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Habitat use by Veery (*Catharus fuscescens*) in southern Ontario

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Abstract
Veery (*Catharus fuscescens*) is a breeding migrant thrush that nests throughout much of the temperate forests within Canada. Habitat loss and degradation is thought to be responsible for a steady decline in Veery populations since 1970. We studied habitat characteristics of occupied Veery territories versus unoccupied adjacent areas in southern Ontario during the 2016 breeding season. Occupied territories were characterized as riparian deciduous forests dominated by ash (*Fraxinus* spp.), Black Cherry (*Prunus serotina*), and Red Maple (*Acer rubrum)* trees with an understorey of Balsam Fir (*Abies balsamea*) and ferns (order Polypodiales); the presence of fruit-producing plants such as Riverbank Grape (*Vitis riparia*) and Bunchberry (*Cornus canadensis*) also was important.

Key words: *Catharus fuscescens*; nesting habitat; habitat use; Veery

Introduction

Veery (*Catharus fuscescens*) is a migrant thrush that breeds in Canada and the northern United States (Heckscher *et al.* 2020). According to the North American Breeding Bird Surveys, Veery has experienced a 25–50% population decline since 1970 in its breeding grounds in Ontario (Environment and Climate Change Canada 2017). The steady decline in Veery populations has warranted calls for a re-evaluation of the conservation status of Veery and further research on threats to their breeding habitat (Heckscher 2004, 2020).

Disturbances to forest structure and species composition can have a strong impact on the abundance and diversity of bird species in an area; therefore, it is important to have a detailed understanding of the habitat needs of individual bird species (Fleishman *et al.* 2003; Bennett *et al.* 2014; Meyer *et al.* 2015). Studies of habitat use in birds aim to describe how habitat features determine species abundance (Jones 2001). Although habitat use is largely determined by forest structure and species composition, additional factors include prey abundance, conspecific-attraction, and physical boundaries such as forest edges (Ramsay *et al.* 1999; Jones and Robertson 2001; Harper *et al.* 2005).

Preferred breeding habitat of Veery generally consists of large tracts of deciduous forest with riparian areas, but the species can also be found in second-growth forest fragments and mesic upland forests (Bertin 1977; Herkert 1995; Burke and Nol 2000). Previous studies have described the importance of a well-developed forest floor and shrub understorey as necessary for Veery foraging and nesting (Paszkowski 1984; Heckscher 2004; Kearns *et al.* 2006). However, Heckscher (2004) noted that more research is needed on particular mechanisms of habitat use for Veery with emphasis on regional studies to understand which plant communities are important for Veery conservation.

The objective of our study was to compare habitat characteristics of occupied Veery territories with adjacent unoccupied areas in mixed forests of the Great Lakes/St. Lawrence lowlands of southern Ontario, Canada. These data could help inform regional species-specific conservation and environmental management actions by describing habitat types and plant species associated with Veery territories.

Study Area

The study sites were situated within five forest tracts (mean area 0.35 km^2; range 0.15–0.86 km^2) located across a 150 km^2 area in the southern region of the Lake Simcoe watershed in south-central Ontario, Canada (44.2233°N, 79.3278°W). This area of

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the Lake Simcoe region is associated with a mix of large riparian areas, upland hardwood forests, and reforested Red Pine (*Pinus resinosa* Aiton) plantations (Harpley and Milne 1996). The research sites varied from relatively undisturbed forests and wetlands along the Black River and Zephyr Creek, to recreational public forests. The area has recently seen fairly widespread establishment of common invasive species including Dog-strangling Vine (*Vincetoxicum rossicum* (Kleopow) Barbaricz), Garlic Mustard (*Alliaria petiolata* (M. Bieberstein) Cavara & Grande; C.H., P.H., and R.M. pers. obs.), and Emerald Ash Borer (*Agrilus planipennis*; Marchant 2011).

Following a year of preliminary study and site selection in 2015, the study areas were selected for the presence of breeding Veery. The forest sites tended to be dominated by an overstorey of Sugar Maple (*Acer saccharum* Marshall), Red Maple (*Acer rubrum* L.), and ash (*Fraxinus* spp.). Additional tree species in these forest sites included Black Cherry (*Prunus serotina* Ehrhart), Ironwood (*Ostrya virginiana* (Miller) K. Koch), and Red Pine. Understories were well developed and included large numbers of Balsam Fir (*Abies balsamea* (L.) Miller), Alternate-leaved Dogwood (*Cornus alternifolia* L. f.), Common Buckthorn (*Rhamnus cathartica* L.), and saplings of Sugar Maple, Red Maple, and White Ash (*Fraxinus americana* L.).

Climate normals from 1981 to 2010 from the Udora weather station (44.2625°N, 79.1614°W), 15 km from the furthest field site, indicate that May 2016 had comparable temperature to the climate mean (13.5°C versus 12.2°C) and lower rainfall than the climate mean (31.2 mm versus 82.1mm). Similarly, June 2016 had comparable temperatures (17.8°C versus 18°C) and substantially lower rainfall (40.6 mm versus 106.6 mm) to the climate mean (Environment and Climate Change Canada 2016).

Methods

Bird surveys

Surveys occurred daily by one observer from 16 May to 1 July 2016 using transects at each of the five study areas (Calmé and Desrochers 2000; Kearns *et al.* 2006). We surveyed 16 transect routes in total each ~250 m in length. Each transect was walked at a steady pace over 30 min once a week for a total of seven weeks. Transect routes were arranged to cover as much accessible area as possible at each of these five study sites; transects within a site were located at least 1 km apart. Veeries were initially detected by sound, followed by visual confirmation when possible. The detection range on a transect was 300 m. We recorded the initial location of each bird on a handheld global positioning system (GPS) unit (Garmin eTrex 10; Garmin Ltd., Olathe, Kansas, USA; Kearns *et al.* 2006; Ballantyne and Nol 2011). Because the birds were not marked and to reduce the risk of double-counting, we excluded observations with similar GPS coordinates on adjacent transects; pairs were counted as a single observation (Kearns *et al.* 2006).

Sites were surveyed primarily during the morning from 0700 to 1100 EDT with occasional surveys completed during the evening from 1600 to 2000 because Veery vocalizes at both dawn and dusk (Heckscher 2007; Belinsky *et al.* 2012). We did not experienced problems detecting Veery later in the morning, when singing rates can decline, because the transect routes were done quite slowly over a small area and we detected at least one on each route. The survey period of 16 May to 1 July encompasses Veery arrival to nesting areas, breeding, and fledging of young (Robbins *et al.* 1989; Gauthier and Aubry 1996; Heckscher 2007; Heckscher *et al.* 2020). Surveys were not conducted when there was inclement weather, including any precipitation or strong winds (>28 km/h; Nol *et al.* 2005).

Veery territories were estimated using the plot mapping technique, where territory is approximated based on initial point observations taken during repeated visits along a transect route (Christman 1984; Jones and Robertson 2001). We used the "kernel density" function in ArcMap 10.4 (ESRI, Redlands, California, USA) to produce territory maps from the point observations based on the seven visits conducted at each site (Ferrato *et al.* 2017). Veery territories (n = 12) ranged in size from 0.2 to 0.8 ha (mean 0.31 ha) and did not overlap.

Vegetation sampling

Vegetation sampling was completed in July 2016, using a nested quadrat approach consisting of tree survey (n = 24: 12 in Veery territories and 12 in adjacent areas) and forest floor survey quadrats (n = 93: 57 in Veery territories and 36 in adjacent areas). To compare habitat characteristics between occupied territories and unoccupied adjacent areas, each Veery territory was paired with an available unoccupied adjacent area within the same continuous woodlot within each forest study area; thus, each pair was not subject to landscape level boundaries such as forest edges (Burke and Nol 2000). Unoccupied adjacent areas were circular and ~0.4 ha in size, to match the size of the Veery territories. The centre of an unoccupied adjacent area was chosen using a random number generator that determined direction (0–359º) from the centre of the paired occupied territory and distance (50–1000 m) from the edge of the paired territory or forest edges (Jones and Robertson 2001; Heckscher 2004). The maximum 1 km was chosen because the largest Veery territory was ~1 km wide. The minimum distance acts as a buffer area between the unoccupied adjacent areas and paired territory and 50 m was chosen because it is the approximate radius of a 0.4 ha circle.

Tree composition was surveyed with 250 m^2 (15.8 m × 15.8 m) survey quadrats centred on the mean point between all Veery observations in each territory as determined by the "meancenter" function in ArcMap. Another 250 m^2 tree composition plot was completed in the centre of the adjacent unoccupied area. All trees with >8 cm diameter at breast height (dbh) were counted within one of three size categories: small (8–22 cm dbh), medium (23–38 cm dbh), and large (>38 cm dbh). All individual trees and shrubs were counted by species within the forest quadrat area (Bergeron 2000). Three types of trees were counted in groups because we had low numbers of individual species despite the group being a large part of the forest: (1) ash, (2) poplar (*Populus* spp.), and (3) conifer (excluding Balsam Fir). Species in the conifer category included pine (*Pinus* spp.), spruce (*Picea* spp.), and Eastern White Cedar (*Thuja occidentalis* L.).

Forest floor quadrats were established within each of the 12 Veery territories and 12 adjacent unoccupied areas. Forest floor habitat was sampled with 0.25 m^2 Daubenmire quadrats (Daubenmire 1959) at randomly determined points using ArcMap's "create random points" function, which generated random GPS coordinates (Ballantyne and Nol 2011). We sampled larger Veery territories (0.4–0.8 ha, n = 7) with six sampling points and smaller territories (<0.4 ha, n = 5) with three sampling points. Three sampling points also were used in the adjacent unoccupied areas.

We measured percentage cover of: (1) forbs, (2) grass, (3) leaf litter, (4) bare ground, (5) fruit-producing plants, (6) moss, (7) water, (8) fern (order Polypodiales), (9) horsetail (*Equisetum* spp.), and (10) canopy cover in each Daubermire forest floor quadrat. We also counted (11) logs (>8 cm diameter), (12) dead trees (>8 cm diameter), (13) vines, and measured (14) canopy height. As well, landscape-level variables included (15) minimum distance to edge, (16) minimum distance to water, and (17) forest patch size. In our estimation of vegetation cover for forest floor quadrat surveys, we combined all fern species into one category that included primarily: Ostrich Fern (*Matteuccia struthiopteris* (L.) Todaro), Sensitive Fern (*Onoclea sensibilis* L.), and Bracken Fern (*Pteridium aquilinum* (L.) Kuhn). We noted several fruit-producing plant species which we observed Veeries consuming (C.H. pers. obs.) that we also combined. The dominant species were Canada Mayflower (*Maianthemum canadense* Desfontaines), Woodland Strawberry (*Fragaria vesca* L.), Riverbank Grape (*Vitis riparia* Michaux), and Bunchberry (*Cornus canadensis* L.).

Statistical analyses

Statistical analyses were performed using the "vegan" (Oksanen *et al.* 2015) package in R 3.3.0 (R Core Team 2016). Habitat variables which were not normally distributed according to Shapiro-Wilk tests in R were transformed using log transformations (Ramsay *et al.* 1999). Mean and SE values are presented as untransformed data to allow for clear interpretation.

We compared occupied territories versus unoccupied adjacent areas using principal components analysis (PCA) with the "prcomp" function in R (Ramsay *et al.* 1999; R Core Team 2016). Sites were evaluated based on measurements within the following categories: (1) physical forest characteristics (e.g., canopy height, leaf litter amount) and (2) tree and shrub species (Ramsay *et al.* 1999; Calmé and Derochers 2000; Dellinger *et al.* 2007). We generated PCA biplots for both forest physical characteristics and forest species using the first and second principal components (PC1, PC2) generated during each respective analysis. On the PCA biplots, we plotted 95% confidence ellipses to visualize the variance of occupied territory compared with the variance of available territory. We also compared values for each habitat forest characteristic between occupied and available territory using two-tailed paired Wilcoxon tests (Ramsay *et al.* 1999).

Results

We surveyed 12 Veery territories paired with 12 unoccupied adjacent areas across the five study areas. Tree species composition widely varied across each of the forest sites. Across all Veery territories, 28 species of trees were observed with an average of 8.4 tree species in each territory. Between territories and unoccupied adjacent areas, we found three significant (P < 0.05) differences (Table 1) after adjusting P-values using the Holm-Bonferroni method (Holm 1979). Veery territories had higher mean abundance of Black Cherry trees, a greater number of logs, and a lower number of medium sized trees (23–38 cm dbh).

Principal components analysis (PCA) of physical forest characteristics generated three principal components which explained 57.72% of the total variance (Table 2). PC1 explained 26.26% of the total variance and had high negative loadings from canopy height, canopy cover, leaf litter cover, and number of large-sized trees (≥38 cm dbh). Therefore, PC1 likely differentiates second-growth forest from mature forest communities. PC2 explained 18.01% of the total variance and had high positive loadings from fern cover, moss, number of logs, and number of vines, suggesting that this component is describing humid, riparian habitat. PC3 explained 13.45% of the total variance and likely describes riparian habitat with high negative

TABLE 1. Comparison of habitat between occupied territories and adjacent, unoccupied areas. Veery (*Catharus fuscescens*) territories ($n = 12$) were paired with nearby unoccupied adjacent areas ($n = 12$) in the same forest patch. Comparisons were made using two-tailed paired Wilcoxon signed-rank tests. Non-normal data were log transformed for analysis, but original, untransformed data are shown in table.

Variable	Occupied sites Mean ± SD	Unoccupied sites Mean ± SD	*P*
Fruiting plants (%)	21.48 ± 14.65	9.00 ± 11.96	0.8712
Fern (%)	21.52 ± 24.76	3.00 ± 8.38	0.6534
Canopy cover (%)	79.18 ± 12.24	48.23 ± 33.63	0.2065
No. medium trees (23–38cm dbh)	1.94 ± 0.95	4.20 ± 1.91	0.0430
No. logs	9.43 ± 4.36	2.60 ± 1.84	0.0018
No. Black Cherry (*Prunus serotina*)	1.59 ± 1.10	0.07 ± 0.21	0.0037
No. dogwood	2.63 ± 2.28	0.60 ± 0.80	0.2426
No. Red Maple (*Acer rubrum*)	2.74 ± 2.56	0.80 ± 1.33	0.8157

TABLE 2. Eigenvectors from principal components analysis of habitat structure between Veery (*Catharus fuscescens*) territories and unoccupied adjacent areas. Non-normal data were log transformed. Only the first three principal components are included.

Variable	Principal Components		
	PC1	PC2	PC3
Forbs	−0.0327	0.2465	−0.0696
Grass	0.1541	−0.2568	−0.2148
Leaf litter	−0.3896	−0.1353	0.0227
Bare ground	0.2730	0.0641	−0.3699
Berries	−0.0391	0.2152	−0.2123
Moss	0.2576	0.3142	−0.2052
Standing water	0.1647	−0.0725	0.5384
Fern	0.1234	0.3841	0.1493
Horsetail	−0.3337	0.0774	0.1244
Canopy cover	−0.3501	0.2362	−0.0550
Small trees (8–22cm dbh)	0.2451	0.0223	0.3129
Medium trees (23–38cm dbh)	0.0828	−0.4284	−0.1318
Large trees (>38cm dbh)	−0.3095	0.1664	−0.0105
Canopy height	−0.3675	−0.1096	−0.1935
Logs	−0.2145	0.0503	0.0503
Dead trees	−0.0187	0.4764	0.4764
Vines	0.2285	0.3719	−0.1071
Eigenvalue	2.2916	1.8982	1.6399
Cumulative proportion (%)	26.26	44.27	57.72

contributions from dead trees and standing water and a positive contribution from bare ground cover. The PCA biplot of physical forest characteristics with confidence ellipses ($P < 0.05$) shows a distinction between occupied Veery territories and adjacent areas based on the first two principal components (Figure 1).

PCA of forest tree species generated three principal components which explained 55.4% of the variance (Table 3). PC1 explained 28.81% of the total variance which was composed of high loadings by riparian species including poplar, Red Maple, and alder (*Alnus* spp.) and strong negative components of upland forest species: Sugar Maple, American Beech (*Fagus grandifolia* Ehrhart), and Basswood (*Tilia americana* L.). PC2 explained 15.64% of variance composed of high contributions by deciduous tree species and a strong negative contribution from non-Balsam Fir conifers. PC3 explained 10.95% of the variance and was composed of positive components from lowland species including alder and Paper Birch (*Betula papyrifera*

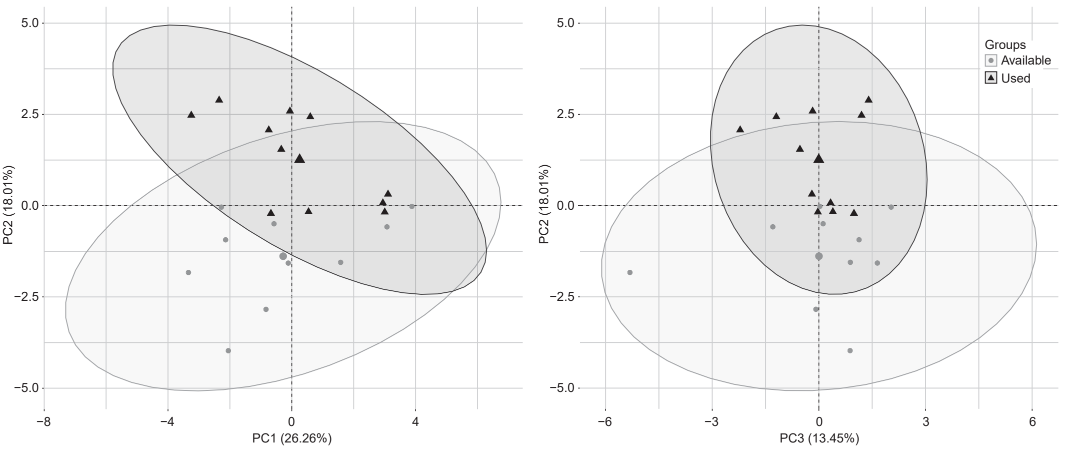

FIGURE 1. Biplots of PC1, PC2, and PC3 scores from principal components analysis (PCA) of habitat structure between Veery (*Catharus fuscescens*) territories and unoccupied adjacent areas in the Lake Simcoe watershed, Ontario, 2016.

TABLE 3. Eigenvectors from principal components analysis of forest tree species between Veery (*Catharus fuscescens*) territories and adjacent unoccupied areas. Non-normal data were log transformed. Only the first three principal components are included.

Variable	Principal Components		
	PC1	PC2	PC3
Alder	0.3151	−0.0515	0.2954
Ash	0.0825	−0.2799	0.0245
Basswood	−0.2732	−0.2199	0.0723
Beech	−0.2719	−0.3019	0.1146
Birch, Paper	0.2104	0.1629	0.5171
Buckthorn	0.2614	−0.2218	0.0471
Cherry, Black	0.1907	−0.4612	−0.2637
Conifer (Cedar, Pine, Spruce)	−0.0172	0.4296	−0.0370
Dogwood	0.2620	−0.3489	0.1086
Fir, Balsam	0.1914	−0.0480	0.1743
Maple, Red	0.3500	−0.2189	−0.1575
Maple, Sugar	−0.4100	−0.2206	0.0491
Ironwood	−0.2439	−0.2757	0.3574
Oak, Red	0.0863	−0.0075	−0.5887
Poplar	0.3651	0.0996	0.0980
Eigenvalue	2.0789	1.5317	1.2812
Cumulative proportion (%)	28.81	44.45	55.40

Marshall) and a strong negative component from Red Oak (*Quercus rubra* L.), a prominent upland species. The PCA biplot of tree species with confidence ellipses ($P < 0.05$) shows a distinction between occupied Veery territories and adjacent areas based on the first two principal components (Figure 2).

Discussion

The results support the hypothesis that there are components of habitat structure and species composition that are significant predictors of Veery habitat use. We found Veery generally occupied sites characterized by the multivariate analysis as second-growth, having low, open forest canopies with standing water and little leaf litter, and few mature trees. In our study area, second-growth habitat was either degraded, regenerating forests, or forests located on floodplains, adjacent to rivers and wetlands. LaRue *et al.* (1994) also found that Veery occupied second-growth forest, could tolerate disturbed sites, and was associated with

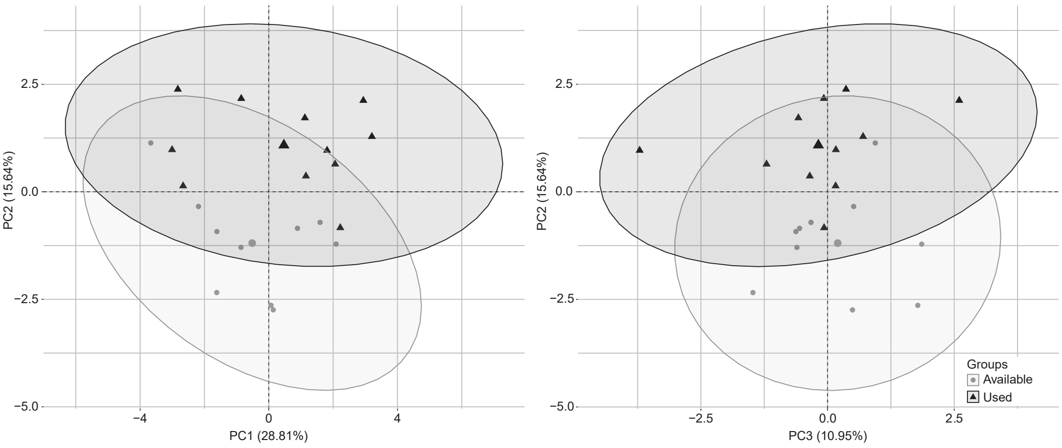

FIGURE 2. Biplots of PC1, PC2, and PC3 scores from principal components analysis (PCA) of forest tree species between Veery (*Catharus fuscescens*) territories and adjacent unoccupied areas in the Lake Simcoe watershed, Ontario, 2016.

riparian habitats. Humid, riparian forests in our study areas were characterized by a forest floor covered by fern and moss, and abundant Riverbank Grape vines hanging from Red Maple, alder, poplar, dogwood, and buckthorn. Our multivariate analysis highlights many of these same features in Veery occupied areas. Veery was found in areas with a high ground cover of fern and moss, as well as large numbers of vines and logs (Table 2) and was associated with each of these riparian tree species (Table 3). Golet *et al.* (2001) highlights Red Maple swamps as an important habitat for Veery.

Our multivariate analyses of tree species composition indicate that Veery were more likely to occupy deciduous forest communities as opposed to coniferous or mixed forests (Table 3). These results are also consistent with findings by Thompson and Capen (1988), who found that Veery was a resident of deciduous, heavily forested habitat with dense understorey. In our study, Veery territories were most commonly located in forests with an overstorey of ash trees and Red Maple (Figure 2). Forests dominated by ash trees and Red Maple most strongly covaried with Black Cherry, American Beech, Ironwood, and dogwood trees. One notable exception to the preference for deciduous trees was the widespread abundance of understorey Balsam Fir in Veery territories. Kearns *et al.* (2006) found that although Veery frequently nested in the dense forest understorey, they also nested within the lower sections of Balsam Fir up to 4 m tall. Veery constructs nests low to the ground in the protection of dense understorey as noted by Heckscher (2004). Thus, we consider Balsam Fir to be a species that significantly contributes to Veery habitat as an understorey species.

Veery primarily forages on insects and to a lesser extent, fruit during the breeding season (Wolfe *et al.* 2014; Heckscher *et al.* 2020). However, Veery and other *Catharus* species readily consume grapes when available, from wild Riverbank Grape or even wine grape vineyards (Beal 1915; Jubb and Cunningham 1976; C.H. pers. obs.). Of the 28 species of tree observed in Veery occupied areas, Black Cherry was the most dominant fruit-bearing tree and there were significantly more Black Cherry trees in occupied compared to unoccupied adjacent areas (Table 1). We suggest that food sources such as Riverbank Grape and Black Cherry may be important components of Veery habitat when available.

The presence of standing water in wet forests was considered a significant habitat variable in our study because Veery has an affinity for moist forested habitats (Paszowski 1984; Heckscher *et al.* 2020). The abundant logs we found in forested wetlands and riparian areas (mostly Paper Birch, Trembling Aspen [*Populus tremuloides* Michaux], and Large-toothed Aspen [*Populus grandidentata* Michaux]) were likely killed by seasonal flooding. However, the greatest proportion of logs by a substantial margin were ash species (C.H. pers. obs.). The large number of dead ash trees and logs is likely due to the presence of the Emerald Ash Borer, which has been highly destructive in Ontario and has been present in our study area since at least 2011 (Poland and McCullough 2006; Marchant 2011). While Veery occupied areas contained significantly more logs than unoccupied areas (Table 1), it is difficult to determine whether this is due to a potential association with ash trees or with riparian habitat.

For habitat management, especially of declining species such as Wood Thrush (*Hylocichla mustelina*) and Veery, it is important to recognize that ideal breeding habitat likely requires a complex arrangement of habitat varied in species composition and structure. Supporting previous research of Veery habitat, we found that riparian areas and second-growth forests were frequently occupied habitats (Paszowski 1984; LaRue *et al.* 1994; Golet *et al.* 2001; Heckscher 2004; Heckscher *et al.* 2020). The status of ash trees is of particular importance for Veery habitat at our forest study areas within the Lake Simcoe watershed. Ash trees are a significant component of Veery habitat and the continued spread of infestations of Emerald Ash Borer may threaten future habitat use in the area. Despite widespread infected and fallen ash trees throughout the study area, there are still many healthy ash trees which may benefit from preventative treatment (Marchant 2011).

Author Contributions

Writing—Original Draft: C.H.; Writing—Review & Editing: C.H., P.H., and R.M.; Conceptualization: C.H., P.H., and R.M.; Investigation: C.H.; Methodology: C.H., P.H., and R.M.; Formal Analysis: C.H.; Funding Acquisition: P.H.

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