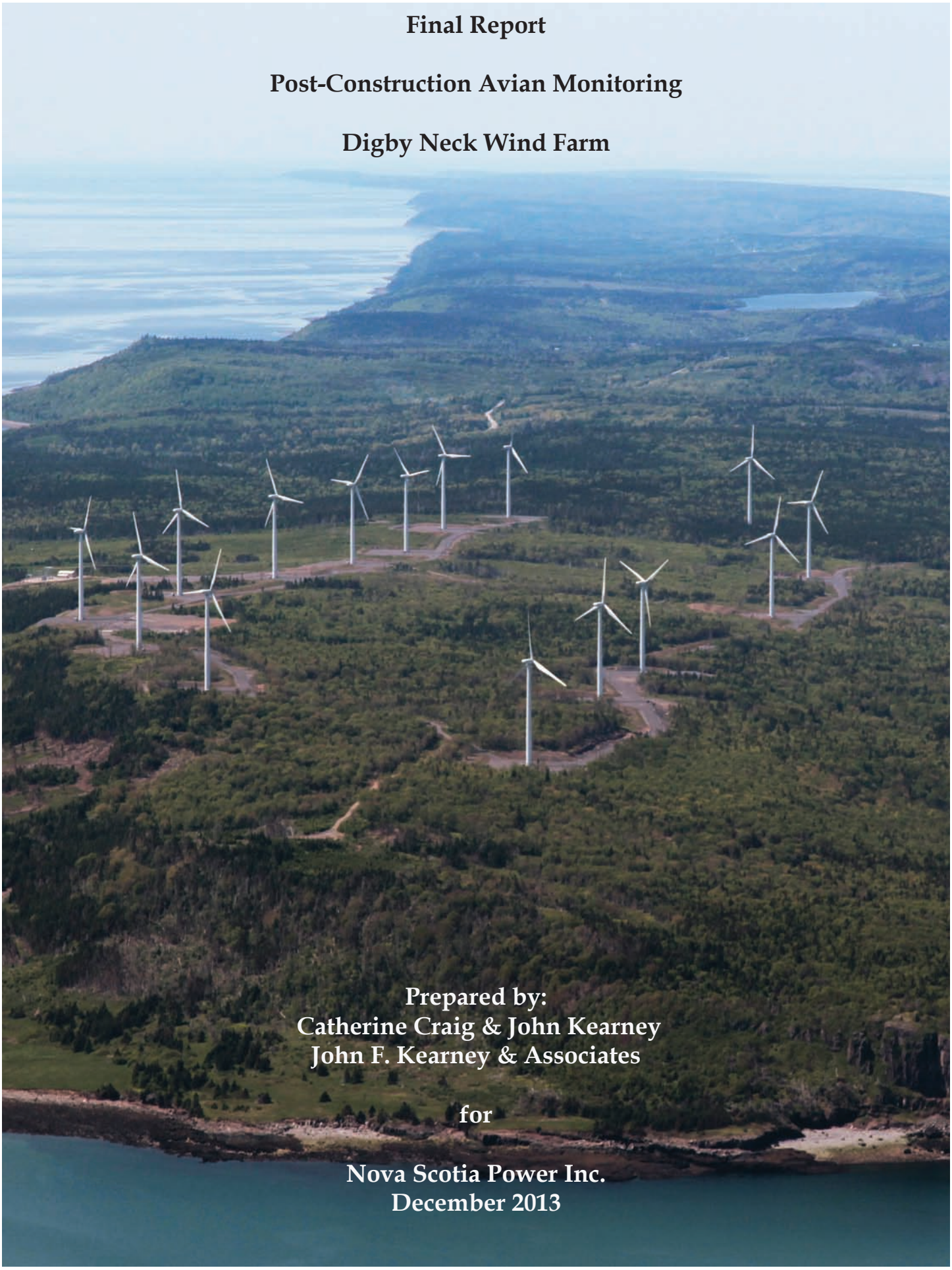
Final Report

Post-Construction Avian Monitoring

Digby Neck Wind Farm



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for

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INTRODUCTION

Located approximately 16 kilometers from Digby, Nova Scotia, the Digby Neck Wind Farm began operating 20 turbines with a total capacity of 30 megawatts in the autumn of 2010. Land cover at the wind farm site is mainly forested, including both softwood and hardwood species. In 2008 and 2009, prior to construction, a baseline study of avifauna at the site was conducted (Stantec 2009). When the wind farm was approved, Nova Scotia Power was required to develop a bird monitoring program and mortality study at the site.

A two-year post-construction monitoring program was proposed by John F. Kearney and Associates in 2011 (Kearney 2011) and monitoring was conducted in 2011 and 2012. The plan was created to meet the following ten objectives:

1. Determine changes in breeding bird populations in the study area through relative changes in abundance and an analysis of keystone species and species guilds of the coniferous and mixed forest;
2. Determine the effects of turbine noise and human activities on the breeding distribution of birds in the study area;
3. Determine the use of habitats by breeding birds and migrating birds in stop-over and, where possible, compare with pre-construction conditions;
4. Explore the possible effects of habitat fragmentation on bird populations in the coniferous/mixed wood forest;
5. Analyse the behaviour of birds in diurnal and nocturnal passage in relation to wind turbines;
6. Determine the effects of the wind farm on species of special conservation concern and their habitats;
7. Determine the mortality of birds from collision with wind turbines;
8. Explore the use of alternative survey methods and technologies for the effective, including cost effective, monitoring of wind energy facilities;
9. Make recommendations for adaptive management of bird habitats and risk abatement at wind energy facilities; and
10. Contribute to the national database on avian wind facility studies.

The wind farm is located near the beginning of a long peninsula that ends at Brier Island, a location known to be an important stopover site for migratory birds (Mills and Laviolette 2011). Thurber (2010) found that larger numbers of birds migrated over Brier Island in the fall than at more southern locations in southwest Nova Scotia.

Land cover at the wind farm site is mainly forested, including both softwood and hardwood species.

This report summarizes the results of post-construction bird monitoring at the wind farm site. The results of the mortality study were provided in a separate report (Kearney 2013).

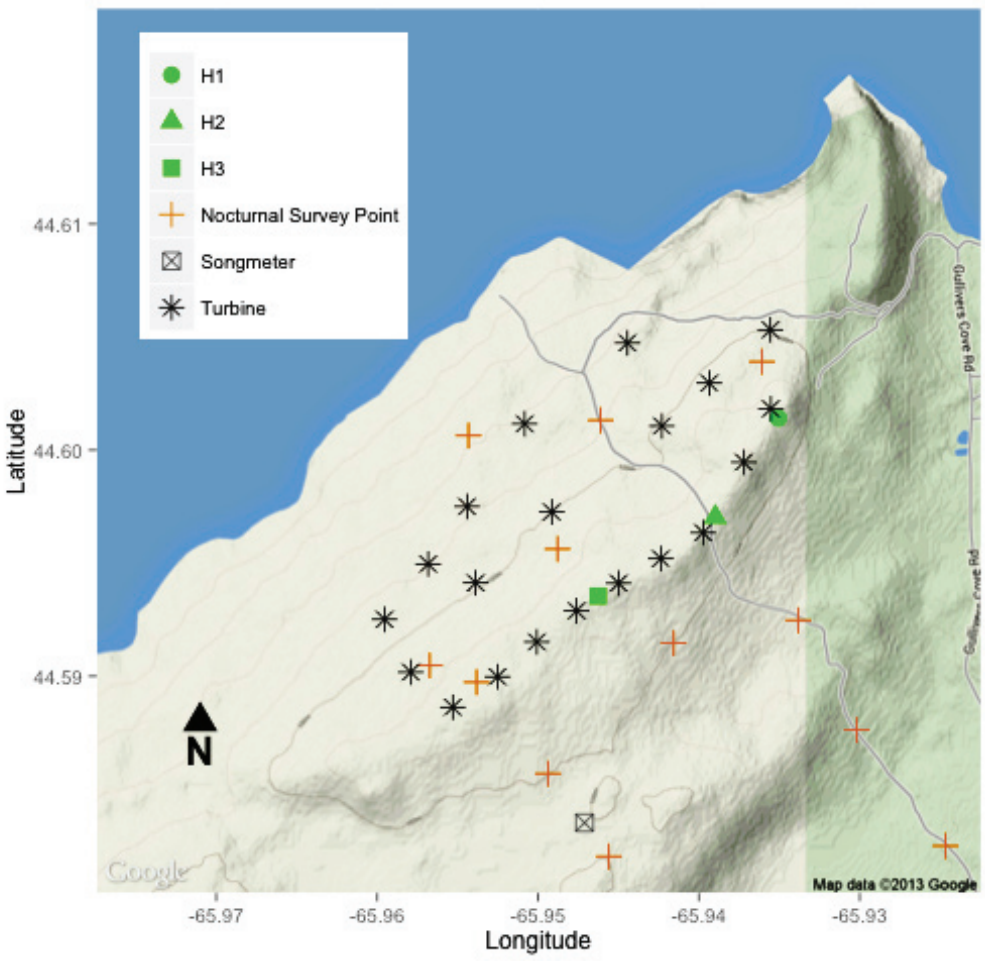
METHODS

Field Survey Methods

The year-round bird monitoring surveys outlined in the post-construction monitoring proposal (Kearney 2011) were completed as follows.

Collision risk analysis of birds in diurnal passage

A modified version of the "Band Collision Risk Model", using the methods described by Kearney (2010) and Madders and Whitfield (2006), was used to observe and analyze the behaviour of birds near operating turbines. Observations were conducted in the spring and fall after migration transect surveys were completed, with the aim of completing three 30-minute watches between 10 am and 1:30 pm (Map 1). However, one viewpoint (H1) was later abandoned due to poor panoramic visibility. At each location, the study site was broken into 90-degree quadrants. For each quadrant the sky and canopy were scanned slowly and horizontally, starting near the horizon and ending at zenith. In between these slower scans, quick panoramic scans were completed to detect close birds moving through quickly. Both a 20-60x80 spotting scope and 8x binoculars were used to detect and identify birds. The directions of the birds and movement direction were determined using a compass and noted relative to magnetic north.



Map 1 - Viewpoints (H1, H2, H3) and other survey points

Acoustic monitoring of nocturnal passage

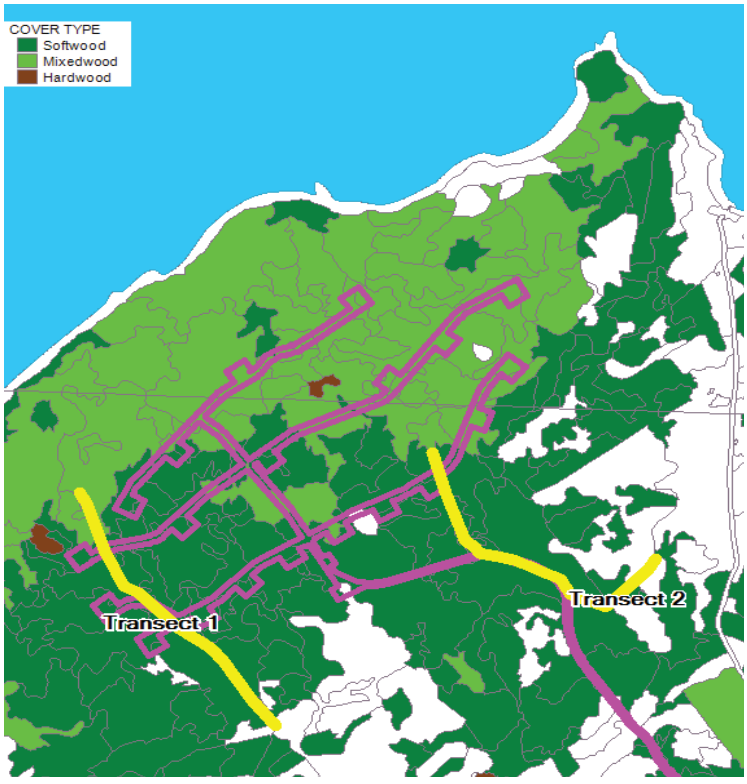
Acoustic monitoring took place during the autumn of 2011 and the spring of 2012 to detect birds that were passing over the site. A SongMeter (produced by Wildlife Acoustics) was stationed on the wind farm site (Map 1). Recording began each night at the end of civil twilight and ended each morning at the beginning of civil twilight.

The acoustic files were processed and analyzed using Raven Pro Sound Analysis Software. Separate detectors were used for two frequency ranges: "high band" (6000-11000-Hz) and "low band" (2250-3750 Hz) to extract possible bird calls. For high band detections, a Random Forest (RF) model was used to eliminate the majority of false positives and the remaining tracks were classified by an analyst. However, for the low band range, extensive contamination from non-target sounds and the prevalence of sounds that are similar to some target species' calls resulted in so many tracks being selected that they could not be processed efficiently. Therefore, instead of classifying every call, a Minimum Call Rate was determined by reviewing 20 selections predicted by the RF model to be true calls. Reviewing these selections showed which species were present and which were calling most actively in the low band frequency range.

There are some calls that are difficult to separate to the species level, such as Blackpoll and Yellow Warbler, thus some tracks were identified only to higher-level taxonomic classifications.

Migration stop-over transects with point counts

Two transects were surveyed each week between April 1 and May 31 and between August 15 and October 31. The transects are 1500 m in length and divided in to three 500 m segments (Map 2). All birds detected along the transects were recorded in the following distance categories from the observer: <50 m, 50-100 m, >100 m, and flying overhead. Additionally, six ten-minute point counts were completed at locations at least 250 m apart along each transect. Birds detected at each point count were noted in the same distance categories as birds along the rest of the transect.



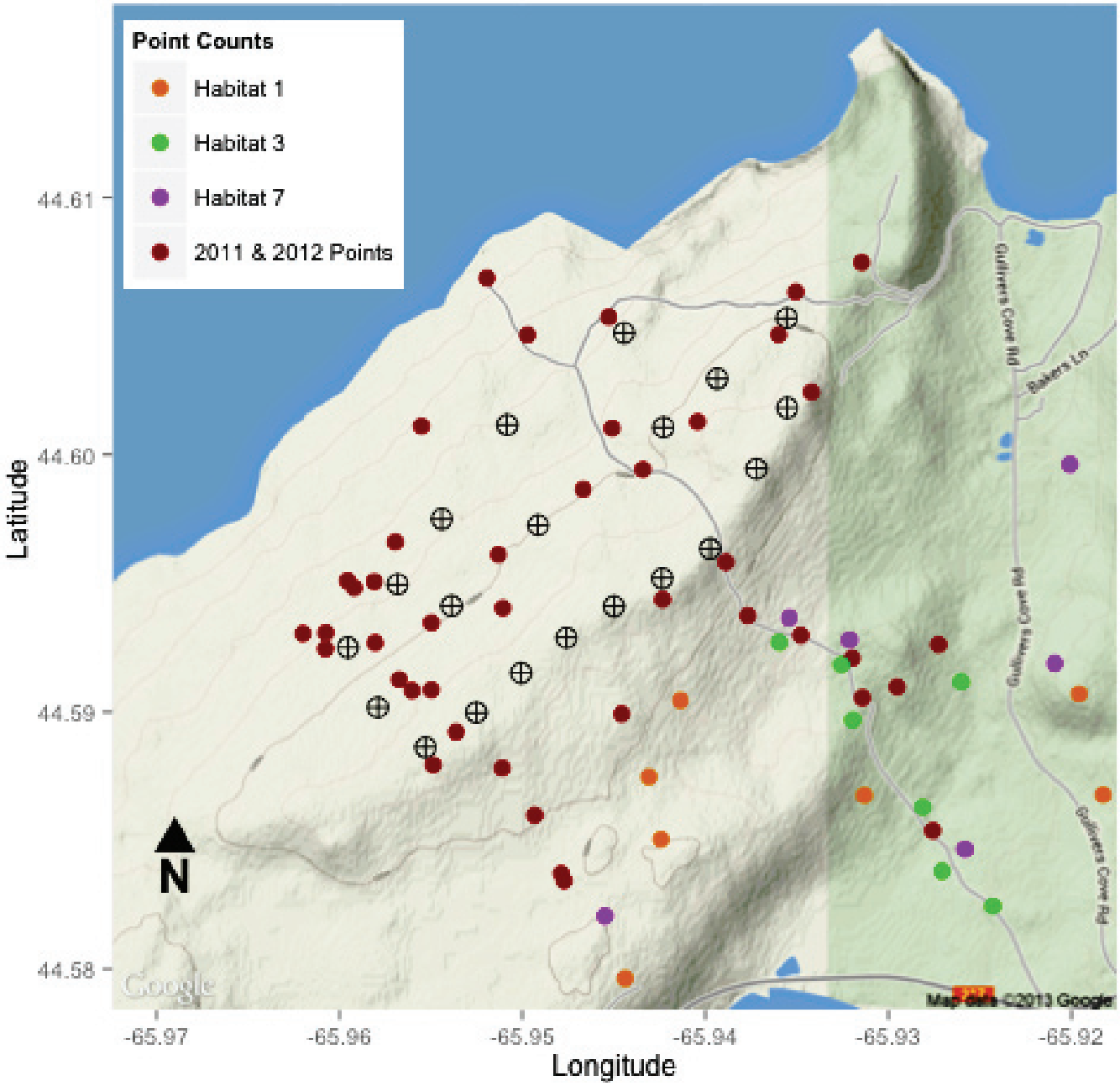
Map 2 - Location of stop-over transects

Early breeding season point counts

Data from the twelve point counts from the migration transects completed in the spring, were also used to detect early breeding woodpeckers and passerine birds in late April and May.

Peak breeding season point counts

Breeding season point counts were completed at 42 locations during June of 2011 and 2012 (Map 3). In 2012, an additional 20 locations were sampled, split between 3 habitat types, with each point placed in a differnet distance-from-turbine class. Point counts were 10 minutes long and all birds detected were recorded in the same distance classes as were used for the migration transect surveys.



Map 3 - Breeding Point Counts

Nocturnal surveys

Nocturnal surveys targeting Eastern Whip-poor-will and Common Nighthawk were conducted in June 2012 using the Ontario Whip-poor-will Project's roadside survey protocol (Bird Studies Canada 2012). Surveys targeting Common Nighthawk began 30 minutes before sunset and those targeting Eastern Whip-poor-will began just after moonrise. Both surveys used two separate listening periods of three minutes each at 12

locations (Map 1). Non-target species detected were recorded as incidental observations.

Owl surveys were completed in the spring of 2011 and 2012 following the protocol of the Atlantic Canada Nocturnal Owl Survey (Takats et al. 2001). Six survey locations spread throughout the wind farm site were visited.

Winter survey

Three types of winter surveys were completed: general area searches, systematic area searches, and transect surveys. General area searches cover broad areas of the wind farm site while systematic area searches follow line transects. The transect surveys were completed along the same transects surveyed for, and using the same methodology as, the breeding bird and migration surveys.

Habitat

Habitat at survey locations was classified in to seven categories as shown in Table 1.

Table 1 - Habitat classifications used for point counts and transect segments

Classification number	Habitat Description
1	Disturbed habitat or early succession
2	Disturbed or early succession alongside mature deciduous
3	Mixed forest
4	Coniferous forest
5	Mature deciduous
6	Agricultural or residential
7	Disturbed habitat or early succession alongside mixed forest

The same two transects were used for all transect surveys. Transect 1 mainly contains points in either disturbed habitat/early successional or mixed forest, whereas Transect 2 contains more points along edges where these two habitats meet. The breeding point counts contain points from a broader range of habitat.

RESULTS

Spring Migration

Transects with point counts

Spring migration surveys with point counts were conducted along two transects in both 2011 and 2012. Each transect was surveyed eight times between April 8th and May 31st in 2011 and nine times between April 4th and June 6th in 2012. Surveys in 2012 were completed during the early to mid-morning, but in 2011 many surveys were not completed until the mid to late afternoon. This likely decreased the number of birds that were detected in 2011, making comparisons between the two years difficult.

A total of 2961 birds of 77 species were detected at the wind farm site during spring migration: 519

individuals of 46 species in 2011 and 2442 individuals of 70 species in 2012. The four most frequently detected species were the same in both years and along each transect: American Robin, Song Sparrow, White-throated Sparrow, and Common Yellowthroat. The most unusual species detected was a single Sandhill Crane, seen flying nearby the wind farm site.

The majority of birds detected were passerines (Table 2), which were mostly warblers, sparrows, thrushes, finches, and corvids (Table 3).

Table 2 - Number of individuals of each taxonomic order and average number per survey day detected along transects during spring migration in each year. Raptor orders are grouped together.

Order	Total number of individuals detected		Average number detected per survey day	
	2011	2012	2011	2012
Passerines	463	2316	57.9	257.3
Woodpeckers	14	47	1.8	5.2
Diurnal Raptors	17	12	2.1	1.3
Shorebirds/Gulls	5	21	0.6	2.3
Doves	6	20	0.8	2.2
Grouse/Pheasant	6	12	0.8	1.3
Ducks/Geese	1	7	0.1	0.8
Loons	5		0.6	
Hummingbirds		3		0.3
Cormorants		3		0.3
Owls	1	1	0.1	0.1
Cranes	1		0.1	

Table 3 - Numbers of individuals of each passerine family and average number per survey day detected along transects during spring migration. Species names are listed when only one species in a family was detected.

Family/Species	Total number of individuals detected		Average number detected per survey day	
	2011	2012	2011	2012
Warblers	111	711	13.9	79.0
Sparrows	133	551	16.6	61.2
Thrushes	102	453	12.8	50.3
Finches	39	169	4.9	18.8
Corvids	30	116	3.8	12.9
Flycatchers	11	66	1.4	7.3
Golden-crowned Kinglet	12	63	1.5	7.0
Blackbirds	3	65	0.4	7.2
Chickadees	4	61	0.5	6.8
Winter Wren	7	22	0.9	2.4
Vireos	7	17	0.9	1.9
Red-breasted Nuthatch	3	13	0.4	1.4
Gray Catbird		4		0.4
Cedar Waxwing		2		0.2
Cardinals/Grosbeaks	1	1	0.1	0.1
Tree Swallow		2		0.2

A greater number of birds were detected along Transect 2 than along Transect 1 in both years (Figure 1). For almost every survey in 2012, more birds were detected than on any survey in 2011. It may be that there were actually more birds migrating through in 2012, but because many surveys in 2011 were completed later in

the day when birds are typically less active, the 2011 data is less reliable. Due to these inconsistent methods, only the 2012 data was used for further analysis.

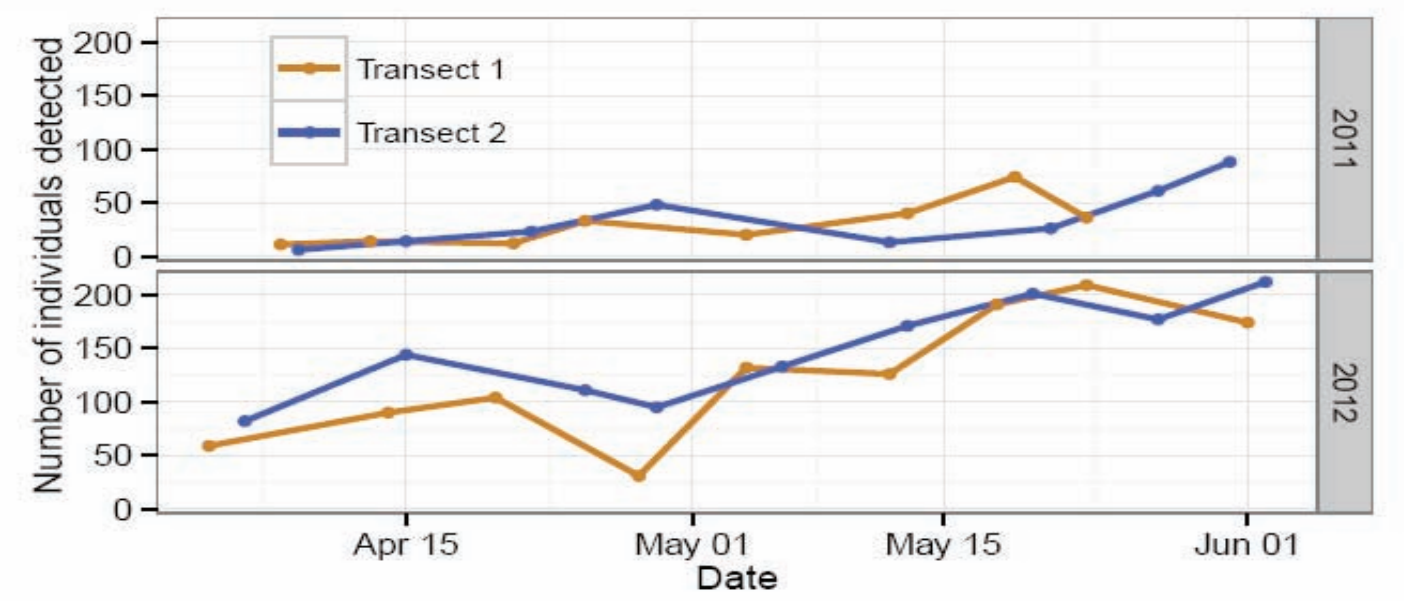


Figure 1 - Numbers of birds detected along each transect in the spring of 2011 and 2012.

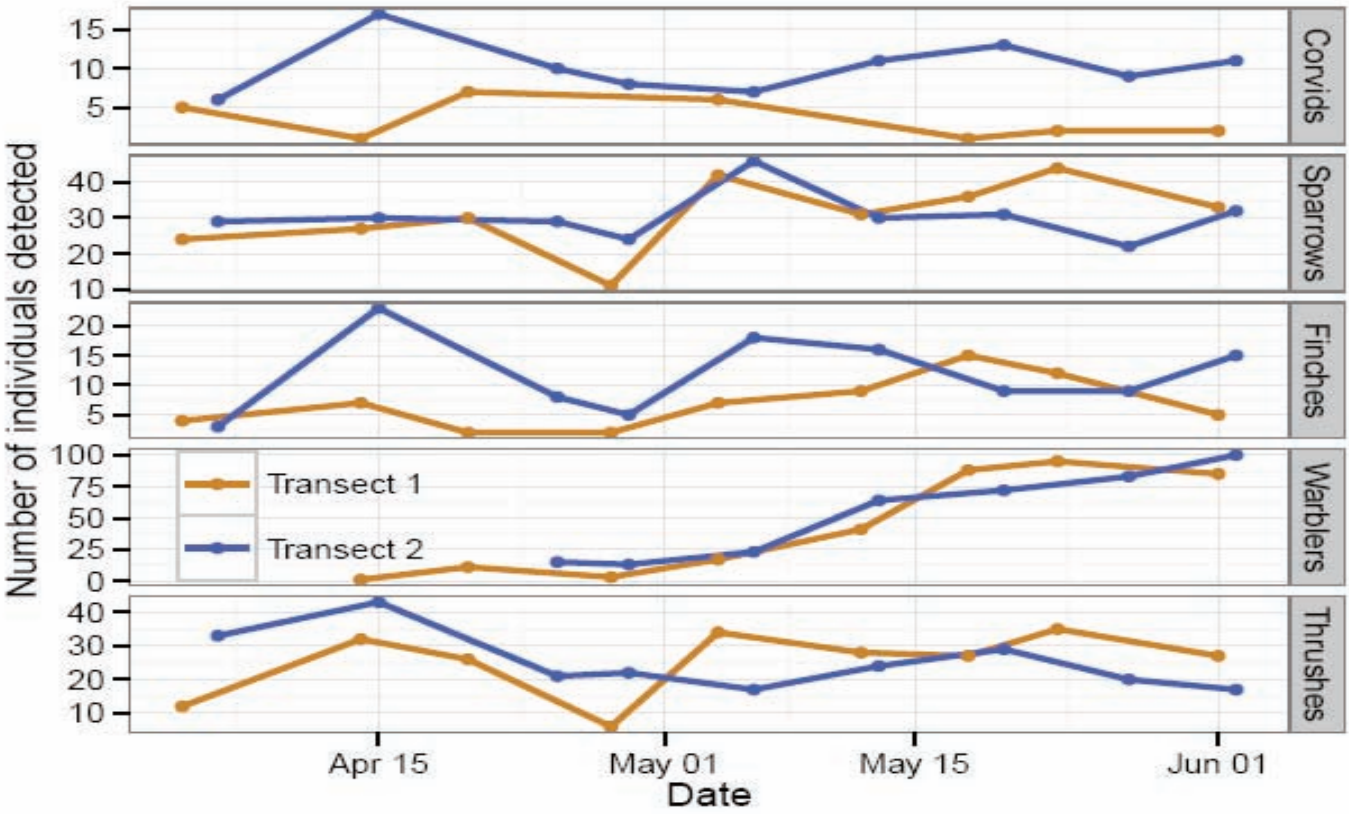


Figure 2 - Numbers of birds in each family detected along each transect in 2012. Note that the y-axis scales are different for each family.

In 2012, overall bird numbers along both Transect 1 and Transect 2 generally increased throughout

the spring (Figure 1), with the exception of a dip in numbers in late April/early May, which corresponds to a drop in sparrow, finch, and thrush observations (Figure 2). Corvids, finches, and thrushes were all detected in peak number in mid-April, although they continued to be detected throughout the spring. The first warblers were detected later than other families and numbers increased steadily through to early June, likely driving the upward trend in the overall bird numbers. Sparrow numbers also increased in May.

Differences in the numbers of each family detected between habitat types appear to be small (Table 4).

Table 4 - Average number of birds in each passerine family detected per day in each habitat type during point counts in the spring of 2012.

Family	Average number detected per day at point counts in each habitat		
	Disturbed or early successional	Mixed forest	Disturbed or early successional alongside mixed forest
Corvids	0.6	0.2	0.9
Blackbirds	0.4	0.2	0.3
Finches	0.4	1.1	0.9
Sparrows	3.3	1.8	3.2
Warblers	3.0	3.9	2.7
Thrushes	2.2	2.3	2.2

Acoustic Data

During the spring of 2012, birds with high frequency calls were detected on 36 nights between April 11th and June 2nd. The majority of the 321 flight calls detected were sparrows or warblers, with very low numbers of Indigo Buntings and Golden-crowned Kinglets (Table 5). Twenty-one species were identified and most flight calls were identified to at least genus or family. White-throated Sparrow was by far the most frequently detected species (119 flight calls detected), followed by Savannah Sparrow (39), Common Yellowthroat (24), and Ovenbird (21).

Table 5 - Number of flight calls detected within the high band range for each bird family in the spring of 2012. Species are listed when only one species from within a family was detected.

Family/Species	Number of flight calls detected
Sparrows	183
Warblers	115
Golden-crowned Kinglet	2
Indigo Bunting	1
Unidentified Passerine	20

The largest number of sparrow flight calls were detected at the site in early May, with smaller peaks in mid-April and mid-May, whereas the majority of warbler flight calls were detected in mid-May (Figure 3). These trends were broadly similar for each species within these families.

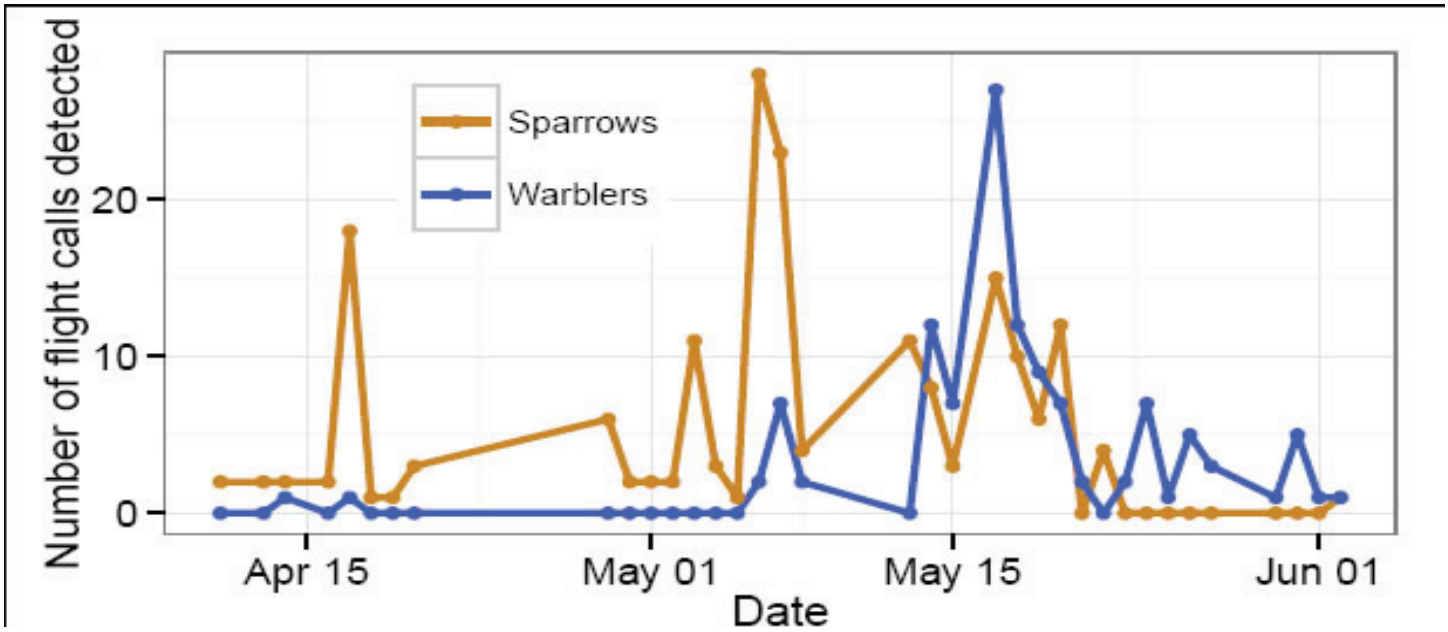


Figure 3 - Number of warbler and sparrow flight calls detected by acousic monitoring throughout the spring of 2012.

The number of sparrow flight calls detected peaked at three hours and seven hours after civil dusk, whereas the greatest number of warbler flight calls was detected at two and four hours after civil dusk (Figure 4). There was little difference among sparrow species in the number of flight calls detected throughout the night. There were some differences between warbler species, but generally, the number of flight calls of each species peaked in the middle of the night and very few were detected close to sunrise.

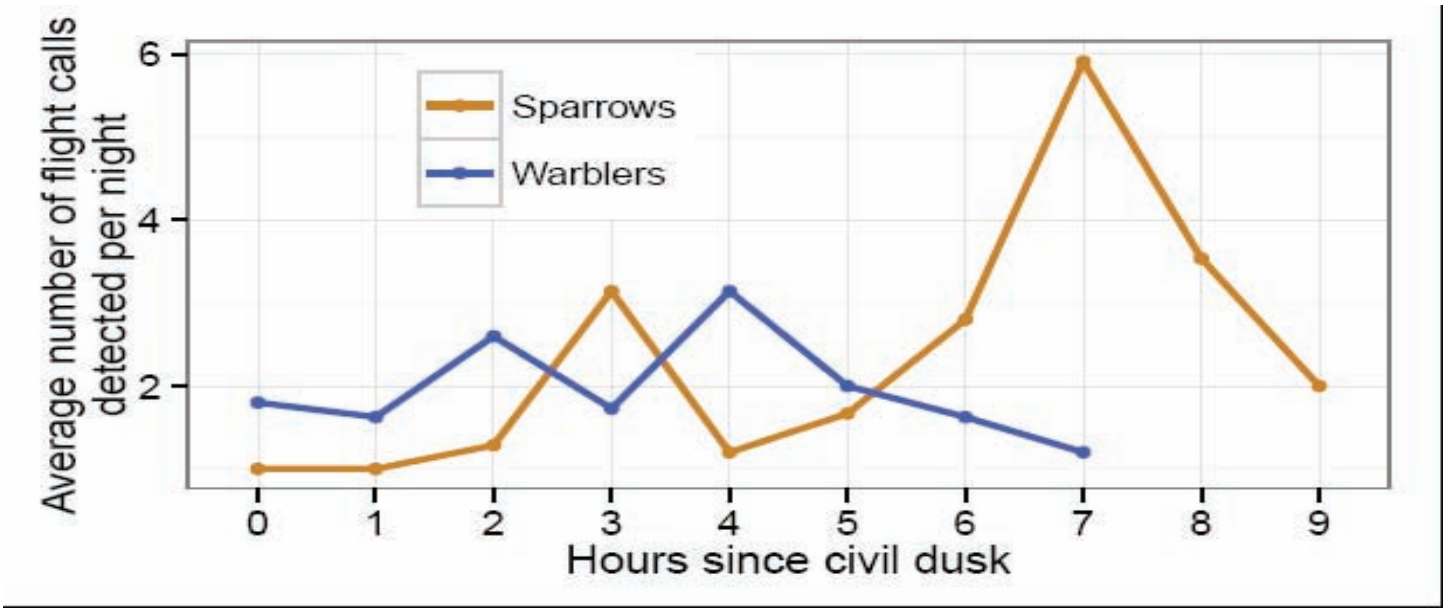


Figure 4 - Average number of warbler and sparrow flight calls detected within each hour after civil dusk by acoustic monitoring in the spring of 2012.

Diurnal passage

In 2011, it was noted that few birds were seen during diurnal passage surveys and only one Bald Eagle

was suspected to be a migrating raptor. In 2012, 17 surveys were completed from each of two viewpoints between April 14th and June 4th and a more extensive dataset was recorded and analyzed. Most of the 687 individual birds observed were ducks, passerines, gulls, or raptors (Table 6).

Table 6 - Numbers of birds detected during spring diurnal passage surveys in 2012.

Order	Number of individuals detected	Average number detected per survey day
Ducks	250	14.7
Passerines	150	8.8
Gulls	131	7.7
Raptors	132	7.8
Woodpeckers	11	0.6
Doves	8	0.5
Cranes	2	0.1
Cormorants	2	0.1
Hummingbirds	1	0.1

The most frequently detected raptors were Red-tailed Hawk, Turkey Vulture, and Northern Harrier (Table 7). American Robin, Common Raven, American Goldfinch, and American Crow were the most frequently detected passerines. Two species of gull, Herring Gull and Greater Black-backed Gull, were detected. All ducks observed were in one flock of 250 Common Eiders on June 4th.

Table 7 - Numbers of each raptor species detected during spring diurnal passage surveys in 2012.

Species	Total number of individuals detected	Average number detected per survey day
Red-tailed Hawk	37	2.2
Turkey Vulture	33	1.9
Northern Harrier	26	1.5
Broad-winged Hawk	5	0.3
Osprey	5	0.3
Merlin	4	0.2
Peregrine Falcon	3	0.2
American Kestrel	2	0.1
Cooper’s Hawk	2	0.1
Red-shouldered Hawk	2	0.1
Bald Eagle	1	0.1
Sharp-shinned Hawk	1	0.1
Unidentified Hawk	10	0.6
Unknown Accipiter	1	0.1

Passerine and raptor numbers per day were never very high (Figure 5). The largest numbers of raptors were present in mid-April and mid-May and each peak included multiple species. For passerines, corvids and thrushes were consistently detected, but finches and warblers were not observed prior to early May.

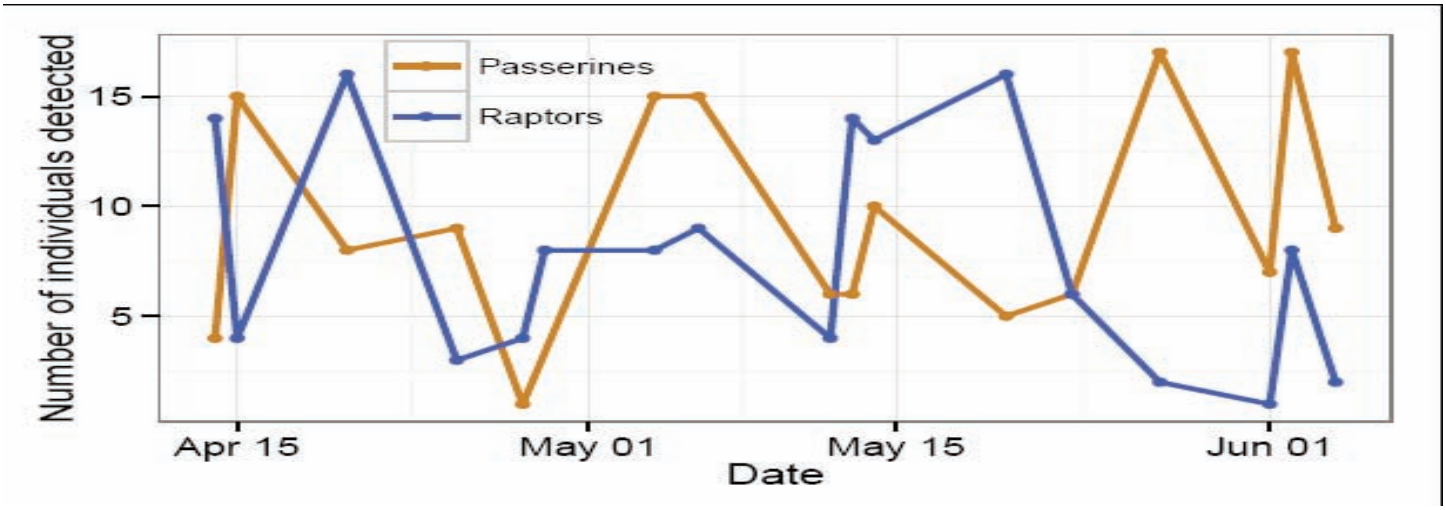


Figure 5 - Numbers of passerines and raptors detected during diurnal passage surveys during the spring of 2012.

Fifty percent of the individuals detected were observed at blade height (Table 8), however this number does include a flock of 250 Common Eiders. For raptors and passerines, the majority were observed above or below the blade height with 19% of raptors and 38% of passerines observed at blade altitude.

Table 8 - Numbers of birds observed within each altitude category during the spring of 2012. Blade sweeps at 40-120 m.

Altitude (metres)	Total number of individuals	Number of raptors	Number of passerines	Total number of flocks
>120	42	33	2	36
40-120	340	25	56	52
0-40	123	35	64	96
<0	181	39	27	94

Birds observed were moving in all directions, but it appears slightly more were moving southwest or northeast than were moving in other directions (Figure 6).

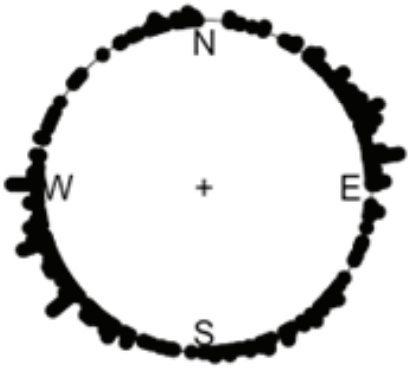


Figure 6 - Movement directions of individuals birds observed during spring diurnal passage surveys in 2012. The longer bars indicate a greater number of birds moving in that direction.

Owl Survey

Owl surveys were conducted on April 9th and 29th, 2011 and April 18th, 2012. In 2011, no owls were detected, but it was noted that wind may have reduced the observer's ability to detect birds on those nights. In 2012, three Great-Horned Owls and seven American Woodcocks were detected at the wind farm site.

Breeding Bird Surveys

Point Counts

Point count surveys for breeding birds were conducted at 42 locations between June 1st and June 30th in 2011 and between June 10th and July 1st, 2012. For points surveyed multiple times in 2011, only the first survey on or later than June 10th was included to allow comparisons to the 2012 data. In 2012, an additional 20 points were surveyed to provide additional data for examining how the wind farm might affect breeding birds.

In 2011 and 2012, 41 and 50 species, respectively, were detected among the 42 point counts. An additional 6 species were detected along the additional 20 point counts completed only in 2012. The majority of the birds detected were passerines and most of these were warblers, sparrows, and thrushes. The most common species were similar between years and included White-throated Sparrow, American Robin, Common Yellowthroat, Magnolia Warbler, Black-throated Green Warbler, Alder Flycatcher, Song Sparrow, and Swainson's Thrush.

The greatest numbers of individual birds were detected in the habitat classified as disturbed/early succession alongside mixed forest in 2011, and in disturbed/early succession in 2012 (Table 9). In both years, the greatest number of species were detected in disturbed/early succession habitat alongside mixed forest, but there were many more points located in this habitat than any other. Only one coniferous forest point was surveyed; however, Yellow-bellied Flycatcher was detected only at this point.

Table 9 - Numbers of individual birds and bird species detected in each habitat type during the breeding season in 2011 and 2012.

Habitat	Number of points surveyed	Average number of birds detected per point		Total number of species detected	
		2011	2012	2011	2012
Disturbed/early succession	4	8.0	29.8	12	22
Disturbed/early succession	6	6.8	14.8	16	26
Mixed forest	11	5.0	10.5	20	23
Coniferous forest	1	4.0	8.0	4	6
Disturbed/early succession	20	9.9	20.1	36	38

A set of 20 points, split between three habitat categories, was used to look at whether numbers of breeding birds differ with distance from turbines. For mixed forest and disturbed/early successional alongside mixed forest, there were lower numbers of birds at the closest point (500 m from a turbine), but for disturbed/early successional alongside mixed forest lower numbers were also found at the sites furthest from turbines (Figure 7). Mixed forest points generally did have increased numbers of birds at points further from turbines. However, disturbed and early successional habitat was the opposite, with more birds present at points closer to turbines.

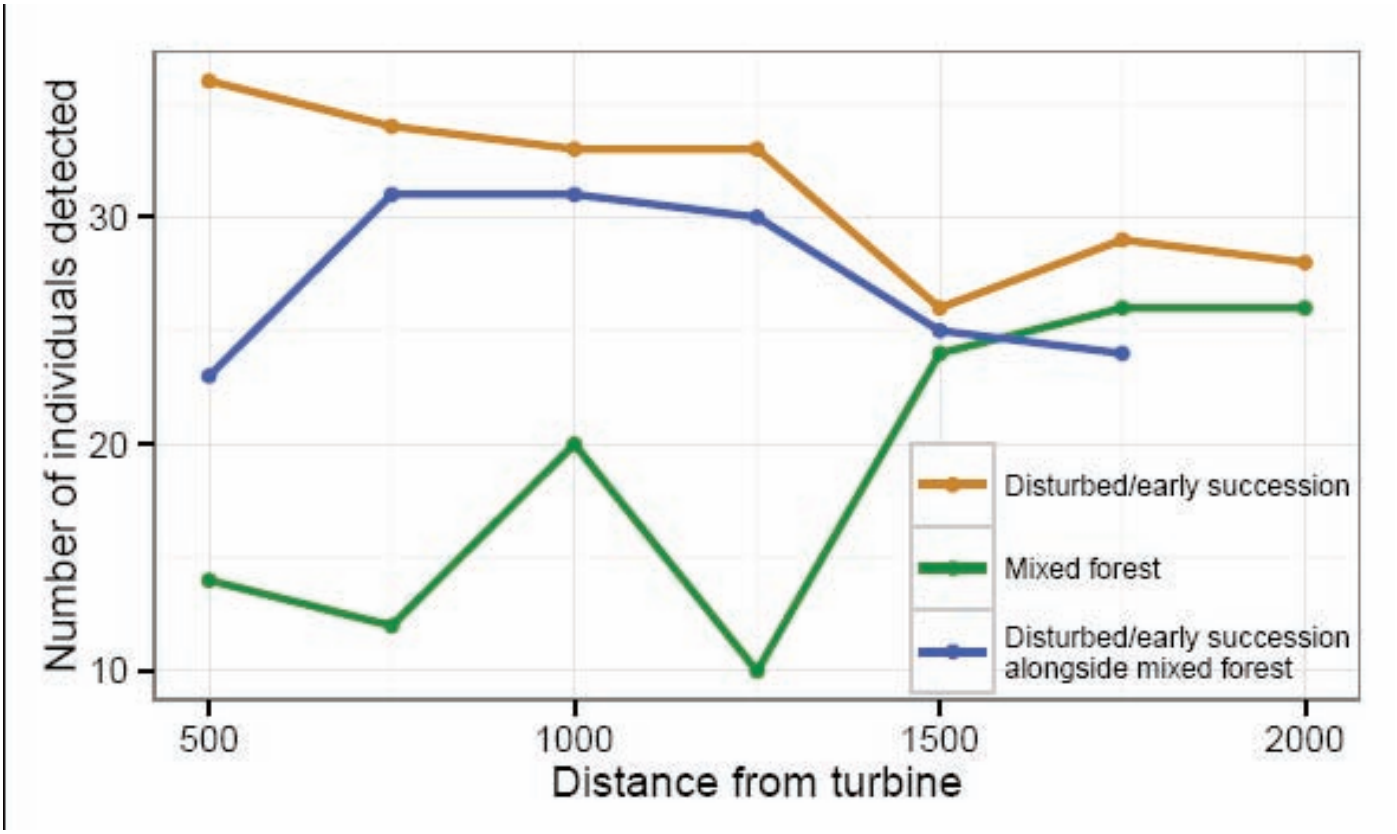


Figure 7- Numbers of birds detected during the breeding season at points located at varying distances from turbines in three habitat types.

Nocturnal surveys

The Common Nighthawk and Eastern Whip-poor-will surveys were conducted on the same night from dusk on June 7th to the early morning of June 8th. Neither target species was detected at any of the 12 stops. However, 89 individuals of 24 species were detected. All birds detected were noted within an hour after sunset. The most frequently detected birds were American Robin, Swainson's Thrush, and White-throated Sparrow. American Woodcock is the only bird detected known to be active at night during the breeding season. Two American Woodcock were detected at Stop 9, 51 minutes after sunset.

Fall Migration

Transects and point counts

Fall migration surveys were conducted in 2011 and 2012 along two transects. Each transect was surveyed eleven times between August 17th and October 29th, 2011 and nine times between August 18th and November 4th, 2012. Surveys in 2012 were completed during the early to mid-morning, but in 2011 many surveys were not completed until the mid to late afternoon.

A total of 6453 individual birds of 82 species were detected at the wind farm site during fall migration: 1305 individuals of 58 species in 2011 and 5148 individuals of 77 species in 2012. The most frequently detected species were somewhat similar between years and included American Goldfinch, American Robin, Blue Jay, Yellow-rumped Warbler, Song Sparrow, and Black-capped Chickadee. The most frequently detected

bird in 2012, Red-winged Blackbird (1123 individuals), was mainly present in large flocks on only October 19th.

The vast majority of the birds detected were passerines (Table 10). Blackbirds were the most common passerine family detected due to the large flocks previously mentioned. Finches, corvids, thrushes, warblers, and sparrows composed the majority of the other birds detected (Table 11).

Table 10 - Number of individuals detected and average number detected per survey day for each taxonomic order during fall migration in each year.

Order	Total number of individuals detected		Average number detected per survey day	
	2011	2012	2011	2012
Passerines	1215	4900	110.5	544.4
Woodpeckers	24	108	2.2	12.0
Raptors	25	73	2.3	8.1
Shorebirds/Gulls	24	37	2.2	4.1
Doves	10	16	0.9	1.8
Hummingbirds	4	5	0.4	0.6
Grouse	1	3	0.1	0.3
Kingfishers		2		0.2
Loons	1	1	0.1	0.1
Cranes		1		0.1
Herons		1		0.1
Owls		1		0.1
Cormorants	1		0.1	

Table 11 - Numbers of individuals and average numbers detected per survey day by passerine family during fall migration for each year. Includes only families for which > 10 individuals were detected in one of the two survey years. Species names are listed when only one species in a family was detected.

Family/Species	Total number of individuals detected		Average number detected per survey day	
	2011	2012	2011	2012
Blackbirds		1250		139.9
Finches	232	694	21.1	77.1
Ravens/Crows/Jays	245	570	22.3	63.3
Thrushes	63	711	5.7	79.0
Warblers	306	399	27.8	44.3
Sparrows	183	419	16.6	46.6
Chickadees	60	204	5.5	22.7
Kinglets	68	129	6.2	14.3
Cedar Waxwing	1	138	0.1	15.3
Red-breasted Nuthatch	40	40	3.6	4.4
Vireos	8	39	0.7	4.3
Flycatchers	7	35	0.6	3.9
Unidentified Passerine		244		27.1

As in the spring, more birds were detected along both transects in 2012 than in 2011 (Figure 8, note that the two y-axis scales are different), most likely because the 2012 surveys were consistently conducted in the morning. The 2011 data were not examined in any more depth due to these inconsistencies.

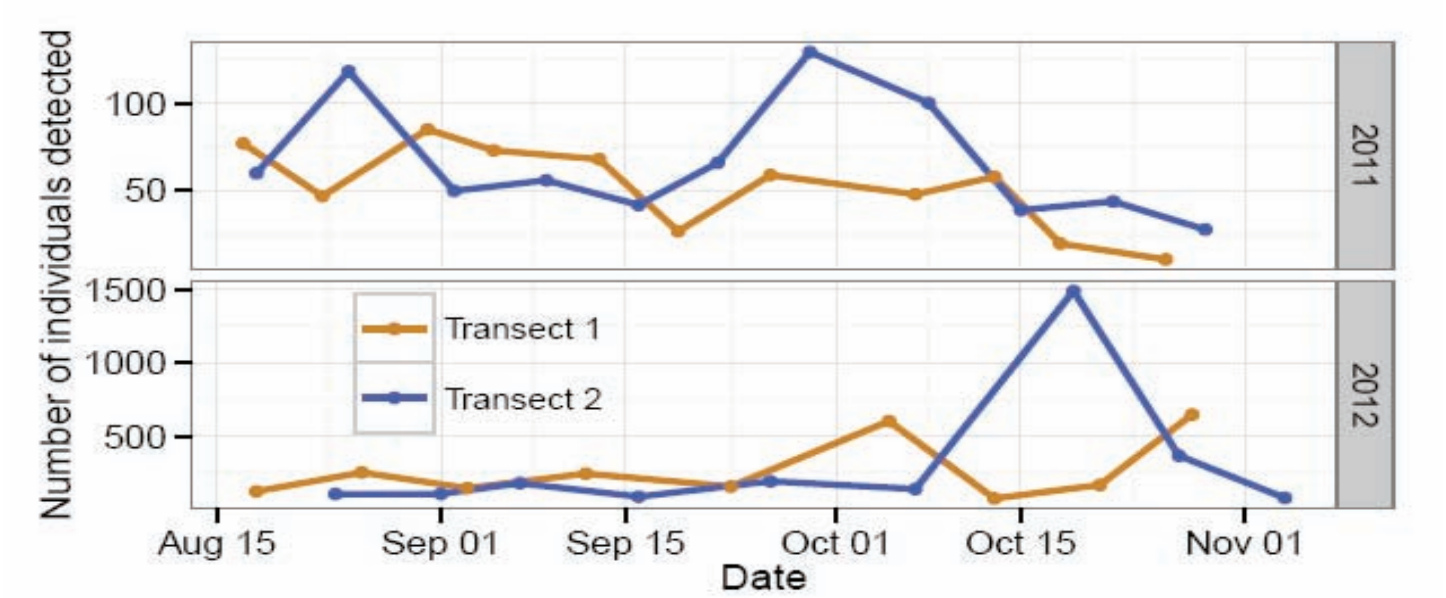


Figure 8 - Numbers of birds detected along each transect in the fall of 2011 and 2012. Note that the y-axis scales are different for each year.

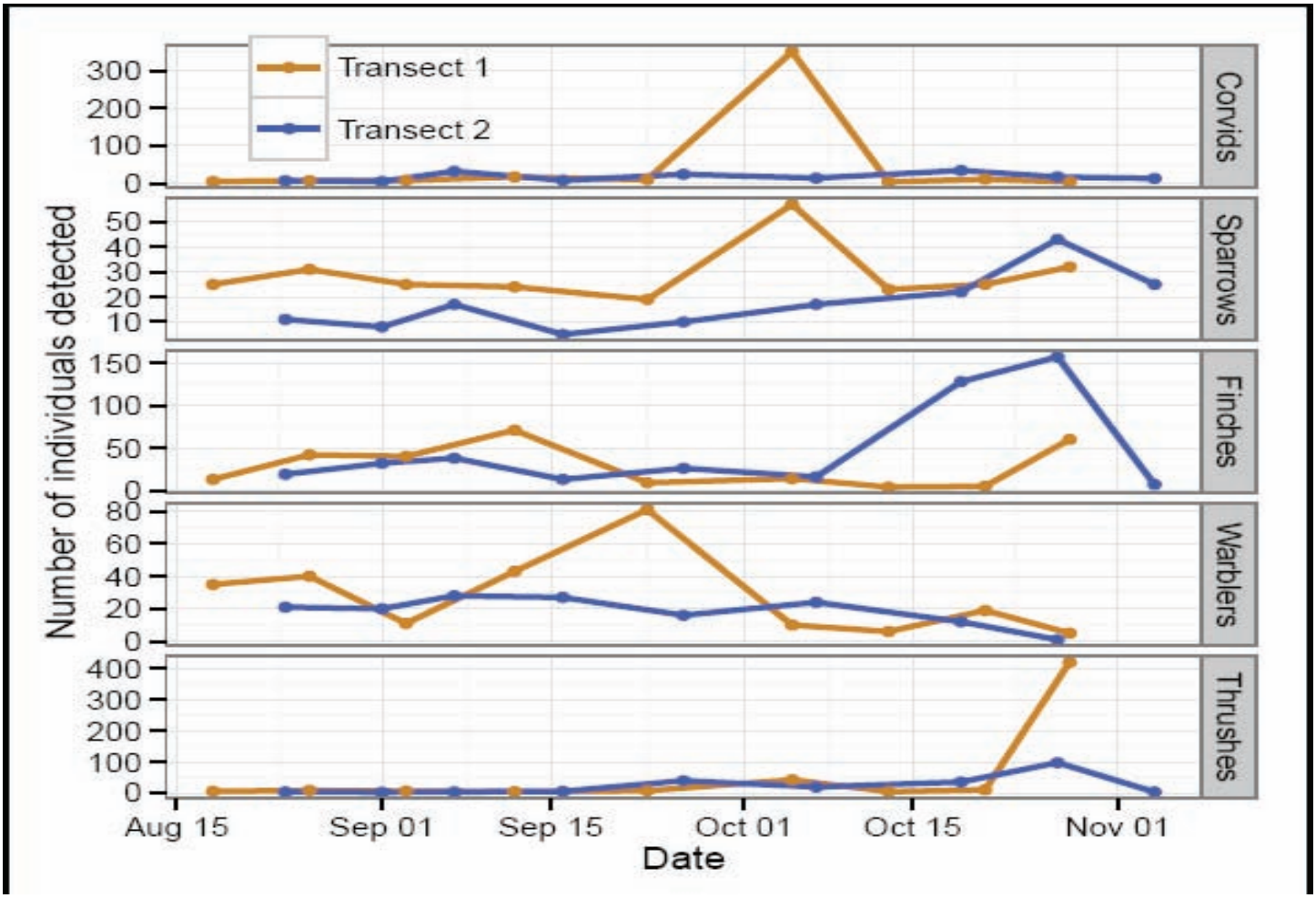


Figure 9 - Numbers of birds in each family detected along each transect in the fall of 2012. Note that the y-axis scales are different for each family.

In 2012, birds appeared to move through in waves throughout August and September (Figure 8) with peaks likely representing observations of warblers and sparrows (Figure 9). The peak numbers of warblers

were detected in mid-late September. In early October, large numbers of corvids were observed at the site and the greatest numbers of sparrows were detected, both along Transect 1. The mid-October spike on Transect 2 (Figure 8) is largely due to flocks of Red-winged Blackbirds; however, if blackbirds are removed from the data, mid-late October bird numbers are still high due to finch observations. In late October, the large numbers of thrushes (mostly American Robins) and finches were observed on Transect 1 and Transect 2, respectively (Figure 9).

Corvids, sparrows, warblers, and thrushes were detected more frequently at point counts in disturbed/early successional habitat than in disturbed/early successional habitat alongside mixed forest or mixed forest (Table 12). Finches and blackbirds were most frequently observed in disturbed/early successional habitat alongside mixed forest.

Table 12 - Average number of birds in each passerine family detected per day at point counts in each habitat during the fall of 2012.

Family	Average number detected per day at point counts in each habitat		
	Disturbed or early successional	Mixed forest	Disturbed or early successional alongside mixed forest
Corvids	7.7	1.8	2.3
Blackbirds		1.3	11.0
Finches	1.5	3.0	3.5
Sparrows	3.8	1.0	1.6
Warblers	3.1	0.8	1.2
Thrushes	5.8	0.6	3.7

Acoustic Data

Migrating birds with high frequency flight calls were detected on 45 nights between September 2nd and October 26th, 2011, and those with low frequency calls were detected on 36 nights between September 2nd and October 24th, 2011.

High frequency

The majority of the 10 002 flight calls detected in the high band frequency range were warblers, followed by sparrows and very low numbers of Indigo Buntings and Golden-crowned Kinglets (Table 13). Flight calls by warblers of the genus *Setophaga* were the most numerous of any genera, but the most frequently detected species in the high band range were Common Yellowthroat (1597 flight calls detected) and White-throated Sparrow (1115 flight calls detected).

Table 13 - Number of flight calls of each bird family detected within the high band frequency in the fall of 2011. Species are listed when only one species within a family was detected.

Family/Species	Number of flight calls detected
Warblers	6209
Sparrows	2216
Indigo Bunting	21
Golden-crowned Kinglet	5
Unidentified Passerine	1551

The majority of warbler detections were in September, with a large peak on Sept 26th, and relatively few warblers were detected in October (Figure 10). The number of sparrows calls detected also peaked in late September, but similar numbers of calls were detected on days in mid-late October (Figure 10). These trends appear to be broadly similar for all species within each family.

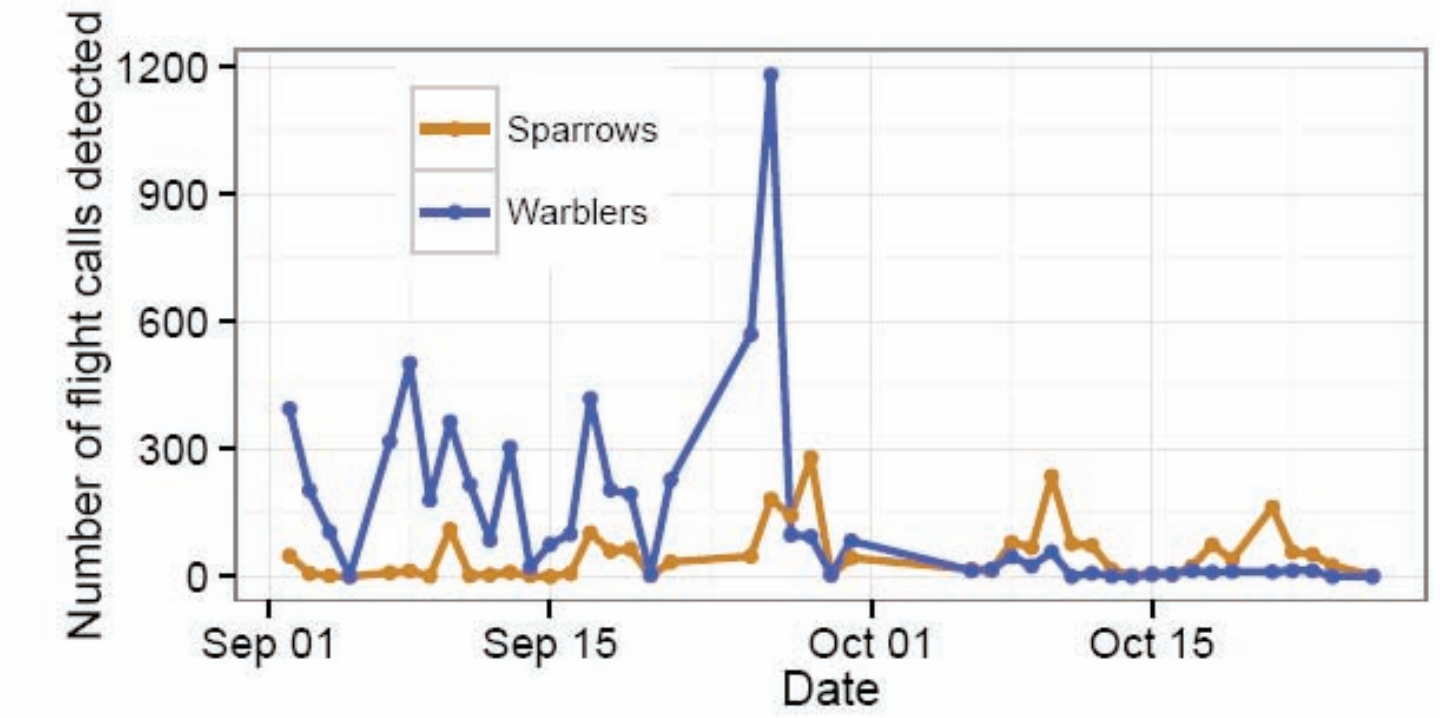


Figure 10 - Numbers of warbler and sparrow flight calls detected by acoustic monitoring throughout the fall of 2011.

The number of warbler flight calls detected at the wind farm site peaked between one and two hours after civil dusk and then declined continuously until sunrise (Figure 11). Sparrow flight call detections peaked slightly at four hours and eleven hours after civil dusk. There were no differences among the species in each family.

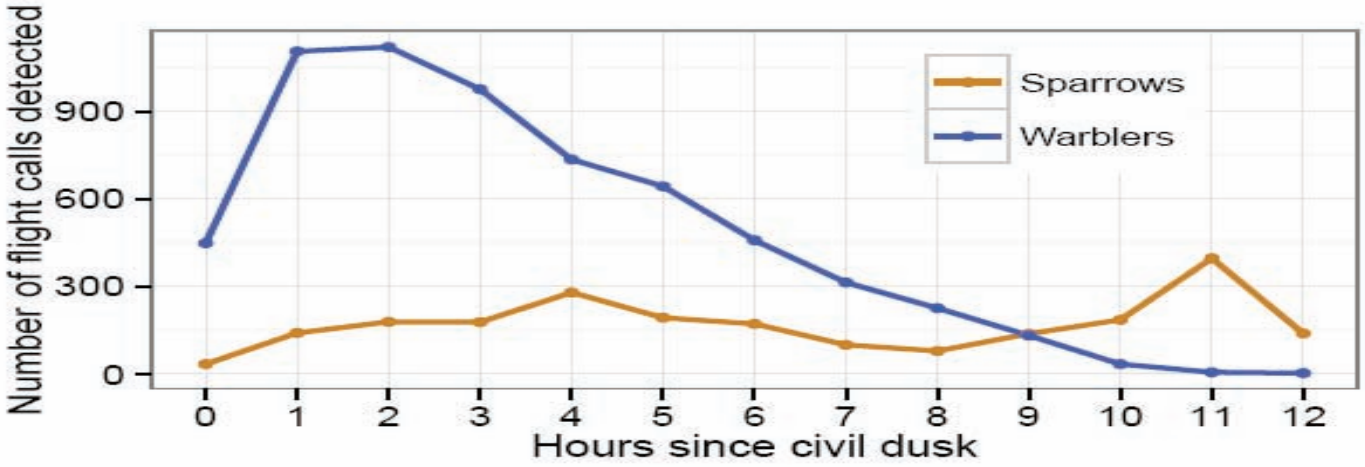


Figure 11 - Average number of warbler and sparrow flight calls detected within each hour after civil dusk by acoustic monitoring in the fall of 2011.

Low frequency

The majority of flight calls detected in the low band frequency range were Swainson's and Hermit Thrush. Very low numbers of Veery, Wood Thrush, Rose-breasted Grosbeak, and Red-winged Blackbird flight calls were also detected. These data are minimum counts rather than total numbers so we cannot make direct comparisons with the species detected in the high band range. There were many calls in the low band that could not be identified.

Swainson's Thrush flight calls were more frequently detected in September, with numbers peaking in early September and very low numbers detected in October (Figure 12). In contrast, Hermit Thrush flight call detections were most frequent in October, peaking late in the month (Figure 12).

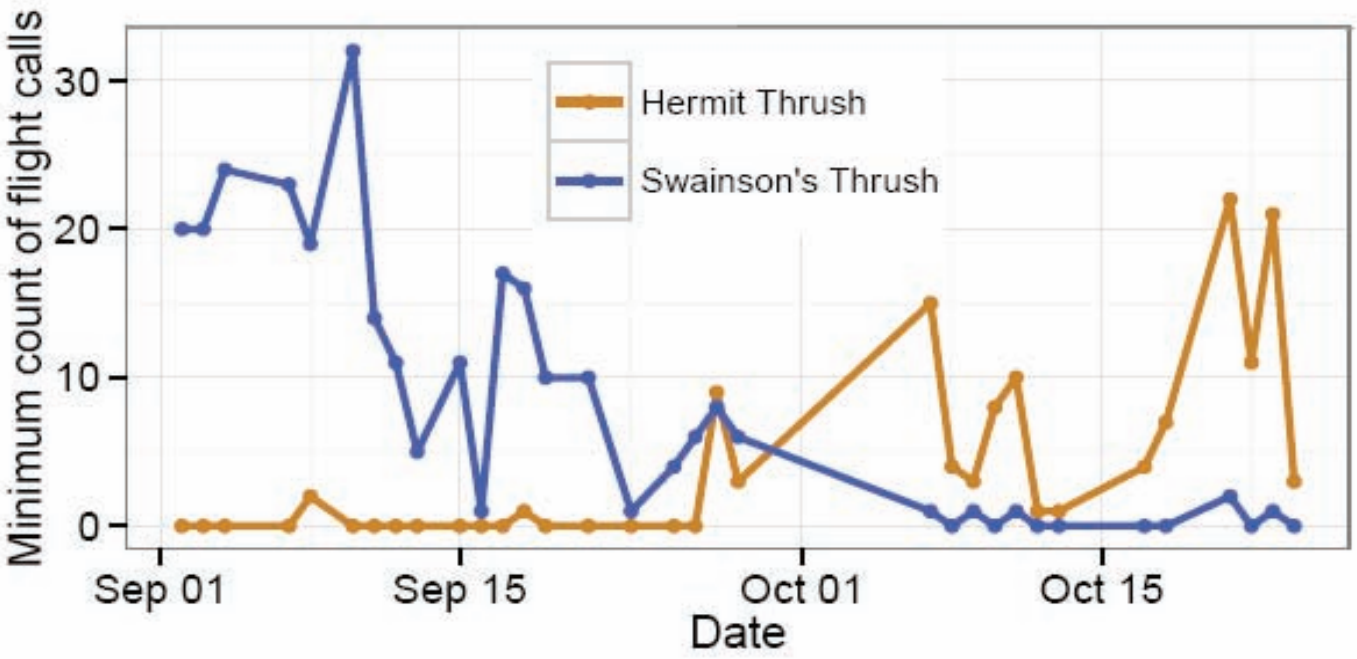


Figure 12 - Minimum counts of Hermit and Swainson's Thrush flight calls detected by acoustic monitoring throughout the fall of 2011.

There were also differences in the time of night when each thrush species was most frequently detected, with Swainson's Thrush detections peaking at nine hours after civil dusk and Hermit Thrush detections peaking eleven hours after civil dusk (Figure 13).

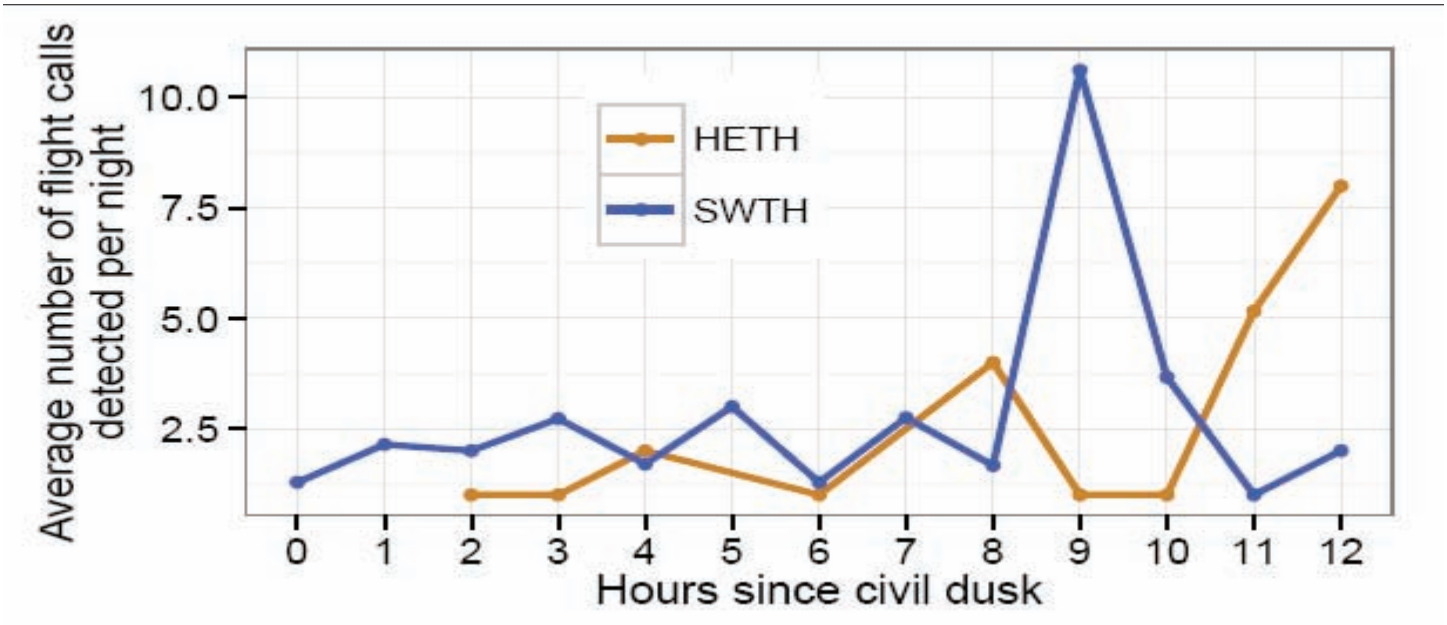


Figure 13 - Average number of Hermit and Swainson's Thrush flight calls detected within each hour after civil dusk by acoustic monitoring in the fall of 2011.

Diurnal passage

In 2011, it was noted that the only major movement of raptors observed was on October 12th when two large kettles of buteos (54 and 17 individuals) were observed in the afternoon, too high up to be identified.

Eighteen surveys were completed from each of two viewpoints between August 18th and November 4th, 2012. The majority of individual birds observed were either passerines or raptors (Table 14).

Table 14 - Numbers of birds in each taxonomic order detected during diurnal passage surveys in the fall of 2012.

Order	Total number of individuals detected	Average number detected per survey day
Passerines	813	45.2
Raptors	399	22.2
Gulls	40	2.2
Waterfowl	21	1.2
Doves	13	0.7
Cormorants & Gannets	11	0.6
Hummingbirds	8	0.4
Woodpeckers	8	0.4
Herons	1	0.1

Table 15 - Numbers of each raptor species detected during diurnal passage surveys during fall migration in 2012.

Species	Total number of individuals detected	Average number detected per survey day
Broad-winged Hawk	146	8.1
Red-tailed Hawk	59	3.3
Sharp-shinned Hawk	43	2.4
Bald Eagle	25	1.4
Unidentified Hawk	24	1.3
Turkey Vulture	22	1.2
Merlin	17	1.0
Northern Harrier	16	0.9
Unidentified Raptor	16	0.9
American Kestrel	13	0.7
Osprey	9	0.5
Peregrine Falcon	9	0.5

The greatest numbers of raptors were detected in mid-September, but small peaks in numbers also occurred in early and mid-October (Figure 14). These peaks mainly represent increased observations of Broad-winged Hawk, except for in mid-October when Red-tailed Hawk was the most frequently detected raptor. Passerine numbers peaked in early September, early October, and late October (Figure 14), representing primarily waxwings, corvids, and thrushes, respectively. Finch numbers contributed to each of these peaks also.

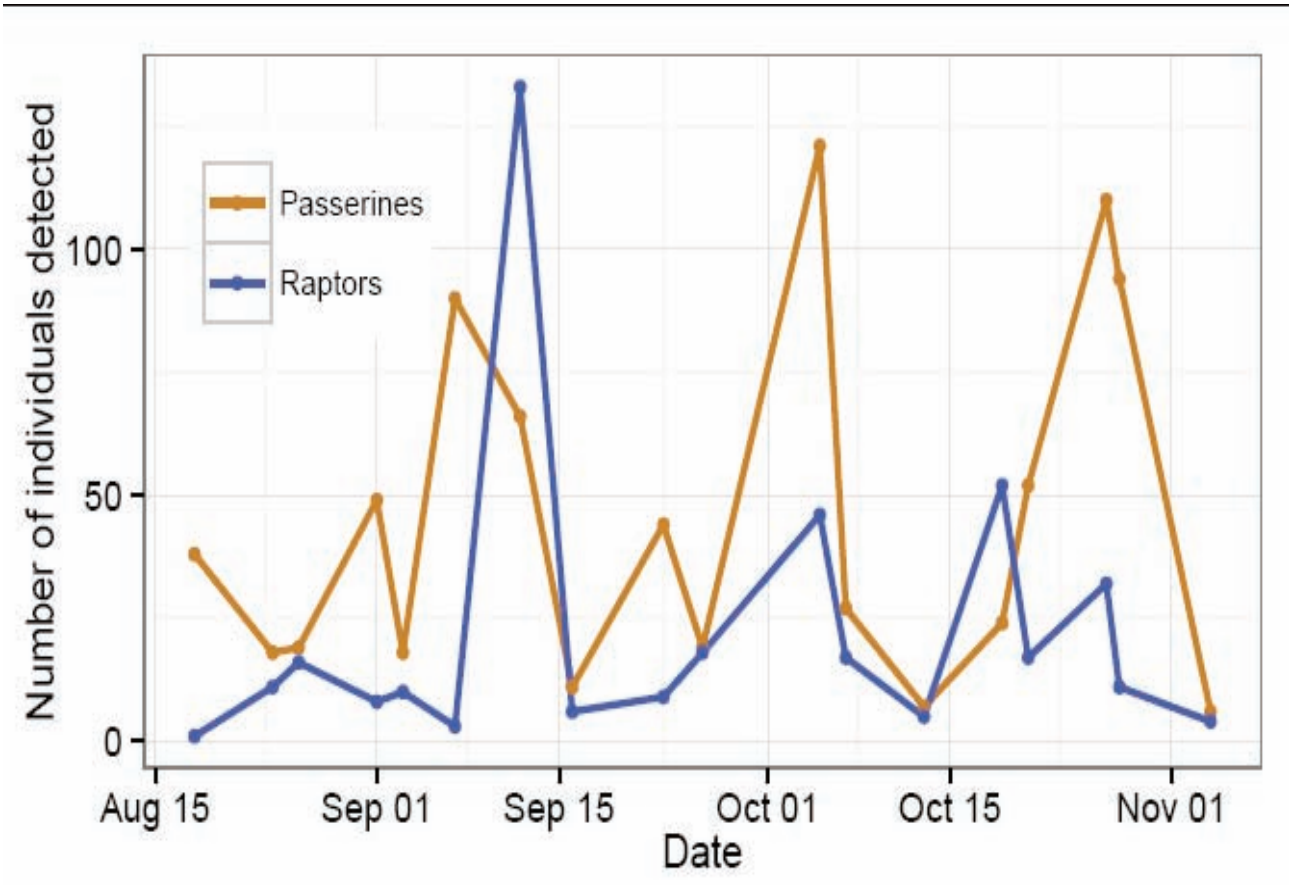


Figure 14 - Numbers of passerines and raptors detected during diurnal passage surveys during the fall of 2012.

The majority of birds detected were flying at altitudes above or below the blades, with only 22% of

flocks and 20% of individuals within blade altitude (Table 16).

Table 16 - Numbers of birds detected within each altitude category.
Blade sweeps at 40-120 m.

Altitude (metres)	Total number of individual birds	Number of raptors	Number of passerines	Total number of flocks
>120	249	188	28	89
40-120	265	98	161	95
0-40	480	53	400	160
<0	317	59	223	91

All individuals observed were moving in directions between zero and 136 degrees (north to southeast) (Figure 15).

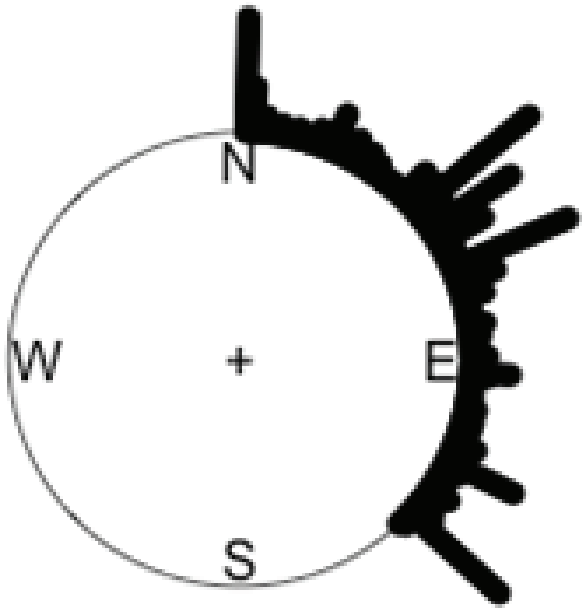


Figure 15 - Movement directions of individual birds observed during fall diurnal passage surveys in 2012. The longer bar indicates a greater number of individuals moving in that direction.

Winter Surveys

General Area Searches

General area searches were completed on six dates between December 28th, 2011 and March 16th, 2012. Only 21 species were detected and no more than eight individuals were detected of any one species. The most frequently detected species were American Crow, Common Raven, Black-capped Chickadee. Red-tailed Hawk and Bald Eagle were the only raptors detected, with three and one individuals observed, respectively.

Systematic Area Searches

In early 2011, systematic area searches were completed on Feb 17th and March 22nd. Over the winter of 2011 to 2012, eight systematic area searches were completed between November 13, 2011 and March 16th, 2012. All surveys were completed within 5 hours of sunrise.

Table 17 shows the numbers of each species detected during these surveys. The most frequently detected species over the winter were Common Raven and Black-capped Chickadee. Only two raptor species, Bald Eagle and Red-tailed Hawk were present. One Red-tailed Hawk seen on February 17th in 2011 was noted to be flying at blade height.

Table 17 - Numbers of each species detected during winter systematic area searches in the winter.

Species	Total number of individuals detected	
	2010-2011	2011-2012
Common Raven	6	9
Black-capped Chickadee	1	12
American Crow		6
Red-tailed Hawk	2	2
Boreal Chickadee		3
Dark-eyed Junco		3
Golden-crowned Kinglet		2
American Robin		2
White-throated Sparrow		2
Ruffed Grouse		1
Bald Eagle		1
Snow Bunting		1
American Goldfinch		1

Most of the birds detected were in mixed forest and disturbed habitat or early successional; however, more birds were detected per distance surveyed in coniferous forest (Table 18).

Table 18 - Numbers of birds detected within each habitat type during systematic area searches over two winters.

Habitat Type	Number of birds detected	Total distance surveyed (m)	Number of birds per meter surveyed
Disturbed or early succession	14	50	0.0038
Mixed forest	22	66	0.0049
Coniferous forest	9	26	0.0054
Disturbed or early succession	9	37	0.0034

Transects

In 2011, Transect 1 was surveyed on November 14th and December 12th and Transect 2 was surveyed on November 28th. Overall, not very many birds were detected; the numbers of each species noted along each transect are listed in Table 19. Of the species detected, Bald Eagle and Common Raven are the most likely to be interacting with the turbines and most Common Raven detected were flying.

Table 19 - Numbers of birds detected along each transect during

the winter of 2011.

Species	Transect 1	Transect 2
American Crow		4
American Goldfinch	1	
American Robin	1	
Bald Eagle		1
Black-capped Chickadee	4	2
Boreal Chickadee	3	
Common Raven	2	4
Dark-eyed Junco	3	
Golden-crowned Kinglet	1	1
Snow Bunting		1
White-throated Sparrow	2	

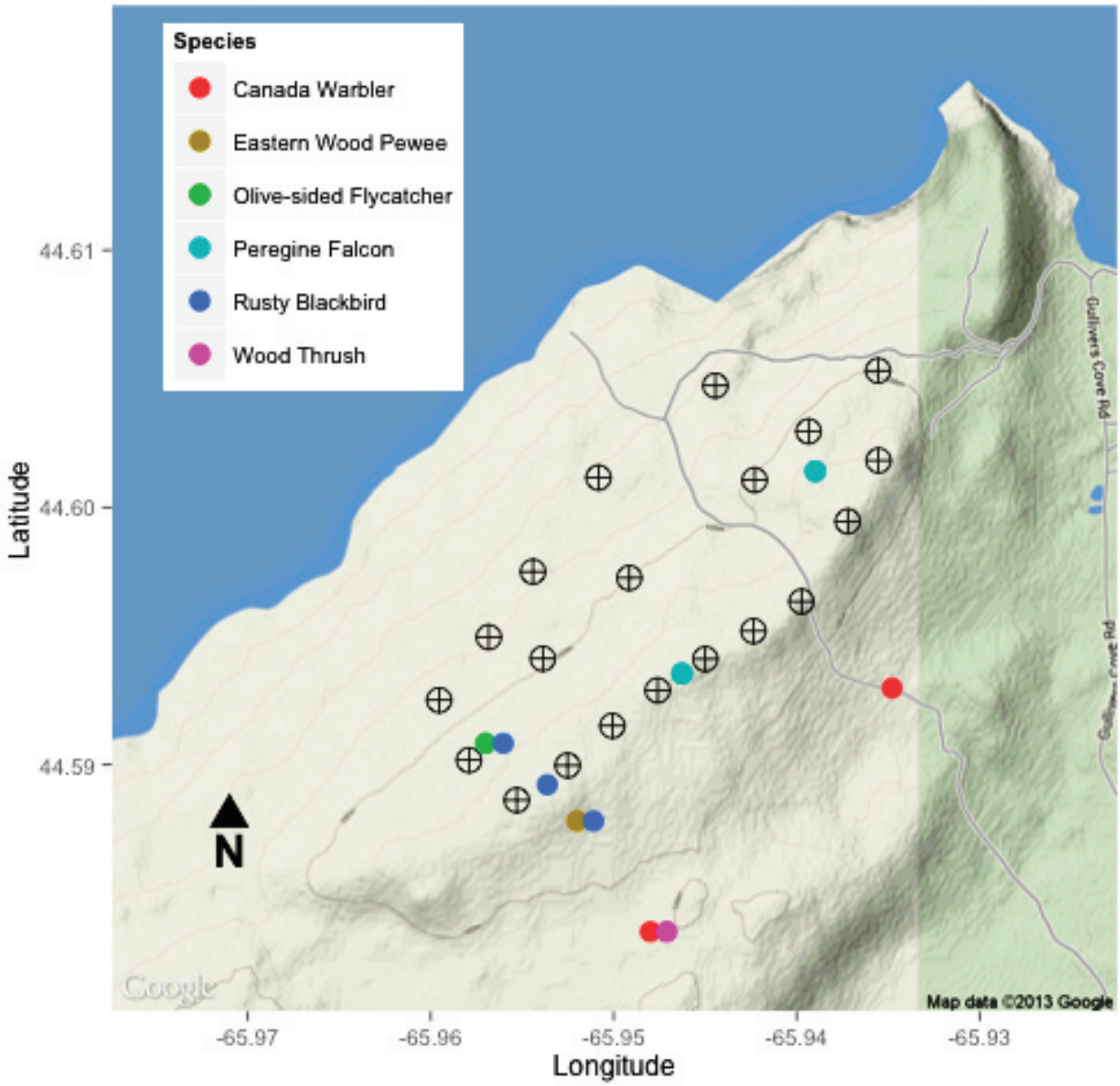
Species At Risk

Thirty-two species of conservation concern were detected at the wind farm site, although many were detected in very low numbers (Table 20). The federally-listed species detected, of which many are ranked as vulnerable, threatened, or endangered in Nova Scotia, were Peregrine Falcon, Olive-sided Flycatcher, Eastern Wood-Pewee, Wood Thrush, Canada Warbler, and Rusty Blackbird. All were detected during spring and/or fall migration (Map 4).

In 2012, nine Peregrine Falcons were detected during fall diurnal observations and three were observed in the spring. Olive-sided Flycatcher and Eastern Wood Pewee were each only detected once, during fall migration transect surveys in 2012. Two Wood Thrush were detected by fall acoustic monitoring, but none were detected at the site during the day. The majority of Canada Warblers were detected by fall acoustic monitoring (50 birds) and one bird was seen on the ground at the site in 2011. Nine Rusty Blackbirds were observed during spring migration in 2012.

Table 20 - Species of conservation concern detected at the wind farm site. For season detected: S - spring, B- breeding, F- fall, W - winter, I - incidental.

Species	NS DNR Ranking	SARA Schedule 1	COSEWIC Listed	COSEWIC Candidate Priority	Season detected
Common Loon	May be at risk				S, F
Turkey Vulture	Sensitive				S, F
American Kestrel				Mid	S, F
Peregrine Falcon	Vulnerable	Threatened	Special Concern		S, F
Greater Yellowlegs	Sensitive				F
Spotted Sandpiper	Sensitive				F
Wilson's Snipe	Sensitive				S
Red-necked Phalarope	Sensitive				S
Belted Kingfisher				High	F
Olive-Sided Flycatcher	Threatened	Threatened	Threatened		F
Eastern Wood-Pewee	Vulnerable		Special Concern		F
Yellow-bellied Flycatcher	Sensitive				S, B, F
Willow Flycatcher	Sensitive				B
Gray Jay	Sensitive				S, B, F
Tree Swallow	Sensitive				S
Boreal Chickadee	Sensitive				S,B, F, W
Golden-crowned Kinglet	Sensitive				S, B, F, W
Ruby-crowned Kinglet	Sensitive				F
Eastern Bluebird	Sensitive				B
Wood Thrush			Threatened		F
Gray Catbird	May be at Risk				S, B, F, W
Tennessee Warbler	Sensitive				F
Cape May Warbler	Sensitive				S, F
Bay-breasted Warbler	Sensitive				S, F
Blackpoll Warbler	Sensitive				S
Wilson's Warbler	Sensitive				F
Canada Warbler	Endangered	Threatened	Threatened		S, F, I
Vesper Sparrow	May be at Risk				S
Rose-breasted Grosbeak	Sensitive				S, B
Rusty Blackbird	Endangered	Special Concern	Special Concern		S
Pine Siskin	Sensitive				S, B, F
Evening Grosbeak				High	S, F



Map 4 - Location of SARA and COSEWIC listed species

DISCUSSION

The above results suggest that greater numbers of passerines and raptors move through the wind farm site in the fall than in the spring. This is particularly true at night, when the acoustic data show many more birds moving through in the fall. However, more individual birds were also detected along transects during fall migration than during spring migration, although this was not true within every family for each year. Greater numbers of most raptors, particularly Broad-winged Hawks, moved through during the fall.

There was also some agreement between the different types of data as to the timing of migration for different bird families. The spring transect and acoustic data both showed that sparrows are detected in varying numbers from late April through to May and warblers are only detected in larger numbers starting around mid-May. The pre-construction data shows similar patterns in arrivals of warblers and sparrows in the spring. In the fall, both acoustic monitoring and transect surveys noted peak warbler numbers in late September and an increase in thrush numbers in late October.

In the pre-construction report, Ian McLaren suggested that although Digby Neck had some larger counts of migrants, these were not high numbers in comparison to the much larger numbers found on Brier Island, especially for night migrants, like warblers (Stantec 2009). Nonetheless, the study of Thurber (2010) suggests that on some nights in the autumn the nocturnal migrants detected at Brier Island could be part of a broader migration front. The results of this study indicate that the numbers of birds in nocturnal passage and stop-over at this wind farm site are higher than at other wind farm sites where comparable studies have been conducted.

Table 21 shows the mean number of birds in stop-over at a number of existing or proposed wind farm sites in Nova Scotia and the total count of high frequency night flight calls detected at these sites. The same methodology and time period (mid-August through October) as designed by Kearney was used at all sites. Acoustic recordings detect birds at lower altitudes and birds detected on stop-over transects must have passed through the altitude where they would be at risk, so these particular numbers are relevant to assessing the risk to birds.

Table 21: Comparison of Stop-over Transects and High Frequency Flight Call Detections at Wind Farm Sites in Nova Scotia

	Stop-over Transects		Acoustic Monitoring	
Location	**Mean/Day**	**Year**	**Calls/Season**	**Year**
Digby Neck	224*	2012	10,002	2011
Canso Peninsula	107	2013	2,016	2013
Pictou-Antigonish Highlands	79	2008	7,899	2011
Browns Mountain	54	2011-2012	4,529	2011
Nuttby Mountain	48	2011-2012	1,271	2011
Loganville Ridge	-	2011	2,095	2011

*Excludes one flock of 1,250 blackbirds

In comparison to other sites, the Digby Neck location may pose a higher collision risk to migrating birds. This concern is echoed in the mortality study (Kearney 2013) where the potential effects of fog remain uncertain.

Lower numbers of birds were detected during the breeding season than during migration. There is some indication that there could be differences in the number breeding at points located closer to the wind farm, depending on habitat, but this result is somewhat uncertain. However, Zimmerling et al. (2013) conclude that although some habitat loss does occur at wind farms, the effects at the population level for most bird species would be relatively small. The effects of noise in the energy industry can also affect breeding birds (Bayne 2008), but again the results here are uncertain.

Very few birds were detected at the wind farm site in the winter, so it is unlikely that the wind turbines have any impact on bird populations during the winter.

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