Habitat Modeling for Landbird Species at Risk in Southwestern Nova Scotia

Final Report for the Nova Scotia Habitat Conservation Fund (year 2, April 2013-Oct 2014) and
Final Report for the Nova Scotia Species at Risk Conservation Fund (June 2013-Oct 2014)

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BACKGROUND, GOALS AND OBJECTIVES

Effective conservation strategies for species at risk require knowledge about their habitats and how they are distributed across the landscape. Our project focused on six landbird species at risk that inhabit forested landscapes in the five counties of Southwestern Nova Scotia. Loss of habitat is a main breeding ground conservation threat for these species. Identification of suitable breeding habitat is a first step towards conserving these landbird Species at Risk (SAR) in this region.

Our main goal was to identify breeding habitat at the site and landscape scales for six recently-listed (Schedule 1 SARA) landbird species at risk in Southwestern Nova Scotia: Common Nighthawk (*Chordeiles minor)*, Chimney Swift (*Chaetura pelagica)*, Eastern Wood Pewee (*Contopus virens*), Olive-sided Flycatcher (*Contopus cooperi)*, Canada Warbler (*Cardellina [Wilsonia] canadensis*), and Rusty Blackbird (*Euphagus carolinus)*. Information about the characteristics of their habitat and its occurrence on the landscape can be used to guide conservation efforts for these landbirds at risk.

Our objectives of the second year of this multi-year project were to: (1) conduct additional landbird at risk surveys and recruit volunteers to contribute new occurrences for these species for use in habitat modeling; (2) conduct additional, detailed habitat surveys for three target species that breed in wet forests (Olive-sided Flycatcher, Canada Warbler, and Rusty Blackbird), to increase sample size for habitat analyses; (3) model the distributions of breeding populations of all six species using GIS; and (4) use our knowledge to conduct education and outreach, and create habitat stewardship tools.

WORK COMPLETED

(1) Bird surveys

Field surveys targeted the three target SAR that breed in forested wetlands and defend territories with loud vocalizations: Canada Warbler, Olive-sided Flycatcher, and Rusty Blackbird.

Surveys were conducted in randomly selected polygons of suitable habitat (as determined by Habitat Suitability Models; Westwood 2012), stratified by ecodistrict and landscape harvest type (whether forest harvesting was evident within 1 km). Each polygon contained three survey sites, at least 250 m apart and at least 100 m from a road. Opportunistic playback surveys were also completed when potentially suitable habitat was encountered *en route* to designated survey sites.

Surveys were conducted between sunrise and 1130 h in fair weather conditions (no rain and wind <30 km/h). Each survey consisted of a 5-minute unlimited-radius point count followed by a 30-second playback for each species, to increase the likelihood of detecting the SAR if present. Distance and direction to each detected landbird SAR were noted, so that UTMs could be adjusted to reflect the actual location of the bird. Point counts were not carried out at opportunistic playbacks sites.

These data were combined with detections from other sources since 2006, including the Maritimes Breeding Bird Atlas (MBBA), the Staicer research lab at Dalhousie, and other volunteers. From this set of points in GIS, a subset of sites were selected for vegetation surveys in an effort to evenly distribute vegetation survey sites among ecodistricts, landbird SAR species, and landscape types.

Opportunistic playback surveys were also conducted late April through early July 2014. Additional records were solicited from volunteers (see also outreach section). All of these records were complied and combined with data from the MBBA and used for our final habitat models.

(2) Habitat surveys

In July and August 2012 and 2013, vegetation surveys were carried out at sites where one or more of the three targeted SAR landbirds had been found. Of the 99 sites sampled, 38 were occupied by Canada Warbler, 45 by Olive-sided Flycatcher, and 37 by Rusty Blackbird **(Table 1)**. Some sites were occupied by two and a few were occupied by all three species.

Landscape types were either harvested forest or in un-harvested forest (Table 1). A site was considered to be in a harvested landscape if the most recent GIS forest inventory layer showed evidence of forest harvest within 1 km of the site. Sites were selected to include the different ecodistricts to the extent possible. Some ecodistricts were larger or had more SAR detections.

At each site, a Forest Ecosystem Classification (FEC) plot was established at the GPS coordinates of the SAR sighting. A variable-radius tree plot was established using a basal area factor 2 prism. Trees within the plot were classified according to canopy position (dominant, co-dominant, intermediate, or suppressed). Species, status (alive or dead), diameter at breast height, height of stem, height at the bottom of the canopy, and an index of tree health were also recorded.

From the FEC plot, two 50-m transects were established to capture variation across site **(Figure 1)**. The transects were at least 90° apart, in directions of potentially usable habitat for the target species. Vegetation structure and composition plots were established at 10-m intervals along each transect, including the centre point, for a total of 11 plots per site. At each, four densiometer readings were taken in each cardinal directions and averaged to provide a measure of canopy cover.

In addition, structural complexity in the lower strata was quantified at each of the 11 vegetation structure and composition plots at each site. We estimated the percent cover of live foliage that occupied several layers: the shrub layer (shrubs and regenerating trees, 0.25 m – 5 m), the herbaceous layer (plants <0.25 m), and the ground layer (bryophytes, lichens, litter, and substrate).

Cover estimates for each layer were made as follows: For the shrub layer, species, height and percent cover of all plants occupying at least 5% of a 4m^2 quadrat (2 m x 2 m square) were recorded. For the herbaceous layer, species and percent cover of all plants occupying at least 5% of a 1m^2 quadrat were recorded. Plants were identified to species except for sphagnum mosses, some asters, and some graminoids (e.g., grasses, sedges, or rushes). All other items occupying at least 5% of the ground layer of the 1 m^2 plot (litter, coarse woody debris, mud). Measurements taken from the 11 vegetation structure and composition plots were averaged to obtain a summary value for each site. This report presents values that have been averaged across sites occupied by each landbird SAR.

Table 1. Number of sites at which habitat surveys were conducted for each landbird SAR and the distribution of habitat surveys across ecodistricts and landscape types.

Species	Landscape type	No. of sites Sampled	Ecodistrict				
			720	730	740	750	760
Rusty Blackbird	Harvested	21	12	2	6	1	0
	Unharvested	16	3	1	7	4	1
Olive-sided Flycatcher	Harvested	26	15	2	5	0	4
	Unharvested	19	2	2	10	3	2
Canada Warbler	Harvested	18	3	2	11	1	1
	Unharvested	20	9	3	1	2	5
All sites combined	Harvested	54	28	7	9	3	7
	Unharvested	45	6	4	24	7	4

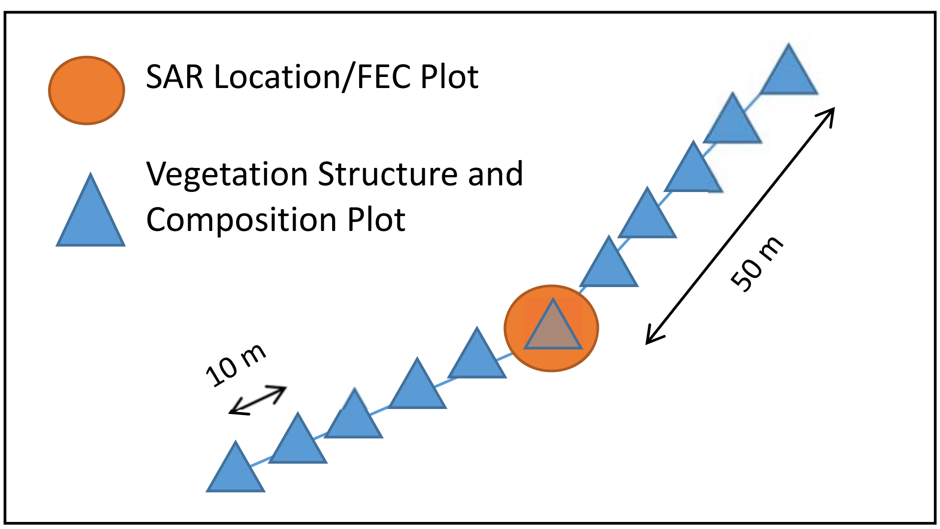


Figure 1: Layout of the habitat plot. An FEC plot was established at the SAR location. Vegetation structure and composition were quantified every 10 m along two 50-m transects starting at and extending from the FEC plot.

The vegetation data set resulted in 143 initial measured or calculated variables. Indicator species analysis (ISA) was used to determine the variables that were significantly associated with a particular species or group. Those that were not statistically or biologically significant, based on expert knowledge and literature, were removed or combined into classes. Remaining variables were assessed for correlation and contribution to variance explained using factor analysis, resulting in the further removal or reclassification of variables with high correlations or low explanatory power. Some exceptions were made for variables expected to have high biological importance. The averages and variances of 26 variables were retained for further analysis **(Table 2)**.

Table 2. Variables used to compare habitat at sites occupied by the three target landbird SAR.

Variable	Description
Canopy closure	Canopy closure as a percent, determined by a densiometer
Mud cover	Percent cover of mud, wet soil, or bare ground that would get muddy
Sphagnum cover	Percent cover of all *Sphagnum* moss species
Water cover	Percent cover of open water or puddle
Cinnamon fern cover	Percent cover of cinnamon fern (*Osmunda cinnamomea*)
Fern cover	Percent cover of all other ferns
Coniferous shrub cover	Percent cover of coniferous trees in the shrub layer
Spruce cover	Percent cover of all species of spruce in the shrub layer
Deciduous shrub cover	Percent cover of broad-leaved plants in the shrub layer
Alder cover	Percent cover of speckled alder (*Alnus incana rugosa*) in shrub layer
Lambkill cover	Percent cover of lambkill (*Kalmia angustifolia*) in the shrub layer
All shrub cover	Percent cover of all plants in the shrub layer
Coniferous shrub height	Average height of coniferous trees in the shrub layer
Spruce height	Average height of all species of spruce in the shrub layer
Deciduous shrub height	Average height of broad-leaved plants in the shrub layer
Alder height	Average height of speckled alder (*Alnus incana rugosa*) in shrub layer
Lambkill height	Average cover of lambkill (*Kalmia angustifolia*) in the shrub layer
All shrub height	Average cover of all shrub layer plants
Tree height	Average height of all trees in forest inventory plots
Stand basal area	Basal area for the site as calculated from prism plots
Coniferous trees <5m	Number of softwood trees less than 5m tall in prism plots
Coniferous trees >5m	Number of softwood trees greater than 5m tall in prism plots
Deciduous trees <5m	Number of hardwood trees less than 5m tall in prism plots
Deciduous trees >5m	Number of hardwood trees greater than 5m tall in prism plots
Snags <5m	Number of standing dead trees less than 5m tall in prism plots
Snags >5m	Number of standing dead trees greater than 5m tall in prism plots

Indicator Species Analysis was used to identify vegetation variables whose abundance and frequency were associated with a particular landbird SAR species or site condition. These analyses were conducted using 4999 randomized Monte Carlo runs. The following groups of sites were tested: occupied vs. unoccupied (for each species), harvested vs. unharvested landscape (for sites occupied by each species).

(3) Habitat models

The habitats of six landbirds at risk – Common Nighthawk (*Chordeiles minor*), Chimney Swift (*Chaetura pelagica*), Olive-sided Flycatcher (*Contopus cooperi*), Eastern Wood-pewee (*Contopus virens*), Canada Warbler (*Cardellina canadensis*), and Rusty Blackbird (*Euphagus carolinus*) – were modeled for the five counties in the Southwest Nova Biosphere Reserve.

The final models presented here were built by Clara Ferrari (Ferrari 2014). Her work built on earlier models created by Dalhousie students Jennifer Randall (2013; Common Nighthawk), Meagan Kindree (2014; Chimney Swift); Siobhan Darlington-Moore (2014; Eastern Wood Pewee), Alana Westwood (2014; Olive-sided Flycatcher, Canada Warbler, and Rusty Blackbird).

Ferarri (2014) revised and improved these models by resolving certain modeling issues, such as spatial autocorrelation, spatial bias, and important environmental features selection. The analysis also incorporated new species location data based on field surveys and public observations obtained through the 2014 breeding season.

All of the models were built using the Maximum Entropy (MaxEnt) algorithm, which uses presence-only data, which is appropriate for rare species. Wetness, structural and anthropogenic features were essential for building the models. The MaxEnt program produced a spatial distribution model for the habitat for each species in GIS.

Two data sets were input into each MaxEnt model:

1. Geo-referenced locations of the species - from various research and volunteer surveys, during the 2006-2014 breeding seasons.
2. Environmental variables - habitat features important in previous studies and that could be represented by available GIS data.

Models extracted information about the habitat around known species locations and used it to extrapolate the distribution of habitat for each species across the landscape. Details of the modeling methods can be found in Ferrari (2014).

(4) Education, outreach, and stewardship

This project contributed to the education, outreach, and stewardship activities of the Landbirds at Risk program, developed in 2012 as a collaboration between Dr. Cindy Staicer at Dalhousie University and the Mersey Tobeatic Research Institute (MTRI). These activities aim to inform and raise awareness about landbirds at risk among people in southwestern Nova Scotia, and to engage them in species conservation and habitat stewardship. Five species (excluding the Eastern Wood Pewee, which was not COSEWIC-listed at the time) were the focus of these activities.

Stewardship coordinators, Dominic Cormier, Marian Kemp and Laura Achenbach, were hired through HSP funds to assist Dr. Staicer in developing the program. Knowledge about the populations and habitat for these landbirds at risk was based on data and experience from our field surveys and augmented with information from the literature, including the status reports (COSEWIC 2006, 2007a, 2007b, 2008a, 2008b, 2012). Stewardship tools developed included: a Landbirds at Risk Habitat conservation brochure, a Landbirds at Risk poster, a public website associated with MTRI, and a Landbirds at Risk data management module on the NS Species at Risk website.

RESULTS

(1) Bird surveys

In total, 337 bird surveys were completed in 2012 and 2013 combined. None of the three targeted wet-forest landbird SAR were found at two-thirds (63%) of the sites visited. The Olive-sided Flycatcher was found at 20% of the sites (68 sites, 42 of which were new sites, from which the species was not previously reported). The Canada Warbler was found at 10% of the sites (32 sites, 15 of which were new sites). The Rusty Blackbird was found at 7% of sites (25 sites, 19 of which were new sites). Additional records of these species were obtained through casual observations made while conducting field work and through reports submitted by the public.

In 2014, reports of Common Nighthawks were submitted from 38 observers or groups in addition to our field team. A total of 55 reports were obtained from 20 May - 21 August 2014. Most birds were both seen and heard. Booming, a courtship and territorial display of males, was most often heard in May and June. We found no evidence that Common Nighthawks were more active under moonlight in early evening. Birds were most often seen near open water or forest, or both, and to a lesser extent, developed areas and clearcuts. Large numbers were reported during migration: a flock of 150 on 12 August, and a flock of 1000 on 21 August.

(2) Habitat surveys

Results of the detailed habitat surveys were summarized to compare habitat characteristics among the three target landbird SAR. The summaries include data obtained from the central FEC plot, including type of ecosites (as visualized in edatopic grids), tree species composition, and vegetation type (VT). The structure and composition plot data (11 per site) were summarized to compare the percent cover of vegetation in the different vertical layers and other ground features. Indicator Species Analysis determined what variables were indicative of sites occupied by each species.

Ecosites

The edatopic grid is a two-dimensional diagram used in the Forest Ecosystem Classification for Nova Scotia to plot sites with respect to relative moisture and nutrient regimes. Soil moisture regime, which ranges from very dry to wet, represents the average moisture available to plants. Soil nutrient regime, which ranges from very rich to very poor, represents the relative availability of nutrients to support plant growth (www.gov.ns.ca/natr/library/forestry/reports/Ecosites.pdf).

Our ecosite data for the three landbird SAR in Southwestern Nova Scotia are summarized in **Figure 2**. Each numbered oval on the edatopic grid represents one of the 17 Acadian group ecosites associated with a particular moisture and nutrient regime, and thus tends to support different vegetation types. None of our samples fell into the driest, very poor ecosites (AC1, AC2, and AC3) or the richer ecosites (AC13, AC14, AC15, AC16, or AC17). Overall, the three landbird SARs inhabited a similar set of ecosites. The majority of plots for all three species were categorized as AC4 (Wet/Very Poor) or AC8 (Wet/Poor). Three ecosites (AC4, AC8 and AC12) accounted for a total of 86% of Canada Warbler sites and four ecosites (AC4, AC7, AC8 and AC12) accounted for 83% of Olive-sided Flycatcher sites, and six ecosites (AC4, AC5, AC6, AC8, AC10, and AC12) accounted for 87% of Rusty Blackbird sites. Less than 10% of other ecosites were inhabited by these species.

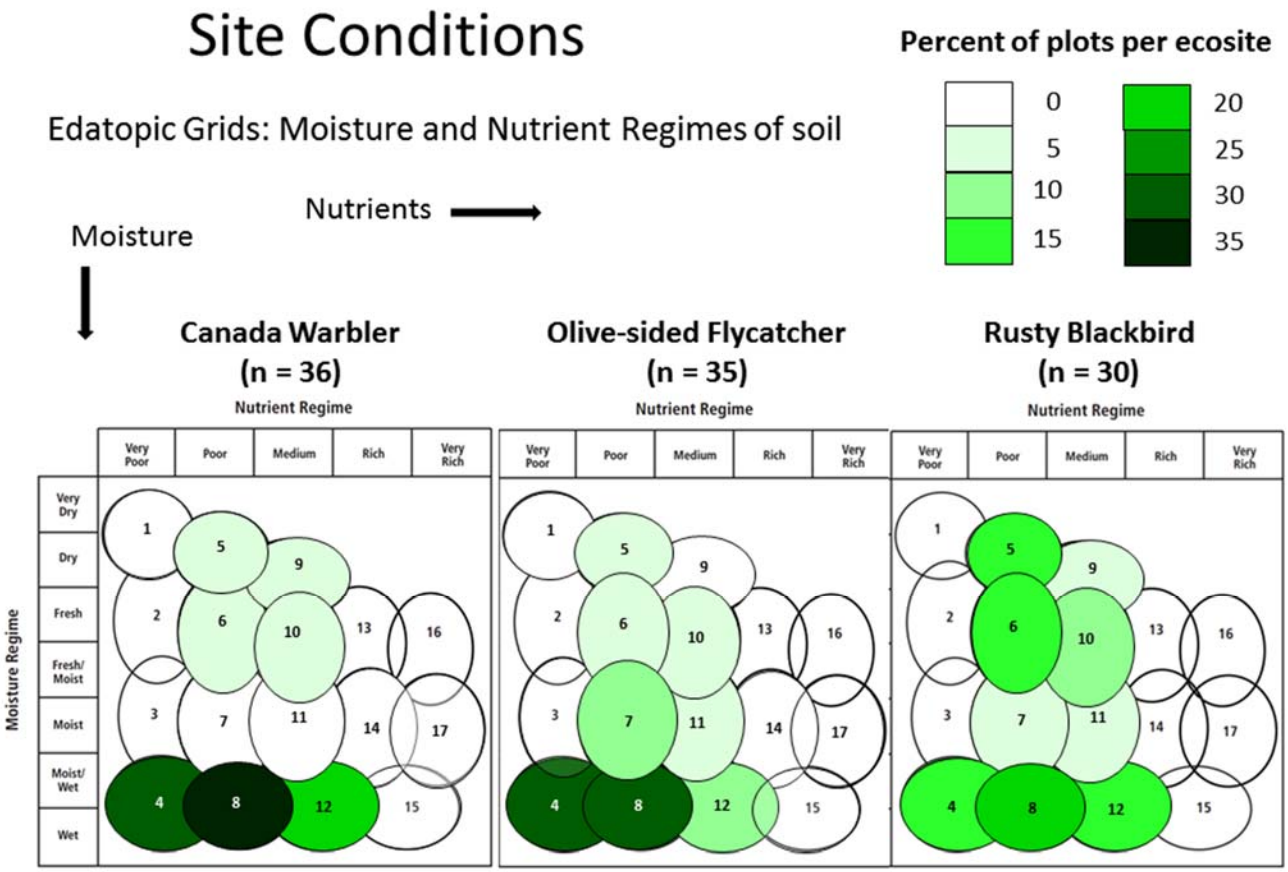


Figure 2. Distribution of habitat sample sites (as determined at FEC plots) on the edatopic grid for the three target landbird SAR. Numbers refer to the 17 Acadian group ecosites. Placement of the ovals on the grid indicates the relative levels of moisture and nutrients of a site. The ecosites become wetter from top to bottom and richer from left to right. The darker the colour, the more landbird SAR sites occurred in that ecosite.

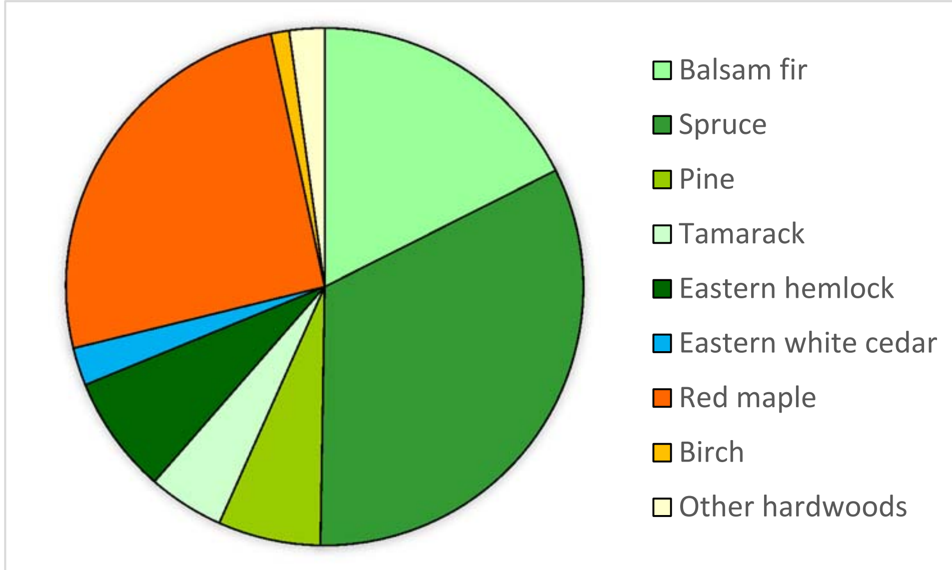
<u>Trees</u>

Tree data from the FEC plots revealed many similarities among the three species of landbird SAR **(Figures 3-4)**. Spruce and balsam fir together made up 57% of the trees in Olive-sided Flycatcher plots, 50% in Canada Warbler plots, and 40% in Rusty Blackbird plots **(Figure 3)**. Pine, hemlock, and hardwoods comprised 53% of the trees in Rusty Blackbird plots. Red maple was common, accounting for about 25% of the trees in the plots of all three SAR. Other hardwoods were less common in the FEC plots. Eastern white cedars occurred in one Canada Warbler plot, located in the Hectanooga cedar swamp, an important area that supported several pairs of this landbird SAR.

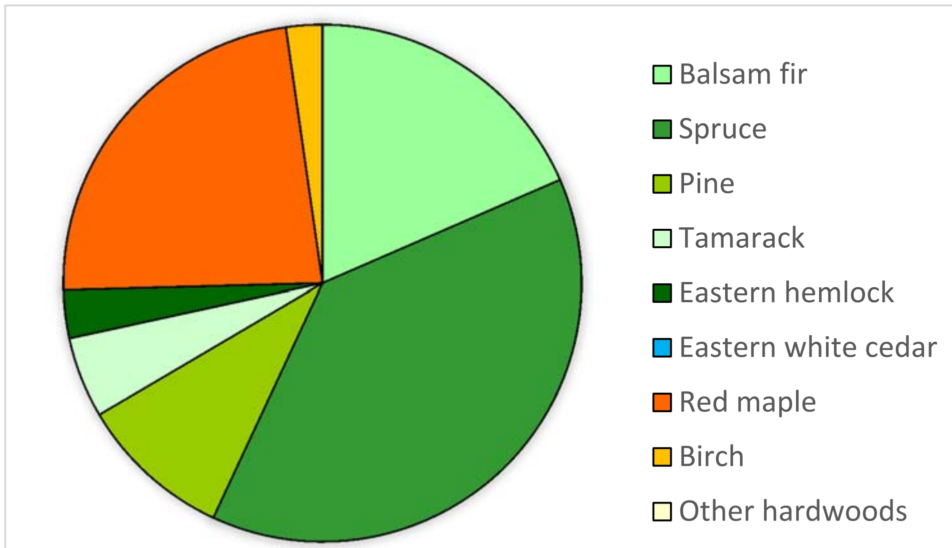
Overall, about half of the trees in FEC plots were live conifers, one-quarter were live deciduous trees, and one-quarter were snags **(Figure 4)**. These proportions were similar for all three landbird SAR. Olive-sided Flycatcher habitat had a slightly higher proportion of snags while Rusty Blackbird habitat had a slightly higher proportion of deciduous trees.

Figure 3. Species composition of live trees in the FEC plot in landbird SAR habitat surveys.

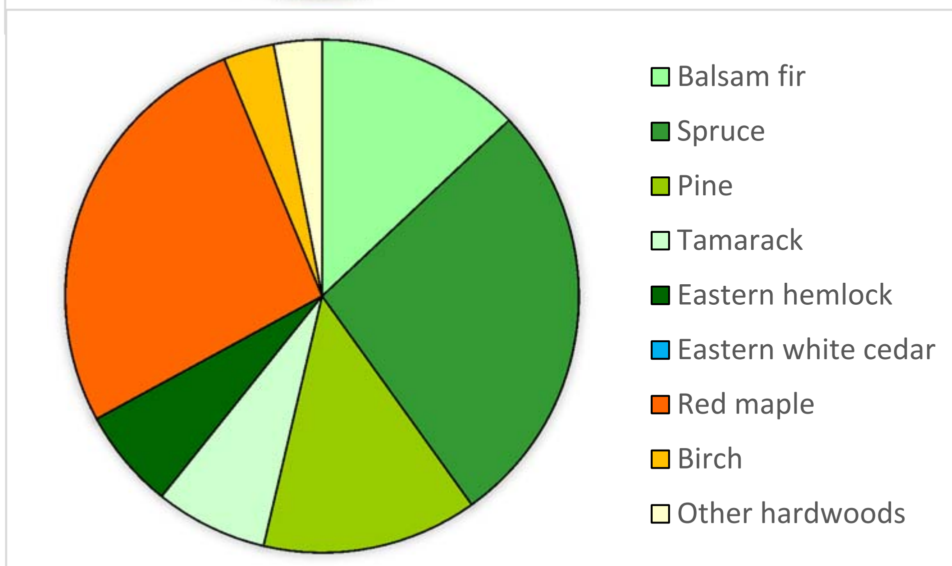
Canada Warbler (n = 38 plots)



Olive-sided Flycatcher (n = 46 plots)



Rusty Blackbird (n = 38 plots)



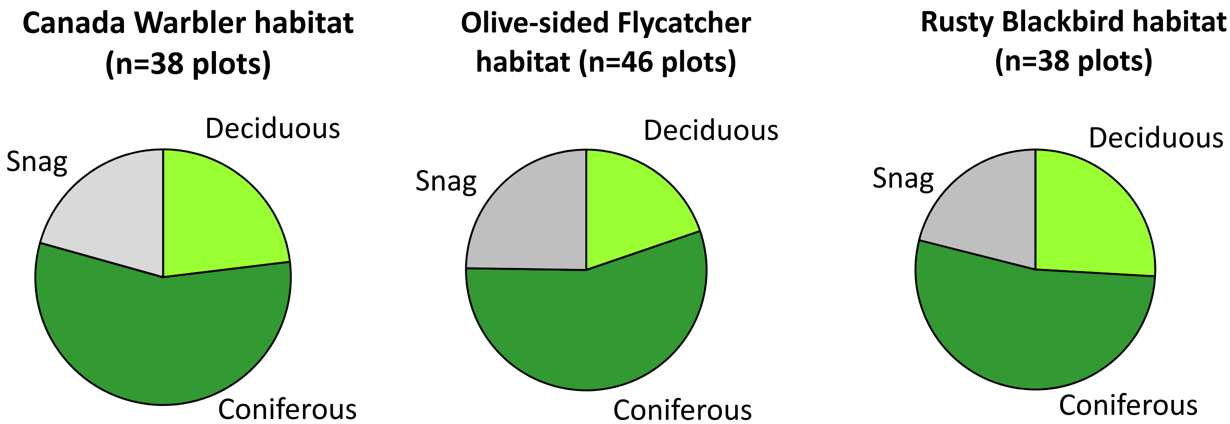


Figure 4. Proportion of trees in the FEC plots that were snags (dead standing trees), live deciduous (broad-leaved) trees and live coniferous trees.

<u>Vegetation structure</u>

Understorey vegetation structure for the 100-m transects centered on each FEC plot is summarized in **Figure 5**. Percent cover of saplings and high shrubs were highest for Canada Warbler. For all three species, coniferous saplings contributed more cover than deciduous saplings. Shrubs contributed most to Canada Warbler habitat and least to Rusty Blackbird habitat. High shrubs (such as alder), cinnamon fern, and sphagnum moss were important components of Canada Warbler habitat. Low shrubs (such as lambkill) and other ferns (primarily bracken) were common in Olive-sided Flycatcher habitat. Compared to the other two species, Rusty Blackbird habitat had less understorey cover above 25 cm.

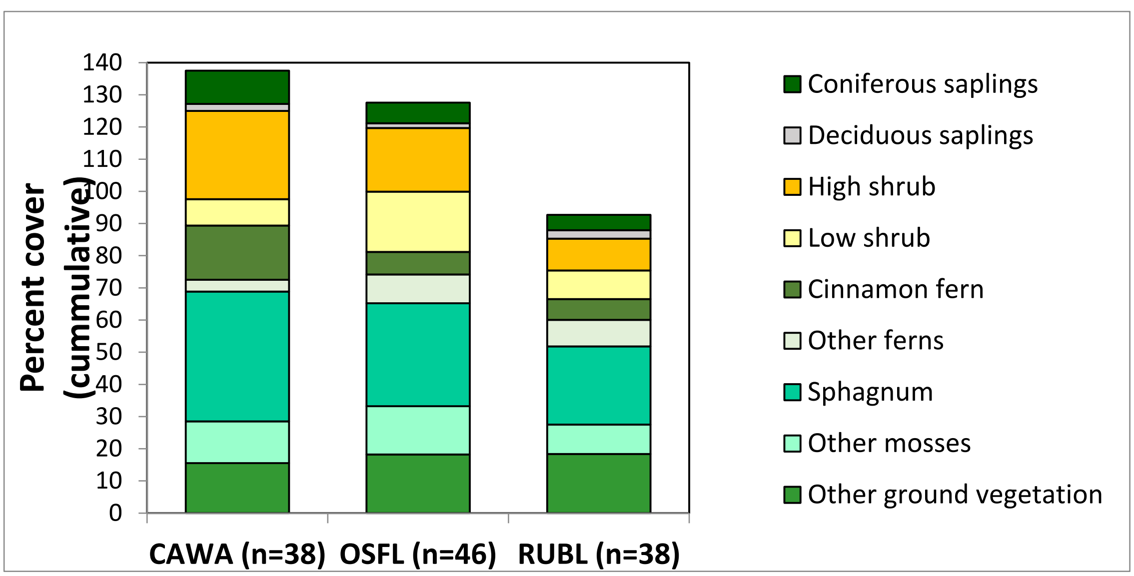


Figure 5. Comparison of vegetation structure in habitat plots for the three landbird SAR. Average percent cover, measured every 10 m along a two 50-m transects centered on the FEC plot.

Vegetation types

The proportions of FEC plots per landbird SAR habitat that were classified into different vegetation types (VTs) are shown in **Figure 6**. The three landbird SARs differed in the proportions of plots that were in wet forest VTs. Most of the Canada Warblers plots (91%) were in wet VTs, either wet coniferous (46%) or wet deciduous (45%). The most common types were WC1 and WD2, typified by black spruce or red maple, cinnamon fern and sphagnum moss.

In comparison, only 56% of Olive-sided Flycatcher plots (34% wet coniferous and 22 % wet deciduous) and only 42% of Rusty Blackbird plots (21% each wet deciduous and wet coniferous) were wet forest VTs. However, WC1 and WD2 were the most common wet forest vegetation types for these species as well.

Olive-sided Flycatcher and Rusty Blackbird plots spanned a wider range of vegetation types (Figure 6). Olive-sided Flycatcher plots also included several spruce VTs, and SP5, with black spruce, lambkill and bracken, was the most common. Rusty Blackbird plots included spruce and spruce-hemlock vegetation types, as well as intolerant hardwood and mixed-wood vegetation types. Some FEC plots for Olive-sided Flycatchers and Rusty Blackbirds had too few trees to determine a vegetation type.

Indicator Species Analysis

Indicator Species Analysis showed that *presence* of Rusty Blackbirds was indicated by more open water, and more coniferous trees and snags taller than 5 m. In *harvested* landscapes, Rusty Blackbird sites were indicated by more lambkill than sites in unharvested landscapes. *Absence* was indicated higher shrubs, more shrub cover, more spruce cover, more deciduous shrub cover, taller deciduous shrubs, higher spruce, more cinnamon fern cover, and higher speckled alders.

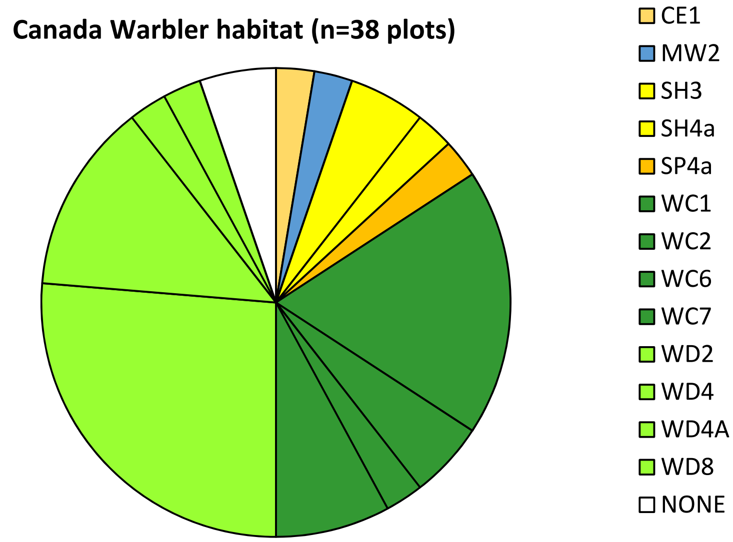
Indicator Species Analysis showed that *presence* of Olive-sided Flycatchers was indicated by more snags less than 5 m tall, and greater height and percent cover of lambkill. In *harvested* landscapes, Olive-sided Flycatcher sites had more lambkill cover and height, as well as higher shrubs overall than sites with this species in unharvested landscapes. *Absence* was indicated by greater canopy closure, greater cover of speckled alder, and higher stand basal area.

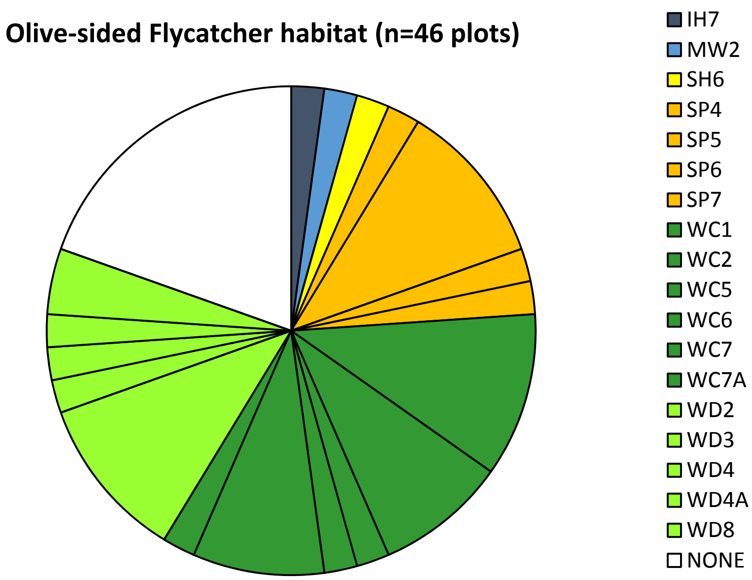
Indicator Species Analysis showed that *presence* of Canada Warblers was indicated by greater cover and height of alder, more cover of deciduous trees greater than 5 m tall, higher canopy closure, more cinnamon fern cover, and greater height of broadleaved shrubs than did sites in unharvested landscapes. In *harvested* landscapes, sites with Canada Warbler had more lambkill, cinnamon ferns, and snags under 5 m. *Absence* was indicated by greater cover of ferns *other than* cinnamon fern.

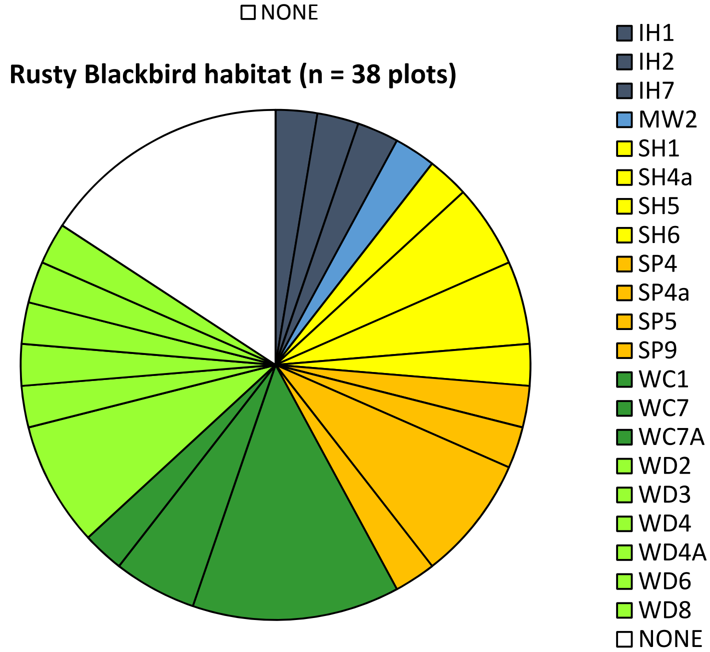
Comparing species, Rusty Blackbird sites were indicated by more open water, Canada Warbler sites were indicated by more cinnamon fern, more and taller alder, and greater cover of the tree canopy and broadleaved shrubs, and Olive-sided Flycatcher sites were not indicated by any variable.

A more detailed treatment of this and additional multivariate statistical analyses of the habitat data will be presented in the dissertation of Alana Westwood, Ph.D. candidate, Dalhousie University Department of Biology.

Figure 6. Proportion of plots categorized as different FEC vegetation types (VT). For more information on VTs, see: novascotia.ca/natr/forestry/veg-types/.







(3) Habitat models

The variables that were calculated in GIS and used to create the final versions of the species distribution habitat models in MaxEnt for each of the six landbird SAR (Ferarri 2014) are shown in **Table 3**.

The term AUC refers to the Area Under the Curve and is a measure of how well the model distinguishes the sites where a species occurred from random locations. The higher the AUC value, the better the model performed. A model with an AUC value greater than 0.7 is considered to have good discriminatory power (Phillips 2005).

The importance of each variable was measured by two estimates: percent contribution and the permutation importance:

- The percent contribution is based on the increase or decrease in regularized gain due to a particular variable, holding other variables constant, for each iteration of the training algorithm.
- For each environmental variable in turn, the permutation importance is determined by measuring the decrease in training AUC when the values of this variable are randomly permuting for the training set. This second estimate does not depend on the path that MaxEnt uses to get the optimal solution, whereas the first estimate does. Therefore, the second estimate was preferentially used to choose the variables (Phillips 2005).

Variables important in each model suggest that Olive-sided Flycatchers, Canada Warblers and Rusty Blackbirds need wet forests that are variously complex, but in different ways, at the site (or stand) and landscape scales. The important variables also suggest that Chimney Swifts and Common Nighthawks need open areas near water within forested landscapes but also use developed areas if they provide suitable nest sites.

The spatially-explicit species distribution models for the six species are shown in the form of maps in **Figures 7-12**. Each map shows the predicted variation in habitat suitability for a species across the region. The likelihood that a species can utilize a given area as breeding habitat is indicated by colour, from least likely (yellow; poorest habitat) to most likely (dark blue; best habitat). Actual occurrence data used to build the models are shown by open circles. Higher resolution images and GIS layers are available upon request (contact Cindy.Staicer@Dal.Ca).

The boundaries of protected areas, as of 2013, are also shown on the maps. All but the Eastern Wood-Pewee appear to be widely distributed across private, crown, and protected lands. Eastern Wood-Pewees need tall, mature upland forest, especially mature stands of white pine, which is now largely restricted to protected lands, especially in and near Kejimkujik NP. Most of the Canada Warbler and Rusty Blackbird habitat appears to exist outside of protected areas. The Tobeatic Wilderness Area plus the crown lands to the SSW comprise a large area of generally unsuitable habitat for all but the Olive-sided Flycatcher.

Most of the area is contained within the Western Region. The predicted habitat of the six species does not appear to be associated with particular ecodistricts (compare habitat maps with map at http://novascotia.ca/natr/forestry/ecological/pdf/ELC_Map.pdf). The predicted habitat of the Common Nighthawk, as well as occurrence records for this species, is associated with river systems (note that the dark blue areas follow rivers on the map).

Table 3. Variables used to create the landbird SAR habitat models with MaxEnt.

Species and AUC of final model	GIS variables used in final MaxEnt models	Percent contribution	Permutation importance
Common Nighthawk (AUC = 0.684)	distance to waterways	24.2	22.9
	distance to_urban areas	19.4	20.0
	distance to_shrubby_wetlands	16.8	22.4
	distance to_low_shrubs	13.0	9.5
	1st story canopy height	12.1	8.2
	distance to clearcuts	10.8	13.5
	2nd story canopy height	3.8	3.4
Chimney Swift (AUC = 0.799)	distance to_urban areas	38.2	30.2
	1st story canopy height	15.2	7.7
	distance to clearcuts	15.1	32.9
	distance to waterways	11.0	14.7
	distance to_dead stands	8.5	6.5
	distance to open wetlands	8.0	5.5
	distance to_low_shrubs	3.9	2.5
Eastern Wood-Pewee (AUC = 0.863)	distance to protected areas	32.0	27.7
	distance to_low_shrubs	22.7	15.6
	1st story canopy height	18.6	12.9
	distance to_urban areas	16.2	27.1
	depth to water table	6.8	11.7
	distance to waterways	3.7	4.9
Olive-sided Flycatcher (AUC = 0.748)	distance to wetlands	26.1	16.7
	distance to_agricultural lands	21.3	16.2
	distance to waterways	17.3	23.5
	distance to clearcuts	14.3	20.5
	forest_type	10.3	11.5
	depth to water table	8.4	5.5
	canopy closure	2.2	6.1
Canada Warbler (AUC = 0.716)	depth to water table	36.8	31.3
	distance to waterways	22.6	21.8
	distance to_uneven_age stands	17.6	10.8
	distance to clearcuts	16.6	22.9
	2nd story canopy height	3.8	8.2
	canopy closure	2.6	5.0
Rusty Blackbird (AUC = 0.766)	depth to water table	42.0	36.8
	distance to_low_shrubs	22.4	13.1
	distance to_agricultural lands	19.4	21.2
	distance to waterways	9.8	28.9
	distance to clearcuts	6.4	0.0

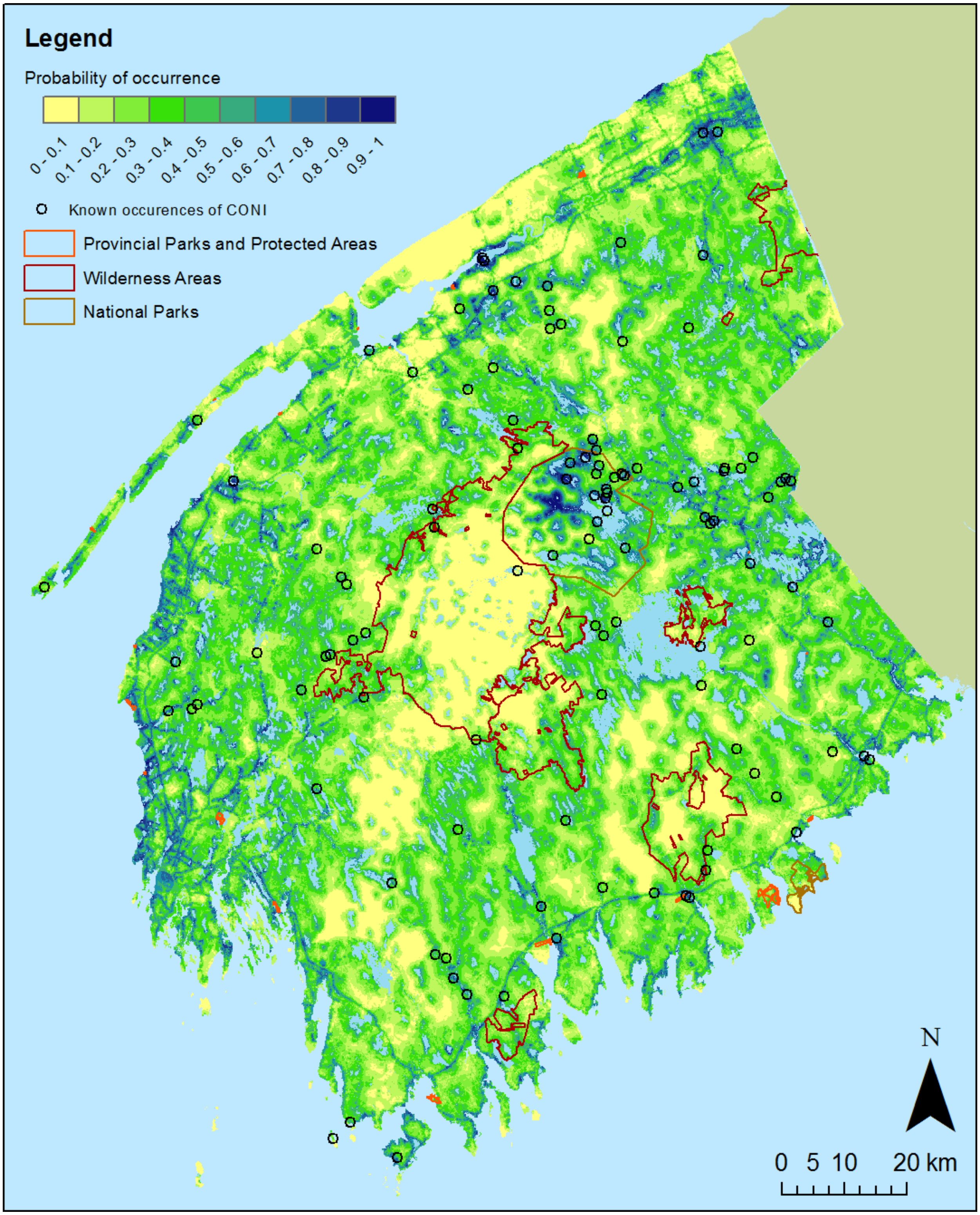


Figure 7. Predicted habitat distribution model for the Common Nighthawk (*Chordeiles minor*) in Southwestern Nova Scotia.

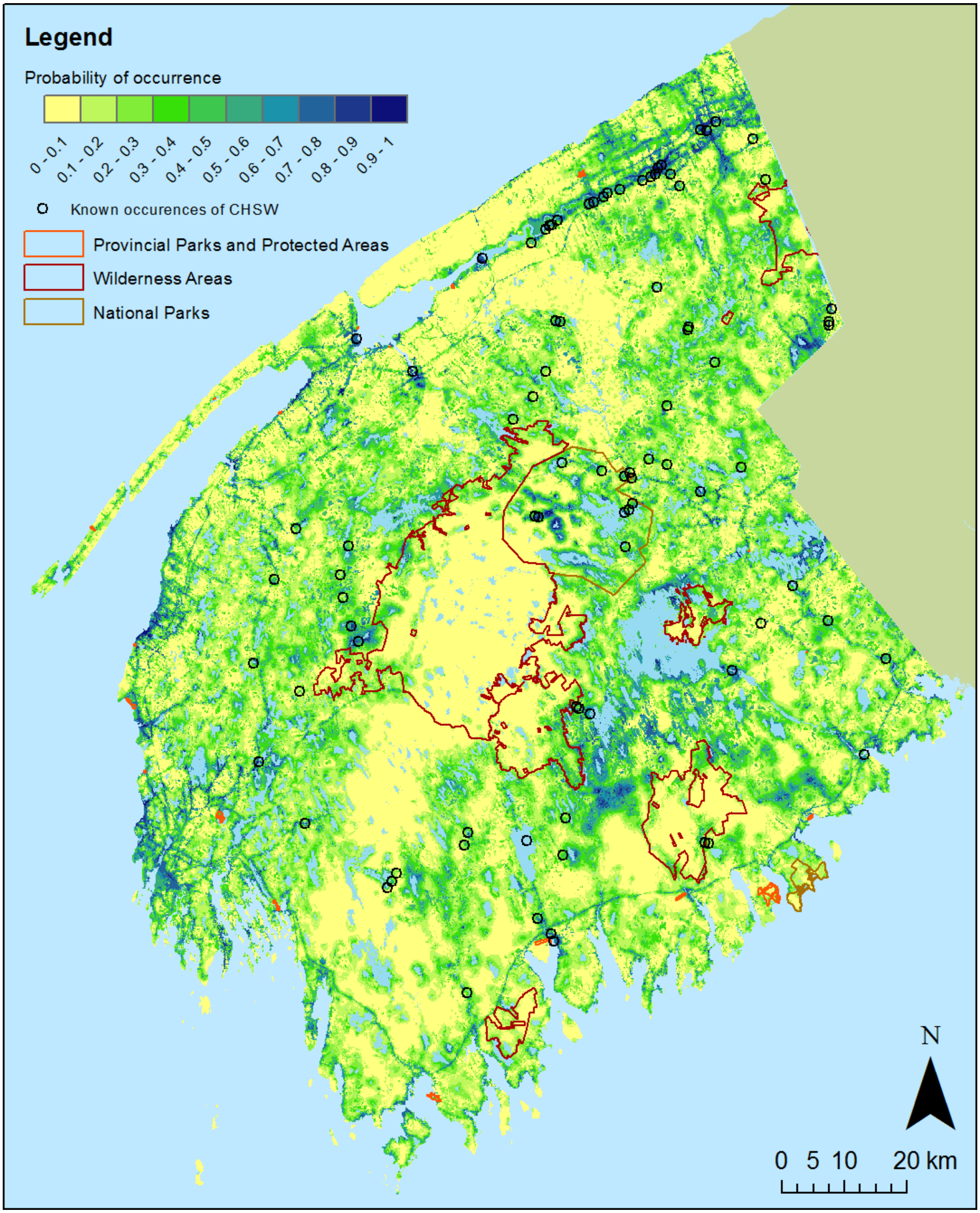


Figure 8. Predicted habitat distribution model for the Chimney Swift (*Chaetura pelagica*) in Southwestern Nova Scotia.

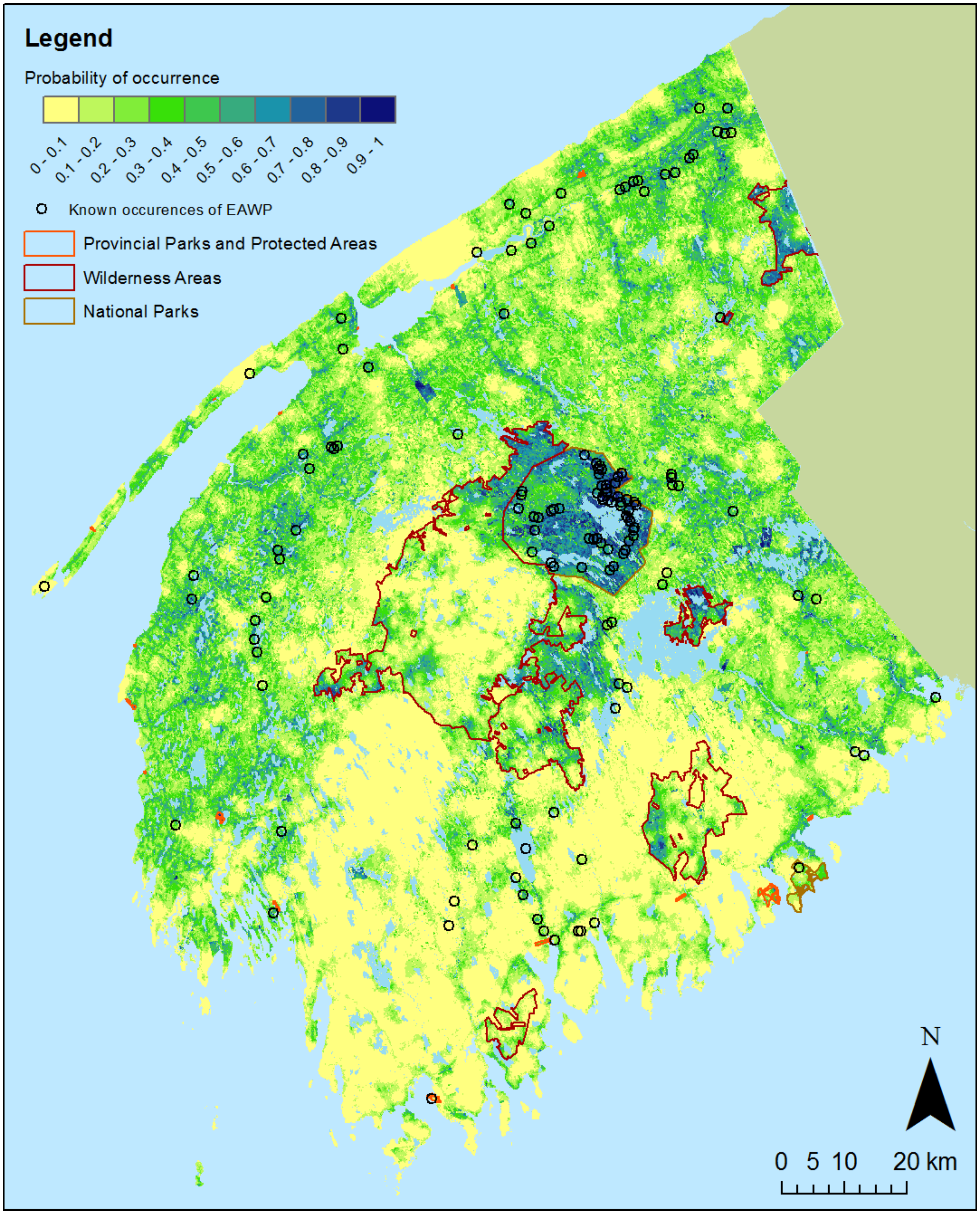


Figure 9. Predicted habitat distribution model for the Eastern Wood-Pewee (*Contopus virens*) in Southwestern Nova Scotia.

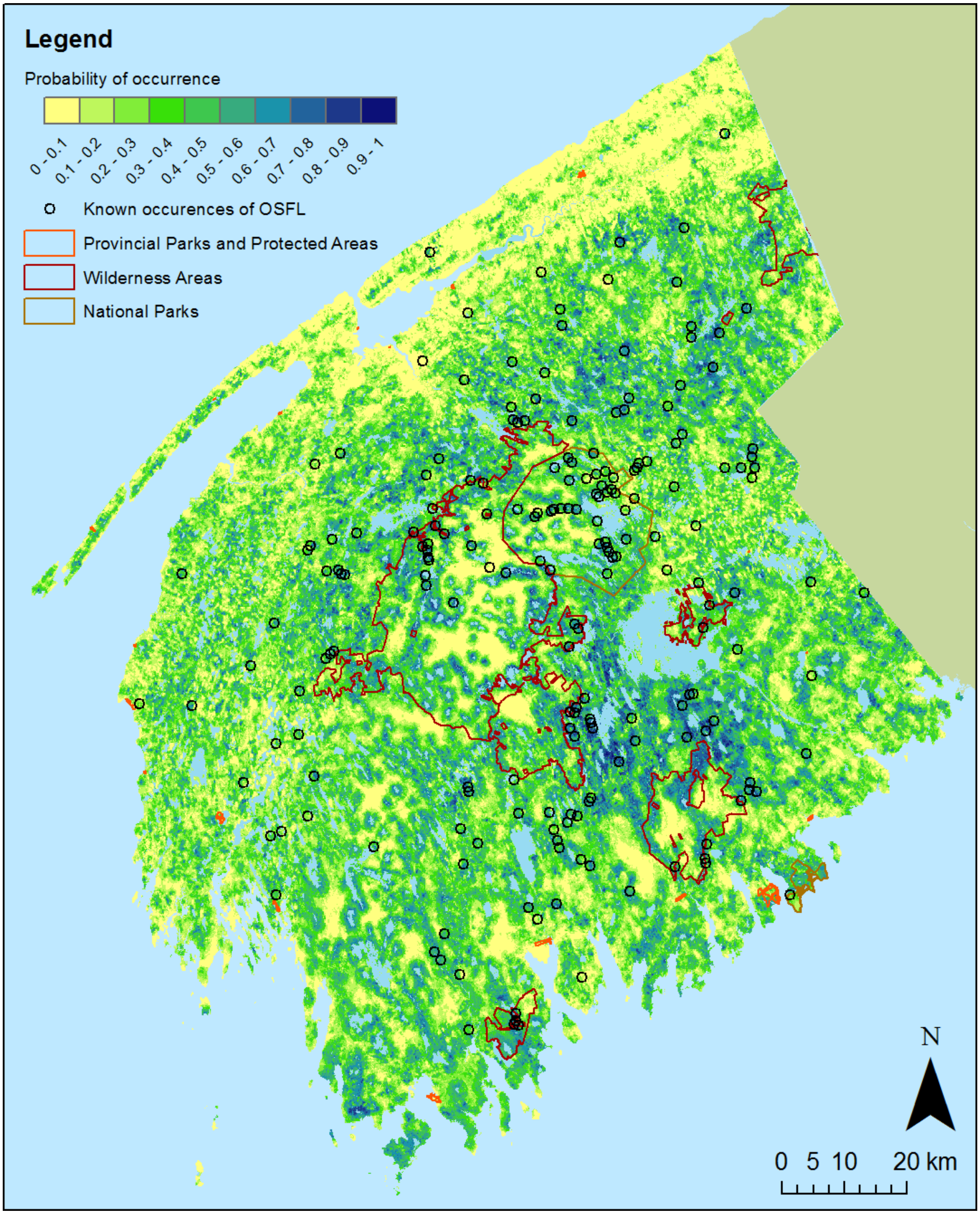


Figure 10. Predicted habitat distribution model for the Olive-sided Flycatcher (C*ontopus cooperi*) in Southwestern Nova Scotia.

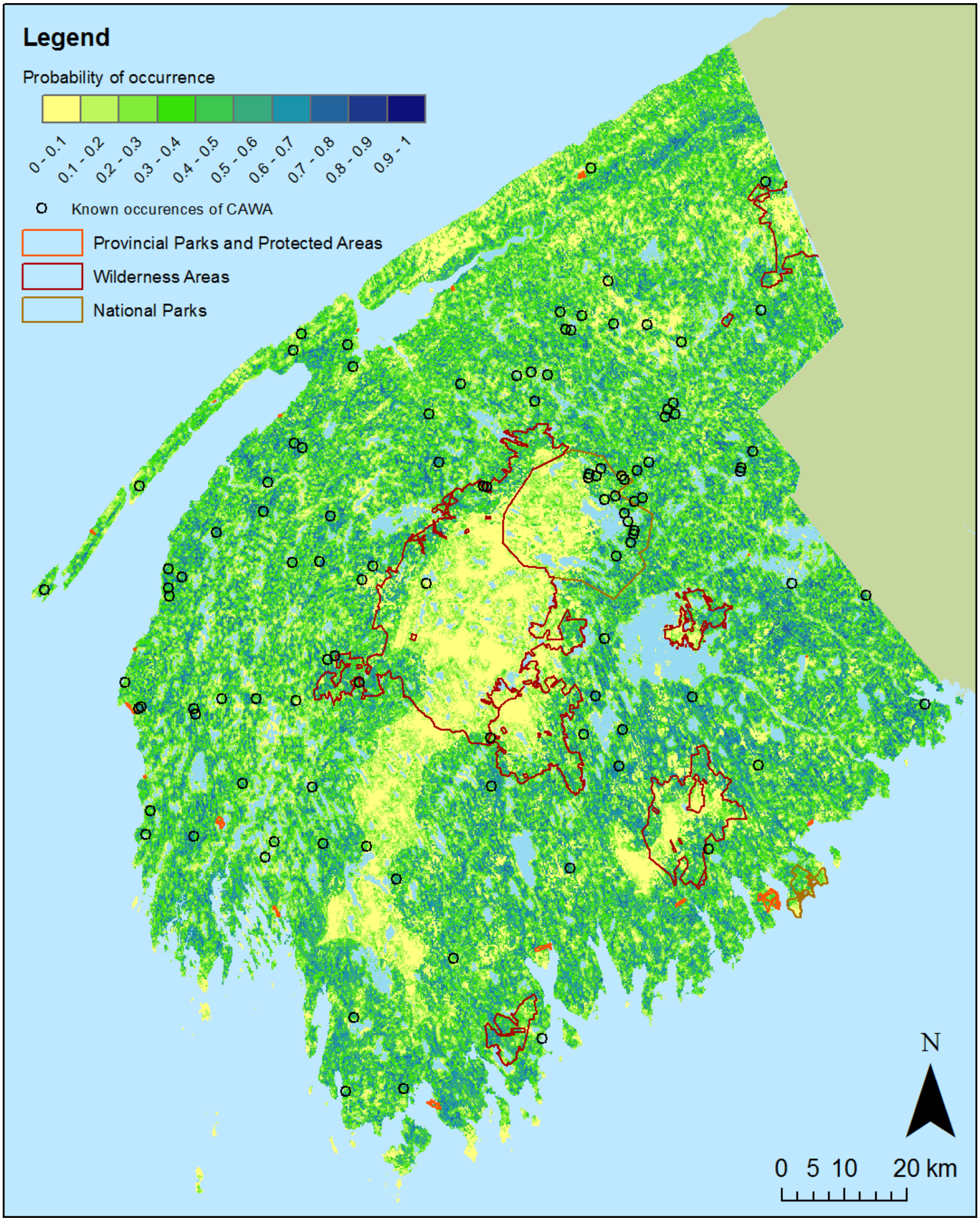


Figure 11. Predicted habitat distribution model for the Canada Warbler (*Cardellina canadensis*) in Southwestern Nova Scotia.

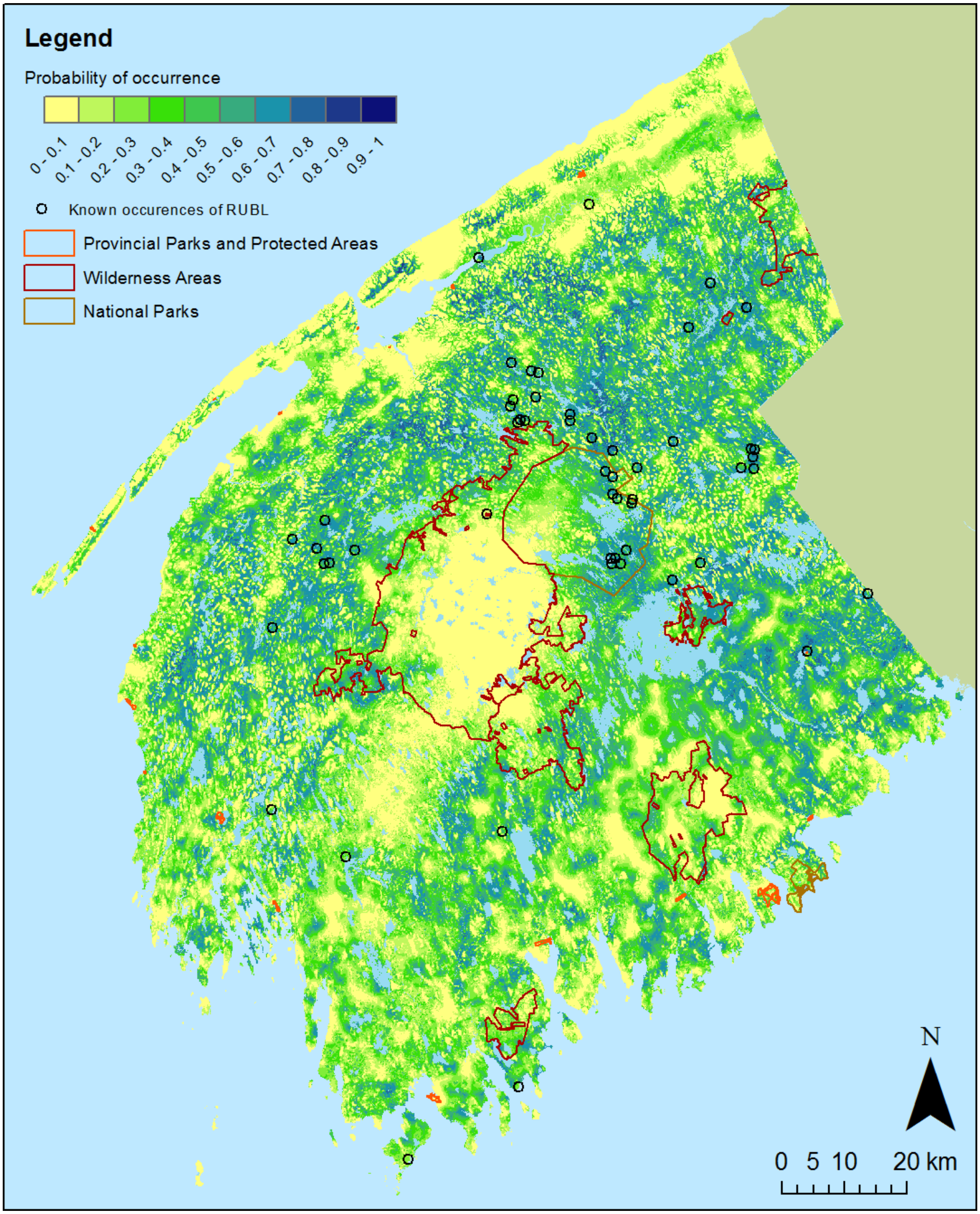


Figure 12. Predicted habitat distribution model for the Rusty Blackbird (*Euphagus carolinus*) in Southwestern Nova Scotia.

(4) Education, outreach, and stewardship

The Landbirds at Risk in Forested Landscapes workshop included elements included:

- Trends, surveys, and status of the five species
- Identification of the five species by sight and sound
- Life history and range (breeding, migration, wintering) of the five species
- Breeding season ecology and behaviour of the five species
- Breeding habitat of the five species
- Habitat comparison for the three wet forest species
- Threats to populations for each of the five species
- Stewardship, including a discussion about how can we steward the habitat for these five species in southwestern NS

This free 2-hour long workshop was given to public audiences at several venues:

- MTRI, morning and evening sessions, 27 March 2013
- Annapolis Royal, 9 February 2014
- Liverpool, 22 February 2014
- Tusket Falls, 8 March 2014
- Bear River, 25 March 2014 (presentation to Bear River First Nations)
- Halifax, 27 March 2014 (presentation at the Bird Society meeting)
- Clare, 9 September 2014 (“Atelier: Oiseaux en péril dans les paysages forestiers”)

In June 2014, a citizen science pilot project to monitor Common Nighthawks was established. Volunteer recruitment was organized by Science Horizons intern Laura Achenbach. The official survey was timed to coincide with moonlit early evenings in June. Additional records were accepted from any time during the summer.

Other outreach activities included:

- "Envirothon" 3 July 2014, a Kejimkujik National Park outreach event
- "Dawn Chorus Walk" 12 July 2014, an MTRI and Kejimkujik National Park event
- "Night creatures talk: The Common Nighthawk", 14 July 2014, a Kejimkujik National Park Outreach event
- CBC Land and Sea filming at Kejimkujik National Park about Landbirds at Risk in Nova Scotia, 25 July 2014
- Short videos of the Rusty Blackbird and Olive-sided Flycatcher were filmed and posted on the MTRI YouTube channel and MTRI Facebook page
- Encouraging the public to submit new landbirds at risk sightings; an e-mail address was available for this purpose (landbirdSAR@merseytobeatic.ca)

Finally, we convened a partners in conservation workshop in late March 2014 to share current knowledge and existing programs, and concerns about landbirds at risk conservation in Nova Scotia. Represented at the meeting were the Nova Scotia Department of Natural Resources, the Nova Scotia Department of Environment, Environment Canada, Nova Scotia Nature Trust, Nature Conservancy of Canada, Atlantic Canada Conservation Data Centre, Nova Scotia Bird Society, Bird Studies Canada, Ecology Action Centre, Parks Canada, the Mersey Tobeatic Research Institute, and Dalhousie University.

ACHIEVEMENTS AND LESSONS LEARNED

This project achieved tangible results that can be applied at the site (stand) and landscape scales in Southwestern Nova Scotia. At the site scale, results from our habitat surveys can be used to identify breeding habitat for Olive-sided Flycatchers, Canada Warblers, and Rusty Blackbirds in the field. In addition to specific features that can be observed when visiting a site (e.g., certain tree species, a well-developed high shrub layer, abundant cinnamon fern, sphagnum moss covering the ground, or the presence of open water or mud), this study identified particular FEC ecosites and vegetation types associated with the presence of these landbird SAR species.

Our surveys verified that the three Landbird SAR that we targeted for our surveys mainly inhabited wet forests. The habitat of these species contained similar proportions of snags (dead standing), live deciduous (broadleaf), and live coniferous trees. All three inhabited conifer-dominated mixedwoods, with red maple making up about one-quarter of the total trees. Black spruce (about two-thirds) or red spruce (about one third) was the dominant conifer, and was most abundant in Olive-sided Flycatcher sites. Rusty Blackbird sites contained a more even distribution of conifer species, even though they are known to nest mainly in thicket of small spruce (Powell 2008).

For the Canada Warbler and Olive-sided Flycatcher, the most common ecosites were AC8 (Wet/Poor) and AC4 (Wet-Very Poor), where tree growth is limited by excessive moisture and low fertility. Typical vegetation on AC8 is coniferous or mixed-wood treed swamps, with spruce, fir, and red maple, and typical vegetation on AC4 is black spruce and tamarack (Neily et al. 2011). Although Olive-sided Flycatchers were also found in a wider range of coniferous-dominated vegetation types, they were most abundant in wet coniferous forest.

Both Rusty Blackbirds and Olive-sided Flycatchers have large territories or home ranges of 10 or more hectares whereas the Canada Warbler territory is about 1 hectare (100 x 100 m) or less, close to the size of the habitat plots in our study. Habitat plots for the other species represented a much smaller fraction of the area used by the birds. Thus it is likely that our surveys more completely characterized Canada Warbler habitat than that of the other species. Our results are consistent with published studies indicating that Canada Warbler preferentially nest in forested areas with a high density of small stems and uneven ground (Hallworth et al. 2008, Goodnow and Reitsma 2011).

Rusty Blackbirds were observed in a wider range of ecosites and vegetation types than the other species, suggesting that particular tree species or vegetation types are less important for this bird. However, sites sampled likely included foraging sites, nesting sites, and various kinds of forest habitat through which individuals move on a daily basis. Rusty Blackbirds forage for invertebrates in shallow water and mud, and nest in small conifers, mainly black spruce (Powell 2008). Although we found Rusty Blackbirds using both unharvested and harvested landscapes, the latter can be ecological traps, as birds nesting there have lower breeding success (Powell et al. 2010).

Additional and more detailed statistical analyses of our habitat data will be presented in the Ph.D. dissertation of Alana Westwood, and in manuscripts submitted for publication, in 2015-2016.

At the landscape scale, our habitat models can be used to identify the location and configuration of predicted breeding habitat for Common Nighthawk, Chimney Swift, Eastern Wood-Pewee, Olive-sided Flycatchers, Canada Warblers, and Rusty Blackbirds across Southwestern Nova Scotia. It is interesting to note that although habitat surveys showed much overlap in the characteristics of sites occupied by the three wet-forest species, the distribution of their predicted habitat was quite different. This may reflect the inability of current GIS layers to capture important site-level habitat features.

Prior to field work, initial habitat suitability index models were built with information from the literature and expert opinion (Westwood 2012). Our field surveys were conducted at sites randomly selected from polygons identified in these models as suitable habitat for one or more of these species. The three target landbird SAR were uncommon in these surveys, occurring at only one third of the sites. Our surveys were a field test of these initial models, confirming that better models were needed.

The Olive-sided Flycatcher was found at twice as may sites as were Canada Warblers, which were found at about twice as many sites as Rusty Blackbirds, the rarest of the three species and the one which has experienced the greatest declines (Greenberg, and Matsuoka 2010). Rather than being more abundant, Olive-sided Flycatchers may simply be easier to detect because of their much louder song.

Our field surveys and efforts of volunteers increased the number of occurrences of landbird SAR for Southwest Nova Scotia. The enhanced database enabled us to develop new habitat models based on GIS data at occurrence locations. Our new habitat models should be more accurate than our initial habitat suitability models as they used the information about the environment at occupied sites.

Our stewardship and outreach activities for landbird SAR reached a large audience and engaged many people. More of the public are now familiar with identification of these species and aware of their conservation status and issues. The positive response by the public also showed that the public is interested in being more involved in the conservation of landbirds.

RECOMMENDATIONS FOR FOLLOW-UP STEPS

The results from our habitat surveys can be used in the field to identify breeding habitat for Olive-sided Flycatchers, Canada Warblers, and Rusty Blackbirds. The information could be used by itself or in conjunction with existing FEC field protocols, and incorporated into best management practices.

The habitat models for the six landbird SAR can be used for local-scale to regional-scale land-use planning. In GIS, the models can be used by government, industry and conservation organizations for land-use decision-making, such as targeting areas of high quality habitat that could be protected or identifying areas where specific forest management techniques are likely to benefit or harm the species. Habitat maps (higher resolution images of the maps in this report) can be used more widely, by land owners and the general public, to identify local areas of good habitat for these species.

The accuracy of our habitat models can be assessed through field tests. The most efficient use of time would be to visit areas of high predicted habitat suitability. For territorial species, the use of playback will enhance the chances of detecting the species if it is indeed present a site. A less direct way of testing the models would be to keep track of whether theses species are detected at sites visited during the breeding season for other kinds of field work. Date, time and UTMs would need to be recorded as well as the landbird species that was present.

Landbirds at risk can be incorporated into current or future research or monitoring programs. Development of accurate maps of forested wetlands would aid greatly in identifying habitat for these landbird SAR. Lidar has great potential for identifying features that are important to these species, such as height of the shrub layer and other features not available currently as GIS layers.

There is much potential for involving the public in conservation of landbirds at risk. People who are not familiar with birds can be trained to look and listen for theses species and to identify breeding habitat. The more information we have about the distribution and abundance of these species, the more informed, targeted, and effective our conservation efforts can be.

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