



Breeding Bird Monitoring

Mid-Atlantic Network 2009 Annual Report

Natural Resource Data Series NPS/MIDN/NRDS—2011/142



ON THE COVER

Common yellowthroat (*Geothlypis trichas*)

Photograph by: Nicolas Bircher

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The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

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. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data.

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Introduction

As part of the Natural Resource Challenge (NPS 1999), the Mid-Atlantic Network (MIDN) has been tasked with monitoring “vital signs,” a suit of physical, chemical, or biological elements or processes that represent the overall health or condition of the network parks’ natural resources. Breeding birds have been selected as one of the Mid-Atlantic Network’s vital signs because they are highly visible, are a reliable indicator of ecological integrity, and face numerous population threats in the region (Comiskey and Callahan 2008).

The Mid-Atlantic Network consists of 10 park units across Pennsylvania and Virginia. During the 2009 pilot monitoring season, three parks were surveyed by skilled volunteers for breeding birds; Booker T. Washington National Monument (NM), Fredericksburg and Spotsylvania National Military Park (NMP), and Valley Forge National Historical Park (NHP, Figure 1). All three parks fall in the Piedmont Bird Conservation Region (BCR), developed by the North American Bird Conservation Initiative (NABCI). BCRs are ecologically distinct units designed to help focus conservation efforts for specific bird communities. In the future, monitoring efforts will be expanded to other parks within the network; hence we use the Piedmont and Southeastern Coastal Plain BCRs.

The two primary objectives for the monitoring protocol are to:

1. Determine annual changes and long-term trends in species composition and relative abundance.
2. Improve our understanding of the relationship between breeding birds, habitats, and park management.

This report summarizes monitoring results for the 2009 monitoring season. We provide park and region-wide abundance metrics for all species, and take note of the spatial distribution of species of conservation concern identified on a continental scale and a regional scale (for the Piedmont/Southeastern Coastal Plain region). We also provide a community-wide assessment of species composition (a “Bird Community Index” or BCI) that informs on ecosystem integrity by evaluating the relative composition of different guilds in the overall bird community.

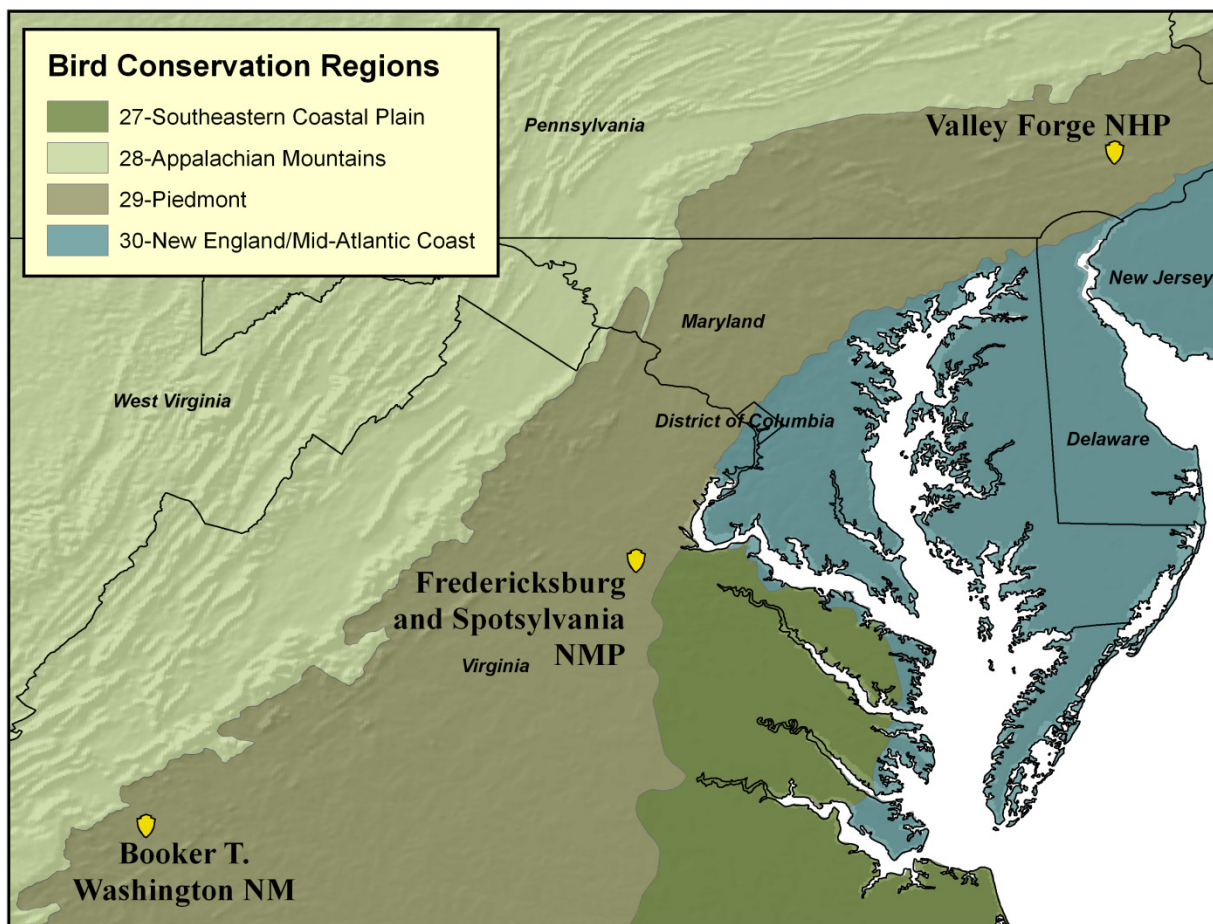


Figure 1. Mid-Atlantic Network parks implementing bird monitoring in 2009 and their associated Bird Conservation Region (BCR).

Methods

Three national parks with a strong volunteer base were selected for avian monitoring for the pilot testing season of the program: Booker T. Washington NM, Fredericksburg and Spotsylvania NMP, and Valley Forge NHP. Monitoring stations were selected by overlaying a 250 m grid on park maps. The grid is the same used for selecting vegetation monitoring plots (Comiskey et al. 2009), but offset by 125 m. This allows for point count stations to be co-located with vegetation monitoring plots, but reduces trampling or otherwise influencing vegetation monitoring data from repeat visits. Stations that were selected were at least 15 m from hiking trails and secondary and tertiary roads (park roads), and 50 m from primary roads, park boundaries, and buildings which are frequented by visitors and may influence bird behavior.

While the parks within the network are primarily forested, many also contain large battlefields managed as grasslands. Resource managers were interested in long-term trends for both of these habitat types. Therefore, each point count station was categorized as either grassland or forest based on vegetation maps available for each park (Patterson 2008, Taverna and Patterson 2008, and Podniesinski et al. 2005). Edge buffers between habitat types were not applied because analysis is on the overall characterization of each habitat type rather than a comparison across types (Ralph et al. 1995). All possible stations that fit these criteria were monitored in the parks, as the goal was as complete a coverage as possible.

Stations were surveyed by skilled volunteers between May 20 and July 14, 2009. Volunteers visited each site at least once per season, and some sites were surveyed multiple times (Table 1). During each survey, volunteers recorded on a field mapping card all birds detected in a ten-minute interval along with the species detected, the minute the bird was first detected, whether the bird was within or beyond 50 m, the type of detection (visual, auditory, both), and the location of the detection. Data were transcribed to paper datasheets, entered into the U.S. Geological Survey (USGS) point-count database (<http://www.pwrc.usgs.gov/point/>), and later verified by the project lead. This document reports on the data collected during this first pilot season.

Table 1. Number of monitoring stations at Booker T. Washington National Monument (BOWA), Fredericksburg and Spotsylvania National Military Park (FRSP), and Valley Forge National Historical Park (VAFO) in 2009 by habitat type, number of surveys per season, and total number of volunteers surveying.

	Total Stations	Grassland Stations	Forest Stations	Average # Surveys/Season	Number of Volunteers
BOWA	16	4	12	3.4	3
FRSP	59	11	48	2.0	8
VAFO	76	39	37	1.0	12

Total Species, Abundance, and Density

To estimate the total number of species encountered, we included species detected within and beyond 50 m, flyovers, and species detected outside of count periods. Here, the goal is to document the total diversity of species across all three parks, so including incidental encounters is not problematic. Total species were estimated across all habitat types, and broken out by grassland versus forested sites.

Special note was also taken for species of conservation concern. Partners in Flight (PIF), a cooperative effort to address the conservation of birds, produced a list of species of conservation concern in their North American Landbird Conservation Plan (Rich et al. 2004). They define two sets of species of concern, “Watchlist” species that face immediate threats due to habitat alteration, declining populations, small population size, and limited distributions, and “Stewardship” species that are representative species of avifaunal biomes that may or may not be in immediate danger. These lists have been developed at the continental and regional scale. We identified both continental and regional (e.g. Piedmont and Southeastern Coastal Plain BCRs) Watchlist and Stewardship species detected across the three parks, and calculated the percent of points in each park where at least one individual was detected.

The relative abundance and density of each species were estimated at the park unit and regional level. Regional, for the sake of this document, refers to data summed across the three parks sampled in the 2009 monitoring season, as opposed to all parks in the network. Detections in the second distance band (beyond 50 m) were excluded for estimations of relative abundance, as accuracy in detection and distance estimates decreases rapidly beyond this distance (Alldredge et al. 2007). Detections outside the count period, flyovers, and counts of unknown species were removed in both relative abundance and density estimates. These detections are not amenable to quantitative estimations of abundance or density, but can be used to estimate total species counts or in monitoring techniques that incorporate presence/absence data. Relative abundance estimates were based on the maximum number of individuals of a given species detected across surveys at a given station, so multiple surveys do not upward inflate the values. When estimating density, all surveys are counted, but are divided by the total number of surveys conducted.

Relative abundance was calculated by dividing the total detections by the number of monitoring stations. While relative abundance can be derived for all species detected, its use as an accurate measure of population size and as an index of population change has been heavily criticized in recent years (Rosenstock et al. 2002, Thompson 2002, Farnsworth et al. 2005) because it does not take into account detection probability which may vary across space and time. When an observer fails to detect a bird, the bird may have been absent, or the observer may not have detected the bird (Mackenzie et al. 2002). A failure to detect a bird that is present can result from many environmental or survey-related obstacles (i.e. wind, distance, weather, observer error). One factor that exerts a strong influence on detection is distance – birds that are more distant to the observer are more difficult to detect. Estimations of density that account for this reduction in detectability relative to distance are a common approach to incorporating detection rates.

To estimate density adjusted with detection probability, a binomial distance method (Buckland 1987) was employed which uses two distance classes: “near” (within 50 m), and “far” (beyond

50 m). Each bird detected was put into one of these two distance classes. Density estimates were applied from Buckland 1987 as:

$$n \log_e(n/n_2)/(r^2 \pi m) \text{ (pg. 369)}$$

n = total number of birds detected

n₂ = total number of birds detected in the “far” class

r = 50 m (first distance class)

m = total number of counts

Estimates were then adjusted to represent birds per hectare by multiplying this value by 1000.

Variance was calculated as:

$$D^2 \{V(n)/n^2 + n^2/[(n -)^2(n - 2)]\}$$

Where D = density and

$$V(n) = [m \sum n_i^2 - (\sum n_i)^2]/(m-1) \text{ (pg. 365)}$$

Each survey was considered a distinct count, as multiple surveys at one point would only improve estimates of density by reducing the variance. Wherever a species was observed in only one distance class, density could not be estimated; therefore some species that were present on counts may be absent from estimations of density. Although the binomial distance method provides a more accurate estimate of density, its conservative approach results in estimates for fewer species. Therefore, both relative abundance and density estimates are provided in this report.

Avian Integrity Scorecards

Avian guilds, or groups of species occupying similar ecological niches, are diverse and can be utilized for assessing response to environmental changes and ecosystem stressors. These guilds can be defined based on foraging behavior and substrate, nesting substrate, migratory distance, and various other life history traits. Changes in ecological condition can variably impact avian guilds, resulting in alterations to the bird community as a whole (Severinghaus 1981, Verner 1984). Bird community assessments, or “indices” (BCIs), yield a quantitative metric that can be used to define the ecological integrity of a sampled area based on the avian community present. BCIs assume that changes in habitat quality or extent, upon which a specific guild is dependent, results in corresponding changes in the representation of that guild within the overall bird community. Within the BCI, guilds are ranked based on specialization, with specialist guilds receiving higher weight over generalist guilds. This ability to use the bird community to reflect ecological condition, particularly in urban areas where impacts can be multi-faceted, provides a valuable and informative indicator for monitoring programs. We recognize that the BCI scores and ratings are based on ecological criteria, and that park management goals may not seek to attain “high ecological integrity”. However, shifts in ecological integrity over time may be indicative of stressors. Additionally, a management scorecard could be developed by park and

MIDN staff that would reflect progress towards avian and ecological management goals for individual parks.

BCIs are designed to represent major habitat types, as bird communities shift markedly by ecosystem. Two major habitat types dominate the parks sampled in the 2009 avian monitoring season in the Mid-Atlantic Network; forest and grassland. O'Connell et al. (2003) developed a forest integrity index for the mid-Atlantic Piedmont and Southeastern Coastal Plain ecoregions that can be applied to the points that fall in forested areas. Coppedge et al. (2006) developed a grassland integrity index in mixed prairie habitat in Oklahoma. Although this area is relatively far from the parks of the mid-Atlantic, the bird community used in this index is similar and, as the only grassland index yet developed, remains the sole tool to assess grassland birds in eastern biomes. As this topic of research expands and is improved upon, the network will consider new methodologies.

Avian Scorecard Methods

For BCI analysis, the 2009 NPS Mid-Atlantic avian data set was first broken out by habitat type, either grassland or forest stations. Birds detected outside the count period, flyovers, and unknown species were removed from the dataset. Only members of the following families were used in BCI analyses: Passeriformes, Columbiformes, Apodiformes, Piciformes, and Cuculiformes. Furthermore, only bird species that were included in the original development of these indices were considered (O'Connell et al. 2003). Therefore, there are some detections of birds that are not included in the integrity analyses. For the forested locations, data were compiled for stations that were visited more than once. Forest integrity estimates based on O'Connell et al. (2003) are built from percent guild representation, so multiple visits provide a more complete picture of the community and not an upward biased BCI score. For the grassland stations, integrity estimates include counts of total individuals, which would be biased by multiple counts. For this reason, only the first count of the season was used to evaluate BCI scores in grassland habitat. It is important to note that although only the first survey was used to estimate grassland BCI scores, subsequent visits were still used to estimate density and gain a better picture of total diversity.

Often, ecological integrity reports aggregate individual integrity metrics to create indices of overall ecosystem scores (Karr 1991, O'Connell et al. 2003). However, some believe that these indices may rely on subjective understanding of the relative importance of each individual metric in estimating overall ecosystem integrity and that by aggregating metrics, individual ecosystem components which may need attention are obscured (Faccio et al. 2010). Therefore, for forested sites, we summarized the data in both manners: across each individual guild and as an aggregated ecosystem score. Summing data across guilds and not simply reporting the total score is especially relevant in this region, as pine-associated species are low in numbers and drive down scores aggregated across all guilds. We compared aggregated scores across parks using a one-way ANOVA, and a Tukey-Kramer post-hoc test to determine which scores were significantly different.

Kriging interpolation methods were used in ArcGIS 9.3 to generate maps of estimated surface of BCI scores between monitoring points for each park. Booker T. Washington NM did not have a sufficient number of monitoring points in the grassland habitat, so for this park only forested habitats were interpolated.

Calculating BCI scores

Forested Stations: All species detected at forested stations were assigned to appropriate guilds that were defined by O'Connell et al. (2003) and shown to respond most strongly to changing forest structure (Appendix B). Proportional guild representation was then calculated for each station. For example, if 2 of 10 species detected at a station were forest interior species, then that station had 20% forest interior species. That guild percentage was then assigned a rank score of 1, 2, 3, or 4 (Table 2) using thresholds derived by O'Connell et al. (2003) for the Piedmont and Southeastern Coastal Plain. This was done for each guild and a final BCI score for a station is then calculated as follows:

$$V1 = \frac{\sum \text{Structural Guild Ranks}}{4}$$

$$V2 = \frac{\sum \text{Functional Guild Ranks}}{4}$$

$$V3 = \frac{\sum \text{Compositional Guild Ranks}}{4}$$

$$BCI = \frac{V1+V2+V3}{9}$$

This final BCI score which ranges from 0.25 – 1.00 can then be then assigned a rank that falls on the Humanistic to Naturalistic scale of 1 to 4 (Table 2). Thus for each station, we derive an individual guild rank score and an aggregate rank score. Station scores are then averaged to provide scores for each park and the region.

Table 2. Rank scores by percent guild representation for forested sites based on O'Connell et al. (2003). See details on these guild assignments in Appendix B.

Guild		Percent Guild Representation			
		Rank = 1 Humanistic	Rank = 2 Moderately Disturbed	Rank = 3 Largely Intact	Rank = 4 Naturalistic
Structural Guilds	Forest Interior	0 - 10.0	10.1 - 20.0	20.1 - 28.0	28.1 - 100
	Pine Associated	0	0.1 - 2.0	2.1 - 5.0	5.1 - 100
	Urban/Suburban	60.1 - 100	47.1 - 60.0	20.1 - 47.0	0 - 20.0
Functional Guilds	Bark Prober	0 - 9.0	9.1 - 16.0	16.1 - 20.0	20.1 - 100
	Upper Canopy Gleaner	0 - 4.0	4.1 - 12.0	12.1 - 18.0	18.1 - 100
	Ground Gleaner	0	0.1 - 3.0	3.1 - 7.0	7.1 - 100
Compositional Guilds	Single Brooded	0 - 16.0	16.1 - 34.0	34.1 - 46.0	46.1 - 100
	Nest Disrupter	23.1 - 100	16.1 - 23.0	0.1 - 16.0	0
	Exotic	11.1 - 100	1.1 - 11.0	0.1 - 1.0	0
Final BCI Score		0.250-0.460	0.461-0.600	0.601-0.730	0.731-1.00

Grassland Stations: Coppedge et al. (2006) used a variety of metrics in developing their grassland BCI. Thirteen response metrics were categorized as either “positive”, having a positive correlation with grassland integrity, or “negative,” having a negative correlation with grassland integrity (Table 3). For these calculations, the grassland data were truncated at the first visit for every station (for many stations, this was the only visit), and guild assignments were made for each individual detected (Appendix C). For each station, each metric was scored on a 10-0 or 0-10 number line for positive and negative metrics, respectively. For the positive metrics, the value at the station is divided by the maximum value of that metric across all parks in the dataset and multiplied by 10. For the negative metrics the value at the station is divided by the maximum, multiplied by 10 and then subtracted from 10. The final BCI score was calculated by summing across these 13 values, and then standardized to fall between 0 and 100 by dividing by 13 (the total number of metrics) and then multiplying by 10. Therefore, individual guild metric scores range from 0-10 and total station BCI scores range from 0-100.

For example, at a given sampling station, 10% of the species observed are aerial foragers. Across all the sampling stations in three-park dataset, 20% is the maximum value observed for percent aerial foraging species. Dividing the observed 10% by the maximum (20%) and multiplying by 10, produces a score of 5 for that guild metric at that station. At the same sampling station, 10% of the individuals observed are residents. Across all sampling stations in the three-park dataset, 40% is the maximum value observed for percent resident individuals. Dividing the observed 10% by the maximum (40%), multiplying by 10, and then subtracted from 10, produces a score of 7.5 for that guild metric at that station.

Table 3. Guild metrics and direction of correlation for integrity of grassland stations based on Coppedge et al. (2006). See details on these guild assignments in Appendix C.

Guild Metrics	
Positive Correlation	Negative Correlation
% aerial foraging spp.	No. of canopy foraging spp.
% grassland obligate individuals	No. of low foraging spp.
% temperate migrant individuals	% canopy nesting individuals
% neotropical migrant spp.	No. of cavity nesting spp.
% insectivorous individuals	% edge habitat individuals
	No. of woodland habitat individuals
	% resident individuals
	% omnivorous individuals

Results

Region-wide

Across the three parks, 84 species of birds were detected. Grassland and forest habitats hosted an equal number of total species, with 70 species detected in each habitat type (Figure 2). At each park, diversity was lower than the regional total, but each park contributed species to this regional total. Of the 84 species, the Red-eyed Vireo and Tufted Titmouse had the highest densities and were the most relatively abundant species. While the Red-Winged Blackbird, Eastern Wood Pewee, Northern Cardinal, and Wood Thrush had similar relative abundance estimates, the Eastern Wood Pewee appeared to have higher density estimates when adjusted for detection probability (Figure 3). All of these species except the Red-Winged Blackbird are more associated with forested habitats.

A variety of Watchlist and Stewardship species were also detected across the three parks (Table 4). It is notable that the Wood Thrush, Eastern Wood-Pewee, Carolina Chickadee, and Indigo Bunting, all species of conservation concern for the Piedmont/Southeastern Coastal Plain BCRs, are among the most common species within the region. Fredericksburg and Spotsylvania NMP hosted the greatest number of species of conservation concern at 28 species, but all parks were rich with species of conservation concern.

The average BCI score for forested stations was 0.698 ± 0.012 SE, giving the region a rating of “largely intact”. There was significant heterogeneity in the average scores across parks (one-way ANOVA, $F_{2,95} = 33.26$, $p < 0.001$, see Figure 4). Fredericksburg and Spotsylvania NMP scored highest for forest avian integrity with an average of 0.765 ± 0.012 SE. Booker T. Washington NM scored the next highest at 0.708 ± 0.025 SE, and this was not significantly different from Fredericksburg and Spotsylvania NMP. Valley Forge NHP scored the lowest at 0.597 ± 0.01 SE, and this score was significantly different from the other two parks.

The average BCI score for grassland stations across all parks was 46.04 ± 1.50 SE. There was no significant heterogeneity in the scores by park (one-way ANOVA, $F_{2,48} = 2.531$, $p = 0.09$, see Figure 5), but this was likely influenced by the low sample size of grassland stations as compared to forested stations. Valley Forge NHP scored the highest among parks in BCI score with 47.8 ± 1.64 SE. Booker T. Washington NM had the next highest score at 41.73 ± 6.71 SE, but with so few grassland stations, the variance was high. Fredericksburg and Spotsylvania NMP scored the lowest at 39.43 ± 3.44 SE.



Figure 2. Total species detected by habitat type for the region and the three Mid-Atlantic Network parks monitored in 2009

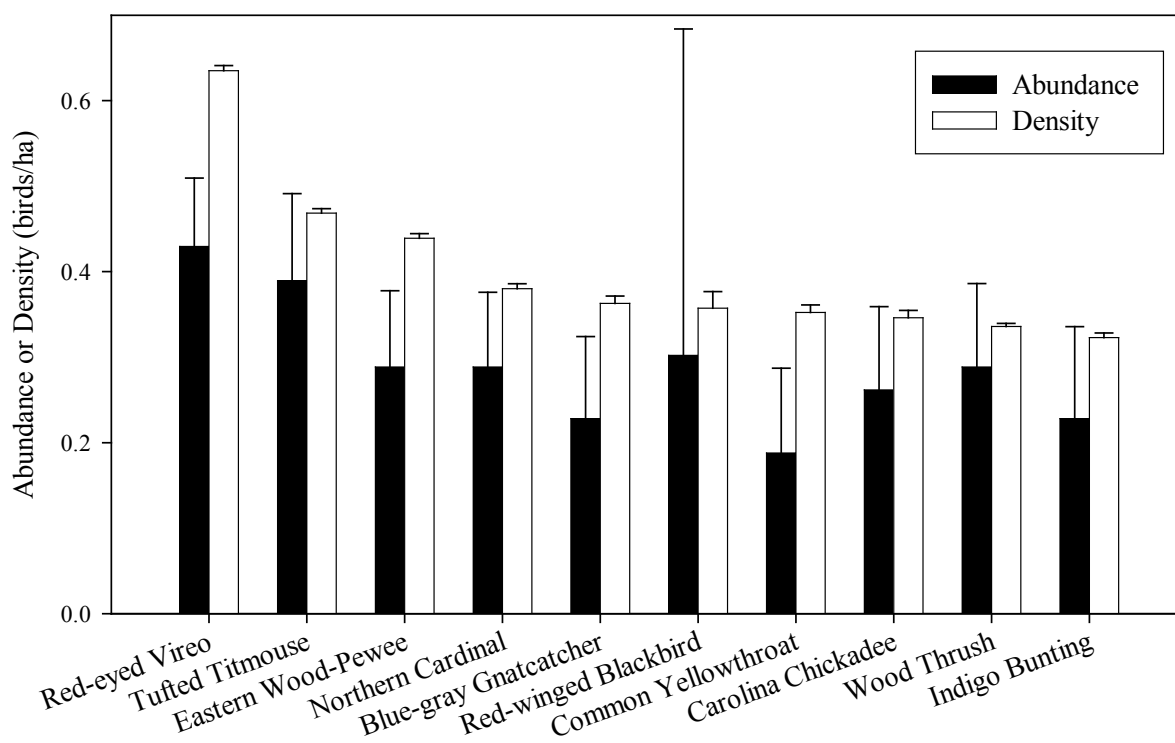


Figure 3. Density and relative abundance estimates with standard error bars for the ten most common species detected across the three Mid-Atlantic Network parks monitored in 2009.

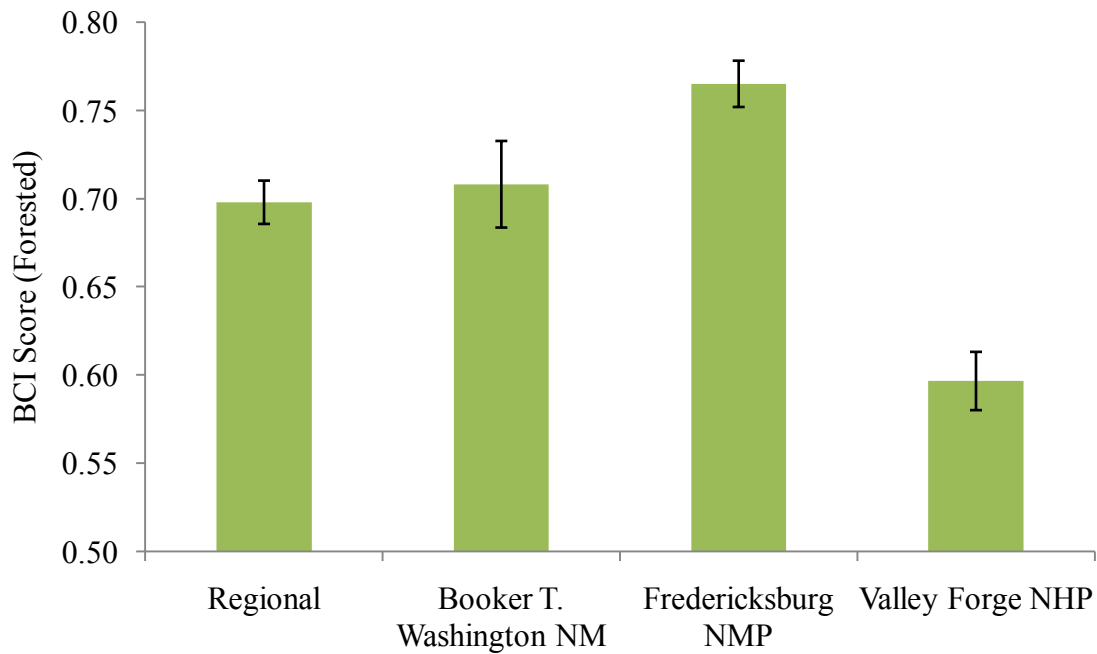


Figure 4. Forest BCI scores with standard error bars for the region and the three Mid-Atlantic Network parks monitored in 2009.

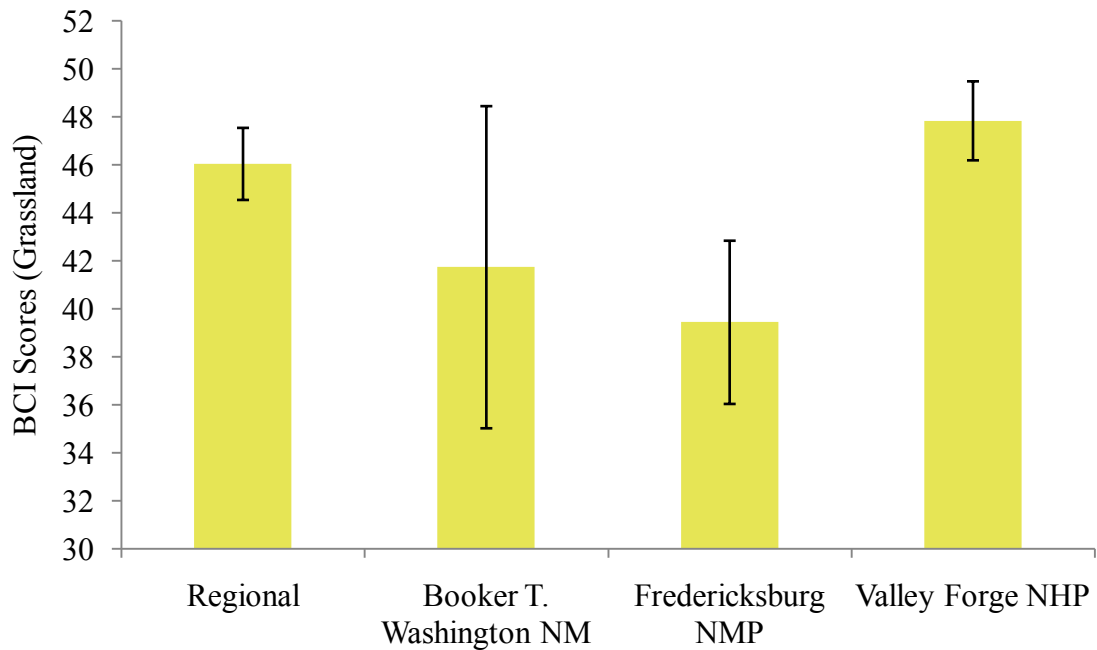


Figure 5. Grassland BCI scores with standard error bars for the region and the three Mid-Atlantic Network parks monitored in 2009

Table 4. Species of regional and continental conservation concern detected at Booker T. Washington NM (BOWA), Fredericksburg and Spotsylvania NMP (FRSP), and Valley Forge NHP (VAFO) in 2009.

Numbers indicate the percent of monitoring locations in each park where at least one individual was detected. Species in italics are of continental concern.

Species	% Monitoring Stations		
	BOWA	FRSP	VAFO
Watchlist Species			
Baltimore Oriole	0.0	0.0	28.4
<i>Blue-winged Warbler</i>	0.0	0.0	1.4
Brown Thrasher	6.3	5.1	2.7
Chimney Swift	0.0	6.8	5.4
Eastern Kingbird	0.0	8.5	16.2
Eastern Meadowlark	37.5	0.0	21.6
Eastern Towhee	12.5	3.4	17.6
Eastern Wood-Pewee	68.8	57.6	28.4
Field Sparrow	37.5	23.7	16.2
Grasshopper Sparrow	12.5	1.7	0.0
Northern Flicker	6.3	3.4	6.8
<i>Prairie Warbler</i>	6.3	5.1	0.0
<i>Willow Flycatcher</i>	0.0	0.0	1.4
<i>Wood Thrush</i>	75.0	66.1	20.3
<i>Worm-eating Warbler</i>	0.0	1.7	0.0
Yellow-billed Cuckoo	6.3	33.9	0.0
Stewardship Species			
<i>Acadian Flycatcher</i>	37.5	42.4	0.0
Blue Grosbeak	0.0	3.4	0.0
Carolina Chickadee	37.5	32.2	23.0
<i>Carolina Wren</i>	75.0	59.3	18.9
Downy Woodpecker	37.5	33.9	14.9
<i>Hooded Warbler</i>	0.0	5.1	0.0
<i>Indigo Bunting</i>	62.5	39.0	8.1
<i>Louisiana Waterthrush</i>	25.0	0.0	0.0
Northern Parula	6.3	3.4	0.0
Orchard Oriole	0.0	1.7	6.8
Pileated Woodpecker	43.8	13.6	0.0
<i>Pine Warbler</i>	12.5	6.8	0.0
Purple Martin	0.0	3.4	0.0
<i>Red-bellied Woodpecker</i>	62.5	33.9	45.9
<i>Red-shouldered Hawk</i>	6.3	1.7	0.0
Summer Tanager	18.8	5.1	0.0
<i>White-eyed Vireo</i>	0.0	0.0	1.4
<i>Yellow-throated Vireo</i>	6.3	1.7	0.0

Results by Park

Booker T. Washington National Monument

A total of 16 stations were established at Booker T. Washington NM in 2009 (Figure 7). Four of the stations were in grassland habitat and 12 were in forest habitat. All stations were surveyed at least once over the breeding season, and several were surveyed multiple times (average 3.4 surveys per station). Surveys were completed by three skilled volunteers.

Fifty-two species were detected across the park, with 43 species detected in forest habitat, and 38 species in grassland habitat. The most common species are shown in Figure 6 along with their abundance and density estimates. Twenty-three Partners in Flight species of conservation concern were detected in the park including 10 species of continental concern (see Table 4).

From BCI analyses, Booker T. Washington NM was ranked as “largely intact” (0.708 ± 0.025 SE) for forested stations, and scored 41.73 ± 6.71 SE for grassland stations, placing it second highest in scores for both habitat types out of the three parks. Table 5 shows the forest BCI score broken down by guilds. Few of the guilds are in the lowest ranking category (humanistic), indicating that the guilds for most forest specialist areas are well represented and the overall integrity is high. Among the guilds ranked as “humanistic” or “moderately disturbed” were “pine associated”, “bark-probers”, and “nest disrupters.” The former two may be indicative of a lack of mature trees and snags while the latter may be indicative of fragmentation effects due to the small size of the park. Pine warblers, which are the sole species in the “pine associated guild” for the region, and also fall in the “bark-probers” guild, may also be underrepresented or difficult to detect.

Table 6 shows the grassland BCI broken down by guilds. In the handful of grassland stations, Booker T. Washington NM scored low for aerial foraging birds, indicating the low number of species in this category. Scores were high for cavity nesting and woodland guilds, indicating that forest encroachment may not be a large issue.

Based on the kriging interpolation (Figure 7), forest integrity appears to be highest in the south and western portions of the park. The lower integrity scores around the northwestern section of the park and around Station 03 may speak of the higher visitor use in the picnic areas and along trails.

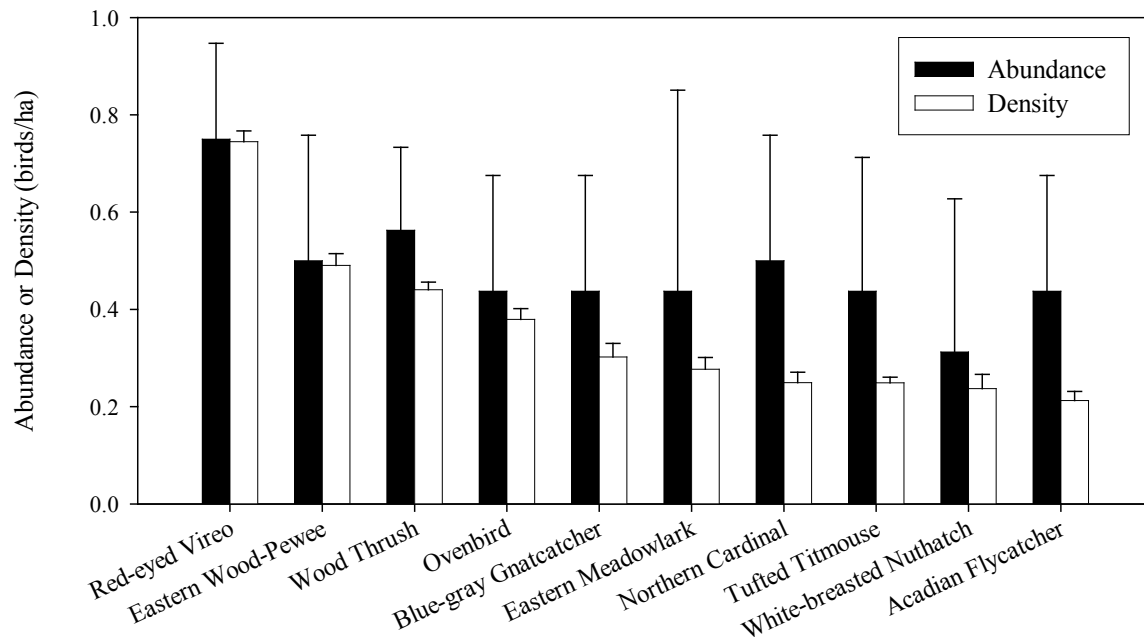


Figure 6. Density and relative abundance estimates with standard error bars for the ten most common avian species detected at Booker T. Washington NM in 2009.

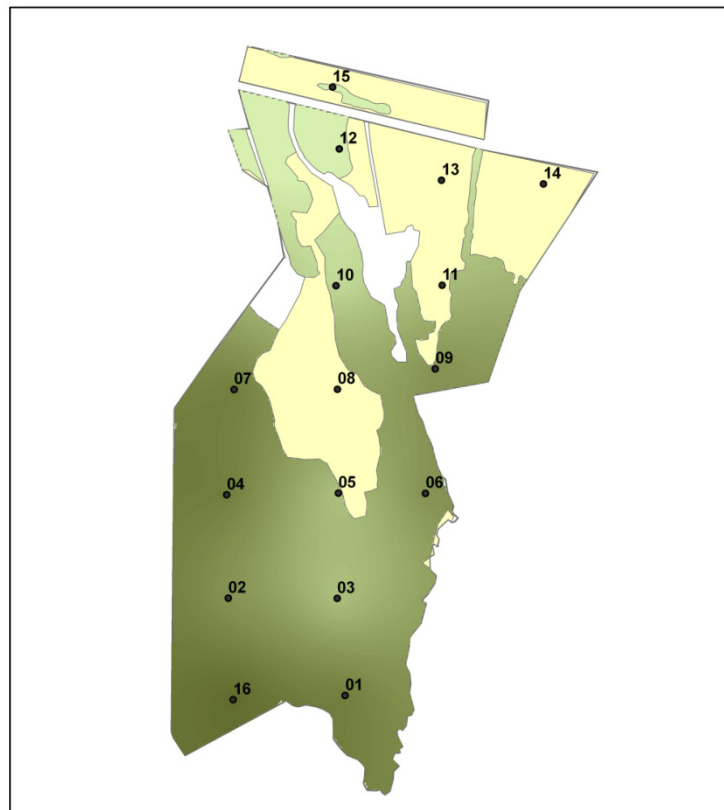


Figure 7. Avian monitoring stations in grassland (yellow) and forested (green) areas and forest BCI scores at Booker T. Washington NM. Darker green indicates higher BCI scores and higher ecological integrity. White indicates areas excluded from analysis.

Table 5. Avian forest guild summary for Booker T. Washington NM. Percents indicate the average percent guild membership at monitoring locations across the park. Ranks are derived from O'Connell et al. (2003).

Guild		Percent	Rank
Structural Guilds	Forest Interior	32.08	Naturalistic
	Pine Associated	0	Humanistic
	Urban/Suburban	37.58	Largely intact
Functional Guilds	Bark Prober	14.73	Moderately disturbed
	Upper Canopy Gleaner	15.99	Largely intact
	Ground Gleaner	6.10	Largely intact
Compositional Guilds	Single Brooded	42.17	Largely intact
	Nest Disrupter	16.34	Moderately disturbed
	Exotic	0	Naturalistic
Total Forest BCI Score		0.708	Largely intact

Table 6. Avian grassland guild summary for Booker T. Washington NM. Individual guild scores range from 0-10 and total BCI score ranges from 0-100. Ranks are derived from Coppedge et al. (2006).

Guild	Avg. Guild Score
% aerial foraging spp.	1.32
No. canopy foraging spp.	3.33
No. ground foraging spp.	3.33
% canopy nesting individuals	5.12
No. cavity nesting spp.	5.00
% grassland obligate individuals	4.53
% edge individuals	4.54
No. woodland individuals	6.92
% resident individuals	3.43
% temperate migrant individuals	3.70
% neotropical migrant spp.	3.30
% insectivorous individuals	4.83
% omnivorous individuals	4.90
Total Grassland BCI score	41.73

Fredericksburg and Spotsylvania National Military Park

A total of 59 stations were established at Fredericksburg and Spotsylvania NMP in 2009 (Figure 9). Eleven of these stations were in grassland habitat, and 48 were in forested habitat. All stations were surveyed at least once over the breeding season, and several were surveyed multiple times (average 2.0 surveys per station). Surveys were completed by eight skilled volunteers.

Fifty-eight species were detected across the park, with 54 species detected in forest habitat and 40 species in grassland habitat. The most abundant species are shown in Figure 8. Twenty-eight Partners in Flight species of conservation concern were detected in the park, including 11 species of continental concern (see Table 4).

From BCI analyses, Fredericksburg and Spotsylvania NMP was ranked “naturalistic” (0.765 ± 0.012 SE) for forested stations, the highest score for forested stations out of the three parks. In grassland habitats, the park scored 39.43 ± 3.44 SE, the lowest score of the three parks. For forested avian integrity, we are able to break down the score by guild (Table 7). Many of the guilds for forest specialist are well represented (in the “naturalistic” category), indicating the guilds in most forest specialist areas are well represented and the overall integrity of forested areas is high. The “pine-associated” guild was the only guild to receive a rank below “largely intact”. Because pine warblers are the sole representative of the “pine associated” guild for parks in MIDN, the low rank may be indicative of a lack of mature pines or the difficulty of detecting the species. We can also break down the grassland score by guild (Table 8). Higher aggregate scores for grassland stations in this park were driven by a lack of ground foraging species, and woodland associated individuals. Interestingly, there was a total lack of grassland obligate individuals in the grassland stations monitored.

The kriging interpolation (Figure 9) indicates higher forest integrity along the southeastern and northwestern section of the park, which are probably less frequented by visitors. Grassland integrity appears to be higher in fields in the northeastern section of the park.

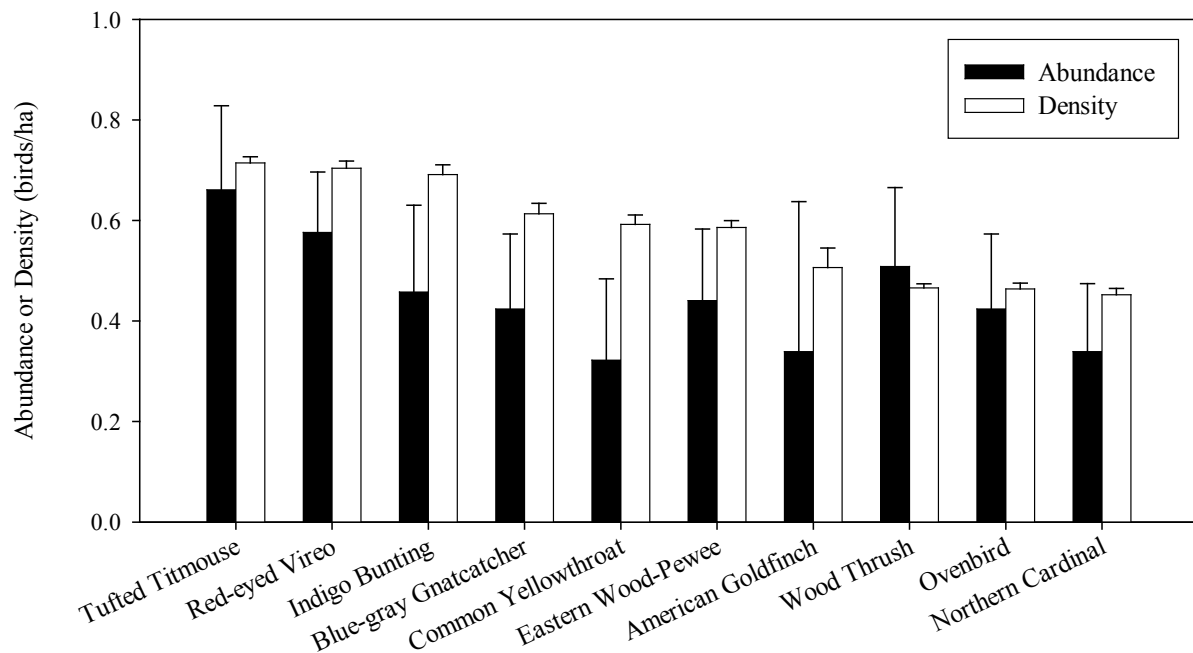


Figure 8. Density and relative abundance estimates with standard error bars for the ten most common avian species detected at Fredericksburg and Spotsylvania NMP in 2009.

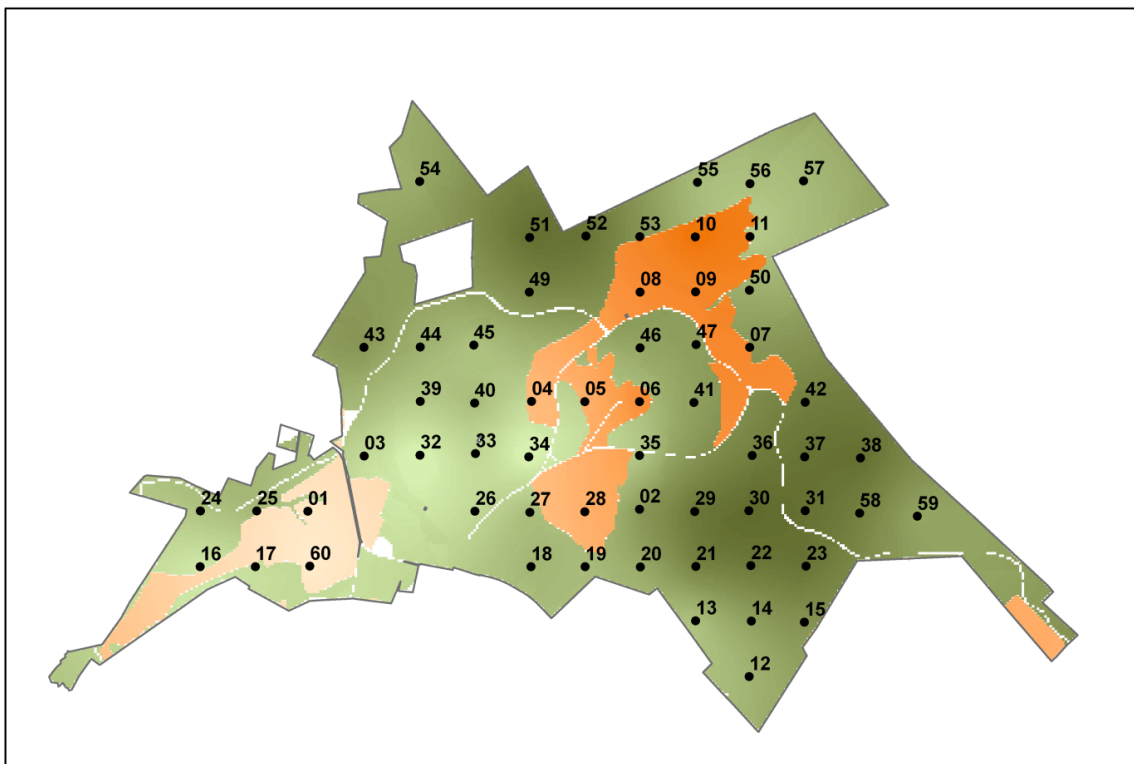


Figure 9. Bird monitoring stations and BCI scores for forest (green) and grassland (orange) areas at Fredericksburg and Spotsylvania NMP. Intensity of colors indicates a higher BCI score and higher ecological integrity. White indicates areas excluded from analysis.

Table 7. Avian forest guild summary for Fredericksburg and Spotsylvania NMP. Percents indicate the average percent guild membership at monitoring locations across the park. Ranks are derived from O'Connell et al. (2003).

Guild		Percent	Rank
Structural Guilds	Forest Interior	38.64	Naturalistic
	Pine Associated	0.81	Moderately disturbed
	Urban/Suburban	26.11	Largely intact
Functional Guilds	Bark Prober	17.53	Largely intact
	Upper Canopy Gleaner	20.77	Naturalistic
	Ground Gleaner	7.23	Naturalistic
Compositional Guilds	Single Brooded	55.24	Naturalistic
	Nest Disrupter	9.36	Largely intact
	Exotic	0	Naturalistic
Total Forest BCI Score		0.765	Largely intact

Table 8. Avian grassland guild summary for Fredericksburg and Spotsylvania NMP. Individual guild scores range from 0-10 and total BCI score ranges from 0-100. Ranks are derived from Coppedge et al. (2006).

Guild	Avg. Guild Score
% aerial foraging spp.	2.91
No. canopy foraging spp.	3.54
No. ground foraging spp.	6.11
% canopy nesting individuals	3.36
No. cavity nesting spp.	5.71
% grassland obligate individuals	0.00
% edge individuals	3.10
No. woodland individuals	7.21
% resident individuals	4.10
% temperate migrant individuals	2.56
% neotropical migrant spp.	4.93
% insectivorous individuals	3.69
% omnivorous individuals	4.05
Total Grassland BCI score	39.43

Valley Forge National Historical Park

A total of 76 stations were established at Valley Forge NHP (Figure 11). Thirty-nine of these stations were located in grassland habitats, and 37 were in forested habitats. All stations were surveyed once per season (average 1.0 survey per station per season). Surveys were conducted by 12 skilled volunteers.

Sixty-one species were detected across the park, with 46 species detected in forest habitat, and 53 species in grassland habitat. The most abundant species are shown in Figure 10. Nineteen Partners in Flight species of conservation concern species were detected in the park, including 7 species of continental concern (see Table 4).

From BCI analyses, Valley Forge NHP was ranked as “moderately disturbed” (0.597 ± 0.017 SE) for forested stations, the lowest score for forested stations out of the three parks. In grassland habitats, the park scored 47.8 ± 1.64 SE, the highest score of the three parks. For forested avian integrity, we are able to break down the score by guild (Table 9). Because pine warblers are the sole representative of the “pine-associated” guild for parks in MIDN, the low rank for this category in Valley Forge NHP may be indicative of a lack of mature pines or the difficulty of detecting the species. The ranking of “moderately disturbed” for the “ground gleaning”, “urban/suburban”, and “nest disrupter” guilds may be indicative of the heavy impact of deer browsing and the urban location of the park. We can also break down the grassland score by guild (Table 10). As in the other two parks, Valley Forge NHP’s higher scores in grassland integrity seem to be largely driven by the lack of forest associated species. Particularly lacking here were canopy foragers, cavity nesters, and woodland associated species.

The kriging interpolation (Figure 11) indicates higher forest integrity in the southwestern section of the park and higher grassland integrity towards the center and eastern sections of the park.

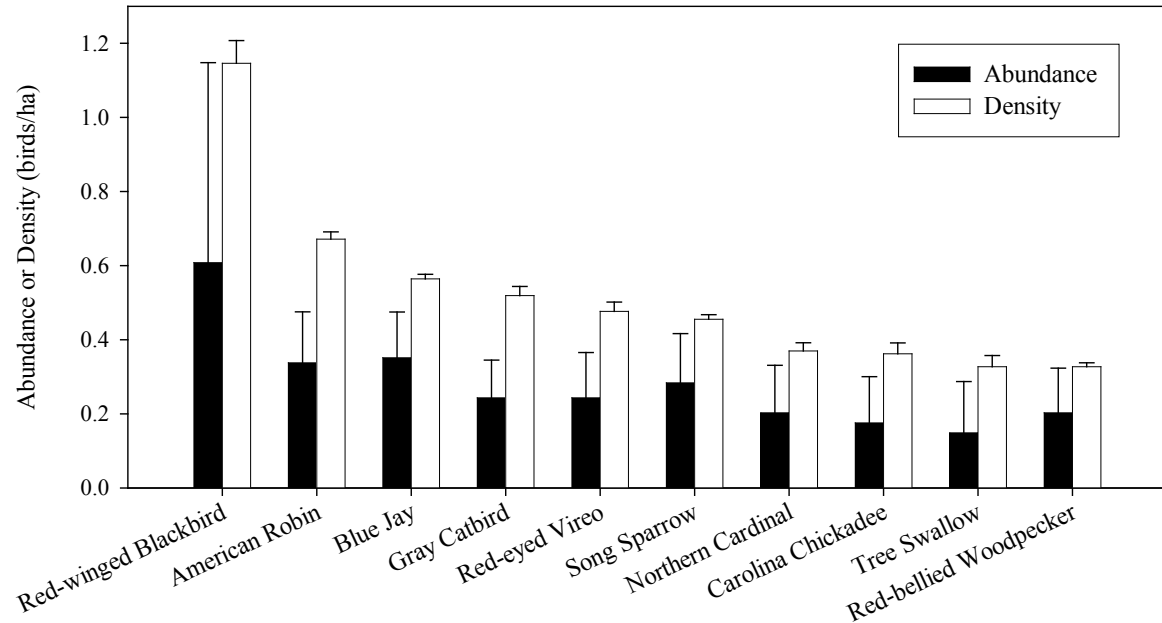


Figure 10. Density and relative abundance estimates with standard error bars for the ten most common avian species at Valley Forge NHP in 2009.

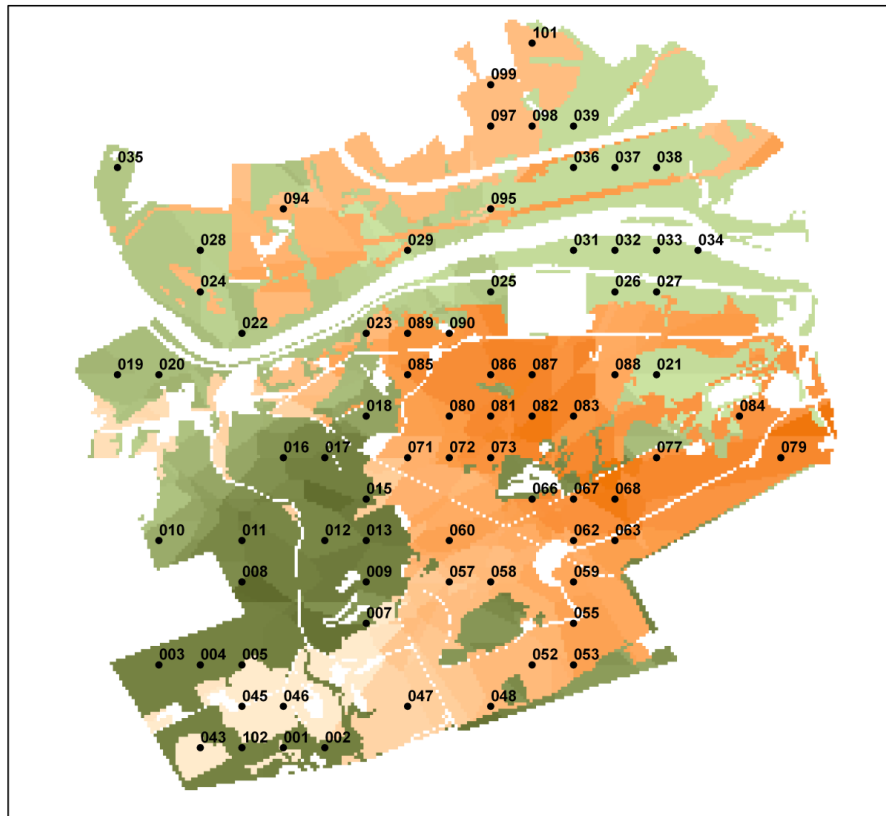


Figure 11. Bird monitoring stations and BCI scores for forested (green) and grassland (orange) areas at Valley Forge NHP. Intensity of colors indicates a higher BCI score and higher ecological integrity. White indicates areas excluded from analysis.

Table 9. Avian forest guild summary for Valley Forge NHP. Percents indicate the average percent guild membership at monitoring locations across the park. Ranks are derived from O'Connell et al. (2003).

Guild		Percent	Rank
Structural Guilds	Forest Interior	22.43	Largely intact
	Pine Associated	0	Humanistic
	Urban/Suburban	47.18	Moderately disturbed
Functional Guilds	Bark Prober	16.38	Largely intact
	Upper Canopy Gleaner	15.47	Largely intact
	Ground Gleaner	0.93	Moderately disturbed
Compositional Guilds	Single Brooded	38.81	Largely intact
	Nest Disrupter	21.87	Moderately disturbed
	Exotic	0	Naturalistic
Total Forest BCI Score		0.597	Moderately disturbed

Table 10. Avian grassland guild summary for Valley Forge NHP. Individual guild scores range from 0-10 and total BCI score ranges from 0-100. Ranks are derived from Coppedge et al. (2006).

Guild	Avg. Guild Score
% aerial foraging spp.	2.02
No. canopy foraging spp.	7.99
No. ground foraging spp.	5.70
% canopy nesting individuals	4.12
No. cavity nesting spp.	7.73
% grassland obligate individuals	1.39
% edge individuals	4.75
No. woodland individuals	6.87
% resident individuals	5.74
% temperate migrant individuals	4.64
% neotropical migrant spp.	3.96
% insectivorous individuals	3.51
% omnivorous individuals	3.78
Total Grassland BCI score	47.80

Discussion

The 2009 avian monitoring season in the Mid-Atlantic Network was successfully implemented with the help of many skilled volunteers. During this monitoring season, three park units were surveyed for avian activity, yielding quantitative information on species richness, abundance, and diversity. These baseline data can be used to establish population trends and changes from year to year, and serve to improve our understanding of the relationships between breeding birds, habitats, and park management. This first monitoring season also highlights many of the species of conservation concern that live and likely breed in the region, including 16 Watchlist species and 18 Stewardship species. One continental Watchlist species, the Wood Thrush, is highly abundant in the region, demonstrating the importance of these park units in providing habitat for species of concern.

From these data, we were also able to evaluate ecosystem integrity via assessment of the bird community by applying a “bird community index.” Analyzing the bird community with the BCI approach reveals differences in integrity scores among parks, and these differences are relevant to large-scale habitat differences. Fredericksburg and Spotsylvania NMP had the highest forest integrity score and this park also had the largest amount of forest cover and largest number of forest monitoring locations. The amount of contiguous forest cover is an important predictor in avian abundance, distribution, and breeding success for forest birds (McGarigal and McComb 1995). Valley Forge NHP, on the other hand, scored highest for grassland integrity, and this park had the greatest number of grassland monitoring stations and grassland cover. Total coverage of grassland habitat is the single best predictor of habitat selection by grassland birds (Fisher and Davis 2010), and Valley Forge NHP has the greatest amount of this important habitat feature. These trends can be seen visually in the interpolated maps, where larger pieces of forest and grassland tend to have the higher integrity scores (Figures 3-5).

Because the methods in developing the forest and grassland BCIs are different, it is not useful to directly compare forest scores to grassland scores. Furthermore, grassland scores are relative to the maximum score in the region, and for this reason, should not be compared to other locations. Forest scores, however, because they are based solely on percent species representation, can be compared across study areas. In the nearby NPS National Capital Region, an assessment of 268 forest monitoring locations in the Piedmont revealed an average BCI score of 0.75 ± 0.009 SE, a score that is not significantly different from the average BCI score in this network (Goodwin and Shriver 2009). Furthermore, the National Capital Region includes Prince William Forest Park (132 of the 268 monitoring locations fell in this park), which at 6,800 ha is the largest continuous piece of piedmont forest currently protected. That the Mid-Atlantic Network scores similarly to the National Capital Region, which contains such a large piece of forest, suggests that the forests of the Mid-Atlantic Network are of overall high integrity.

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Appendix A. Detections, Abundance, Density

Here we present total detections (including flyovers and species detected outside of count periods), abundance, and density metrics for the region and for each park. Species in bold indicate Partners in Flight Watchlist species, italicized species are identified as Stewardship species, and continental species of concern are indicated with astrics (*).

Region-wide

Species	Total Detections	Relative Abundance			Density		
		n	$\bar{x}$	SE	n	$\bar{x}$	SE
<i>Acadian Flycatcher*</i>	67	24	0.161	0.092	64	0.199	0.005
American Crow	158	19	0.128	0.111	139	0.111	0.001
American Goldfinch	87	32	0.215	0.165	52	0.316	0.013
American Kestrel	3	1	0.007	0.082	.	.	.
American Robin	80	31	0.208	0.099	68	0.253	0.006
Baltimore Oriole	27	10	0.067	0.102	25	0.066	0.004
Barn Swallow	32	20	0.134	0.211	.	.	.
Barred Owl	2	.	.	.	.	.	.
Belted Kingfisher	2	2	0.013	0.116	.	.	.
Black Vulture	1	.	.	.	.	.	.
Blue Grosbeak	3	1	0.007	0.082	.	.	.
Blue Jay	128	42	0.282	0.097	116	0.277	0.004
Blue-gray Gnatcatcher	67	34	0.228	0.096	65	0.363	0.009
Blue-winged Warbler	1	1	0.007	0.082	.	.	.
Brown Thrasher	9	7	0.047	0.111	9	0.070	0.014
Brown-headed Cowbird	29	14	0.094	0.144	24	0.108	0.009
Canada Goose	9	2	0.013	0.116	5	0.013	0.006
Canada Warbler	1	1	0.007	0.082	.	.	.
<i>Carolina Chickadee</i>	68	39	0.262	0.097	62	0.346	0.009
<i>Carolina Wren*</i>	114	30	0.201	0.100	112	0.239	0.003
Cedar Waxwing	5	.	.	.	.	.	.
Chimney Swift	20	13	0.087	0.230	14	0.190	0.040
Chipping Sparrow	63	10	0.067	0.079	55	0.057	0.002
Common Grackle	29	3	0.020	0.081	11	0.018	0.003
Common Peafowl	1	.	.	.	.	.	.
Common Yellowthroat	68	28	0.188	0.099	64	0.352	0.009
Cooper's Hawk	1	.	.	.	.	.	.
<i>Downy Woodpecker</i>	46	26	0.174	0.081	44	0.229	0.008
Eastern Bluebird	38	12	0.081	0.086	27	0.082	0.005
Eastern Kingbird	25	8	0.054	0.099	15	0.059	0.007
Eastern Meadowlark	51	13	0.087	0.125	50	0.092	0.003
Eastern Phoebe	27	12	0.081	0.092	26	0.083	0.005
Eastern Towhee*	21	10	0.067	0.079	19	0.085	0.007
Eastern Wood-Pewee	122	43	0.289	0.089	120	0.439	0.005

Appendix A. Detections, Abundance, and Density (continued).

Region-wide (continued).

Species	Total Detections	Relative Abundance			Density		
		n	$\bar{x}$	SE	n	$\bar{x}$	SE
European Starling	127	15	0.101	0.258	106	0.083	0.004
Field Sparrow	48	14	0.094	0.095	45	0.086	0.003
Grasshopper Sparrow	10	2	0.013	0.082	8	0.019	0.004
Gray Catbird	35	19	0.128	0.077	34	0.169	0.008
Great Blue Heron	9	.	.	.	.	.	.
Great Crested Flycatcher	24	5	0.034	0.081	21	0.029	0.002
Hairy Woodpecker	6	3	0.020	0.081	4	0.029	0.015
<i>Hooded Warbler*</i>	3	1	0.007	0.082	2	0.007	0.000
House Finch	1	1	0.007	0.082	.	.	.
House Wren	13	2	0.013	0.082	9	0.012	0.002
<i>Indigo Bunting*</i>	103	34	0.228	0.108	96	0.323	0.005
Killdeer	1	.	.	.	.	.	.
Louisiana Waterthrush	8	.	.	.	.	.	.
Mallard	2	.	.	.	.	.	.
Mourning Dove	49	15	0.101	0.089	42	0.096	0.003
Northern Cardinal	102	43	0.289	0.087	99	0.380	0.006
Northern Flicker	9	5	0.034	0.096	8	0.040	0.009
Northern Mockingbird	20	4	0.027	0.081	19	0.023	0.002
<i>Northern Parula</i>	7	2	0.013	0.082	4	0.029	0.015
Northern Rough-winged Swallow	2	.	.	.	.	.	.
Orchard Oriole	6	6	0.040	0.081	.	.	.
Ovenbird	93	32	0.215	0.098	85	0.299	0.005
<i>Pileated Woodpecker</i>	16	1	0.007	0.082	14	0.005	0.001
<i>Pine Warbler*</i>	6	3	0.020	0.081	5	0.024	0.009
Prairie Warbler*	4	1	0.007	0.082	2	0.007	0.000
Purple Martin	2	.	.	.	.	.	.
<i>Red-bellied Woodpecker*</i>	98	27	0.181	0.087	95	0.186	0.003
Red-eyed Vireo	146	64	0.430	0.080	145	0.635	0.006
Red-shouldered Hawk	2	.	.	.	.	.	.
Red-tailed Hawk	5	.	.	.	.	.	.
Red-winged Blackbird	92	45	0.302	0.382	74	0.357	0.019
Scarlet Tanager	90	35	0.235	0.091	89	0.265	0.004
Song Sparrow	60	22	0.148	0.097	60	0.150	0.004
<i>Summer Tanager</i>	6	1	0.007	0.082	2	0.007	0.000
Tree Swallow	33	11	0.074	0.100	18	0.102	0.010
Tufted Titmouse	142	58	0.389	0.102	141	0.469	0.005
Turkey Vulture	20	1	0.007	0.082	15	0.005	0.001
Veery	2	.	.	.	.	.	.
Warbling Vireo	3	.	.	.	.	.	.

Appendix A. Detections, Abundance, and Density (continued).

Region-wide (continued).

Species	Total Detections	Relative Abundance			Density		
		n	$\bar{x}$	SE	n	$\bar{x}$	SE
White-breasted Nuthatch	60	28	0.188	0.094	58	0.252	0.007
White-eyed Vireo	1	1	0.007	0.082	.	.	.
Wild Turkey	1	1	0.007	0.082	.	.	.
Willow Flycatcher	1	1	0.007	0.082	.	.	.
Wood Thrush*	155	43	0.289	0.098	152	0.336	0.004
Worm-eating Warbler	1	.	.	.	.	.	.
Yellow Warbler	3	1	0.007	0.082	3	0.006	0.006
Yellow-billed Cuckoo	30	6	0.040	0.093	26	0.035	0.002
Yellow-breasted Chat	3	1	0.007	0.082	3	0.017	0.016
<i>Yellow-throated Vireo*</i>	2	1	0.007	0.082	2	0.007	0.000
Yellow-throated Warbler	1	1	0.007	0.082	.	.	.

Booker T. Washington National Monument

Species	Total Detections	Relative Abundance			Density		
		n	$\bar{x}$	SE	n	$\bar{x}$	SE
<i>Acadian Flycatcher*</i>	19	7	0.438	0.238	17	0.213	0.019
American Crow	44	5	0.313	0.214	38	0.126	0.005
American Goldfinch	10	1	0.063	0.250	4	0.027	0.015
American Robin	9	4	0.250	0.289	9	0.172	0.037
Barn Swallow	5	.	.	.	.	.	.
Blue Jay	19	2	0.125	0.242	18	0.050	0.004
Blue-gray Gnatcatcher	19	7	0.438	0.238	17	0.302	0.028
Brown Thrasher	3	3	0.188	0.433	.	.	.
Brown-headed Cowbird	6	.	.	.	.	.	.
Canada Warbler	1	1	0.063	0.250	.	.	.
<i>Carolina Chickadee</i>	14	5	0.313	0.269	12	0.196	0.026
<i>Carolina Wren*</i>	24	2	0.125	0.242	24	0.049	0.003
Cedar Waxwing	5	.	.	.	.	.	.
Chipping Sparrow	39	5	0.313	0.214	37	0.127	0.006
Common Yellowthroat	1	.	.	.	.	.	.
<i>Downy Woodpecker</i>	9	4	0.250	0.224	9	0.125	0.024
Eastern Bluebird	9	3	0.188	0.233	9	0.086	0.016
Eastern Meadowlark	22	7	0.438	0.413	21	0.277	0.024
Eastern Phoebe	14	4	0.250	0.289	14	0.111	0.012
Eastern Towhee	2	.	.	.	.	.	.
Eastern Wood-Pewee	30	8	0.500	0.258	30	0.490	0.024
European Starling	1	.	.	.	.	.	.
Field Sparrow	9	.	.	.	.	.	.

Appendix A. Detections, Abundance, and Density (continued).

Booker T. Washington National Monument (continued).

Species	Total Detections	Relative Abundance			Density		
		n	$\bar{x}$	SE	n	$\bar{x}$	SE
Grasshopper Sparrow	8	1	0.063	0.250	7	0.056	0.015
Great Blue Heron	2	.	.	.	.	.	.
Great Crested Flycatcher	2	2	0.125	0.242	.	.	.
Hairy Woodpecker	1	.	.	.	.	.	.
<i>Indigo Bunting*</i>	31	2	0.125	0.242	30	0.049	0.002
Killdeer	1	.	.	.	.	.	.
Louisiana Waterthrush	8	.	.	.	.	.	.
Mourning Dove	15	3	0.188	0.233	12	0.081	0.011
Northern Cardinal	18	8	0.500	0.258	18	0.249	0.021
Northern Flicker	2	2	0.125	0.354	.	.	.
Northern Mockingbird	6	.	.	.	.	.	.
Northern Parula	5	1	0.063	0.250	.	.	.
Northern Rough-winged Swallow	2	.	.	.	.	.	.
Ovenbird	29	7	0.438	0.238	26	0.379	0.022
Pileated Woodpecker	8	.	.	.	.	.	.
Pine Warbler	2	1	0.063	0.250	.	.	.
Prairie Warbler	1	.	.	.	.	.	.
<i>Red-bellied Woodpecker*</i>	20	6	0.375	0.253	20	0.203	0.015
Red-eyed Vireo	47	12	0.750	0.197	47	0.745	0.022
Red-shouldered Hawk	1	.	.	.	.	.	.
Red-tailed Hawk	3	.	.	.	.	.	.
Scarlet Tanager	19	5	0.313	0.214	19	0.170	0.012
Summer Tanager	3	.	.	.	.	.	.
Tufted Titmouse	33	7	0.438	0.275	32	0.249	0.011
Turkey Vulture	5	.	.	.	.	.	.
White-breasted Nuthatch	13	5	0.313	0.315	13	0.237	0.030
Wood Thrush*	41	9	0.563	0.171	41	0.440	0.016
Yellow-billed Cuckoo	1	.	.	.	.	.	.
Yellow-throated Vireo	1	1	0.063	0.250	.	.	.

Fredericksburg and Spotsylvania National Military Park

Species	Total Detections	Relative Abundance			Density		
		n	$\bar{x}$	SE	n	$\bar{x}$	SE
<i>Acadian Flycatcher*</i>	48	17	0.288	0.143	47	0.326	0.010
American Crow	87	9	0.153	0.222	75	0.118	0.003
American Goldfinch	43	20	0.339	0.298	31	0.506	0.039
American Robin	8	2	0.034	0.129	8	0.025	0.005
Barred Owl	2	.	.	.	.	.	.

Appendix A. Detections, Abundance, and Density (continued).

Fredericksburg and Spotsylvania National Military Park (continued).

Species	Total	Relative Abundance			Density		
	Detections	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Blue Grosbeak	3	1	0.017	0.130	.	.	.
Blue Jay	33	14	0.237	0.181	28	0.213	0.014
Blue-gray Gnatcatcher	45	25	0.424	0.149	45	0.613	0.021
Brown Thrasher	4	3	0.051	0.128	4	0.061	0.034
Brown-headed Cowbird	12	6	0.102	0.124	8	0.122	0.025
<i>Carolina Chickadee</i>	32	21	0.356	0.166	31	0.421	0.023
<i>Carolina Wren*</i>	72	21	0.356	0.166	70	0.411	0.009
Chimney Swift	7	1	0.017	0.130	2	0.015	0.000
Chipping Sparrow	11	2	0.034	0.129	6	0.027	0.008
Common Grackle	22	.	.	.	.	.	.
Common Peafowl	1	.	.	.	.	.	.
Common Yellowthroat	53	19	0.322	0.162	50	0.592	0.019
<i>Downy Woodpecker</i>	24	17	0.288	0.128	23	0.339	0.022
Eastern Bluebird	16	6	0.102	0.124	9	0.109	0.021
Eastern Kingbird	7	3	0.051	0.167	.	.	.
Eastern Phoebe	10	7	0.119	0.142	9	0.149	0.028
Eastern Towhee*	5	1	0.017	0.130	4	0.030	0.016
Eastern Wood-Pewee	65	26	0.441	0.142	63	0.586	0.014
Field Sparrow	21	8	0.136	0.122	18	0.116	0.010
Grasshopper Sparrow	2	1	0.017	0.130	.	.	.
Gray Catbird	2	1	0.017	0.130	2	0.015	0.000
Great Blue Heron	4	.	.	.	.	.	.
Great Crested Flycatcher	10	.	.	.	.	.	.
Hairy Woodpecker	3	2	0.034	0.129	.	.	.
<i>Hooded Warbler*</i>	3	1	0.017	0.130	2	0.015	0.000
House Wren	1	.	.	.	.	.	.
<i>Indigo Bunting*</i>	66	27	0.458	0.173	60	0.691	0.019
Mourning Dove	20	6	0.102	0.146	20	0.078	0.006
Northern Cardinal	57	20	0.339	0.135	55	0.452	0.012
Northern Flicker	2	.	.	.	.	.	.
<i>Northern Parula</i>	2	1	0.017	0.130	2	0.015	0.000
Orchard Oriole	1	1	0.017	0.130	.	.	.
Ovenbird	63	25	0.424	0.149	58	0.464	0.012
<i>Pileated Woodpecker</i>	8	1	0.017	0.130	8	0.012	0.002
<i>Pine Warbler*</i>	4	2	0.034	0.129	4	0.030	0.016
Prairie Warbler*	3	1	0.017	0.130	2	0.015	0.000
Purple Martin	2	.	.	.	.	.	.
<i>Red-bellied Woodpecker*</i>	31	6	0.102	0.146	30	0.087	0.004
Red-eyed Vireo	71	34	0.576	0.120	70	0.704	0.014

Appendix A. Detections, Abundance, and Density (continued).

Fredericksburg and Spotsylvania National Military Park (continued).

Species	Total	Relative Abundance			Density		
	Detections	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Red-shouldered Hawk	1	.	.	.	.	.	.
Scarlet Tanager	60	23	0.390	0.145	59	0.376	0.009
Song Sparrow	1	1	0.017	0.130	.	.	.
Summer Tanager	3	1	0.017	0.130	.	.	.
Tree Swallow	1	.	.	.	.	.	.
Tufted Titmouse	88	39	0.661	0.167	88	0.714	0.012
Turkey Vulture	1	.	.	.	.	.	.
uninterpretable	7	.	.	.	.	.	.
White-breasted Nuthatch	35	14	0.237	0.143	33	0.200	0.010
Wild Turkey	1	1	0.017	0.130	.	.	.
Wood Thrush*	93	30	0.508	0.157	92	0.466	0.008
Worm-eating Warbler	1	.	.	.	.	.	.
Yellow-billed Cuckoo	29	6	0.102	0.146	25	0.075	0.004
Yellow-breasted Chat	3	1	0.017	0.130	3	0.036	0.034
Yellow-throated Vireo	1	.	.	.	.	.	.

Valley Forge National Historical Park

Species	Total	Relative Abundance			Density		
	Detections	n	$\bar{x}$	SE	n	$\bar{x}$	SE
American Crow	27	5	0.068	0.113	26	0.092	0.005
American Goldfinch	34	11	0.149	0.171	17	0.293	0.030
American Kestrel	3	1	0.014	0.116	.	.	.
American Robin	63	25	0.338	0.138	51	0.672	0.019
Baltimore Oriole	27	10	0.135	0.142	25	0.211	0.013
Barn Swallow	27	20	0.270	0.297	.	.	.
Belted Kingfisher	2	2	0.027	0.164	.	.	.
Black Vulture	1	.	.	.	.	.	.
Blue Jay	76	26	0.351	0.123	70	0.564	0.013
Blue-gray Gnatcatcher	3	2	0.027	0.115	3	0.054	0.050
Blue-winged Warbler	1	1	0.014	0.116	.	.	.
Brown Thrasher	2	1	0.014	0.116	2	0.023	0.000
Brown-headed Cowbird	11	8	0.108	0.252	11	0.236	0.049
Canada Goose	9	2	0.027	0.164	5	0.042	0.019
<i>Carolina Chickadee</i>	22	13	0.176	0.125	19	0.362	0.029
<i>Carolina Wren*</i>	18	7	0.095	0.111	18	0.147	0.013
Chimney Swift	13	12	0.162	0.338	.	.	.
Chipping Sparrow	13	3	0.041	0.115	12	0.057	0.008
Common Grackle	7	3	0.041	0.115	6	0.069	0.023

Appendix A. Detections, Abundance, and Density (continued).

Valley Forge National Historical Park (continued).

Species	Total	Relative Abundance			Density		
	Detections	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Common Yellowthroat	14	9	0.122	0.123	13	0.253	0.030
Cooper's Hawk	1	.	.	.	.	.	.
<i>Downy Woodpecker</i>	13	5	0.068	0.113	12	0.174	0.022
Eastern Bluebird	13	3	0.041	0.149	9	0.060	0.011
Eastern Kingbird	18	5	0.068	0.135	12	0.107	0.016
Eastern Meadowlark	29	6	0.081	0.147	29	0.111	0.007
Eastern Phoebe	3	1	0.014	0.116	3	0.020	0.019
Eastern Towhee*	14	9	0.122	0.110	13	0.253	0.029
Eastern Wood-Pewee	27	9	0.122	0.110	27	0.207	0.012
European Starling	126	15	0.203	0.365	106	0.267	0.012
Field Sparrow	18	6	0.081	0.162	18	0.121	0.011
Gray Catbird	33	18	0.243	0.102	32	0.519	0.025
Great Blue Heron	3	.	.	.	.	.	.
Great Crested Flycatcher	12	3	0.041	0.115	10	0.059	0.010
Hairy Woodpecker	2	1	0.014	0.116	2	0.023	0.000
House Finch	1	1	0.014	0.116	.	.	.
House Wren	12	2	0.027	0.115	9	0.037	0.007
<i>Indigo Bunting*</i>	6	5	0.068	0.113	6	0.178	0.052
Mallard	2	.	.	.	.	.	.
Mourning Dove	14	6	0.081	0.131	10	0.152	0.025
Northern Cardinal	27	15	0.203	0.128	26	0.370	0.022
Northern Flicker	5	3	0.041	0.115	5	0.076	0.029
Northern Mockingbird	14	4	0.054	0.114	13	0.079	0.009
Orchard Oriole	5	5	0.068	0.113	.	.	.
Ovenbird	1	.	.	.	.	.	.
<i>Red-bellied Woodpecker*</i>	47	15	0.203	0.121	45	0.327	0.011
Red-eyed Vireo	28	18	0.243	0.122	28	0.477	0.025
Red-tailed Hawk	2	.	.	.	.	.	.
Red-winged Blackbird	92	45	0.608	0.540	74	1.146	0.061
Scarlet Tanager	11	7	0.095	0.128	11	0.184	0.028
Song Sparrow	59	21	0.284	0.133	59	0.455	0.012
Tree Swallow	32	11	0.149	0.138	18	0.327	0.031
Tufted Titmouse	21	12	0.162	0.107	21	0.294	0.022
Turkey Vulture	14	1	0.014	0.116	11	0.017	0.003
uninterpretable	6	.	.	.	.	.	.
Veery	2	.	.	.	.	.	.
Warbling Vireo	3	.	.	.	.	.	.
White-breasted Nuthatch	12	9	0.122	0.135	.	.	.
White-eyed Vireo	1	1	0.014	0.116	.	.	.

Appendix A. Detections, Abundance, and Density (continued).

Valley Forge National Historical Park (continued).

Species	Total	Relative Abundance			Density		
	Detections	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Willow Flycatcher	1	1	0.014	0.116	.	.	.
Wood Thrush*	21	4	0.054	0.141	19	0.074	0.007
Yellow Warbler	3	1	0.014	0.116	3	0.020	0.019
Yellow-throated Warbler	1	1	0.014	0.116	.	.	.

Appendix B. Forested guild assignments

Several guild categories were considered in the development of the forested guild BCI and ultimately, only a subset of these guilds were found to be responsive to forest structure change (O’Connell et al. 2003). For that reason, some of the guild categories below do not cover the guild a species belongs to. For example, Acadian Flycatchers are aerial salliers under the functional guild category. As this guild is not part of the final structure of the BCI, this space is left blank.

Species	Guild		
	Structural	Functional	Compositional
Acadian Flycatcher	forest interior		single brood
American Crow	urban/suburban		nest disruptor
American Goldfinch	urban/suburban		
American Redstart	forest interior		single brood
American Robin	urban/suburban		
Baltimore Oriole		upper canopy forager	single brood
Black-and-White Warbler	forest interior	bark prober	single brood
Blue-gray Gnatcatcher		upper canopy forager	
Brown-headed Cowbird			nest disruptor
Blue Jay	urban/suburban		nest disruptor
Brown Thrasher			single brood
Black-throated Blue Warbler		upper canopy forager	single brood
Black-throated Green Warbler		upper canopy forager	single brood
Carolina Chickadee		bark prober	single brood
Carolina Wren	urban/suburban		
Cedar Waxwing	urban/suburban		
Chipping Sparrow	urban/suburban		
Chimney Swift	urban/suburban		single brood
Common Grackle	urban/suburban		single brood
Downy Woodpecker	urban/suburban	bark prober	nest disruptor
Eastern Kingbird			single brood
Eastern Towhee	forest interior		
Eastern Wood-Pewee	forest interior		single brood
European Starling	urban/suburban		nest disruptor
Fish Crow			exotic
Great Crested Flycatcher			single brood
Gray Catbird	urban/suburban		single brood
Hairy Woodpecker	forest interior	bark prober	single brood
House Finch	urban/suburban		exotic
House Sparrow	urban/suburban		nest disruptor
Hooded Warbler	forest interior		exotic
Kentucky Warbler	forest interior	ground gleaner	single brood
Louisiana Waterthrush	forest interior	ground gleaner	single brood
Mourning Dove	urban/suburban		
Northern Cardinal	urban/suburban		
Northern Flicker		ground gleaner	single brood
Northern Mockingbird	urban/suburban		

Appendix B. Forested guild assignments (continued).

Species	Guild		
	Structural	Functional	Compositional
Northern Parula	forest interior	upper canopy forager	single brood
Northern Waterthrush	forest interior	ground gleaner	single brood
Orchard Oriole			single brood
Ovenbird	forest interior	ground gleaner	single brood
Pine Warbler	pine associated	bark prober	
Pileated Woodpecker	forest interior	bark prober	single brood
Prairie Warbler			single brood
Red-bellied Woodpecker	urban/suburban		nest disruptor
Red-eyed Vireo		upper canopy forager	single brood
Ruby-throated Hummingbird	urban/suburban		
Scarlet Tanager	forest interior	upper canopy forager	single brood
Song Sparrow	urban/suburban		
Tufted Titmouse		bark prober	
Veery	forest interior		single brood
Warbling Vireo		upper canopy forager	
White-breasted Nuthatch	forest interior	bark prober	single brood
Worm-eating Warbler	forest interior		single brood
Wood Thrush	forest interior		single brood
Yellow-billed Cuckoo		upper canopy forager	single brood
Yellow-throated Vireo	forest interior	upper canopy forager	single brood
Yellow-throated Warbler			single brood
Yellow Warbler			single brood

Appendix C. Grassland guild assignments

Species	Guild				
	Foraging	Nesting	Habitat	Migratory	Dietary
American Crow	ground/low shrub	canopy/structure	edge	resident	omnivore
American Goldfinch	canopy	canopy/structure	edge	temperate	omnivore
American Robin	ground/low shrub	canopy/structure	edge	temperate	omnivore
Baltimore Oriole	canopy	canopy/structure	edge	neotropical	omnivore
Barn Swallow	aerial	canopy/structure	edge	neotropical	insectivore
Black-billed Cuckoo	canopy	canopy/structure	woodland	neotropical	Insectivore
Black-capped Chickadee	canopy	cavity	woodland	resident	insectivore
Blue Grosbeak	ground/low shrub	canopy/structure	edge	neotropical	omnivore
Blue Jay	ground/low shrub	canopy/structure	woodland	resident	omnivore
Blue-gray Gnatcatcher	canopy	canopy/structure	edge	neotropical	insectivore
Brown Thrasher	ground/low shrub	ground	edge	temperate	omnivore
Brown-headed Cowbird	ground/low shrub	parasite	grassland facultative	temperate	omnivore
Carolina Chickadee	canopy	cavity	woodland	resident	insectivore
Carolina Wren	canopy	cavity	edge	resident	insectivore
Chimney Swift	aerial	canopy/structure	edge	neotropical	insectivore
Cliff Swallow	aerial	canopy/structure	edge	neotropical	insectivore
Common Grackle	ground/low shrub	canopy/structure	edge	resident	omnivore
Downy Woodpecker	bark	cavity	woodland	resident	insectivore
Eastern Bluebird	ground/low shrub	cavity	grassland facultative	resident	insectivore
Eastern Kingbird	aerial	canopy/structure	grassland facultative	neotropical	insectivore
Eastern Meadowlark	ground/low shrub	ground	grassland obligate	temperate	insectivore
Eastern Phoebe	aerial	canopy/structure	edge	temperate	insectivore
European Starling	ground/low shrub	cavity	edge	exotic	omnivore
Field Sparrow	ground/low shrub	ground	edge	resident	omnivore
Grasshopper Sparrow	ground/low shrub	ground	grassland obligate	temperate	omnivore
Gray Catbird	ground/low shrub	canopy/structure	edge	neotropical	omnivore
Great Crested Flycatcher	aerial	cavity	woodland	neotropical	insectivore
Hairy Woodpecker	bark	cavity	woodland	resident	insectivore
Horned Lark	ground/low shrub	ground	grassland obligate	temperate	omnivore
House Sparrow	ground/low shrub	cavity	edge	exotic	granivore
House Wren	canopy	cavity	edge	temperate	insectivore
Indigo Bunting	canopy	canopy/structure	edge	neotropical	omnivore
Mourning Dove	ground/low shrub	canopy/structure	grassland facultative	temperate	granivore
Northern Cardinal	ground/low shrub	canopy/structure	edge	resident	omnivore
Northern Mockingbird	ground/low shrub	canopy/structure	edge	resident	omnivore
Northern Flicker	ground/low shrub	cavity	edge	resident	insectivore
Orchard Oriole	canopy	canopy/structure	edge	neotropical	insectivore
Purple Martin	aerial	cavity	edge	neotropical	insectivore
Red-bellied Woodpecker	bark	cavity	woodland	resident	insectivore
Red-headed Woodpecker	bark	cavity	woodland	resident	insectivore
Red-winged Blackbird	ground/low shrub	canopy/structure	grassland facultative	temperate	omnivore

Appendix C. Grassland guild assignments (continued).

Species	Guild				
	Foraging	Nesting	Habitat	Migratory	Dietary
Rock Dove	ground/low shrub	canopy/structure	edge	exotic	omnivore
Tufted Titmouse	canopy	cavity	woodland	resident	insectivore
Warbling Vireo	canopy	canopy/structure	woodland	neotropical	insectivore
Yellow-billed Cuckoo	canopy	canopy/structure	woodland	neotropical	insectivore

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