National Park Service
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Natural Resource Stewardship and Science

Streamside Bird Monitoring in the Eastern Rivers and Mountains Network

Fort Necessity National Battlefield
2008–2012

Natural Resource Report NPS/ERMN/NRR—2021/2325



ON THE COVER

Red-eyed Vireo (*Vireo olivaceus*). One of the most abundant bird species at Fort Necessity National Battlefield point count stations. Photo © Bill Thompson.

Streamside Bird Monitoring in the Eastern Rivers and Mountains Network

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U.S. Department of the Interior
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Executive Summary

This report summarizes the first five years of monitoring the streamside bird community at Fort Necessity National Battlefield. During the 2008–2012 time period, two observers conducted 200 point count surveys and detected 2,316 individual birds at 10 point count stations within the park.

Fort Necessity National Battlefield contains a rich and diverse streamside bird community with a total 71 species detected; 65 of which are target species and presumed to be breeding in the park during summer months. The majority of the 20 most abundant species were forest-associated species including both forest interior species and forest generalist species. However, several of the most abundant species were associated with early-successional forests and shrubby fields reflecting the mixed vegetation/habitat structure at the park.

Twenty species overall, and seven of the 20 most abundant species, were of conservation importance in the Appalachian Mountains bird conservation region, highlighting the significance of even a relatively small park like Fort Necessity National Battlefield to avian conservation.

It is not uncommon for land managers to be confronted with multiple species of conservation importance, yet which require very different habitats (e.g., early successional forest and shrubby fields versus older, unfragmented forest stands) and the situation is no different for managers of Fort Necessity National Battlefield. The mosaic of habitats and cultural resource values at the park should allow creation of management zones and management actions that potentially benefit multiple species. Information in this report and future analyses should support these decisions.

Trends in unadjusted abundance over the period of monitoring were assessed for all 65 species in the defined target population (Table E-1). Trends in adjusted abundance that take into account detection probability were estimated for 25 species for which there were sufficient data. Both estimates were included in this report to provide multiple lines of evidence when assessing population trends.

Table E-1. Summary of trends in abundance for 65 bird species at Fort Necessity National Battlefield point count stations from 2008–2012.

Abundance Trend		Number of Species	
Symbol	**Definition**	**(% total)**	**Species**
↑↑	Significant Increase	1 (2%)	Blue-headed Vireo
↑	Increase	6 (9%)	–
↔	Stable	39 (60%)	–
↓	Decrease	15 (23%)	–
↓↓	Significant Decrease	4 (6%)	Blue Jay, Song Sparrow, House Wren, American Redstart

Out of 65 species in the target population, 46 species (71%) appear to be stable or increasing and 19 species (29%) appear to be declining during the period of monitoring. The slope of either the unadjusted or adjusted abundance trend estimates showed statistically significant positive trends for one species and negative trends for four species.

Even though the period of monitoring (5 years) at Fort Necessity National Battlefield is relatively short to assess population trends, the primary message thus far appears to be that most species were stable or increasing in abundance at the park and were species associated with mature deciduous forest—the regional conservation priority.

Despite the lack of significant declines, several species of conservation importance associated with the interior of mature, intact, deciduous forest warrant close attention given that these species have been declining throughout Pennsylvania and the broader Appalachian Mountains region for several decades.

This report provides the first information regarding long-term population trends of breeding birds in Fort Necessity National Battlefield. Continued monitoring will provide new insights and future analyses will explore specific factors linked to population trends. As anthropogenic land use and climate change continue to reshape the Appalachian landscape, park managers will need this information to best allocate effort that aligns with regional conservation planning and other park priorities.

Acknowledgments

Thank you to everyone in Eastern Rivers and Mountains Network (ERMN) for their help developing and implementing this protocol especially Kristina Callahan and Caleb Tzilkowski. And thanks to the Region 1 bird monitoring working group particularly J. P. Schmit, Aaron Weed, Mark Johnson, and Zach Ladin for many helpful discussions and statistical code that greatly improved and streamlined data analyses. Jim Comiskey, Caleb Tzilkowski, Andy Weber, Mark Johnson, Elizabeth Matthews, and Greg Shriver provided reviews and many helpful suggestions on this report. Thanks also to everyone at Fort Necessity National Battlefield for many forms of support, guidance, and assistance and for providing essential seasonal housing. I look forward to working with you on the management implications of this information. Finally, I cannot thank enough the many field technicians who conduct the streamside bird surveys. Special thanks to Brad Ross for his efforts at Fort Necessity National Battlefield.

List of Acronyms

ERMN	Eastern Rivers and Mountains Network
FONE	Fort Necessity National Battlefield
IMD	Inventory and Monitoring Division
NB	National Battlefield
NPS	National Park Service

Introduction

Each summer, more than 130 bird species breed within the national parks of the Eastern Rivers and Mountains Network (ERMN). These birds are essential components of park ecosystems and have tremendous appeal to visitors and stewards of national parks. They rely on habitats associated with the extensive network of forested Appalachian streams to eat, build nests, and raise their young. Some remain in the parks year-round and others, including tanagers, thrushes, vireos, flycatchers, and warblers are migrants that fly thousands of miles twice a year between breeding and wintering areas—connecting the parks, landscapes, and people of eastern North America to those of Central and South America.

The National Park Service Inventory and Monitoring Division implements an integrated long-term ecological monitoring program to track changes in a suite of selected park resources and processes termed "vital signs" (Fancy et al. 2009, Marshall and Piekielek 2007). As part of this program the ERMN monitors breeding bird populations in seven national parks under a peer-reviewed protocol referred to as the streamside bird monitoring protocol (Marshall et al. 2016). The background and justification for monitoring breeding birds, rationale for focusing monitoring on the bird community along streams, monitoring objectives, and other programmatic considerations are described in detail in the protocol.

The information gained from this monitoring program helps inform park management decision making to ensure park resources remain unimpaired for the enjoyment of future generations and to preserve the habitats and ecosystems on which these birds depend.

Marshall et al. (2013) summarized results for the 2007–2012 period for all parks in the ERMN including methods, terminology, and maps of sampling locations.

This report summarizes results with an emphasis on species-specific trends during this time period. Detecting changes in species abundance over time is the primary objective of the protocol (Marshall et al. 2016).

Methods

The following sections describe procedures since monitoring began in 2008 through 2012. Monitoring has continued at Fort Necessity NB since 2012 however the number and location of the point count stations changed in 2013 (Marshall et al. 2016) and additional sites were added in 2019. Future reports will incorporate these data once the revised point count stations are sampled a sufficient number of times.

Field Methods and Sampling Locations

Point count surveys are the most widely used quantitative method of monitoring bird populations (e.g., Ralph et al. 1995) and are used in this protocol as well (Marshall et al. 2016). The survey technique involves using a standardized methodology to record ("count") all birds seen or heard during a fixed amount of time at count locations ("points"). The resultant counts are used as an index of population abundance and are amenable to a number of analytical techniques to correct for potential detection biases (i.e., failing to detect birds that are actually present at the site).

In 2008, 10 point count stations were established adjacent and parallel to the few streams in the park (Figure 1). Point centers were spaced 200 to 250m apart. The tributary to Great Meadows Run was avoided due the cultural focus of this area of the park (but sampling along this stream did begin after 2012). The non-random nature of site establishment means that inferences regarding the bird community and population trends are limited to the areas sampled.

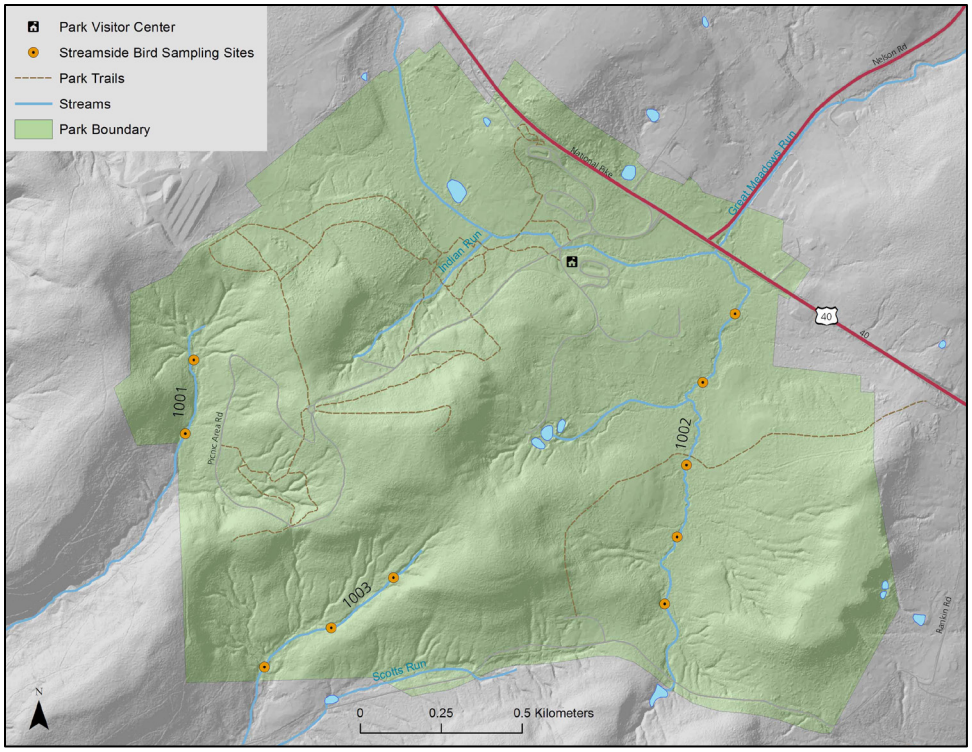


Figure 1. Location of 10 point count stations (orange circles) established to monitor breeding bird populations from 2008 through 2012 at Fort Necessity National Battlefield as part of the Eastern Rivers and Mountains Network streamside bird monitoring protocol.

Data collection consisted of trained and experienced field personnel (here forward; observers) navigating to permanent point count stations (Figure 2) which served as the center of a circular sampling area and remaining at the point counting all birds detected. Count duration was 5 minutes from 2008 through 2010 and increased to 10 minutes in 2011 and 2012. The following information for each individual bird detected was recorded: 1) species identity; 2) type of detection (e.g., song, call, drumming, visual); 3) distance from observer (<50 m, 50–75 m, or >75 m); 4) if the bird was a juvenile; 5) if the bird was flying over the canopy at the time of detection; and 6) the minute of first detection.



Figure 2. Example of multi-colored cable ties and engraved aluminum tree tag used to permanently mark point count stations that are part of the Eastern Rivers and Mountains Network streamside bird monitoring protocol.

Observers visited each point count station four times during each sampling season on days with minimal precipitation and little wind and conducted a single count each visit (temporal replicates). Each point count occurred between sunrise and 4.5 hours after sunrise to limit sampling to the period of the day when birds were most active and vocal (>97% of all detections were auditory meaning that the observer detected a song, call or other audible cue rather than seeing the bird; which is typical of point counts conducted in forested environments).

Target Population

Sampling was limited to the breeding season (mid-May through early-July) for eastern North America resident and neotropical (Central America, South America, and the Caribbean) migratory bird species that potentially breed in the streamside sampling area. Species of the Orders Passeriformes (perching birds including songbirds) were particularly well sampled; additionally, species in the orders Piciformes (woodpeckers), Columbiformes (doves and pigeons), Cuculiformes (cuckoos), and Apodiformes (swifts and hummingbirds) constitute the target population. In the central Appalachians, this group of birds includes about 112 potential species (e.g., O'Connell et al. 2000). In general, these species establish breeding pairs in defined territories for the duration of the sampling period so that the point count methodology can be used to estimate the abundance of breeding birds in the sampled area.

While detections of nocturnal raptors like owls (Strigiformes), diurnal raptors (Accipitriformes), waterfowl (Anseriformes), waders (Peleconiformes), turkey and grouse (Galliformes), and other non-target species do occur, they constitute less than 1% of all detections which effectively precludes these groups from any meaningful status and trends analyses.

Data Analysis

In addition to summaries of the species detected and their conservation status, two indices of abundance were estimated to help evaluate if trends in abundance have occurred over time. The first index, referred to as the "unadjusted" estimate, was calculated by dividing the total number of birds detected by the number of point count stations sampled (i.e., birds per point). The maximum number of detections per species across the four visits was used in this calculation. A hypothetical example is shown in Table 1.

Table 1. Hypothetical example showing the number of birds of a single species detected during each of four visits to six point count stations including the maximum number detected during any single visit.

Point Count Station	Visit 1	Visit 2	Visit 3	Visit 4	Maximum
1	1	1	1	1	1
2	0	1	0	1	1
3	1	0	2	1	2
4	0	0	0	0	0
5	1	0	0	0	1
6	0	0	0	0	0
Mean birds per point					0.83

Because some birds present during the point count period were likely not detected by the observer (Simons et al. 2007, Johnson 2008, Schmidt et al. 2013, Marshall et al. 2016), a second "adjusted" estimate was calculated that incorporated detection probabilities into the abundance estimates. For

the adjusted estimates, the point count data were analyzed with N-mixture models (Royle 2004, Kery et al. 2005) in the 'unmarked' R package using the *pcount* function (Fiske and Chandler 2011) to explicitly estimate both a detection probability and an estimate of abundance adjusted by the detection probability. The data from all sampling years and the four visits within years were fit to four models. These models can be viewed as hypotheses regarding variability over time (e.g., years) in detection probability and bird abundance. Year of sampling was included as a covariate in models where either detection and/or abundance varied through time. No other covariates were used in these analyses. The four models were: a null model where both detection and abundance were constant (i.e., both abundance and detection were the same in all years of sampling and did not vary across years); a model where detection probability varied over time (i.e., sampling years) but abundance was constant; a model where detection probability was constant but abundance varied over time; and a model where both detection and abundance varied over time. All models used the Poisson mixture and K=6 and the analyses were run for each species independently. Abundance estimates for each sampling year were derived from the weighted average of all four models because a best model (AICc < 2) was rarely indicated.

The null model was also used to estimate the mean species abundance across all years of monitoring.

For both the unadjusted and adjusted estimates trends were evaluated by fitting linear models to the annual abundance estimates regressed against year. The linear model slope estimate provides both the direction (e.g., positive slopes indicate increases in abundance over time) and magnitude of change for each species. Species were considered to have statistically significant increases or decreases when the slope was significantly different from zero ($\alpha = 0.05$) and were considered "stable" when the SE of the slope estimate overlapped zero.

All analyses were performed in the statistical software program R (version 4.0.3; R Core Team 2020).

The datasets and statistical code are available from the NPS IRMA Data Store (https://irma.nps.gov/).

Results

Two observers conducted a total of 200 point counts at the 10 point count stations at Fort Necessity NB during the five year period between program inception in 2008 and 2012. All point count stations were sampled the expected four times per year during the appropriate sampling year (100% sampling completeness) and all data were approved or certified prior to analyses as defined by the quality assurance procedures described in the protocol and quality assurance plan (Marshall et al. 2016, Marshall and Callahan 2018).

The two observers detected 2,316 individual birds representing 71 species during all years of sampling (Marshall et al. 2013). These totals do not include records where the observer could not identify the bird to species. Even though observers were encouraged to use an "unidentified bird" category to limit false positive observations, these constituted less than 1.4% of all records across all years and parks due to observer experience and training. The five non-target species observed were Great Horned Owl (*Bubo virginianus*), Belted Kingfisher (*Megaceryle alcyon*), Wild Turkey (*Meleagris gallopavo*), Cooper's Hawk (*Accipiter cooperii*), and Red-tailed Hawk (*Buteo jamaicensis*) and are not considered further in this report. Other non-target observations flagged as "flyovers" (i.e., detected birds were above the forest canopy and not "using" the sampled area) and "juveniles" (birds hatched and fledged during the sampling season) were also excluded from the dataset. In addition (to examine consistent patterns over time), the duration of all 2011–2012 point counts were standardized to 5 minutes in length to be consistent with the 2008–2010 data by excluding all records that occurred after the fifth minute.

Results presented hereafter are based on this standardized dataset of 65 target species and 2,073 records but otherwise include observations from all distance bands and detection types. The Chimney Swift (*Chaetura pelagica*) was the only target species included in Marshall et al. 2013 not included here because all records were flagged as "flyovers" and subsequently excluded.

Species Richness, Abundance, and Conservation Status

On average, observers detected 47 species per year ranging from 39 (2011) to 55 (2010) (Figure 3). Observers detected 9.3 species per point count (ranging from 4 to 16) across all 200 counts conducted.

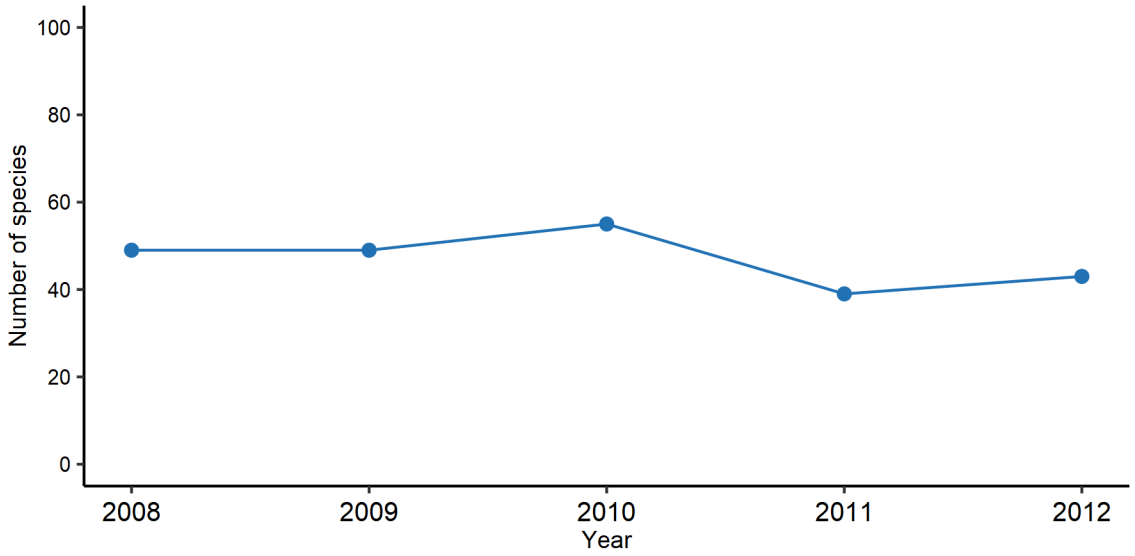


Figure 3. Total number of streamside bird species detected at Fort Necessity National Battlefield point count stations from 2008–2012.

No nonnative bird species or state or federally threatened or endangered species were detected during monitoring.

On average, observers detected 12.4 individual birds per point ranging from 4 to 19 during all years of monitoring. The number of birds detected per point has declined from 2008–2012 (Figure 4).

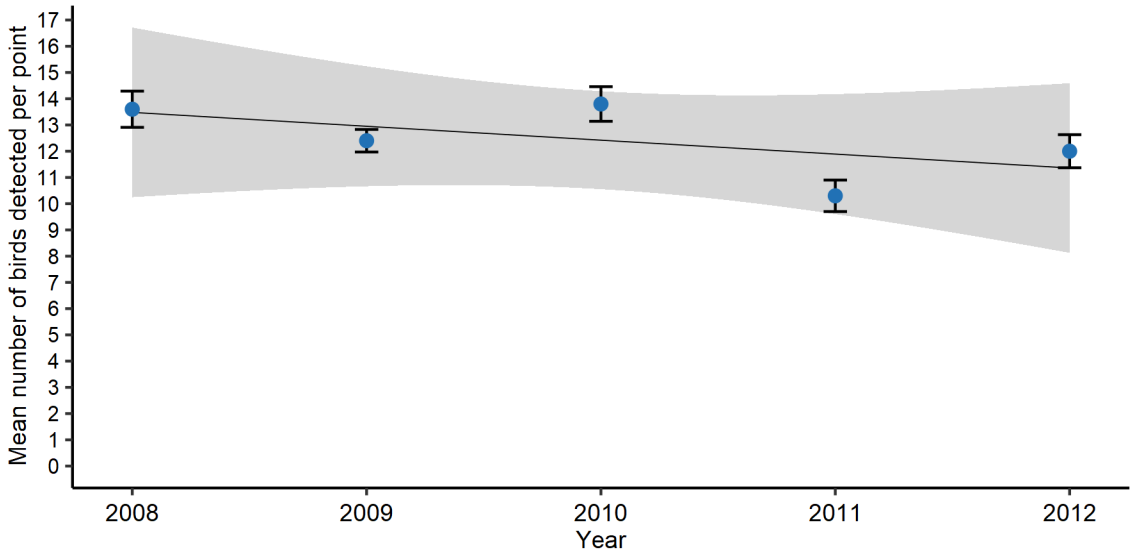


Figure 4. Number of birds detected per point count station at Fort Necessity National Battlefield from 2008–2012. Mean per year (blue circles ±1SD) and linear trend (black horizontal line with ±SE gray shading) depicted.

Appendix 1 summarizes the average abundance from 2008–2012 for all 65 species in the target population (adjusted estimates are available for the 25 species detected most frequently; for species detected less frequently the data were too sparse for the models to converge on an estimate).

The Red-eyed Vireo (scientific names are in Appendix 1) was the most abundant bird species detected at Fort Necessity NB point count stations (Figure 5) and is likely one of the most abundant forest birds in the Appalachians. The majority of the 20 most abundant species were forest-associated species including both forest interior species (e.g., Scarlet Tanager, Wood Thrush, Ovenbird, Acadian Flycatcher, and Hooded Warbler) and forest generalist species (e.g., Red-eyed Vireo, Eastern Wood-Pewee, Indigo Bunting, Black-capped Chickadee, and Tufted Titmouse). However, several of the more abundant species were associated with early-successional forests and shrubby fields (e.g., Common Yellowthroat, Eastern Towhee, and Field Sparrow) reflecting the mixed vegetation/habitat structure at the park.

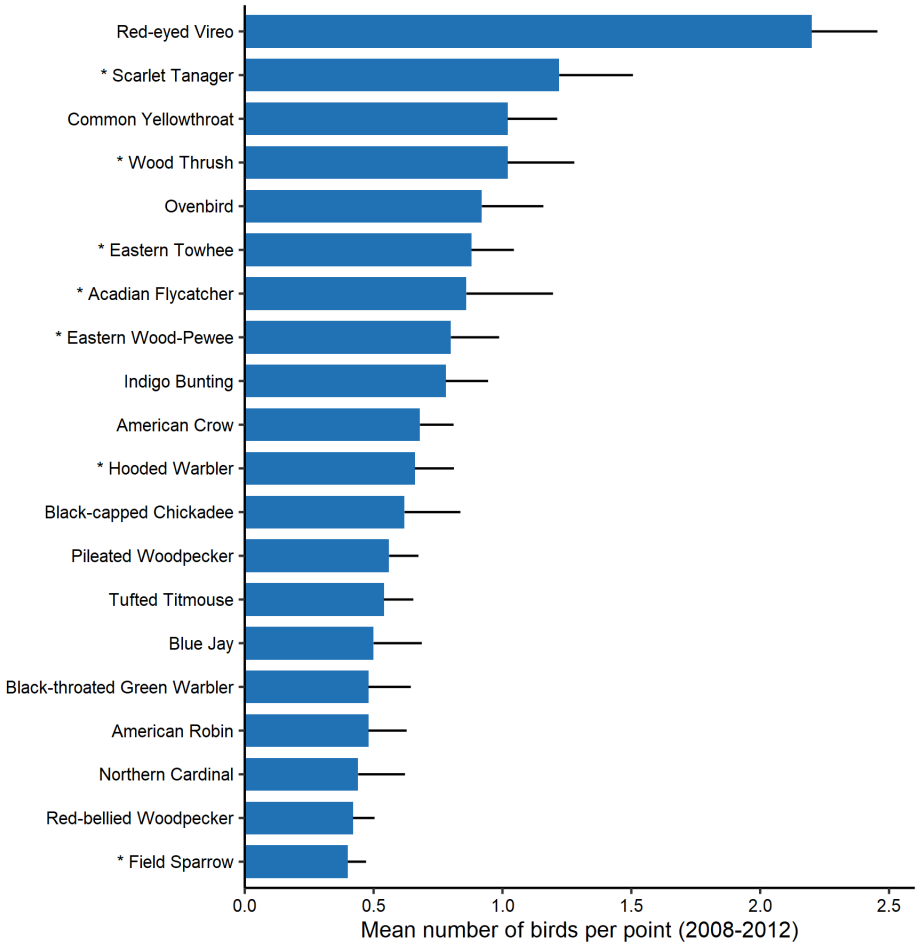


Figure 5. Twenty most abundant streamside bird species at Fort Necessity National Battlefield point count stations from 2008–2019. Bars represent the unadjusted mean birds per point (+1SD) across all years of monitoring. *Species of regional conservation importance (Panjabi et al. 2020).

Twenty species overall (Appendix 1) and seven of the top 20 most abundant species (Figure 5) were of conservation importance in the Appalachian Mountains bird conservation region (BCR 28; https://nabci-us.org/resources/bird-conservation-regions-map/) based on the peer-reviewed ranking criteria of the conservation consortium Partners in Flight (Panjabi et al. 2020).

Conservation "importance" includes one designation for species facing multiple threats and currently in decline ("conservation concern") and a non-mutually exclusive designation ("conservation stewardship") which emphasizes the regional responsibility to maintain these populations because the majority of the global population breeds in the Appalachian Mountains region. Figures 6 and 7 show the most abundant species at Fort Necessity NB point count stations in these two categories, respectively.

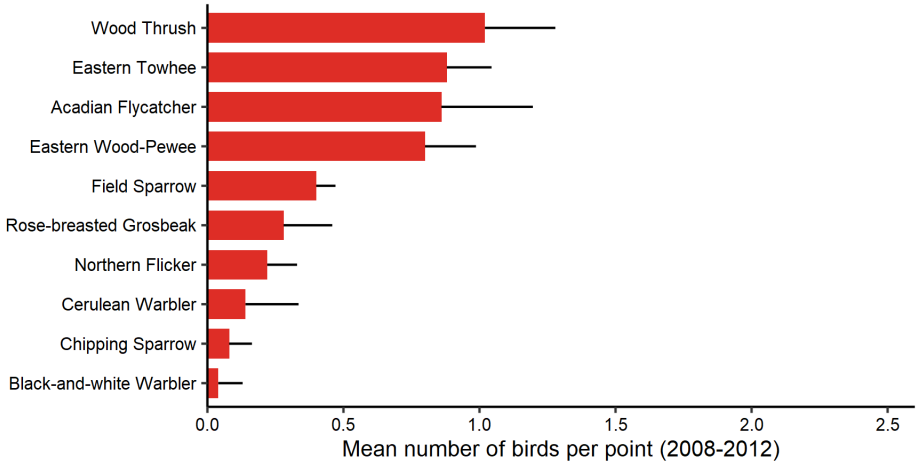


Figure 6. Ten most abundant streamside bird species of regional conservation concern (Panjabi et al. 2020) at Fort Necessity National Battlefield point count stations from 2008–2012. Bars represent the mean unadjusted birds per point (+1SD) across all years of monitoring.

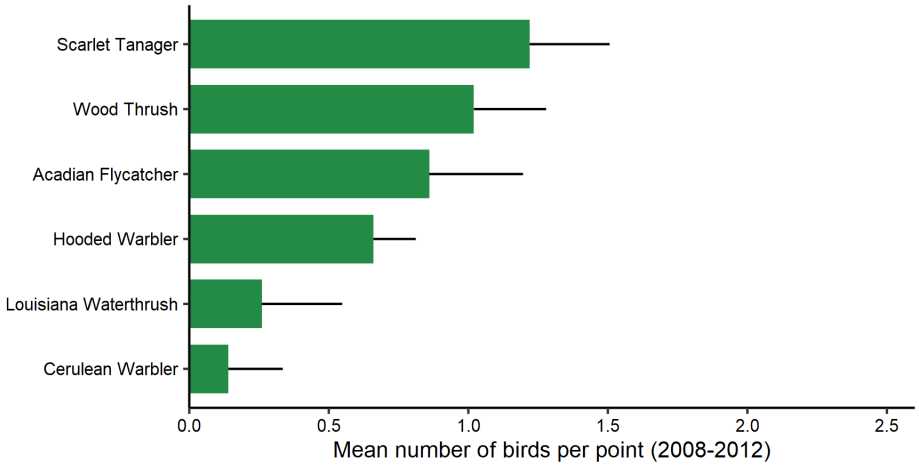


Figure 7. Abundance of streamside bird species of regional conservation stewardship (Panjabi et al. 2020) at Fort Necessity National Battlefield point count stations from 2008–2012. Bars represent the mean unadjusted birds per point (+1SD) across all years of monitoring.

Trends in Abundance

Trends in unadjusted abundance were estimated for all 65 species in the target population. Trends in adjusted abundance were estimated for 25 species for which there were sufficient data (Appendix 1). Several examples of species-specific trends are shown below.

The Red-eyed Vireo, Scarlet Tanager, and Wood Thrush were among the most abundant species at Fort Necessity NB point count stations and each appeared to be stable during the period of monitoring (Figures 8–10).

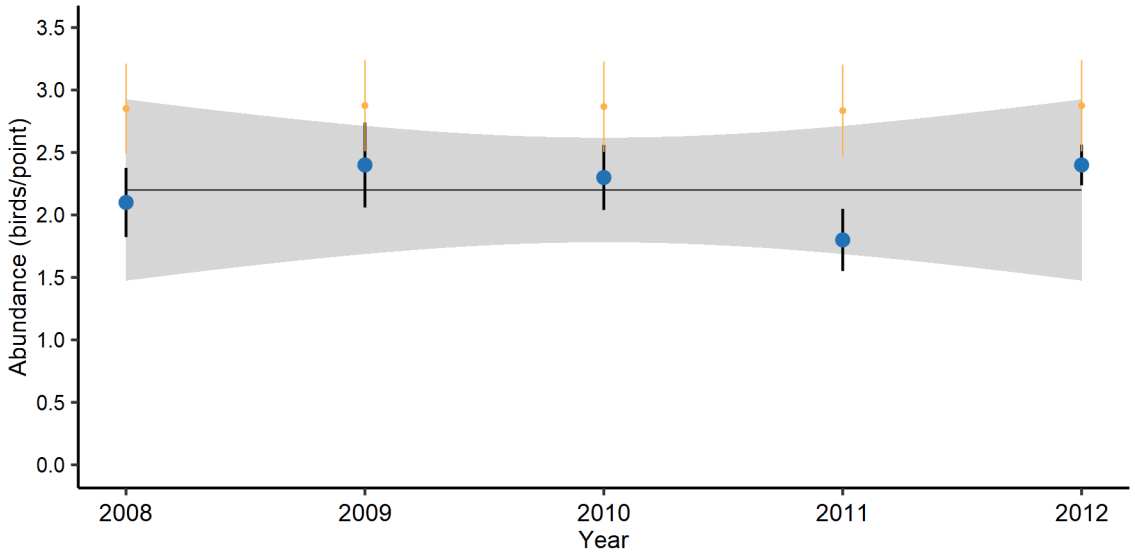


Figure 8. Red-eyed Vireo abundance at Fort Necessity National Battlefield point count stations from 2008–2012. Unadjusted (blue circles ±1SD) and adjusted (yellow circles ±SE) abundance estimates shown. Linear trend (black horizontal line with ±SE gray shading) of unadjusted estimates suggests a stable population over time. Adjusted estimates also show evidence of a stable population over time (linear trend line not shown).

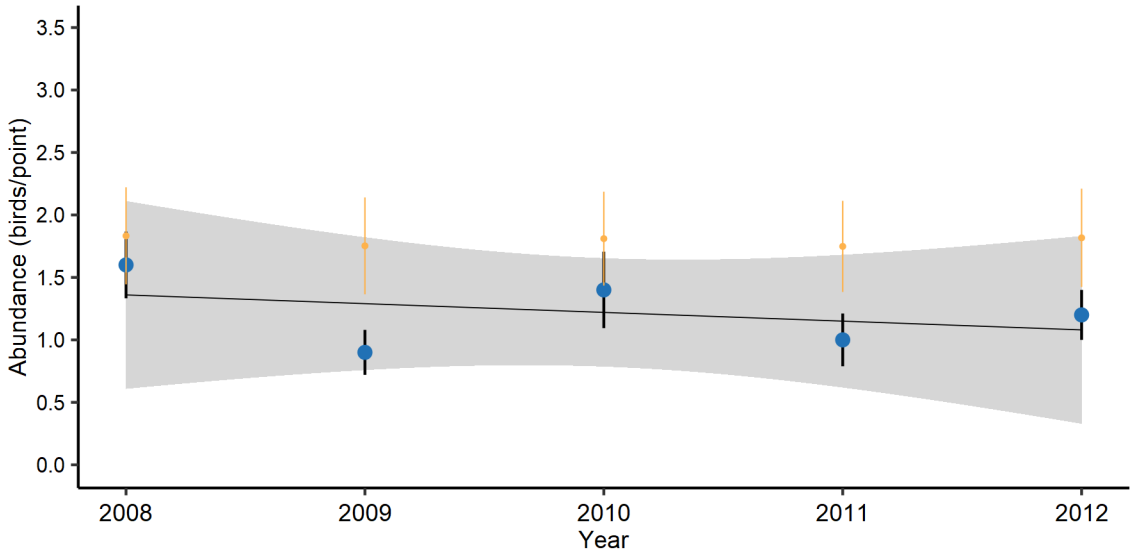


Figure 9. Scarlet Tanager abundance at Fort Necessity National Battlefield point count stations from 2008–2019. Unadjusted (blue circles ±1SD) and adjusted (yellow circles ±SE) abundance estimates shown. Linear trend (black horizontal line with ±SE gray shading) of unadjusted estimates suggests a stable population over time. Adjusted estimates also show evidence of a stable population over time (linear trend line not shown).

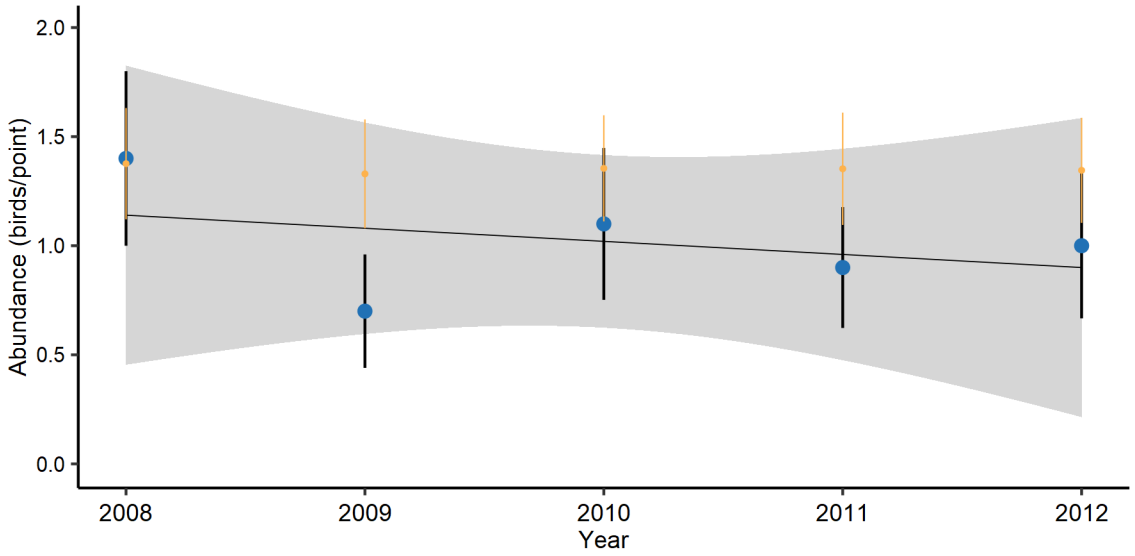


Figure 10. Wood Thrush abundance at Fort Necessity National Battlefield point count stations from 2008–2019. Unadjusted (blue circles ±1SD) and adjusted (yellow circles ±SE) abundance estimates shown. Linear trend (black horizontal line with ±SE gray shading) of unadjusted estimates suggests a stable population over time. Adjusted estimates also show evidence of a stable population over time (linear trend line not shown).

The Blue-head Vireo was a less abundant species but appeared to be significantly increasing during the period of monitoring (Figure 11). In contrast, the Blue Jay was one of four species that appeared to be significantly declining (Figure 12).

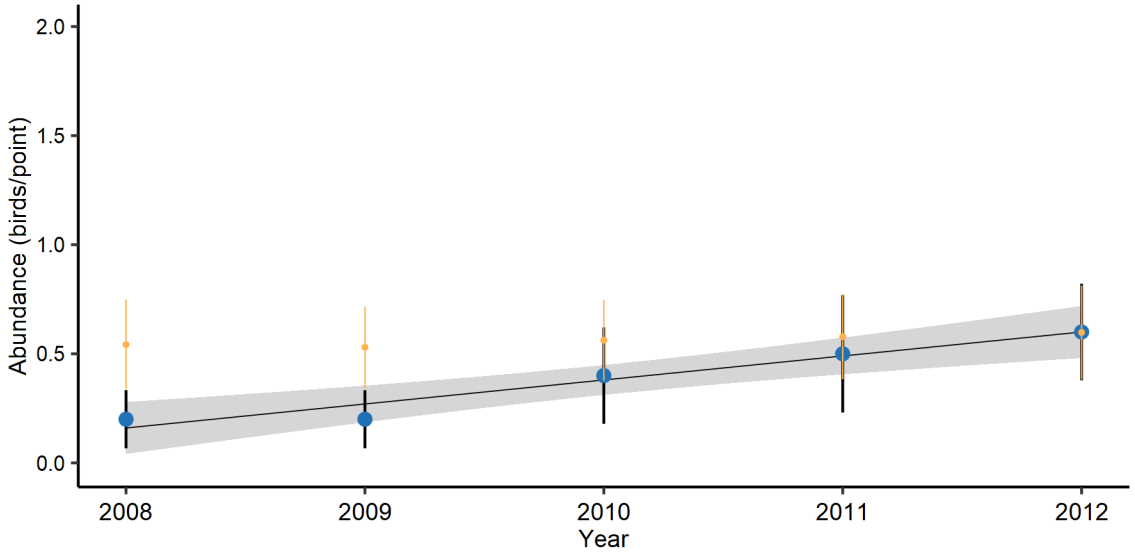


Figure 11. Blue-headed Vireo abundance at Fort Necessity National Battlefield point count stations from 2008–2012. Unadjusted (blue circles ±1SD) and adjusted (yellow circles ±SE) abundance estimates shown. Linear trend (black horizontal line with ±SE gray shading) of unadjusted estimates suggests an increase in abundance over time. Adjusted estimates do not show evidence of change over time (linear trend line not shown).

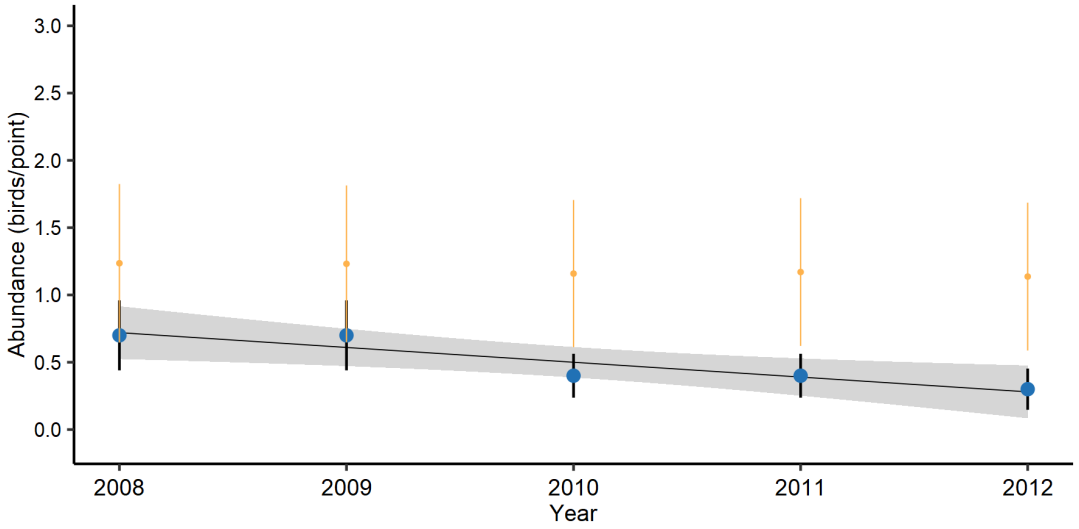


Figure 12. Blue Jay abundance at Fort Necessity National Battlefield point count stations from 2008–2012. Unadjusted (blue circles ±1SD) and adjusted (yellow circles ±SE) abundance estimates shown. Linear trend (black horizontal line with ±SE gray shading) of unadjusted estimates suggests a decrease in abundance over time. Adjusted estimates do not show evidence of change over time (linear trend line not shown).

Recalling that the slope of the linear model provides both the direction and magnitude of change, results for numerous species can be presented in a concise format using just this statistic. Trend estimates for the 20 most abundant species were summarized this way in Figure 13 and for all 65 target species in Appendix 2. Among the 20 most abundant species, two appear to be increasing, three appear to be declining, and 15 appear stable during the period of monitoring. Of the 20 most abundance species, only the Blue Jay showed a significant decline in abundance.

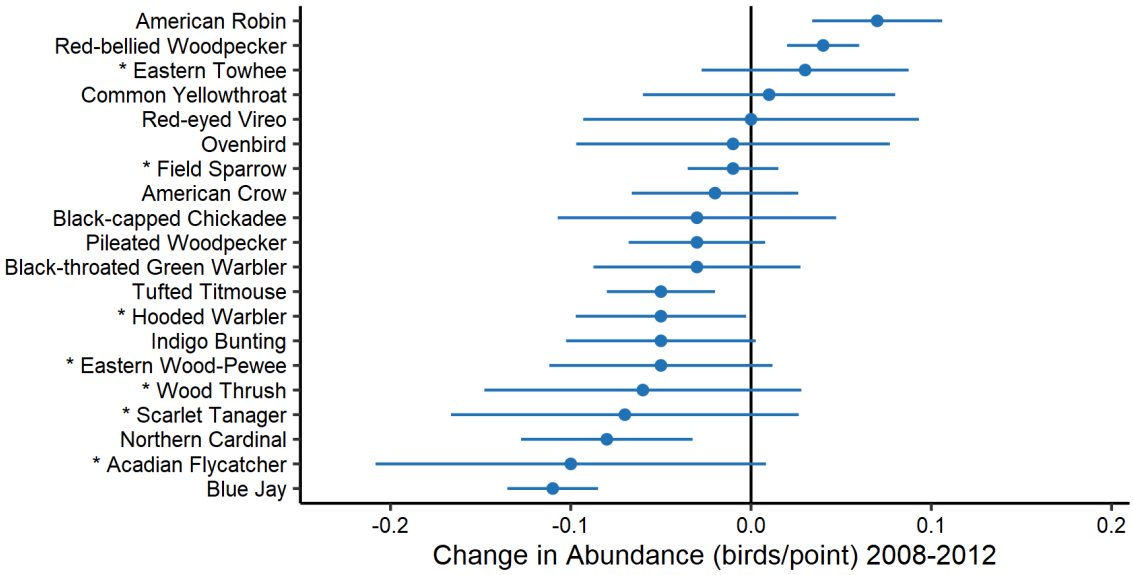


Figure 13. Trend estimates (slope ±SE of linear model regressing unadjusted abundance estimates against sampling year) for the twenty most abundant streamside bird species at Fort Necessity National Battlefield point count stations from 2008–2019. Slope values >0 indicate a linear increase in abundance over time and values <0 indicate a linear decrease in abundance over time. Values where the SE of the estimate includes 0 indicate no change in abundance over time. *Species of regional conservation importance (Panjabi et al. 2020).

Discussion

This report summarizes the first five years of monitoring the streamside bird community at Fort Necessity NB extending the analyses in Marshall et al. (2013). During the 2008–2012 time period, two observers conducted 200 point count surveys and detected 2,316 individual birds at 10 point count stations within the park.

Fort Necessity NB contains a rich and diverse streamside bird community with a total 71 species detected; 65 of which are target species and presumed to be breeding in the park during summer months. The majority of the 20 most abundant species were forest-associated species including both forest interior species and forest generalist species. However, several of the most abundant species were associated with early-successional forests and shrubby fields reflecting the mixed vegetation/habitat structure at the park.

Twenty species overall, and seven of the 20 most abundant species, were of conservation importance in the Appalachian Mountains bird conservation region, highlighting the significance of even a relatively small park like Fort Necessity NB to avian conservation.

It is not uncommon for land managers to be confronted with multiple species of conservation importance, yet which require very different habitats (e.g., early successional forest and shrubby fields versus older, unfragmented forest stands) and the situation is no different for managers of Fort Necessity NB. The mosaic of habitats and cultural resource values at the park should allow creation of management zones and management actions that potentially benefit multiple species. Information in this report and future analyses should support these decisions.

Trends in unadjusted abundance over the period of monitoring were assessed for all 65 species in the defined target population (Appendix 1 and 2). Trends in adjusted abundance that take into account detection probability were estimated for 25 species for which there were sufficient data. Both estimates were included in this report to provide multiple lines of evidence when assessing population trends.

Out of 65 species in the target population, 46 species (71%) appear to be stable or increasing and 19 species (29%) appear to be declining during the period of monitoring (Table 2). The slope of either the unadjusted or adjusted abundance trend estimates (or both; Appendix 1) showed statistically significant positive trends for one species and negative trends for four species (Table 2).

Table 2. Summary of trends in unadjusted abundance for 65 bird species at Fort Necessity National Battlefield point count stations from 2008–2012. Significant increases or decreases determined by a significant ($p<0.05$) linear model slope of either the unadjusted or adjusted abundance estimates (Appendix 1).

Abundance Trend		Number of Species	
Symbol	Definition	(% total)	Species
↑↑	Significant Increase	1 (2%)	Blue-headed Vireo
↑	Increase	6 (9%)	–
↔	Stable	39 (60%)	–
↓	Decrease	15 (23%)	–
↓↓	Significant Decrease	4 (6%)	Blue Jay, Song Sparrow, House Wren, American Redstart

Even though the period of monitoring (5 years) at Fort Necessity NB is relatively short to assess population trends, the primary message thus far appears to be that most species were stable or increasing in abundance at the park and were species associated with mature deciduous forest—the regional conservation priority. Of the 20 most abundant species at the park, only one (Blue Jay) showed a significant increase or decrease. It was surprising that Blue Jays appear to be declining at the park given that the species has been increasing in Pennsylvania in recent years (but have been declining in the broader Appalachian Mountains region; Sauer et al. 2020).

Despite the lack of significant declines, several species of conservation importance associated with the interior of mature, intact, deciduous forest (e.g., Wood Thrush, Scarlet Tanager, and Acadian Flycatcher) warrant close attention given that these species have been declining throughout Pennsylvania and the broader Appalachian Mountains region for several decades (Robinson et al. 1995, Rosenberg et al. 2019, Sauer et al. 2020).

This report provides the first information regarding population trends of breeding birds in Fort Necessity NB. Continued monitoring will provide new insights and future analyses will explore specific factors linked to population trends. As anthropogenic land use and climate change continue to reshape the Appalachian landscape, park managers will need this information to best allocate effort that aligns with regional conservation planning and other park priorities.

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Appendix 1. Abundance and trend estimate for 65 target bird species detected at Fort Necessity National Battlefield point count stations 2008–2012.

Table A1-1. Trend estimate based on slope of linear model regressing abundance estimate against sampling year. Species sorted from highest to lowest unadjusted abundance estimates. Taxonomy follows Chesser et al. (2019). [SD, standard deviation; SE, standard error; p, p-value].

Common Name	Scientific Name	Unadjusted Abundance (mean)	Unadjusted Abundance (1SD)	Unadjusted Linear Trend	Unadjusted Linear Trend (SE)	Unadjusted Linear Trend (p)	Adjusted Abundance (mean)	Adjusted Abundance (SE)	Adjusted Linear Trend	Adjusted Linear Trend (SE)	Adjusted Linear Trend (p)
Red-eyed Vireo	*Vireo olivaceus*	2.200	0.255	0.000	0.093	1.000	1.938	0.243	0.001	0.006	0.942
Scarlet Tanager*^	*Piranga olivacea*	1.220	0.286	−0.070	0.096	0.520	1.843	0.455	−0.004	0.014	0.814
Wood Thrush*+^	*Hylocichla mustelina*	1.020	0.259	−0.060	0.088	0.544	1.851	0.291	−0.004	0.006	0.560
Common Yellowthroat	*Geothlypis trichas*	1.020	0.192	0.010	0.070	0.895	–	–	–	–	–
Ovenbird	*Seiurus aurocapilla*	0.920	0.239	−0.010	0.087	0.916	0.968	0.135	−0.001	0.012	0.919
Eastern Towhee*+	*Pipilo erythrophthalmus*	0.880	0.164	0.030	0.057	0.638	0.163	0.086	0.004	0.003	0.319
Acadian Flycatcher*+^	*Empidonax virescens*	0.860	0.336	−0.100	0.108	0.424	1.508	0.167	−0.028	0.031	0.432
Eastern Wood-Pewee*+	*Contopus virens*	0.800	0.187	−0.050	0.062	0.478	0.457	0.601	0.002	0.008	0.828
Indigo Bunting	*Passerina cyanea*	0.780	0.164	−0.050	0.053	0.412	0.082	0.035	−0.001	0.002	0.728
American Crow	*Corvus brachyrhynchos*	0.680	0.130	−0.020	0.046	0.694	0.688	0.532	−0.001	0.005	0.823

* Species of conservation importance: Regional Importance, as determined by Partners in Flight (Panjabi 2020).

\+ Species of conservation importance: Regional Concern, as determined by Partners in Flight (Panjabi 2020).

^ Species of conservation importance: Regional Stewardship, as determined by Partners in Flight (Panjabi 2020).

Table A1-1 (continued). Trend estimate based on slope of linear model regressing abundance estimate against sampling year. Species sorted from highest to lowest unadjusted abundance estimates. Taxonomy follows Chesser et al. (2019). [SD, standard deviation; SE, standard error; p, p-value].

Common Name	Scientific Name	Unadjusted Abundance (mean)	Unadjusted Abundance (1SD)	Unadjusted Linear Trend	Unadjusted Linear Trend (SE)	Unadjusted Linear Trend (p)	Adjusted Abundance (mean)	Adjusted Abundance (SE)	Adjusted Linear Trend	Adjusted Linear Trend (SE)	Adjusted Linear Trend (p)
Hooded Warbler*^	*Setophaga citrina*	0.660	0.152	−0.050	0.047	0.368	0.179	0.059	0.026	0.020	0.285
Black-capped Chickadee	*Poecile atricapillus*	0.620	0.217	−0.030	0.077	0.724	0.878	2.316	−0.008	0.016	0.643
Pileated Woodpecker	*Dryocopus pileatus*	0.560	0.114	−0.030	0.038	0.486	0.353	0.148	−0.006	0.005	0.298
Tufted Titmouse	*Baeolophus bicolor*	0.540	0.114	−0.050	0.030	0.194	1.885	0.576	−0.004	0.002	0.129
Blue Jay	*Cyanocitta cristata*	0.500	0.187	−0.110	0.025	0.022	1.193	0.748	−0.026	0.006	0.027
Black-throated Green Warbler	*Setophaga virens*	0.480	0.164	−0.030	0.057	0.638	0.249	0.089	−0.002	0.007	0.762
American Robin	*Turdus migratorius*	0.480	0.148	0.070	0.036	0.148	0.986	1.845	0.018	0.016	0.332
Northern Cardinal	*Cardinalis cardinalis*	0.440	0.182	−0.080	0.048	0.191	0.425	0.217	−0.018	0.010	0.176
Red-bellied Woodpecker	*Melanerpes carolinus*	0.420	0.084	0.040	0.020	0.139	0.986	1.845	0.003	0.002	0.128
Field Sparrow*+	*Spizella pusilla*	0.400	0.071	−0.010	0.025	0.718	0.013	0.013	0.000	0.001	0.680
White-breasted Nuthatch	*Sitta carolinensis*	0.380	0.356	0.170	0.085	0.141	0.066	0.041	0.319	0.166	0.150
Blue-headed Vireo	*Vireo solitarius*	0.380	0.179	0.110	0.015	0.006	0.478	0.133	0.016	0.004	0.023

* Species of conservation importance: Regional Importance, as determined by Partners in Flight (Panjabi 2020).

+ Species of conservation importance: Regional Concern, as determined by Partners in Flight (Panjabi 2020).

^ Species of conservation importance: Regional Stewardship, as determined by Partners in Flight (Panjabi 2020).

Table A1-1 (continued). Trend estimate based on slope of linear model regressing abundance estimate against sampling year. Species sorted from highest to lowest unadjusted abundance estimates. Taxonomy follows Chesser et al. (2019). [SD, standard deviation; SE, standard error; p, p-value].

Common Name	Scientific Name	Unadjusted Abundance (mean)	Unadjusted Abundance (1SD)	Unadjusted Linear Trend	Unadjusted Linear Trend (SE)	Unadjusted Linear Trend (p)	Adjusted Abundance (mean)	Adjusted Abundance (SE)	Adjusted Linear Trend	Adjusted Linear Trend (SE)	Adjusted Linear Trend (p)
Brown Creeper	*Certhia americana*	0.380	0.045	0.010	0.015	0.559	1.072	1.571	0.001	0.001	0.456
Chestnut-sided Warbler	*Setophaga pensylvanica*	0.360	0.055	0.000	0.020	1.000	–	–	–	–	–
American Redstart	*Setophaga ruticilla*	0.340	0.182	−0.100	0.033	0.055	0.276	0.060	−0.023	0.006	0.028
Gray Catbird	*Dumetella carolinensis*	0.300	0.100	0.000	0.037	1.000	–	–	–	–	–
Rose-breasted Grosbeak*+	*Pheucticus ludovicianus*	0.280	0.179	−0.080	0.046	0.182	–	–	–	–	–
Louisiana Waterthrush*^	*Parkesia motacilla*	0.260	0.288	−0.160	0.050	0.050	1.641	0.374	−0.026	0.011	0.107
Song Sparrow	*Melospiza melodia*	0.260	0.114	−0.070	0.010	0.006	–	–	–	–	–
Cedar Waxwing	*Bombycilla cedrorum*	0.260	0.241	−0.040	0.085	0.670	–	–	–	–	–
Northern Flicker*+	*Colaptes auratus*	0.220	0.110	−0.030	0.036	0.466	1.146	1.390	−0.010	0.004	0.074
Blackburnian Warbler	*Setophaga fusca*	0.220	0.130	0.000	0.048	1.000	–	–	–	–	–
Brown-headed Cowbird	*Molothrus ater*	0.180	0.045	−0.020	0.012	0.182	–	–	–	–	–

* Species of conservation importance: Regional Importance, as determined by Partners in Flight (Panjabi 2020).

+ Species of conservation importance: Regional Concern, as determined by Partners in Flight (Panjabi 2020).

^ Species of conservation importance: Regional Stewardship, as determined by Partners in Flight (Panjabi 2020).

Table A1-1 (continued). Trend estimate based on slope of linear model regressing abundance estimate against sampling year. Species sorted from highest to lowest unadjusted abundance estimates. Taxonomy follows Chesser et al. (2019). [SD, standard deviation; SE, standard error; p, p-value].

Common Name	Scientific Name	Unadjusted Abundance (mean)	Unadjusted Abundance (1SD)	Unadjusted Linear Trend	Unadjusted Linear Trend (SE)	Unadjusted Linear Trend (p)	Adjusted Abundance (mean)	Adjusted Abundance (SE)	Adjusted Linear Trend	Adjusted Linear Trend (SE)	Adjusted Linear Trend (p)
House Wren	*Troglodytes aedon*	0.160	0.134	−0.080	0.016	0.016	–	–	–	–	–
Downy Woodpecker	*Dryobates pubescens*	0.140	0.114	0.050	0.030	0.194	–	–	–	–	–
Cerulean Warbler*+^	*Setophaga cerulea*	0.140	0.195	−0.080	0.054	0.236	–	–	–	–	–
American Goldfinch	*Spinus tristis*	0.120	0.084	−0.010	0.030	0.761	–	–	–	–	–
Northern Parula	*Setophaga americana*	0.100	0.071	−0.030	0.019	0.215	–	–	–	–	–
Blue-gray Gnatcatcher	*Polioptila caerulea*	0.100	0.122	−0.050	0.034	0.239	–	–	–	–	–
Ruby-throated Hummingbird	*Archilochus colubris*	0.080	0.084	0.020	0.028	0.530	–	–	–	–	–
Hairy Woodpecker	*Dryobates villosus*	0.080	0.130	−0.020	0.046	0.694	–	–	–	–	–
Chipping Sparrow*+	*Spizella passerina*	0.080	0.084	−0.010	0.030	0.761	–	–	–	–	–
Common Raven	*Corvus corax*	0.080	0.130	−0.010	0.047	0.846	–	–	–	–	–
Magnolia Warbler	*Setophaga magnolia*	0.080	0.084	0.000	0.031	1.000	–	–	–	–	–
Yellow-throated Vireo	*Vireo flavifrons*	0.060	0.055	0.010	0.019	0.638	–	–	–	–	–

* Species of conservation importance: Regional Importance, as determined by Partners in Flight (Panjabi 2020).

+ Species of conservation importance: Regional Concern, as determined by Partners in Flight (Panjabi 2020).

^ Species of conservation importance: Regional Stewardship, as determined by Partners in Flight (Panjabi 2020).

Table A1-1 (continued). Trend estimate based on slope of linear model regressing abundance estimate against sampling year. Species sorted from highest to lowest unadjusted abundance estimates. Taxonomy follows Chesser et al. (2019). [SD, standard deviation; SE, standard error; p, p-value].

Common Name	Scientific Name	Unadjusted Abundance (mean)	Unadjusted Abundance (1SD)	Unadjusted Linear Trend	Unadjusted Linear Trend (SE)	Unadjusted Linear Trend (p)	Adjusted Abundance (mean)	Adjusted Abundance (SE)	Adjusted Linear Trend	Adjusted Linear Trend (SE)	Adjusted Linear Trend (p)
Baltimore Oriole	*Icterus galbula*	0.060	0.089	−0.010	0.032	0.776	–	–	–	–	–
Great Crested Flycatcher	*Myiarchus crinitus*	0.060	0.089	0.000	0.033	1.000	–	–	–	–	–
Black-and-white Warbler*+	*Mniotilta varia*	0.040	0.089	−0.040	0.023	0.182	–	–	–	–	–
Common Grackle*+	*Quiscalus quiscula*	0.040	0.055	−0.020	0.016	0.308	–	–	–	–	–
Mourning Dove	*Zenaida macroura*	0.040	0.055	−0.020	0.016	0.308	–	–	–	–	–
Brown Thrasher	*Toxostoma rufum*	0.040	0.089	0.020	0.031	0.559	–	–	–	–	–
Golden-winged Warbler*+	*Vermivora chrysoptera*	0.040	0.055	−0.010	0.019	0.638	–	–	–	–	–
Yellow Warbler	*Setophaga petechia*	0.040	0.055	−0.010	0.019	0.638	–	–	–	–	–
Prairie Warbler*+	*Setophaga discolor*	0.040	0.055	0.010	0.019	0.638	–	–	–	–	–
Red-winged Blackbird	*Agelaius phoeniceus*	0.020	0.045	0.020	0.012	0.182	–	–	–	–	–
White-eyed Vireo	*Vireo griseus*	0.020	0.045	0.020	0.012	0.182	–	–	–	–	–
Black-billed Cuckoo*+	*Coccyzus erythropthalmus*	0.020	0.045	−0.020	0.012	0.182	–	–	–	–	–

* Species of conservation importance: Regional Importance, as determined by Partners in Flight (Panjabi 2020).

+ Species of conservation importance: Regional Concern, as determined by Partners in Flight (Panjabi 2020).

^ Species of conservation importance: Regional Stewardship, as determined by Partners in Flight (Panjabi 2020).

Table A1-1 (continued). Trend estimate based on slope of linear model regressing abundance estimate against sampling year. Species sorted from highest to lowest unadjusted abundance estimates. Taxonomy follows Chesser et al. (2019). [SD, standard deviation; SE, standard error; p, p-value].

Common Name	Scientific Name	Unadjusted Abundance (mean)	Unadjusted Abundance (1SD)	Unadjusted Linear Trend	Unadjusted Linear Trend (SE)	Unadjusted Linear Trend (p)	Adjusted Abundance (mean)	Adjusted Abundance (SE)	Adjusted Linear Trend	Adjusted Linear Trend (SE)	Adjusted Linear Trend (p)
Eastern Phoebe	*Sayornis phoebe*	0.020	0.045	−0.020	0.012	0.182	–	–	–	–	–
Winter Wren	*Troglodytes hiemalis*	0.020	0.045	−0.020	0.012	0.182	–	–	–	–	–
Vesper Sparrow	*Pooecetes gramineus*	0.020	0.045	−0.010	0.015	0.559	–	–	–	–	–
Yellow-breasted Chat*+	*Icteria virens*	0.020	0.045	−0.010	0.015	0.559	–	–	–	–	–
Golden-crowned Kinglet	*Regulus satrapa*	0.020	0.045	0.010	0.015	0.559	–	–	–	–	–
Least Flycatcher*+	*Empidonax minimus*	0.020	0.045	0.000	0.016	1.000	–	–	–	–	–
Yellow-billed Cuckoo*+	*Coccyzus americanus*	0.020	0.045	0.000	0.016	1.000	–	–	–	–	–
Yellow-rumped Warbler	*Setophaga coronata*	0.020	0.045	0.000	0.016	1.000	–	–	–	–	–

* Species of conservation importance: Regional Importance, as determined by Partners in Flight (Panjabi 2020).

+ Species of conservation importance: Regional Concern, as determined by Partners in Flight (Panjabi 2020).

^ Species of conservation importance: Regional Stewardship, as determined by Partners in Flight (Panjabi 2020).

Appendix 2. Trend estimate for 65 target bird species detected at Fort Necessity National Battlefield point count stations 2008–2012.

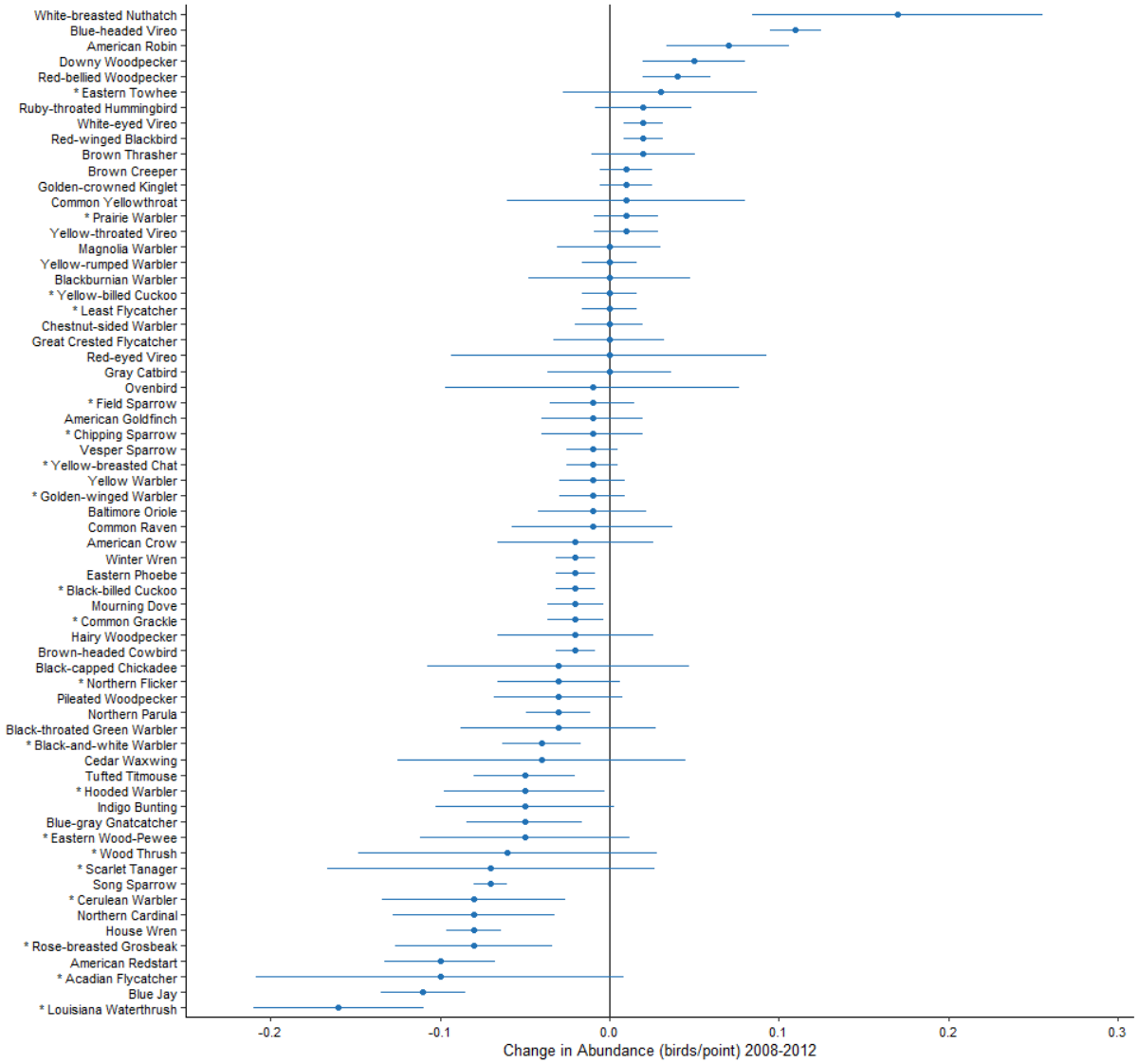


Figure A2-1. Slope ± standard error of linear model regressing unadjusted abundance estimates against sampling year. *Species of regional conservation importance (Panjabi et al. 2020). Scientific names in Appendix 1.

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.

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