# Norfolk Sand Plain Forest Bird Monitoring Program: 2016 (pilot) annual report

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**Abstract**

We evaluated a pilot study for its suitability and application in a long-term monitoring program for forest birds in the Norfolk Sand Plain, Ontario, Canada. We selected sampling stations using a Generalized Random Tessellation Stratified (GRTS) spatially-balanced survey design in order to minimize sampling biases in our study area. We used a robust-design, hierarchal distance-sampling model to examine factors affecting detection probability and abundance of a suite of forest bird species. We also documented occurrences of rare species-at-risk (e.g., Cerulean Warbler) at our sampling stations. Abundance estimates for 6 out of 10 common species appeared to be related to the amount of interior forest cover within 1 km of sampling stations. Estimates of abundance for 7 out of 10 species were reasonable and precise enough to likely provide reliable population trend estimates for long-term monitoring within our study area.

**Introduction**

Forest birds in the Norfolk Sand Plain region of southwestern Ontario have been monitored under various projects and surveys since the 1980s, including Prothonotary Warbler (*Protonotaria citrea*), Hooded Warbler (*Setophaga citrina*), Acadian Flycatcher (*Empidonax virescens*), and Louisiana Waterthrush (*Parkesia motacilla*)surveys (e.g., Gartshore 1988, Deschamp and McCracken 1998, Whittam et al. 2002). Bird Studies Canada has been a major player in the foundational and ongoing efforts for these surveys, which have resulted significant contributions to our knowledge of species occurrence, distribution, and habitat associations. Three Important Bird Areas have identified in the region. Most surveys have been strongly biased towards being conducted on public lands. But, given that most of the landscape in southwestern Ontario is private, there is great potential for the role of habitat stewardship in managing and restoring forests in the region. Moreover, many forest bird populations are in significant decline despite still being quite common. Examples of significantly declining species in BCR13-ON (based on long-term Breeding Bird Survey trends) include Eastern Wood-Pewee (*Contopus virens*), Least Flycatcher (*Empidonax minimus*), Great Crested Flycatcher (*Myiarchus crinitus*), and Baltimore Oriole (*Icterus galbula*) (Environment and Climate Change Canada, 2014).

The forested lands throughout the Norfolk Sand Plain are considered biodiversity hotspots within the Carolinian Region and are home to many rare and endangered plants and animals. The region has the highest proportion of forested land in southwestern Ontario. Although the forests are fragmented to a large degree, many large corridor valleys and floodplain connect forest patches together (e.g., Big Creek and Otter Creek valleys). Thus, the region provides are good range of intact and fragmented forest patches distributed among a mix of private and public lands.

We were interested in designing a forest bird monitoring program that would minimize biases in surveying public lands and areas with greater forest cover, ultimately aiming to provide a general picture of the state of forest bird populations across the region. Although this study is meant to be part of a longer-term effort, we provide here, an evaluation of the pilot study for its suitability and application in a long-term monitoring program. We also examine factors affecting detection probability, availability and abundance of a suite of forest bird species using a robust-design, hierarchal distance-sampling model (Chandler et al. 2011). Finally, we document occurrences of rare species-at-risk encountered using this methodology because we are interested in comparing results with targeted rare species-at-risk data.

## *Methods*

### *Study Area and Study Design*

We defined our study area as the southern portion of the Habitat Stewardship Program Norfolk Sand Plain Terrestrial Priority Area (https://www.ec.gc.ca/hsp-pih/; Figure 1). This area was used primarily because it has been historically used by BSC in forest bird surveys and it is an area of ecological distinction rather than based on political, jurisdictional, or other arbitrary boundaries.

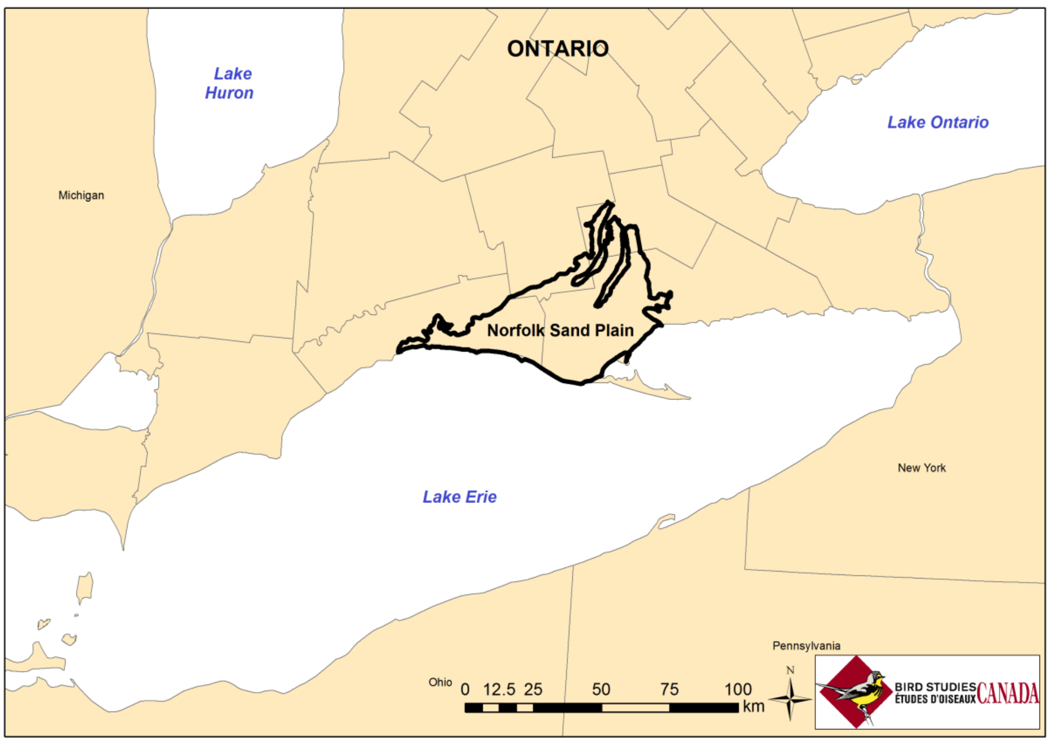


**Figure 1.** Map of the Norfolk Sand Plain study area boundary (thick black line) and surrounding area. Municipal (county) boundaries are shown for Ontario (thin black lines).

We overlaid a 5 km grid on the study area resulting in 137 complete and fractional (hereafter, sliver) squares, of which, 38 (28%) were less than half of the area of the complete squares. We therefore combined sliver squares with nearby squares to form squares that were closer to the area of a complete square (i.e., 2500 ha) and this resulted in a total 98 squares. We calculated the proportional area of public land and forest cover (derived from SOLRIS 2008) within each square and categorized the squares as either public land (≥1% area) or private land (<1% area), as well as a gradient of forest cover categories, including low (7-16%), medium-low (16-22%), medium-high (22-30%), and high (30-46%) forest cover. This categorization resulted in 8 unique combinations of land ownership and forest cover (Table 1). Squares classified as private land tended to have lower forest cover, whereas those classified as public land tended to have higher forest cover.

**Table 1.** Number of survey squares classified into 8 unique combinations of land ownership and forest cover.

| Classification code | Classification description | Frequency |
|---|---|---|
| P1-F1 | Private land, low forest cover | 19 |
| P1-F2 | Private land, med-low forest cover | 14 |
| P1-F3 | Private land, med-high forest cover | 12 |
| P1-F4 | Private land, high forest cover | 4 |
| P2-F1 | Public land, low forest cover | 6 |
| P2-F2 | Public land, med-low forest cover | 10 |
| P2-F3 | Public land, med-high forest cover | 12 |
| P2-F4 | Public land, high forest cover | 21 |

We conducted a Generalized Random Tessellation Stratified (GRTS) spatially-balanced survey design (*spsurvey* package in R; Kincaid and Olsen 2015) by selecting two replicate squares in each of the 8 uniquely-classified squares for a total of 16 survey squares (Table 2). We randomly-generated point count stations within these squares using the following criteria; stations were placed in forests within 100 m of a forest edge; distance between stations was >250 m. We randomly-selected 10 stations (if available) per square, which resulted in the selection of 150 potential survey stations (120 on private lands and 30 on public lands).

*<u>Permissions and access to stations</u>*

Field surveyors were supplied with maps including property boundaries and station locations. Field surveyors visited residences associated with the property boundaries and attempted to make contact with landowners to obtain permission to survey. If an in-person meeting was not possible, surveyors left a letter describing the project in the mailbox with a callback phone number. This was by far the most challenging and time consuming aspect of the project, as most landowners were not home or available during visits. For roughly half of all stations (56/120; 47%), we were unable to obtain permission to survey because property owners were unavailable during visits and did not call back when we left contact information in the mailbox. Roughly one-quarter (17/66; 26%) of stations where we were able to ask for permission to survey, landowners did not give permission. We obtained permission to survey at 49 stations on private lands and 30 stations on public lands. One survey square was not accessible because of a smaller area available for sampling, low forest cover and consequently only 4 available stations, all of which we were not granted permission to survey in. This square should have been replaced, but logistical reasons prevented us from doing so. The sampling distribution of accessible stations within squares is shown in Figure 2.

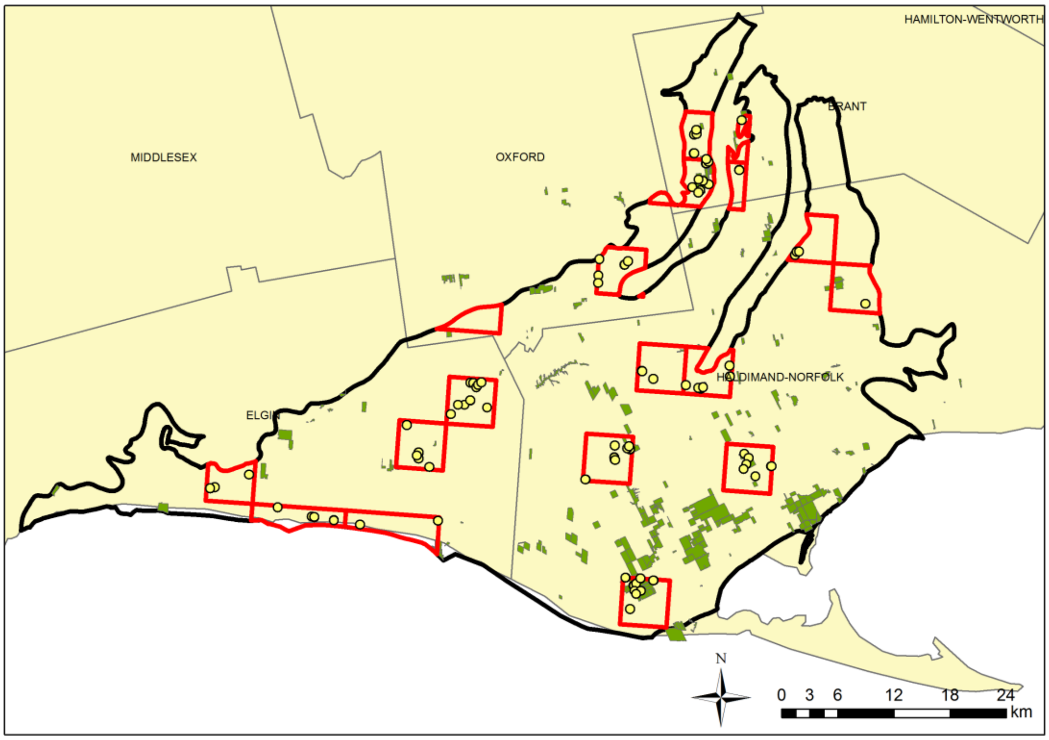


**Figure 2.** Map of survey squares (outlined in red, n=16) and survey stations (yellow points, n=79) within the study area (outlined in black). Public lands are shown as green shaded polygons.

*Point count surveys*

Field surveyors visited survey stations during two mornings between sunrise and 5 hours after sunrise from 24 May to 7 July and conducted a 5-minute point count, recording all individual birds heard or seen. Duration between the first and second visits to stations was greater than 2 weeks. During the first visit, surveyors recorded station-habitat data, including stand basal area (2-factor prism) for all tree species and the estimated vegetation density (scale of 0-10) at 4 vertical strata; 0-6 m (understory), 6-12 m (mid-story), 12-18 m (canopy), >18 m (super-canopy).

*Analysis*

We estimated the abundance and availability of 10 species of forest birds within the study area using hierarchal distance sampling models (Chandler et al. 2011). To explain variation in abundance, we used station-habitat data and the amount of interior forest cover within 1 km of the station; the latter of which,we extracted using landcover data (SOLRIS 2008) in ArcGIS. Station-habitat data included: total stand basal area; species-grouped basal area for climax- (hard maple [e.g., *Acer saccharum*], American beech [*Fagus grandifolia*], yellow birch [*Betula alleghaniensis*], ash sp.[*Fraxinus*]) and successional- (soft maple [e.g., *Acer rubrum*], poplar sp.[*Populus*], white birch [*Betula papyrifera*], black cherry[*Prunus serotina*]) type deciduous forest; basal area for dead trees, White Pine (*Pinus strobus*) and oak (*Quercus*) species; and vertical strata vegetation density at the understory, mid-story and super-canopy. We examined a correlation matrix of the independent variables and removed the canopy density variable from the analysis due to high correlation with total basal area and understory density (Spearman rank: -.4<*r*>.4). To examine variation in whether individuals were available for sampling, we were mostly interested in temporal effects, including date and time of day.

The robust-design, hierarchal distance sampling model allows for various distance detection functions, including half-normal and hazard functions, as well as Poisson and Negative Binomial distributions for fitting count data (Chandler et al. 2011). The term, availability, in our model refers to a higher level of detection probability; the variation in abundance between each of the 2 visits to a station. As such, we fit temporal effects including time of day and Julian date to the availability part of our model. We initiated model selection by fitting null models to combinations of the detection functions and distributions mentioned above for each bird species. We proceeded to the next step using the model with the lowest AIC (Akaike Criteria Information) value. We then fit an additive global model (i.e., no interactions) and used backward-stepwise model selection relying on AIC values from models to inform the process of selecting the best-fitting, most parsimonious model. We first sequentially removed temporal-effects variables from the availability process, followed by sequential removal of variables in the abundance part of the model until no further reduction in AIC values occurred. We tested the overall fit of the global model for each species using parametric bootstrapping with 100 simulations and the *Chi*-square fit statistic; *P* values > 0.05 indicated adequate fit (Fiske and Chandler 2015).

All analyses were performed using the R programming language (R Development Core Team 2015). To facilitate model convergence and comparison of estimates across variables and species, we z-transformed all of the covariates prior to analysis (Kéry and Chandler 2012). Models were fitted using the gdistsamp function in the package unmarked (Chandler et al. 2011, Fiske et al. 2015).

## *Results*

We completed 158 point count surveys, with 2 visits at 79 stations in 15 survey squares. We detected 2694 individuals of 85 species during point count surveys. Species-at-risk were observed throughout the study area, but Eastern Wood-Pewee and Wood Thrush (*Hylocichla mustelina*) were the most commonly encountered (Table 2, Figure 2-4.).

**Table 2.** Number of stations (n) where species-at-risk and other target study species were observed. Species-at-risk listings in Ontario and Canada are shown (SC = Special Concern, THR = Threatened, END = Endangered).

| Species | n (%) | COSSARO[1] | COSEWIC[2] |
|---|---|---|---|
| Red-headed Woodpecker | 1 (1) | SC | THR |
| Eastern Wood-Pewee | 66 (84) | SC | SC |
| Acadian Flycatcher | 2 (3) | END | END |
| Wood Thrush | 49 (62) | SC | THR |
| Cerulean Warbler | 7 (9) | THR | END |
| Louisiana Waterthrush | 2 (3) | SC | THR |
| Great Crested Flycatcher | 58 (73) | - | - |
| Red-eyed Vireo | 77 (97) | - | - |
| Veery | 44 (56) | - | - |
| Hooded Warbler | 15 (19) | - | - |
| Ovenbird | 26 (33) | - | - |
| Scarlet Tanager | 44 (56) | - | - |
| Rose-breasted Grosbeak | 45 (57) | - | - |
| Baltimore Oriole | 32 (41) | - | - |

[1] Committee on the Status of Species-at-Risk in Ontario

[2] Committee of the Status of Endangered Wildlife in Canada

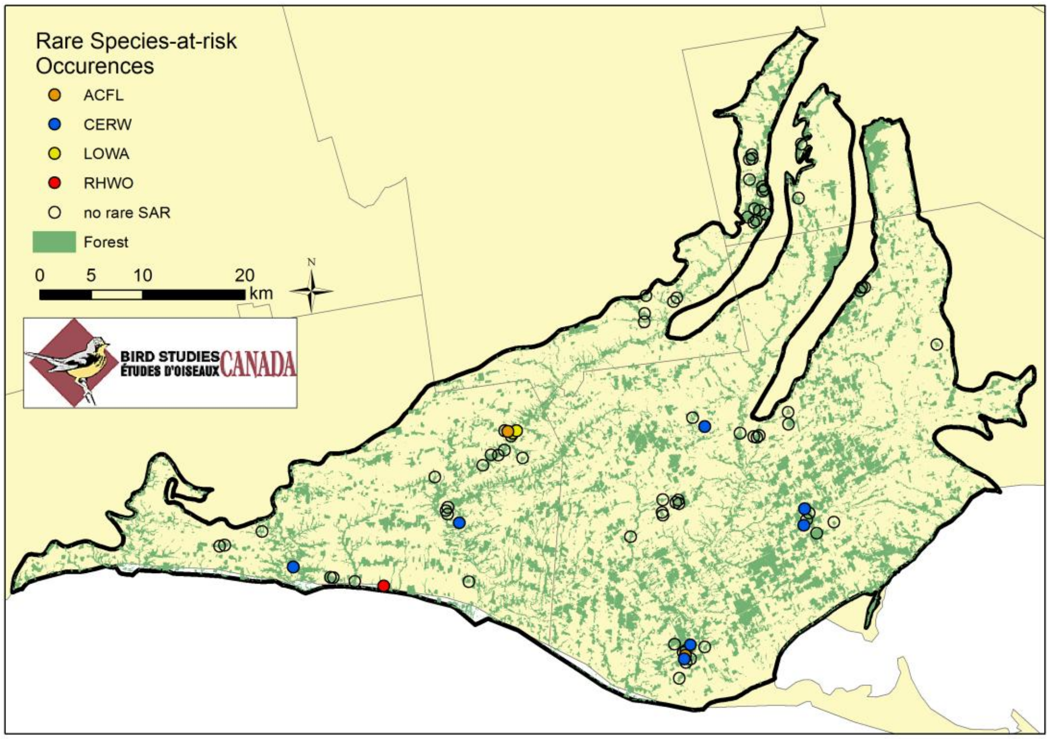


**Figure 3.** Rare species-at-risk observed during 2016 point count surveys. ACFL=Acadian Flycatcher, CERW=Cerulean Warbler, LOWA=Louisiana Waterthrush, RHWO=Red-headed Woodpecker.

Newly-discovered breeding locations of Acadian Flycatcher (n=1), Cerulean Warbler (*Setophaga cerulean;* n= 4) and Red-headed Woodpecker (*Melanerpes erythrocephalus*; n=1) were identified in 2016, almost all of which were on private land. However, all of these individuals, excluding the Acadian Flycatcher, were detected in only one (of the 2) of the point count survey visits and therefore, the breeding status of most of these individuals in unknown.

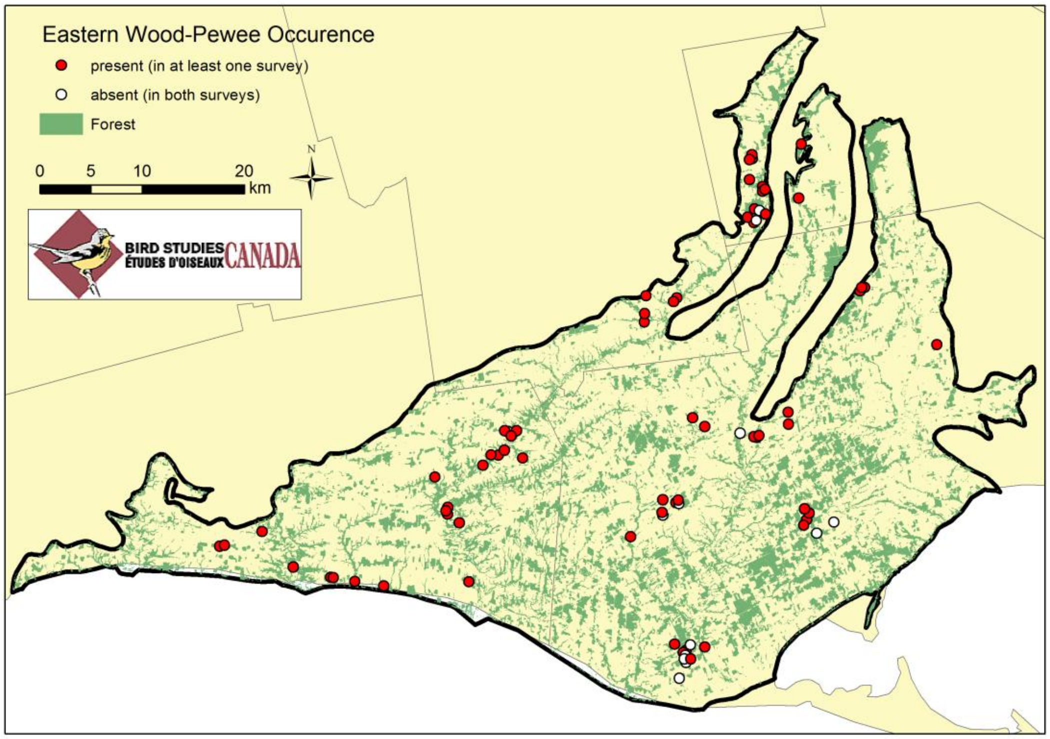


**Figure 4.** Eastern Wood-Pewee occurence based on point count surveys in the Norfolk Sand Plain during 2016.

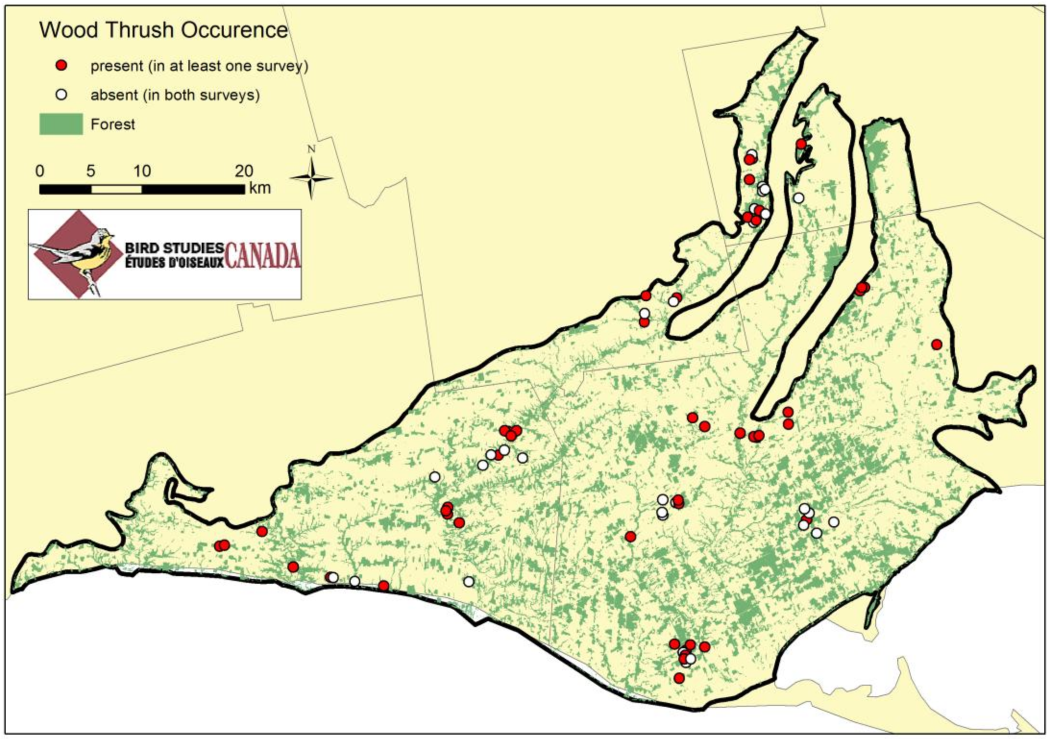


**Figure 5.** Wood Thrush occurrence based on point count surveys in the Norfolk Sand Plain during 2016.

Global models for all species adequately fit the data (*Chi*-square tests: $P > 0.05$). Variables included in the best models varied considerably between species (Table 3). Species' effective radius for sampling varied, with both flycatchers and Scarlet Tanager (*Piranga olivacea*) having greatest detection distances, followed in order by thrushes, warblers and Red-eyed Vireo (*Vireo olivaceus*), Rose-breasted Grosbeak (*Pheucticus ludovicianus*) and Baltimore Oriole. Availability of individuals (for sampling) varied considerably among species and was negatively affected by time of day and to a lesser degree by date. Five of the ten species responded in abundance to variation in the amount of interior forest cover within 1 km. Site-specific habitat variables had no consistent response across species models. Abundance of Eastern Wood-Pewee and Great Crested Flycatcher was not related to any habitat variables, while Wood Thrush, Veery (*Catharus fuscescens*), Hooded Warbler, and Ovenbird (*Seiurus aurocapilla*) abundance significantly increased with greater amounts of interior forest within 1 km. Wood Thrush abundance also increased significantly with increased vegetation understory density. Scarlet Tanager abundance significantly decreased with increased vegetation super-canopy density.

**Table 3.** Parameter estimates of best-fitting models explaining variation in availability and abundance for 10 forest bird species in the Norfolk Sand Plain, Ontario, Canada. Model distribution: P=Poisson, NB=Negative Binomial. Distance detection function refers to the type of curve fit to the distance observations of birds. Effective radius is the threshold limit at which probability of observation declines precipitously. Availability refers to whether individuals were available to be detected determined by presence or absence between the two survey visits (back-transform: $e^{\phi}/[1+e^{\phi}]$). Abundance refers to the number of individuals estimated in a 150 m radius point count plot (back-transform: $e^{\lambda}$). TBA=total basal area, BA =basal area, Pw=white pine, Dead=dead trees. See methods for clarification on other variable definitions.

| | | | | Availability (ϕ) | | | Abundance (λ) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Distribution | Distance Detection Function | Effective Radius (m) | Intercept | Date | Time of day | Intercept | TBA | BA Climax sp. | BA Succession sp. | BA Oak | BA Pw | BA Dead | Under-story density | Mid-story density | Super-canopy density | Interior Forest Cover (1km) |
| Eastern Wood-Pewee | P | Hazard | 103 | 1.35 | | | **0.91** | | | | | | | | | | |
| Great Crested Flycatcher | P | Hazard | **97** | **-2.35** | | **-0.50** | **2.69** | | | | | | | | | | |
| Red-eyed Vireo | P | Hazard | **72** | 1.27 | 0.39 | | **2.58** | | | | | | NA | | | | 0.10 |
| Veery | NB | Hazard | **92** | -0.45 | | | **1.45** | -0.16 | 0.22 | 0.33 | 0.11 | | NA | | 0.21 | | **0.26** |
| Wood Thrush | P | Hazard | **93** | 2.81 | -1.00 | **-2.60** | **0.59** | | | | | | NA | **0.25** | | | **0.26** |
| Hooded Warbler | NB | Half-norm | **84** | 3.18 | | -2.50 | **-1.02** | | | | -1.20 | | NA | | -0.52 | | **0.75** |
| Ovenbird | NB | Hazard | **87** | 0.70 | | -1.00 | 0.33 | | | | | | NA | | | | **0.68** |
| Scarlet Tanager | P | Hazard | 104 | **-2.32** | | | **2.15** | | | | 0.25 | -0.59 | NA | | | **-0.32** | |
| Rose-breasted Grosbeak | P | Half-norm | **64** | -1.43 | **-0.40** | -0.20 | **2.45** | | | | | | NA | | | -0.21 | |
| Baltimore Oriole | P | Half-norm | **53** | 1.19 | | -2.50 | **1.13** | | 0.25 | | | | NA | 0.34 | | | -0.25 |

## *Discussion*

Major aims of our study were to examine factors affecting detection probability and abundance of forest birds and to document and monitor breeding sites of rare species-at-risk throughout the Norfolk Sand Plain study area. We employed a GRTS-design strategy to minimize sampling biases, for example, in our study area forest cover is greatest where land is publicly-owned (e.g., Conservation Authorities). Thus, our study design balanced our selection of sites by forest cover density and whether the forest cover was associated with public land. Overall, we struggled to achieve a large sample due to accessibility issues on private lands. However, we gained access to 49 stations on private land and it is expected that in future years the number of private lands surveyed will increase to some manageable threshold.

We did not encounter a significant number of rare species-at-risk birds during our surveys. However, Cerulean Warblers were found at 4 locations where we have no prior knowledge of their occurrence at those sites. It is unknown whether these individuals were transients or breeders, since they were not encountered on both survey visits. However, this is not unusual for this species, as we have estimated availability ($\phi$) for Cerulean Warblers at ~0.5 in the Frontenac Arch of Ontario (BSC, unpublished data). Regardless, it is a promising result, as the species is very scarce on private lands in southwestern Ontario (BSC unpublished data).

Overall, we believe our current study design and methodology is best-suited for monitoring populations of the following species in the Norfolk Sand Plain: Eastern Wood-Pewee, Red-eyed Vireo, Wood Thrush, Veery, Hooded Warbler, Ovenbird and Baltimore Oriole. Abundance estimates for Great Crested Flycatcher, Scarlet Tanager, and Rose-breasted Grosbeak were extremely inflated (see below).

Detection distances of most species appeared reasonable. As might be expected, the simple and loud songs of Eastern Wood-Pewee and Great Crested Flycatcher resulted in some of the largest effective sampling radii. However, Eastern Wood-Pewee and Scarlet Tanager had non-significant estimates for effective sampling radii, due to high variance in the hazard function estimate. We examined raw data and found that for both species, there appeared to be observer avoidance biases, such that birds were disproportionately recorded in lower densities in the 0-50 m distance band compared to the 50-100 m band. Conversely, Rose-breasted Grosbeak and Baltimore Oriole had the lowest effective radii distance, which might be attributed to softer, less boisterous singing in these species.

Availability estimates varied widely among species. Great Crested Flycatcher, Rose-breasted Grosbeak, and Scarlet Tanager had the lowest estimates of availability, which unreasonably inflated abundance estimates for these species. For example, the mean maximum number of Great Crested Flycatchers (per station) observed across both visits was 0.9, whereas the predicted abundance per station was 14.7; about 16 times higher. Availability for most species was negatively related to time of day effects, most notably for Wood Thrush; typically an early morning singer. Given this, it may be somewhat beneficial to restrict future surveys to being conducted earlier in the morning (e.g., 4 hours after sunrise instead of 5). It is also possible that availability in some species was affected by variation in detection of females or non-singing birds, as we did not differentiate between observation types (i.e., calling vs. singing) in our study. Thus, it is also recommended that future surveys differentiate between birds singing and contact-calling, as well as visual-only observations.

It should be noted that because we sampled stations within interior forest (i.e., >100 m from abrupt edges), we have introduced some level of bias. Larger forest fragments were more likely to be sampled over smaller fragments in our study within a given survey square, although we likely reduced this bias to some extent due to our stratified sampling design. For forest generalist species, such as Eastern Wood-Pewee, it may still be that there is an avoidance of habitat characteristics associated with smaller forest patches, but within interior forest wood-pewee abundance is not associated with any specific habitat conditions; as we found in this study. As such, readers should remain cautious interpreting the results of this study accordingly.

The most notable effect on abundance of forest birds in this study was the amount of forest interior within 1 km of the sampling station. Wood Thrush, Veery, Hooded Warbler, and Ovenbird abundance was significantly and positively related to interior forest cover. Wood Thrush also responded positively to increases in understory vegetation density. These results agree with the findings of other studies, where Wood Thrush tend to prefer interior forest with a dense understory structure, which is also associated with higher nesting and fledgling success (Whitcomb et al. 1981, Galli et al. 1976, Lynch 1987, Robinson and Wilcove 1994, Hoover et al .1995, Rosenberg et al. 2003, Driscoll et al. 2005). We also found that Veery abundance tended to increase at sites with more interior forest cover, lower basal area, higher diversity of trees and a higher density of mid-story vegetation (i.e., younger forests). Other studies report very similar patterns to those presented here for Veery (e.g., Rosenberg et al. 2003, Bevier et al. 2005). The Ovenbird is a prime example of an area-sensitive species and is often shown to have higher demographic parameters (e.g., nest success) in larger forest patches (e.g., Wenny et al. 1993, Donovan et al. 1995, Burke and Nol 1998, Porneluzi and Faaborg 1999, Flaspohler et al. 2001). Thus, it is maybe not surprising that we found Ovenbird abundance to be associated with the amount of forest interior cover. Hooded Warblers also tend to occupy larger forest patches more consistently than smaller fragments and nest success tends to be higher in large forest patches (Robbins 1979, Donovan and Flather 2002, Rush and Stutchbury 2008). In addition to a positive relationship to interior forest cover, we found Hooded Warblers tended to be less abundant in sites with more oak species and where mid-story vegetation density was higher. To our knowledge, other studies have not observed these patterns, but it is possible that these variables are correlated to other biologically-relevant variables that we did not capture in our habitat data.

In conclusion, we evaluated a pilot study for its suitability and application in a long-term monitoring program for forest birds in the Norfolk Sand Plain, Ontario, Canada. We examined factors affecting detection probability and abundance of a suite of forest bird species and documented occurrences of rare species-at-risk (e.g., Cerulean Warbler). The abundance of 6 out of 10 common species appeared to be related to the amount of interior forest cover. Estimates of abundance for 7 out of 10 species were reasonable and precise enough to likely provide reliable population trend estimates for long-term monitoring within our study area.

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