



Bird Community Monitoring at Lincoln Boyhood National Memorial, Indiana

Status Report 2007–2019

Natural Resource Report NPS/HTLN/NRR—2020/2162



ON THE COVER

Sign at entrance to Lincoln Boyhood National Memorial
Photography by NPS, Heartland Network

Bird Community Monitoring at Lincoln Boyhood National Memorial, Indiana

Status Report 2007–2019

Natural Resource Report NPS/HTLN/NRR—2020/2162

David G. Peitz,¹ and Kathleen A. Kull²

¹National Park Service
Heartland Inventory and Monitoring Network
Wilson's Creek National Battlefield
6424 West Farm Road 182
Republic, Missouri 65738

²American Conservation Experience
Heartland Inventory and Monitoring Network
Wilson's Creek National Battlefield
6424 West Farm Road 182
Republic, Missouri 65738

Editing and Design by
Tani Hubbard

National Park Service &
Northern Rockies Conservation Cooperative
12661 E. Broadway Blvd.
Tucson, AZ 85748

July 2020

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols. This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from [the Heartland Inventory and Monitoring Network website](#), and the [Natural Resource Publications Management website](#). If you have difficulty accessing information in this publication, particularly if using assistive technology, please email irma@nps.gov.

Please cite this publication as:

Peitz, D. G., and K. A. Kull. 2020. Bird community monitoring at Lincoln Boyhood National Memorial, Indiana: Status report 2007–2019. Natural Resource Report NPS/HTLN/NRR—2020/2162. National Park Service, Fort Collins, Colorado. <https://doi.org/10.36967/nrr-2278006>.

Contents

Page

Figures iv

Tables iv

Appendices iv

Executive Summary v

Acknowledgments vi

Introduction 1

 Objectives 3

Methods 4

 Site Selection 4

 Bird Surveys 4

 Habitat Assessment 6

 Data Analysis 6

Results 10

 Bird Surveys 10

 Habitat Assessment 15

Discussion 16

Literature Cited 17

Figures

Page

Figure 1. Location of Lincoln Boyhood National Memorial (LIBO), Indiana, within the Central Hardwoods Bird Conservation Region. 1

Figure 2. Bird plot locations on Lincoln Boyhood National Memorial, Indiana. Vegetation mapping and classification provided by Diamond et al. (draft) 5

Figure 3. Comparison of bird population trends from habitats on Lincoln Boyhood National Memorial (LIBO), Indiana, (2007 and 2019, excluding 2008–2009) with those of the larger Central Hardwoods Bird Conservation Region (2005 through 2015; from Breeding Bird Surveys [BBS]). 13

Figure 4. Trends in bird community diversity, richness, and species distribution evenness for Lincoln Boyhood National Memorial, Indiana, between 2007 and 2019, excluding 2008 and 2009. 14

Tables

Page

Table 1. Number of plots sampled, and sampling dates for breeding bird surveys conducted at Lincoln Boyhood National Memorial, Indiana, by year. 4

Table 2. Bird species recorded during breeding bird surveys at Lincoln Boyhood National Memorial, Indiana, from 2007 through 2019. 10

Appendices

Page

Appendix A. Plots Sampled 19

Appendix B. Proportion of Upland Plots Occupied and Abundance (Corrected for Undetected Individuals) 20

Appendix C. Proportion of Plots Occupied and Abundance (Not Corrected for Undetected Individuals) 21

Appendix D. Park Trends 24

Appendix E. Regional Trends 25

Appendix F. Habitat Parameters 27

Appendix G. Trees Found on Lincoln Boyhood National Memorial 30

Executive Summary

Breeding bird surveys were initiated on Lincoln Boyhood National Memorial, Indiana, in 2007 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, on bird populations. Birds were sampled using point counts with 35 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.

Birds were surveyed on as many of the 35 variable circular plots as possible in 9 of the last 13 years, resulting in 180 plot visits. Surveys have yielded records for 82 different bird species. Sixty-five of the species recorded are classified as permanent or summer residents, fourteen are classified as migrants through the area, and three are classified as winter residents. Three species recorded are considered *species of conservation concern* for the Central Hardwoods Bird Conservation Region, the bird conservation region in which Lincoln Boyhood National Memorial is located. Five of the 65 resident species were recorded on Lincoln Boyhood National Memorial frequently enough to determine trends in their populations. With 82% of the 80.4 ha of park in various woodland types, it is not surprising that about 43 of the breeding bird species recorded utilize this habitat type.

Based on population trends, the bird community at Lincoln Boyhood National Memorial is faring similarly to the bird communities in the Central Hardwoods Bird Conservation Region as a whole. Stable diversity, richness, and evenness values suggest that the park's habitat has remained constant in terms of its ability to meet the needs of many bird species, and the habitat currently present provides for the somewhat rich array of breeding species annually. However, this species-rich community structure could be altered if significant portions of the park's woodlands were removed, or some of the less common habitats were lost.

Acknowledgments

We would like to thank the staff of Lincoln Boyhood National Memorial, Indiana, for allowing us access to the park during our breeding bird surveys. We would especially like to thank Paula Alexander for her coordination of surveys with volunteers. A debt of thanks is owed volunteer birders J. K. Thompson and A. R. Steeples for conducting many of the surveys on the park.

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 also critical as widespread habitat loss to agriculture and urban and industrial development threaten the integrity of the region for birds.

Lincoln Boyhood National Memorial, Indiana, is located in the Central Hardwoods Bird Conservation Region (Figure 1). This 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 long-term health of North America's native bird populations (NABCI 2019).

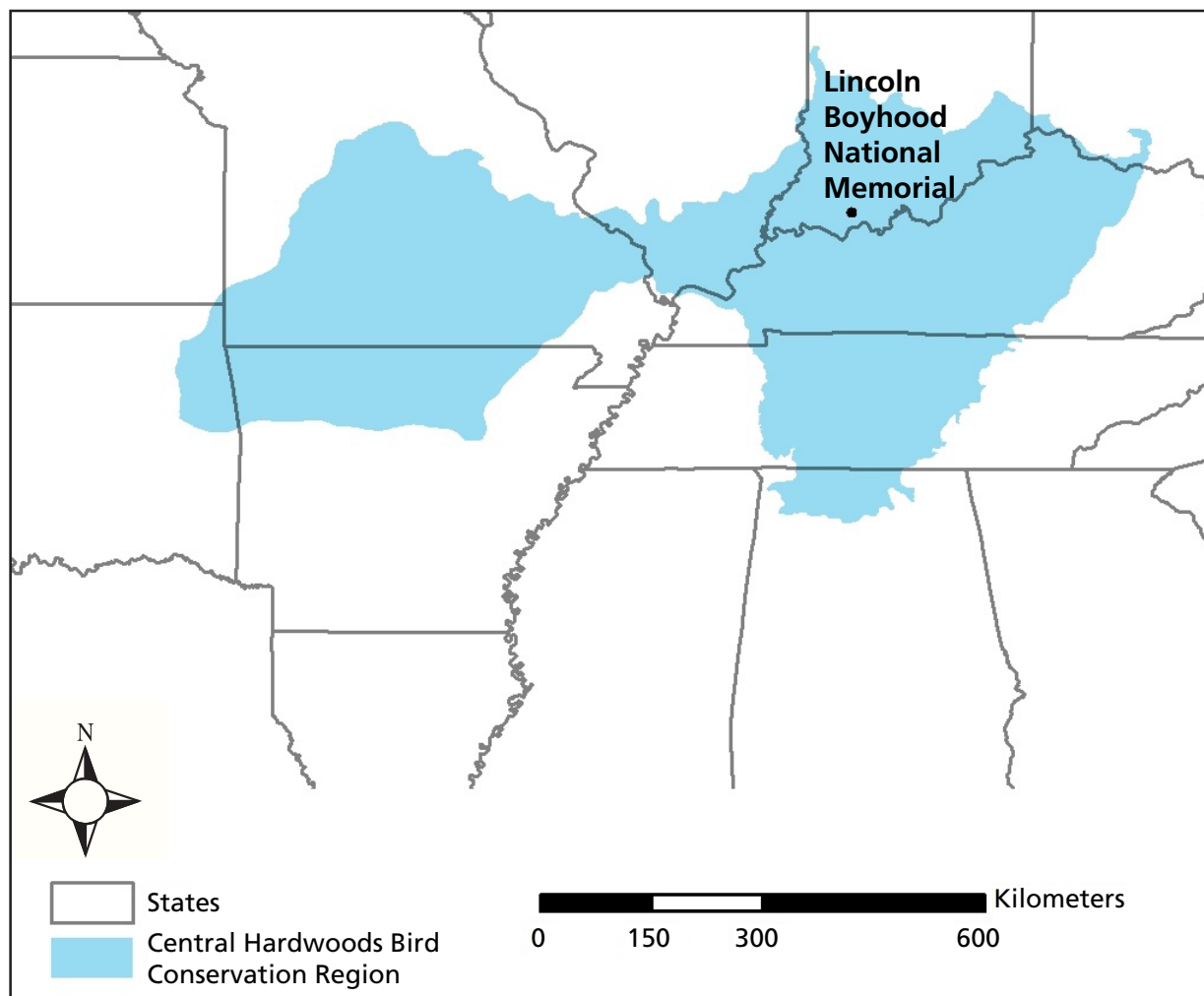


Figure 1. Location of Lincoln Boyhood National Memorial (LIBO), Indiana, within the Central Hardwoods Bird Conservation Region.

Lincoln Boyhood National Memorial lies in the Interior Low Plateaus section of the Central Hardwoods Bird Conservation Region (NABCI 2019). The area is dominated by an oak-hickory deciduous forest inhabited by interior forest species, such as Cerulean Warbler (*Setophaga cerulea*), Worm-eating Warbler (*Helmitheros vermivorum*), and Louisiana Waterthrush (*Parkesia motacilla*). The region includes some of the most extensive forests in the middle of the continent and is probably a source for populations of these birds for many surrounding areas. Threats to the region include deforestation for agriculture and urbanization. High priority birds of the region include Bald Eagle (*Haliaeetus leucocephalus*), Peregrine Falcon (*Falco peregrinus*), Black Rail (*Laterallus jamaicensis*), Eastern Whip-poor-will (*Antrostomus vociferus*), Red-headed Woodpecker (*Melanerpes erythrocephalus*), Loggerhead Shrike (*Lanius ludovicianus*), Bell's Vireo (*Vireo bellii*), Brown-headed Nuthatch (*Sitta pusilla*), Bewick's Wren (*Thryomanes bewickii*), Sedge Wren (*Cistothorus platensis*), Wood Thrush (*Hylocichla mustelina*), Blue-winged Warbler (*Vermivora cyanoptera*), Prairie Warbler (*Setophaga discolor*), Cerulean Warbler, Worm-eating Warbler, Swainson's Warbler (*Limnithlypis swainsonii*), Kentucky Warbler (*Geothlypis formosus*), Bachman's Sparrow (*Peucaea aestivalis*), Henslow's Sparrow

(*Ammodramus henslowii*), and Painted Bunting (*Passerina ciris*; U.S. Fish and Wildlife Service 2008). Approximately 119 species of breeding birds can be found in the habitat of the Central Hardwoods Bird Conservation Region around Lincoln Boyhood National Memorial (Mumford and Keller 1984).

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 Lincoln Boyhood National Memorial show evidence of long-term population decline (Sauer et al. 2017). In fact, 43% of the species have populations reported to be in decline within the Central Hardwoods Bird Conservation Region, with species such as the Chimney Swift (*Chaetura pelagica*), Common Grackle (*Quiscalus quiscula*), House Sparrow (*Passer domesticus*), and Northern Bobwhite (*Colinus virginianus*) declining at alarming rates.

We will use long-term trends in the composition and abundance of bird populations as indicators of ecosystem integrity at Arkansas Post National Memorial. 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



Louisiana Waterthrushes (*Parkesia motacilla*) live in the oak-hickory forests at Lincoln Boyhood National Memorial. NPS

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 Lincoln Boyhood National Memorial.

Objectives

There are two primary objectives for monitoring breeding birds at Lincoln Boyhood National Memorial:

- Identify significant temporal changes in the species composition and abundance of bird communities that occur on Lincoln Boyhood National Memorial 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 9 years of monitoring (2007–2019, excluding 2008–2010 and 2012).

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 35 permanent plots on Lincoln Boyhood National Memorial for monitoring bird population sizes and community composition (Figure 2). Monitoring occurred on 8 to 35 sites annually depending on the year (Table 1). In years when only 8 plots were sampled, it was the same 8 plots.

Starting in 2013, breeding bird monitoring was conducted by volunteers three out of every four years, allowing Heartland Inventory and Monitoring (I&M) Network to modify their sampling schedule to visit the park every fourth year. To facilitate this change, 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—2007, 2011, 2015 and 2019.

During bird surveys in 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 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.

Table 1. Number of plots sampled, and sampling dates for breeding bird surveys conducted at Lincoln Boyhood National Memorial, Indiana, by year. Also listed are observer(s) who conducted the surveys.

Year	Sampling Dates	Number of Plots Sampled	Observer(s)
2007	June 9 – June 10	35	D.G. Peitz*
2011	May 20 – May 21	35	D.G. Peitz*
2013	April 8	8	J.K. Thompson, A.R. Steeples
2014	May 1	8	J.K. Thompson, A.R. Steeples
2015	May 15 – May 16	35	D.G. Peitz*
2016	April 22	8	J.K. Thompson, A.R. Steeples
2017	May 8	8	J.K. Thompson, A.R. Steeples
2018	April 26	8	J.K. Thompson, A.R. Steeples
2019	May 17 – May 18	35	D.J. Marcum*

*Heartland I&M Network staff.

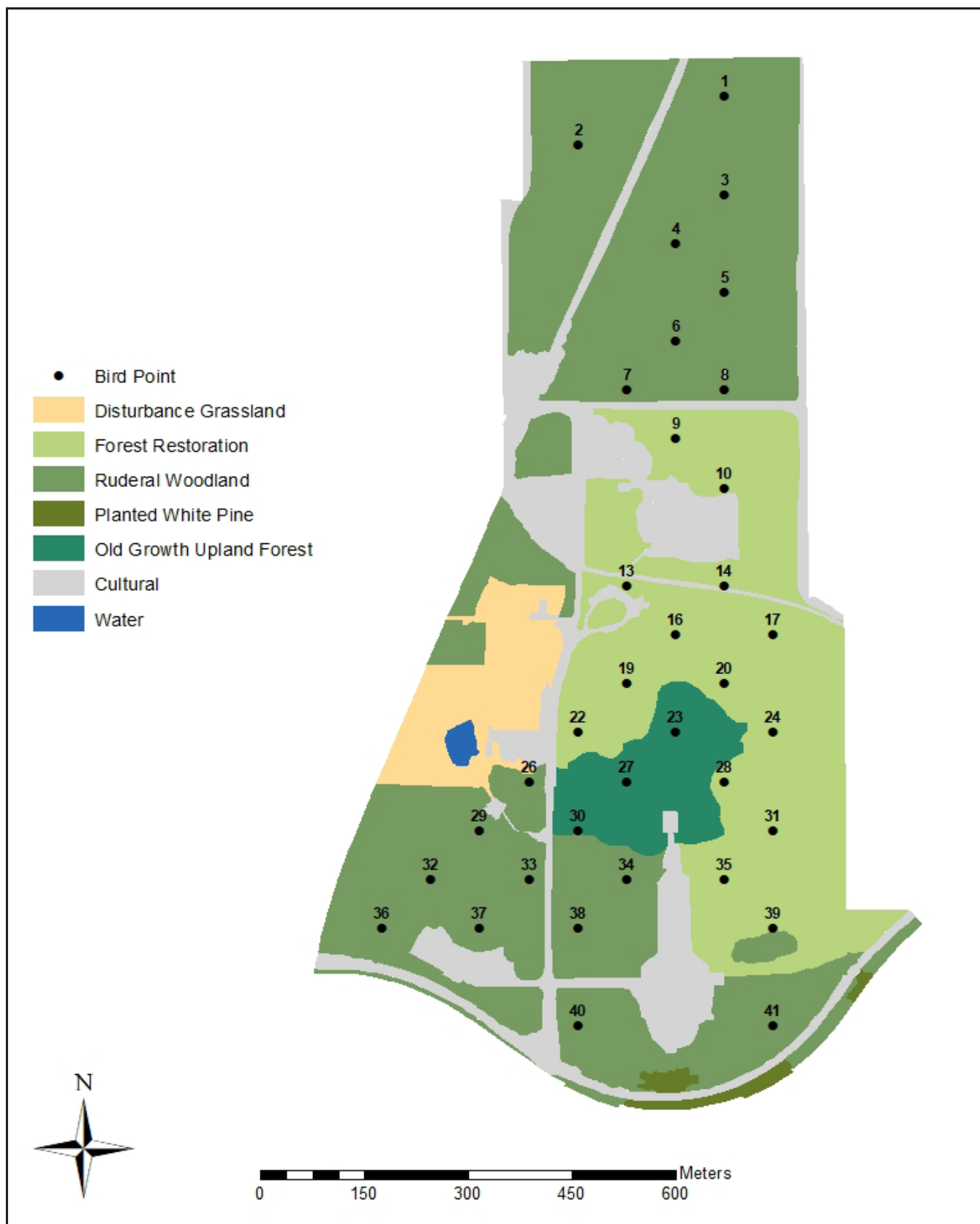


Figure 2. Bird plot locations on Lincoln Boyhood National Memorial, Indiana. Vegetation mapping and classification provided by Diamond et al. (draft)

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 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 various vegetation types (lawn, woodland, other) 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 meters above the 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 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. 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).

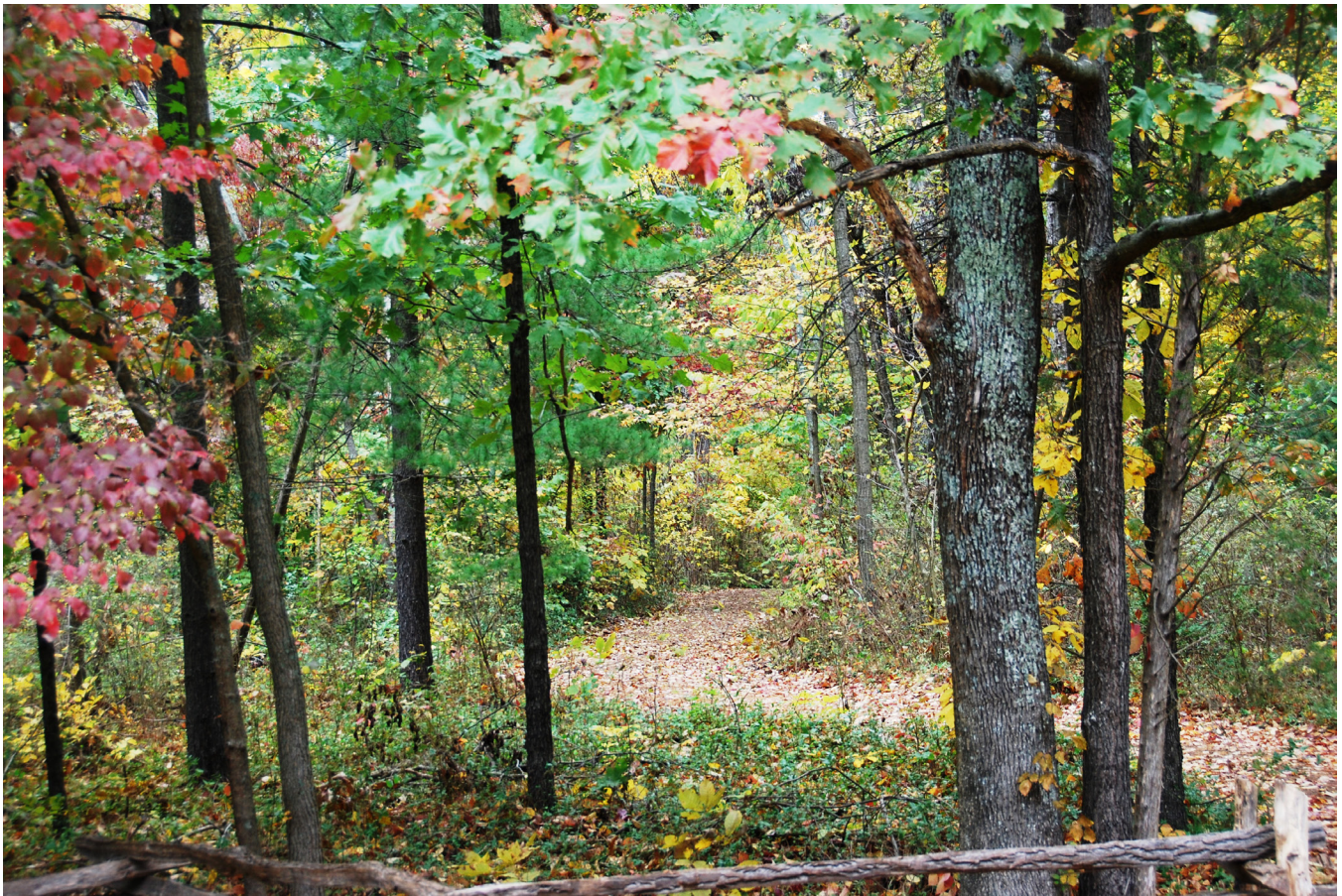
Data Analysis

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 Lincoln Boyhood National Memorial. 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 three species: Blue-gray Gnatcatcher (*Polioptila caerulea*), Eastern Wood-Pewee (*Contopus virens*), and Indigo Bunting (*Passerina cyanea*). The Uniform + Cosine function was chosen for two species: Northern Cardinal (*Cardinalis cardinalis*) and Tufted Titmouse (*Baeolophus bicolor*). Appendix B contains abundances for these species. 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 50-m radius (0.79 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.



Lincoln Boyhood National Memorial, Indiana. NPS

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. This software takes into account serial correlation in count data among years and overdispersion. Although TRIM has the capacity to estimate missing data, we restricted our regression analysis to the eight plots sampled in most years (Appendix D). By doing this we analyzed a consistent ratio of plots across years.

For this report, we also obtained regional breeding bird trends for the Central Hardwoods Bird Conservation Region 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 11-year period of available data to maximize the accuracy of regional trend results without going beyond the sampling period at Lincoln Boyhood National Memorial.

We compared regional trends with those calculated using TRIM for Lincoln Boyhood National Memorial (Figure 3). Regional trends with a confidence interval that straddled zero were classified as uncertain for comparison with results from Lincoln Boyhood National Memorial. 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 application EstimateS (Colwell 2013) was used to calculate the ACE and ICE estimators.



Red-headed Woodpecker (*Melanerpes erythrocephalus*) is a species of conservation concern for the Central Hardwoods Bird Conservation Region and a year-round resident on Lincoln Boyhood National Memorial. NPS

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). In 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 2007 on Lincoln Boyhood National Memorial, as many of the 35 variable circular plots as possible were sampled in each of the 9 survey years (there were no surveys in 2008–2010 and 2012), resulting in a total of 181 plot visits (Table 1). Eighty-two species were recorded during surveys (Table 2). Sixty-five of the 82 species recorded are classified as permanent or summer

residents (Mumford and Keller 1984). Fourteen species are classified as migrants through the area, and three species are classified as winter residents. Three species recorded—Kentucky Warbler (*Geothlypis formosa*), Red-headed Woodpecker (*Melanerpes erthrocephalus*), and Wood Thrush (*Hylocichla mustelina*)—are considered species of conservation concern for the Central Hardwoods Bird Conservation Region (U.S. Fish and Wildlife Service 2008).

Table 2. Bird species recorded during breeding bird surveys at Lincoln Boyhood National Memorial, Indiana, from 2007 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	<i>Empidonax virescens</i>	ACFL	SR
American Crow	<i>Corvus brachyrhynchos</i>	AMCR	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
Barred Owl	<i>Strix varia</i>	BDOW	R
Bay-breasted Warbler	<i>Setophaga castanea</i>	BBWA	M
Black-and-white Warbler	<i>Mniotilta varia</i>	BAWW	M
Black-billed Cuckoo ^B	<i>Coccyzus erythrophthalmus</i>	BBCU	SR
Blackburnian Warbler	<i>Setophaga fusca</i>	BLBW	M
Black-capped Chickadee	<i>Poecile atricapillus</i>	BCCH	WR
Blackpoll Warbler	<i>Setophaga striata</i>	BLPW	M
Black Vulture ^B	<i>Coragyps atratus</i>	BLVU	SR
Blue-gray Gnatcatcher	<i>Poliophtila caerulea</i>	BGGN	SR
Blue Grosbeak ^B	<i>Passerina caerulea</i>	BLGR	SR
Blue Jay	<i>Cyanocitta cristata</i>	BLJA	R
Brown-headed Cowbird	<i>Molothrus ater</i>	BHCO	R
Carolina Chickadee	<i>Poecile carolinensis</i>	CACH	R
Carolina Wren	<i>Thryothorus ludovicianus</i>	CARW	R
Cedar Waxwing ^B	<i>Bombicilla cedrorum</i>	CEDW	R
Chestnut-sided Warbler	<i>Setophaga pensylvanica</i>	CSWA	M
Chimney Swift	<i>Chaetura pelagica</i>	CHSW	SR

^A Residency: M = late migrant; SR = summer resident; R = year-round resident; WR = winter resident according to Mumford and Keller (1984).

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

^C Species of conservation concern for the Central Hardwoods Bird Conservation Region (U.S. Fish and Wildlife Service 2008; also in bold).

Table 2 (continued). Bird species recorded during breeding bird surveys at Lincoln Boyhood National Memorial, Indiana, from 2007 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
Chipping Sparrow	<i>Spizella passerine</i>	CHSP	SR
Common Grackle	<i>Quiscalus quiscula</i>	COGR	R
Common Yellowthroat	<i>Geothlypis trichas</i>	COYE	SR
Downy Woodpecker	<i>Picoides pubescens</i>	DOWO	R
Eastern Bluebird	<i>Sialis sialis</i>	EABL	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
Gray Catbird	<i>Dumetella carolinensis</i>	GRCA	R
Great Crested Flycatcher	<i>Myiarchus crinitus</i>	GCFL	SR
Golden-winged Warbler	<i>Vermivora chrysoptera</i>	GWWA	M
Hairy Woodpecker	<i>Picoides villosus</i>	HAWO	R
Hooded Warbler	<i>Setophaga citrina</i>	HOWA	SR
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^C	<i>Geothlypis Formosa</i>	KEWA	SR
Killdeer	<i>Charadrius vociferous</i>	KILL	R
Louisiana Waterthrush	<i>Parkesia motacilla</i>	LOWA	SR
Magnolia Warbler	<i>Setophaga magnolia</i>	MAWA	M
Mississippi Kite ^B	<i>Ictinia mississippiensis</i>	MIKI	M
Mourning Dove	<i>Zenaida macroura</i>	MODO	R
Nashville Warbler	<i>Leiostyris alpestris</i>	NAWA	M
Northern Bobwhite	<i>Colinus virginianus</i>	NOBO	R
Northern Cardinal	<i>Cardinalis cardinalis</i>	NOCA	R
Northern Flicker	<i>Colaptes auratus</i>	YSFL	R
Northern Mockingbird	<i>Mimus polyglottos</i>	NOMO	R
Northern Parula	<i>Setophaga Americana</i>	NOPA	SR
Ovenbird	<i>Seiurus aurocapilla</i>	OVEN	SR
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

^A Residency: M = late migrant; SR = summer resident; R = year-round resident; WR = winter resident according to Mumford and Keller (1984).

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

^C Species of conservation concern for the Central Hardwoods Bird Conservation Region (U.S. Fish and Wildlife Service 2008; also in bold).

Table 2 (continued). Bird species recorded during breeding bird surveys at Lincoln Boyhood National Memorial, Indiana, from 2007 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
Red-headed Woodpecker^C	<i>Melanerpes erthrocephalus</i>	RHWO	R
Red-tailed Hawk	<i>Buteo jamaicensis</i>	RTHA	R
Red-winged Blackbird	<i>Agelaius phoeniceus</i>	RWBL	R
Rose-breasted Grosbeak	<i>Pheucticus ludovicianus</i>	RBGR	M
Ruby-throated Hummingbird	<i>Archilochus colubris</i>	RTHU	SR
Scarlet Tanager	<i>Piranga olivacea</i>	SCTA	SR
Sharp-shinned Hawk	<i>Accipiter striatus</i>	SSHA	R
Song Sparrow	<i>Melospiza melodia</i>	SOSP	R
Summer Tanager	<i>Piranga rubra</i>	SUTA	SR
Swainson's Thrush	<i>Catharus ustulatus</i>	SWTH	M
Tennessee Warbler	<i>Leiothlypis peregrine</i>	TEWA	M
Tufted Titmouse	<i>Baeolophus bicolor</i>	TUTI	R
Turkey Vulture	<i>Cathartes aura</i>	TUVU	R
Veery	<i>Catharus fuscescens</i>	VEER	M
White-breasted Nuthatch	<i>Sitta carolinensis</i>	WBNU	R
White-eyed Vireo	<i>Vireo griseus</i>	WEVI	SR
White-throated Sparrow	<i>Zonotrichia albicollis</i>	WTSP	WR
Wild Turkey ^B	<i>Meleagris gallopavo</i>	WITU	R
Wood Thrush^C	<i>Hylocichla mustelina</i>	WOTH	SR
Yellow-bellied Sapsucker	<i>Sphyrapicus varius</i>	YBSA	WR
Yellow-billed Cuckoo	<i>Coccyzus americanus</i>	YBCU	SR
Yellow-rumped Warbler	<i>Setophaga coronate</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 petechial</i>	YEWA	SR

^A Residency: M = late migrant; SR = summer resident; R = year-round resident; WR = winter resident according to Mumford and Keller (1984).

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

^C Species of conservation concern for the Central Hardwoods Bird Conservation Region (U.S. Fish and Wildlife Service 2008; also in bold).

Five breeding species on Lincoln Boyhood National Memorial were observed in sufficient numbers to calculate annual abundances with some degree of confidence (Appendix B). These five species offer the best opportunities for monitoring the influence of changing habitats on bird species within the park. Four of these species—Blue-gray Gnatcatcher (*Poliophtila caerulea*), Eastern Wood-pewee (*Contopus virens*), Indigo Bunting (*Passerina cyanea*), and Tufted Titmouse (*Baeolophus bicolor*)—have

stable populations (Figure 3 and Appendix D). One species—Northern Cardinal (*Cardinalis cardinalis*)—has an increasing population. None of the abundant species observed have a declining population. Three breeding species recorded—Blue-gray Gnatcatcher, Eastern Wood-pewee, and Northern Cardinal—have stable population trends within the larger Central Hardwoods Bird Conservation Region for the period of 2005 to 2015 (roughly coinciding with the surveys on Lincoln Boyhood National Memorial;

Figure 3 and Appendix E). The population of Tufted Titmouse was increasing region-wide, while the population of Indigo Bunting was declining during that same time period.

For the bird community on Lincoln Boyhood National Memorial, diversity ($P = 0.99$), richness ($P = 0.86$), and evenness ($P = 0.97$) in distribution of individuals across species in the breeding bird community were unchanged over the nine monitoring years since 2007 (Figure 4). Richness averaged 23 species

annually. Average estimated species richness was 31 by the ACE estimator and 34 by the ICE estimator. However, these results should be interpreted with caution as inter-annual variability in the number of plots sampled and observers undoubtedly influenced these metrics. For example, diversity and richness were consistently higher for years when 35 plots were sampled by trained observers when compared to years when only eight plots were sampled by volunteers.

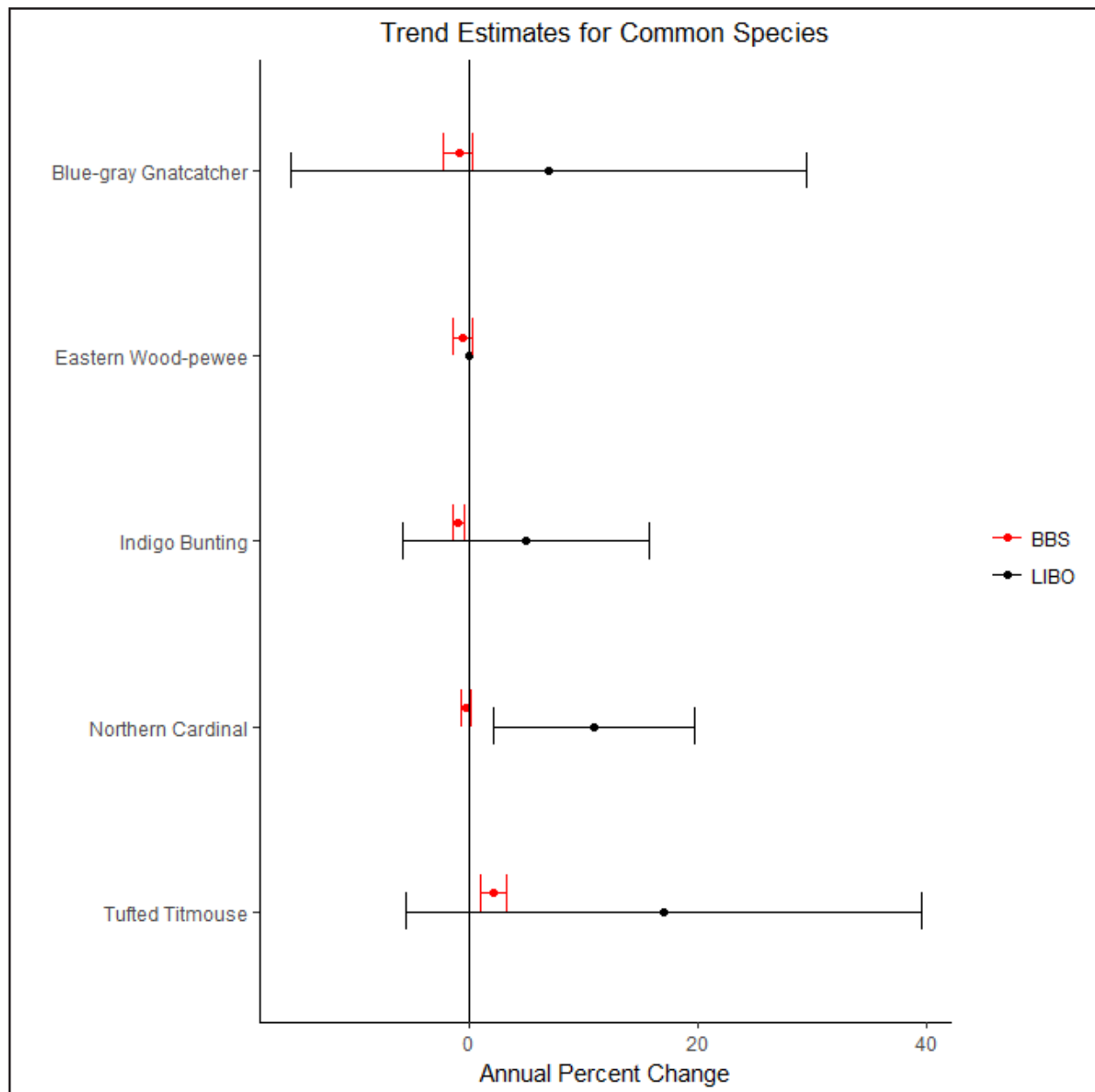


Figure 3. Comparison of bird population trends from habitats on Lincoln Boyhood National Memorial (LIBO), Indiana, (2007 and 2019, excluding 2008–2009) with those of the larger Central Hardwoods Bird Conservation Region (2005 through 2015; from Breeding Bird Surveys [BBS]). Error bars represent 95% confidence intervals.

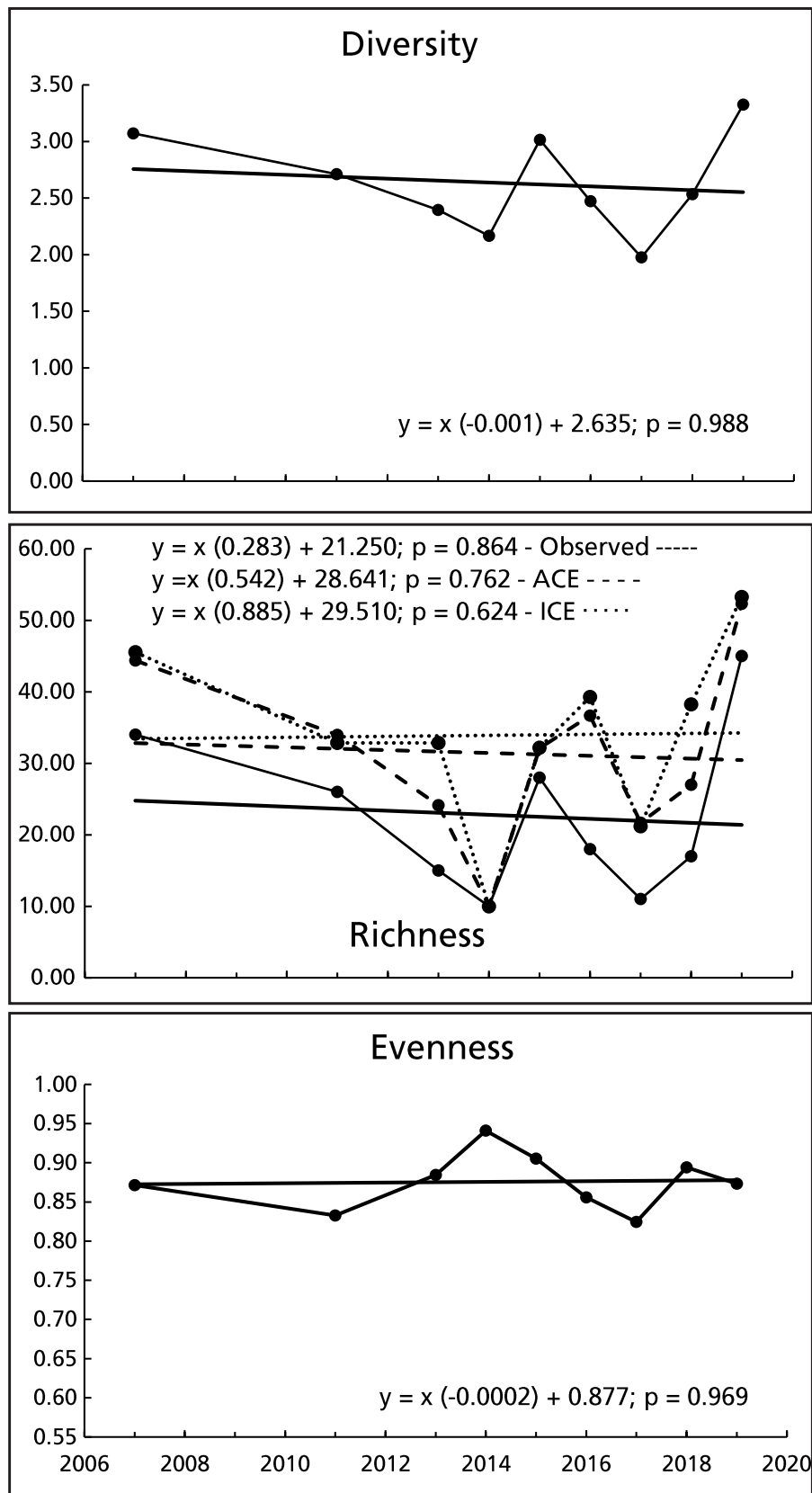


Figure 4. Trends in bird community diversity, richness, and species distribution evenness for Lincoln Boyhood National Memorial, Indiana, between 2007 and 2019, excluding 2008 and 2009.

Habitat Assessment

When sampled, habitat plots consisted primarily of the woodland type (77–94%), with lesser amounts of other types present (Appendix F). Total canopy cover averaged 85–97% on plots, with cover provided mostly by hardwood trees (84–97%). Basal area of hardwood trees averaged 14.29–25.93 m²/ha, and canopy height averaged 22.31–30.77 m. Hardwood tree species greater than 15.1 cm in diameter from 15 different families contributed primarily to the canopy cover and basal area (Appendix G). However, most of the largest trees occurred in the Aceraceae (maples), Magnoliaceae (magnolias), and Platanaceae (sycamore) families. Canopy cover of conifers averaged <1% on plots. Basal area of conifer trees averaged <1 m²/ha, and canopy height averaged 0.00–1.18 m.

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

to early-June) was generally below 0.75 m, when sampled (Appendix F). However, it should be noted that horizontal vegetation cover was recorded in all profile height classes to 2.00 m. Average vertical structure diversity estimates across years ranged from 24–36% for plots. Plots were primarily unvegetated (83–88%) at ground level, with some bare soil (3–15%) exposed (Appendix F). Deciduous litter (39–78%) covered plots, with lesser amounts of woody debris (6–20%), rock (<1–1%), grass litter (<1%), and conifer litter (<1%) present. Foliar cover on plots was dominated by woody shrubs and vines (2–24%) and tree seedlings (2–13%), followed by forbs (4–9%), cool-season grasses (<1–3%), and mosses and lichens (<1–1%; Appendix F). Warm-season grasses were not recorded at the time of monitoring. Total foliar coverage averaged 19–47% across plots.



Blue-gray Gnatcatcher (*Poliophtila caerulea*) is a common summer resident at Lincoln Boyhood National Memorial. Its populations are stable on the park and in the Central Hardwoods Bird Conservation Region. NPS

Discussion

Breeding bird surveys that were initiated at Lincoln Boyhood National Memorial in 2007 assist the park in assessing the integrity of habitat through time. During the 10 monitoring years since 2007, 82 bird species were recorded. Sixty-five are permanent or summer residents to the area (Mumford and Keller 1984). Therefore, these 65 species have some value in characterizing the breeding bird community of Lincoln Boyhood National Memorial and the habitat they rely on. These 65 species represent approximately 57% of the breeding species known from the region (Mumford and Keller 1984). The three resident species on Lincoln Boyhood National Memorial that are species of conservation concern for the Central Hardwoods Bird Conservation Region—Kentucky Warbler (*Geothlypis formosa*), Red-headed Woodpecker (*Melanerpes erythrocephalus*), and Wood Thrush (*Hylocichla mustelina*)—should be given special consideration in natural resource management decisions.

With 82% of the 80.4 ha of park in various woodland types (Diamond et al. draft), properly managing this habitat for the approximately 43 bird species that breed in woodlands is of high importance. By doing so, management also benefits migrant woodland obligates on the park as well as a host of other species. All three species of conservation concern occur in the various woodland habitats on the park.

Comparing population trends on the park with regional trends for the Central Hardwoods Bird Conservation Region (Figure 3) suggests that the bird community at Lincoln Boyhood National Memorial is faring similarly to bird communities in the region

as a whole. The Blue-gray Gnatcatcher (*Polioptila caerulea*) and Eastern Wood-pewee (*Contopus virens*) have stable populations on both the park and within the region. The Indigo Bunting (*Passerina cyanea*) has a stable park population but a declining region-wide population, while the Tufted Titmouse (*Baeolophus bicolor*) has a stable park population and an increasing region-wide population. The final species with enough observations to calculate a park trend—Northern Cardinal (*Cardinalis cardinalis*)—is increasing on the park and stable region wide. Vegetation management decisions should consider the potential impacts to bird habitat, especially for the five most abundant species, as the effects of management on their population trends can be more readily identified. However, with only five out of sixty-five breeding species recorded in significant numbers to calculate population trends, the habitat requirements of all breeding birds on the park need consideration, especially the three species of conservation concern for the Central Hardwoods Bird Conservation Region.

Over the 13 years of bird monitoring on Lincoln Boyhood National Memorial, the stable diversity, richness, and evenness values suggest that the park's habitat has remained relatively unchanged (Figure 4). The habitat currently present provides for a number of breeding woodland species and habitat generalists (average of 23 bird species observed annually on the park). However, this species community structure could be altered if significant portions of the park's woodlands were removed or if some of the less common habitats were lost.

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.
- 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. draft. Vegetation mapping and classification of Lincoln Boyhood National Memorial, Indiana. National Park Service.
- Fancy, S. G. 1997. A new approach for analyzing bird densities from variable circular plot counts. *Pacific Science* 51:107–114.
- Gregory, R. D., J. Reif, L. Fornasari, I. J. Burfield, P. Chylarecki, A. Van Strien, P. Vorisek, F. D. R. Jiguet, and A. W. Gmelig Meyling. 2007. Population trends of widespread woodland birds in Europe. *Ibis* 149:78–97.
- ITIS (Integrated Taxonomic Information System). 2019. Integrated taxonomic information system. Available at <http://www.itis.gov> (accessed 12 August 2019).
- Karr, J. R., and D. R. Dudley. 1981. Ecological perspective on water quality goals. *Environmental Management* 5:55–68.
- Karr, J. R. 1991. Biological integrity: a long-neglected aspect of water resource management. *Ecological Applications* 1:66–84.
- 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, editors. Status and management of neotropical migratory birds. U.S. Forest Service General Technical Report RM-229.
- Mumford, R. E., and C. E. Keller. 1984. The birds of Indiana. Indiana University Press, Bloomington. 376pp.
- NABCI (North American Bird Conservation Initiative). 2019. North American bird conservation initiative. Available at <https://nabci-us.org/resources/bird-conservation-regions-map> (accessed 24 October 2019).
- Pannekoek, J., and A. J. Van Strien. 2005. TRIM 3.54 manual (TRENDS and Indices for Monitoring data). Statistics Netherlands, Voorburg, The Netherlands.
- 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/HTL/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.

- 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, MD.
- Shannon, C. E. 1949. The mathematical theory of communication. University of Illinois Press, Urbana, Illinois. 177 pp.
- U.S. Fish and Wildlife Service. 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.

Appendix A. Plots Sampled

Table A1. Plots sampled on Lincoln Boyhood National Memorial, Indiana, between 2007 and 2019 and gross habitat type. "Yes" indicates plot was sampled; "No" indicates it was not.

Plot	2007	2011	2013	2014	2015	2016	2017	2018	2019	Plot Type
LIBO1	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO2	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO3*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Woodland
LIBO4	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO5	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO6	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO7	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO8*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Woodland
LIBO9	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO10	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO13	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO14*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Woodland
LIBO16	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO17	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO19*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Woodland
LIBO20	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO22	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO23	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO24	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO26*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Woodland
LIBO27	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO28*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Woodland
LIBO29	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO30	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO31	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO32*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Woodland
LIBO33	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO34*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Woodland
LIBO35	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO36	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO37	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO38	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO39	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO40	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland
LIBO41	Yes	Yes	No	No	Yes	No	No	No	Yes	Woodland

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

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 Lincoln Boyhood National Memorial, Indiana, during the 2007, 2011, and 2013 through 2019 breeding 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)								
	2007 n=35	2011 n=35	2013 n=8	2014 n=8	2015 n=35	2016 n=8	2017 n=8	2018 n=8	2019 n=35
Blue-gray Gnatcatcher	0.23 (69)	0.29 (79)	0 (0)	0 (0)	0.31 (92)	0.25 (521)	0 (0)	0.13 (–)	0.69 (193)
Eastern Wood-pewee	0.20 (9)	0.17 (7)	0 (0)	0 (0)	0.23 (7)	0 (0)	0 (0)	0 (0)	0.91 (35)
Indigo Bunting	0.26 (30)	0.71 (84)	0 (0)	0 (0)	0.20 (26)	0 (0)	0.13 (0)	0 (0)	0.80 (105)
Northern Cardinal	0.54 (66)	0.26 (25)	0.63 (55)	0.63 (33)	0.40 (48)	0.75 (0)	0.75 (21)	0.88 (–)	0.89 (113)
Tufted Titmouse	0.31 (38)	0.34 (30)	0.88 (81)	0.63 (81)	0.40 (34)	0.25 (–)	0.75 (81)	0.63 (–)	0.77 (77)

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

Table C1. Annual proportion of plots occupied (includes flyovers) by year, and estimated abundance (determined using bird within 50-m of plot center) of breeding bird species at Lincoln Boyhood National Memorial, Indiana during the 2007, 2011, and 2013 through 2019 breeding bird surveys. 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)								
	2007 n=35	2011 n=35	2013 n=8	2014 n=8	2015 n=35	2016 n=8	2017 n=8	2018 n=8	2019 n=35
Acadian Flycatcher	0.06 (6)	0.09 (9)	0.13 (–)	0 (0)	0.03 (3)	0 (0)	0 (0)	0 (0)	0.71 (50)
American Crow	0.23 (12)	0.20 (44)	0 (0)	0 (0)	0.06 (6)	0.13 (0)	0 (0)	0.25 (0)	0.51 (3)
American Redstart	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (12)
American Robin	0.06 (3)	0.03 (3)	0.25 (26)	0 (0)	0.09 (3)	0.13 (52)	0.38 (–)	0.13 (–)	0.03 (–)
American Woodcock	0.03 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Baltimore Oriole	0 (0)	0.03 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Barred Owl	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (–)
Blue Jay	0.09 (–)	0.03 (–)	0.13 (13)	0.38 (26)	0.11 (–)	0.38 (–)	0.25 (–)	0.38 (–)	0.23 (9)
Brown-headed Cowbird	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.13 (13)	0 (0)	0.13 (0)	0.40 (44)
Carolina Chickadee	0.09 (3)	0.09 (6)	0.50 (52)	0.25 (26)	0.06 (9)	0.13 (–)	0 (0)	0 (0)	0.23 (21)
Carolina Wren	0.23 (3)	0.20 (14)	0.13 (26)	0.25 (–)	0.06 (3)	0 (0)	0 (0)	0.25 (13)	0.46 (12)
Chimney Swift	0.03 (–)	0 (0)	0 (0)	0 (0)	0.03 (–)	0 (0)	0 (0)	0 (0)	0.26 (–)
Chipping Sparrow	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (12)
Common Grackle	0.03 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Common Yellowthroat	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.09 (–)
Downy Woodpecker	0 (0)	0 (0)	0.13 (–)	0 (0)	0.03 (3)	0.13 (13)	0.13 (13)	0.13 (–)	0.34 (32)
Eastern Bluebird	0 (0)	0.03 (0)	0 (0)	0.50 (52)	0 (0)	0.13 (–)	0 (0)	0.13 (–)	0.03 (–)
Eastern Phoebe	0 (0)	0.03 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.03 (–)

* Species of conservation concern for the Central Hardwoods Bird Conservation Region (U.S. Fish and Wildlife Service 2008; also in bold).

Table C1 (continued). Annual proportion of plots occupied (includes flyovers) by year, and estimated abundance (determined using bird within 50-m of plot center) of breeding bird species at Lincoln Boyhood National Memorial, Indiana during the 2007, 2011, and 2013 through 2019 breeding bird surveys. 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)								
	2007 n=35	2011 n=35	2013 n=8	2014 n=8	2015 n=35	2016 n=8	2017 n=8	2018 n=8	2019 n=35
Eastern Towhee	0.03 (–)	0 (0)	0.25 (13)	0.25 (13)	0.14 (12)	0.13 (–)	0 (0)	0 (0)	0.11 (9)
Gray Catbird	0.06 (6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Great Crested Flycatcher	0.11 (6)	0.29 (27)	0 (0)	0 (0)	0.11 (12)	0 (0)	0 (0)	0 (0)	0.46 (21)
Hairy Woodpecker	0 (0)	0.03 (–)	0 (0)	0 (0)	0.03 (3)	0 (0)	0 (0)	0 (0)	0.11 (9)
Hooded Warbler	0 (0)	0 (0)	0 (0)	0 (0)	0.03 (3)	0 (0)	0 (0)	0 (0)	0 (0)
House Sparrow	0 (0)	0 (0)	0.13 (39)	0 (0)	0 (0)	0.25 (52)	0.13 (13)	0 (0)	0 (0)
House Wren	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (3)
Kentucky Warbler*	0.03 (3)	0 (0)	0 (0)	0 (0)	0.11 (9)	0 (0)	0 (0)	0 (0)	0.26 (15)
Killdeer	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.25 (–)	0.03 (–)
Louisiana Waterthrush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.03 (3)
Mourning Dove	0 (0)	0 (0)	0.13 (13)	0 (0)	0 (0)	0 (0)	0 (0)	0.13 (–)	0.20 (3)
Northern Bobwhite	0.03 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Northern Flicker	0 (0)	0 (0)	0.13 (13)	0 (0)	0 (0)	0.13 (13)	0 (0)	0 (0)	0.03 (3)
Northern Mockingbird	0 (0)	0.03 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.03 (–)
Northern Parula	0.09 (–)	0.11 (9)	0 (0)	0 (0)	0.14 (18)	0 (0)	0 (0)	0 (0)	0.26 (12)
Ovenbird	0.03 (–)	0.06 (3)	0 (0)	0.13 (13)	0 (0)	0 (0)	0 (0)	0 (0)	0.03 (–)
Pileated Woodpecker	0.06 (6)	0.09 (–)	0.38 (26)	0.13 (13)	0.06 (6)	0 (0)	0.13 (13)	0.13 (–)	0.37 (6)
Prothonotary Warbler	0.03 (3)	0 (0)	0 (0)	0.13 (13)	0 (0)	0 (0)	0 (0)	0.13 (–)	0 (0)
Purple Martin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (–)
Red-bellied Woodpecker	0.20 (9)	0.06 (–)	0.13 (13)	0.13 (13)	0.14 (9)	0.63 (–)	0.13 (–)	0.88 (–)	0.71 (44)

* Species of conservation concern for the Central Hardwoods Bird Conservation Region (U.S. Fish and Wildlife Service 2008; also in bold).

Table C1 (continued). Annual proportion of plots occupied (includes flyovers) by year, and estimated abundance (determined using bird within 50-m of plot center) of breeding bird species at Lincoln Boyhood National Memorial, Indiana during the 2007, 2011, and 2013 through 2019 breeding bird surveys. 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)								
	2007 n=35	2011 n=35	2013 n=8	2014 n=8	2015 n=35	2016 n=8	2017 n=8	2018 n=8	2019 n=35
Red-eyed Vireo	0.09 (12)	0 (0)	0 (0)	0 (0)	0.20 (18)	0 (0)	0 (0)	0 (0)	0.86 (71)
Red-headed Woodpecker*	0.06 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.13 (13)	0 (0)	0.06 (6)
Red-tailed Hawk	0 (0)	0.03 (3)	0 (0)	0.13 (–)	0 (0)	0 (0)	0 (0)	0.13 (–)	0.03 (3)
Red-winged Blackbird	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.13 (–)	0 (0)	0.13 (–)	0 (0)
Ruby-throated Hummingbird	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (15)
Scarlet Tanager	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.13 (13)	0 (0)	0 (0)	0.34 (21)
Sharp-shinned Hawk	0.03 (3)	0.03 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Song Sparrow	0 (0)	0 (0)	0.13 (13)	0 (0)	0 (0)	0.13 (–)	0 (0)	0 (0)	0.03 (–)
Summer Tanager	0.03 (3)	0.17 (6)	0 (0)	0 (0)	0.06 (3)	0 (0)	0 (0)	0 (0)	0.46 (27)
Turkey Vulture	0 (0)	0 (0)	0 (0)	0.25 (26)	0 (0)	0.50 (–)	0.25 (–)	0.13 (–)	0.06 (–)
White-breasted Nuthatch	0.17 (12)	0.06 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.14 (9)
White-eyed Vireo	0 (0)	0.03 (0)	0 (0)	0 (0)	0.03 (3)	0 (0)	0 (0)	0 (0)	0.06 (–)
Wood Thrush*	0.11 (3)	0 (0)	0 (0)	0 (0)	0.14 (6)	0 (0)	0 (0)	0 (0)	0.49 (24)
Yellow-billed Cuckoo	0.23 (–)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.29 (9)
Yellow-throated Vireo	0.11 (9)	0.23 (15)	0 (0)	0 (0)	0.17 (12)	0 (0)	0 (0)	0 (0)	0.14 (3)
Yellow-throated Warbler	0.03 (3)	0.03 (3)	0 (0)	0 (0)	0.03 (3)	0 (0)	0 (0)	0 (0)	0.26 (3)
Yellow Warbler	0.03 (–)	0.11 (6)	0 (0)	0 (0)	0.11 (9)	0 (0)	0 (0)	0 (0)	0 (0)

* Species of conservation concern for the Central Hardwoods Bird Conservation Region (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 Lincoln Boyhood National Memorial, Indiana, during the 2007, 2011, and 2013 through 2019 spring bird surveys..

Common Name	Trend ^A	SE of Slope	Trend Classification ^B
Blue-gray Gnatcatcher	1.07	0.12	Uncertain
Eastern Wood-pewee	–	–	–
Indigo Bunting	1.05	0.06	Uncertain
Northern Cardinal	1.11	0.05	Moderate increase
Tufted Titmouse	1.17	0.12	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.

Appendix E. Regional Trends

Table E1. Regional trends in breeding birds recorded on Lincoln Boyhood National Memorial, Indiana, for years 2005 through 2015. Regional trend data from Breeding Bird Surveys (BBS; Sauer et al. 2017).

Common Name	Trend	95% Confidence Interval	
		Lower	Upper
Acadian Flycatcher	1.66	0.79	2.74
American Crow	-0.43	-1.23	0.39
American Redstart	5.61	1.62	10.74
American Robin	-1.01	-1.88	-0.12
American Woodcock	1.24	-8.85	12.39
Baltimore Oriole	0.23	-1.99	2.25
Barred Owl	3.47	-0.96	7.95
Black-billed Cuckoo ^A	-2.12	-6.70	3.91
Black Vulture ^A	6.58	-1.17	14.50
Blue-gray Gnatcatcher	-0.86	-2.15	0.28
Blue Grosbeak ^A	2.44	1.21	3.70
Blue Jay	-1.38	-2.17	-0.54
Brown-headed Cowbird	-1.41	-2.36	-0.55
Carolina Chickadee	-1.33	-2.73	0.04
Carolina Wren	-3.80	-5.07	-2.51
Cedar Waxwing ^A	-6.18	-9.96	-2.49
Chimney Swift	-3.10	-4.33	-1.72
Chipping Sparrow	0.76	-0.28	1.75
Common Grackle	-3.78	-4.87	-2.85
Common Yellowthroat	-0.84	-1.68	0.01
Downy Woodpecker	0.09	-1.50	1.73
Eastern Bluebird	-5.40	-6.95	-3.84
Eastern Phoebe	-1.11	-2.38	0.11
Eastern Towhee	-1.17	-2.21	-0.09
Eastern Wood-Pewee	-0.50	-1.35	0.37
Gray Catbird	-2.21	-3.50	-0.87
Great Crested Flycatcher	-0.29	-1.35	0.78
Hairy Woodpecker	1.30	-0.50	3.29
Hooded Warbler	3.79	1.26	7.06
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^B	-0.16	-1.57	1.24

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

^B Species of conservation concern for the Central Hardwoods Bird Conservation Region (U.S. Fish and Wildlife Service 2008; also in bold).

Table E1 (continued). Regional trends in breeding birds recorded on Lincoln Boyhood National Memorial, Indiana, for years 2005 through 2015. Regional trend data from Breeding Bird Surveys (BBS; Sauer et al. 2017).

Common Name	Trend	95% Confidence Interval	
		Lower	Upper
Killdeer	-1.14	-1.57	1.24
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 Mockingbird	0.90	-0.13	1.97
Northern Parula	3.35	2.06	4.45
Ovenbird	1.65	-0.51	3.99
Pileated Woodpecker	0.78	-0.56	2.10
Prothonotary Warbler	0.38	-2.51	3.07
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^B	0.36	-1.93	2.77
Red-tailed Hawk	0.82	-1.21	2.56
Red-winged Blackbird	-1.83	-2.85	-0.77
Ruby-throated Hummingbird	0.91	-1.17	2.84
Scarlet Tanager	1.90	0.39	3.45
Sharp-shinned Hawk	2.33	-2.39	7.51
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
White-breasted Nuthatch	-0.88	-2.92	1.07
White-eyed Vireo	0.49	-0.63	1.63
Wild Turkey ^A	7.29	1.50	12.93
Wood Thrush^B	0.07	-1.06	1.28
Yellow-billed Cuckoo	-0.23	-1.99	1.58
Yellow-throated Vireo	1.63	0.39	2.96
Yellow-throated Warbler	3.05	1.48	4.59
Yellow Warbler	-2.02	-4.99	0.94

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

^B Species considered of conservation concern for the Central Hardwoods Bird Conservation Region (U.S. Fish and Wildlife Service 2008; also in bold).

Appendix F. Habitat Parameters

Tables F1 through F3 show the averages for habitat parameters in three different sized plots in the habitat at Lincoln Boyhood National Memorial, Indiana, during the bird breeding seasons in 2007, 2011, 2015, and 2019.

Table F1. Average percent cover ($\pm$ std dev) of each habitat type in 50-m-radius plots at Lincoln Boyhood National Memorial, Indiana, during the bird breeding seasons in 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	2007	2011	2015	2019
Lawn (%)	0.09 ($\pm$ 0.51)	0.17 ($\pm$ 0.71)	0.46 ($\pm$ 2.53)	0.43 ($\pm$ 2.54)
Woodland (%)	78.64 ($\pm$ 19.40)	84.86 ($\pm$ 17.52)	94.07 ($\pm$ 8.85)	92.07 ($\pm$ 13.89)
Other (%)	0.09 ($\pm$ 0.51)	2.43 ($\pm$ 14.37)	0.43 ($\pm$ 2.54)	0
Trail	1.16 ($\pm$ 2.68)	0.56 ($\pm$ 1.03)	0.81 ($\pm$ 2.65)	0.56 ($\pm$ 1.03)
Paved road (%)	0.49 ($\pm$ 1.05)	0.81 ($\pm$ 1.31)	0.70 ($\pm$ 2.63)	0.23 ($\pm$ 0.71)
Railroad tracks (%)	0.53 ($\pm$ 2.57)	0.51 ($\pm$ 2.57)	0.51 ($\pm$ 2.57)	1.16 ($\pm$ 6.34)
Stream (%)	0	0	0	0.10 ($\pm$ 0.51)

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-radius subplots in the habitat at Lincoln Boyhood National Memorial, Indiana, during the bird breeding seasons in 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	2007	2011	2015	2019
Canopy cover	Hardwood (%)	92.66 (± 7.00)	84.12 (± 6.42)	96.91 (± 2.17)	89.18 (± 4.30)
	Conifer (%)	0.41 (± 2.07)	0.42 (± 1.51)	0.41 (± 2.42)	0.29 (± 1.21)
	Total cover (%)	92.73 (± 7.05)	84.66 (± 5.39)	96.27 (± 4.35)	89.47 (± 4.19)
Canopy height	Hardwood (m)	22.31 (± 7.26)	27.22 (± 6.54)	30.77 (± 7.69)	22.41 (± 9.46)
	Conifer (m)	0.93 (± 3.29)	1.18 (± 4.28)	0	1.10 (± 3.59)
Basal area	Hardwood (m ² /ha)	19.43 (± 6.67)	27.07 (± 13.50)	14.29 (± 5.77)	25.93 (± 7.43)
	Conifer (m ² /ha)	0.36 (± 1.07)	0.71 (± 1.97)	0.21 (± 0.71)	0.21 (± 0.71)
	Total (m ² /ha)	19.79 (± 7.11)	27.79 (± 13.42)	14.50 (± 5.65)	26.14 (± 7.46)
Horizontal vegetation profile—measured at 15 m north of plot center (percent cover at different height increments)	0.00–0.25 m (%)	–	92.57 (± 11.06)	92.50 (± 10.30)	89.92 (± 17.04)
	0.00–0.50 m (%)	88.36 (± 20.94)	–	–	–
	0.25–0.50 m (%)	–	76.86 (± 30.89)	78.29 (± 28.49)	70.18 (± 31.58)
	0.25–0.75 m (%)	70.09 (± 31.98)	–	–	–
	0.50–0.75 m (%)	–	54.36 (± 36.41)	61.64 (± 38.99)	57.83 (± 32.80)
	0.50–1.00 m (%)	49.37 (± 33.06)	–	–	–
	0.75–1.00 m (%)	–	44.04 (± 38.05)	55.36 (± 42.47)	50.64 (± 36.86)
	0.75–1.25 m (%)	27.33 (± 30.61)	–	–	–
	1.00–1.25 m (%)	–	39.57 (± 37.41)	49.47 (± 43.13)	42.64 (± 36.02)
	1.00–1.50 m (%)	20.13 (± 27.64)	–	–	–
	1.25–1.50 m (%)	–	31.40 (± 35.54)	44.10 (± 44.93)	40.71 (± 36.85)
	1.25–1.75 m (%)	17.67 (± 26.09)	–	–	–
	1.50–1.75 m (%)	–	28.67 (± 36.28)	35.94 (± 44.34)	39.49 (± 38.47)
	1.50–2.00 m (%)	14.67 (± 21.53)	–	–	–
	1.75–2.00 m (%)	–	29.13 (± 39.14)	34.24 (± 45.19)	37.91 (± 34.79)
Vertical structure diversity (%)	n/a	24.22 (± 13.32)	36.25 (± 15.83)	41.09 (± 16.00)	34.62 (± 15.19)

Table F3. Average ($\pm$ std dev) percent of soil substrate cover and plant guild cover in 1.78-m-radius sample plots in habitat at Lincoln Boyhood National Memorial, Indiana, during the bird breeding seasons in 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	2007	2011	2015	2019
Deciduous litter (%)	38.66 ($\pm$ 20.08)	70.57 ($\pm$ 17.96)	77.79 ($\pm$ 15.69)	66.79 ($\pm$ 22.32)
Conifer litter (%)	0.09 ($\pm$ 0.51)	0.06 ($\pm$ 0.16)	0.04 ($\pm$ 0.14)	0.46 ($\pm$ 2.53)
Grass litter (%)	0.43 ($\pm$ 0.50)	0.93 ($\pm$ 2.54)	0.30 ($\pm$ 0.25)	0.31 ($\pm$ 0.25)
Bare soil (%)	6.57 ($\pm$ 7.50)	2.67 ($\pm$ 7.38)	2.61 ($\pm$ 8.78)	14.56 ($\pm$ 19.25)
Rock (%)	0.10 ($\pm$ 0.51)	1.17 ($\pm$ 6.34)	0.43 ($\pm$ 2.54)	1.61 ($\pm$ 6.75)
Woody debris (%)	5.80 ($\pm$ 12.30)	19.97 ($\pm$ 13.68)	7.34 ($\pm$ 7.62)	5.94 ($\pm$ 9.18)
Unvegetated (%)	87.14 ($\pm$ 4.78)	84.36 ($\pm$ 13.82)	88.36 ($\pm$ 8.83)	82.64 ($\pm$ 11.23)
Cool-season grass (%)	0.63 ($\pm$ 0.89)	3.07 ($\pm$ 8.96)	0.53 ($\pm$ 0.80)	1.91 ($\pm$ 4.18)
Forb (%)	6.23 ($\pm$ 7.71)	7.43 ($\pm$ 6.72)	4.44 ($\pm$ 10.86)	8.77 ($\pm$ 13.24)
Moss and lichen (%)	0.06 ($\pm$ 0.16)	1.34 ($\pm$ 3.47)	0.74 ($\pm$ 2.62)	2.10 ($\pm$ 4.16)
Woody shrub and vine (%)	1.91 ($\pm$ 4.21)	18.94 ($\pm$ 15.38)	10.96 ($\pm$ 11.45)	24.20 ($\pm$ 19.65)
Tree seedling (%)	3.49 ($\pm$ 5.41)	10.40 ($\pm$ 10.69)	1.91 ($\pm$ 2.59)	13.24 ($\pm$ 13.59)
Total foliar (%)	29.40 ($\pm$ 12.51)	39.59 ($\pm$ 17.47)	19.07 ($\pm$ 13.29)	46.91 ($\pm$ 26.72)

Appendix G. Trees Found on Lincoln Boyhood National Memorial

Table G1. Stems per hectare of trees found on Lincoln Boyhood National Memorial, Indiana, by size class in 2007, 2011, 2015, and 2019 bird breeding seasons. Stems per hectare of trees are reported by family.

Stem Size Class (cm diameter)	Family	2007	2011	2015	2019
<1.0 cm	Aceraceae	80	22	629	917
	Araliaceae	0	0	0	18
	Betulaceae	0	0	0	58
	Caprifoliaceae	0	0	65	0
	Cornaceae	0	0	109	33
	Fabaceae	0	4	102	211
	Hamamelidaceae	7	0	84	51
	Juglandaceae	15	0	18	131
	Lauraceae	58	18	189	80
	Magnoliaceae	87	4	51	44
	Moraceae	0	0	0	11
	Oleaceae	116	142	316	335
	Rosaceae	0	0	4	7
	Snag	0	0	91	156
	Staphyleaceae	0	0	222	0
	Ulmaceae	0	0	113	196
1.1–2.5 cm	Aceraceae	164	18	338	535
	Betulaceae	76	0	0	33
	Caprifoliaceae	0	0	4	0
	Cornaceae	84	4	4	7
	Ebenaceae	0	0	0	4
	Fabaceae	4	47	47	105
	Fagaceae	0	0	11	4
	Hamamelidaceae	7	0	22	25
	Juglandaceae	84	0	4	69
	Lauraceae	124	0	113	15
	Magnoliaceae	15	4	76	65
	Oleaceae	95	25	69	102
	Snag	138	11	18	51
	Staphyleaceae	0	0	40	0
	Ulmaceae	15	7	47	91

Table G1 (continued). Stems per hectare of trees found on Lincoln Boyhood National Memorial, Indiana, by size class in 2007, 2011, 2015, and 2019 bird breeding seasons. Stems per hectare of trees are reported by family.

Stem Size Class (cm diameter)	Family	2007	2011	2015	2019
2.6–8.0 cm	Aceraceae	153	65	102	218
	Caprifoliaceae	0	0	4	0
	Cornaceae	33	47	76	22
	Cupressaceae	0	0	4	0
	Fabaceae	7	36	29	44
	Fagaceae	11	4	4	7
	Hamamelidaceae	11	15	18	25
	Juglandaceae	47	0	4	4
	Lauraceae	25	4	55	7
	Magnoliaceae	33	7	51	44
	Moraceae	0	0	7	7
	Nyssaceae	0	0	0	4
	Oleaceae	36	29	95	22
	Platanaceae	0	0	7	4
	Snag	73	95	62	44
	Ulmaceae	36	25	44	84
8.1–15.0 cm	Aceraceae	62	55	47	80
	Cornaceae	11	4	11	4
	Cupressaceae	4	4	7	4
	Fabaceae	0	4	0	7
	Fagaceae	4	0	7	0
	Hamamelidaceae	11	11	11	15
	Juglandaceae	15	4	4	0
	Lauraceae	11	0	0	0
	Magnoliaceae	22	7	0	0
	Moraceae	0	0	0	4
	Nyssaceae	0	0	0	4
	Oleaceae	0	4	18	11
	Rosaceae	0	4	4	0
	Snag	22	25	11	18
	Ulmaceae	18	7	18	11

Table G1 (continued). Stems per hectare of trees found on Lincoln Boyhood National Memorial, Indiana, by size class in 2007, 2011, 2015, and 2019 bird breeding seasons. Stems per hectare of trees are reported by family.

Stem Size Class (cm diameter)	Family	2007	2011	2015	2019
15.1–23.0 cm	Aceraceae	40	22	44	55
	Betulaceae	0	4	0	0
	Cornaceae	4	0	0	0
	Cupressaceae	0	4	0	4
	Ebenaceae	0	4	4	0
	Fabaceae	0	4	0	0
	Fagaceae	0	4	0	4
	Hamamelidaceae	11	4	0	0
	Juglandaceae	15	7	0	7
	Lauraceae	4	0	0	0
	Magnoliaceae	4	4	7	15
	Oleaceae	0	11	11	4
	Pinaceae	4	0	4	4
	Platanaceae	0	0	4	0
	Rosaceae	0	0	0	4
	Snag	11	11	4	0
	Ulmaceae	4	0	4	7
23.1–38.0 cm	Aceraceae	44	22	33	36
	Betulaceae	0	0	4	4
	Fabaceae	0	0	4	0
	Fagaceae	0	4	4	4
	Hamamelidaceae	33	22	7	47
	Juglandaceae	22	18	0	11
	Lauraceae	4	0	0	0
	Magnoliaceae	4	15	11	15
	Oleaceae	0	7	11	7
	Rosaceae	4	4	0	0
	Snag	7	7	0	11
	Ulmaceae	0	7	4	4
>38.0 cm	Aceraceae	22	15	11	18
	Fabaceae	4	0	0	0
	Fagaceae	4	7	0	0
	Hamamelidaceae	0	18	4	7
	Juglandaceae	0	0	0	4
	Magnoliaceae	15	18	18	11
	Oleaceae	0	4	7	7
	Platanaceae	11	7	7	11
	Rosaceae	0	0	4	0
	Snag	0	4	4	0

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525