	14	64
	Fabaceae	0	0	7	0
	Juglandaceae	57	28	28	21
	Moraceae	85	85	50	78
	Oleaceae	7	14	0	14
	Rosaceae	0	7	0	0
	Sapotaceae	7	0	0	0
	Snag	0	0	7	0
	Ulmaceae	0	35	35	35
23.1–38.0 cm	Cannabaceae	7	21	28	35
	Fabaceae	14	0	0	0
	Fagaceae	7	7	0	0
	Juglandaceae	35	28	35	35
	Moraceae	14	0	21	35
	Plantanaceae	0	7	0	0
	Snag	0	14	0	7
	Ulmaceae	7	0	14	14
>38.0 cm	Cannabaceae	14	14	0	14
	Fagaceae	0	0	7	7
	Juglandaceae	0	7	7	21
	Moraceae	7	7	0	7
	Plantanaceae	7	14	7	0
	Salicaceae	0	7	0	0

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