



Bird Community Monitoring at Hopewell Culture National Historical Park, Ohio

Status Report 2005–2019

Natural Resource Report NPS/HTLN/NRR—2020/2163



ON THE COVER

Landscape at Hopewell Culture National Historical Park
Photography by NPS, Heartland Network

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Executive Summary

Breeding bird surveys were initiated on Hopewell Culture National Historical Park, Ohio, in 2005 to assess temporal changes in the species composition and abundance of birds on the park. These data also improve our understanding of relationships between breeding birds and their habitat and the effects of management actions, such as invasive plant species control and grassland field restorations, on bird populations. Birds were sampled using point counts with 27 variable circular plots located on a systematic grid of 400 x 400-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 15 years since initiating our breeding bird survey, birds were surveyed on as many of the 27 variable circular plots as possible annually, resulting in 403 plot visits. Surveys have yielded records for 112 different species of birds. Ninety-eight of the species recorded are classified as permanent or summer residents, 13 are classified as migrants through the area, and one as a winter resident. Fourteen species recorded are considered *species of conservation concern* for the Eastern Tallgrass Prairie and/or the Appalachian Mountains bird conservation regions, the bird conservation regions in which Hopewell Culture National Historical Park is located.

Nine of the 98 resident species were recorded on Hopewell Culture National Historical Park frequently enough to determine trends in their populations. Six species had increasing populations on the park, and the other three had stable populations. With 71% of the 338 ha of natural vegetation on Hopewell Culture National Historical Park in various old field (grassland) types, it is not surprising that about 16 of the breeding bird species recorded utilize this habitat type almost exclusively.

Based on population trends, the bird community at Hopewell Culture National Historical Park is faring similarly to or better than the bird communities in the larger Eastern Tallgrass Prairie and/or Appalachian Mountains bird conservation regions. Increasing diversity and richness values, along with stable evenness values, suggest that the park's habitat is improving in terms of its ability to meet the needs of more breeding bird species, and the habitat currently present provides for the rich array of breeding species annually. However, this species-rich community structure could be altered if significant portions of the park's old fields (grasslands) were removed or converted back to agricultural fields or if some of the less common habitats were lost.

Acknowledgments

We would like to thank the staff of Hopewell Culture National Historical Park, Ohio, for allowing us access to the park during our breeding bird surveys, and for assisting with coordinating many of the bird surveying efforts. We would also like to thank the staff and volunteers who assisted with bird surveys on the park: D. L. Hess, C. L. Jones, J. Foor, D. Bostic, W. Bostic, D. Reiner, J. T. Nelson, A. L. Molloy, J. Hutcherson, B. J. Lombardo, J. S. Sisler, S. R. Roethle, A. J. Travers, A. T. Smith, and J. R. Snider.

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. 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. Management activities that preserve 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). The National Park Service plays a role in bird conservation under the authority of the Migratory Bird Treaty Act of 1918 (as amended) and Executive Order 13186, Responsibilities of Federal

Agencies to Protect Migratory Birds. Bird monitoring is critical as widespread habitat loss to agriculture and urban and industrial development threaten the integrity of the region for birds.

Hopewell Culture National Historical Park, Ohio, is located on the border of the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions (Figure 1). These are two 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 long-term health of North America's native bird populations (NABCI 2019).

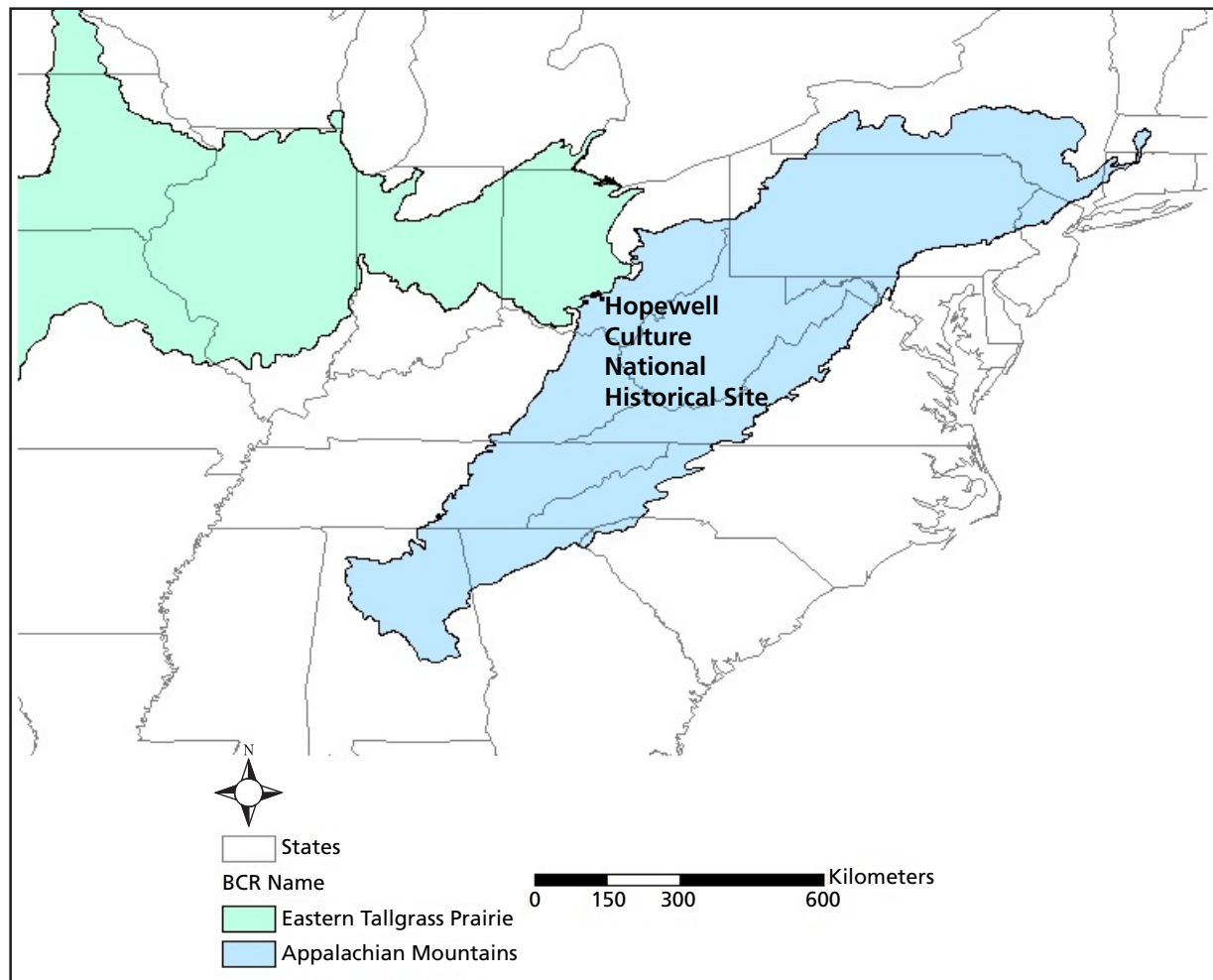


Figure 1. Location of Hopewell Culture National Historical Park (HOCU), Ohio, within the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions.

The Eastern Tallgrass Prairie Bird Conservation Region historically consisted of the tallest and lush-est grasslands of the Great Plains (NABCI 2019). However, forests dominate the region in the east, creating an oak-savanna ecotone between the eastern woodlands and the western prairie. The Appalachian Mountains Bird Conservation Region has a rugged terrain dominated by oak-hickory and other deciduous forest types at lower elevations and by various combinations of pine, hemlock, spruce, and fir in higher areas (NABCI 2019). Flatter portions are used for agriculture; however, the majority of this region is forested. High priority birds common to both regions include Peregrine Falcon (*Falco peregrinus*), Upland Sandpiper (*Bartramia longicauda*), Eastern Whip-poor-will (*Antrostomus vociferus*), Red-headed Woodpecker (*Melanerpes erythrocephalus*), Loggerhead Shrike (*Lanius ludovicianus*), Bewick's Wren (*Thryomanes bewickii*), Wood Thrush (*Hylocichla mustelina*), Blue-winged Warbler (*Vermivora cyanoptera*), Cerulean Warbler (*Setophaga cerulea*), Kentucky Warbler (*Geothlypis formosa*), and Henslow's Sparrow (*Ammodramus henslowii*); U.S. Fish and Wildlife Service 2008). Approximately 126 species of breeding birds can be found in the habitats of the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions around Hopewell Culture National Historical Park (Peterjohn 2001).

Data collected during the U.S. Geological Survey's annual North American Breeding Bird Surveys (BBS) between 1966 and 2015 indicate that a number of bird species breeding at Hopewell Culture National Historical Park show evidence of long-term population decline (Sauer et al. 2017). In fact, between 41% (Eastern Tallgrass Prairie Bird Conservation Region) and 58% (Appalachian Mountains Bird Conservation Region) of the species have populations reported to be in decline, with species such as the Grasshopper Sparrow (*Ammodramus savannarum*), Northern Bobwhite (*Colinus virginianus*), and Ring-necked Pheasant (*Phasianus colchicus*) declining at alarming rates in both regions.

We will use long-term trends in the composition and abundance of bird populations as indicators of *ecosystem integrity* at Hopewell Culture National Historical Park. Ecosystem integrity is defined as the system's capability to support and maintain a balanced, integrated, 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 change 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 Hopewell Culture National Historical Park.



Henslow's Sparrow (*Ammodramus henslowii*) is a summer resident at Hopewell Culture National Historical Park and is a species of conservation concern in both the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions. Photo by Jeremy Stringfield.

Objectives

There are two primary objectives for monitoring breeding birds at Hopewell Culture National Historical Park:

- Identify significant temporal changes in the species composition and abundance of bird communities that occur on Hopewell Culture National Historical Park during the breeding season.
- Improve our understanding of relationships between breeding birds and their habitat and the

effects of management actions (such as forest restoration 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 15 years of monitoring (2005–2019).

Methods

Site Selection

Permanent monitoring locations or *plots* were selected by overlaying a systematic grid of 400 x 400-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 27 permanent plots on Hopewell Culture National Historical Park for monitoring bird population sizes and community composition (Figure 2). Monitoring occurred on all 27 plots annually, except for 2011 and 2016 when 26 plots were sampled (Table 1).

Starting in 2008, breeding bird monitoring was conducted by park staff and volunteers in three out of every four years, allowing the Heartland Inventory and Monitoring (I&M) Network to modify their sampling schedule to visit the park every fourth year. To facilitate this change, park staff and volunteers were asked to visit as many plots annually as their

schedules would allow. Heartland I&M Network monitored all available plots during their fourth-year visits—2011, 2015 and 2019.

During bird surveys in 2005, 2006, 2007, 2011, 2015, and 2019, monitoring plots were located using navigation waypoints (Peitz et al. 2008) in a GPS 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. During bird surveys in other years when habitat assessments were not conducted, monitoring plots were located using a GPS unit, but plot locations 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

Table 1. Number of plots sampled and sampling dates for breeding bird surveys conducted at Hopewell Culture National Historical Park, Ohio, by year. Also listed are observer(s) who conducted the surveys.

Year	Sampling Dates	Number of Plots Sampled	Observer(s)
2005	June 1–June 3	27	D.G. Peitz*
2006	May 31–June 2	27	D.G. Peitz*
2007	June 12–June 13	27	D.G. Peitz*
2008	May 9–June 2	27	D.L. Hess, C.L. Jones, J. Foor, D. Bostic, W. Bostic
2009	May 23–June 12	27	D.L. Hess, D. Reiner, C.L. Jones
2010	May 15–June 7	27	D.L. Hess, D. Reiner, J.T. Nelson
2011	May 22–May 24	26	D.G. Peitz*
2012	May 19–June 1	27	D.L. Hess, D. Reiner, A.L. Molloy, J. Hutcherson
2013	May 24–May 30	27	D.L. Hess, D. Reiner, B.J. Lombardo
2014	May 28–June 6	27	D.L. Hess, D. Reiner, J.S. Sisler, S.R. Roethle
2015	May 12–May 14	27	D.G. Peitz*
2016	June 15–June 28	26	B.J. Lombardo, A.L. Molloy, J.J. Sisler, A.J. Travers, J.R. Snider
2017	June 1–June 6	27	D.L. Hess, A.L. Molloy, J.J. Sisler
2018	May 30–June 1	27	A.L. Molloy, J.J. Sisler, J.R. Snider
2019	May 14–May 16	27	D.J. Marcum*, A.T. Smith, J.R. Snider

*Heartland I&M Network staff.

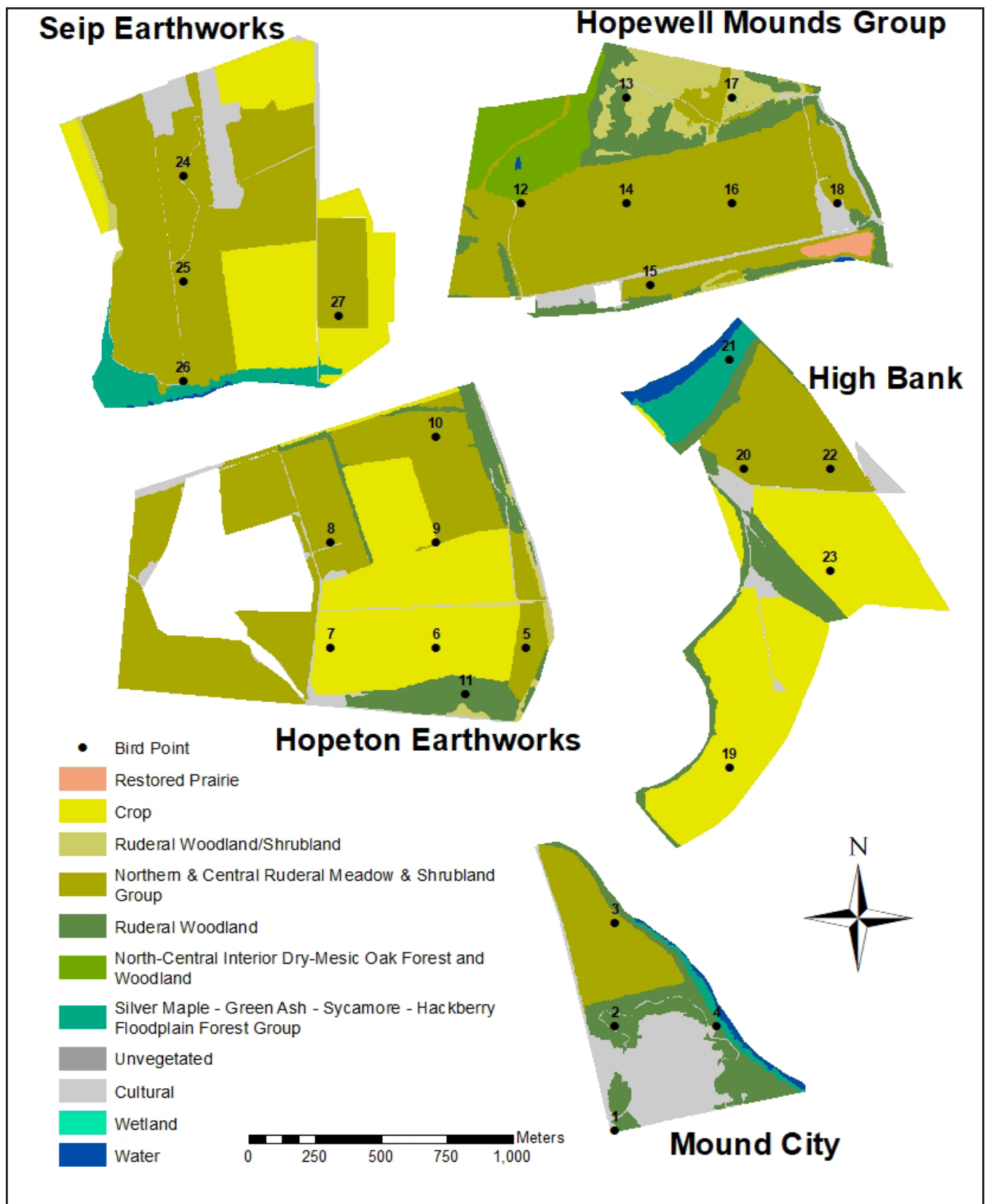


Figure 2. Bird plot locations on Hopewell Culture National Historical Park, Ohio. Vegetation mapping and classification provided by Kindscher et al. (draft).



Woodland and field habitats with a view of Native American earthen mounds near the visitor center at Hopewell Culture National Historical Park, Ohio. NPS

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 rather than individual birds. During analysis, each individual in a cluster or flock was treated as a separate observation. After completing a count at a plot and filling out the data sheet, the observer navigated to the next plot using a GPS 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 birds in the morning from when it was light enough to observe birds to four hours after sunrise.

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. Individual birds recorded

from a previous plot were noted and excluded from analysis except when developing detection functions using Distance software.

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 2005–2007, 2011, 2015, and 2019. During years when habitat assessments were made, plots were visited in generally the same order they were surveyed 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. They also set up 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 were not remeasured in subsequent years. The amount of each vegetation type (lawn; old fields, including crop fields and prairies; shrub; woodland) and road and water cover on each 50-m-radius plot were recorded. As 5-m-radius subplots were sampled, horizontal vegetation cover was estimated in 0.25-m intervals from 0.0 to 2.0 m above the ground surface using a 0.15-m-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 and herbaceous vegetation. Trees were tallied 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, or >38.0 cm) on subplots located in riparian habitat. Lastly, at a 1.78-m-radius 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 diameter), and unvegetated. Foliar cover was estimated for six plant guilds, including warm-season grasses, 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 (migrant, permanent resident, summer resident, or winter resident) of each bird species recorded was determined. Identifying the residency of each species helps to exclude migrants from analysis of breeding birds within Hopewell Culture National Historical Park. Proportion of plots occupied by each bird species was calculated (total number of plots occupied by a species/plots surveyed) and reported in Appendices B and C.

For species with greater than 60 observations recorded, Distance software (Distance 6.0 Release 2) was used to determine the park-wide abundance of each (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.

The Hazard-rate + Simple polynomial function was selected for eight species: American Goldfinch (*Spinus tristis*), Common Yellowthroat (*Geothlypis trichas*), Eastern Meadowlark (*Sturnella magna*), European Starling (*Sturnus vulgaris*), Indigo Bunting (*Passerina cyanea*), Northern Cardinal (*Cardinalis cardinalis*), Red-winged Blackbird (*Agelaius*

phoeniceus), and Song Sparrow (*Melospiza melodia*). The Half-normal + Cosine function was chosen for Field Sparrow (*Spizella pusilla*). Abundances for these species are reported in Appendix B. For species with fewer than 60 observations, park-wide abundance (Appendix C) was calculated by first deriving a species density from observations recorded within a 200-m radius (12.56 ha) around each plot center and then calculating abundance based on average plot densities.

For species with adequate abundance (those with greater than 60 observations), 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 D. 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 step-wise procedure. This software takes into account serial correlation in count data among years and overdispersion.

For this report, we also obtained regional breeding bird trends for both the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions during the period of 2005 to 2015 from the Breeding Bird Survey (BBS) website of the USGS Patuxent Wildlife Research Center (Appendix E; 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 16-year period of available data to maximize the accuracy of regional trend results without going beyond the sampling period at Hopewell Culture National Historical Park.

We compared regional trends with those calculated using TRIM for Hopewell Culture National Historical Park (Figure 3). Regional trends with a confidence interval that straddled zero were classified as uncertain for comparison with results from the park. 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 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 determined as the total number of bird taxa recorded annually. Species distribution evenness values were calculated using Pielou (J'):

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

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. Different species richness estimators will produce varying estimates, however, 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



Indigo Bunting (*Passerina cyanea*) populations are increasing at Hopewell Culture National Historical Park, Ohio, and are stable in the Eastern Tallgrass Prairie Bird Conservation Region, but are declining slightly in the Appalachian Mountains Bird Conservation Region. NPS

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 et al. (2008). Annual averages ($\pm$ std dev) for semi-permanent plot data, including road and water cover, were calculated from plot estimates (Appendix F). Between 2005 and 2007, averages ($\pm$ std dev) for horizontal vegetation cover between 0–0.50, 0.25–0.75, 0.5–1.0, 0.75–1.25, 1.0–1.50, 1.25–1.75, and 1.5–2.00 m were calculated across plots, and in 2011, 2015, and 2019, 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 and reported. Average ($\pm$ std dev) annual vertical structure diversity was estimated and reported by habitat type as well. Vertical structure 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 and reported (Appendix F). Foliar cover by guild of warm-season grasses, cool-season grasses, forbs, mosses and lichens, shrubs and vines, tree seedlings and total foliar cover (<1.5 m tall) were also averaged ($\pm$ std dev) across plots. Trees were identified to family and size class before summing stems per hectare for the park (Appendix G).

Results

Bird Surveys

Since initiating breeding bird surveys in 2005 on Hopewell Culture National Historical Park, as many of the 27 variable circular plots as possible were sampled annually, resulting in a total of 403 plot visits (Table 1). One hundred and twelve different bird species have been recorded during surveys (Table 2). Ninety-eight of the 112 species recorded are classified as permanent or summer residents to the area (Peterjohn 2001).

Thirteen species—Blackburnian Warbler (*Setophaga fusca*), Blackpoll Warbler (*Setophaga striata*), Black-throated Blue Warbler (*Setophaga caerulescens*), Bobolink (*Dolichonyx oryzivorus*), Chestnut-sided Warbler (*Setophaga pensylvanic*), Double-crested Cormorant (*Phalacrocorax auritus*), Least Flycatcher (*Empidonax minimus*), Northern Harrier (*Circus cyaneus*), Rose-breasted Grosbeak (*Pheucticus ludovicianus*) Sedge Wren (*Cistothorus platensis*), Swainson's Thrush (*Catharus ustulatus*), Tennessee

Warbler (*Leiothlypis peregrina*), and Yellow-rumped Warbler (*Setophaga coronata*)—are classified as migrants through the area, and one species—Golden-crowned Kinglet (*Regulus satrapa*)—is classified as a winter resident to the area. Fourteen species recorded—Acadian Flycatcher (*Empidonax virescens*), Bald Eagle (*Haliaeetus leucocephalus*), Bewick's Wren (*Thryomanes bewickii*), Blue-winged Warbler (*Vermivora cyanoptera*), Cerulean Warbler (*Setophaga cerulea*), Dickcissel (*Spiza americana*), Field Sparrow (*Spizella pusilla*), Grasshopper Sparrow (*Ammodramus savannarum*), Henslow's Sparrow (*Ammodramus henslowii*), Northern Flicker (*Colaptes auratus*), Prairie Warbler (*Setophaga discolor*), Prothonotary Warbler (*Protonotaria citrea*), Wood Thrush (*Hylocichla mustelina*), and Worm-eating Warbler (*Helmitheros vermivorum*)—are considered species of conservation concern for the Eastern Tallgrass Prairie and/or Appalachian Mountains bird conservation regions (U.S. Fish and Wildlife Service 2008).

Table 2. Bird species recorded during breeding bird surveys at Hopewell Culture National Historical Park, Ohio, from 2005 through 2019. 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 website (ITIS 2019, accessed 12 August 2019).

Common Name	Scientific Name	AOU Code	Residency ^A
Acadian Flycatcher^B	<i>Empidonax virescens</i>	ACFL	SR
American Crow	<i>Corvus brachyrhynchos</i>	AMCR	R
American Goldfinch	<i>Spinus tristis</i>	AMGO	R
American Kestrel	<i>Falco sparverius</i>	AMKE	SR
American Redstart	<i>Setophaga ruticilla</i>	AMRE	SR
American Robin	<i>Turdus migratorius</i>	AMRO	R
American Woodcock ^C	<i>Scolopax minor</i>	AMWO	SR
Bald Eagle^B	<i>Haliaeetus leucocephalus</i>	BAEA	SR
Baltimore Oriole	<i>Icterus galbula</i>	BAOR	SR
Bank Swallow	<i>Riparia riparia</i>	BANS	SR
Barn Swallow	<i>Hirundo rustica</i>	BARS	SR
Belted Kingfisher	<i>Megasceryle alcyon</i>	BEKI	R
Bewick's Wren^B	<i>Thryomanes bewickii</i>	BEWR	SR
Blackburnian Warbler ^C	<i>Setophaga fusca</i>	BLBW	M

^A Residency: M = late migrant; SR = summer resident; R = year-round resident; WR = winter resident according to Peterjohn (2001).

^B Species of conservation concern for the Eastern Tallgrass Prairie and/or Appalachian Mountain bird conservation regions (U.S. Fish and Wildlife Service 2008; also in bold).

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

Table 2 (continued). Bird species recorded during breeding bird surveys at Hopewell Culture National Historical Park, Ohio, from 2005 through 2019. 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 2019, accessed 12 August 2019).

Common Name	Scientific Name	AOU Code	Residency ^A
Blackpoll Warbler	<i>Setophaga striata</i>	BLPW	M
Black-throated Blue Warbler ^C	<i>Setophaga caerulescens</i>	BTBW	M
Black Vulture	<i>Coragyps atratus</i>	BLVU	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
Blue-winged Warbler^B	<i>Vermivora cyanoptera</i>	BWWA	SR
Bobolink	<i>Dolichonyx oryzivorus</i>	BOBO	M
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>Bombicilla cedrorum</i>	CEDW	R
Cerulean Warbler^{B,C}	<i>Setophaga cerulea</i>	CERW	SR
Chestnut-sided Warbler ^C	<i>Setophaga pensylvanica</i>	CSWA	M
Chimney Swift	<i>Chaetura pelagica</i>	CHSW	SR
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 Yellowthroat	<i>Geothlypis trichas</i>	COYE	SR
Cooper's Hawk	<i>Accipiter cooperii</i>	COHA	R
Dickcissel^B	<i>Spiza americana</i>	DICK	SR
Double-crested Cormorant	<i>Phalacrocorax auritus</i>	DCCO	M
Downy Woodpecker	<i>Picoides pubescens</i>	DOWO	R
Eastern Bluebird	<i>Sialis sialis</i>	EABL	SR
Eastern Kingbird	<i>Tyrannus tyrannus</i>	EAKI	SR
Eastern Meadowlark	<i>Sturnella magna</i>	EAME	R
Eastern Phoebe	<i>Sayornis phoebe</i>	EAPH	SR
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^B	<i>Spizella pusilla</i>	FISP	R
Grasshopper Sparrow^B	<i>Ammodramus savannarum</i>	GRSP	SR

^A Residency: M = late migrant; SR = summer resident; R = year-round resident; WR = winter resident according to Peterjohn (2001).

^B Species of conservation concern for the Eastern Tallgrass Prairie and/or Appalachian Mountain bird conservation regions (U.S. Fish and Wildlife Service 2008; also in bold).

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

Table 2 (continued). Bird species recorded during breeding bird surveys at Hopewell Culture National Historical Park, Ohio, from 2005 through 2019. 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 2019, accessed 12 August 2019).

Common Name	Scientific Name	AOU Code	Residency ^A
Gray Catbird	<i>Dumetella carolinensis</i>	GRCA	SR
Great Blue Heron	<i>Ardea herodias</i>	GBHE	SR
Great Crested Flycatcher	<i>Myiarchus crinitus</i>	GCFL	SR
Green Heron	<i>Butorides virescens</i>	GRHE	SR
Golden-crowned Kinglet ^C	<i>Regulus satrapa</i>	GCKI	WR
Hairy Woodpecker	<i>Picoides villosus</i>	HAWO	R
Henslow's Sparrow^B	<i>Ammodramus henslowii</i>	HESP	SR
Hooded Warbler	<i>Setophaga citrina</i>	HOWA	SR
Horned Lark	<i>Eremophila alpestris</i>	HOLA	R
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
Killdeer	<i>Charadrius vociferus</i>	KILL	SR
Least Flycatcher	<i>Empidonax minimus</i>	LEFL	M
Mallard	<i>Anas platyrhynchos</i>	MALL	SR
Mourning Dove	<i>Zenaida macroura</i>	MODO	R
Northern Bobwhite	<i>Colinus virginianus</i>	NOBO	R
Northern Cardinal	<i>Cardinalis cardinalis</i>	NOCA	R
Northern Flicker^B	<i>Colaptes auratus</i>	YSFL	R
Northern Harrier	<i>Circus cyaneus</i>	NOHA	M
Northern Mockingbird	<i>Mimus polyglottos</i>	NOMO	R
Northern Parula	<i>Setophaga americana</i>	NOPA	SR
Northern Rough-winged Swallow	<i>Stelgidopteryx serripennis</i>	NRWS	SR
Orchard Oriole	<i>Icterus spurius</i>	OROR	SR
Ovenbird ^C	<i>Seiurus aurocapilla</i>	OVEN	SR
Pileated Woodpecker	<i>Dryocopus pileatus</i>	PIWO	R
Prairie Warbler^B	<i>Setophaga discolor</i>	PRAW	SR
Prothonotary Warbler^B	<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-tailed Hawk	<i>Buteo jamaicensis</i>	RTHA	R
Red-winged Blackbird	<i>Agelaius phoeniceus</i>	RWBL	R

^A Residency: M = late migrant; SR = summer resident; R = year-round resident; WR = winter resident according to Peterjohn (2001).

^B Species of conservation concern for the Eastern Tallgrass Prairie and/or Appalachian Mountain bird conservation regions (U.S. Fish and Wildlife Service 2008; also in bold).

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

Table 2 (continued). Bird species recorded during breeding bird surveys at Hopewell Culture National Historical Park, Ohio, from 2005 through 2019. 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 2019, accessed 12 August 2019).

Common Name	Scientific Name	AOU Code	Residency ^A
Ring-necked Pheasant	<i>Phasianus colchicus</i>	RPHE	R
Rock Dove	<i>Columba livia</i>	RODO	R
Rose-breasted Grosbeak	<i>Pheucticus ludovicianus</i>	RBGR	M
Ruby-throated Hummingbird	<i>Archilochus colubris</i>	RTHU	SR
Savannah Sparrow	<i>Passerculus sandwichensis</i>	SAVS	SR
Scarlet Tanager	<i>Piranga olivacea</i>	SCTA	SR
Sedge Wren^B	<i>Cistothorus platensis</i>	SEWR	M
Song Sparrow	<i>Melospiza melodia</i>	SOSP	R
Spotted Sandpiper	<i>Actitis macularius</i>	SPSA	R
Summer Tanager	<i>Piranga rubra</i>	SUTA	SR
Swainson's Thrush	<i>Catharus ustulatus</i>	SWTH	M
Tennessee Warbler	<i>Leiothlypis peregrina</i>	TEWA	M
Tree Swallow	<i>Tachycineta bicolor</i>	TRES	SR
Tufted Titmouse	<i>Baeolophus bicolor</i>	TUTI	R
Turkey Vulture	<i>Cathartes aura</i>	TUVU	SR
Vesper Sparrow ^C	<i>Pooecetes gramineus</i>	VESP	SR
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
Willow Flycatcher	<i>Empidonax traillii</i>	WIFL	SR
Wood Duck	<i>Aix sponsa</i>	WODU	SR
Wood Thrush^B	<i>Hylocichla mustelina</i>	WOTH	SR
Worm-eating Warbler^B	<i>Helmitheros vermivorum</i>	WEWA	R
Yellow-billed Cuckoo	<i>Coccyzus americanus</i>	YBCU	SR
Yellow-breasted Chat	<i>Icteria virens</i>	YBCH	SR
Yellow-rumped Warbler	<i>Setophaga coronata</i>	MYWA	M
Yellow-throated Vireo	<i>Vireo flavifrons</i>	YTVI	SR
Yellow-throated Warbler	<i>Setophaga dominica</i>	YTWA	SR
Yellow Warbler	<i>Setophaga petechia</i>	YEWA	SR

^A Residency: M = late migrant; SR = summer resident; R = year-round resident; WR = winter resident according to Peterjohn (2001).

^B Species of conservation concern for the Eastern Tallgrass Prairie and/or Appalachian Mountain bird conservation regions (U.S. Fish and Wildlife Service 2008; also in bold).

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

Nine breeding species—American Goldfinch (*Spinus tristis*), Common Yellowthroat (*Geothlypis trichas*), Eastern Meadowlark (*Sturnella magna*), European Starling (*Sturnus vulgaris*), Field Sparrow, Indigo Bunting (*Passerina cyanea*), Northern Cardinal (*Cardinalis cardinalis*), Red-winged Blackbird (*Agelaius phoeniceus*), and Song Sparrow (*Melospiza melodia*)—were observed in sufficient numbers on Hopewell Culture National Historical Park to calculate their abundances with some degree of confidence (Appendix B). These nine species offer the best

opportunities for monitoring the influence of changing habitats on bird species. Six of these species—Common Yellowthroat, Eastern Meadowlark, Field Sparrow, Indigo Bunting, Northern Cardinal, and Song Sparrow—have increasing populations (Figures 3A and 3B; Appendix D). Three species—American Goldfinch, European Starling, and Red-winged Blackbird—have stable populations.

Six of the abundant breeding species—Common Yellowthroat, Eastern Meadowlark, European Starling, Field Sparrow, Red-winged Blackbird, and

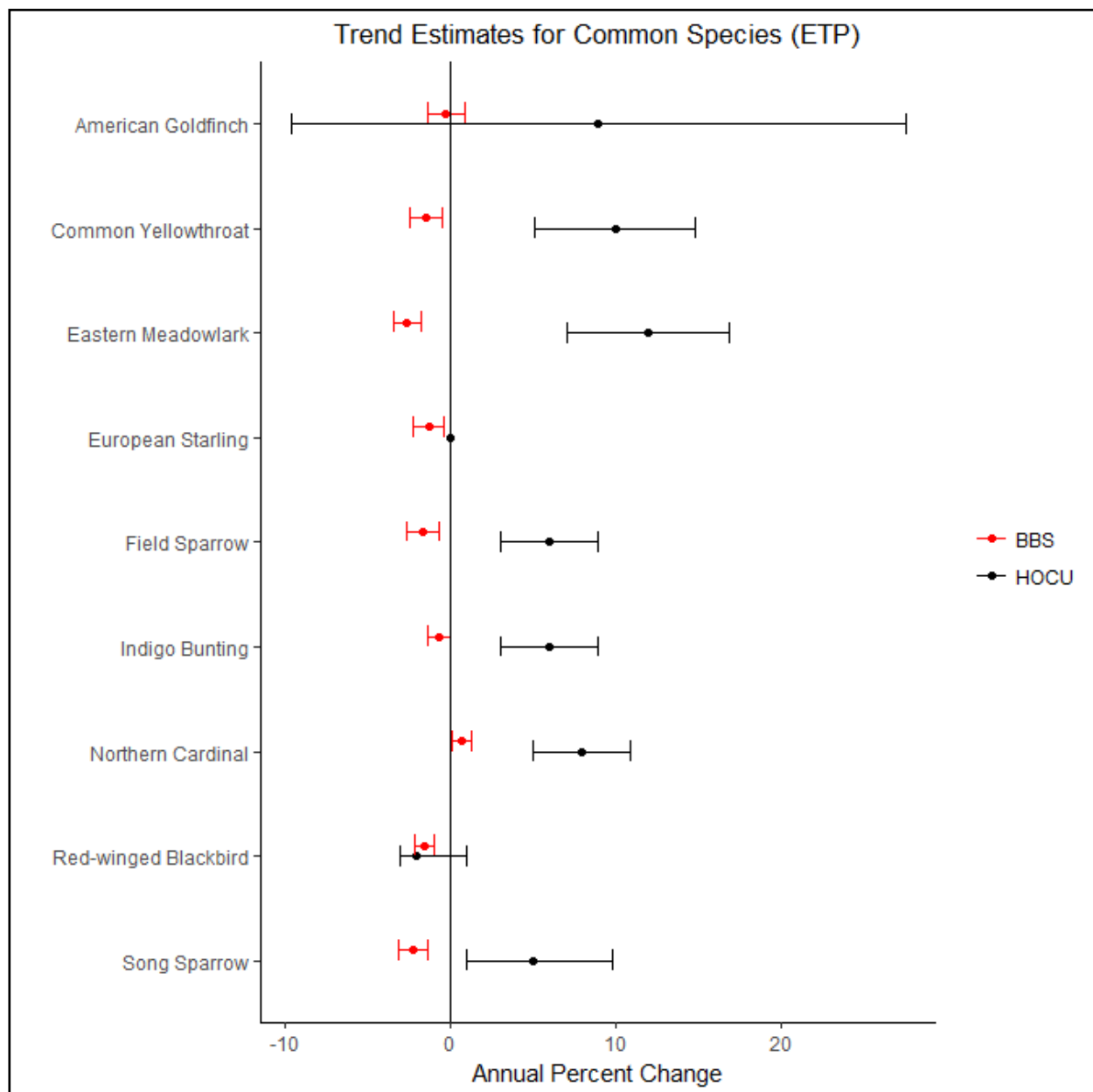


Figure 3A. Comparison of bird population trends from habitats on Hopewell Culture National Historical Park (HOCU), Ohio, (2005 through 2019) with those of the larger Eastern Tallgrass Prairie (ETP) Bird Conservation Region (2005 through 2015; from Breeding Bird Surveys [BBS]). Error bars represent 95% confidence intervals.

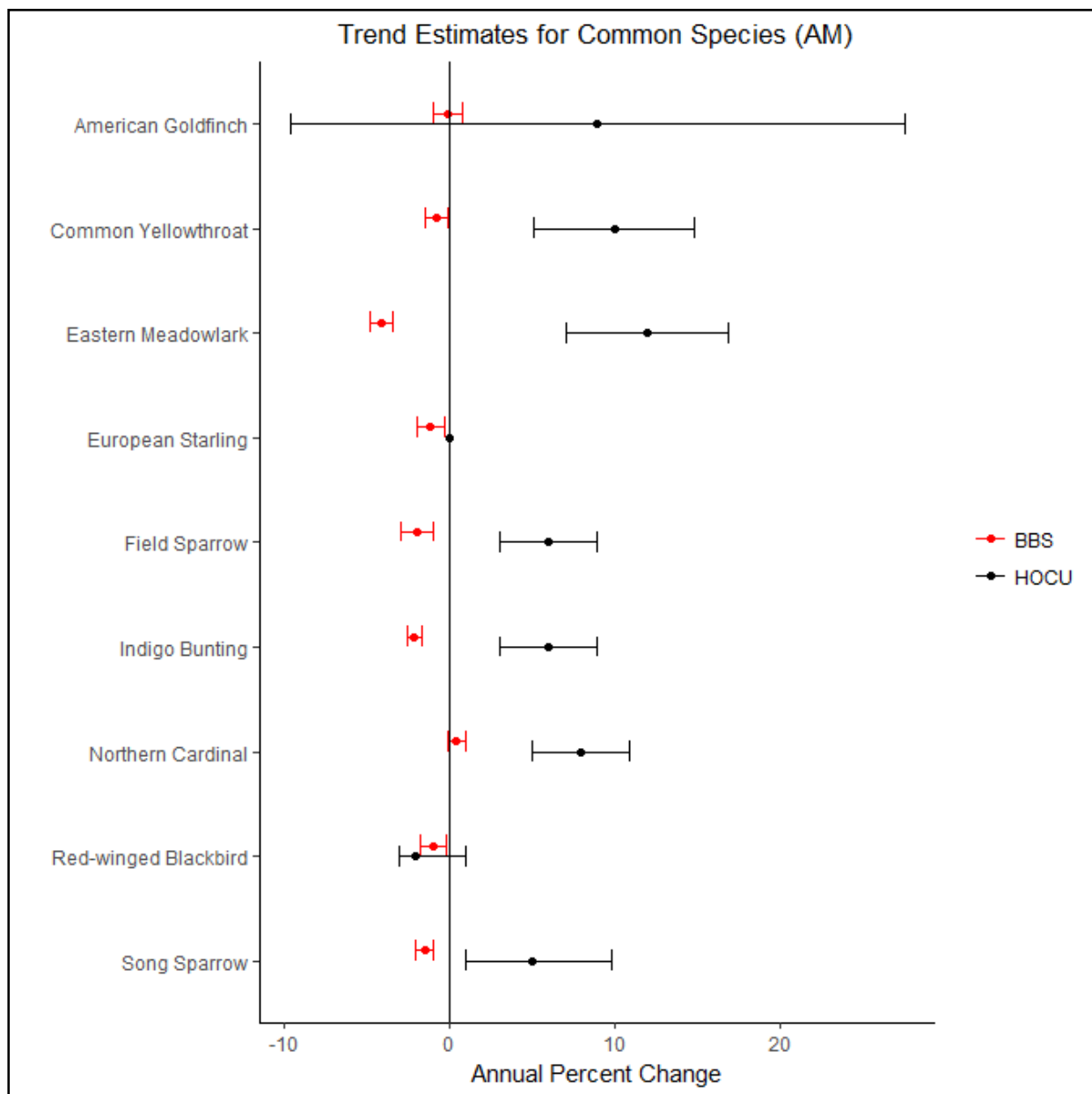


Figure 3B. Comparison of bird population trends from habitats on Hopewell Culture National Historical Park (HOCU), Ohio, (2005 through 2019) with those of the larger Appalachian Mountains (AM) Bird Conservation Region (2005 through 2015; from Breeding Bird Surveys [BBS]). Error bars represent 95% confidence intervals.

Song Sparrow—have populations that are declining across both the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions for a period (2005–2015) that roughly coincides with our surveys (Figures 3A and 3B; Appendix E). American Goldfinch populations are stable in both regions. However, Indigo Bunting populations that are stable in the Eastern Tallgrass Prairie Bird Conservation Region are declining slightly in the Appalachian Mountains Bird Conservation Region, and Northern Cardinal populations that are stable in the Appalachian Mountains Bird Conservation Region, are

increasing slightly in the Eastern Tallgrass Prairie Bird Conservation Region.

For the bird community on Hopewell Culture National Historical Park, diversity ($P = 0.04$) and richness ($P = 0.04$) increased significantly over the 15 monitoring years since 2005 (Figure 4). The evenness ($P = 0.11$) in distribution of individuals across species in the breeding bird community was unchanged. Richness averaged 56 species annually. Average estimated species richness was 65 by the ACE estimator and 69 by the ICE estimator.

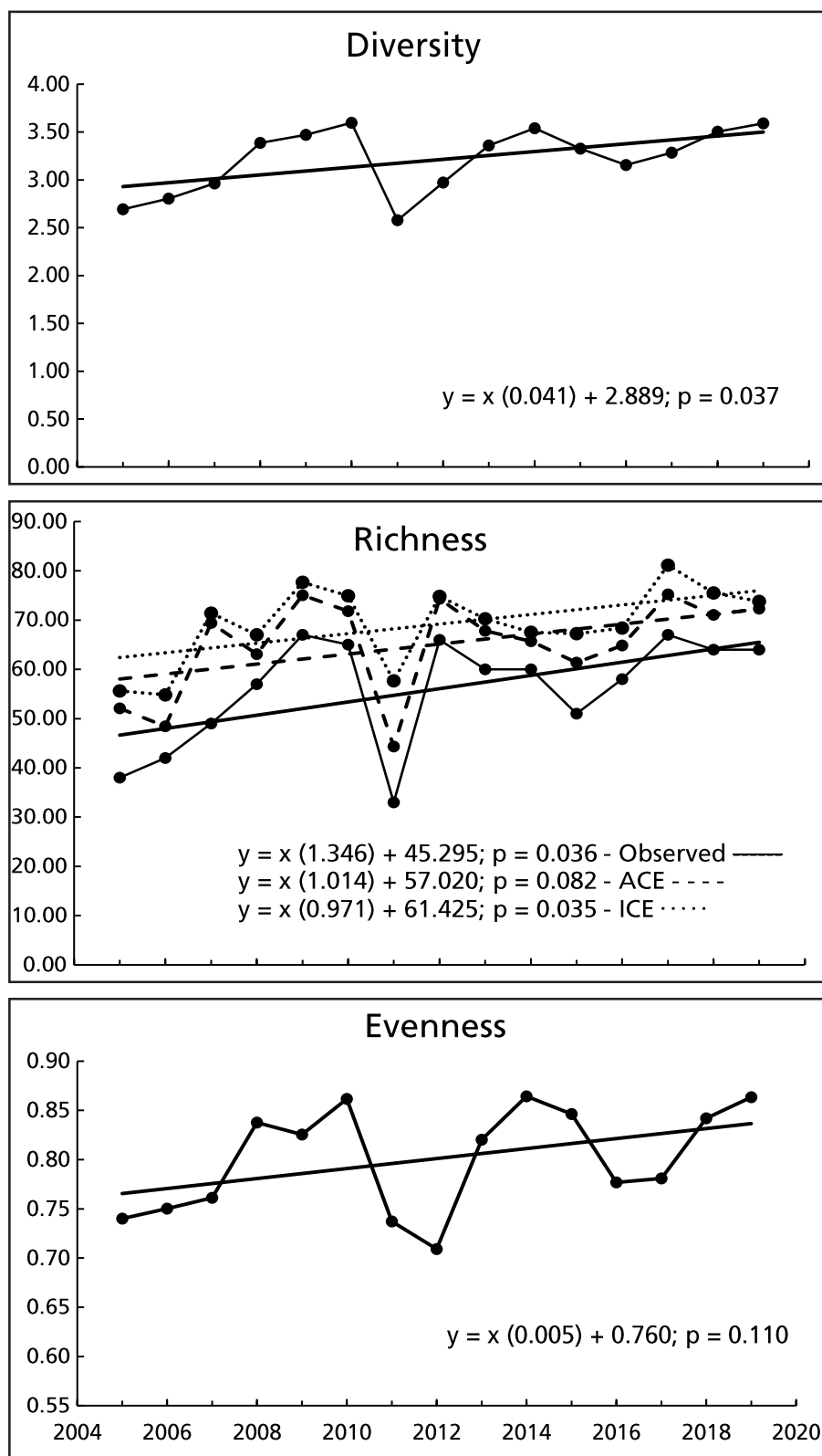


Figure 4. Trends in bird community diversity, richness, and species distribution evenness for Hopewell Culture National Historical Park, Ohio, between 2005 and 2019.

Habitat Assessment

When sampled, habitat plots consisted primarily of the old field (grassland) type (64–76%), with lesser amounts of other types present (Appendix F). Total canopy cover averaged 15–25% on plots, with cover provided exclusively by hardwood trees. Basal area of hardwood trees averaged 2.50–5.93 m²/ha, and canopy height averaged 2.20–5.19 m. Hardwood tree species greater than 15.1 cm in diameter from six different families contributed primarily to the canopy cover and basal area (Appendix G). However, most of the largest trees occurred in the Aceraceae (maple) and Ulmaceae (elm) families.

Across all plots, the horizontal profile height of vegetation at the time of assessment (mid-May to

early-June) was generally below 1.0 m (Appendix F). However, it should be noted that horizontal vegetation cover was recorded in all profile height classes to 2.0 m. Average vertical structure diversity estimates across years ranged from 15–20% for plots. Plots were primarily unvegetated (43–87%) at ground level, with some bare soil (15–58%) exposed (Appendix F). Grass litter (13–9%) covered plots, with lesser amounts of deciduous litter (2–10%), woody debris (1–4%), and rock (0–2%) present. Foliar cover on plots was dominated by forbs (8–49%) and cool-season grasses (16–38%), followed by warm-season grasses (<1–3%), tree seedlings (<1–3%), and mosses and lichens (0–4%; Appendix F). Total foliar coverage averaged 45–75% across plots.



The Red-winged Blackbird (*Agelaius phoeniceus*) population is stable at Hopewell Culture National Historical Park, while populations in the larger regions are declining. NPS

Discussion

Breeding bird surveys that were initiated at Hopewell Culture National Historical Park in 2005 assist the park in assessing the integrity of habitat through time. During the 15 years of surveys, 112 bird species were recorded. Ninety-eight species are permanent or summer residents to the area (Peterjohn 2001). Therefore, these species have some value in characterizing the breeding bird community of Hopewell Culture National Historical Park and the habitat they rely on. These 98 species represent approximately 85% of the breeding species known from the region (Peterjohn 2001). The 14 resident species on Hopewell Culture National Historical Park that are considered species of conservation concern for the Eastern Tallgrass Prairie and/or Appalachian Mountains bird conservation regions should be given special consideration in natural resource management decisions. One of these species of conservation concern—Field Sparrow (*Spizella pusilla*)—was recorded in sufficient numbers to track trends. The Field Sparrow uses primarily brushy old field (grassland) habitat. Therefore, the needs of this species in old field (grassland) habitat management decisions should be given additional considerations because we can track the influence of management efforts on its population.

With 71% of the 338 ha of natural vegetation on Hopewell Culture National Historical Park in various old field (grassland) types (Diamond et al. draft), properly managing this habitat for the approximately 16 bird species that breed in it is of high importance. By doing so, management also benefits migrant grassland obligates on the park, as well as a host of other species. Seven of the 14 species of conservation concern occur in the various old field (grassland) habitats on the park. One of these species—Bewick's Wren (*Thryomanes bewickii*)—is quite rare in the eastern part of the Eastern Tallgrass

Prairie Bird Conservation Region and in the Appalachian Mountains Bird Conservation Region, adding to the importance of old field (grassland) habitat to their wellbeing. However, the Bewick's Wren was only recorded on the park in 2006, suggesting in all likelihood that it no longer utilizes the park and perhaps that part of its range.

Overall, the bird community at Hopewell Culture National Historical Park is faring similarly to or better than the bird communities in the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions (Figure 3). Of the nine species on the park with sufficient abundance to calculate trends, six species on the park have increasing populations, and only one species, Northern Cardinal (*Cardinalis cardinalis*), has an increasing trend in either of the regions (the Eastern Tallgrass Prairie Bird Conservation Region). The Eastern Tallgrass Prairie Bird Conservation Region also has six species with populations in decline, and the two remaining species have stable populations. The Appalachian Mountains Bird Conservation Region has seven species with populations in decline and two species with stable populations.

Over the 15 years of bird monitoring on Hopewell Culture National Historical Park, increasing diversity and richness values, along with stable distribution evenness values, suggest that the park's habitat is improving in terms of its ability to meet the needs of more breeding bird species (Figure 4). The habitat currently present provides for the rich array of breeding species seen (average of 56 species observed annually). However, this species-rich community structure could be altered if significant portions of the park's old fields (grasslands) were developed or returned to agriculture fields or if some of the less common habitats were lost.

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Appendix A. Plots Sampled

Table A1. Plots sampled on Hopewell Culture National Historical Park, Ohio, between 2005 and 2019 and gross habitat type. “Yes” indicates plot was sampled; “No” indicates it was not.

Plot	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Plot Type
HOCU1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Lawn/Woodland
HOCU2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Woodland
HOCU3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Fescue-Orchard Grass
HOCU4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Lawn/Riparian Woodland
HOCU5	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Fescue-Orchard Grass
HOCU6	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Fescue-Orchard Grass
HOCU7	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Fescue-Orchard Grass
HOCU8	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Fescue-Orchard Grass
HOCU9	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Fescue-Orchard Grass
HOCU10	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Restored Prairie
HOCU11	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Riparian Woodland
HOCU12	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Old Field
HOCU13	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Shrub/Woodland
HOCU14	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Fescue-Orchard Grass
HOCU15	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Old Field
HOCU16	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Fescue-Orchard Grass
HOCU17	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Old Field
HOCU18	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Fescue-Orchard Grass
HOCU19	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Old Field
HOCU20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Fescue-Orchard Grass
HOCU21	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Riparian Woodland
HOCU22	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Fescue-Orchard Grass
HOCU23	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Old Field
HOCU24	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Old Field

Table A1 (continued). Plots sampled on Hopewell Culture National Historical Park, Ohio, between 2005 and 2019 and gross habitat type. “Yes” indicates plot was sampled; “No” indicates it was not.

Plot	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Plot Type
HOCU25	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Old Field
HOCU26	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Old Field/Riparian Woodland
HOCU27	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Old Field

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

Table B1. Annual proportion of plots occupied (includes flyovers) by year and estimated abundance of breeding bird species (determined using Distance software) at Hopewell Culture National Historical Park, Ohio, during the 2005 through 2019 spring bird surveys (n = number of plots sampled) An en-dash (–) denotes when an annual abundance value could not be calculated because the species was present but the distance measures from observers were beyond the plot perimeter.

Common Name	Proportion of Plots Occupied (Abundance)														
	2005 n=27	2006 n=27	2007 n=27	2008 n=27	2009 n=27	2010 n=27	2011 n=26	2012 n=27	2013 n=27	2014 n=27	2015 n=27	2016 n=26	2017 n=27	2018 n=27	2019 n=27
American Goldfinch	0.04 (48)	0.11 (139)	0.15 (139)	0.19 (53)	0.19 (251)	0.48 (–)	0 (0)	0.30 (133)	0.48 (376)	0.30 (53)	0.07 (–)	0.33 (142)	0.48 (1066)	0.37 (224)	0.59 (434)
Common Yellowthroat	0.15 (61)	0.11 (44)	0.30 (117)	0.63 (–)	0.52 (79)	0.55 (–)	0.39 (146)	0.63 (42)	0.56 (–)	0.52 (17)	0.19 (77)	0.74 (67)	0.48 (–)	0.44 (141)	0.74 (348)
Eastern Meadowlark	0.33 (20)	0.19 (28)	0.11 (14)	0.44 (32)	0.56 (32)	0.56 (23)	0.15 (19)	0.41 (13)	0.41 (38)	0.44 (21)	0.33 (54)	0.44 (29)	0.48 (–)	0.56 (62)	0.52 (123)
European Starling	0.04 (–)	0.04 (–)	0.22 (888)	0.33 (1021)	0.37 (1201)	0.44 (1075)	0.04 (888)	0.59 (3830)	0.44 (4806)	0.52 (1021)	0.07 (786)	0.26 (2723)	0.37 (–)	0.30 (1075)	0.33 (3782)
Field Sparrow*	0.26 (28)	0.22 (66)	0.33 (92)	0.59 (8)	0.44 (9)	0.37 (8)	0.23 (46)	0.41 (9)	0.63 (27)	0.67 (8)	0.33 (53)	0.48 (20)	0.52 (–)	0.56 (32)	0.59 (141)
Indigo Bunting	0.19 (107)	0.15 (102)	0.41 (205)	0.30 (24)	0.37 (28)	0.48 (50)	0.19 (123)	0.44 (–)	0.44 (28)	0.63 (94)	0.26 (163)	0.44 (63)	0.41 (–)	0.26 (50)	0.63 (489)
Northern Cardinal	0.22 (46)	0.19 (44)	0.37 (110)	0.37 (13)	0.48 (–)	0.41 (13)	0.15 (44)	0.56 (16)	0.37 (–)	0.52 (–)	0.15 (39)	0.41 (34)	0.52 (–)	0.67 (40)	0.67 (234)
Red-winged Blackbird	0.67 (474)	0.67 (420)	0.67 (353)	0.82 (319)	0.78 (307)	0.78 (336)	0.81 (319)	0.59 (254)	0.78 (261)	0.78 (396)	0.52 (230)	0.59 (142)	0.81 (–)	0.74 (142)	0.78 (322)
Song Sparrow	0.26 (84)	0.04 (53)	0.30 (93)	0.70 (61)	0.52 (90)	0.63 (16)	0.15 (80)	0.56 (–)	0.44 (18)	0.59 (15)	0.07 (24)	0.56 (–)	0.44 (–)	0.52 (16)	0.67 (341)

* Species of conservation concern for either or both the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions (U.S. Fish and Wildlife Service 2008; also in bold).

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

Table C1. Annual proportion of plots occupied by (includes flyovers), and estimated abundance of breeding bird species (determined using birds within 200 m of plot center) at Hopewell Culture National Historical Park, Ohio, during the 2005 to 2019 spring bird surveys (n = number of plots sampled). An en-dash (–) denotes when an annual abundance value could not be calculated because the species was present but the distance measures from observers were beyond the plot perimeter.

Common Name	Proportion of Plots Occupied (Abundance)														
	2005 n=27	2006 n=27	2007 n=27	2008 n=27	2009 n=27	2010 n=27	2011 n=26	2012 n=27	2013 n=27	2014 n=27	2015 n=27	2016 n=26	2017 n=27	2018 n=27	2019 n=27
Acadian Flycatcher*	0 (0)	0 (0)	0.04 (1)	0 (0)	0.04 (–)	0.04 (–)	0 (0)	0 (0)	0.04 (–)	0.04 (–)	0 (0)	0.07 (–)	0.04 (–)	0.04 (–)	0 (0)
American Crow	0.07 (–)	0.07 (–)	0.04 (–)	0.15 (–)	0.33 (–)	0.15 (–)	0.04 (–)	0.37 (–)	0.26 (–)	0.37 (–)	0.11 (–)	0.30 (3)	0.37 (–)	0.33 (–)	0.52 (14)
American Kestrel	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 (–)	0 (0)	0 (0)
American Redstart	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0.04 (–)	0 (0)	0 (0)	0.04 (–)	0 (0)	0.04 (1)	0 (0)	0 (0)	0.04 (–)	0.11 (6)
American Robin	0.22 (3)	0.19 (10)	0.22 (10)	0.19 (0)	0.37 (0)	0.59 (3)	0.15 (6)	0.44 (3)	0.26 (1)	0.52 (3)	0.30 (7)	0.48 (6)	0.41 (0)	0.44 (1)	0.59 (22)
Bald Eagle*	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)
Baltimore Oriole	0.04 (1)	0 (0)	0.07 (3)	0.11 (0)	0.11 (1)	0.30 (0)	0 (0)	0.07 (0)	0.15 (0)	0.11 (1)	0.07 (3)	0.33 (1)	0.07 (0)	0.11 (4)	0.07 (3)
Bank Swallow	0 (0)	0.04 (–)	0 (0)	0 (0)	0.04 (–)	0.15 (–)	0 (0)	0.15 (–)	0.07 (–)	0.15 (–)	0 (0)	0.04 (–)	0.04 (–)	0.11 (–)	0 (0)
Barn Swallow	0 (0)	0.04 (–)	0 (0)	0.22 (–)	0.07 (–)	0.22 (–)	0.08 (–)	0.11 (3)	0.11 (–)	0.41 (–)	0.19 (–)	0.26 (–)	0.37 (–)	0.26 (8)	0.19 (–)
Belted Kingfisher	0.04 (1)	0.04 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0 (0)
Bewick's Wren*	0 (0)	0.15 (7)	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)
Black Vulture	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (3)	0 (0)	0.04 (–)	0 (0)

*Species of conservation concern for either or both the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions (U.S. Fish and Wildlife Service 2008; also in bold).

Table C1 (continued). Annual proportion of plots occupied by (includes flyovers), and estimated abundance of breeding bird species (determined using birds within 200 m of plot center) at Hopewell Culture National Historical Park, Ohio, during the 2005 to 2019 spring bird surveys (n = number of plots sampled). An en-dash (–) denotes when an annual abundance value could not be calculated because the species was present but the distance measures from observers were beyond the plot perimeter.

Common Name	Proportion of Plots Occupied (Abundance)														
	2005 n=27	2006 n=27	2007 n=27	2008 n=27	2009 n=27	2010 n=27	2011 n=26	2012 n=27	2013 n=27	2014 n=27	2015 n=27	2016 n=26	2017 n=27	2018 n=27	2019 n=27
Blue-gray Gnatcatcher	0.04 (1)	0 (0)	0.04 (1)	0.11 (1)	0.11 (–)	0.11 (–)	0 (0)	0.07 (–)	0.07 (–)	0.22 (–)	0.11 (4)	0.07 (–)	0.11 (–)	0.11 (–)	0.07 (3)
Blue Grosbeak	0 (0)	0.04 (7)	0.04 (–)	0 (0)	0.04 (–)	0.04 (–)	0 (0)	0 (0)	0.07 (1)	0.04 (–)	0 (0)	0.04 (1)	0.11 (–)	0 (0)	0 (0)
Blue Jay	0.04 (1)	0.07 (3)	0.07 (3)	0.26 (1)	0.15 (–)	0.26 (3)	0.08 (–)	0.15 (–)	0.15 (–)	0.19 (–)	0 (0)	0.22 (–)	0.22 (–)	0.19 (–)	0.37 (14)
Blue-winged Warbler*	0 (0)	0.04 (1)	0 (0)	0.04 (–)	0 (0)	0 (0)	0 (0)	0.07 (–)	0.04 (–)	0 (0)	0.04 (3)	0 (0)	0 (0)	0 (0)	0 (0)
Brown-headed Cowbird	0.04 (–)	0.04 (–)	0 (0)	0.07 (–)	0.19 (–)	0.15 (–)	0.04 (1)	0.15 (3)	0.07 (1)	0.26 (1)	0.11 (1)	0.11 (1)	0.04 (–)	0.26 (4)	0.22 (13)
Brown Thrasher	0 (0)	0.11 (6)	0.11 (3)	0.19 (1)	0.11 (–)	0.15 (1)	0.12 (4)	0.11 (–)	0.22 (–)	0.26 (1)	0.04 (1)	0.04 (–)	0.26 (–)	0.11 (1)	0.19 (7)
Canada Goose	0 (0)	0.04 (–)	0 (0)	0.07 (–)	0.04 (–)	0.11 (–)	0 (0)	0.07 (–)	0.04 (–)	0 (0)	0.07 (–)	0 (0)	0 (0)	0.04 (–)	0.15 (1)
Carolina Chickadee	0 (0)	0 (0)	0.07 (3)	0 (0)	0 (0)	0.07 (1)	0 (0)	0.07 (1)	0.07 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.07 (3)
Carolina Wren	0.26 (8)	0.11 (3)	0.11 (3)	0.15 (–)	0.15 (–)	0.15 (–)	0 (0)	0.33 (–)	0.44 (–)	0.04 (–)	0.04 (1)	0.15 (–)	0.37 (–)	0.07 (–)	0.48 (15)
Cedar Waxwing	0 (0)	0 (0)	0 (0)	0.07 (–)	0.04 (–)	0.15 (7)	0 (0)	0.11 (–)	0.22 (–)	0.11 (1)	0 (0)	0.04 (–)	0.11 (–)	0.07 (–)	0.07 (7)
Chimney Swift	0 (0)	0 (0)	0 (0)	0.04 (–)	0.22 (–)	0.11 (–)	0.04 (–)	0.11 (–)	0.07 (–)	0 (0)	0.07 (–)	0.04 (–)	0 (0)	0 (0)	0.15 (–)
Chipping Sparrow	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0.04 (–)	0.04 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0.15 (3)	0.07 (–)	0.07 (–)	0 (0)
Cliff Swallow	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0.04 (–)	0 (0)	0 (0)	0 (0)	0.07 (–)	0.04 (–)	0.04 (–)	0.07 (–)
Common Grackle	0 (0)	0 (0)	0.07 (–)	0.48 (3)	0.52 (8)	0.78 (8)	0 (0)	0.78 (3)	0.52 (3)	0.56 (15)	0.11 (3)	0.30 (3)	0.41 (–)	0.33 (21)	0.22 (3)

*Species of conservation concern for either or both the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions (U.S. Fish and Wildlife Service 2008; also in bold).

Table C1 (continued). Annual proportion of plots occupied by (includes flyovers), and estimated abundance of breeding bird species (determined using birds within 200 m of plot center) at Hopewell Culture National Historical Park, Ohio, during the 2005 to 2019 spring bird surveys (n = number of plots sampled). An en-dash (–) denotes when an annual abundance value could not be calculated because the species was present but the distance measures from observers were beyond the plot perimeter.

Common Name	Proportion of Plots Occupied (Abundance)														
	2005 n=27	2006 n=27	2007 n=27	2008 n=27	2009 n=27	2010 n=27	2011 n=26	2012 n=27	2013 n=27	2014 n=27	2015 n=27	2016 n=26	2017 n=27	2018 n=27	2019 n=27
Cooper's Hawk	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0 (0)	0.04 (–)	0.04 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (3)
Dickcissel*	0.22 (13)	0.11 (7)	0.19 (10)	0.07 (4)	0.15 (6)	0.07 (–)	0 (0)	0.19 (4)	0.26 (4)	0.41 (4)	0.11 (4)	0.30 (7)	0.19 (–)	0.33 (4)	0 (0)
Downy Woodpecker	0 (0)	0 (0)	0.04 (1)	0.04 (–)	0.11 (–)	0.15 (1)	0 (0)	0.11 (–)	0 (0)	0.07 (–)	0 (0)	0.04 (–)	0.11 (–)	0 (0)	0.11 (4)
Eastern Bluebird	0 (0)	0.07 (4)	0 (0)	0.15 (3)	0.07 (3)	0 (0)	0 (0)	0.22 (1)	0.07 (3)	0.22 (–)	0.15 (7)	0.19 (7)	0.11 (–)	0 (0)	0.11 (4)
Eastern Kingbird	0 (0)	0.04 (–)	0 (0)	0.19 (4)	0.07 (1)	0.07 (–)	0 (0)	0.11 (4)	0.07 (–)	0.11 (3)	0.04 (1)	0 (0)	0.07 (–)	0.07 (3)	0.26 (10)
Eastern Phoebe	0.04 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0.07 (1)	0.04 (–)	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0.04 (1)
Eastern Towhee	0.11 (3)	0.07 (3)	0.19 (4)	0.37 (–)	0.15 (–)	0.30 (–)	0.08 (3)	0.15 (–)	0.30 (–)	0.22 (–)	0.26 (10)	0.22 (–)	0.37 (–)	0.07 (–)	0.19 (–)
Eastern Wood-pewee	0.04 (1)	0.19 (6)	0.07 (1)	0.15 (–)	0.11 (–)	0.11 (–)	0 (0)	0.07 (–)	0.04 (–)	0.22 (–)	0.07 (3)	0.07 (–)	0.11 (–)	0.11 (–)	0 (0)
Grasshopper Sparrow*	0.19 (1)	0.26 (1)	0.15 (1)	0.19 (1)	0.19 (1)	0.30 (1)	0.19 (10)	0.19 (–)	0.33 (4)	0.26 (1)	0.33 (17)	0.07 (–)	0.15 (–)	0.22 (1)	0.37 (24)
Gray Catbird	0 (0)	0.04 (1)	0.04 (–)	0.22 (–)	0.22 (1)	0.22 (1)	0.04 (1)	0.11 (–)	0.26 (1)	0.11 (–)	0.07 (3)	0.19 (–)	0.15 (–)	0.30 (4)	0.37 (17)
Great Blue Heron	0.07 (–)	0.07 (–)	0 (0)	0.07 (1)	0.11 (–)	0.11 (–)	0.04 (–)	0.15 (–)	0.15 (–)	0.04 (–)	0 (0)	0 (0)	0.04 (–)	0 (0)	0 (0)
Great Crested Flycatcher	0 (0)	0 (0)	0 (0)	0.04 (–)	0.04 (–)	0 (0)	0.04 (1)	0.11 (–)	0 (0)	0.04 (–)	0 (0)	0.11 (–)	0.11 (–)	0 (0)	0 (0)
Green Heron	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0.04 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Hairy Woodpecker	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)	0.04 (–)	0 (0)

*Species of conservation concern for either or both the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions (U.S. Fish and Wildlife Service 2008; also in bold).

Table C1 (continued). Annual proportion of plots occupied by (includes flyovers), and estimated abundance of breeding bird species (determined using birds within 200 m of plot center) at Hopewell Culture National Historical Park, Ohio, during the 2005 to 2019 spring bird surveys (n = number of plots sampled). An en-dash (–) denotes when an annual abundance value could not be calculated because the species was present but the distance measures from observers were beyond the plot perimeter.

Common Name	Proportion of Plots Occupied (Abundance)														
	2005 n=27	2006 n=27	2007 n=27	2008 n=27	2009 n=27	2010 n=27	2011 n=26	2012 n=27	2013 n=27	2014 n=27	2015 n=27	2016 n=26	2017 n=27	2018 n=27	2019 n=27
Henslow's Sparrow*	0.04 (3)	0.04 (3)	0.04 (4)	0 (0)	0.07 (–)	0.19 (–)	0 (0)	0.11 (–)	0.19 (–)	0.11 (–)	0.07 (3)	0.15 (–)	0.15 (–)	0.19 (7)	0.37 (21)
Hooded Warbler	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0 (0)	0 (0)
Horned Lark	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0 (0)	0.04 (1)	0 (0)	0 (0)	0 (0)	0.04 (1)
House Finch	0.04 (1)	0 (0)	0 (0)	0 (0)	0.04 (–)	0.04 (–)	0 (0)	0.04 (–)	0.11 (–)	0 (0)	0 (0)	0.04 (–)	0 (0)	0 (0)	0 (0)
House Sparrow	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)	0.07 (3)	0 (0)
House Wren	0.04 (1)	0 (0)	0.11 (–)	0.22 (1)	0.19 (–)	0.30 (–)	0.04 (1)	0.07 (–)	0.22 (–)	0.19 (–)	0.11 (4)	0.11 (–)	0.22 (–)	0.22 (–)	0.37 (17)
Killdeer	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0.04 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0.04 (–)	0 (0)	0.04 (–)	0.04 (–)
Mallard	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0.04 (–)	0 (0)	0 (0)	0.04 (–)	0 (0)	0.04 (–)	0 (0)	0 (0)	0 (0)
Mourning Dove	0.04 (1)	0.11 (4)	0.07 (–)	0.37 (7)	0.33 (1)	0.30 (1)	0.04 (1)	0.37 (10)	0.30 (3)	0.33 (3)	0.19 (7)	0.33 (10)	0.41 (–)	0.48 (3)	0.37 (7)
Northern Bobwhite	0.11 (–)	0.04 (3)	0.04 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0.11 (4)	0 (0)	0 (0)	0 (0)	0 (0)
Northern Flicker*	0 (0)	0 (0)	0.04 (–)	0 (0)	0.15 (1)	0.11 (–)	0 (0)	0.11 (–)	0.07 (–)	0.15 (–)	0 (0)	0 (0)	0.07 (–)	0.11 (–)	0 (0)
Northern Mockingbird	0 (0)	0 (0)	0.07 (3)	0 (0)	0.07 (–)	0.04 (–)	0.04 (1)	0.04 (–)	0.04 (1)	0.04 (1)	0.07 (3)	0 (0)	0 (0)	0.07 (–)	0 (0)
Northern Parula	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0.04 (–)	0 (0)	0 (0)	0.04 (–)	0.04 (–)	0 (0)
Northern Rough-winged Swallow	0 (0)	0 (0)	0.04 (–)	0.07 (1)	0.19 (3)	0.15 (3)	0 (0)	0.22 (1)	0.26 (–)	0.30 (14)	0 (0)	0.19 (–)	0.07 (–)	0.11 (–)	0 (0)

*Species of conservation concern for either or both the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions (U.S. Fish and Wildlife Service 2008; also in bold).

Table C1 (continued). Annual proportion of plots occupied by (includes flyovers), and estimated abundance of breeding bird species (determined using birds within 200 m of plot center) at Hopewell Culture National Historical Park, Ohio, during the 2005 to 2019 spring bird surveys (n = number of plots sampled). An en-dash (–) denotes when an annual abundance value could not be calculated because the species was present but the distance measures from observers were beyond the plot perimeter.

Common Name	Proportion of Plots Occupied (Abundance)														
	2005 n=27	2006 n=27	2007 n=27	2008 n=27	2009 n=27	2010 n=27	2011 n=26	2012 n=27	2013 n=27	2014 n=27	2015 n=27	2016 n=26	2017 n=27	2018 n=27	2019 n=27
Orchard Oriole	0 (0)	0 (0)	0.07 (–)	0.19 (1)	0.15 (1)	0.15 (–)	0 (0)	0.11 (3)	0.07 (–)	0.19 (–)	0.04 (3)	0 (0)	0.26 (–)	0.15 (–)	0.11 (3)
Pileated Woodpecker	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (1)	0 (0)	0.04 (–)	0.07 (–)	0.04 (–)
Prairie Warbler*	0 (0)	0 (0)	0 (0)	0 (0)	0.15 (3)	0 (0)	0 (0)	0 (0)	0.04 (–)	0.07 (–)	0 (0)	0 (0)	0.07 (–)	0.07 (–)	0.04 (3)
Prothonotary Warbler*	0 (0)	0 (0)	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)
Purple Martin	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0.04 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.07 (1)
Red-bellied Woodpecker	0 (0)	0 (0)	0.04 (–)	0.07 (–)	0.15 (–)	0.19 (1)	0.04 (1)	0.11 (–)	0.07 (–)	0.30 (1)	0.04 (1)	0 (0)	0.15 (–)	0.30 (1)	0.22 (7)
Red-eyed Vireo	0.04 (–)	0.07 (3)	0.04 (1)	0.07 (–)	0.26 (–)	0.15 (–)	0 (0)	0.15 (–)	0.11 (–)	0.19 (–)	0.04 (1)	0.15 (–)	0.15 (–)	0.04 (–)	0.11 (–)
Red-tailed Hawk	0.04 (1)	0.04 (1)	0.07 (–)	0.04 (–)	0 (0)	0.11 (1)	0 (0)	0.07 (1)	0 (0)	0 (0)	0.04 (–)	0.04 (–)	0.11 (–)	0.04 (–)	0.07 (–)
Ring-necked Pheasant	0.22 (3)	0.04 (–)	0.04 (–)	0.04 (–)	0.19 (–)	0.04 (–)	0 (0)	0.07 (–)	0.04 (–)	0.04 (–)	0.04 (–)	0.07 (–)	0.04 (–)	0.11 (–)	0.04 (–)
Rock Dove	0.04 (3)	0 (0)	0 (0)	0 (0)	0.07 (3)	0.04 (–)	0 (0)	0.07 (–)	0 (0)	0.04 (–)	0 (0)	0.11 (–)	0.04 (–)	0.07 (–)	0 (0)
Ruby-throated Hummingbird	0 (0)	0 (0)	0 (0)	0.04 (–)	0.04 (–)	0.04 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Savannah Sparrow	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0 (0)	0.04 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Scarlet Tanager	0 (0)	0 (0)	0 (0)	0.07 (–)	0.04 (–)	0 (0)	0 (0)	0.04 (–)	0.07 (–)	0.04 (–)	0 (0)	0.04 (–)	0.11 (–)	0.04 (–)	0.04 (1)
Spotted Sandpiper	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)	0 (0)	0.04 (1)

*Species of conservation concern for either or both the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions (U.S. Fish and Wildlife Service 2008; also in bold).

Table C1 (continued). Annual proportion of plots occupied by (includes flyovers), and estimated abundance of breeding bird species (determined using birds within 200 m of plot center) at Hopewell Culture National Historical Park, Ohio, during the 2005 to 2019 spring bird surveys (n = number of plots sampled). An en-dash (–) denotes when an annual abundance value could not be calculated because the species was present but the distance measures from observers were beyond the plot perimeter.

Common Name	Proportion of Plots Occupied (Abundance)														
	2005 n=27	2006 n=27	2007 n=27	2008 n=27	2009 n=27	2010 n=27	2011 n=26	2012 n=27	2013 n=27	2014 n=27	2015 n=27	2016 n=26	2017 n=27	2018 n=27	2019 n=27
Summer Tanager	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (3)	0 (0)	0 (0)	0 (0)	0 (0)
Tree Swallow	0.26 (13)	0.07 (–)	0.07 (4)	0.22 (1)	0.19 (3)	0.19 (4)	0.23 (3)	0.26 (3)	0.15 (3)	0.11 (1)	0.26 (3)	0.22 (–)	0.15 (–)	0.22 (1)	0.22 (–)
Tufted Titmouse	0.11 (3)	0.07 (1)	0 (0)	0.26 (–)	0.15 (–)	0.19 (–)	0 (0)	0.19 (–)	0.30 (–)	0.22 (–)	0.15 (4)	0.33 (–)	0.33 (–)	0.26 (–)	0.30 (10)
Turkey Vulture	0.04 (–)	0 (0)	0 (0)	0.11 (–)	0.07 (1)	0 (0)	0 (0)	0.11 (–)	0.22 (–)	0.15 (3)	0.07 (–)	0.15 (6)	0.15 (–)	0.11 (–)	0.07 (–)
Warbling Vireo	0 (0)	0 (0)	0.04 (1)	0 (0)	0.11 (–)	0.15 (–)	0 (0)	0.19 (1)	0.15 (–)	0.22 (–)	0 (0)	0.04 (–)	0.04 (–)	0 (0)	0.11 (4)
White-breasted Nuthatch	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0.04 (–)	0 (0)	0.04 (–)	0 (0)	0 (0)	0 (0)	0.07 (–)	0.11 (–)	0 (0)	0 (0)
White-eyed Vireo	0 (0)	0 (0)	0.04 (–)	0.37 (–)	0.15 (–)	0.07 (–)	0 (0)	0.04 (–)	0.11 (–)	0.07 (–)	0 (0)	0 (0)	0.15 (–)	0.04 (–)	0.26 (13)
Wild Turkey	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)	0 (0)	0.11 (3)
Willow Flycatcher	0 (0)	0 (0)	0.15 (4)	0.04 (–)	0.30 (6)	0.22 (1)	0 (0)	0.07 (–)	0.04 (–)	0.30 (3)	0 (0)	0.19 (–)	0.19 (–)	0.07 (4)	0.07 (3)
Wood Duck	0 (0)	0 (0)	0.04 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)
Wood Thrush*	0.07 (1)	0.11 (4)	0.11 (3)	0.30 (–)	0.22 (–)	0.15 (–)	0.04 (1)	0.26 (–)	0.07 (–)	0.19 (–)	0.15 (6)	0.41 (–)	0.33 (–)	0.11 (–)	0.26 (6)
Worm-eating Warbler*	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)	0 (0)	0.04 (13)
Yellow-billed Cuckoo	0 (0)	0.04 (1)	0.07 (–)	0.04 (–)	0.11 (–)	0 (0)	0 (0)	0.04 (–)	0 (0)	0 (0)	0.04 (–)	0 (0)	0.04 (–)	0.04 (–)	0 (0)
Yellow-breasted Chat	0.19 (7)	0.22 (8)	0.11 (4)	0.22 (–)	0.22 (–)	0.22 (3)	0.15 (6)	0.26 (–)	0.04 (–)	0.19 (–)	0.04 (1)	0.11 (–)	0.22 (–)	0.15 (–)	0.04 (1)

*Species of conservation concern for either or both the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions (U.S. Fish and Wildlife Service 2008; also in bold).

Table C1 (continued). Annual proportion of plots occupied by (includes flyovers), and estimated abundance of breeding bird species (determined using birds within 200 m of plot center) at Hopewell Culture National Historical Park, Ohio, during the 2005 to 2019 spring bird surveys (n = number of plots sampled). An en-dash (–) denotes when an annual abundance value could not be calculated because the species was present but the distance measures from observers were beyond the plot perimeter.

Common Name	Proportion of Plots Occupied (Abundance)														
	2005 n=27	2006 n=27	2007 n=27	2008 n=27	2009 n=27	2010 n=27	2011 n=26	2012 n=27	2013 n=27	2014 n=27	2015 n=27	2016 n=26	2017 n=27	2018 n=27	2019 n=27
Yellow-throated Vireo	0 (0)	0 (0)	0.04 (–)	0.04 (–)	0 (0)	0.04 (–)	0.08 (3)	0 (0)	0.04 (–)	0 (0)	0 (0)	0.04 (–)	0 (0)	0 (0)	0.15 (6)
Yellow-throated Warbler	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.04 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.07 (–)	0.04 (–)	0 (0)	0.04 (1)
Yellow Warbler	0.15 (1)	0.15 (8)	0.04 (1)	0.30 (–)	0.30 (3)	0.22 (3)	0 (0)	0.07 (–)	0.15 (1)	0.22 (–)	0.07 (3)	0 (0)	0.15 (–)	0.19 (1)	0.26 (11)

*Species of conservation concern for either or both the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions (U.S. Fish and Wildlife Service 2008; also in bold).

Appendix D. Park Trends

Table D1. Trends, annual change in abundance (individuals), of breeding birds recorded on Hopewell Culture National Historical Park, Ohio, from 2005 through 2019.

Common Name	Trend ^A	SE of Slope	Trend Classification ^B
American Goldfinch	1.09	0.10	Uncertain
Common Yellowthroat	1.10	0.03	Moderate Increase
Eastern Meadowlark	1.12	0.03	Strong Increase
European Starling	1.23	0.75	Uncertain
Field Sparrow^C	1.06	0.02	Moderate Increase
Indigo Bunting	1.06	0.02	Moderate Increase
Northern Cardinal	1.08	0.02	Moderate Increase
Red-winged Blackbird	0.98	0.01	Stable
Song Sparrow	1.05	0.03	Uncertain

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

^B Trend classification types depending on statistical significance and magnitude (Pannekoek and Van Strien 2005; Van Strien et al. 2001) and following 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—increase 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 if 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—significantly more than 5% per year. Criterion: upper limit of confidence interval < 0.95.

^C Species of conservation concern for either or both the Eastern Tallgrass Prairie and Appalachian Mountain bird conservation regions (U.S. Fish and Wildlife Service 2008; also in bold).

Appendix E. Regional Trends

Table E1. Regional trends in breeding birds recorded on Hopewell Culture National Historical Park, Ohio, from 2005 through 2015. Regional trend data are from Breeding Bird Surveys (BBS; Sauer et al. 2017).

Common Name	Eastern Tallgrass Prairie (ETP) Bird Conservation Region Trend (percent change in population size)	ETP Trend 95% Confidence Interval		Appalachian Mountains (AM) Bird Conservation Region Trend (percent change in population size)	AM Trend 95% Confidence Interval	
		Lower	Upper		Lower	Upper
Acadian Flycatcher^A	1.31	-1.47	4.55	-0.42	-1.53	1.01
American Crow	0.41	-0.52	1.32	0.60	0.16	1.07
American Goldfinch	-0.24	-1.36	0.92	-0.01	-0.89	0.86
American Kestrel	-1.21	-3.16	0.70	-0.07	-2.09	2.13
American Redstart	4.10	-1.16	11.84	0.55	-0.60	1.70
American Robin	0.77	0.18	1.36	0.44	-0.01	0.88
American Woodcock ^B	1.52	-9.44	17.26	-0.92	-7.04	6.21
Bald Eagle^A	27.44	18.57	36.69	15.15	6.28	25.20
Baltimore Oriole	-1.68	-2.74	-0.75	-1.93	-3.12	-0.72
Bank Swallow	0.14	-5.53	5.46	-4.40	-12.37	3.41
Barn Swallow	-0.88	-1.80	0.05	-0.16	-0.97	0.69
Belted Kingfisher	-2.17	-5.61	0.75	-1.09	-2.68	0.42
Bewick's Wren^A	-0.24	-8.14	6.38	-16.70	-28.94	-6.39
Black Vulture	-35.42	-83.65	34.24	8.83	1.88	16.25
Blue-gray Gnatcatcher	1.41	-0.94	3.55	-1.00	-2.08	0.08
Blue Grosbeak	4.19	2.48	6.34	-0.36	-1.57	0.77
Blue Jay	-0.88	-1.82	0.10	-0.52	-1.12	0.06
Blue-winged Warbler	1.88	-7.52	9.24	0.44	-2.20	3.78
Brown-headed Cowbird	-0.66	-1.45	0.14	-2.84	-3.90	-1.89
Brown Thrasher	-1.71	-2.40	-1.02	0.31	-0.46	1.11
Canada Goose	16.17	9.25	23.31	11.10	4.36	16.63
Carolina Chickadee	1.88	-0.99	4.91	-0.32	-1.18	0.53
Carolina Wren	-2.56	-4.60	-0.46	-2.58	-4.09	-1.22
Cedar Waxwing	1.27	-1.26	3.88	1.31	-0.49	3.13
Cerulean Warbler	-3.24	-20.88	16.30	-1.61	-4.43	2.17
Chimney Swift	-4.23	-5.32	-3.18	-2.33	-3.23	-1.50
Chipping Sparrow	1.83	0.74	2.95	-1.68	-2.28	-1.08
Cliff Swallow	16.18	10.86	19.94	11.79	-6.29	18.72
Common Grackle	-4.15	-5.17	-3.18	-2.41	-3.28	-1.56
Common Yellowthroat	-1.40	-2.39	-0.44	-0.78	-1.47	-0.07
Cooper's Hawk	9.05	5.48	12.31	4.08	1.27	6.51
Dickcissel^A	0.34	-0.80	1.49	10.20	-7.26	35.38

^A Species of conservation concern for either or both the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions (U.S. Fish and Wildlife Service 2008; also in bold).

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

Table E1 (continued). Regional trends in breeding birds recorded on Hopewell Culture National Historical Park, Ohio, from 2005 through 2015. Regional trend data are from Breeding Bird Surveys (BBS; Sauer et al. 2017).

Common Name	Eastern Tallgrass Prairie (ETP) Bird Conservation Region Trend (percent change in population size)	ETP Trend 95% Confidence Interval		Appalachian Mountains (AM) Bird Conservation Region Trend (percent change in population size)	AM Trend 95% Confidence Interval	
		Lower	Upper		Lower	Upper
Downy Woodpecker	0.48	-0.86	1.89	-1.17	-2.28	-0.16
Eastern Bluebird	-0.68	-2.46	1.15	0.28	-1.12	1.59
Eastern Kingbird	-2.38	-3.46	-1.35	-0.90	-1.60	-0.15
Eastern Meadowlark	-2.58	-3.42	-1.73	-4.07	-4.79	-3.35
Eastern Phoebe	0.17	-1.35	1.69	-1.95	-3.00	-0.90
Eastern Towhee	1.83	0.46	3.28	-0.09	-0.76	0.59
Eastern Wood-Pewee	-0.61	-1.69	0.43	-1.61	-2.37	-0.80
European Starling	-1.25	-2.19	-0.39	-1.14	-1.96	-0.27
Field Sparrow^A	-1.62	-2.62	-0.63	-1.96	-2.90	-0.92
Grasshopper Sparrow^A	-4.84	-6.76	-3.10	-5.38	-6.92	-3.74
Gray Catbird	1.33	0.42	2.25	1.41	0.80	2.06
Great Blue Heron	0.69	-1.09	2.46	3.17	0.46	5.83
Great Crested Flycatcher	-1.17	-2.61	0.13	-0.88	-1.76	0.03
Green Heron	-1.79	-4.08	-0.02	-1.45	-2.80	-0.17
Hairy Woodpecker	1.04	-1.35	3.98	1.56	0.00	3.20
Henslow's Sparrow^A	3.13	-5.11	8.74	-3.61	-10.67	2.75
Hooded Warbler	-7.38	-42.32	11.93	2.32	0.80	4.08
Horned Lark	-3.14	-4.24	-2.04	1.65	-3.86	7.98
House Finch	1.39	-1.24	4.35	-3.33	-5.41	-1.23
House Sparrow ^B	-3.15	-4.05	-2.12	-3.29	-4.10	-2.47
House Wren	0.41	-0.45	1.33	-0.95	-1.77	-0.09
Indigo Bunting	-0.60	-1.29	0.07	-2.08	-2.52	-1.64
Killdeer	0.36	-0.74	1.42	-1.76	-3.04	-0.51
Mallard	2.06	-1.44	5.68	1.22	-2.09	3.85
Mourning Dove	-1.69	-2.37	-0.98	0.55	-0.10	1.19
Northern Bobwhite	-3.07	-4.49	-1.63	-8.53	-10.77	-6.09
Northern Cardinal	0.75	0.18	1.35	0.48	-0.04	0.98
Northern Flicker^A	-3.27	-4.23	-2.31	-0.63	-1.75	0.48
Northern Mockingbird	-1.46	-2.73	-0.17	0.41	-0.49	1.36
Northern Parula	3.66	1.40	5.63	1.50	0.29	3.02
Northern Rough-winged Swallow	1.91	-0.11	4.05	0.97	-0.58	2.45
Orchard Oriole	-1.30	-3.17	0.49	0.66	-0.63	2.42
Ovenbird ^B	4.76	-0.00	9.29	2.04	1.32	2.74

^A Species of conservation concern for either or both the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions (U.S. Fish and Wildlife Service 2008; also in bold).

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

Table E1 (continued). Regional trends in breeding birds recorded on Hopewell Culture National Historical Park, Ohio, from 2005 through 2015. Regional trend data are from Breeding Bird Surveys (BBS; Sauer et al. 2017).

Common Name	Eastern Tallgrass Prairie (ETP) Bird Conservation Region Trend (percent change in population size)	ETP Trend 95% Confidence Interval		Appalachian Mountains (AM) Bird Conservation Region Trend (percent change in population size)	AM Trend 95% Confidence Interval	
		Lower	Upper		Lower	Upper
Pileated Woodpecker	5.05	1.83	7.54	1.52	0.42	2.59
Prairie Warbler^A	1.50	-3.41	8.90	-2.17	-3.93	-0.22
Prothonotary Warbler^A	4.54	0.30	9.52	-2.58	-9.60	4.70
Purple Martin	1.66	-1.26	5.43	-2.23	-5.04	0.18
Red-bellied Woodpecker	1.24	0.13	2.31	2.79	1.91	3.66
Red-eyed Vireo	1.27	-0.24	2.72	0.14	-0.32	0.59
Red-tailed Hawk	0.61	-0.79	1.92	2.19	0.37	3.89
Red-winged Blackbird	-1.52	-2.12	-0.94	-0.97	-1.74	-0.19
Ring-necked Pheasant	-2.29	-5.21	0.73	-5.78	-8.13	-3.25
Rock Dove	-2.41	-3.64	-0.99	-1.04	-2.86	0.59
Ruby-throated Hummingbird	1.49	-1.60	3.72	0.50	-1.13	1.94
Savannah Sparrow	-6.47	-9.50	-3.62	-3.93	-5.48	-2.45
Scarlet Tanager	-0.09	-3.48	2.87	-0.22	-1.09	0.71
Song Sparrow	-2.20	-3.10	-1.31	-1.43	-2.00	-0.92
Spotted Sandpiper	2.19	-4.67	9.83	-5.66	-9.81	-1.09
Summer Tanager	4.30	2.16	6.21	-1.72	-3.83	0.38
Tree Swallow	4.35	1.29	7.54	5.37	3.53	7.41
Tufted Titmouse	2.65	1.19	4.16	1.02	0.30	1.79
Turkey Vulture	6.42	4.08	8.31	3.74	1.82	5.57
Vesper Sparrow ^B	0.45	-1.60	2.70	-7.31	-10.39	-4.51
Warbling Vireo	-0.13	-1.39	1.06	0.34	-1.15	1.58
White-breasted Nuthatch	1.63	-0.33	3.43	2.03	0.61	3.35
White-eyed Vireo	1.06	-2.20	3.95	1.90	0.59	3.47
Wild Turkey	8.42	3.95	12.81	6.03	2.85	9.44
Willow Flycatcher	-0.44	-2.14	1.19	-1.42	-3.03	0.09
Wood Duck	3.34	0.97	5.88	2.83	-0.44	6.10
Wood Thrush^A	1.81	-0.16	4.02	-1.17	-1.91	-0.44
Worm-eating Warbler	2.62	-21.05	18.02	1.34	-0.60	3.77
Yellow-billed Cuckoo	-0.74	-2.77	1.38	-3.14	-4.69	-1.42
Yellow-breasted Chat	-1.38	-3.85	0.62	-1.60	-2.67	-0.36
Yellow-throated Vireo	4.06	1.71	6.22	-0.02	-1.47	1.62
Yellow-throated Warbler	4.35	-0.48	12.07	1.31	-0.23	2.89
Yellow Warbler	1.00	-0.79	2.87	-2.27	-3.31	-1.25

^A Species of conservation concern for either or both the Eastern Tallgrass Prairie and Appalachian Mountains bird conservation regions (U.S. Fish and Wildlife Service 2008; also in bold).

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

Appendix F. Habitat Parameters

Tables F1 through F3 show the averages for habitat parameters in three different sized plots in the habitat at Hopewell Culture National Historical Park, Ohio, during the bird breeding seasons in 2005 to 2007, 2011, 2015, and 2019.

Table F1. Average percent cover ($\pm$ std dev) of each habitat type in 50-m-radius plots at Hopewell Culture National Historical Park, Ohio, during the bird breeding seasons in 2005 to 2007, 2011, 2015, and 2019. 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	2005	2006	2007	2011	2015	2019
Lawn (%)	1.11 (± 4.00)	1.78 (± 4.80)	0.02 (± 0.10)	5.35 (± 18.02)	5.09 (± 15.21)	1.94 (± 7.67)
Old fields (%)	72.31 (± 40.51)	72.87 (± 37.94)	63.83 (± 40.46)	65.02 (± 41.24)	69.04 (± 41.93)	76.30 (± 38.88)
Shrub (%)	4.17 (± 18.87)	0.67 (± 2.92)	0	1.46 (± 7.35)	0.56 (± 2.89)	0.56 (± 2.89)
Woodland (%)	15.15 (± 32.74)	19.39 (± 34.85)	21.46 (± 37.25)	13.73 (± 29.09)	15.98 (± 31.22)	16.70 (± 33.55)
Trail (%)	0.11 (± 0.58)	0.11 (± 0.58)	0.11 (± 0.58)	0.42 (± 0.97)	0.28 (± 0.80)	0.11 (± 0.58)
Pasture road (%)	0.13 (± 0.58)	1.35 (± 4.01)	0.26 (± 0.80)	0.06 (± 0.16)	0.02 (± 0.10)	0.13 (± 0.58)
Paved road (%)	0	2.06 (± 7.66)	0.59 (± 2.88)	0.35 (± 0.98)	2.06 (± 7.66)	0.78 (± 2.95)
Stream (%)	1.41 (± 7.21)	0.78 (± 2.95)	0.02 (± 0.10)	0.25 (± 0.82)	0.24 (± 0.80)	0.04 (± 0.13)

Table F2. 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 habitat at Hopewell Culture National Historical Park, Ohio during the bird breeding seasons in 2005 to 2007, 2011, 2015, and 2019. 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	2005	2006	2007	2011	2015	2019
Canopy cover	Hardwood (%)	22.03 ($\pm$ 40.81)	25.02 ($\pm$ 43.13)	19.50 ($\pm$ 36.65)	15.41 ($\pm$ 30.62)	20.66 ($\pm$ 35.42)	19.98 ($\pm$ 36.50)
	Total cover (%)	22.03 ($\pm$ 40.81)	25.02 ($\pm$ 43.13)	19.50 ($\pm$ 36.65)	15.41 ($\pm$ 30.62)	20.66 ($\pm$ 35.42)	19.98 ($\pm$ 36.50)
Canopy height	Hardwood (m)	3.44 ($\pm$ 7.44)	3.73 ($\pm$ 6.96)	2.26 ($\pm$ 5.04)	5.43 ($\pm$ 9.04)	5.19 ($\pm$ 11.06)	4.59 ($\pm$ 10.41)
Basal area	Hardwood (m ² /ha)	4.91 ($\pm$ 11.9)	4.72 ($\pm$ 11.5)	2.50 ($\pm$ 6.43)	4.81 ($\pm$ 12.02)	3.52 ($\pm$ 8.70)	5.93 ($\pm$ 12.54)
	Total (m ² /ha)	4.91 ($\pm$ 11.9)	4.72 ($\pm$ 11.5)	2.50 ($\pm$ 6.43)	4.81 ($\pm$ 12.02)	3.52 ($\pm$ 8.70)	5.93 ($\pm$ 12.54)
Horizontal vegetation profile—measured at 15 m north of plot center (percent cover at different height increments)	0.00–0.25 m (%)	–	–	–	84.75 ($\pm$ 29.65)	77.61 ($\pm$ 34.07)	89.17 ($\pm$ 21.42)
	0.00–0.50 m (%)	97.04 ($\pm$ 2.41)	94.44 ($\pm$ 15.88)	95.28 ($\pm$ 11.55)	–	–	–
	0.25–0.50 m (%)	–	–	–	79.81 ($\pm$ 35.96)	50.93 ($\pm$ 43.51)	77.50 ($\pm$ 35.40)
	0.25–0.75 m (%)	90.00 ($\pm$ 20.02)	89.54 ($\pm$ 24.67)	90.83 ($\pm$ 24.11)	–	–	–
	0.50–0.75 m (%)	–	–	–	67.98 ($\pm$ 37.34)	25.57 ($\pm$ 37.74)	41.02 ($\pm$ 38.13)
	0.50–1.25 m (%)	73.46 ($\pm$ 36.16)	70.57 ($\pm$ 32.80)	70.67 ($\pm$ 37.09)	–	–	–
	0.75–1.00 m (%)	–	–	–	43.10 ($\pm$ 35.58)	13.91 ($\pm$ 32.49)	19.82 ($\pm$ 30.40)
	0.75–1.25 m (%)	47.28 ($\pm$ 41.88)	34.54 ($\pm$ 39.39)	32.41 ($\pm$ 36.76)	–	–	–
	1.00–1.25 m (%)	–	–	–	23.27 ($\pm$ 34.44)	10.39 ($\pm$ 29.95)	11.95 ($\pm$ 24.62)
	1.00–1.50 m (%)	21.87 ($\pm$ 35.48)	14.44 ($\pm$ 32.27)	13.48 ($\pm$ 31.30)	–	–	–
	1.25–1.50 m (%)	–	–	–	10.77 ($\pm$ 30.48)	7.80 ($\pm$ 26.02)	12.87 ($\pm$ 29.09)
	1.25–1.75 m (%)	14.70 ($\pm$ 30.26)	13.46 ($\pm$ 31.31)	14.00 ($\pm$ 34.22)	–	–	–
	1.50–1.75 m (%)	–	–	–	10.77 ($\pm$ 30.48)	7.22 ($\pm$ 26.02)	13.60 ($\pm$ 30.62)
	1.50–2.00 m (%)	13.26 ($\pm$ 31.39)	11.61 ($\pm$ 29.78)	12.22 ($\pm$ 31.56)	–	–	–
	1.75–2.00 m (%)	–	–	–	10.77 ($\pm$ 30.48)	7.22 ($\pm$ 26.02)	10.83 ($\pm$ 28.40)
Vertical structure diversity (%)	n/a	18.34 ($\pm$ 15.10)	17.27 ($\pm$ 12.69)	19.50 ($\pm$ 16.03)	17.31 ($\pm$ 14.87)	14.81 ($\pm$ 11.74)	17.80 ($\pm$ 15.71)

Table F3. Average ($\pm$ std dev) soil substrate percent cover and plant guild percent cover cover in 1.78-m-radius sample plots in habitat at Hopewell Culture National Historical Park, Ohio during the bird breeding seasons in 2005 to 2007, 2011, 2015, and 2019. 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	2005	2006	2007	2011	2015	2019
Deciduous litter (%)	6.83 ($\pm$ 17.76)	7.80 ($\pm$ 20.71)	1.74 ($\pm$ 7.19)	4.25 ($\pm$ 10.59)	5.48 ($\pm$ 14.11)	10.35 ($\pm$ 21.36)
Grass litter (%)	22.22 ($\pm$ 26.89)	18.17 ($\pm$ 21.66)	23.04 ($\pm$ 17.99)	19.64 ($\pm$ 23.62)	12.87 ($\pm$ 14.42)	39.48 ($\pm$ 30.02)
Bare soil (%)	58.37 ($\pm$ 27.91)	63.26 ($\pm$ 23.49)	32.78 ($\pm$ 17.51)	30.31 ($\pm$ 27.38)	14.76 ($\pm$ 25.02)	19.43 ($\pm$ 21.60)
Rock (%)	1.39 ($\pm$ 7.22)	1.63 ($\pm$ 3.89)	0.20 ($\pm$ 0.59)	0.04 ($\pm$ 0.14)	0	0.04 ($\pm$ 0.13)
Woody debris (%)	0.96 ($\pm$ 2.96)	0.93 ($\pm$ 2.97)	0.17 ($\pm$ 0.59)	3.25 ($\pm$ 12.45)	4.26 ($\pm$ 10.38)	1.02 ($\pm$ 3.00)
Unvegetated (%)	86.57 ($\pm$ 8.86)	78.33 ($\pm$ 10.47)	85.93 ($\pm$ 3.34)	54.52 ($\pm$ 18.84)	43.37 ($\pm$ 29.80)	70.93 ($\pm$ 12.52)
Warm-season grass (%)	0.02 ($\pm$ 0.10)	0.17 ($\pm$ 0.59)	0.89 ($\pm$ 1.04)	2.40 ($\pm$ 12.26)	2.69 ($\pm$ 8.02)	3.33 ($\pm$ 10.26)
Cool-season grass (%)	20.89 ($\pm$ 25.49)	25.61 ($\pm$ 24.29)	15.70 ($\pm$ 13.21)	26.31 ($\pm$ 24.52)	24.72 ($\pm$ 23.92)	37.5 ($\pm$ 29.69)
Forb (%)	20.54 ($\pm$ 20.22)	30.89 ($\pm$ 21.94)	8.00 ($\pm$ 8.39)	48.58 ($\pm$ 20.57)	32.28 ($\pm$ 19.48)	38.89 ($\pm$ 20.10)
Moss and lichen (%)	0	4.19 ($\pm$ 5.41)	0	0.73 ($\pm$ 2.92)	0.41 (0.95)	0.89 ($\pm$ 2.98)
Woody shrub and vine (%)	4.19 ($\pm$ 12.31)	1.80 ($\pm$ 4.01)	0.61 ($\pm$ 2.88)	8.92 ($\pm$ 18.79)	2.91 ($\pm$ 7.98)	6.80 ($\pm$ 12.25)
Tree seedling (%)	2.57 ($\pm$ 11.99)	2.82 ($\pm$ 10.00)	0.22 ($\pm$ 0.59)	0.31 ($\pm$ 0.81)	0.28 ($\pm$ 0.80)	1.57 ($\pm$ 4.02)
Total foliar (%)	45.65 ($\pm$ 20.94)	59.35 ($\pm$ 17.84)	45.19 ($\pm$ 16.17)	74.71 ($\pm$ 15.75)	60.02 ($\pm$ 25.88)	75.37 ($\pm$ 16.45)

Appendix G. Trees Found on Hopewell Culture National Historical Park

Table G1. Stems per hectare of trees found on Hopewell Culture National Historical Park, Ohio, by size class, during the 2005 through 2007, 2011, 2015, and 2019 bird breeding seasons. Stems per hectare of trees are reported by family.

Stem Size Class (cm diameter)	Family	2005	2006	2007	2011	2015	2019
<1.0 cm	Aceraceae	160	57	14	64	14	57
	Caprifoliaceae	24	0	0	0	269	0
	Elaeagnaceae	9	0	0	20	66	99
	Hippocastanaceae	0	0	0	0	0	5
	Oleaceae	5	5	5	5	9	19
	Rosaceae	236	0	42	5	0	5
	Snag	9	14	0	0	0	80
	Ulmaceae	0	0	0	0	0	5
1.1–2.5 cm	Aceraceae	151	80	9	15	5	38
	Caprifoliaceae	85	52	5	0	19	0
	Elaeagnaceae	14	9	28	10	9	28
	Fabaceae	0	0	0	0	5	19
	Hippocastanaceae	0	0	5	0	0	24
	Juglandaceae	0	0	0	5	0	9
	Moraceae	0	0	0	5	0	0
	Oleaceae	5	9	9	24	0	24
	Rosaceae	42	207	94	118	9	0
	Snag	24	52	0	0	0	85
	Ulmaceae	0	0	5	5	0	14
2.6–8.0 cm	Aceraceae	85	85	19	29	28	75
	Betulaceae	5	0	0	0	0	0
	Caprifoliaceae	0	5	5	0	0	0
	Elaeagnaceae	99	104	28	5	5	28
	Fabaceae	0	5	0	0	0	0
	Hippocastanaceae	14	9	9	0	0	9
	Juglandaceae	14	9	9	0	5	5
	Moraceae	0	14	5	15	0	28
	Oleaceae	24	28	28	5	5	19
	Rosaceae	42	269	179	49	5	52
	Snag	24	33	19	10	14	52
	Tiliaceae	5	0	0	0	0	0
	Ulmaceae	28	24	5	15	0	24

Table G1 (continued). Stems per hectare of trees found on Hopewell Culture National Historical Park, Ohio, by size class, during the 2005 through 2007, 2011, 2015, and 2019 bird breeding seasons. Stems per hectare of trees are reported by family.

Stem Size Class (cm diameter)	Family	2005	2006	2007	2011	2015	2019
8.1–15.0 cm	Aceraceae	14	14	24	5	24	0
	Elaeagnaceae	0	5	9	0	0	0
	Fabaceae	0	0	0	0	9	0
	Hippocastanaceae	0	5	0	0	0	9
	Juglandaceae	5	0	19	0	0	5
	Moraceae	0	5	5	0	0	0
	Oleaceae	0	5	14	5	9	28
	Rosaceae	5	9	0	5	0	5
	Snag	0	14	14	0	9	9
	Tiliaceae	28	0	0	0	0	0
	Ulmaceae	24	14	14	29	33	33
15.1–23.0 cm	Aceraceae	9	0	9	5	0	0
	Juglandaceae	0	5	5	5	5	5
	Oleaceae	0	0	0	5	5	5
	Rosaceae	0	0	5	0	0	5
	Snag	0	5	14	5	19	19
	Tiliaceae	5	0	0	0	0	0
	Ulmaceae	5	9	0	5	9	5
23.1–38.0 cm	Aceraceae	0	5	5	0	0	0
	Juglandaceae	0	0	5	5	5	0
	Snag	5	0	5	5	5	0
	Ulmaceae	5	19	14	5	0	9
>38.0 cm	Aceraceae	5	9	5	0	0	0
	Platanaceae	0	0	0	0	0	9
	Snag	9	9	0	5	0	0
	Ulmaceae	5	5	0	0	0	0

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