Avian Baseline Study & Environmental Impact Assessment Glen Dhu Wind Farm

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Executive Summary

This report presents the findings of a baseline study and an environmental assessment of the potential impact of the Glen Dhu Wind Farm on birds.

Bird surveys were conducted over a 13-month period from June 2007 to July 2008. These consisted of a preliminary assessment (June-July 2007) and four seasonal components; autumn migration (August-October 2007), winter season (November 2007-March 2008), spring migration (April-May 2008), and peak breeding season (June-July 2008).

The cold winters and cool summers, and fertile and well-drained soils have favoured the growth of a predominant hardwood forest on the Pictou-Antigonish Highlands. A fully mature, climax forest in this area consists of shade-tolerant Sugar Maple, Yellow Birch, and Beech. Today, forestry is the main human activity in the study area, followed by deer hunting, recreational vehicle use, and hiking.

Research methods varied according to the season and to meet the multiple objectives of a baseline study and risk assessment. During the autumn and spring migration periods, three types of surveys were conducted; migration stop-over, nocturnal passage, and diurnal passage. The winter survey gauged the number of birds overwintering in the study area and their distribution in different woodland habitats. The breeding bird survey measured the number and species of birds that nest in the study area with particular attention to their habitat requirements.

In total 3,650 individual birds of 80 species were recorded during the autumn migration stop-over surveys. The highest numbers occurred during the periods, August 28 to September 6 and October 7 to 16. The diversity of bird species was highest during the 30-day period from August 28 to September 26. The highest counts were achieved when wind was calm, or with light winds from the northwest, west, and north. More birds were seen in the most disturbed habitats and with the most "edge", i.e., the "clearcut, regenerating, and early succession" habitat type. Twenty-four species demonstrated significant habitat relationships.

The before dawn descent of Hermit Thrushes was the most distinctive aspect of the autumn nocturnal passage counts. This species was heard on ten of sixteen nocturnal counts with the number of thrush notes heard ranging from 1 to 89 from September 11 – October 19. The highest number of calls was heard on October 1st.

Nine species of hawks and eagle were observed during the autumn diurnal passage surveys. These occurred in small numbers and irregularly at all observation points throughout the autumn. Thus, the study area does not appear to be an important site for diurnal raptor passage during the autumn migration. The most common of these raptors, the Bald Eagle, consisted of a local population that is not migratory.

The Common Raven, also a local population, was the most frequently seen passerine species during the diurnal passage surveys. For woodpeckers and small to medium-sized passerines (i.e., excluding ravens), 49% of observations recorded a flight direction of west, compared to 18% for east, 13% for north, and 20% for south. This pattern of flight direction held for all wind directions.

Few birds wintered on the Pictou-Antigonish Highlands, especially on the higher elevations where winter conditions are the most extreme. The density of birds in winter increases with lessening amounts of edge and with rising amounts of forest cover. Thus clearcuts and early succession forest had the smallest densities of birds (0.55/hectare) and mature deciduous the largest

(1.77/hectare). Only 19 species of birds were seen in the study area during the winter period. The most common bird was Black-capped Chickadee, occurring in all habitats but most abundantly in mature deciduous.

In total, 4,916 individual birds of 75 species were recorded during the spring migration stop-over surveys. The data suggests that spring migration stop-over in the study area consists of three waves of decreasing intensity. In mid-April, the first wave in is dominated by American Robins, Dark-eyed Juncos, and Song Sparrows. The second wave in late April and early May consists largely of Yellow-bellied Sapsuckers, Northern Flickers, Ruby-crowned Kinglets, Hermit Thrushes, Yellow-rumped Warblers, and White-throated Sparrows. The third wave in mid to late May is made up of flycatchers, forest warblers, and Red-eyed Vireos. The peak in total birds occurred from April 11-30 with a peak in species diversity from April 21-30. The highest mean counts occurred when the night wind was from the southeast at 12 to 19 km/hour on average, the second highest mean counts when winds were from the south at 7 to 11 km/hour. Habitat relationships with birds were not as strong in the spring migration stop-over as in the autumn. One can discern, as in the autumn, the influence of the edge effect as mean total birds tends to decrease with decreasing edge and increasing forest canopy; from clearcuts to mature deciduous forest. Seventeen species demonstrated significant habitat relationships during the spring migration.

The nocturnal passage counts were much lower in the spring than in the fall. Very few Hermit Thrushes were heard, and the pattern of their sounds was different.

Diurnal passage migration was also much less in the spring than in the fall. No birds were seen in twenty-four percent of the one-half hour observation blocks compared to only eight percent in the autumn. The mean number of birds seen per block was 3.00 birds in contrast to 7.08 birds in the autumn. Hawks, water birds, woodpeckers, and passerines were less diversified by species and less abundant in total numbers than in the autumn. Only the Red-tailed Hawk was seen more frequently in the spring (24% of time blocks) than in the autumn (12%). The locally resident Bald Eagles and Common Ravens were present in comparable numbers and frequency during the spring. Sixty-seven percent of woodpeckers and passerines were flying northeast or east. It is worth noting that the most common flight direction during the daytime in both the autumn and spring was 45 degrees from the prevailing nocturnal flight direction described for Maritime passerines, that is, west rather than southwest and east rather than northeast.

The breeding season surveys consisted of three components: crepuscular and nocturnal birds, early breeders, and peak season breeders.

Twilight and nocturnal area searches detected breeding birds that are not normally seen during the daytime. These include American Woodcock, Great Horned Owl, Barred Owl, and Northern Saw-whet Owl. The three owl species were heard in a mix of forest habitats with the Barred Owl the most associated with mature Sugar Maple-Yellow Birch-Beech habitat. The American Woodcock was found almost exclusively in clearcut and regenerating areas, often near a wet area.

Bird species that began their nesting season before June 1 were considered early breeders in this study. The twenty-four point counts along the migration stop-over transects were used to survey these birds. The most abundant early breeder was White-throated Sparrow with a mean of 2.71 per point count station and occurring at 92% of the stations. It was closely followed by the American Robin with a mean of 2.54 and occurrence of 92%. Species occurring on two-thirds or more of the point count stations were in rank order, Ovenbird, Yellow-rumped Warbler, Dark-eyed Junco, Magnolia Warbler, Blue Jay, Black-capped Chickadee, Hermit Thrush, and Yellow-bellied Sapsucker.

There were significant differences in the use of habitat types by total number of early breeders. Highest counts were obtained in clearcuts, and early succession forest followed by mid to late succession mixed aged mixed forests. There were no significant differences between particular habitat types. Nine species of early breeders demonstrated significant habitat relationships.

The peak breeding survey consisted of 204 point counts dispersed throughout the study area. Each point count was surveyed one time between June 3 and July 3. Red-eyed Vireo was the most common bird during the peak breeding season and was detected on 74% of all point counts. The White-throated Sparrow, American Robin, and Ovenbird maintained their ranking among the top four most common species and were detected on 57-61% of point counts. The Black-throated Green Warbler was also seen or heard on 57% of point counts. There were significant statistical differences in the total number of peak breeding birds according to habitat type. The highest counts were obtained on residential and agricultural habitat, followed by disturbed forest habitat to mature forests in decreasing order. There were also significant differences between individual habitat types. The clearcut and early succession habitat had significantly greater number of birds than mature coniferous and deciduous. The clearcut and early succession alongside mature deciduous habitat and the mid to late succession habitat both had greater total birds than mature deciduous. Species diversity follows the same pattern relative to habitat use. There were significant differences in species diversity at the overall habitat level of analysis and between specific habitat types. Clearcuts and early succession forests were significantly more diverse in bird species than mid to late succession, mature coniferous, and mature deciduous. Clearcuts and early succession forests alongside mature deciduous, mid to late succession forests, and residential and agricultural land were more diverse than mature deciduous. Fifteen species showed significant preference for specific habitat types. For two species, their numbers were significantly higher in one habitat type than all five other habitats. These were Ovenbird for mature deciduous and Black-throated Green Warbler for mature coniferous. Among the other species showing statistically strong preferences for specific habitats were Alder Flycatcher, White-throated Sparrow, Song Sparrow, and Common Yellowthroat for clearcuts and early succession forests, Least Flycatcher, Mourning Warbler, and Common Yellowthroat for clearcuts and early succession alongside mature deciduous, and Red-eyed Vireo and Least Flycatcher for mature deciduous.

The mean number of birds seen at each of the point count stations was considerably higher in the early breeding season compared to peak breeding; nearly twice as high. This is due to the fact that the early breeding point counts in April and May were conducted repetitively. The mean of total of birds was highest with calm winds (13.38) and lowest at wind speeds up to 20-29/km/hr (11.25), but these differences proved to be not statistically significant; nor were the effects of visibility (fog). The number of birds detected was significantly less in light rain compared to no precipitation (8.69 vs. 12.23). The time of morning, from sunrise to 4 hours after sunrise, did not have significant effect on the mean total birds detected.

In total from June 2007 to July 2008, 90 species of breeding birds were found in the study area of which 28 were possible breeders, 34 probable breeders, and 28 confirmed breeders using the criteria of the Maritime Breeding Bird Atlas.

Both the nocturnal passage and diurnal passage surveys in the autumn point to the need to evaluate the risk to migrating and commuting bird for collisions with wind turbines.

The nocturnal passage surveys provided evidence that the American Woodcock and Hermit Thrush are descending to the ground in the dark from one hour to one-half hour before sunrise during their autumn migration. Those birds descending to ground in the immediate vicinity of wind turbines are thus potentially at risk from collisions with the rotating blades. It was also noted that these descents are of the greatest magnitude under calm wind conditions. Thus there might be a natural mitigation of this risk as the blades may not be rotating when the numbers descending are highest. There is a need to understand this phenomenon more completely. An acoustic monitoring study should be conducted in the autumn of 2008 to evaluate further the potential risk of collision for these species and possible mitigation measures.

Wind turbines may also pose a threat to the American Woodcock during the time they are engaged in breeding flight songs. Male woodcocks will use almost any size open, relatively flat, area as a display ground, sometimes far from their preferred diurnal habitat. During the first few years after construction, it may be necessary to cover open areas with brush or find other ways to discourage woodcocks from using the cleared areas around newly constructed wind turbines as a platform for their flight songs.

During the diurnal passage the species most likely to be flying at the height of the blade sweep are Bald Eagle (38% of observations), Sharp-shinned Hawk (33%), Red-tailed Hawk (33%), Common Raven (22%), warbler species unspecified (15%), American Robin (14%), passerine species unspecified (7%), and Yellow-rumped Warbler (6%). Of particular concern among these species are Bald Eagle and Common Raven. They are present throughout the spring and autumn and were among the species most often seen during the diurnal passage surveys, particularly the latter. The analysis suggests that soaring birds such as diurnal raptors, gulls, and corvids are more likely to be flying at blade height when the turbines are placed near steep cliff edges. In addition, the data suggest that Bald Eagles are the most likely to fly at blade height due both to vertical air flows and a higher flying altitude, with or without air current assistance. Additional studies documenting the overall and seasonal abundance of raptors and corvids in the study area and more detailed behavioural studies at specific proposed turbine sites in the autumn of 2008 would further define the risks involved. Until additional research becomes available, serious consideration should be given to setting back wind turbines from steeply-inclined ridges where updrafts are most conducive for soaring. Again, the optimal set-back distance requires further study.

The two species listed as "special concern" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Peregrine Falcon and Rusty Blackbird were seen only once each in the study area in the autumn migration. The three species listed as "threatened" by COSEWIC were seen during the breeding season. These are Chimney Swift, Olive-sided Flycatcher, and Canada Warbler.

Two Chimney Swifts were seen together in flight in early July 2008 at the extreme southwest corner of the study area. Generally Chimney Swifts nest in towns or cities, and it is most likely these were foraging birds. While it is possible that Chimney Swifts will nest in large dead trees in mature forests, there is not enough evidence at this time to warrant a consideration of the possible impacts of a wind farm on this species.

The Olive-sided Flycatcher was seen on 8 occasions during the spring migration and on 12 breeding point counts. This suggests the species is fairly widespread in the study area in suitable nesting habitat; clearcuts and early successional forests. The existence of large snags in clearcut or burned areas adjacent to forests appears to be a critical component of this species habitat. The causes of decline of this flycatcher are unknown and are puzzling since the availability of suitable habitat is increasing. Due to the unknown causes for the decline in the Olive-sided Flycatcher, it is difficult to assess the impact of a wind farm on its population in the study area. The construction of a wind farm should not negatively affect the habitat available to Olive-sided Flycatchers. Where wind turbines are placed in habitats suitable for this species, large snags should be cut down for at least 150 metres around their perimeter. This will help lessen the risk of collisions with rotating wind turbine blades.

The Canada Warbler was seen on four occasions. The first two were during the breeding season in 2007; one a single individual near Vamey's Lake and a pair in the southern portion of the study area. In 2008, a male accompanied by a female was singing near the edge of Vamey's Lake in their spring migration period, and a single male in the exact same location as in 2007 in the southern portion of the study area. The breeding habitat of the Canada Warbler is moist, mixed coniferous-deciduous forest, with a well developed understory, often near open water. The decline of Canada Warbler is believed to be related to the loss or degradation of nesting habitat. Studies in New England and the Middle Atlantic States reported the Canada Warbler was one of the top five species most sensitive to forest fragmentation. At a more site-specific level, studies have shown that the clearing of brush and understory in forests, as well as grazing by ungulates, negatively affects their population. The clearing of land for turbine construction is not likely to impact the Canada Warbler since turbines are built on higher ground, way from moist woodlands. The construction or improvement of roads and the construction of ancillary structures should avoid removing forest understory in wet areas.

This study shows repeatedly the importance of a variety of forest habitat types for bird populations. Cleared and early successional forest habitats with a high degree of edge are critical for many birds during the migration and breeding periods. Mid to late successional and mature coniferous forests are the preferred habitat of a number of the most common breeding birds. Deciduous forests may be essential as overwintering areas and provide the habitat of the first and fourth most abundant birds in the study area during the peak breeding period, Red-eyed Vireo and Ovenbird. At this time, the greatest threat to the mature Sugar Maple-Yellow Birch-Beech hardwood forest and associated bird habitats on the Pictou-Antigonish Highlands is from harvesting for firewood. Given that wind farm development would take place in a variety of early to late successional forest areas, the loss of mature deciduous woodlands would likely be small, especially in comparison to forestry operations. For those species listed as "Yellow" status by the Province of Nova Scotia or as a "Priority Species" by Partners in Flight, recovery depends on a broad, concerted effort by all forest users. This is the approach recommended by Partners in Flight. Their plan focuses on conserving and restoring the populations of the Canada Warbler and Black-throated Blue Warbler since in doing so, the situation of all other stable or declining species would improve as well.

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Introduction

This report presents the findings of a baseline study and an environmental assessment of the potential impact of the Glen Dhu Wind Farm on birds.

The proposed Glen Dhu Wind Farm is located on the Pictou-Antigonish Highlands between New Glasgow and Antigonish, Nova Scotia. The proposal calls for the development of up to 75 wind turbines with a total 100+ megawatt capacity. The study area for this assessment thus encompasses a large area of approximately 5,500 hectares. The actual wind turbines placements and associated infrastructure, when completed, would occupy closer to 100 hectares, spread over the entire study area. The location of the study area is outlined in red in Figure 1 (click blue hyperlink to view figures and tables, and then click blue "return to text" link to continue reading document).

Bird surveys were conducted over a 13-month period from June 2007 to July 2008. These consisted of a preliminary assessment (June-July 2007) and four seasonal components; autumn migration (August-October 2007), winter residency (November 2007-March 2008), spring migration (April-May 2008), and peak breeding season (June-July 2008).

This report on the survey results is written both for those people who know much about birds and their ecology and those people who may have a limited knowledge of birds but are interested in the environmental dimensions of wind farm development. Throughout the text, hyperlinks are provided to an online bird guide of the Cornell Laboratory of Ornithology for those who wish to know more about the species being discussed in the text.

In order to begin an avian environmental assessment of a wind farm site, it is necessary to describe the basic social and ecological context in which this development would take place.

The Natural History of the Glen Dhu Wind Farm Site

An outline of the natural history of the Glen Dhu Wind Farm site is important for understanding some essential dimensions of the autumn migration of birds in the area. Geological and cultural histories greatly influence forest habitats and these, in turn, affect the use of the area by migrating birds. The information in this section is based on Davis and Browne (1996) unless otherwise noted.

Geological History

The geological history of the Glen Dhu Wind Farm site begins with the volcanic activity of the Pre-Cambrian period that ended some 540 million years ago. Remnants of this time can be seen in the neck of an ancient volcano at Sugarloaf Hill just south of Malignant Cove and in the lava rock on the beaches at Arisaig Point. During the Silurian and Devonian periods (443 to 354 million years ago), the area was covered by a shallow sea in which marine sediments were deposited over the base rock. The fossils that can be easily seen at Arisaig Provincial Park; the brachiopods, trilobites, crinoids, cephalopods, ostracods, and bryozoans; demonstrate the rich diversity of life that characterized this period.

During the late Devonian period, a process of mountain building, known as the Acadian Orogeny, lifted these sediments along a number of fault lines to form the Pictou-Antigonish Highlands. This particular mountain building process included the Northern Appalachians from New York to Newfoundland and the Gaspé. It is upon these Highlands that the Glen Dhu wind farm site is located. The largest of the fault lines is the Hollow Fault which extends from Cape George to New Glasgow. Between Bailey's Brook and Malignant Cove, the Hollow Fault today forms a straight valley with a high and steep forested cliff on its southern side. This valley is known as the Hollow or *Glen Dubh*, the Gaelic words for Dark Valley (see Figure 2). It is after this scenic landscape that the wind farm is named.

During the Carboniferous period, the Pictou-Antigonish Highlands became an island surrounded by the sea. With time the sea receded, and erosion carved the various subsidiary fault lines of the Highlands into valleys. Marshy Hope, along the Trans-Canada Highway, is one example of these valleys. The elevation of the Highlands ranges between 100 and 300 metres above sea level providing spectacular views of the Northumberland Strait and surrounding countryside as exemplified in Figure 3.

Water and Soil

Unlike much of Nova Scotia, there are very few lakes and ponds on the Pictou-Antigonish Highlands. There are, however, many rivers and streams which follow a branching pattern in draining to the sea. The water is somewhat acidic with a ph that averages 6.4. Soils are relatively shallow, shaly loams with substantial levels of organic material in the surface layer.

Climate

Because of their elevation, the Pictou-Antigonish Highlands experience longer winters, lower temperatures and greater daily temperature ranges, greater precipitation and more snowfall, and shorter growing seasons than in surrounding lowland areas. Freezing temperatures last from November to April, precipitation exceeds 1200 mm and snowfall exceeds 300 cm per year. The Highlands experience higher relative humidity and hence more cloudiness than the lowlands, and of practical importance to this study, has greater exposure to winds. Figure 4 shows how the higher humidity on the Highlands can result in cloudy conditions when it is sunny elsewhere.

Plants and Forest

The cold winters and cool summers, and the fertile and well-drained soils have favoured the growth of a predominant hardwood forest on the Pictou-Antigonish Highlands. A fully mature, climax forest in this area consists of shade-tolerant Sugar Maple, Yellow Birch, and Beech. The Highlands represent the most northeastern distribution of this type of forest in North America. Figure 5 shows a mature Sugar Maple-Yellow Birch-Beech woodland in the study area.

When disturbed by fire, disease, or logging, this forest will regenerate first with shade intolerant species such as red maple, white and grey birch, and aspen. As forest succession continues more shade tolerant species such as spruces and fir intrude into the understory. At mid-successional stages, shade tolerant species form a mixed hardwood-softwood forest. If left undisturbed, the forest will in most cases return to a mature Sugar Maple-Yellow Birch-Beech forest once again. Plants of the Alleghanian floral element, which is usually found further south, are associated with this forest.

Animals

The hardwood forest of the Pictou-Antigonish Highlands provides habitat for many wildlife species. The fertile soils support a diverse fauna which together with rotting logs provide habitat for insects, salamanders, wood frogs, small mammals, woodpeckers, and denning bears. The area, especially the disturbed portions of forest, provides good habitat for deer and moose. The Highlands provide breeding habitats for a wide variety of bird species in which the White-throated Sparrow, American Robin, Red-eyed Vireo, and Magnolia Warbler are the most abundant (Kearney 2007). On a calm night on the Highlands, the air is filled with the calls of Coyotes and Barred Owls.

Culture

The Mi'kmaq, the aboriginal people of Nova Scotia, have inhabited the land for at least eleven thousand years. At the time of European contact, there was a Mi'kmaq settlement near the study area at Merigomish. The Antigonish-Pictou Highlands were likely a hunting area for moose during the winter months. There were a few French settlers on Big Island, near Merigomish, in the early Eighteenth Century (Patterson 1877). A large immigration of Highland Scots to the area began in the 1770s during the Highland Clearance in West Scotland. The Scots settled first in the town of Pictou and in 1783, the settlers arrived in Merigomish and Arisaig. During the first half of the Nineteenth Century, as farmland became less available in the coastal areas, small farms were established on the Highlands. Because of the short growing season and marginal nature of the lands, these farms were eventually abandoned, and the cleared lands reverted to the Sugar Maple-Yellow Birch-Beech forest.

Today, forestry is the main human activity in the study area, followed by deer hunting, recreational vehicle use, and hiking. The area is largely uninhabited except for the seasonal use of hunting camps and summer cottages. Forestry involves the logging of both softwood species for pulp and paper production and hardwood species for firewood. While pulp and paper production was the mainstay of the forest industry in the area, there is, according to local woods workers, increasing demand for hardwoods for firewood. This is the result of a shift in energy consumption patterns away from non-renewable petroleum products to renewable sources such as wood. At the same time, economic conditions in the pulp and paper industry are currently at a low due to high energy costs, unfavourable foreign exchange rates, and decreasing demand. It is reported by woodlot owners that when they clear cut the Sugar Maple-Yellow Birch-Beech forest, it is replanted two to three years later in softwood species and subsequently treated with herbicides to prevent natural succession to a hardwood forest. It remains to be seen if this management practice will continue if economic conditions, favouring the production of hardwoods, keep on their current course. Figure 6 shows a clear cut softwood forest and a stack of sugar maple logs destined for firewood.

The combined activities of forestry and hunting in the study area have, over the decades, led to the development of an extensive network of woods roads. The map in Figure 7 shows the relative scarcity of human habitations in the study area compared to surrounding areas in the lowlands, together with a system of woods roads that matches the branching pattern of the numerous streams and brooks. This road network has led to a patchy forest composition, as it has allowed wood harvesters access to small blocks of forest for logging. Two power lines that run through the study area are the other marks of human infrastructure on the proposed wind farm site.

In summary, the Glen Dhu Wind Farm site on the Pictou-Antigonish Highlands is somewhat isolated from the mainstream of human social and economic activities in the surrounding populated areas in the lowlands. On the other hand, it cannot be classified as a "wilderness" area. The Wildlife Conservation Society Canada in collaboration with the project, "Two Countries, One Forest", has developed quantitative measures of the human ecological footprint in the Northern Appalachian/Acadian Ecoregion. As shown in Figure 8, most of the Glen Dhu Wind Farm site ranks from 11 to 40 on a scale of 0 to 100 relative to the intensity of the ecological footprint from human development activities.

Research Methods and Cautions

Research methods varied according to the season and to meet the multiple objectives of a baseline study and risk assessment.

During the autumn and spring migration periods, three types of surveys were conducted; migration stop-over, nocturnal passage, and diurnal passage. Surveys of migration stop-over determine the number and kinds of birds that land in the study area during their period of migration and the importance of different habitat types in supporting the food and other needs of migrating birds while in the area. Surveys of nocturnal passage migration provide a measure of the number and species of birds that migrate over the study area at night. Surveys of diurnal passage migration examine the number, species, altitude, and behaviour of birds flying over the studying area during the daytime. There is not always a clear distinction between these three dimensions of migration. Birds seen on a migration stop-over survey may have alighted only momentarily while migrating during the day time. Birds that have migrated all night can sometimes be seen flying in great numbers during the early hours of a diurnal passage count as they attempt to gain their bearings or seek suitable feeding areas.

The winter survey gauged the number of birds overwintering in the study area and their distribution in different woodland habitats.

The breeding bird survey measured the number and species of birds that nest in the study area with particular attention to their habitat requirements. This survey was supplemented by counts of bird sounds made by species that are usually detectable only at night or in the twilight hours.

In conducting an environmental assessment of the impact of a wind farm on migrating birds, migration stop-over counts provide an estimate of the overall magnitude of bird migration in the area, and the possible impact of the wind farm on the habitats available for these birds while migrating. While nocturnal and diurnal passage counts also provide a measure of the importance of the area for migrating birds, it is also a critical component for evaluating the risk to birds from collisions with the rotating blades of wind turbines. The breeding and winter surveys provide important information on the numbers, diversity, and habitat use of bird species that permanently reside on the site or in nearby areas, that travel from more southerly areas to breed in the area, or that arrive from more northerly areas to spend the winter on the Pictou-Antigonish Highlands.

Migration Stop-over Surveys

Four transects were established in the study area; one in the northern section, two in the middle, and one in the southern section. Each transect was also located on a property designated as a potential site for the placement of wind turbines. A transect was 1500 metres (m) in length and consisted of three segments of 500 m with different habitat types dominating in each segment. Each transect also had six point counts. The point counts were distributed at stops located at 100 m, 350 m, 600 m, 850 m, 1100 m, and 1350 m along the length of the transect. All birds seen or heard within the distance bands of <50 m, 50-100 m, >100 m, and flying overhead were recorded separately. The placement of the transects is shown in Figure 9. Transects 1 and 3 are located on a westerly section of the plateau of the Pictou-Antigonish Highlands. Transects 2 and 4 are located on steep inclines or near the edge of a ridge.

During the autumn migration, each of the four transects was surveyed once from August 28 to 31. One transect was completed each day from September 2 to 21. From September 22-October 23, each of the four transects was completed 5 times. The transect surveys began at sunrise. Each took approximately 2.5 hours to complete while each point count was precisely 10 minutes in duration.

During the spring migration, each of the four transects was surveyed four times between April 8 to May 7. One transect was completed each day from May 8-31 (except for 5 days when there was heavy rain or dense fog). Each of the four transects was surveyed once between June 1-9. The spring transect surveys were begun one-half hour later than the autumn surveys since many birds became active later in the morning with the cold dawn temperatures and sometimes snowy conditions during the spring.

It is necessary to add some words of caution about the precision of transects and point counts during the migration season. Survey methods are an attempt to measure bird populations in a dynamic and complex situation. During the migration periods, birds can be moving rapidly and concentrated in flocks that can skew results in one direction or another if they are or are not detected. Different species of birds can have behaviours that make them more or less easy to detect than other species. Sudden changes in weather conditions can result in large-scale movements of birds that can last for a very short period and thus easily missed altogether if one is not at the right place at the right time.

Survey methods must thus try to account as much as possible for these "vagaries" of bird migration. Transects are a common method of measuring bird populations during the migration season, and a variation on the "fixed-width line transect" method is the one recommended by the Canadian Wildlife Service (Environment Canada 2007) for the environmental impact assessment of wind farms. In this method, all birds seen within distinct distance bands from the observer walking the transect line are recorded. Ideally, fixed-width line transects work best when coefficients of detectability for each species are first determined by conducting initial transects that measure the distance of each individual bird from the observer and then these coefficients are used to adjust survey results (Emlen 1971).While all line-transect methods have been shown to have significant biases when compared to more intensive and costly survey methods, they remain a viable alternative for environmental impact assessments subject to time constraints (Tilghman and Rusch 1981).

Point counts are the most common survey method for measuring populations of breeding birds and like transects, provide the most accurate results relative to the time and cost invested in the survey (Ralph, Droege, and Saur 1995). Point counts are sometimes used for migration and overwintering studies when there is an interest in the importance of habitat to the migrating or overwintering birds (Lynch 1995; Wang and Finch 2002; Wilson, Twedt, and Elliott 2000).

Using both the line transect and point count methodologies in this study was an attempt to gauge both the main movements of birds through the study area and the use of habitats by birds that stop briefly or spend several days or more. At the same time, an analysis of the birds counted within the 50-m distance band of both the transects and point counts will, in most cases, produce the most reliable results. Nonetheless, some species such as Blue Jays, Common Ravens, and Northern Flicker can sense well in advance the approach of the observer and will leave the 50-m band, or are easily detectable at greater distances than most birds. Thus the greater than 50-m bands will be important in some dimensions of the analysis.

Diurnal Passage Surveys

Diurnal passage surveys were conducted from eight different observation points in the study area. The choice of the observation points was based on the extent to which they provided as close as possible to a 360 degree extended view of the air space around the observation point, the probability this space was located along a migration or commuting corridor, and its proximity to a potential site for the placement of wind turbines. Most of the diurnal passage surveys were conducted from mid-morning to early afternoon, the time when warm air thermals rise from the land. The movements of such birds such as raptors (hawks) and corvids (ravens) are often timed so they can ride these thermals. Diurnal passage surveys were also conducted periodically in the early morning and mid to late afternoon to detect the passage of other species.

The diurnal passage surveys consisted of a number of 0.5 hour blocks of observations. All birds seen or heard during this time were recorded according to their species, location and altitude relative to the observer (not to the point over which they were flying), flight direction, and number of individuals. For each bird, a note was made as to whether the bird was sufficiently close and at the right altitude to pass through the sweep of a turbine blade if a turbine(s) was located at the observation point. During the time of the study, the design of the turbines proposed for this site had a blade sweep between 50 and 125 m in height. In total, 130 observation blocks were completed between August 29 and October 23, and 50 observation blocks April 7 and June 6. The difference in the amount of time spent in diurnal passage surveys between these two seasons is indicative of the greater intensity of autumn passage compared to the spring.

Nocturnal Passage Surveys

Nocturnal passage consisted in listening for bird calls within the one half hour before first light, that is, beginning at one hour before sunrise. This is the time that many passerines (songbirds) descend from higher altitudes in search of landing locations. All bird sounds heard in the half-hour block were counted and when possible, identified to species or family groups. It is important to note that each sound was counted and that individual birds can make a sound more than once when flying overhead.

These auditory counts were originally conducted on an experimental basis for gauging the possible significance of nocturnal movement of birds on the study site. Originally, three nocturnal passage surveys were to be conducted during the autumn migration but the results of these three counts indicated that more surveys were warranted. In total, sixteen nocturnal passage surveys were conducted from September 3 and October 23 and five surveys from May 4-26.

A more thorough monitoring of nocturnal passage would require a greater number of counts and during more periods of the night, aided by computerized acoustic monitoring, thermal imaging, or radar studies.

Winter Survey

The Pictou-Antigonish Highlands in winter are characterized by deep snow, high winds, low temperatures, and hence, dangerous wind chill factors. Access to the higher elevations is possible only by snowmobile. These higher elevations on the upper plateau of the Glen Dhu Wind Farm site were surveyed in the earlier part of the winter before the heavy snowfalls. During the latter half of the winter, the lower elevations that could be safely accessed by walking were surveyed.

The winter survey consisted of standardized area searches in which all the birds in a specific area were counted. The standardized area search is a variation of the fixed-width transect in that birds are counted within distance bands from the walking observer. This enables a certain level of quantification of the abundance of birds in different habitats. However, unlike the fixed-width transects, individual birds were counted on both the outbound and inbound length of the area search. This is possible in winter since there are so few birds that there is little risk of counting individual birds more than once.

From November 1 to March 31, fifteen standardized area searches were conducted in the study area (4 in November, 2 in December, 2 in January, 4 in February, and 3 in March). The outbound length of the area search varied between 1000 and 1900 metres.

Breeding Bird Survey

Nesting in the study area can begin as early as the last week of February (Great Horned Owl) and first week of March (Common Raven) and continue to mid-September (Red-eyed Vireo, American Goldfinch and others). The vast majority of birds, including many of the early and late breeders, are engaged in nesting activities during the months of June and early July. Thus the weeks extending from June 1 to July 15 are referred to in this study as the peak breeding season.

During the peak breeding season, 204 point counts were conducted in the study area. The time of morning for conducting point counts was from one-half hour before sunrise to 4 hours after sunrise from June 1-21. Between June 22 and July 3, point counts were not made more than 3 hours after sunrise since the regularity of singing declines earlier in the morning. No point counts were made after July 3rd when the singing of many birds dropped off dramatically.

Each point count was classified into one of 6 habitat types; 1) clearcut or early succession forest, 2) clearcut or early succession alongside mature deciduous forest, 3) mid-to late succession (mixed) forest, 4) coniferous forest, 5) mature deciduous forest, and 6) agricultural or residential area.

Weather conditions on a potential wind farm pose some problems for obtaining valid point count data. Wind makes it difficult to hear birds. This problem is compounded in a heavily forested area due to the rustling of leaves. Fog makes it difficult to see birds and depresses bird activity. Birds also become inactive in heavy rain. Thus the Glen Dhu Wind Farm site due to its windy conditions and high elevation (hence frequent fog) requires some flexibility in choosing acceptable conditions for conducting point counts. Point counts were not made when wind conditions exceeded 29 km/hour, when visibility was less than 100 metres, or precipitation was greater than a light rain.

The point counts conducted as part of the spring migration stop-over surveys served as a measure of the abundance of early breeders. The start of the breeding period, as opposed to migration period, of these early nesters was determined by using the data of the Maritime Breeding Bird Atlas (http://www.mba-aom.ca/english/breeding_dates.pdf).

Three area searches were made for crepuscular and nocturnal species during the period from April 15-21. There was no attempt to quantify this auditory data but the location of the breeding calls of these species was recorded with a GPS device.

It is important to point out the benefits and limitations of point counts. As mentioned previously in reference to migration stop-over surveys, the detectability of birds can greatly influence survey results. Point counts made during the breeding season are greatly skewed toward detecting singing males. Many birds are probably not seen or heard. Studies estimate that point counts typically detect from 50-80% of the birds present depending on the length of each count or the number of counts performed repeatedly at the same station (Cyr, Lepage, and Freemark 1995; Petit et al. 1995; Barker and Sauer 1995) To detect all of the species and individuals present in forested areas, sampling time at each station was found to be 100 minutes (Buskirk and McDonald 1995). Thus trade-offs must be made among the amount of time sampling at each point, the size of the area to be sampled, and the number of habitats surveyed. Point counts of 10-minute duration thus do not provide good estimates of the absolute population of birds, but as noted by Petit et al. (1995), studies have shown that the mean number of birds of each species detected using these shorter point counts proportionately correspond well with measures of absolute numbers. Hence, they can be used to estimate the relative abundance of the species present. Moreover, if one assumes that a constant fraction of the total population is counted in particular habitats or from one year to the next, then point counts can provide a useful index of habitat use, population trends over time, and responses to changing habitat (Pendleton 1995; Dawson, Smith, and Robbins 1995; Ralph, Droege, and Sauer 1995). Thus the objective of this breeding survey is to provide baseline data to monitor population trends both generally and in relation to habitat changes over time.

Weather Data

Weather observations were taken at the beginning of each transect segment, at each point count, at the start of each standardized area search, and at the beginning of each half hour block in the diurnal and nocturnal passage counts. These observations included temperature, sky cover, cloud type, precipitation, wind direction and speed, and visibility.

Hourly weather data was downloaded for the Caribou Island weather stations for the night before each autumn and spring migration survey. The Caribou Island weather station is located between 35.5 and 41.6 kilometres from the transects and observation points.

Statistical Analysis

The survey data was subjected to a variety of statistical analyses. Dr. Ian McLaren at Dalhousie University provided valuable assistance in conducting the automated back-ward stepping general linear models for the main effects and interactions of weather, habitat, and seasonality variables on the total number of birds in the stop-over surveys. The remainder of the statistical analyses was conducted using the Statistical Package for the Social Sciences (SPSS), Systat, and Excel spreadsheets. The interpretation of all statistical results is that of the author.

Autumn Migration

Overview

The autumn migration of birds in Northeastern Nova Scotia can be first detected in early July with the passage of sandpipers on their journey from Arctic and boreal nesting grounds to the Gulf of Mexico, the Caribbean, Central and South America. These migrating birds occur primarily in coastal areas in Nova Scotia. Many other species, including local nesting birds, begin their southward journey in August with the peak fall migration occurring in the last week of August to early October. By mid-October and early November, many of the birds seen in the study area have arrived from other areas to spend the winter there or to move from there to more southerly or coastal areas later on if food supplies become scarce.

Migration Stop-over

In total 3,650 individual birds of 80 species were recorded during the migration stop-over surveys. These data are used to examine the effects of seasonality, daily weather conditions, and habitat, on the birds migrating through the study area.

The Effects of Seasonality on Migration Stop-over

The number of birds recorded on the migration stop-over surveys was divided into ten-day intervals. The highest numbers occurred during the periods, August 28 to September 6 and October 7 to 16. Figure 10 represents the number of individual birds seen per transect at all distances from the observer (<50 m, 50-100 m, >100 m, and flying overhead) and gives a sense of the overall magnitude of bird activity during the migratory periods. Figure 11, however, represents only the birds counted within 50 m of the observer for each of the three segments (including their point counts) that make up a transect. As discussed in the research methods, the 50 m band within segments and point counts are, for most species, a more representative indication of bird abundance. The small differences in mean total birds per period and the high degree of variance in those means indicate that seasonality did not have a significant effect on the number of birds migrating through the study area. This conclusion was derived using both a one-way analysis of variance (ANOVA) and a backward stepping general linear model (GLM). The latter method also confirmed that seasonality was not a significant effect when compared to other factors such as weather and habitat.

The diversity of bird species was highest during the 30-day period from August 28 to September 26. Figure 12 shows mean total species per day at all distances while Figure 13 presents the mean total species per segment within the 50 m band. Using a univariate GLM and backward stepping GLM, seasonality was a significant and the most powerful effect on species diversity compared to weather and habitat.

The actual composition of species diversity and the mean number of each species by 10-day interval is given in Table 1. For many species, one can discern in this table a clear pattern of their mean numbers either increasing or decreasing during the migration period. However, using a one-way analysis of variance (ANOVA), only 10 species demonstrate a statistically significant seasonality pattern for counts made in the <50 m transect segments. These species are Hairy Woodpecker, Red-eyed Vireo, Winter Wren, Golden-crowned Kinglet, Magnolia Warbler, Black-throated Blue Warbler, Black-throated Green Warbler, Blackburnian Warbler, Ovenbird, and Common Yellowthroat (see Figure 14). Most of these species are decreasing during the migration period, except for Hairy Woodpecker and Golden-crowned Kinglet, which are increasing. It is also important to note that all of these species nest in the Sugar Maple-Yellow Birch-Beech and coniferous woodlots of the Pictou-Antigonish Highlands. Thus, a decreasing seasonal pattern may represent as much the timing of their departure as it is an indication of transients migrating through the study area.

As previously mentioned, some species are more likely to be or more easily detected at distances greater than 50 m due to their behaviour patterns and vocalizations. A one-way ANOVA of transects at all distances from the observer revealed five additional species having a statistically significant seasonal pattern. These are American Crow, American Robin, Cedar Waxwing, Yellow-rumped Warbler, and American Goldfinch (see Figure 15). While many people might think of crows as permanent and largely non-migratory residents throughout Nova Scotia, they are in fact an uncommon bird on the Pictou-Antigonish Highlands. Their presence there in the autumn thus most likely represents a seasonal movement of some kind.

The Effects of Daily Weather on Migration Stop-over

The effects of weather on the number of birds migrating in the study area were explored by using automated backward-stepping general linear models. In this statistical procedure, the effects of various weather factors can be tested against each other and the effects of seasonality and habitat. The procedure was run for the 50-m band of the survey samples for entire transects, segments, and point counts (only the last two containing habitat data). Wind direction and wind speed, during both the previous night of the surveys and during the surveys were the factors demonstrating varying degrees of effect on total bird numbers. These weather effects appeared less significant or non-existent in those samples containing habitat data. Nonetheless, the weather factor showing a strong degree of statistical significance in all the samples was the interaction of wind direction and wind speed during the time of the survey. This interaction between wind speed and wind direction for the entire transects is presented in tabular form in Table 2. The highest counts were achieved when wind was calm, or with light winds from the northwest, west, and north. The percent occurrence of these combinations of wind direction and speed is shown in Table 3.

By treating "calm" as a wind direction, the effect of wind direction and speed can be visually represented by plotting these two weather effects with mean total birds in a radar graph (Figure 16). From this visualization, it appears that the total numbers of birds during the autumn migration is likely to be highest when there are light winds at speeds of 0 to 11 km/hr from west to north during the time of the count. The previous statement is visually represented in Figure 17A by removing the "calm" category from the radar graph. A contrast analysis of variance indicated that the number of birds during the counts were significantly higher when wind direction was from the W, NW, and N compared to SE, S, and SW ($p=0.006$).

The analysis of the segment data for wind direction and speed was consistent with the data for entire transects but revealed one anomaly in this pattern. The second highest count recorded for one transect segment was at dawn on September 10th, when there was a light wind from the east following a northeast wind the previous night. That was the only night during the autumn migration period of 2007 when winds were from the northeast. This is represented in Figure 17B.

These findings are consistent with the radar studies of Richardson (1972, 1978) which showed how both diurnal and nocturnal migrants, especially passerines, fly predominately in a broad south southwest to west southwest front over Nova Scotia in the autumn. These SSW-WSW movements were the most dense when winds were from the north to east, providing a tailwind. These SSW-WSW movements were frequently noted at the centre of high pressure systems where winds were light and variable, often around a westerly flow. Finally, north or northwest winds immediately following a cold front brought birds heading southeast or south from inland Maritime areas to the coast or offshore.

Weather did not have a significant effect on species diversity compared to habitat and seasonality when tested by a backward stepping GLM and a univariate GLM. There was some statistical evidence that the interaction of night wind direction and speed had a modest effect on species diversity on transect segments (highest with light to moderate winds from west to southeast). While this finding may indicate some evidence for the occurrence of reverse migration, the small number of species detected at the segment level of analysis means this trend must be viewed with a great deal of caution.

The Effects of Habitat on Migration Stop-over

The habitats on 50-m band of transect segments were classified into five habitat types. These types are based on the natural succession of the Sugar Maple-Yellow Birch-Beech climax forest of the Pictou-Antigonish Highlands. Thus the types follow a sequence from disturbance (primarily by forestry) through to early, mid, and late succession to the mature stage. In addition, mature coniferous woodland can occur naturally where conditions are favourable for their growth (like ravines), or as plantations.

Due to the patchy nature of private woodlot forestry practices in the study area, it is difficult to find a continuous 500 m segment of a "pure" habitat type. Rather, segments tend to be dominated by a particular habitat type. Point counts, however, cover a smaller area (0.25 hectares compared to the 2.5 hectare segments) and thus tend to represent more homogenous habitat units. Table 4 describes the habitat types in more detail and the frequency of their occurrence in the segments and point counts.

Each transect consists of a unique combination of habitat types as represented in the combination of their three segments and six point counts. Transect 1 (see Figure 18) contains within its 1500 m length a model of forest succession. It begins with regenerating clearcuts with some small portions of an early succession species composition (young spruce-fir, birches, and aspen). It then continues into a mid-succession (mixed coniferous-deciduous forest) grading into late succession as the transect continues. In the late succession section, many tall coniferous trees are dead or dying, with more windfalls apparent after any high-wind storm. Finally it becomes an almost pure deciduous forest of Sugar Maple, Yellow Birch, and Beech with a modicum of Striped Maple and Balsam Fir. Transect 2 (see Figure 19) is the most heterogeneous and diversely managed woodland of the four transects and contains spruce, fir, and red pine plantations, clearcuts of Sugar Maple for firewood, and selectively logged mature deciduous. Transect 3 (see Figure 20) is the most heavily logged transect and consists largely of recent and regenerating clearcuts. Transect 4 (See Figure 21) is the steepest transect falling 82 m from mature coniferous at its peak through a mature deciduous slope, to a level mixed forest segment at its end.

The automated back-ward stepping general linear models showed a strong relationship between mean total birds and habitat types for both segments and point counts. The distribution of the birds in the segments and point counts were also similar. Table 5 lists the mean total birds in the 50-m band by habitat type for segments and point counts. More birds were seen in the most disturbed habitats, i.e., the "clearcut, regenerating, and early succession" habitat type. However a pair-wise comparison using the Tukey Honestly Significant Difference (HSD) test indicated that there was a significant difference in habitat type only between "clearcut, regenerating, and early succession" and "mature deciduous". This relationship held at the levels of segments and point counts. This result suggests that during the fall migration the critical habitat factor is the amount of "edge" provided by a habitat. Edge offers diverse food sources, a clear view for detecting predators and for visual orientation when moving, and thickets for protection. The significant habitat difference thus occurred between habitats having the most edge, those disturbed by forestry, and those having the least edge, mature deciduous woodlots.

A univariate general linear model shows that there was also a strong statistical relationship between habitat type and species diversity when compared to other factors affecting the migration of birds. Table 6 lists the mean number of species counted by habitat type for both segments and point counts in the 50-m band. Since the Levene Statistic indicated the analysis of variance of species by habitat did not meet the condition of the equality of variances, it was necessary to do a pair-wise analysis of species by habitat using the Tahmane's T2 test. Nonetheless, no habitat types were significantly different at the 95% confidence level. On the other hand, the analysis of variance of the point counts did meet the necessary conditions and the Tukey HSD test showed a significant positive difference between "clearcut, regenerating, and early succession" with both "mature deciduous" and "clearcut, regenerating, and early succession alongside mature deciduous". These results for species diversity parallel those of total birds and are likely also related to edge effects to some degree.

A species by species pair-wise analysis of the relationship to habitat types also required the use of the Tahmane's T2 test. In total, 17 species demonstrated significant habitat relationships at the segment level of analysis and 9 species at the point count level in the 50-m band. An even fewer number (7 at the segment level and 5 at the point count level) showed significant habitat preferences at the 95% confidence level for specific habitat types (see Table 7). When examined at the 90% confidence level, these numbers increased somewhat (11 species at the segment level and 6 at the point count level). At this confidence level, there was also a somewhat greater distinction in the variety of habitat preferences (see Table 8). As might be expected, many of the species showing the strongest relationship to particular habitat types were those preferring the "clearcut, regeneration, and early succession" habitat and avoiding the "mature deciduous" habitat (Northern Flicker, Ruby-crowned Kinglet, Common Yellowthroat, Song Sparrow, Swamp Sparrow, and White-throated Sparrow). Only the Red-eyed Vireo and Hermit Thrush showed a degree of significant preference for "mature deciduous". The Golden-crowned Kinglet and Yellow-rumped Warbler showed some statistically distinguishable preference for mature coniferous.

When segments and point counts were analyzed by all distances from the observer, six additional species were found to have significant habitat relationships (see Table 9). These were Red-tailed Hawk, Pileated Woodpecker, Blue Jay, Common Raven, White-winged Crossbill, and Pine Siskin. Again, the general tendency was for significant habitat specific results favouring edge habitat (clear-cut, regeneration, and early succession) over mature deciduous.

Nocturnal Passage Migration

The location of the four nocturnal passage listening points is plotted in Figure 22. These cover the northern, middle, and southern sections of the study area, and all are in the same location as a larger set of diurnal passage observation points.

The call notes of most birds heard were classified as either passerine (songbirds) species unspecified or thrush species unspecified. Additional birds that were heard and classified to species level were Black-bellied Plover and American Woodcock. Three Black-bellied Plovers were heard on one occasion (October 14). Passerines were heard on eight of sixteen nocturnal counts with numbers per count ranging between two to three "chip" notes, except for September 26th when 18 notes were heard. The American Woodcock was heard on 4 occasions from October 1-14. One to three wing "twitterings" were heard per count except for October 5th when 26 distinct "twitterings" were heard overhead in the dark. Since some of these birds were circling around, it is estimated that these noises represented 10 to 13 individual birds. On most counts, one of more of these woodcocks landed nearby and gave their ground-based "peent" notes.

The before dawn descent of thrushes was the most distinctive aspect of the nocturnal passage counts. Thrushes were heard on ten of sixteen nocturnal counts with the number of thrush notes heard ranging from 1 to 90. All thrush flight calls heard were those of the Hermit Thrush except for one Swainson's Thrush. Similarly, all thrushes that could be identified in the twilight by sight or by the sound of their ground calls were Hermit Thrushes. Thus, hereafter, the report of the nocturnal passage counts will refer only to Hermit Thrushes.

Each Hermit Thrush count followed a similar pattern. About 10 minutes into the 30 minute count (50 minutes before sunrise), the first flight call of a thrush would be heard. The first notes heard were faint but continued to get louder as the minutes passed, indicating descent. Most of the thrush flight calls were heard from 10 to 25 minutes into the 30 minute count (50 to 35 minutes before sunrise). From 25 to 30 minutes after the start of the count (35 to 30 minutes before sunrise), the calls tapered off, some birds were obviously circling low overhead, flight calls were very loud, and ground calls were heard nearby the observer. After the count was completed, thrushes were frequently and often numerously seen on the roads, usually in mature deciduous woodlands, leading to the location of the migration stop-over transects (30 minutes before, to sunrise). During the migration stop-over surveys, relatively few thrushes were detected compared to what was heard or seen on the ground just before dawn.

Table 10 provides further details on the nocturnal passage of the Hermit Thrush. The thrushes were recorded at all listening points. The highest counts were recorded at Point 6, located in the northeast section of the study area. The second highest counts occurred at Point 4 in the southern section. The three highest counts occurred under similar weather conditions; calm at the time of the count, southwest winds at 7-11 km/hr during the night, and seasonably cool temperatures (-3 to 2 degrees C.). In contrast, the counts for which no thrushes were heard were characterized by winds 20-50 km/hr from a variety of directions with seasonably warm temperatures (8 to 16 degrees C.). The highest number of Hermit Thrush flights calls heard during a 30-minute count was 89 on October 1st. It was estimated that an individual thrush is heard two to three times when passing overhead. Thus this number would represent about 30-45 birds.

Given the widespread and regular occurrence of a Herman Thrush descent over the study area before dawn in the study area, there is evidence suggesting that the Sugar Maple-Yellow Birch-Beech forest of the Pictou-Antigonish Highlands is a major stopover area for this species. While it remains a mystery as to where these birds go after dawn, there is some statistical support, albeit weak, that this species favours mature deciduous habitats. Some of the Hermit Thrushes counted during the stop-over surveys in mature deciduous habitat were almost missed since they were feeding silently on the ground and camoflauged by their plumage in the autumn leaf litter. Indeed some were missed because on more than one occasion, thrushes were seen on the return walk of the transect (but not included in survey results). It is possible that other survey methods and/or the development of a detectability coefficient would provide a better measure of Hermit Thrush abundance in the mature deciduous forest during the autumn migration.

Diurnal Passage Migration

The location of the diurnal passage observation points are shown in Figure 23. Among the seven observation points, three (Points 2, 4, and 5) were visited more regularly due to their location on local flyways. Observation Point 5 is at an elevation of 240 m and overlooks the Hollow or Glen Dhu, and beyond that the coastal slope of the Northumberland Strait. It is 5.6 km from the wharf at Lismore. Observation Point 2, at an elevation of 200 m, overlooks the area where the Hollow broadens out. It overlooks the coastal slope towards Big Island and Merigomish and is 7.8 km from the shore. Observation Point 4, at 210 m, is 14.3 km from the shore. Its view is primarily southward toward the interior deciduous forest of the Pictou-Antigonish Highlands.

Observation Points 5 and 2 were on the edge of steep slopes facing the gradual slope of the coastal plain. Observation Point 4 was on a gentle slope overlooking a valley. These topographical features have significance for the development of warm air thermals and updrafts for soaring birds to be discussed later.

Every bird or every group of birds of the same type passing through the observation space at these points was recorded as one observation. Observations were divided into 30 minute time blocks. If a bird flew through the observation space and then flew through it again later in the same time block, it would have been recorded as two observations. If two or more birds of the same species flew through the observation space flying in the same direction and at the same altitude category, then it was one observation of x number of individuals. If two or more birds of the same species flew through the observation area in different directions or at different altitudes, then there were y_1, y_2… observations of x_1, x_2… individual birds for each flight direction and altitude category.

Diurnal Raptors

Nine species of hawks and eagle were observed during the diurnal passage surveys. These occurred in small numbers and irregularly at all observation points throughout the autumn except for the Bald Eagle (observed in 17% of time blocks), Red-tailed Hawk (12%) and Sharp-shinned Hawk (8%). There was no discernable pattern in the direction of movement of hawks. The median time of observation ranged between 0945-1130 hours for species that were seen more than once. The results of the hawk migration are summarized in Table 11. The study area does not appear to be an important site for diurnal raptor passage during the autumn migration. The most common of these raptors, the Bald Eagle, consisted of a local population that was not migratory.

Water Birds

Water birds were very infrequently seen during the diurnal passage surveys. Most were flying toward the coast at all observation points. The most common was Herring Gull (recorded in 5% of time blocks). The movements of water birds are summarized in Table 12.

Woodpeckers and Passerines

The observations of woodpecker and passerine species are summarized in Table 13.

The Common Raven was the most frequently seen bird during the diurnal passage surveys. This species occurred in 43% of the time blocks, usually in groups of two birds (average of 1.67). The raven, like the Bald Eagle, is a local, non-migratory species. Observations were related to their commuting to different feeding areas and roosts and for the purposes of social displays or riding thermals. On October 7th, seventeen ravens were seen at Observation Point 2 at 0800 hours (45 minutes after sunrise) and appeared to be heading from an inland roost toward coastal feeding areas. Otherwise, there was no directional pattern to the movements of ravens.

Other frequently observed passerines were Yellow-rumped Warbler (24% of time blocks), Blue Jay (22%), American Robin (19%), American Goldfinch (17%), Dark-eyed Junco (15%), and Purple Finch (14%). The most observed woodpecker was Northern Flicker (4%).

The median time of observation for the most abundant species ranged between 0900 and 1100 hours.

The flight directions of observed birds were categorized into only four cardinal directions; north, east, south, and west. This classification was chosen since many birds are frequently changing their headings or start with one heading and end with another.

For woodpeckers and small to medium-sized passerines (i.e., excluding ravens), 49% of observations recorded a flight direction of west, compared to 18% for east, 13% for north, and 20% for south. This pattern of flight direction held for all wind directions. Moreover, west was the prevailing wind direction (39% of all time blocks). A matrix of flight directions during each wind direction category for major species groupings is presented in Table 14. This is visually represented for all species in Figure 24.

A similar pattern emerged for flight direction when compared to wind speed. Fifty-two percent of woodpeckers and small to medium-sized passerine observations recorded a westerly flight direction for wind speeds from 0-19 km/hr, compared to 18% for east, 12% for north, and 18% for south. At 20 km/hr or more, flight directions were more variable. The most common wind speed was 12-19 km/hr (35% of all time blocks) for which category 53% of bird observations recorded a westerly direction, 16% northerly, 16% easterly, and 15% southerly. The pattern of flight directions with different wind speeds can be seen in Table 15 and Figure 25.

Pearson's chi-square test confirmed that the both the wind direction-flight direction and wind speed-flight direction paired categories are significantly different from each other at the 95% level of probability.

These results are once again consistent with the findings of Richardson's (1972, 1978) radar studies. He found that birds migrating southwest during the night and finding themselves over water at dawn, reoriented to the west and northwest, and often continued in this direction throughout the morning. Given the northeast-southwest alignment of the coast of Eastern North America, this re-orientation direction would inevitably bring birds back to land (Baird and Nisbet 1960; Able 1977; Richardson 1972, 1978, 1982, 1990; Alerstam 1990; Licthti 2006). In the case of the study area, the birds observed heading west were already well inland. This could nonetheless be related to a reorientation earlier in the morning over water. It is also possible that the birds in the study area were heading for the coast. Flying west from any point in the study area will bring birds to the coast, along the shores of the Northumberland Strait. Richardson (1998) notes that during diurnal migration birds often concentrate along coastlines, ridges, or rivers, especially when these features are aligned within 45 degrees of the preferred flight direction.

Winter Season

Few birds wintered on the Pictou-Antigonish Highlands, especially on the higher elevations where winter conditions are the most extreme. Throughout the winter period, November through March, the mean number of birds seen per hectare was one.

The location of the winter standardized area counts are shown in Figure 26. Since each area was a different size, the number of birds present in winter is here reported in bird densities per hectare by habitat type. The habitat types are the same five as described for the autumn migration with the addition of a sixth habitat type: residential and agricultural. Agricultural land consisted of hayfields and blueberry farms.

Figure 27 presents the mean number of birds by habitat type during the winter. The differences between habitat types are not statistically significant, as can be seen in the wide 95% confidence limits. This is likely due to the small numbers of birds and total counts. Keeping in mind the statistical limitations, the winter data suggest the inverse of the autumn migration relative to habitat preferences. The density of birds in winter increases with lessening amounts of edge and with rising amounts of forest cover. Thus clearcuts and early succession forest had the smallest densities of birds (0.55/hectare) and mature deciduous the largest (1.77/hectare).

Only 19 species of birds were seen in the study area during the winter period. Table 16 gives the mean number of birds per hectare detected by species and habitat within 50 metres of the walking observer. The most common bird was Black-capped Chickadee, occurring in all habitats but most abundantly in mature deciduous. Three species did have statistically significant habitat preferences; Hairy Woodpecker and White-breasted Nuthatch for mature deciduous and Boreal Chickadee for mature coniferous. Other bird species observed at greater than 50 metres or flying are noted by habitat in Table 17. The most common winter finches during the winter of 2007-2008 were Pine Grosbeak and Common Redpoll. Other winter finches were few or absent.

Spring Migration

Overview

Spring migration in northern Nova Scotia begins in March. As the melt of snow and water bodies progresses during the month, so too does the number of migrating water birds, hawks, and passerines. On the Pictou-Antigonish Highlands it is still very much winter in March, with deep snow cover and low wind chills. During April the pace of migration and the number of returning species increases. During the month of May a wide diversity of birds pass through the area or arrive on their breeding territories. Some migration continues through the first seven to ten days of June for the latest arrivals.

Migration Stop-over

In total, 4,916 individual birds of 75 species were recorded during the spring migration stop-over surveys. As for the autumn migration, this information will be used to examine the effects of seasonality, weather, and habitat on the spring migration of birds in the study area.

The Effects of Seasonality on Migration Stop-over

Figure 28 presents an overall picture of the magnitude of spring migration in the study area with a graph of the mean total number of birds seen per transect at all distances by 10-day period. There is a statistically significant seasonal effect resulting in continuous increase in the number of birds from early April to early June. However, unlike the fall migration, there is a major complication in the counts made during spring migration stop-over. As the season progresses, there is a growing number of birds present that are not migrating but on their breeding territories. To account for this fact, analyses were also made of the total number of birds on migration stop-over by progressively eliminating from the data analysis any species that had started breeding activities (establishment of territories, courtship, nest building, etc). The breeding calendar of the Maritimes Breeding Bird Atlas (http://www.mba-aom.ca/) was used as a reference in establishing these cut-off dates.

Figure 29 shows the mean total number of birds per transect at all distances by 10-day period without the inclusion of breeding birds. This graph reveals a very different picture of spring migration stop-over in the study area. Using the Tukey Test of Homogeneous Subsets, there is strong statistical support (at the 95% probability level) for a peak migration occurring from April 11-30. When the analysis is conducted for transect segments at less than 50 metres, the peak period is even earlier, from April 11-20, according to the Tukey Test of Homogeneous Subsets (see Figure 30 for the mean total number of birds per transect segment at less than 50 metres). An automated backward stepping GLM also demonstrated the statistical significance of seasonality on total birds recorded. However this effect was not as strong as weather effects (see below).

A similar pattern emerges for the effects of seasonality on species diversity. As demonstrated in Figure 31, there is a steady increase in the mean number of bird species seen per transect at all distances from April 1 to June 9. However, when breeding birds are removed from the analysis, as seen in Figure 32, there is a statistically significant peak in species diversity much earlier, from April 21-30.

Table 18 shows the mean number of each species recorded per transect at all distances by ten-day period while Figure 33 graphically represents 26 species having a statistically significant seasonal pattern in the <50m transect segments.

Many more birds were recorded on the transects during the spring migration than during the previous autumn. This does not mean that the study area is more important as a stop-over area in the spring than in the fall. Birds are much more apparent in the spring as they sing and engage in various territorial and courtship pursuits. This greatly enhances the detectability of birds in a forest environment. For example, the apparent seasonal pattern in the records for the Ruffed Grouse, a non-migratory bird, is due to changes in its detectability. Its "drumming" is apparent throughout the forest in April while for the rest of the year it is usually only seen or heard when disturbed at close range. In addition, as already noted, there is the difficulty of distinguishing birds on migration stop-over from breeding residents. The removal of birds from the stop-over analysis once their breeding season commences has a couple of problems associated with it. First, there is no specific information on the timing of the breeding season in the study area. The use of the data from the Maritime Breeding Bird Atlas is a good alternative but the data may not correspond exactly to the actually timing of breeding on the Pictou-Antigonish Highlands. Second, within one species there can be early and late breeders. Some birds might be present in the study area on migration stop-over while others of the same species have commenced breeding activities.

Despite the limitations of the data, the analysis suggests that migration stop-over in the study area consists of three waves of decreasing intensity. In mid-April, the first wave in is dominated by American Robins, Dark-eyed Juncos, and Song Sparrows. The second wave in late April and early May consists largely of Yellow-bellied Sapsuckers, Northern Flickers, Ruby-crowned Kinglets, Hermit Thrushes, Yellow-rumped Warblers, and White-throated Sparrows. The third wave in mid to late May is made up of flycatchers, forest warblers, and Red-eyed Vireos.

The Effects of Weather on Migration Stop-over

An automated backward stepping GLM indicated that weather, compared to seasonality and habitat, had the strongest effect on the mean number of birds recorded on the survey transects. The most powerful of these effects was the wind direction during the night before the survey. This weather effect was most evident and statistically significant at the level of transect segments. Wind speed also had a strong effect. Table 19 lists the mean number of birds per transect segment at less than 50 metres for each combination of wind direction and speed on the nights preceding the survey. Table 20 lists the number of transect segments for each combination of night wind speed and direction. Figure 34 presents the information in Table 19 in a radar graph. The highest mean counts occurred on six segments when the night wind was from the southeast at 12 to 19 km/hour on average. The second highest mean counts occurred on twenty-one segments when winds were from the south at 7 to 11 km/hour.

Wind direction at the time of the survey for birds seen at all distances during the point counts also were statistically significant as an effect on mean numbers. Counts were highest for the "calm" wind direction closely followed by southeast. Mean numbers were lowest when the wind was from the east or west.

The effects of weather on species diversity followed the same pattern as for total birds at both the segment and point count levels.

The radar studies of Richardson (1971) for the spring migration in the Maritime Provinces demonstrated that the predominant flight direction is northeast, east northeast, and even east. Migration was most dense with west, southwest, and south winds. This study of migration stop-over also shows that migrants were often numerous on days following south winds during the night, more so than any other wind direction than southeast. The highest concentrations following southeast winds might be explained by a westerly drift of nocturnal migrants heading northeast to Cape Breton Island and Newfoundland.

The Effects of Habitat on Migration Stop-over

The same transects were used in the spring migration as in the autumn. These transects and their habitats were previously referred to in Figure 18, 19, 20 and 21. Table 4 describes the habitat types.

Habitat relationships with birds were not as strong in the spring migration stop-over as in the autumn. After removing breeding birds from the analysis, the mean number of birds per transect segment within the 50 metre band in the spring is illustrated in Figure 35. One can discern, as in the autumn, the influence of the edge effect as mean total birds tends to decrease with decreasing edge and increasing forest canopy; from clearcuts to mature deciduous forest. This trend is much clearer by using a backward stepping glm to generate a graph of the least square means of total birds for habitat types (see Figure 36). The least square means adjusts the habitat related means to account for other effects in the model such as season and weather. In this model, there is a distinct and continuous decline in means from clearcuts to mature deciduous.

The ANOVA and Tukey HSD tests, however, showed no significant difference in total birds among habitat types at the segment level or the point count level within the 50 metre band. It was only with total birds at all distances in the point counts that there was a significant difference between habitat types at the 95% confidence level (see Figure 37). In this case, the Tukey HSD pair-wise comparison showed significant difference only between the habitat types of clearcut, regeneration, and early succession with mature deciduous. Given the much higher detectability of birds due to singing, courting, and the lack of foliage through much of the spring season and given the more homogenous habitat types found in the point counts, it is appropriate to look beyond the 50 metre band for habitat analysis.

The automated backward stepping GLMs indicated that habitat had a statistically significant effect on species diversity only at the level of point counts at all distances. The analysis of variance of individual species resulted in eleven species having significant habitat relationships at the level of transect segments in the 50 metre band and thirteen species having significant relationships for point counts at all distance (95% confidence level). Of these, a pair-wise analysis using the Tamhane's T2 test showed that only three species at the level of transect segments in the 50 metre band and seven species at the level of point counts at all distances had statistically significant preferences for specific habitat types. These results are summarized in Table 21. In particular, Alder Flycatcher, Song Sparrow, Lincoln's Sparrow, Swamp Sparrow, and White-throated Sparrow showed some statistically significant degree of preference for clearcuts, regeneration, and early succession habitat. Black-and-white Warbler preferred mid-to-late succession forest, Ruby-crowned Kinglet sought both mid-to-late succession and mature coniferous, while the Black-throated Blue Warbler preferred mature deciduous.

Nocturnal Passage Migration

Nocturnal passage counts were conducted in May at sites 2, 4, and 5, as marked on the map in Figure 22. The nocturnal counts were much lower in the spring than in the fall. Very few Hermit Thrushes were heard (see Table 22) and the pattern of their sounds was different. Rather than being heard overhead, the flight calls of these birds were closer to the horizon near tree-top level. The highest count (6 flight calls) was recorded on May 4 which corresponds with the peak of Hermit Thrush counts during the migration stop-over surveys. Clement (2000, p. 318) notes that the spring migration of the Hermit Thrush follows the reverse route of that taken in the autumn. He goes on to say that numbers in spring vary from year to year, being abundant in some years and nearly absent in others.

Diurnal Passage Migration

The location of the diurnal passage observation points is plotted in Figure 23. These are the same points used during the autumn migration except for the addition of point 8 which looks northeastward "down" the Hollow. Observation methods were the same as in the autumn. However, the flight direction of birds was recorded in eight cardinal directions instead of four.

Diurnal passage migration was much less in the spring than in the fall. No birds were seen in twenty-four percent of the one-half hour observation blocks compared to only eight percent in the autumn. The mean number of birds seen per block was 3.00 birds in contrast to 7.08 birds in the autumn.

Hawks, water birds, woodpeckers, and passerines were less diversified by species and less abundant in total numbers than in the autumn. Only the Red-tailed Hawk was seen more frequently in the spring (24% of time blocks) than in the autumn (12%). The locally resident Bald Eagles and

Common Ravens were present in comparable numbers and frequency during the spring. Table 23 summarizes the occurrence and abundance of birds seen in the spring passage migration survey.

Spring passage migration was most intense in the morning before 10 am. As can be seen in Table 24, sixty-seven percent of woodpeckers and passerines were flying northeast or east, the predominate direction observed by Richardson (1971) in his spring migration radar studies. This is a direct heading to the southwest coast of Cape Breton Island from the study area. Sixty-six percent of diurnal passage took place with winds from the west, southwest, or south. Seventy percent of passage occurred with winds less than twenty kilometres per hour.

It is worth noting that the most common flight direction during the daytime in both the autumn and spring was 45 degrees from the prevailing nocturnal flight direction described for Maritime passerines, that is, west rather than southwest and east rather than northeast. This again suggests that passerines are concentrating along a linear topographic feature, in this case, the shore of the Northumberland Strait which roughly follows a west to east direction.

Breeding Season

The breeding season surveys consisted of three components: crepuscular and nocturnal birds, early breeders, and peak season breeders.

Crepuscular and Nocturnal Breeding Birds

Twilight and nocturnal area searches detected breeding birds that are not normally seen during the daytime. In the study area, this includes American Woodcock, Great Horned Owl, Barred Owl, and Northern Saw-whet Owl. Figure 38 shows the area search routes and the location of each individual bird heard during the survey. Several observations made during the daytime are also included.

The three owl species were heard in a mix of forest habitats with the Barred Owl the most associated with mature Sugar Maple-Yellow Birch-Beech habitat. The American Woodcock was found almost exclusively in clearcut and regenerating areas, often near a wet area.

Early Breeding

Bird species that began their nesting season before June 1 were considered early breeders in this study. The twenty-four point counts along the migration stop-over transects were used to survey these birds. As each species entered their nesting season, they were counted on these point counts as breeders rather than migrants. Between April 8 and June 2, each of these point counts was surveyed nine times. The maximum number of each species observed at each point count station was used for the analysis of early breeding. For each species, only the data obtained during their particular time of breeding was compiled. Better statistical results were achieved using the birds observed at all distances rather than in the 50 metre band.

Table 25 summarizes the results of the point count analysis for early breeders. The most abundant early breeder was White-throated Sparrow with a mean of 2.71 per point count station and occurring at 92% of the stations. It was closely followed by the American Robin with a mean of 2.54 and occurrence of 92%. Species occurring on two-thirds or more of the stations were in rank order, Ovenbird, Yellow-rumped Warbler, Dark-eyed Junco, Magnolia Warbler, Blue Jay, Black-capped Chickadee, Hermit Thrush, and Yellow-bellied Sapsucker.

An analysis of variance (ANOVA) indicated that there were significant differences (at the 95% level) in the use of habitat types by total number of early breeders, irrespective of species (see Figure 39). Highest counts were obtained in clearcuts, and early succession forest followed by mid to late succession mixed aged mixed forests. A pair-wise analysis using the Tukey HSD test revealed no significant difference between particular habitat types occupied by all early breeding birds. A limitation of point count surveys during the breeding season is that they do not adequately account for species that forage in some habitats, such as thrushes do in clearcuts but nest in deeper woods with a complete canopy.

An ANOVA showed significant differences in the use of breeding habitat types by different species only at the 90% level (see Figure 40). Nonetheless, nine species of early breeders demonstrated significant habitat relationships at the 95% level. Pair-wise analysis for individual species also indicated some degree of habitat preference for five species of early breeders (see Table 26). Northern Flicker, Common Yellowthroat, and White-throated Sparrow showed a preference for clearcuts and early succession habitat, Dark-eyed Junco for clearcuts and early succession alongside mature deciduous, and Ovenbird for mature deciduous.

Peak Breeding

The peak breeding survey consisted of 204 point counts dispersed throughout the study area. Their location can be seen in Figure 41. Each point count was surveyed one time between June 3 and July 3. In contrast to early breeding season point counts, priority was given to broad geographical coverage at the cost of intensive coverage at the station level.

Table 27 presents a summary of the results of the peak breeding bird survey. Red-eyed Vireo was the most common bird during the peak breeding season and was detected on 74% of all point counts. The White-throated Sparrow, American Robin, and Ovenbird maintained their ranking among the top four most common species but were detected on 57-61% of point counts rather than on two-thirds or more. The Black-throated Green Warbler was also seen or heard on 57% of point counts.

An ANOVA revealed that there were significant statistical differences (at 95% level of probability) in the total number of peak breeding birds according to habitat type. Figure 42 demonstrates that the highest counts were obtained on residential and agricultural habitat, followed by disturbed forest habitat to mature forests in decreasing order. A pair wise comparison with the Tukey HSD test found significant difference between individual habitat types. The clearcut and early succession habitat had significantly greater number of birds than mature coniferous and deciduous. The clearcut and early succession alongside mature deciduous habitat and the mid to late succession habitat both had greater total birds than mature deciduous.

Figure 43 shows that species diversity follows the same pattern relative to habitat use but with even greater statistical strength. There were significant differences in species diversity at the overall habitat level of analysis and between specific habitat types. Clearcuts and early succession forests were significantly more diverse in bird species than mid to late succession, mature coniferous, and mature deciduous. Clearcuts and early succession forests alongside mature deciduous, mid to late succession forests, and residential and agricultural land were more diverse than mature deciduous.

Individual bird species also showed strong habitat relationships during the peak breeding season. As shown in Table 28, twenty-nine species showed significant habitat relationships at the 95% level of confidence. Of these, fifteen showed significant preference for specific habitat types. For two species, their numbers were significantly higher in one habitat type than all five other habitats. These were Ovenbird for mature deciduous and Black-throated Green Warbler for mature coniferous. Among the other species showing statistically strong preferences for specific habitats were Alder Flycatcher, White-throated Sparrow, Song Sparrow, and Common Yellowthroat for clearcuts and early succession forests, Least Flycatcher, Mourning Warbler, and Common Yellowthroat for clearcuts and early succession alongside mature deciduous, and Red-eyed Vireo and Least Flycatcher for mature deciduous.

Effects of Survey Effort, Seasonality, Weather, and Time of Day on Point Count Results

The mean number of birds seen at each of the point count stations was considerably higher in the early breeding season compared to peak breeding; nearly twice as high. This is due to the fact that the early breeding point counts in April and May were conducted repetitively. Total effort at each point count station was 90 minutes, close to the 100 minutes other studies have determined as necessary to detect all breeding birds present (see Research Methods section). In reality, the effort was much less for those species beginning nesting later in the season. However, all species at all 24 early breeding point count stations were surveyed at least twice.

Table 29 lists the rank of the early breeders in April and May next to their equivalent rank during June and July (with later breeders removed from the scoring). Despite large differences in the absolute numbers of birds recorded per station, 67% of the most common early breeders (occurring on 40% or more of the point count stations) had a difference in rank of only 0 to 3 points. These results provide some further evidence of the usefulness of point counts in measuring the relative rather than absolute abundance of breeding birds.

ANOVA tests were applied to weather, time of day, and total birds data for the peak breeding season (see Figure 44). While the mean of total of birds was highest with calm winds (13.38) and lowest at wind speeds up to 20-29/km/hr (11.25), the differences were not statistically significant. Nor were the effects of visibility (fog). The number of birds detected was significantly less in light rain compared to no precipitation (8.69 vs. 12.23). The time of morning, from sunrise to 4 hours after sunrise, did not have significant effect on the mean total birds detected.

Breeding Status

Throughout the point count surveys, evidence of the breeding status of birds in the study area was noted. Such evidence was also gathered during the preliminary assessment in the study area during June and July of 2007. Using the criteria established for the Maritime Breeding Bird Atlas, each species was classified as a "possible", "probable", or "confirmed" breeder (see http://www.mba-aom.ca/ for more details). In total from June 2007 to July 2008, 90 species of breeding birds were found in the study area of which 28 were possible breeders, 34 probable breeders, and 28 confirmed breeders. Table 30 lists the status of each species.

Risk Assessment and Mitigation Measures

This section will assess the potential effects of wind farm development on the birds in the study area. It is important to note again that this study was conducted before the finalization of turbine placements and turbine design. What was known were the properties upon which turbines would be built and the leading candidate for turbine design.

The risk assessment will be divided into the following topics: collision risks, displacement from disturbance, barrier effects, species of special concern, and habitat effects.

Overview

There are no major concentrations of birds that occurred in the study area during the autumn and migration. Nonetheless, the area is an important migration stop-over for various species of woodland birds. The pre-dawn descent of Hermit Thrushes and the waves of migrating warblers in the autumn, and the woods filled with thrushes and sapsuckers during the spring migration make this area a noteworthy part of the avian ecology of Nova Scotia. However, these events occur over a wide area of the Pictou-Antigonish Highlands and are not unique or confined to the study area or specific turbine properties. The following sections address specific issues related to wind farm development.

Birds at Risk from Collisions with Wind Turbines

Both the nocturnal passage and diurnal passage surveys in the autumn point to the need to evaluate the risk to migrating and commuting bird for collisions with wind turbines.

The nocturnal passage surveys provided evidence that the American Woodcock and Hermit Thrush are descending to the ground in the dark from one hour to one-half hour before sunrise during their autumn migration. Those birds descending to ground in the immediate vicinity of wind turbines are thus potentially at risk from collisions with the rotating blades.

It was also noted that these descents are of the greatest magnitude under calm wind conditions. Thus there might be a natural mitigation of this risk as the blades may not be rotating when the numbers descending are highest.

There is a need to understand this phenomenon more completely. An acoustic monitoring study should be conducted in the autumn of 2008 to evaluate further the potential risk of collision for these species and possible mitigation measures.

Wind turbines may also pose a threat to the American Woodcock during the time they are engaged in flight songs. Male woodcocks will use almost any size open, relatively flat area, with bare ground, short grass, or even patches of snow, as a display ground, sometimes far from their preferred diurnal habitat (Keppie and Whiting Jr. 1994). During the first few years after construction, it may be necessary to cover such open areas with brush or find other ways to discourage woodcocks from using the cleared areas around newly constructed wind turbines as a platform for their flight songs.

During the diurnal passage surveys, the flight altitude, relative to the observation point, of all birds was recorded in categories of <0 m (birds flying below the elevation of the observation point), 0-50 m, 50-125 m (the sweep of the turbine blades if located at the observation point), and greater than 125 m. The species of birds, along with the number of observations, passing through the 50-125 m altitude category is presented in Table 31. The data from the autumn migration was used since there are a much greater number of passage migrants during this season. The species, for which there are more than 10 observations, most likely to be flying at the height of the blade sweep are Bald Eagle (38% of observations), Sharp-shinned Hawk (33%), Red-tailed Hawk (33%), Common Raven (22%), warbler species unspecified (15%), American Robin (14%), passerine species unspecified (7%), and Yellow-rumped Warbler (6%).

Of particular concern among these species are Bald Eagle and Common Raven. They are present throughout the autumn and were among the species most often seen during the diurnal passage surveys, particularly the latter. Table 32 presents data for the flight altitude of these two species by the three most surveyed observations points; Numbers 5, 2, and 4. One might expect that birds would be seen soaring more often at Observation Points 5 and 2 since they are located near the top edge of the southern side of a steep slope overlooking the Hollow and the coastal slope. Both thermals, up-drafts caused by the warmer temperatures at ground level in the lowlands, and orographic flows, caused by vertical step-up of air at ridges, would create favourable conditions for the riding of air currents by soaring birds, especially near the ridge edge. In contrast, Observation Point 4 is not close to the warmer temperatures generated in the lowlands and is located atop a gentle slope from the valley to the south. The data indicate that there is little difference in the tendency of Bald Eagles to fly at blade height among the three observation points. There is a noticeable difference in flight altitudes for Common Ravens between the three sites but these difference are not significant using the Pearson Chi-square test.

However, when a statistical analysis is employed using all observations of all species that flew at blade height at all observation points in the autumn, a Pearson Chi-square test shows a significant difference between the observation points ($p=0.038$). When this test compares Observation Points 4 and 5, the significance is greater ($p=0.020$), and stronger still when one combines the observations for Points 2 and 5, the two atop steep ridges, and compare them to Point 4, atop a gentler slope ($p=0.006$). The last analysis also shows a significant difference for the Common Raven at a 90% confidence level (p=.0.098).

This analysis suggests that soaring birds such as diurnal raptors, gulls, and corvids are more likely to be flying at blade height when the turbines are placed near steep cliff edges. In addition, the data suggest that Bald Eagles are the most likely to fly at blade height due both to vertical air flows and a higher flying altitude, with or without air current assistance.

Additional studies documenting the overall and seasonal abundance of raptors and corvids in the study area and more detailed behavioural studies at specific proposed turbine sites in the autumn of 2008 would further define the risks involved. Until additional research becomes available, serious consideration should be given to setting back wind turbines from steeply-inclined ridges where updrafts are most conducive for soaring. Again, the optimal set-back distance requires further study.

Since the field work was completed, the design of the wind turbines for the Glen Dhu site has changed, with the sweep of the turbine blades reaching down to 38 metres above the ground instead of 50 metres. This will put the flight paths of more soaring birds and small passerines at blade height than what is indicated by this study.

Displacement from Disturbance

Displacement from disturbance is an equivalent of habitat loss when during the construction and post-construction phase of wind farm development, the visual, noise, and vibration effects of the turbines and the disturbance created by construction and maintenance crews, their vehicles and machinery drive birds from the area (Drewitt and Langston 2006). Some preliminary evidence suggests that birds do not habituate to wind farm disturbance and that the effects actually become more pronounced over time (Stewart, Pullin, and Coles 2004). The extent of these impacts is best determined through a well-designed post-construction monitoring program.

Barrier Effects

The barrier effect is a result of wind farms causing birds to alter their flight paths to avoid wind turbines. This positive behaviour can become a negative impact when avoiding the turbine arrays can cause birds to lose too much energy or create stress.

The results of the diurnal passage surveys suggest that many passerine birds over the study area in the early morning are off-course or otherwise re-orienting to locate a migration corridor. After a night of migration, they may have a limited energy budget remaining to find a suitable landing location. For this and other reasons, the construction of wind turbines in clusters is considered one of the "best practices" of wind farm design and provides corridors for birds to fly through safely (Drewitt and Langston 2006).

The results of the diurnal passage survey also demonstrated that significant numbers of birds were flying in a westerly or easterly direction. Thus, there is further reason to construct turbines in clusters, rather than rows, especially rows perpendicular to an east-west axis.

Species of Concern

Table 33 list the species of birds for which their populations in Nova Scotia are considered by various conservation agencies to be at higher degrees of risk for serious decline or extirpation. Table 34 summarizes the status of these species of concern in the study area. The two species listed as "special concern" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Peregrine Falcon and Rusty Blackbird were seen only once each in the study area in the autumn migration. The three species listed as "threatened" by COSEWIC were seen during the breeding season and will be discussed in more detail below. The other species listed as "yellow" by the Province of Nova Scotia or as a priority species by Partners in Flight involve largely habitat questions and will be dealt with in the next section of this assessment.

Chimney Swift

Two Chimney Swifts were seen together in flight in early July 2008 at the extreme southwest corner of the study area. Generally Chimney Swifts nest in towns or cities, and it is most likely these were foraging birds. While it is possible that Chimney Swifts will nest in large dead trees in mature forests, there is not enough evidence at this time to warrant a consideration of the possible impacts of a wind farm on this species.

Olive-sided Flycatcher

The Olive-sided Flycatcher was seen on 8 occasions during the spring migration and on 12 breeding point counts (see Figure 45). This suggests the species is fairly widespread in the study area in suitable nesting habitat; clearcuts and early successional forests. Photos of the breeding habitat of the Olive-sided Flycatcher in the study area can be seen in Figure 46.

The existence of large snags in clearcut or burned areas adjacent to forests (to build a nest) appears to be a critical component of this species' habitat (Altman and Sallabanks 2000). The causes of decline of this flycatcher are unknown and are puzzling since the availability of suitable habitat is increasing. Studies indicate that reproductive success is much less in clearcuts than in burnt over areas (Altman and Sallabanks 2000). It has been surmised that there is some critical factor lacking or present (like squirrel predation) in clearcuts compared to burnt areas.

Olive-sided Flycatchers feed from the top of a large snag and usually catch insects by flying outward horizontally or downward. Occasionally (about 17% of forays) they will fly upwards to catch prey (Altman and Sallabanks 2000).

Due to the unknown causes for the decline in the Olive-sided Flycatcher, it is difficult to assess the impact of a wind farm on its population in the study area. The construction of a wind farm should not negatively affect the habitat available to Olive-sided Flycatchers. Where wind turbines are placed in habitats suitable for this species, large snags should be cut down for at least 150 metres around their perimeter. This will help lessen the risk of collisions with rotating wind turbine blades.

Canada Warbler

The Canada Warbler was seen on four occasions. The first two were during the breeding season in 2007; one a single individual near Vamey's Lake and a pair in the southern portion of the study area (see map in Figure 47). In 2008, a male accompanied by a female was singing near the edge of Vamey's Lake in their spring migration period, and a single male in the exact same location as in 2007 in the southern portion of the study area.

The breeding habitat of the Canada Warbler is moist, mixed coniferous-deciduous forest, with a well developed understory, often near open water (Conway 1999). The breeding habitat of the Canada Warbler in the study area is shown in Figure 48.

The decline of Canada Warbler is believed to be related to the loss or degradation of nesting habitat (Conway 1999). The forestry practices aimed at reducing the deciduous component of Maritime forests have likely had a negative impact (Erskine 1992). Studies in New England and the Middle Atlantic States reported the Canada Warbler was one of the top five species most sensitive to forest fragmentation. At a more site-specific level, studies have shown that the clearing of brush and understory in forests, as well as grazing by ungulates, negatively affects their populations (Conway 1999).

The clearing of land for turbine construction is not likely to impact the Canada Warbler since turbines are built on higher ground, way from moist woodlands. The construction or improvement of roads and the construction of ancillary structures should avoid removing forest understory in wet areas. The wetlands and wet forests around Vamey's Lake and the wet forests in the southern section of the study area are the most promising habitat for the Canada Warbler. Wind farm development near these areas would most likely pose the greatest threat to existing populations of Canada Warbler or to their potential growth.

The problem of forest fragmentation is addressed in the next section.

Habitat Effects

This study shows repeatedly the importance of a variety of forest habitat types for bird populations. Cleared and early successional forest habitats with a high degree of edge are critical for many birds during the migration and breeding periods. Mid to late successional and mature coniferous forests are the preferred habitat of a number of the most common breeding birds. Deciduous forests may be essential as overwintering areas and provide the habitat of the first and fourth most abundant birds in the study area during the peak breeding period, Red-eyed Vireo and Ovenbird.

At this time, the greatest threat to the mature Sugar Maple-Yellow Birch-Beech hardwood forest and associated bird habitats on the Pictou-Antigonish Highlands is from harvesting for firewood. The local price per cord in the summer of 2008 for wood cut, split, and delivered is about 20% higher than at the same time last year. Thus, there is a strong likelihood of a continuing increase in hardwood harvest with further loss of mature forest habitat and more forest fragmentation. Given that wind farm development would take place in a variety of early to late successional forest areas, the loss of mature deciduous woodlands would likely be small, especially in comparison to forestry operations.

For those species listed as "Yellow" status by the Province of Nova Scotia or as a "Priority Species" by Partners in Flight, recovery depends on a broad, concerted effort by all forest users. This is the approach recommended by Partners in Flight (Rosenberg and Hodgman 2000). Their plan focuses on conserving and restoring the populations of the Canada Warbler and Black-throated Blue Warbler since in doing so, the situation of all other stable or declining species would improve as well. The elements of their plan are as follows:

• maintaining a balance of forest-age structures, including adequate amounts of mid-successional as well as late-successional forest

• ensuring long-term tree-species composition; i.e. prevent loss of particular species, such as hemlock, white pine, or beech, through disease or selective harvest

• ensuring adequate structural diversity, especially regarding understory components (shrubs, treefalls); monitor effects of natural disturbances (e.g. wind storms) as well as deer browsing and forestry practices

• setting maximum allowable levels of forest fragmentation due to forestry practices or planned development; e.g. do not allow any 10,000 km^2 landscape to fall below 70% forest cover

• identify and designate Bird Conservation Areas (BCA), within which long-term sustainability of priority bird populations is a primary management objective

This approach requires that industry, conservation groups, and First Nation, municipal, provincial, and federal governments intensify their efforts toward integrated management of the forest ecosystem over a sufficiently large area.

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The cover is a collage of photos taken by Bernard Burke, Anita Pouliot, and the author. All other photos and graphic materials are by the author unless otherwise noted.

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Figures

Figure 1. Location of Study Area (Outlined in Red)

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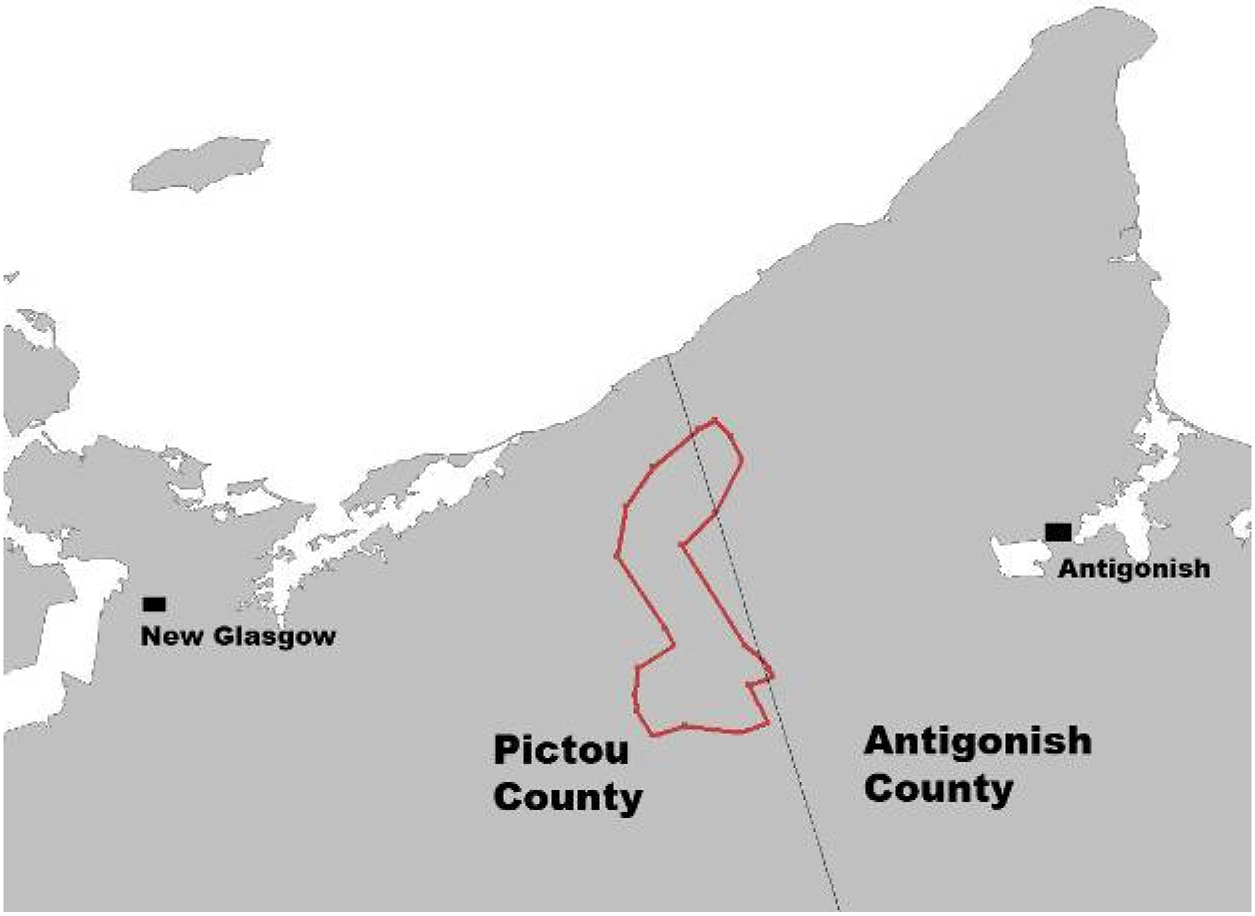

Figure 2. The Hollow or *Glen Dubh* (Dark Valley)

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Figure 3. View from Pictou-Antigonish Highlands towards the Northumberland Strait

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Figure 4. Fog Bank on Glen Dhu Wind Farm Site

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Figure 5. Mature Sugar Maple-Yellow Birch-Beech Woodland near the Glen Dhu Road
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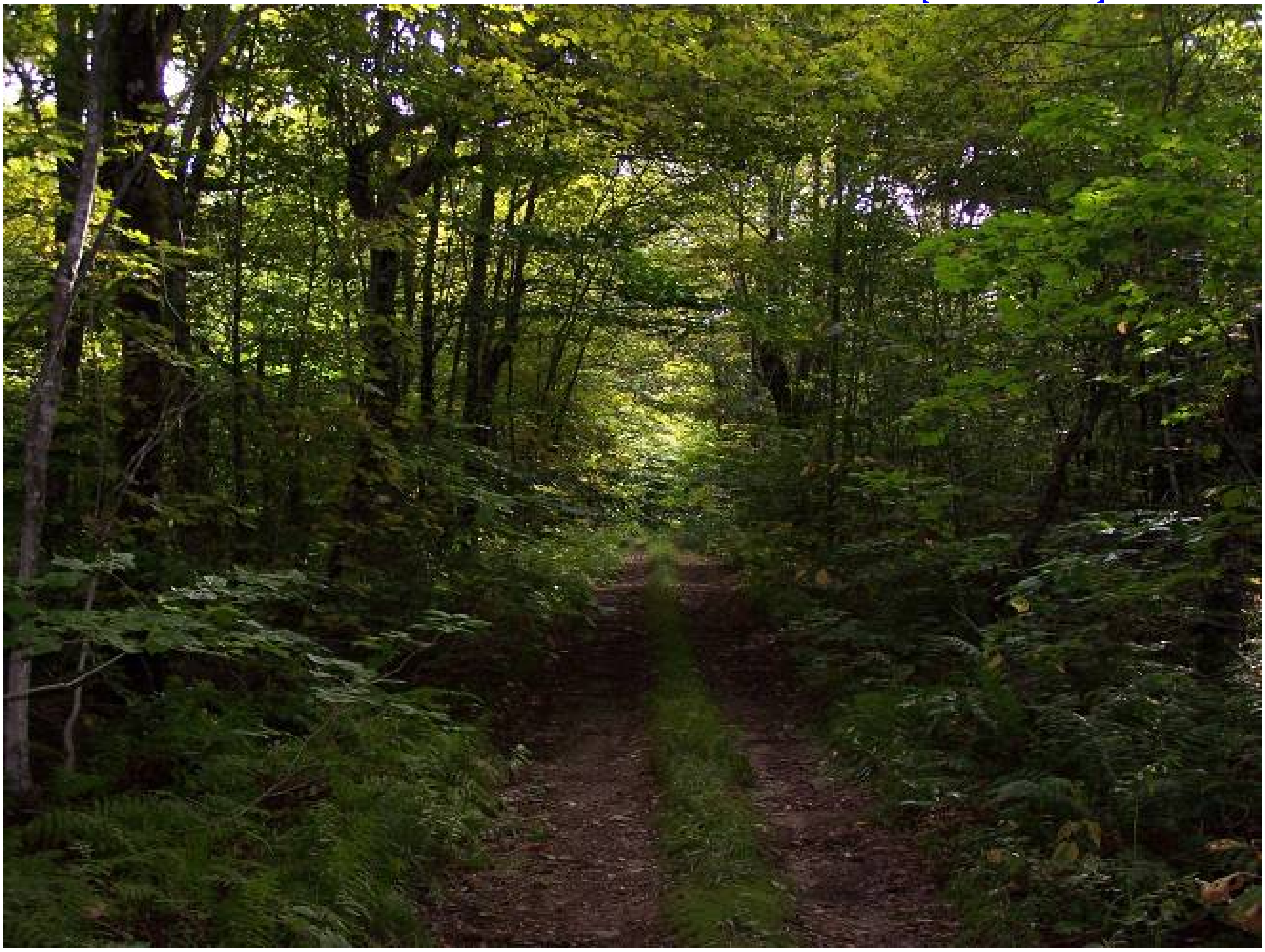

Figure 6. Clearcut Spruce Forest (Top) and Stack of Sugar Maple Logs for Firewood (Below)

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Figure 7. Cultural Infrastructure on the Glen Dhu Wind Farm Site

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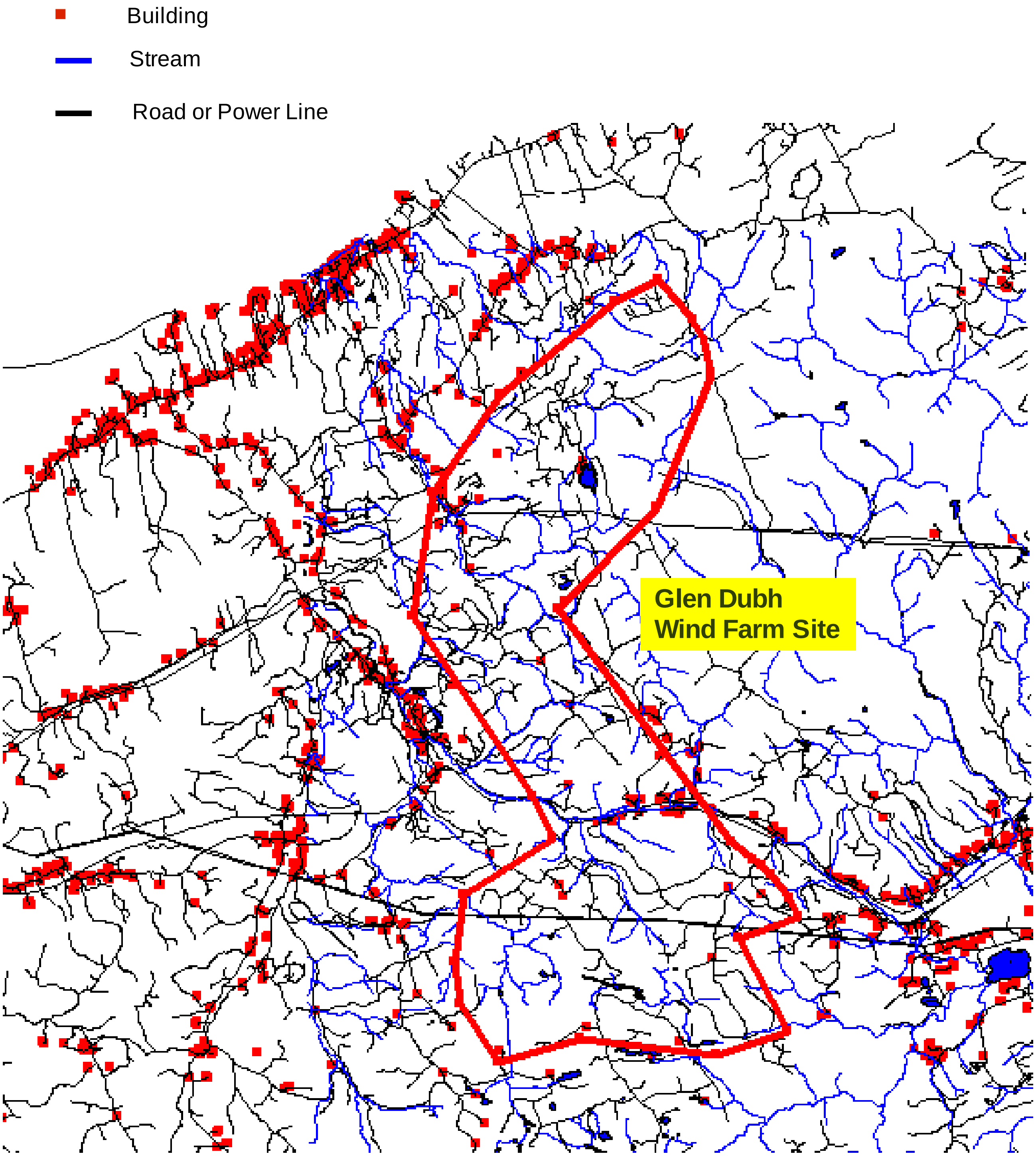

Figure 8. Human Ecological Footprint on the Pictou-Antigonish Highlands from Least (0) to Most Intense (100) Impact (Two Countries One Forest 2007)

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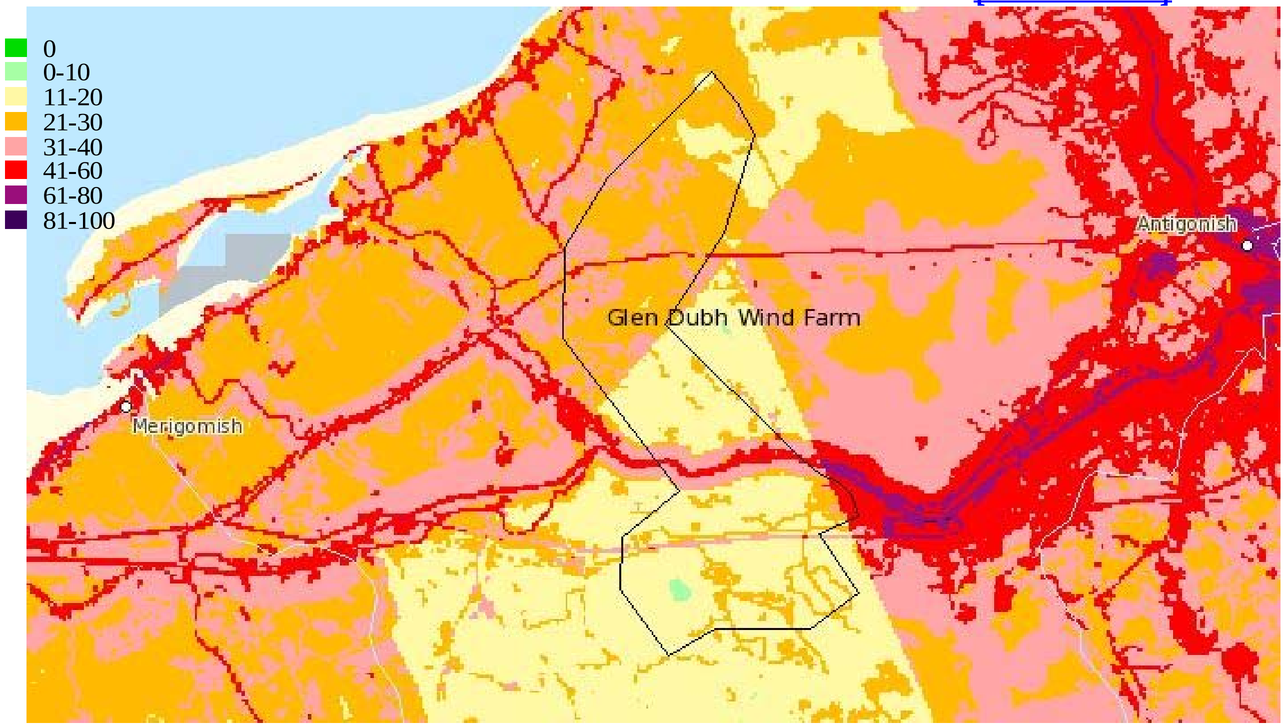

Figure 9. Location of Transects

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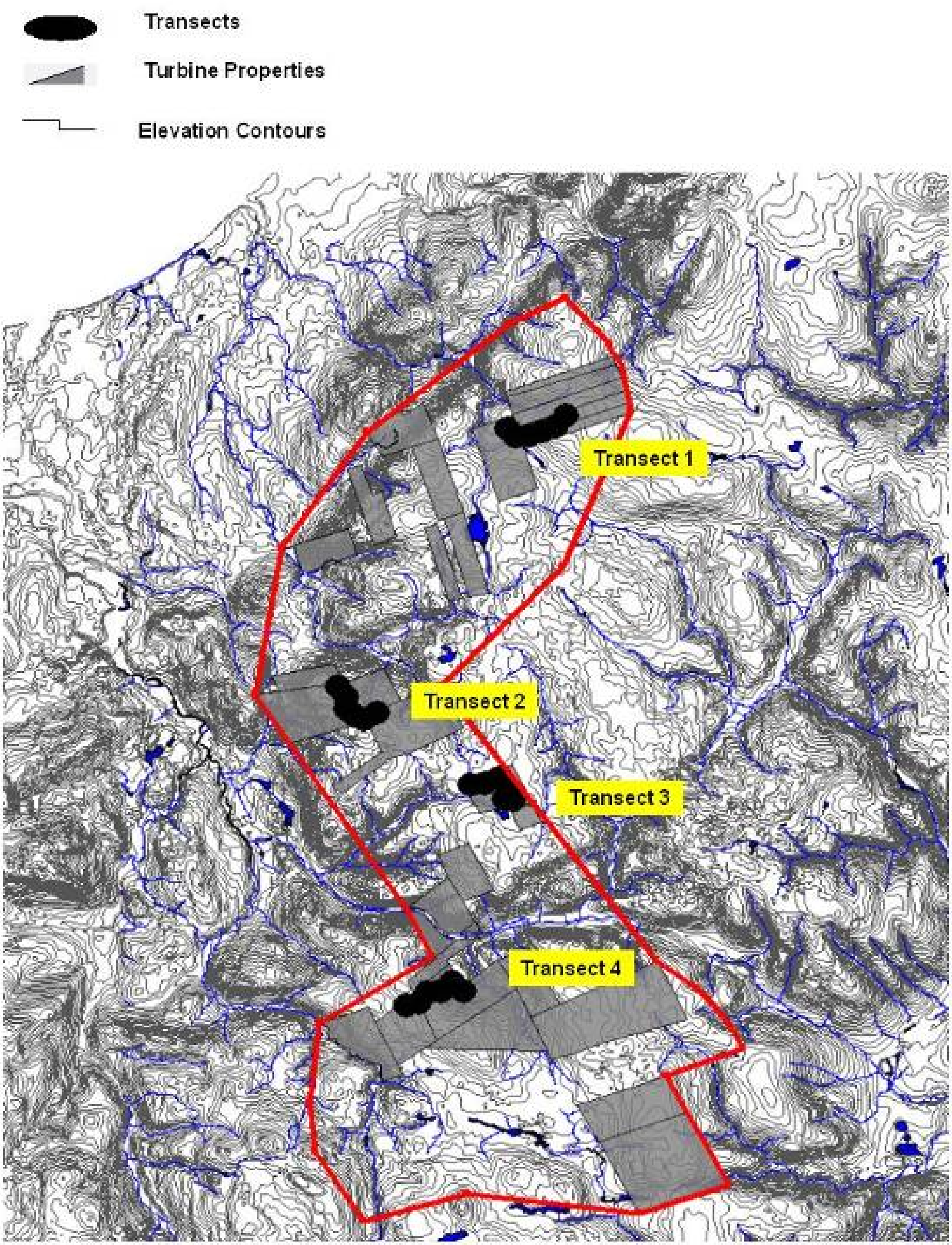

Figure 10. Mean Total Number of Birds per Transect at All Distances by 10-Day Period during Autumn Migration (With 95% confidence limits)

[Back to Text]

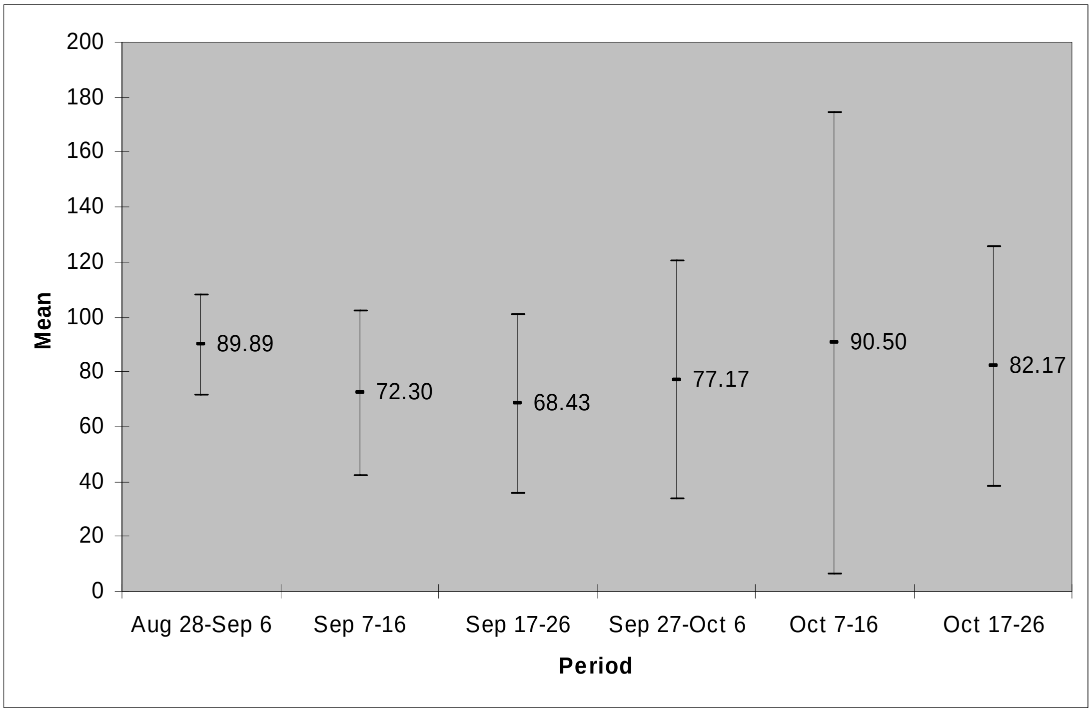

Figure 11. Mean Total Number of Birds per Transect Segment at < 50 m by 10-Day Period during Autumn Migration (With 95% confidence limits)

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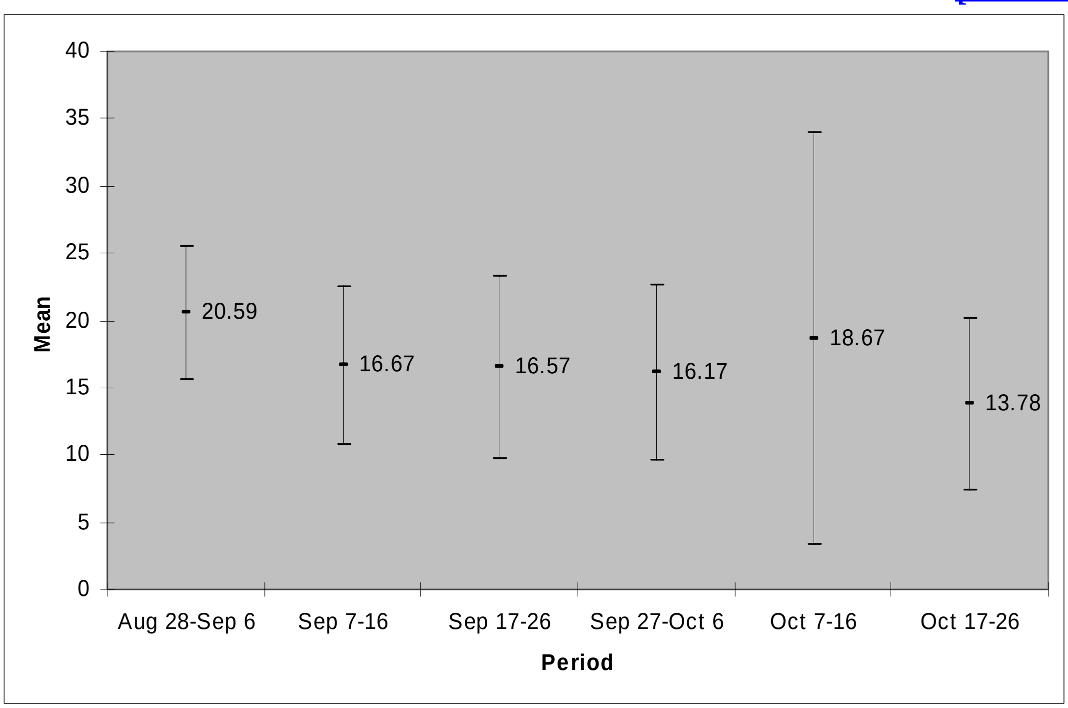

Figure 12. Mean Total Species of Birds per Transect at All Distances by 10-Day Period during Autumn Migration (With 95% confidence limits)

[Back to Text]

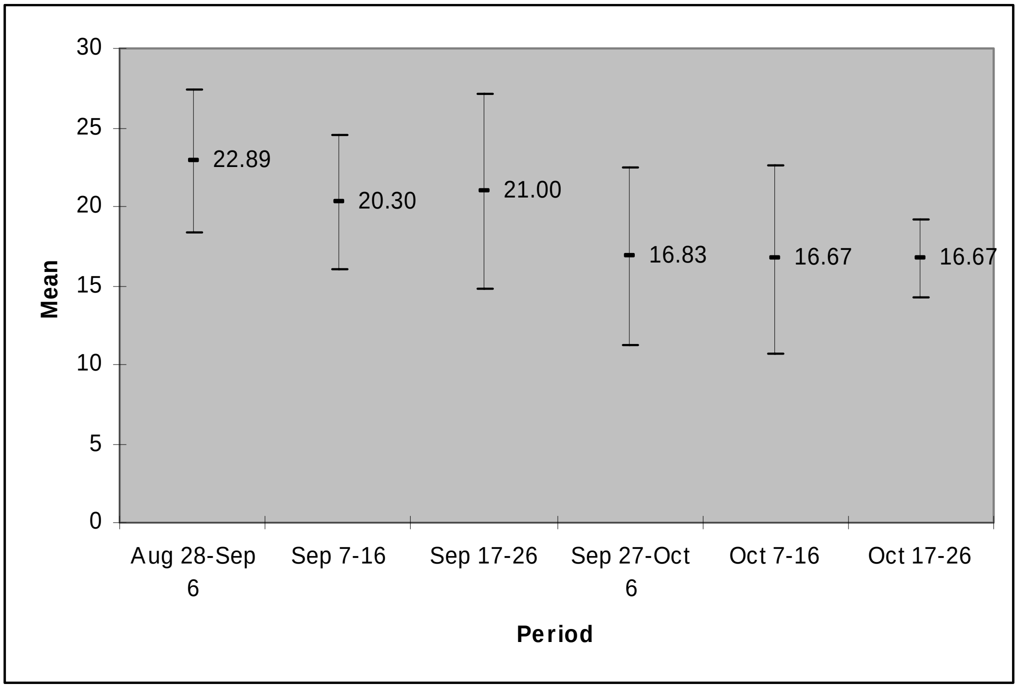

Figure 13. Mean Total Species of Birds per Transect Segment at <50 m by 10-Day Period during Autumn Migration (With 95% confidence limits)

[Back to Text]

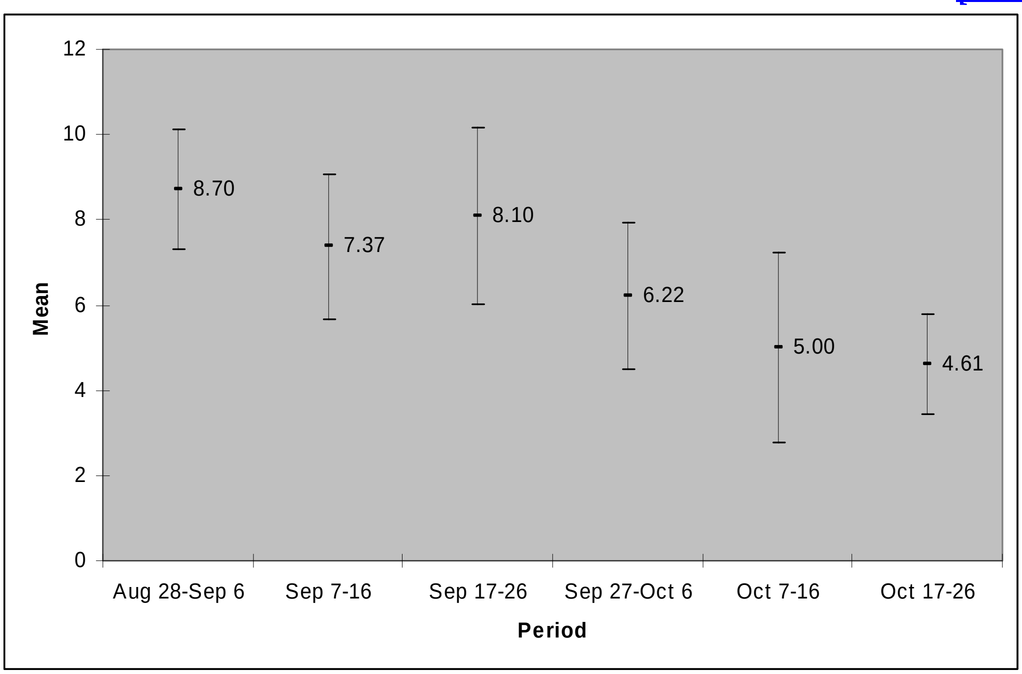

Figure 14. Mean Number of Birds by Species Demonstrating Statistically Significant Seasonal Patterns per Transect Segment <50 m by 10-Day Period during Autumn Migration

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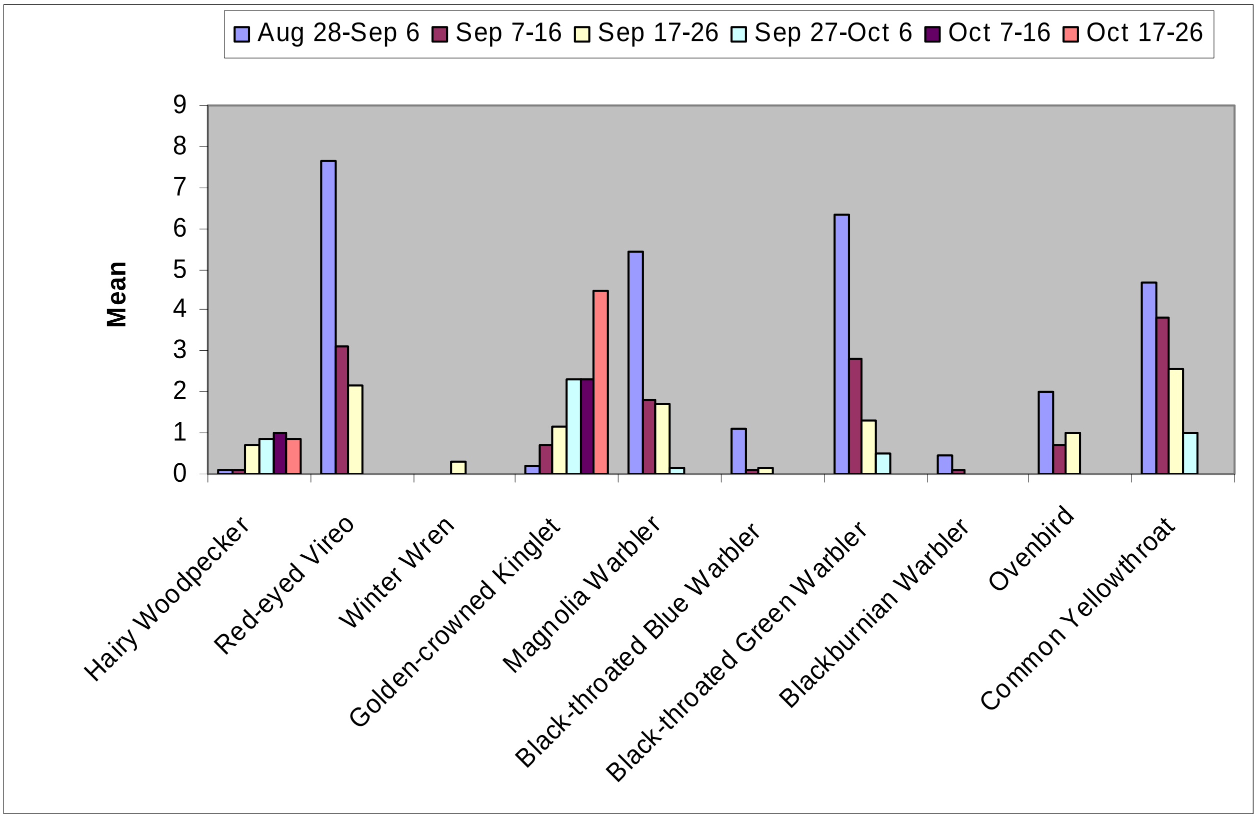

Figure 15. Mean Number of Birds by Species More Easily Detected at Distances >50 m and Demonstrating Statistically Significant Seasonal Patterns by 10-Day Period during Autumn Migration

[Back to Text]

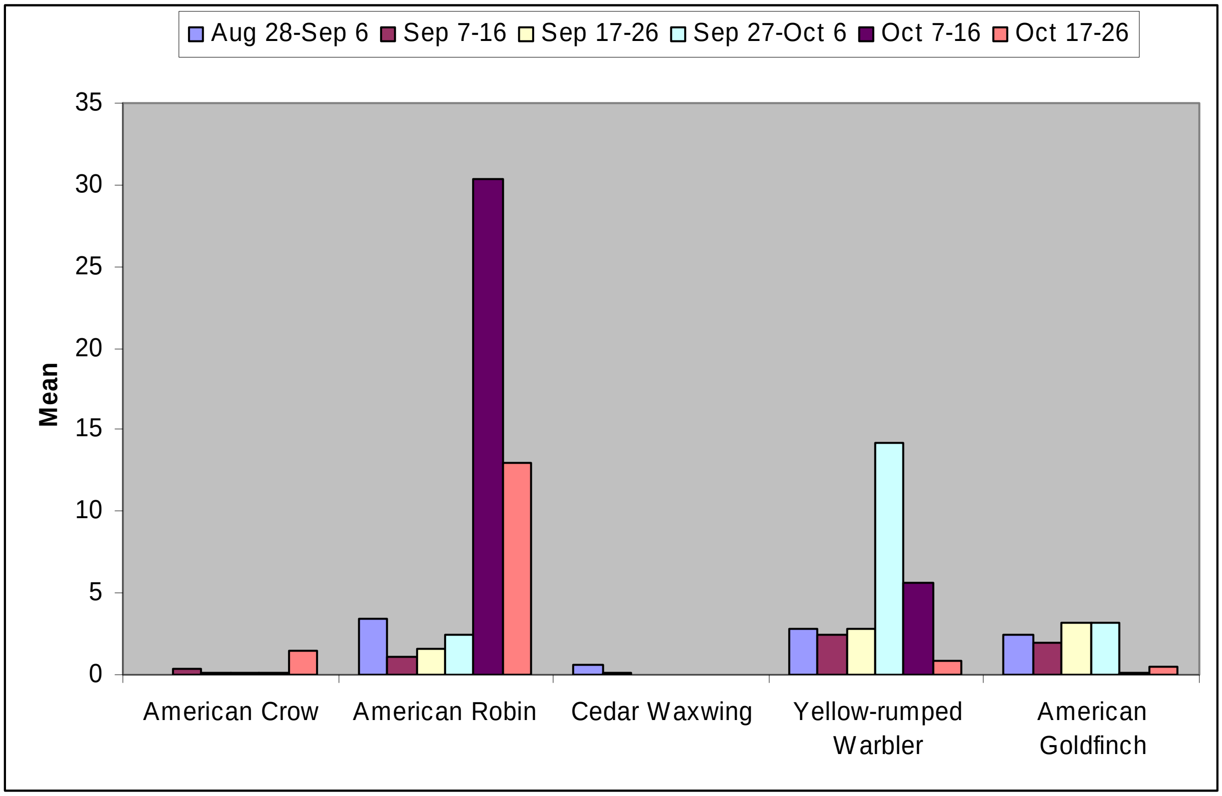

Figure 16. Radar Plot of Mean Total Birds, Wind Speed, and Wind Direction per Transect during Autumn Migration

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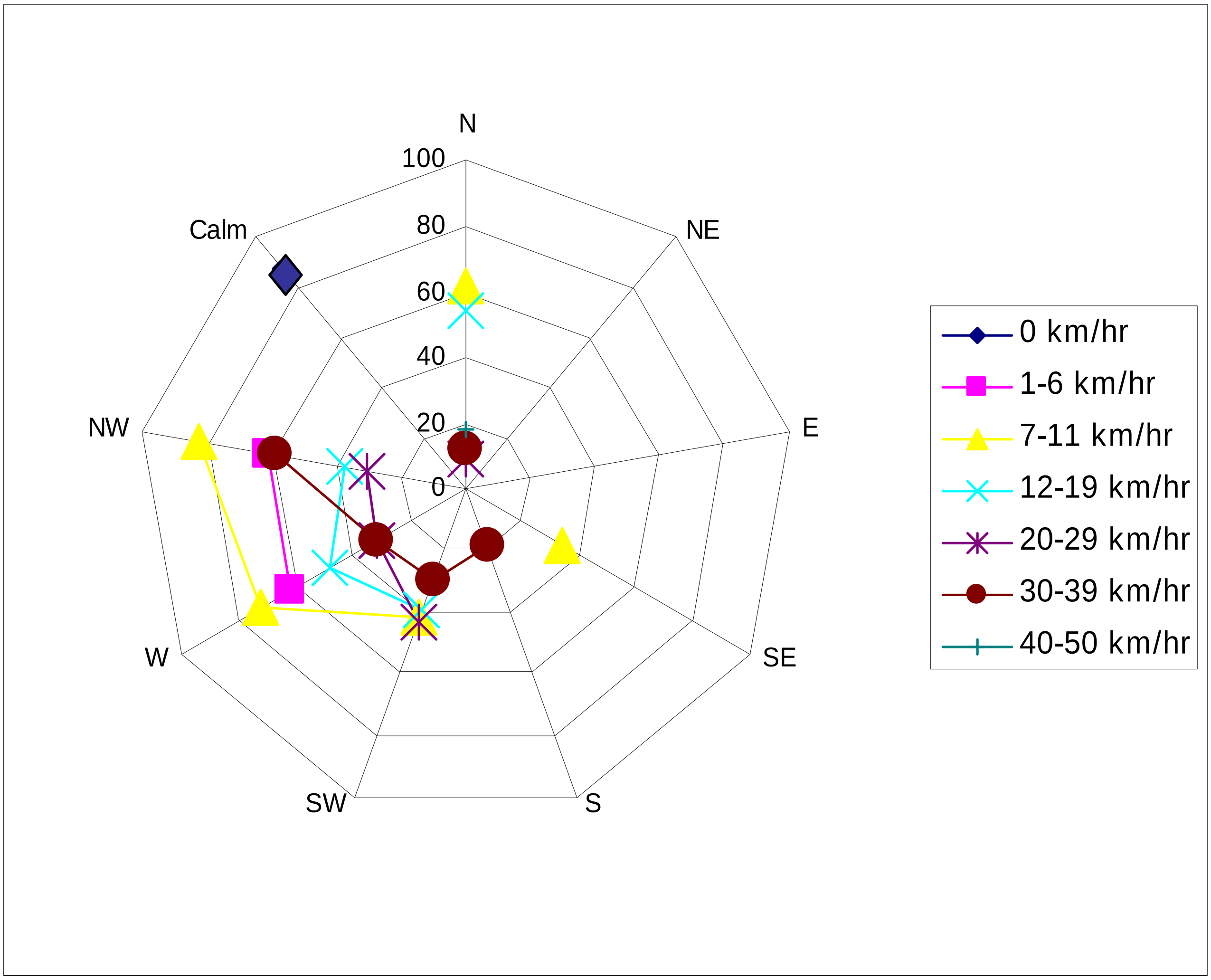

Figure 17. Radar Plot of Mean Total Birds, Wind Speed, and Wind Direction – Without "Calm" Direction – during Autumn Migration

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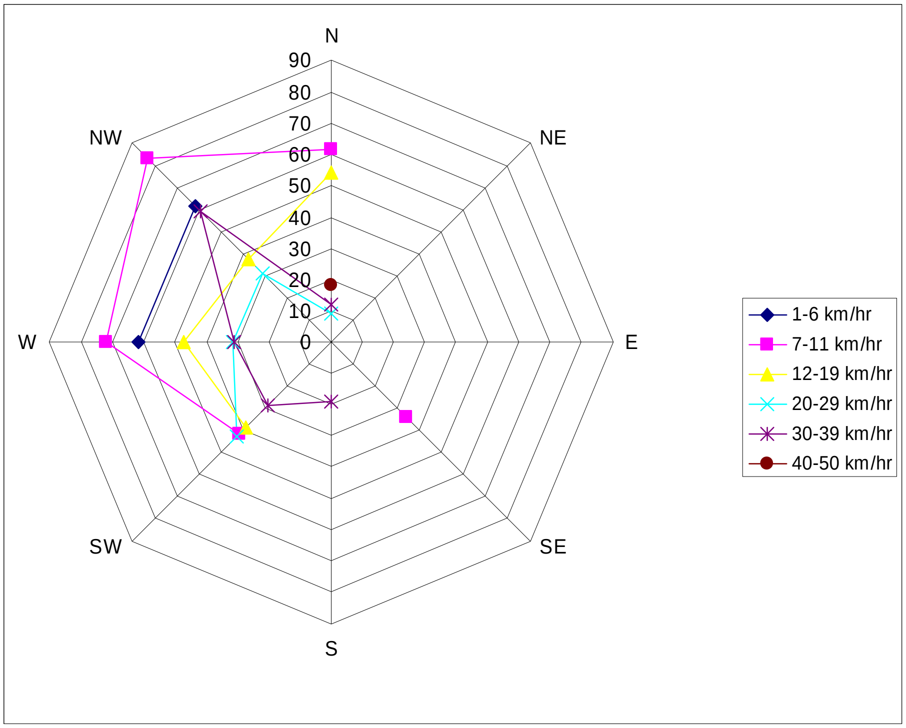
A. Per Transect



B. Per Segment of Transects

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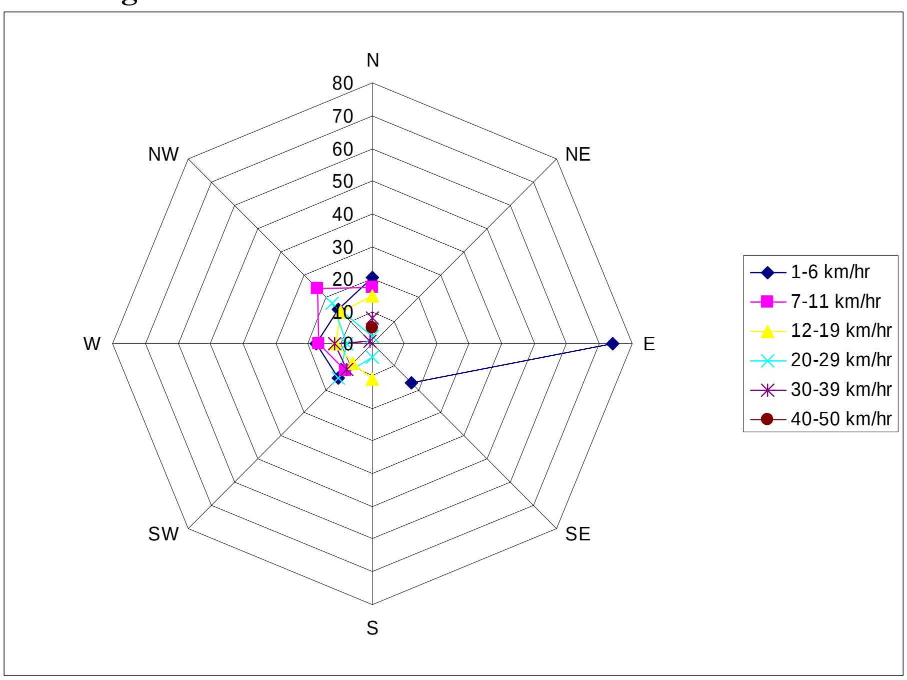

Figure 18. Forest Composition in Transect 1

[Back to Autumn Migration] [Back to Spring Migration]

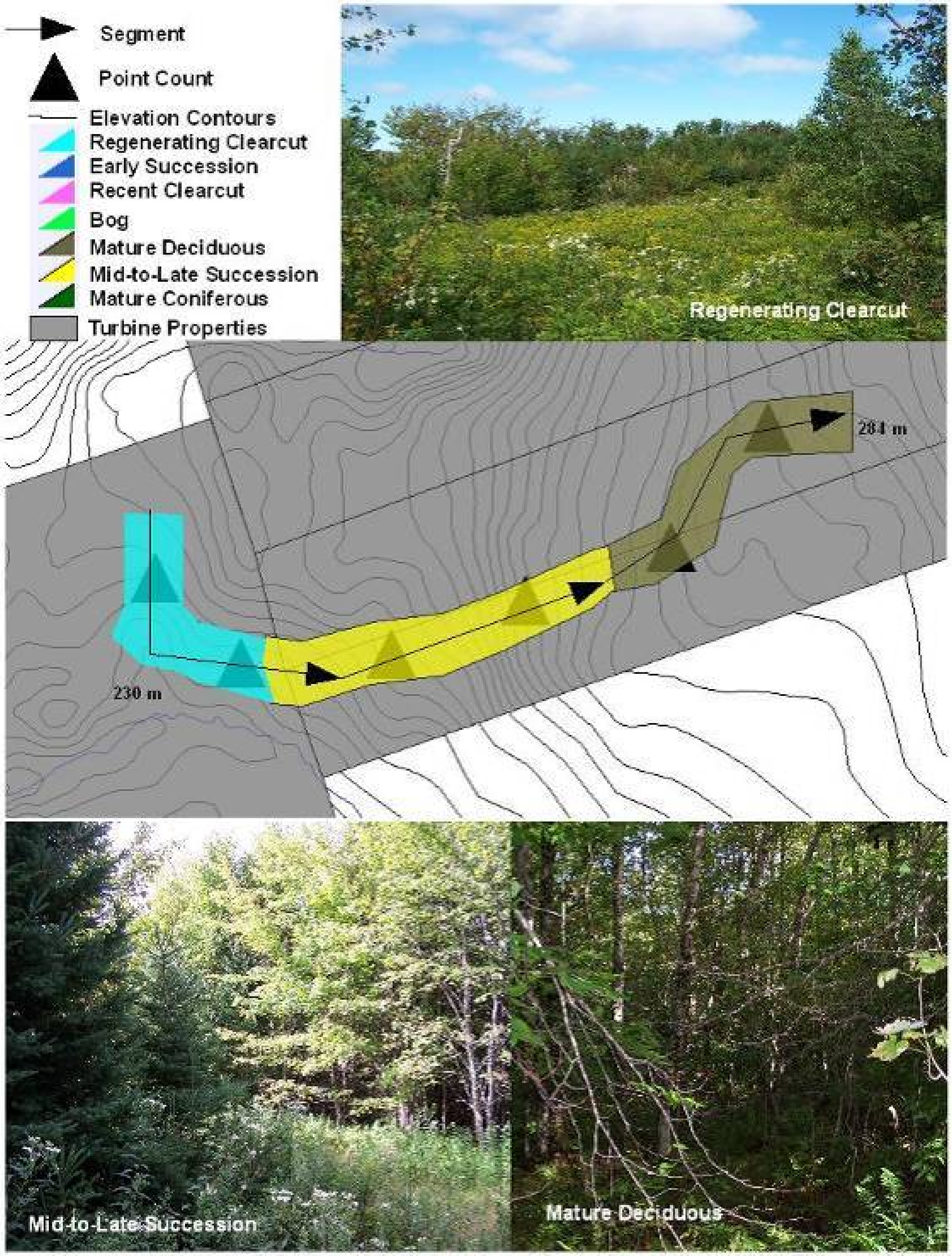

Figure 19. Forest Composition in Transect 2

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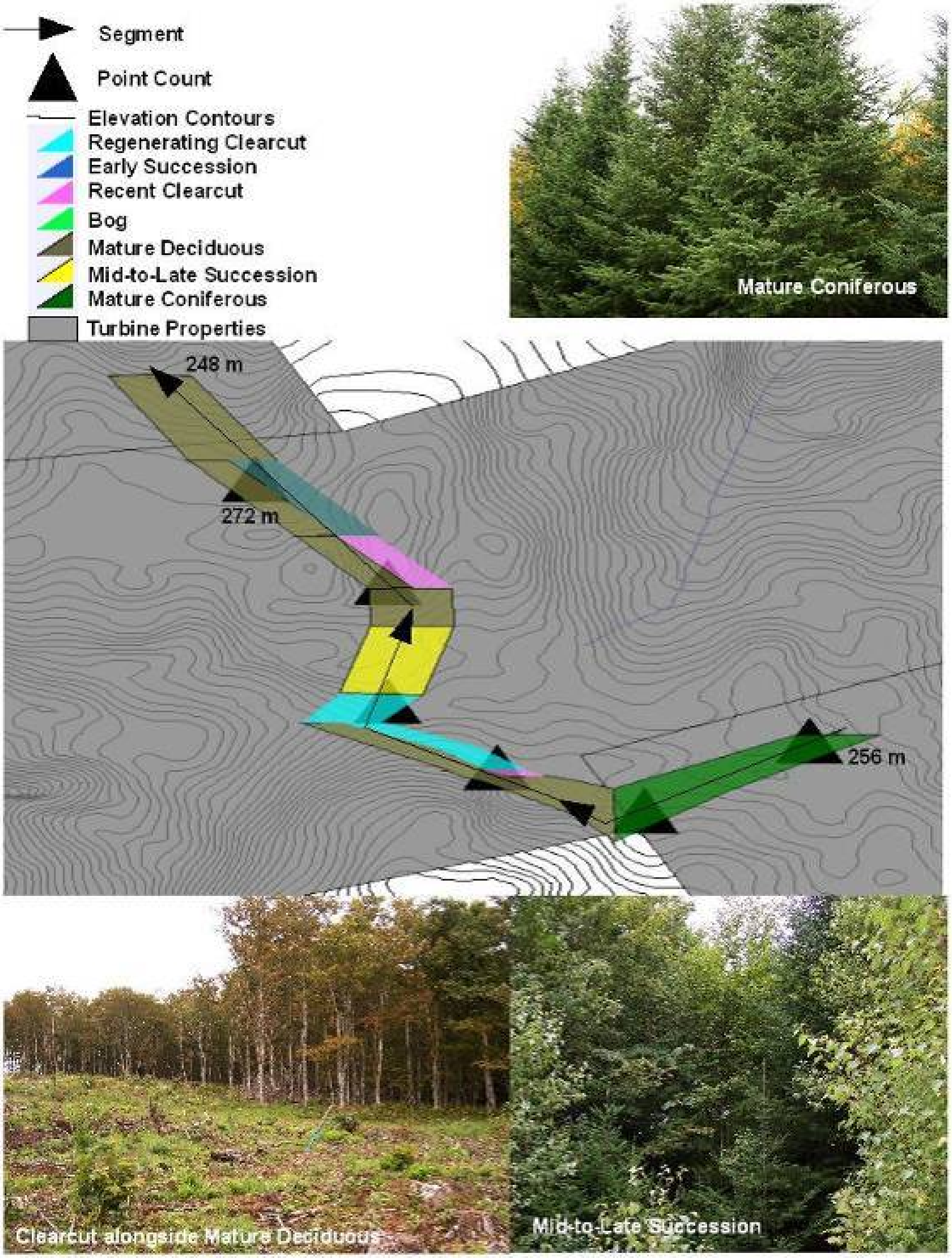

Figure 20. Forest Composition in Transect 3

[Back to Autumn Migration] [Back to Spring Migration]

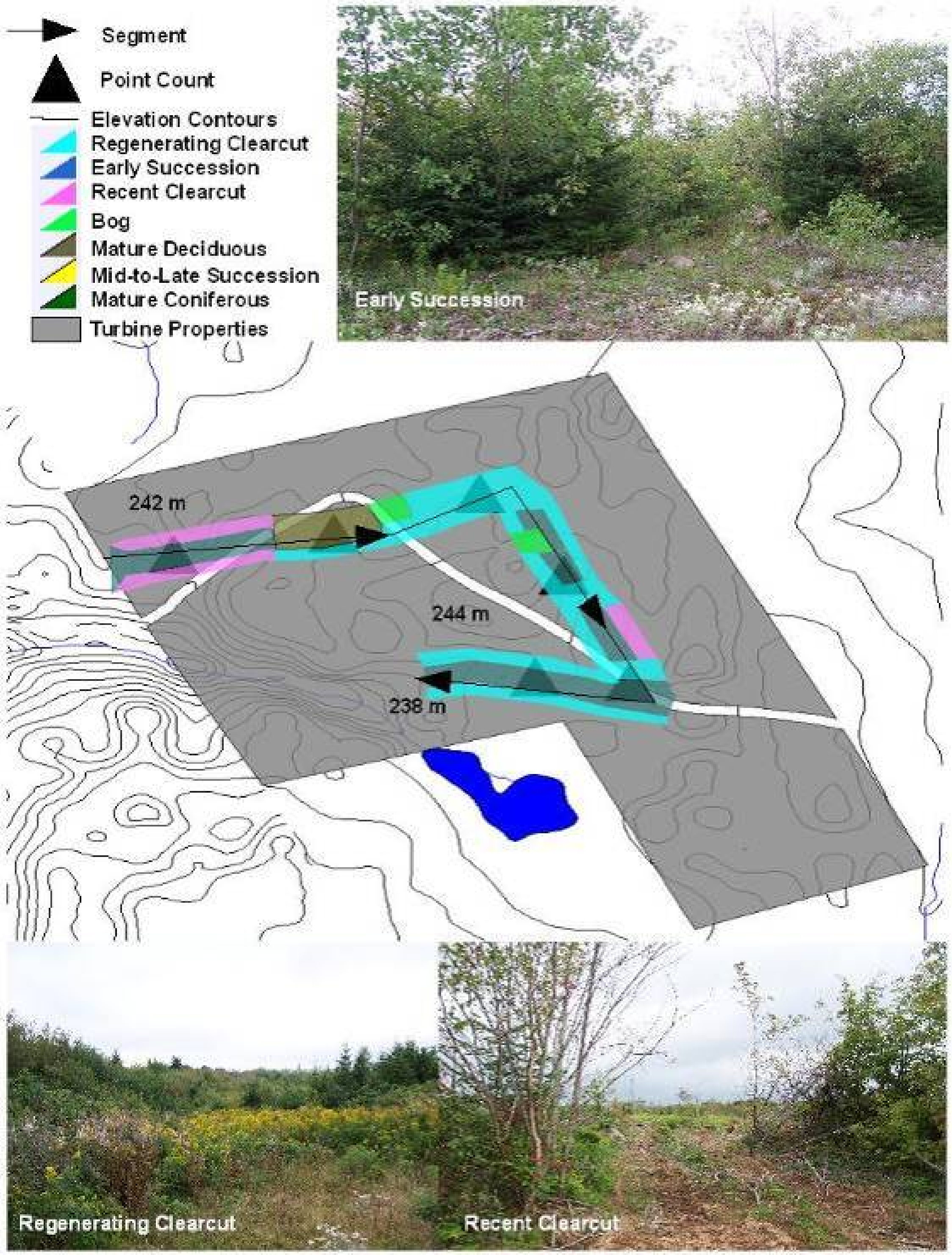

Figure 21. Forest Composition in Transect 4

[Back to Autumn Migration] [Back to Spring Migration]

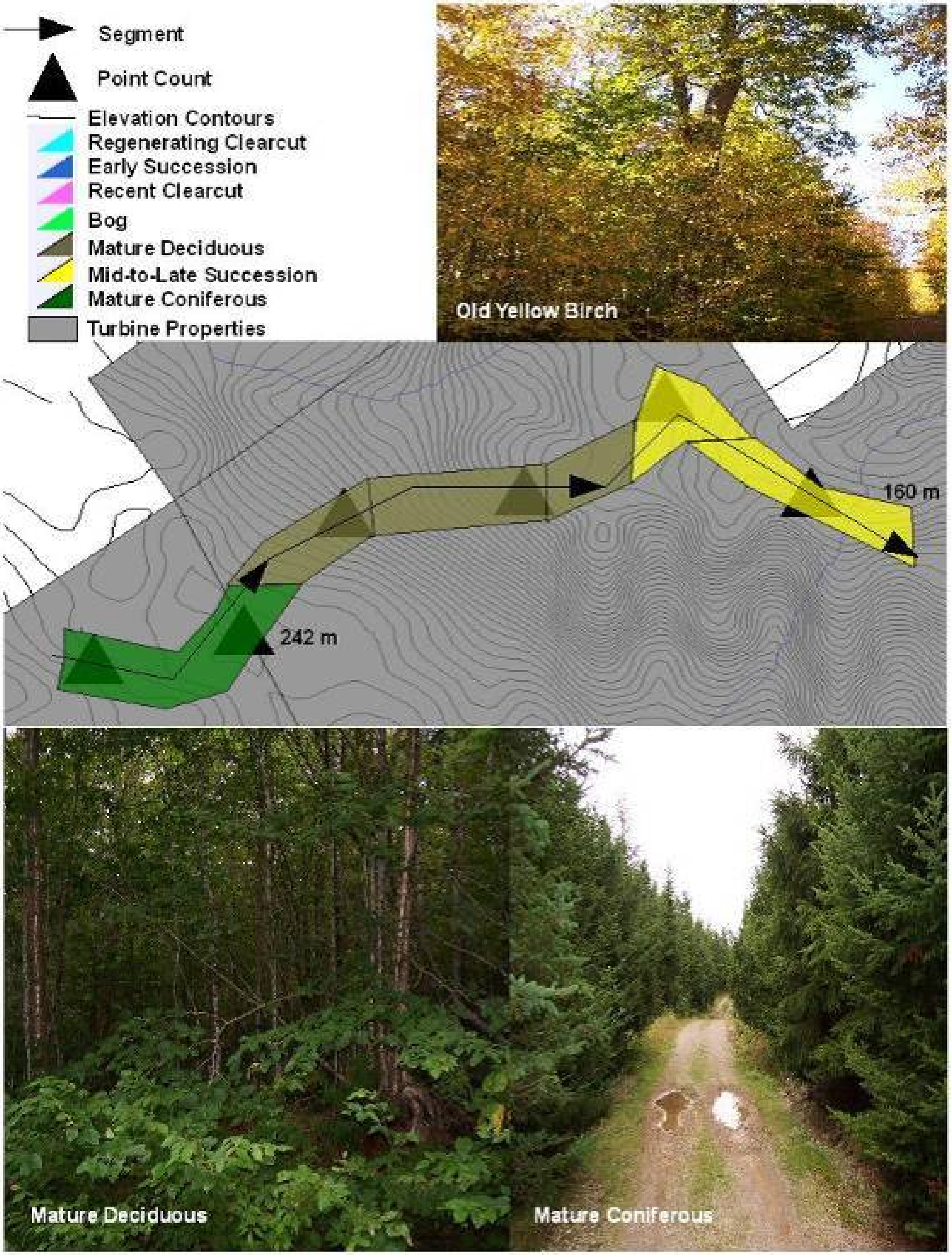

Figure 22. Location of Nocturnal Passage Listening Points

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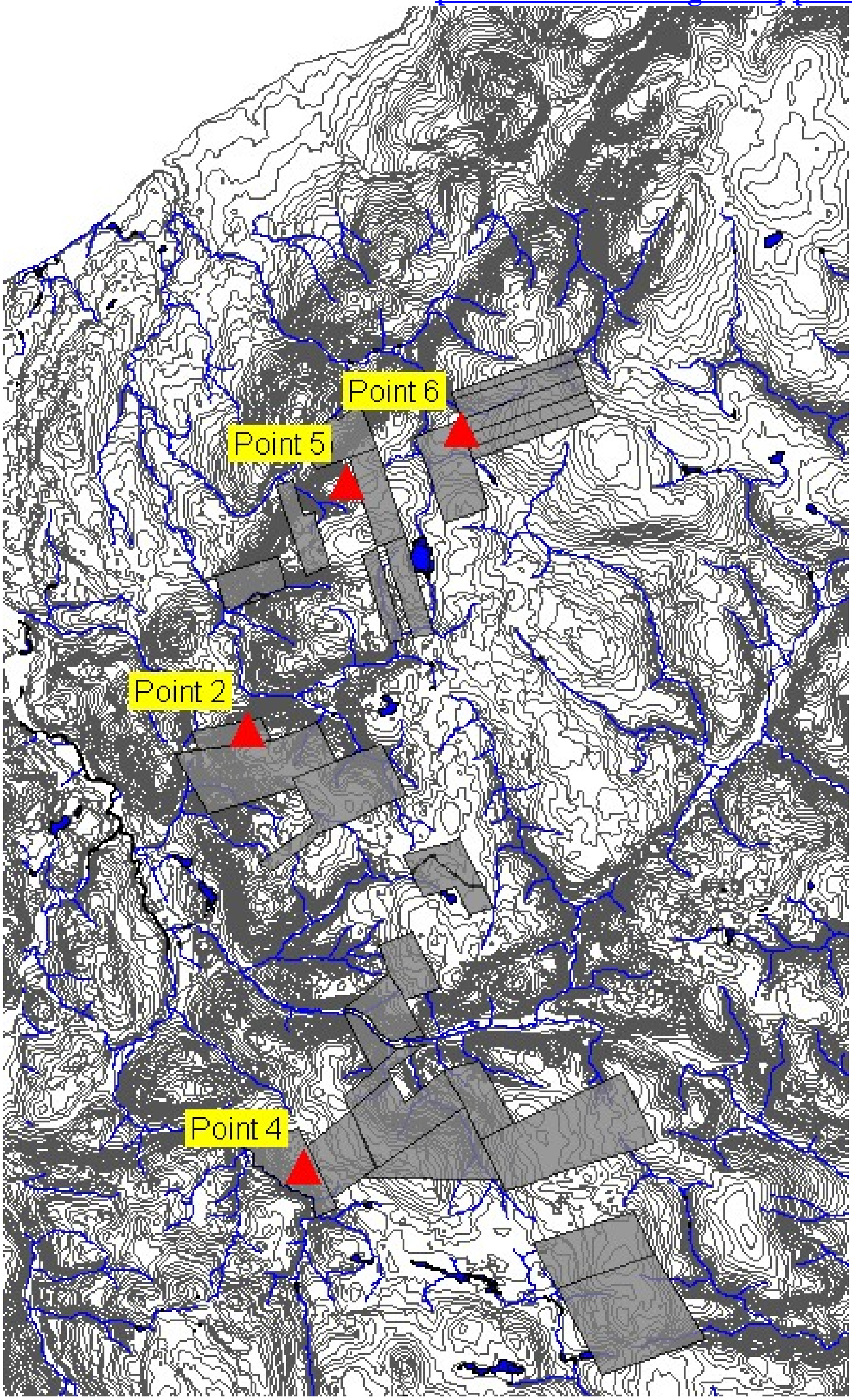
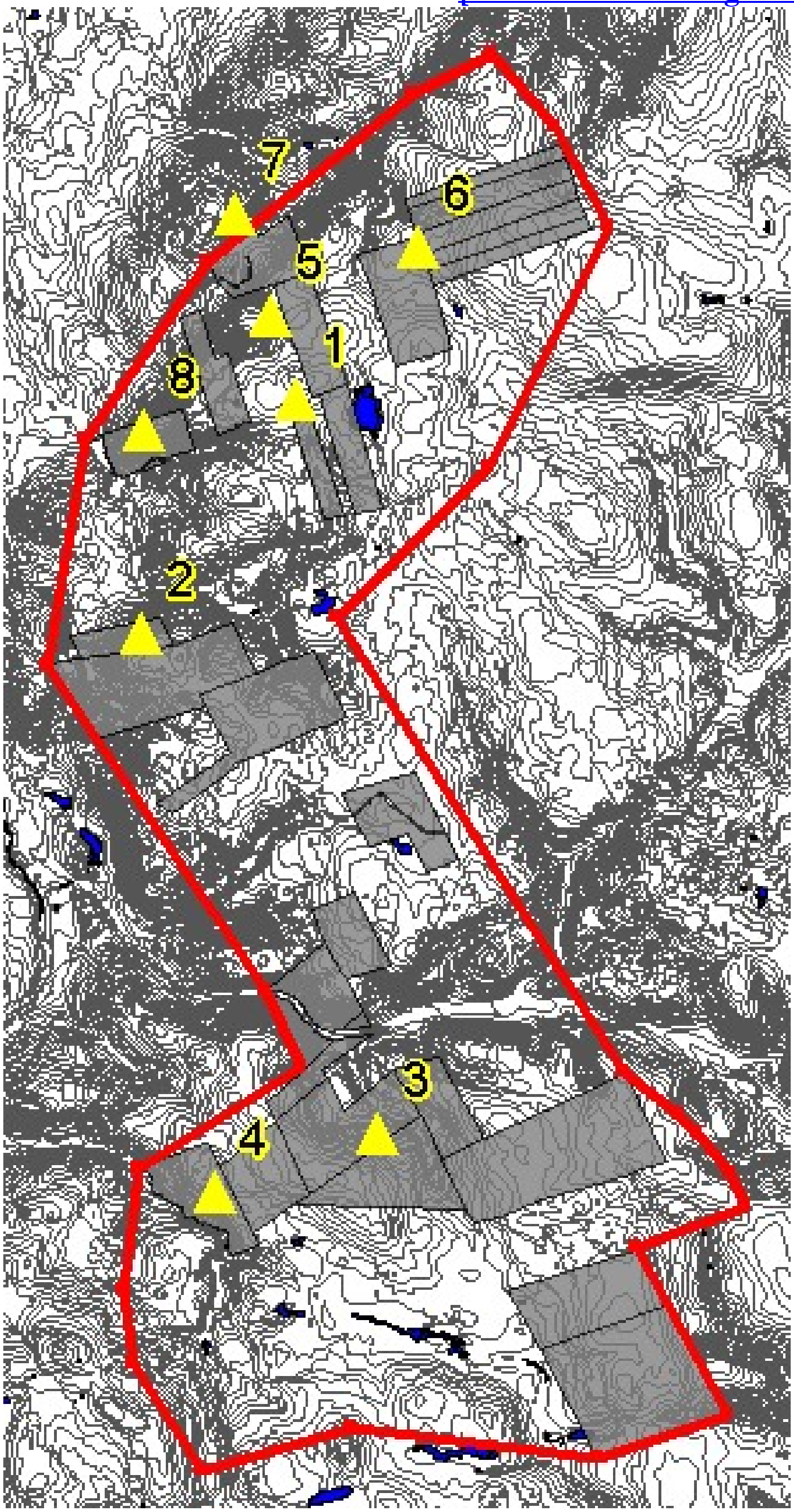


Figure 23. Location of Diurnal Passage Observation Points

[Back to Autumn Migration] [Back to Spring Migration]



Point 5

Point 2

Point 4

Figure 24. Flight Direction and Wind Direction for Woodpeckers and Small to Medium-sized Passerines Observed in Diurnal Passage during the Autumn Migration

[Return to Text]

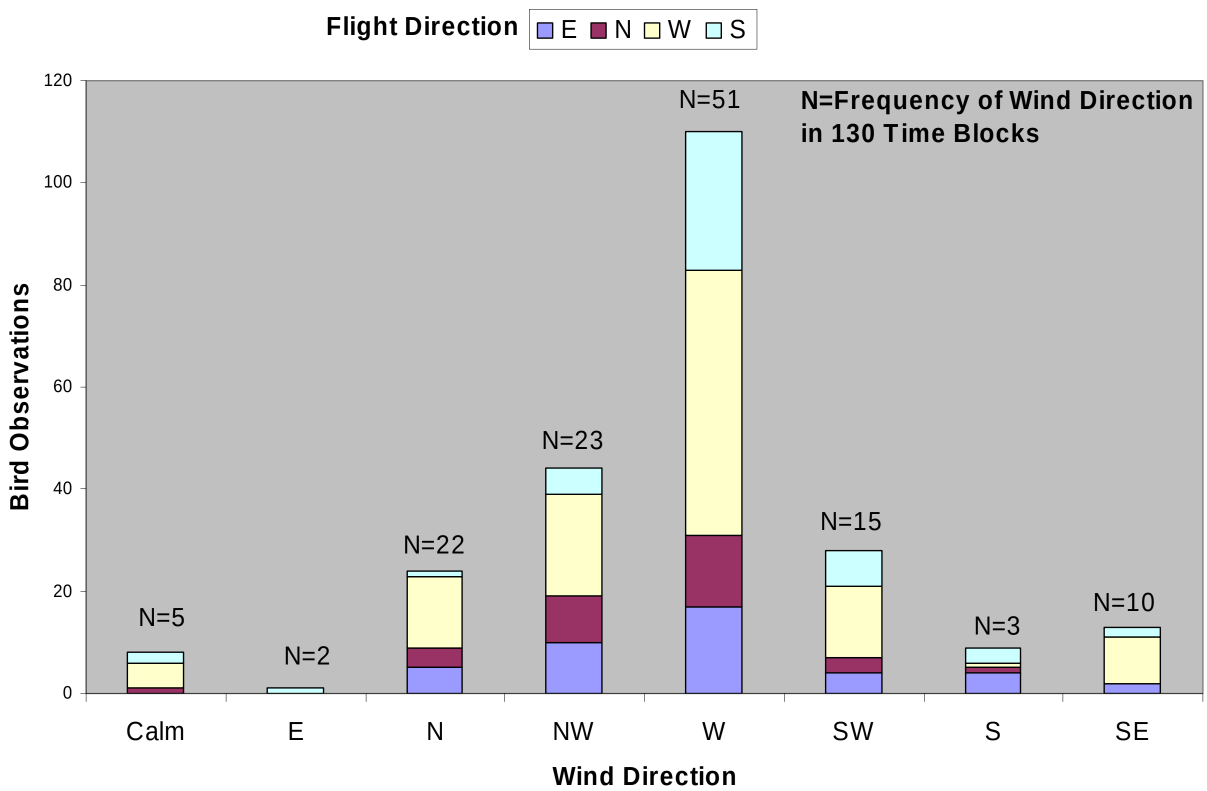


Figure 25. Flight Direction and Wind Speed for Woodpeckers and Small to Medium- sized Passerines Observed in Diurnal Passage during the Autumn Migration

[Back to Text]

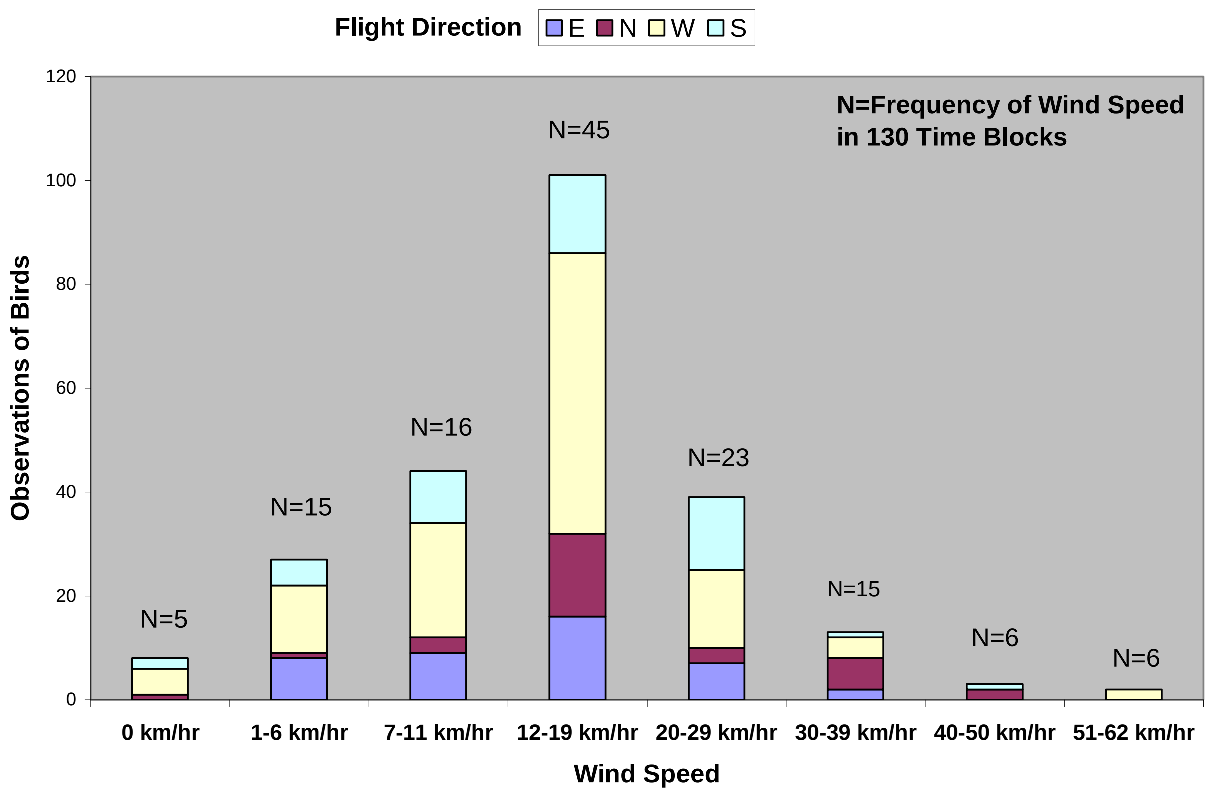


Figure 26. Location of Winter Standardized Area Counts

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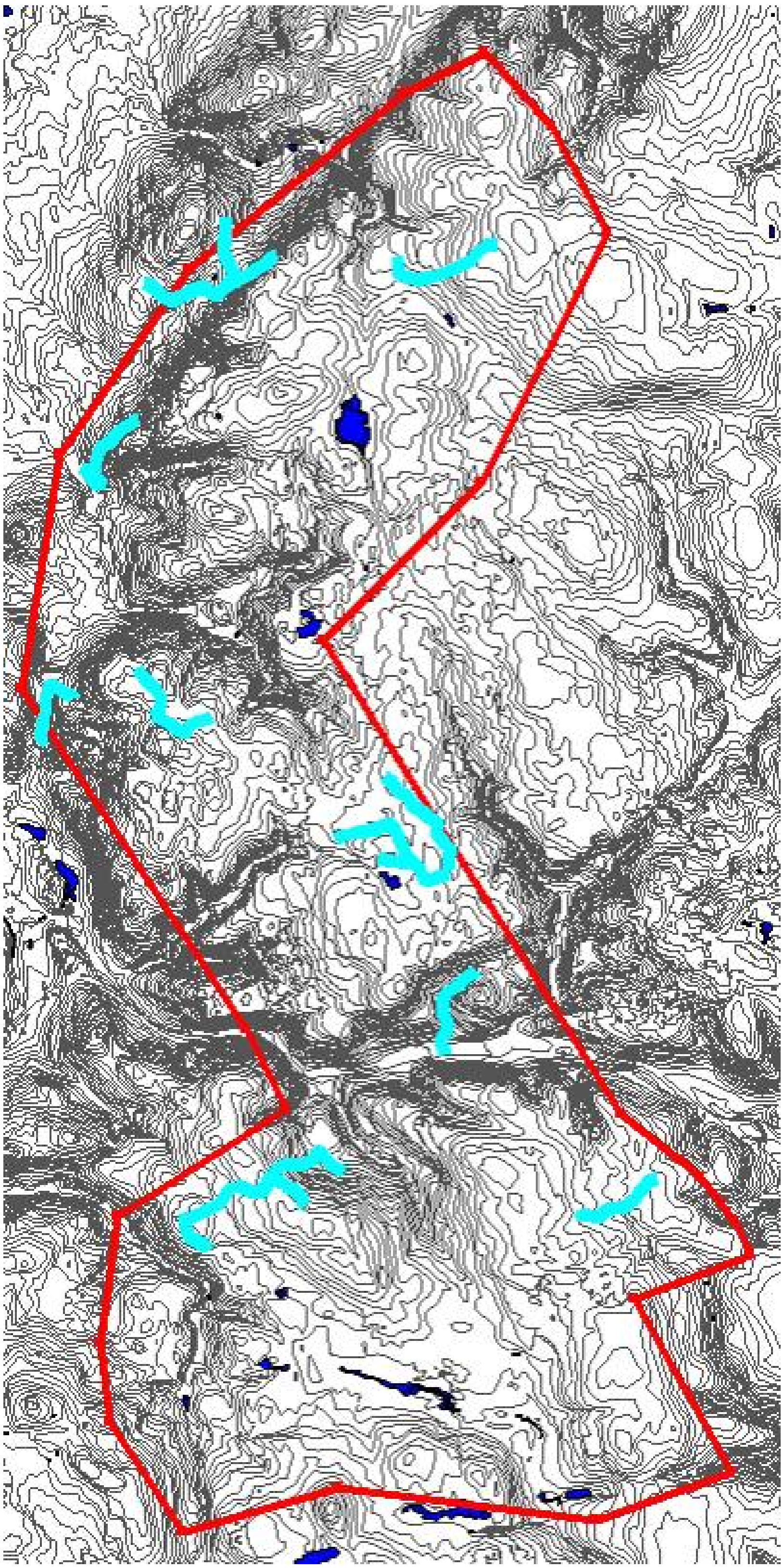

Figure 27. Mean Birds per Hectare by Habitat Type in Winter (With 95% confidence limits)

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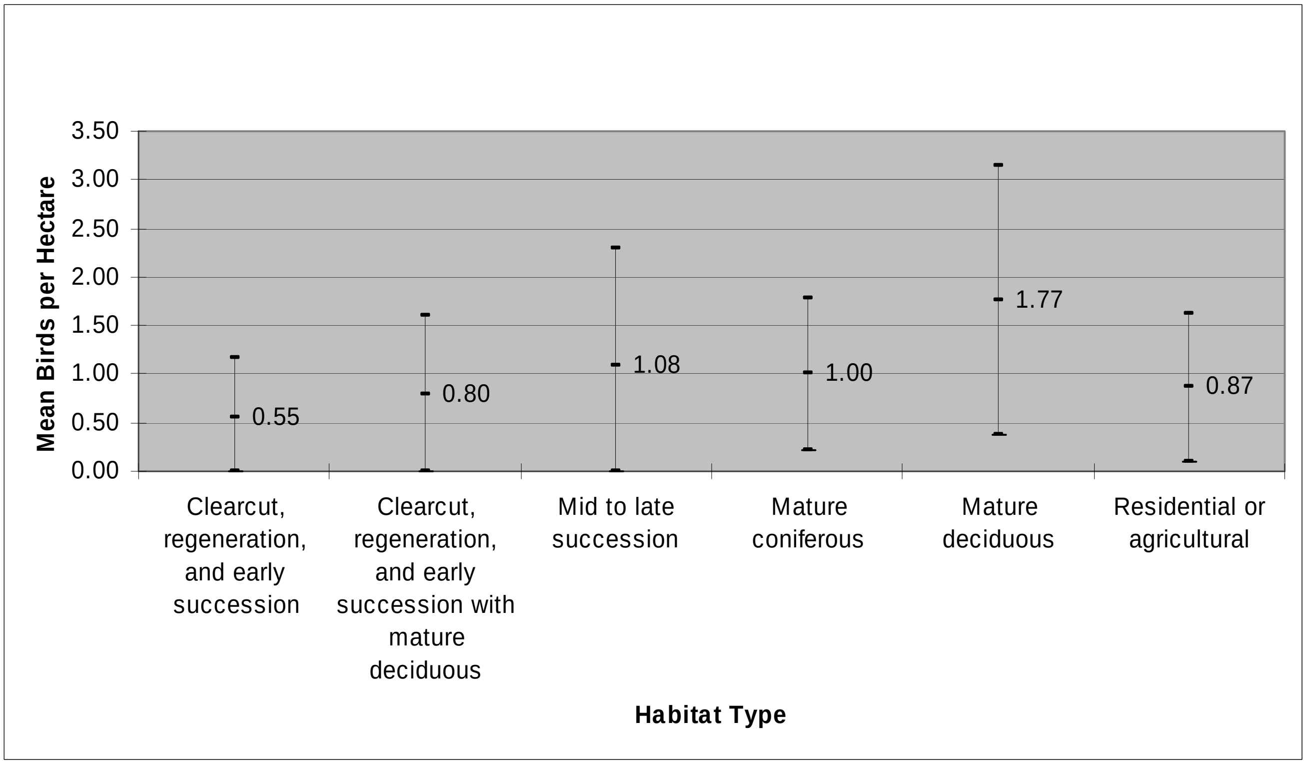

Figure 28. Mean Total Number of Birds per Transect at All Distances by 10-day Period during the Spring Migration (With 95% confidence limits)

[Back to Text]

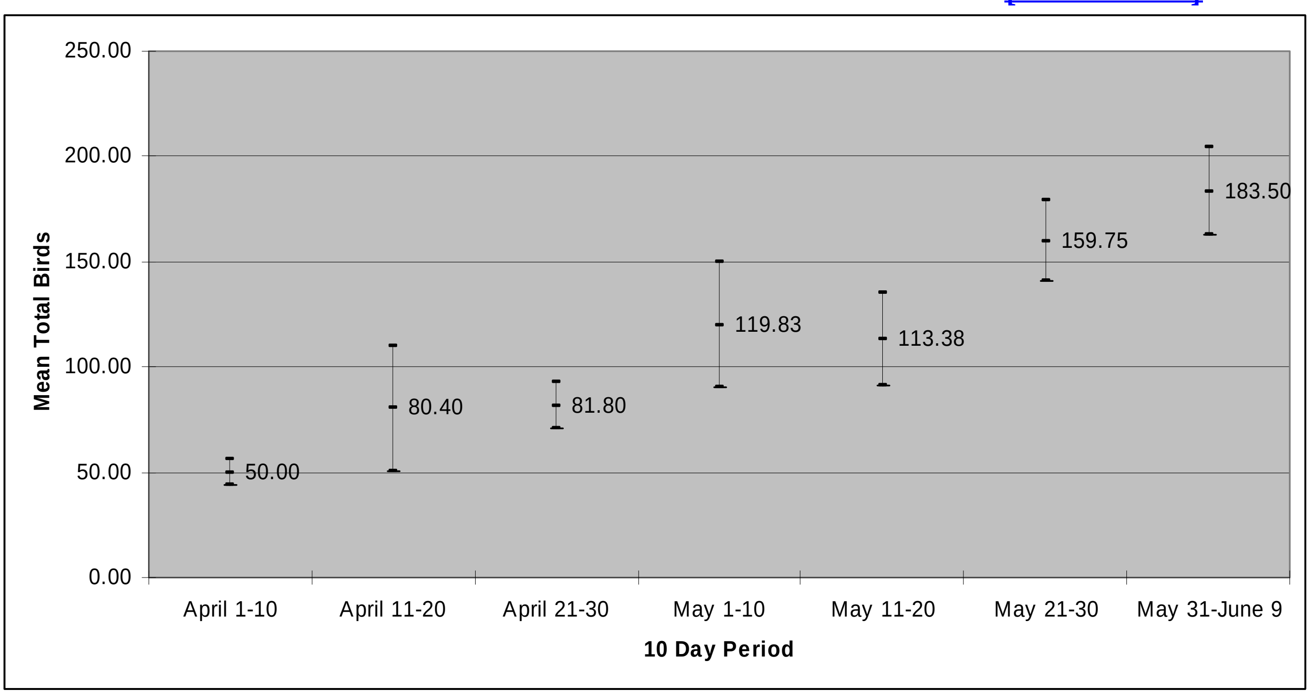

Figure 29. Mean Total Number of Birds per Transect at All Distances by 10-day Period without Breeding Birds during the Spring Migration (With 95% confidence limits)

[Back to Text]

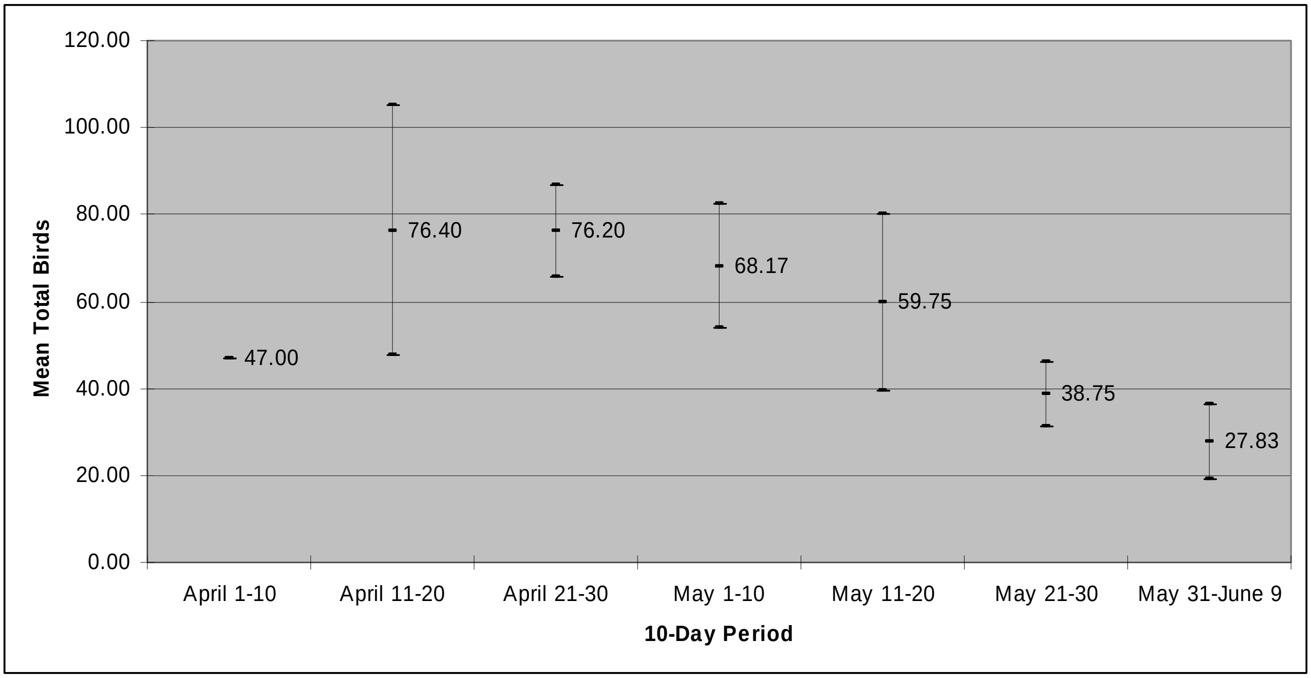

Figure 30. Mean Total Number of Birds per Transect Segment at <50m by 10-day Period without Breeding Birds during the Spring Migration (With 95% confidence limits)

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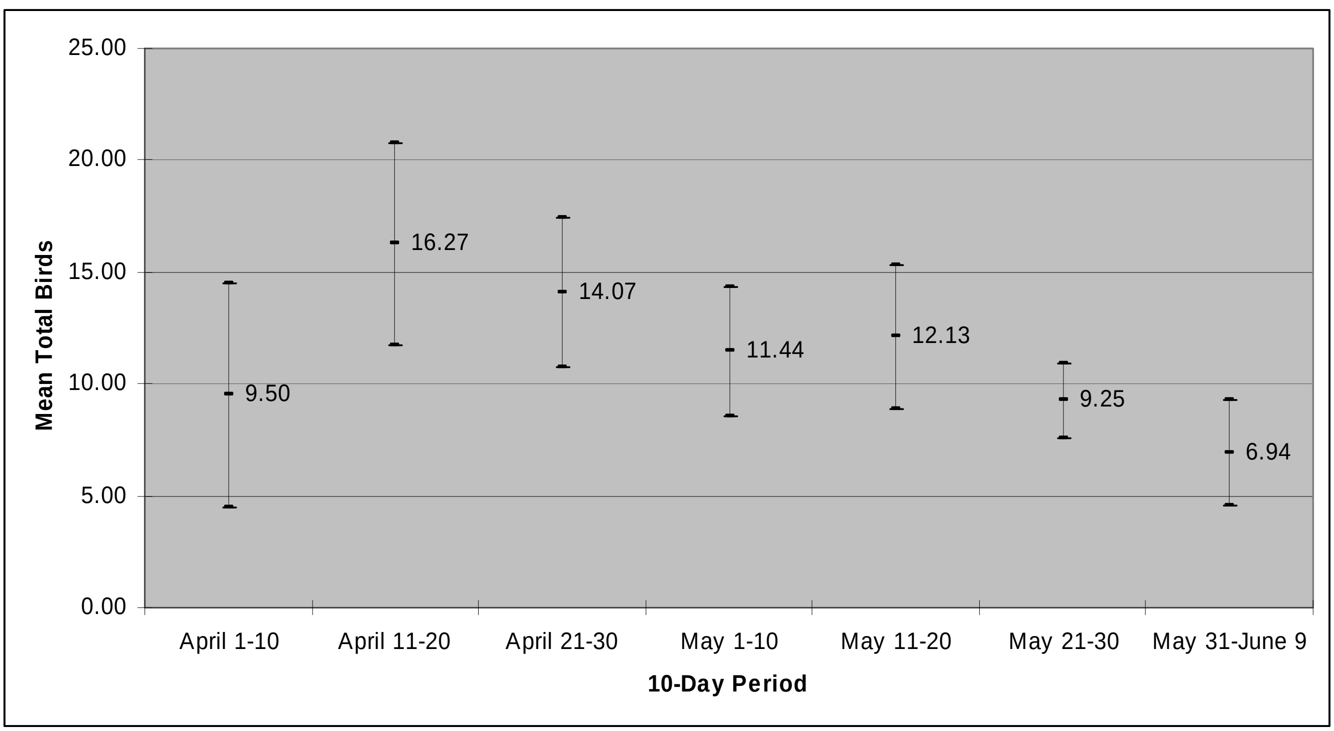

Figure 31. Mean Total Species of Birds by Transect at All Distances during the Spring Migration (With 95% confidence limits)

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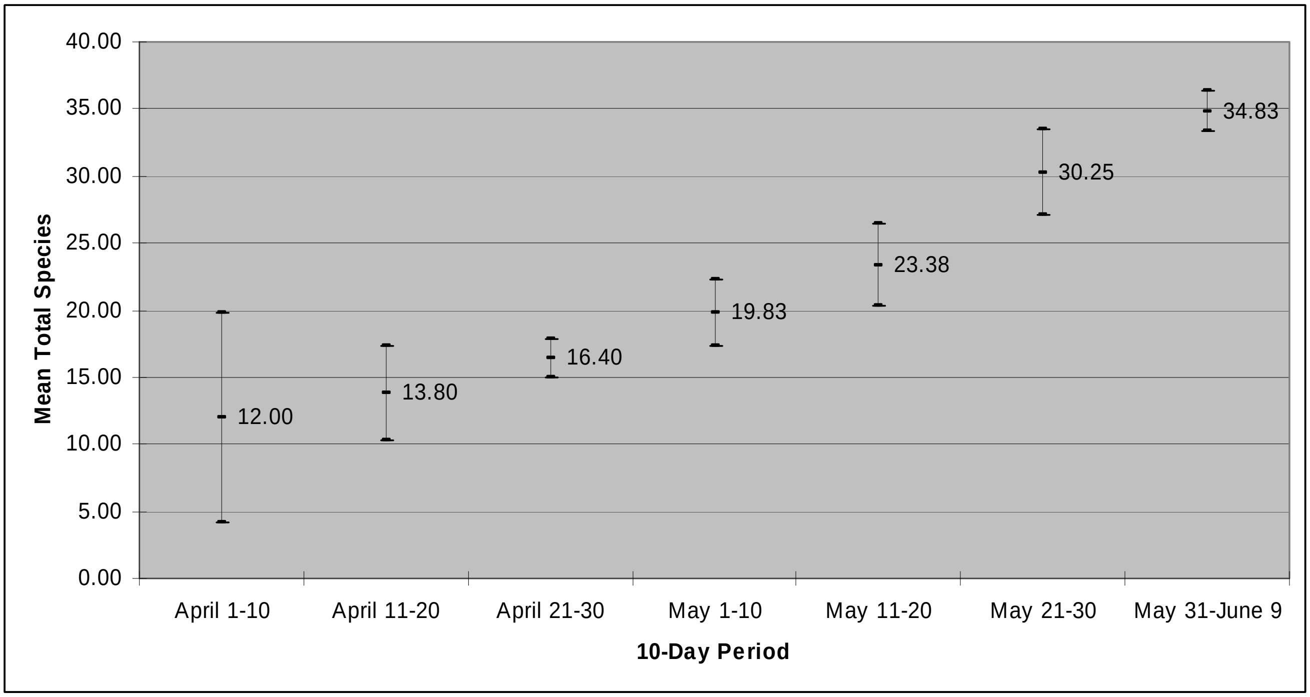

Figure 32. Means Total Species of Birds by Transect Segment at <50m without Breeders during the Spring Migration (With 95% confidence limits)

[Back to Text]

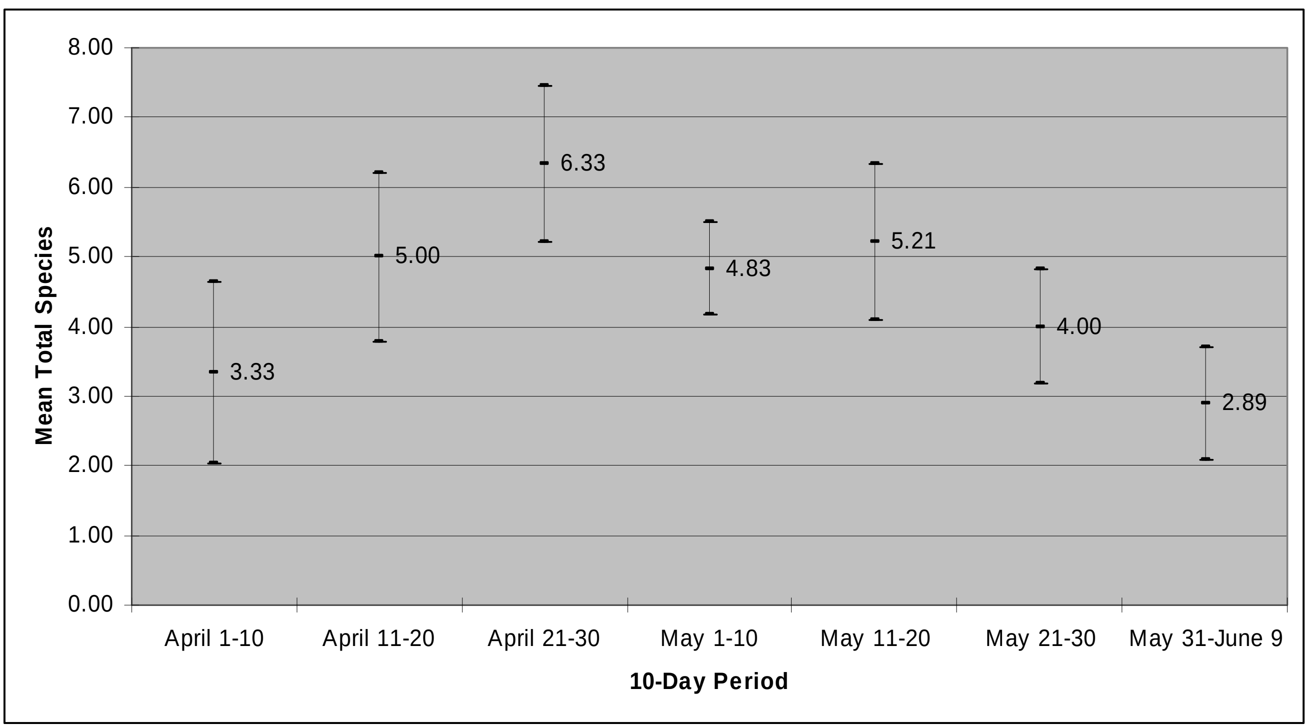

Figure 33. Species with Statistically Significant Seasonal Pattern for Transect Segments at <50m during Spring Migration (Breeding season to right of vertical line)

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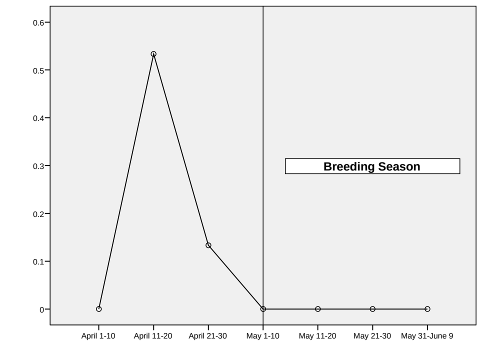
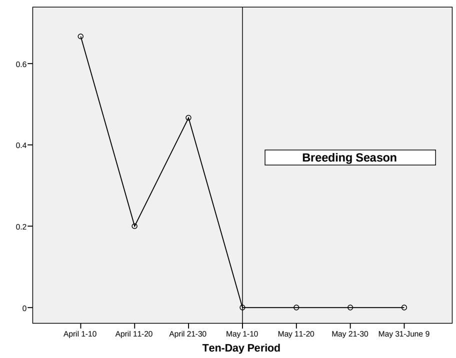
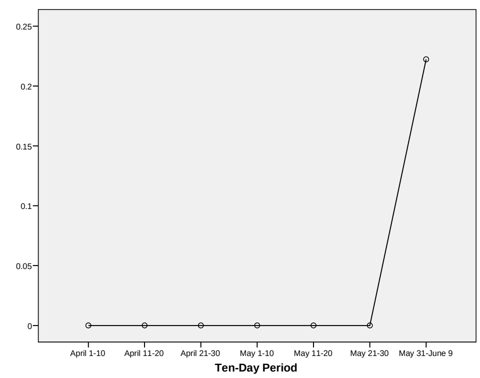
Ruffed Grouse



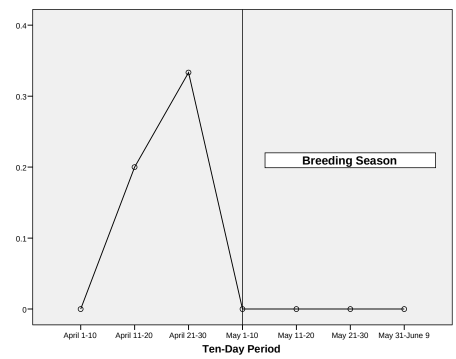
Hairy Woodpecker



Ruby-throated Hummingbird



Northern Flicker



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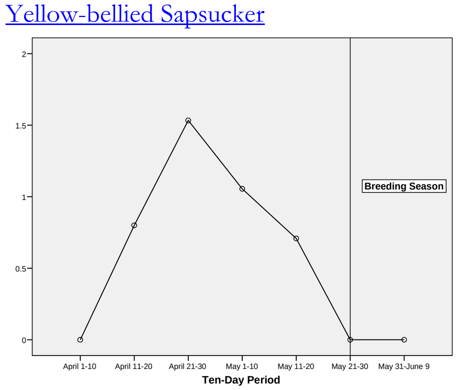
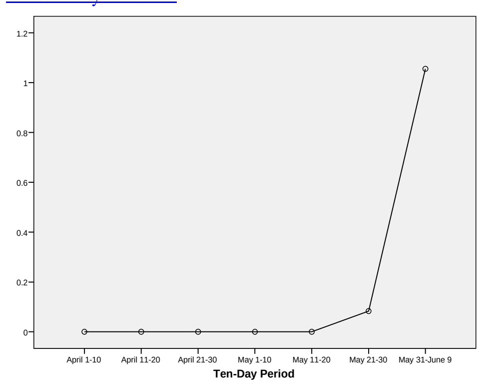
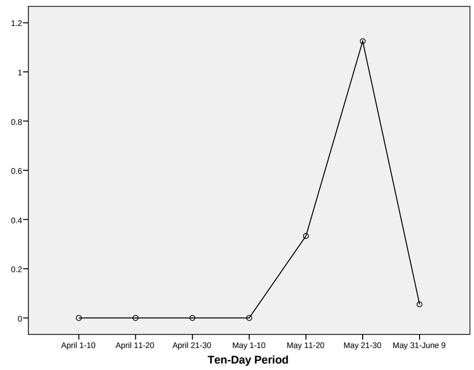


Alder Flycatcher



Least Flycatcher



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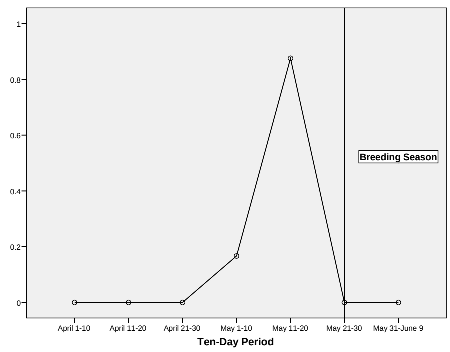

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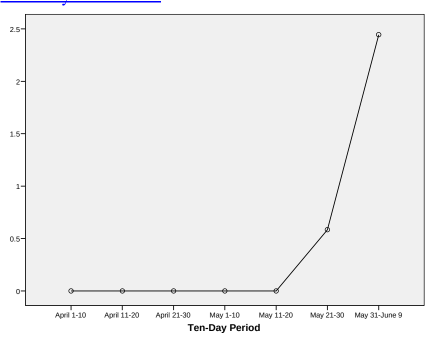

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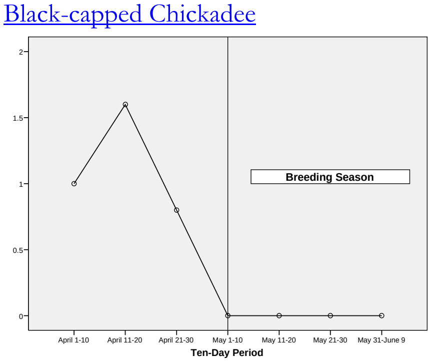

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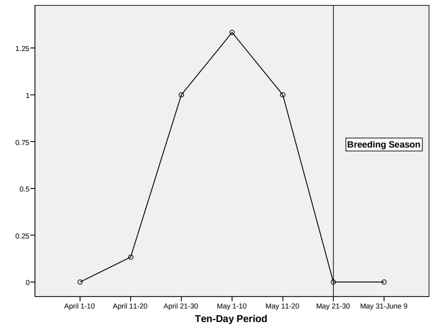

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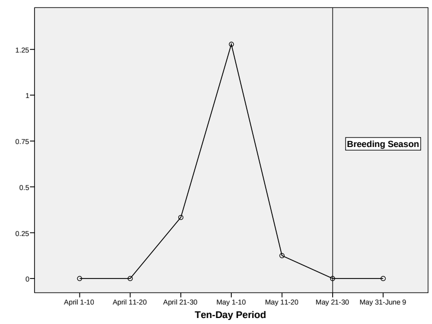

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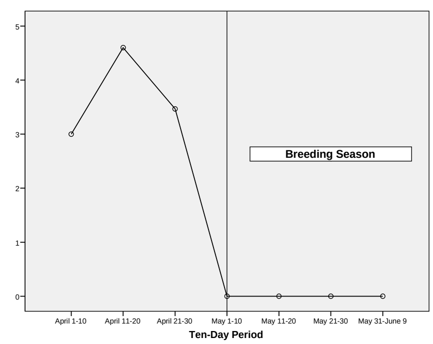

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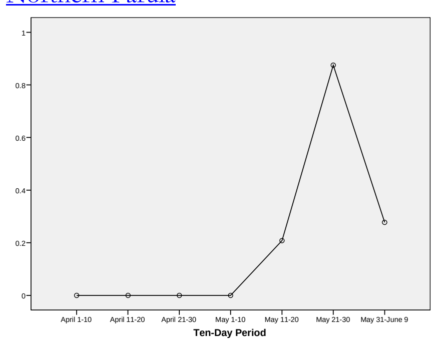

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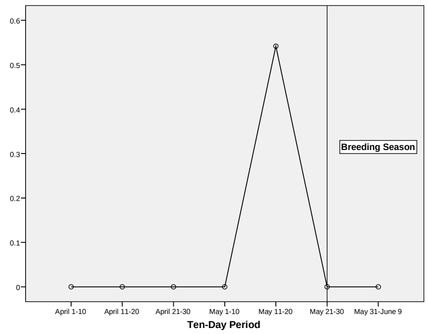
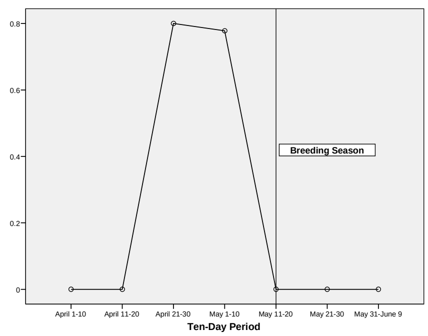
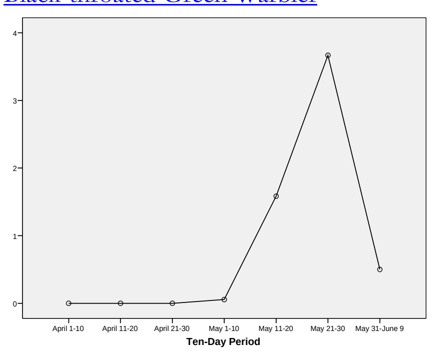


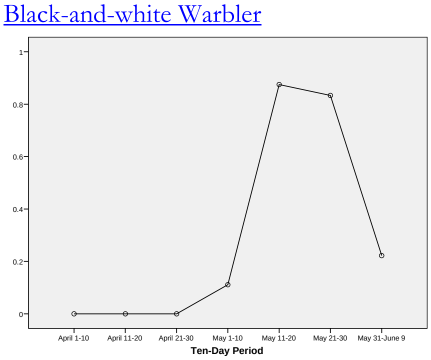
Yellow-rumped Warbler



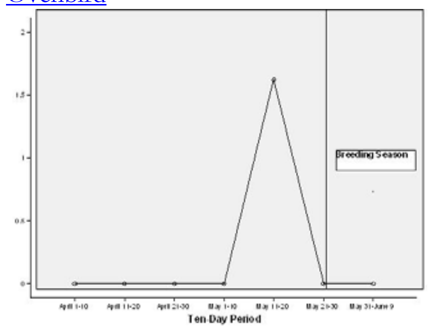
Black-throated Green Warbler



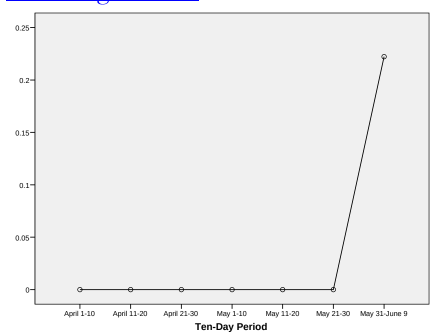
Black-and-white Warbler



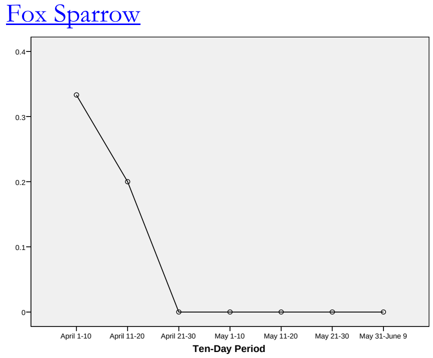
Ovenbird



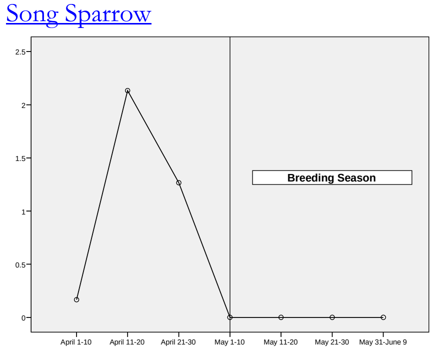
Mourning Warbler



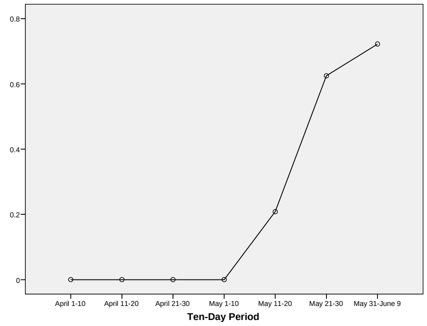
Fox Sparrow



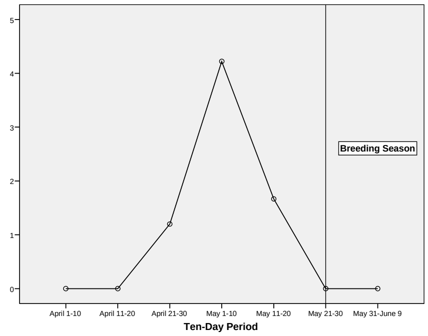
Song Sparrow



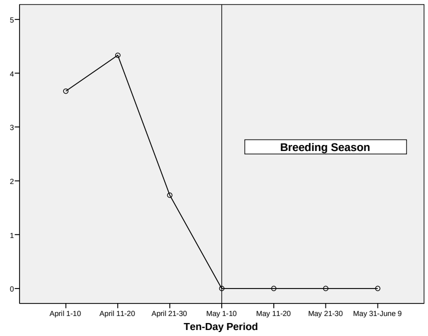
Lincoln's Sparrow



White-throated Sparrow



Dark-eyed Junco



Purple Finch

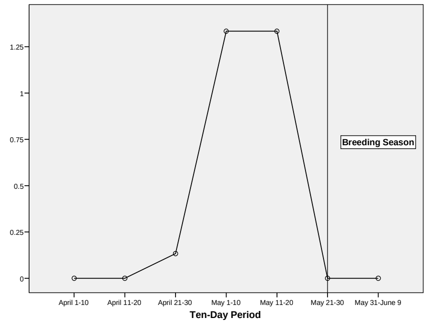


Figure 34. Mean Total Birds per Transect Segment at <50 m by Wind Direction and Speed for the Night before the Surveys during the Spring Migration

[Back to Text]

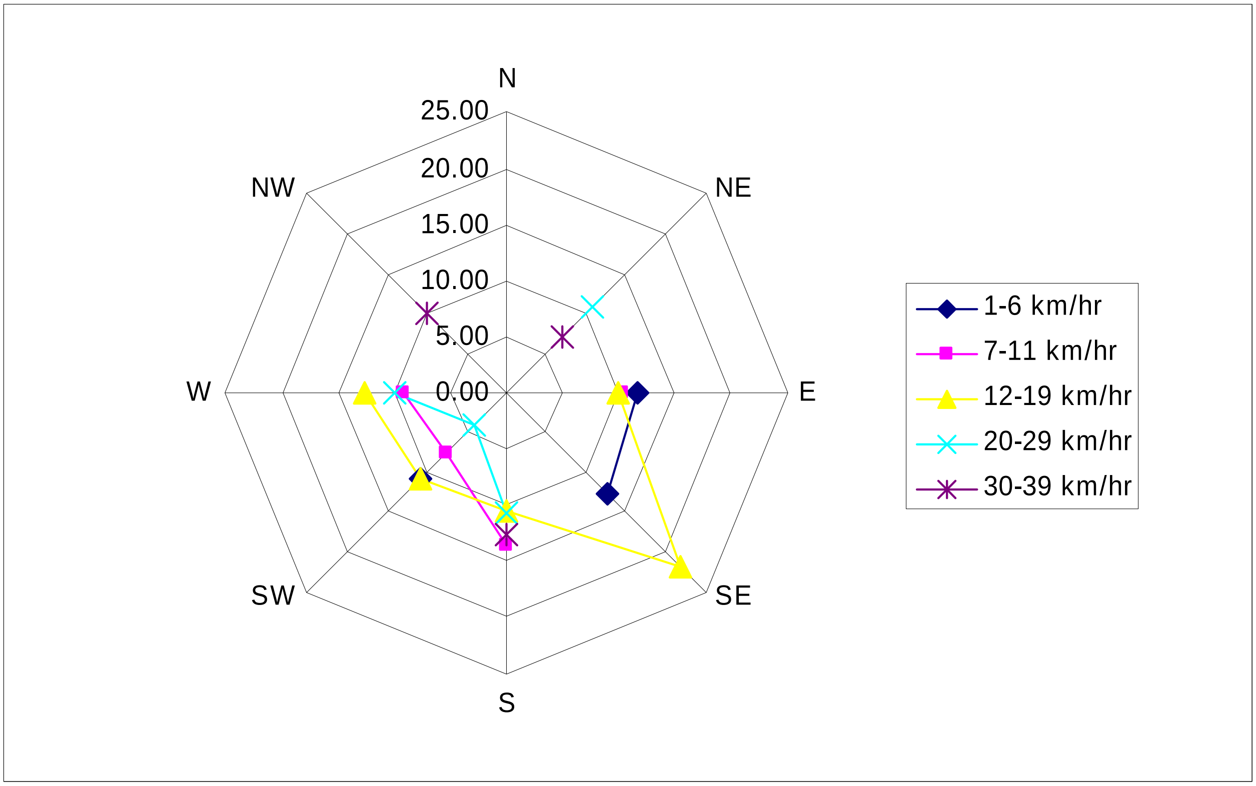


Figure 35. Mean Total Birds per Transect Segment at <50m by Habitat Type during the Spring Migration

[Back to Text]

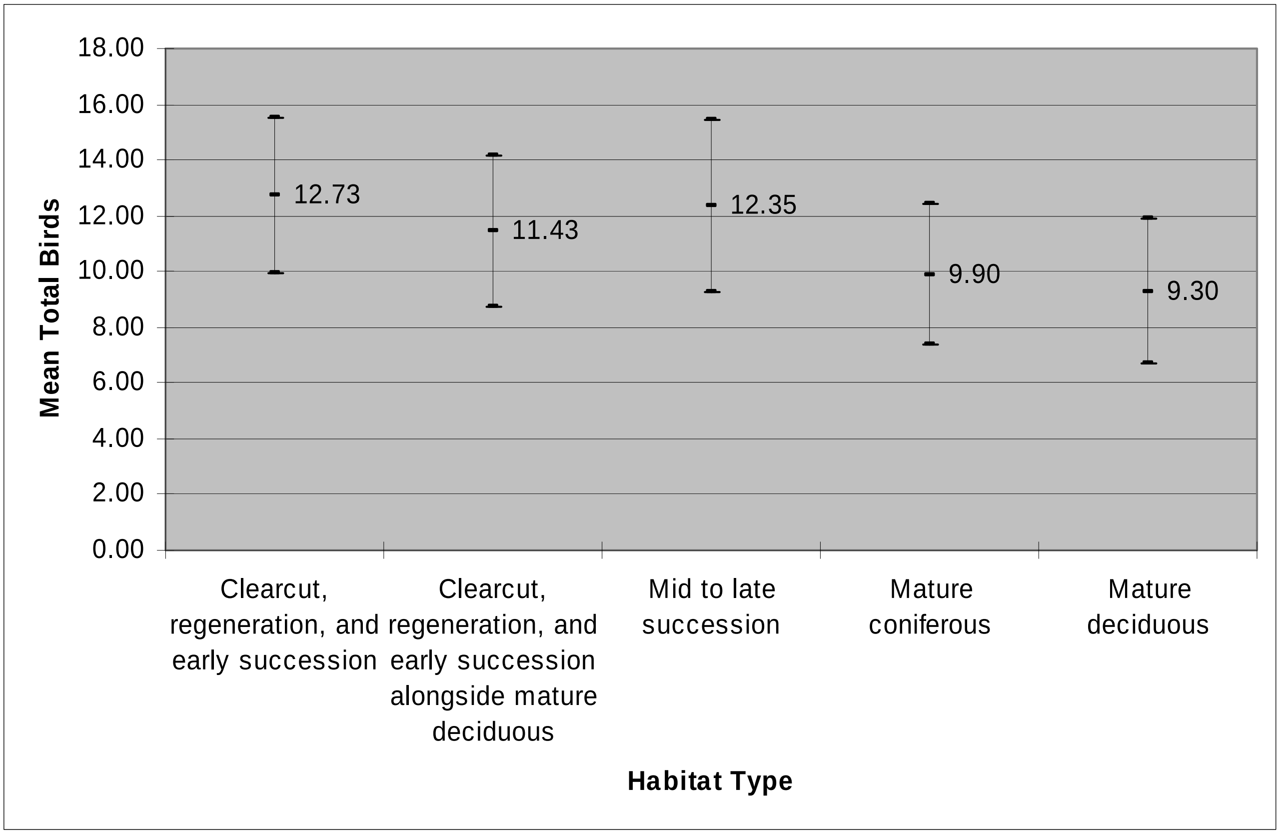


Figure 36. Least Square Means of Total Birds by Habitat Segments <50m by Habitat Type during the Spring Migration

[Back to Text]

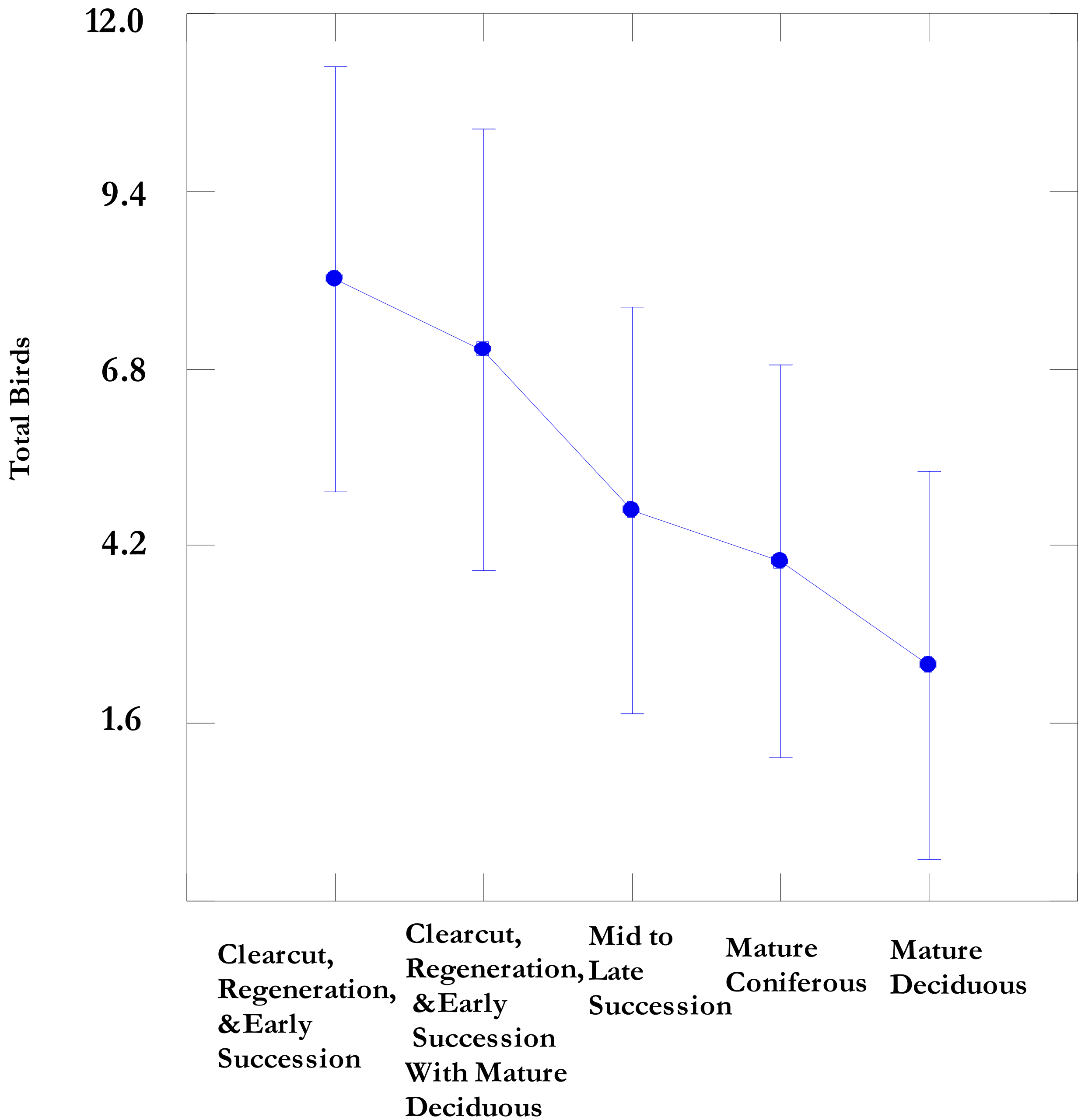


Figure 37. Mean Total Birds for Point Counts at All Distances by Habitat Type during the Spring Migration

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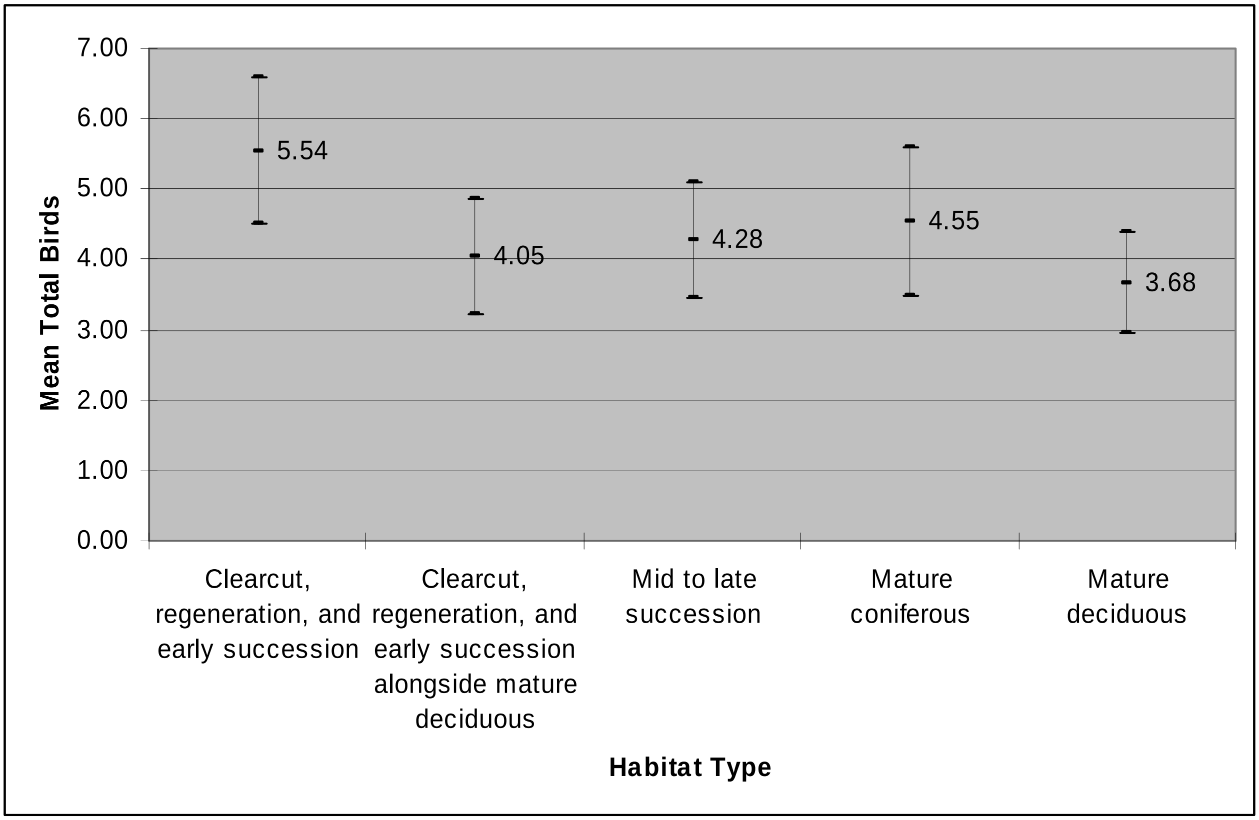

Figure 38. Area Search Routes for Crepuscular and Nocturnal Breeding Birds with Location of Birds Heard

[Back to Text]

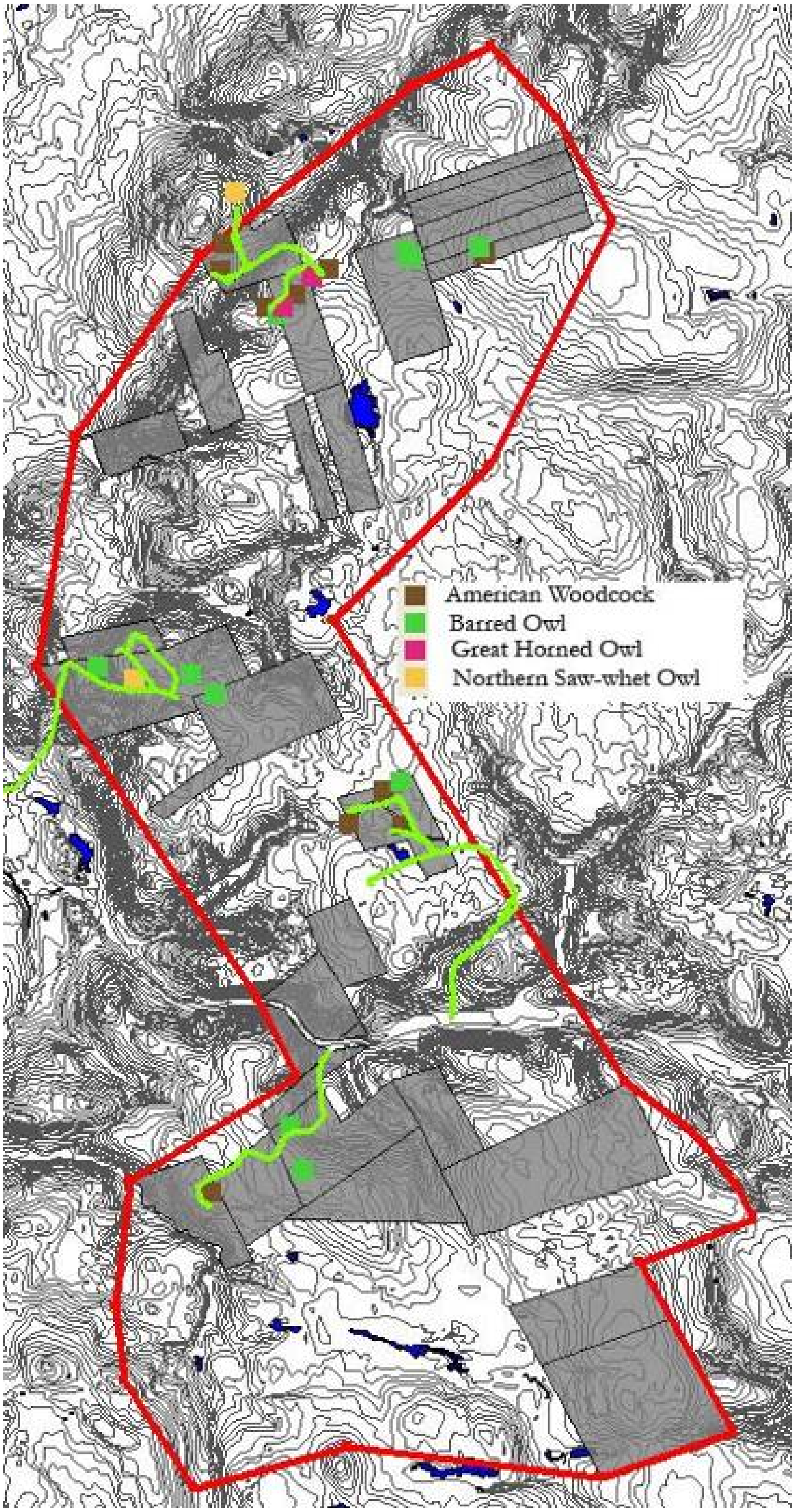

Figure 39. Mean Total Abundance of Early Breeders for Point Counts at All Distance by Habitat Type (With 95% confidence limits)

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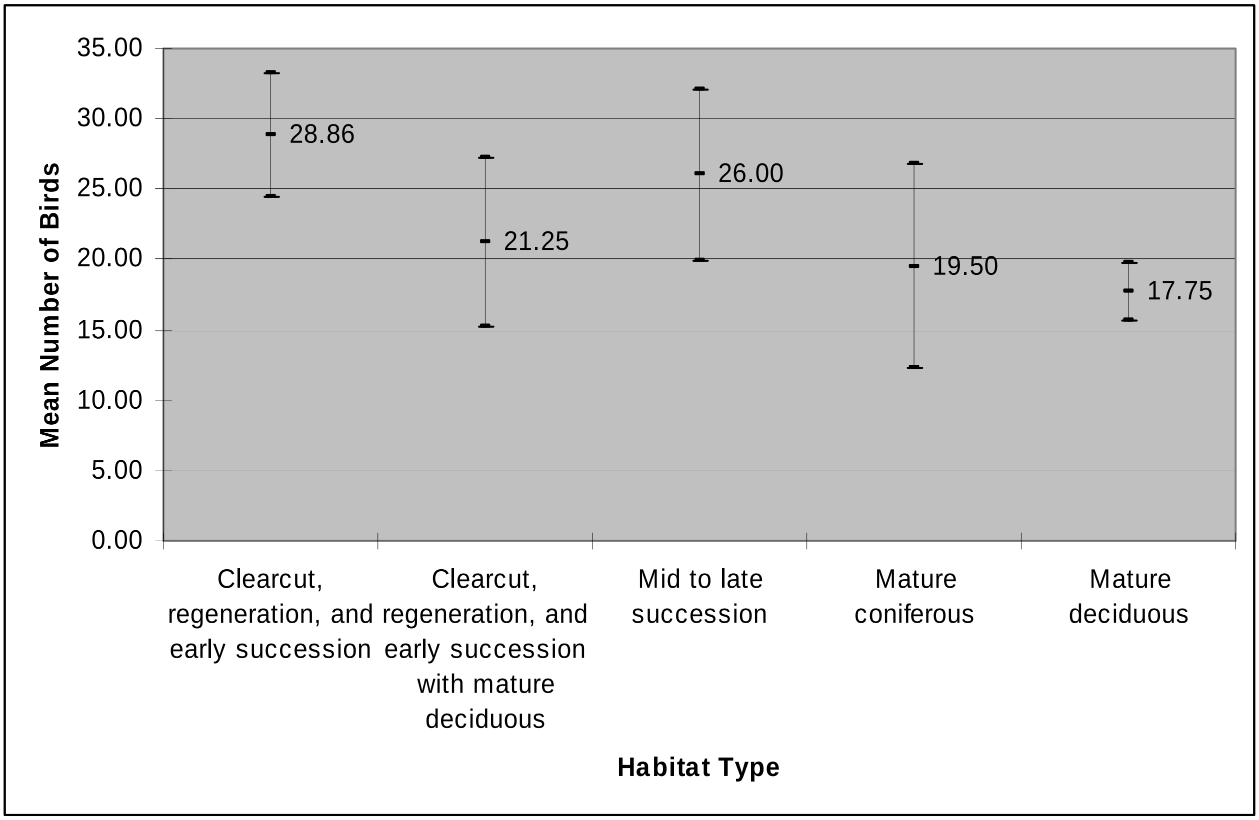

Figure 40. Mean Species Diversity of Early Breeders for Point Counts at All Distances by Habitat Type (With 95% confidence limits)

[Back to Text]

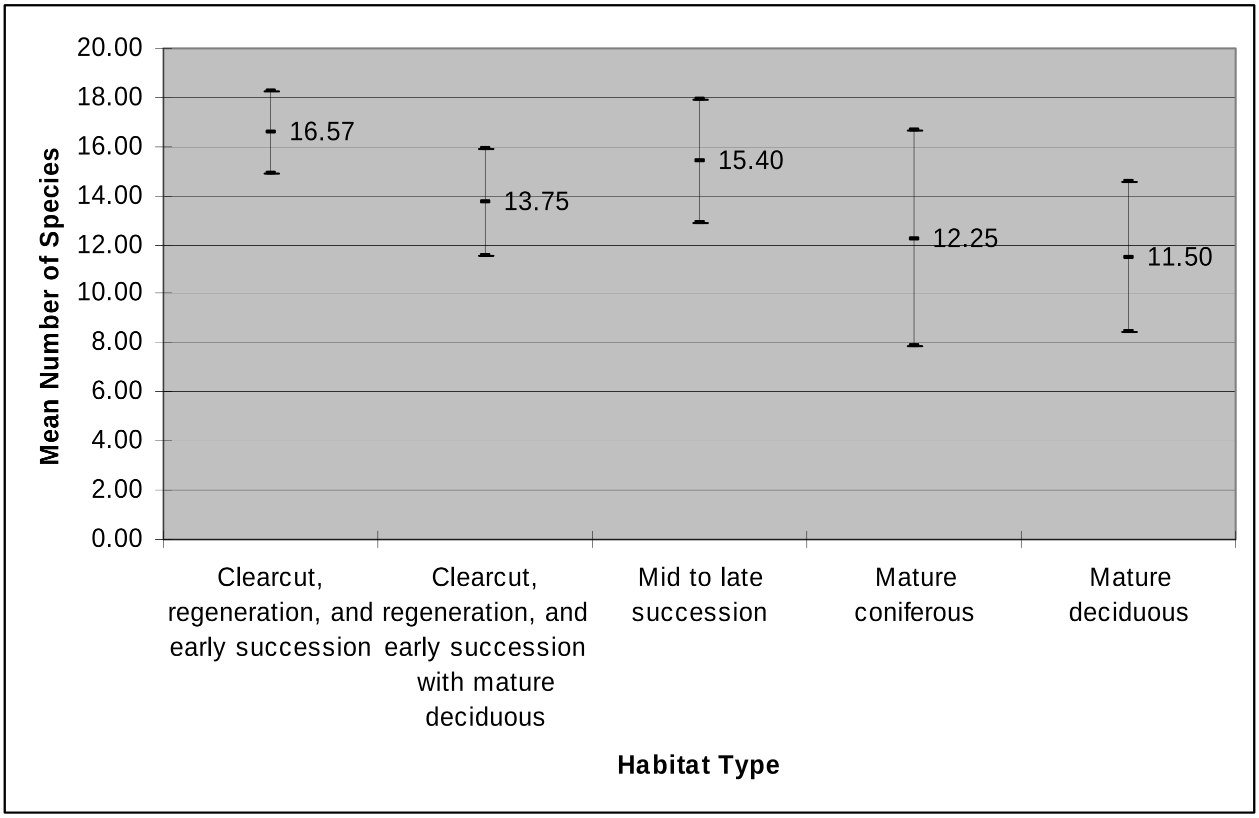

Figure 41. Location of Point Counts for the Peak Breeding Survey

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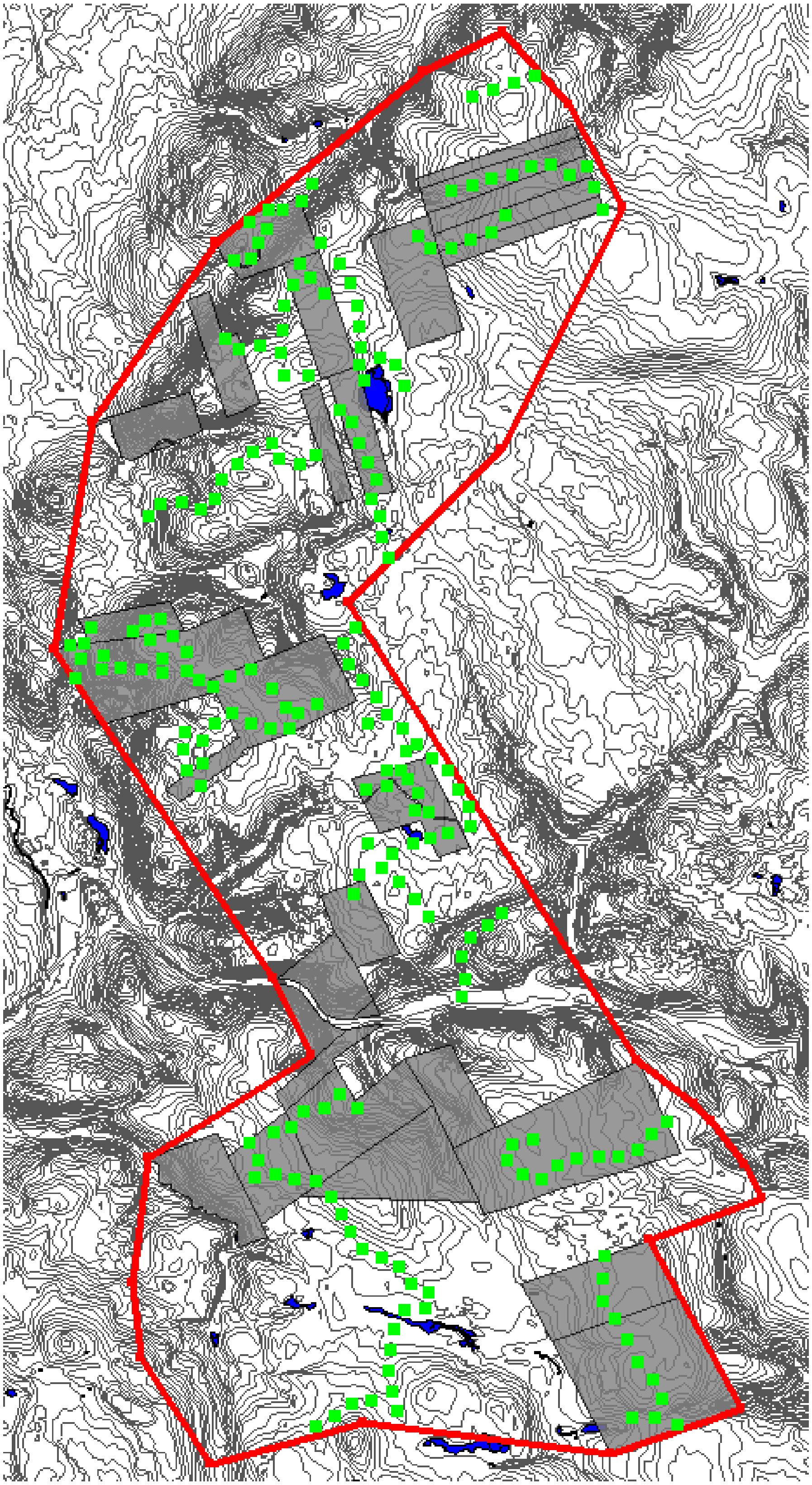

Figure 42. Mean Total Abundance of Peak Season Breeders for Point Counts at All Distance by Habitat Type (With 95% confidence limits)

[Back to Text]

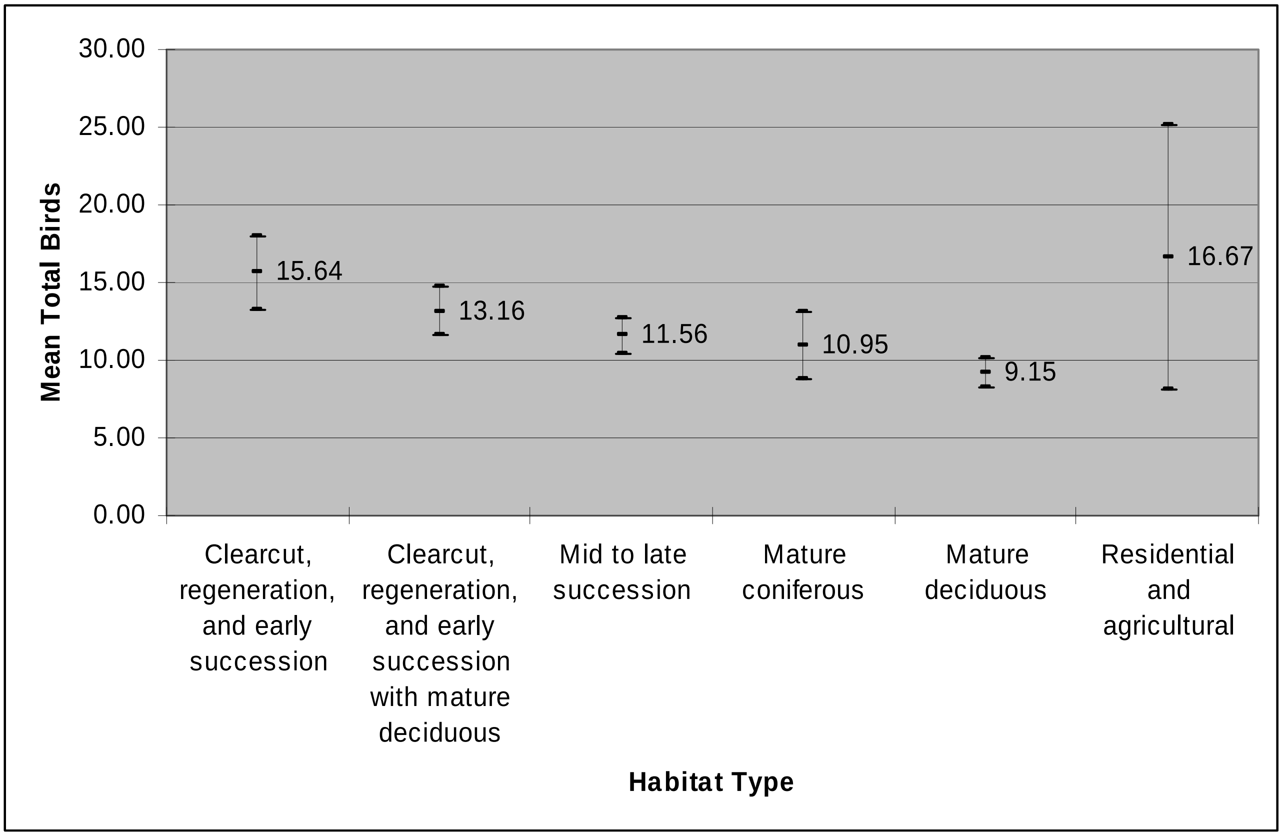

Figure 43. Mean Species Diversity of Peak Season Breeders for Point Counts at All Distances by Habitat Type (With 95% confidence limits)

[Back to Text]

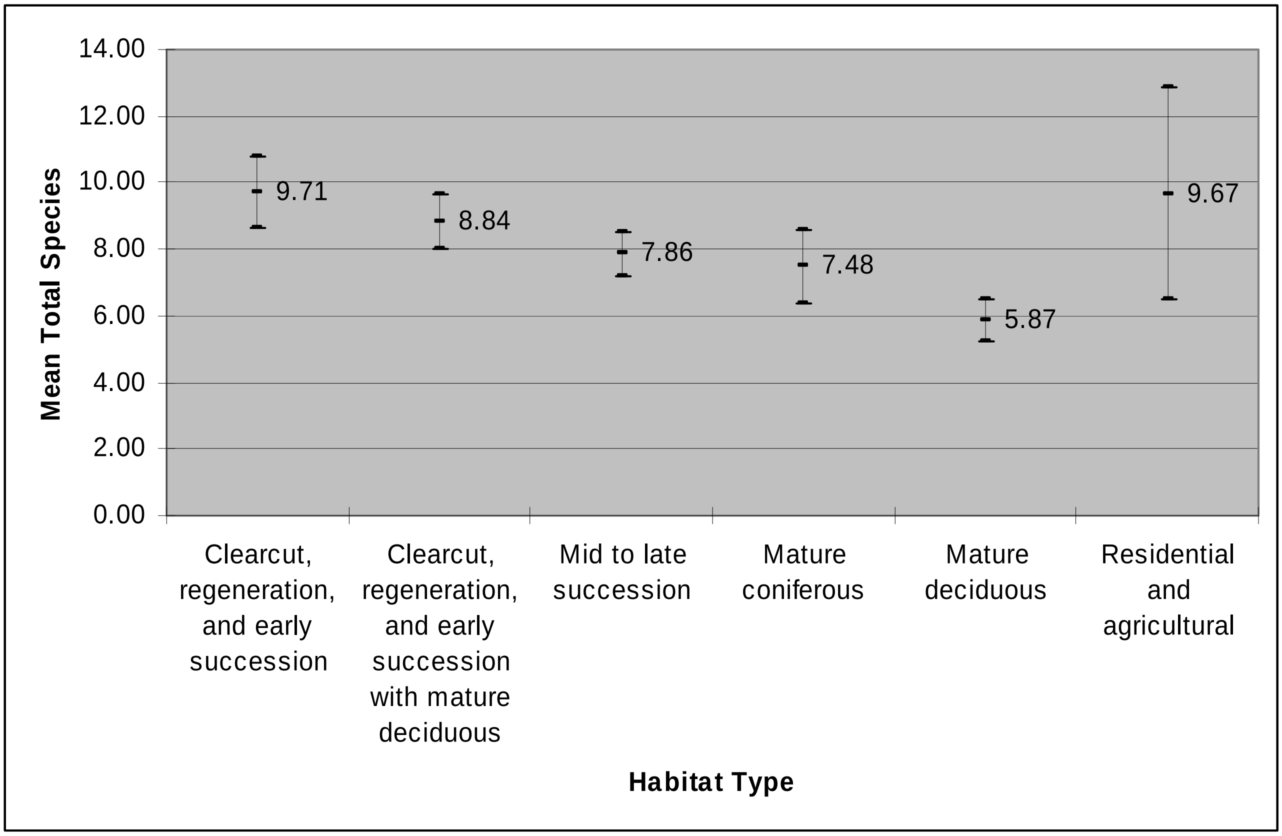

Figure 44. Effects of Weather and Time of Day on Mean Total Birds for Peak Breeding Point Counts

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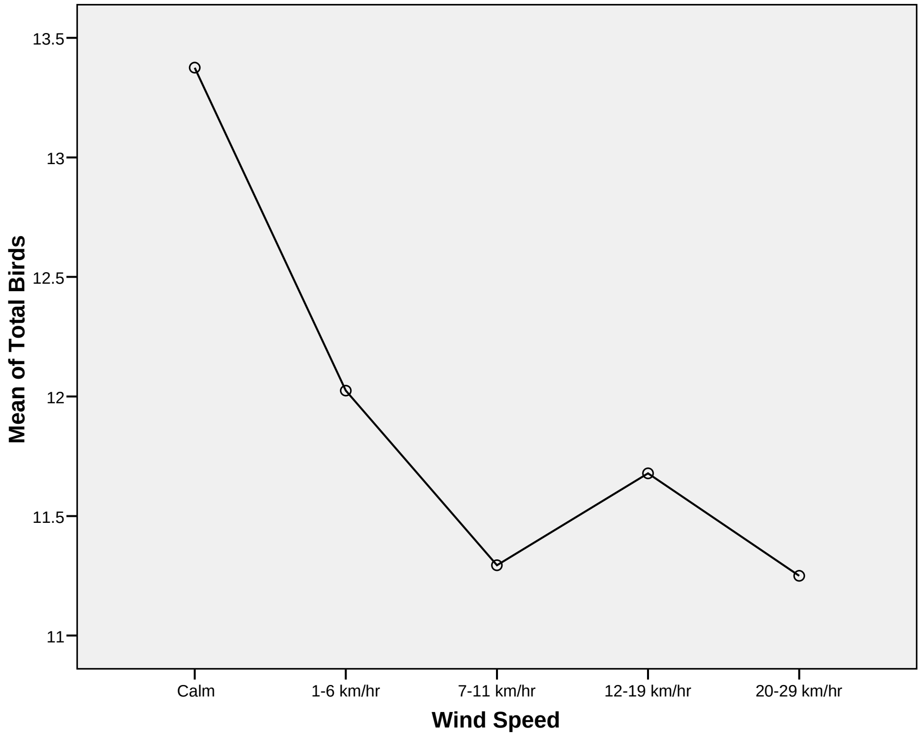

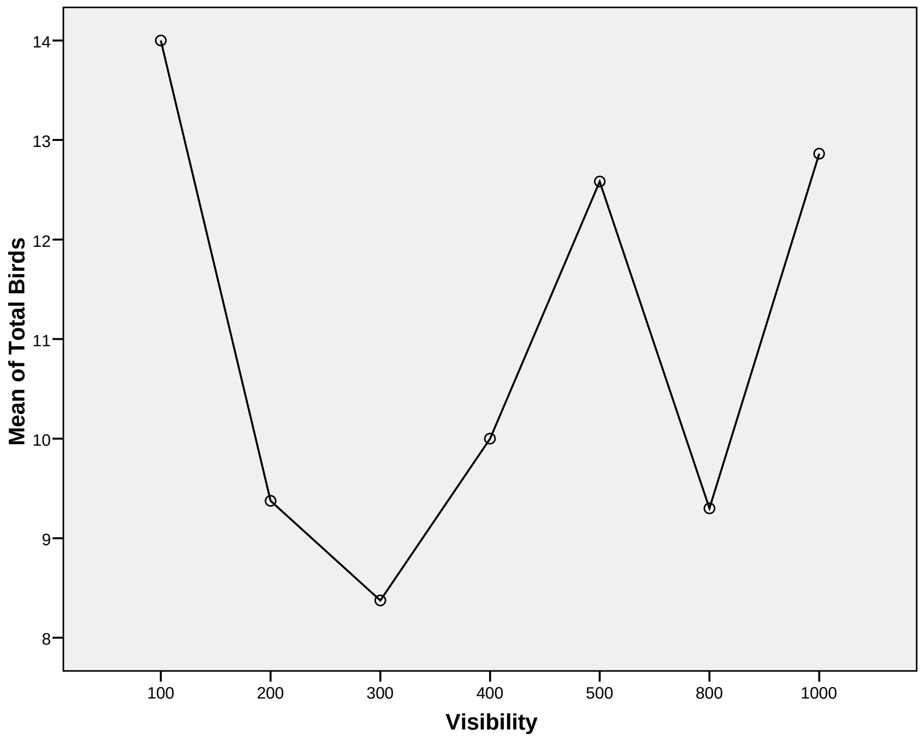

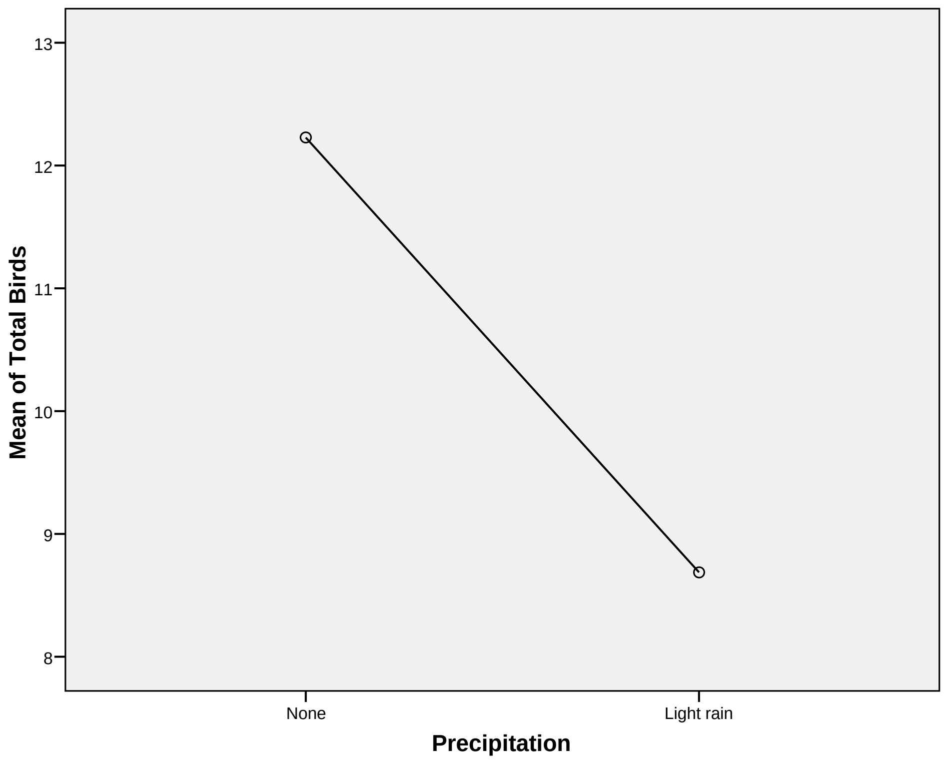
13
12
11
10
9
8
Mean of Total Birds
None
Light rain
Precipitation

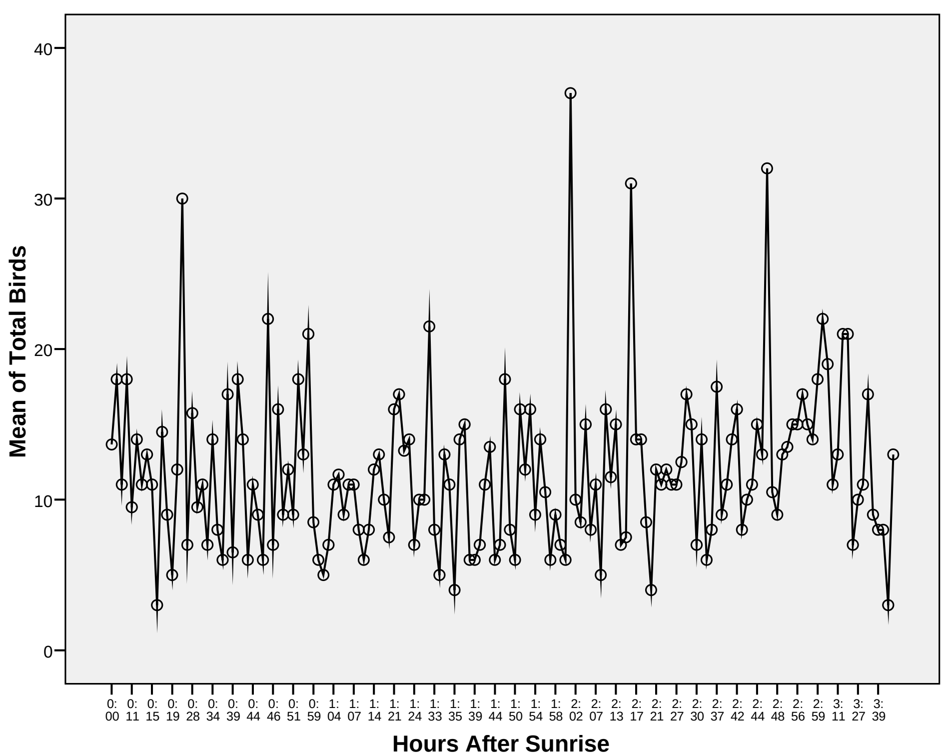
40
30
20
10
0
Mean of Total Birds
0:00 0:11 0:15 0:19 0:28 0:34 0:39 0:44 0:46 0:51 0:59 1:04 1:07 1:14 1:21 1:24 1:33 1:35 1:39 1:44 1:50 1:54 1:58 2:02 2:07 2:13 2:17 2:21 2:27 2:30 2:37 2:42 2:44 2:48 2:56 2:59 3:11 3:27 3:39
Hours After Sunrise

Figure 45. Map of Breeding Locations of Olive-sided Flycatcher

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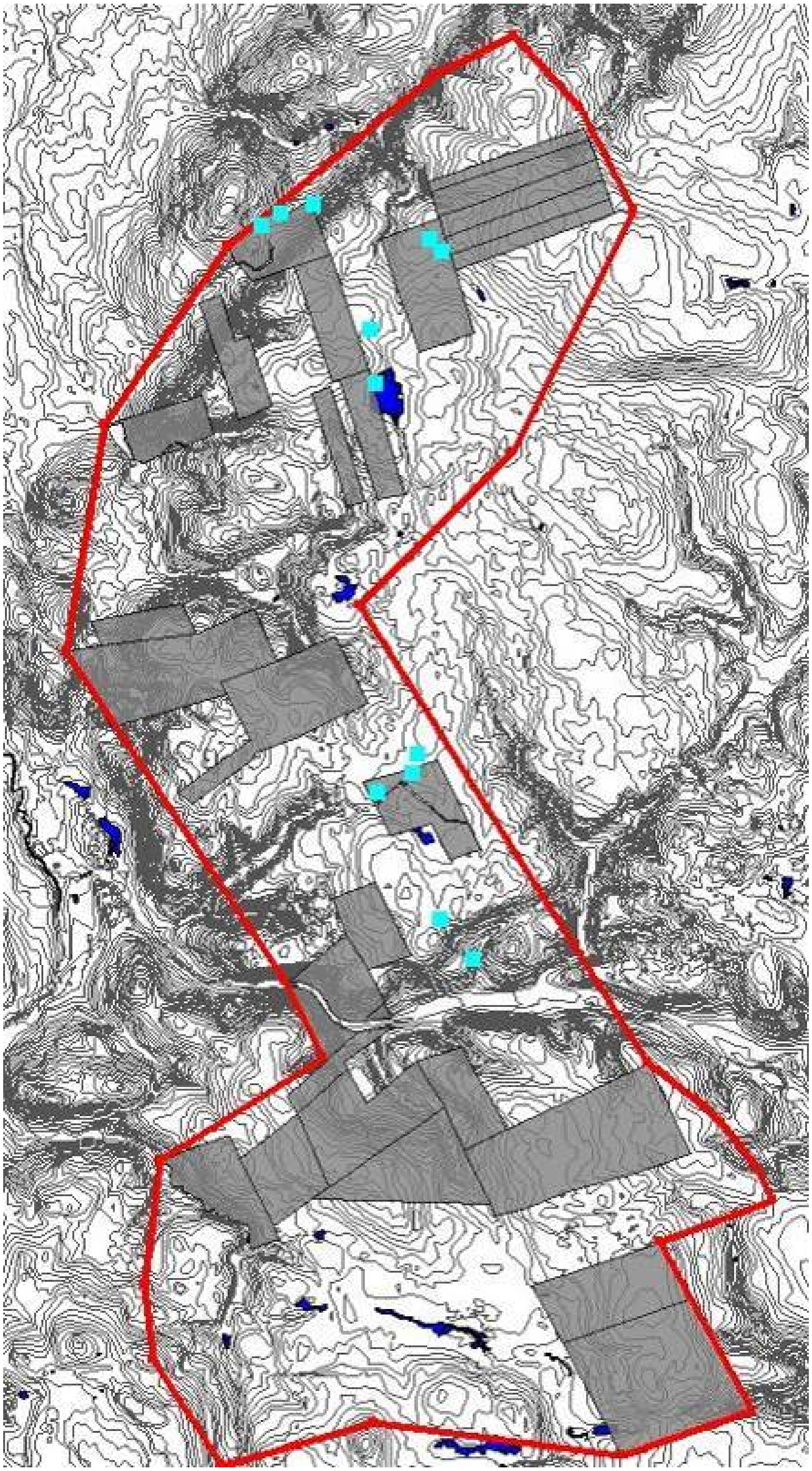

Figure 46. Habitat of Olive-sided Flycatcher in the Study Area

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Figure 47. Map of Sighting Locations of the Canada Warbler

[Back to Text]

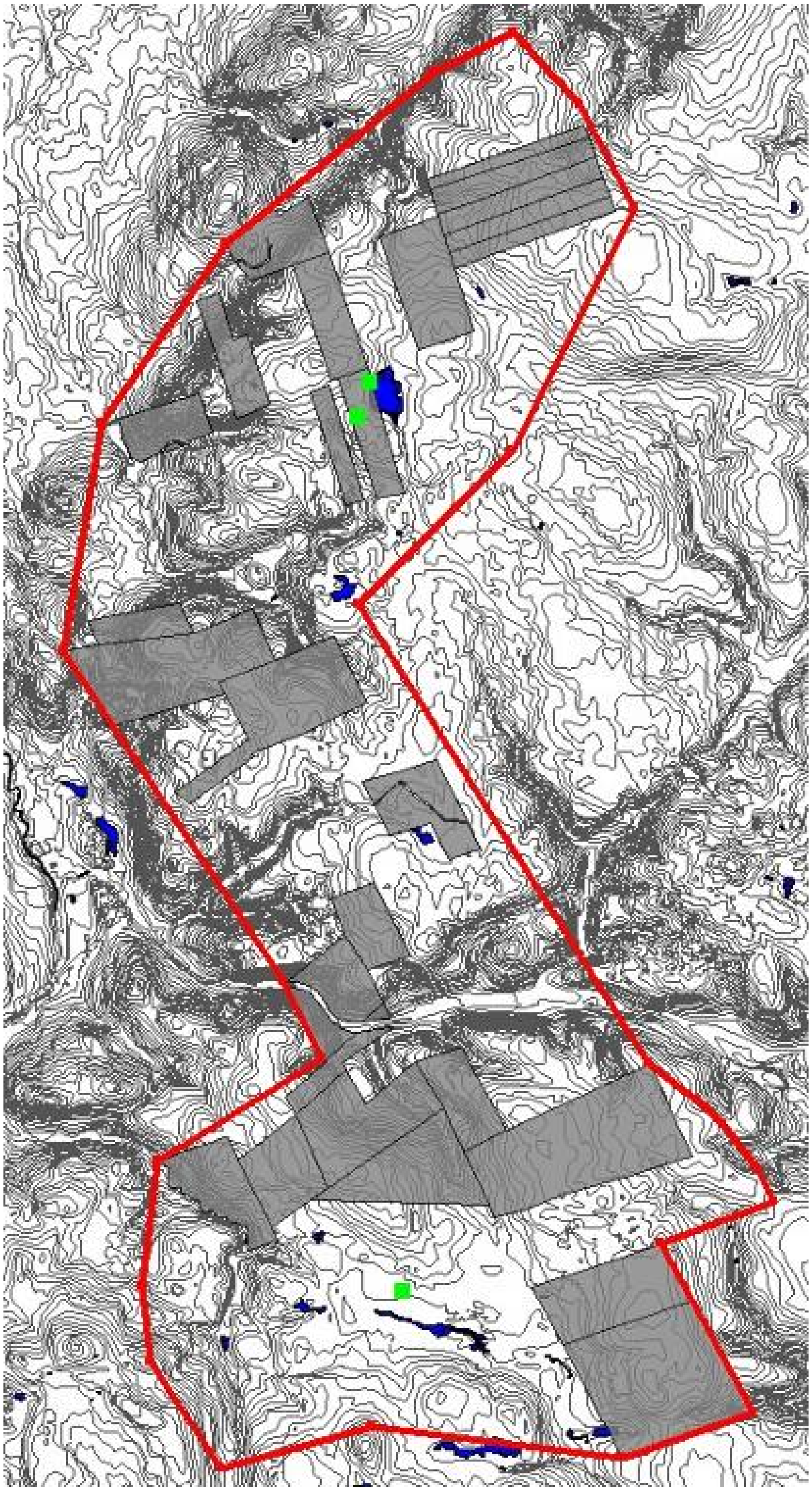

Figure 48. The Breeding Habitat of the Canada Warbler in the Study Area

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Tables

Table 1. Mean Number of Individual Species per Transect at All Distances by 10-Day Interval during the Autumn Migration

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	Aug 28-Sep 6	Sep 7-16	Sep 17-26	Sep 27-Oct 6	Oct 7-16	Oct 17-26	Total
Canada Goose	0.00	0.00	0.00	0.17	0.83	1.83	0.39
Ruffed Grouse	0.00	0.10	0.43	0.00	0.67	0.83	0.30
Double-crested Cormorant	0.00	0.90	0.00	0.00	0.00	0.00	0.20
Bald Eagle	0.00	0.00	0.00	0.00	0.50	0.17	0.09
Northern Harrier	0.00	0.10	0.00	0.00	0.00	0.00	0.02
Red-tailed Hawk	0.22	0.20	0.00	0.17	0.00	0.00	0.11
Sharp-shinned Hawk	0.33	0.60	0.29	0.00	0.33	0.00	0.30
American Kestrel	0.00	0.10	0.00	0.00	0.00	0.00	0.02
Merlin	0.00	0.00	0.00	0.17	0.00	0.00	0.02
Semipalmated Plover	0.11	0.00	0.00	0.00	0.00	0.00	0.02
Solitary Sandpiper	0.00	0.20	0.00	0.00	0.00	0.00	0.05
Herring Gull	0.00	0.00	0.00	0.00	0.17	0.00	0.02
Barred Owl	0.11	0.00	0.00	0.00	0.17	0.00	0.05
Ruby-throated Hummingbird	0.11	0.00	0.00	0.00	0.00	0.00	0.02
Belted Kingfisher	0.11	0.10	0.14	0.00	0.00	0.00	0.07
Downy Woodpecker	0.11	0.10	0.43	0.17	0.17	0.17	0.18
Hairy Woodpecker	0.22	0.70	1.14	1.83	1.67	1.50	1.07
Black-backed Woodpecker	0.00	0.00	0.14	0.00	0.00	0.00	0.02
Northern Flicker	4.44	2.80	2.29	0.67	0.17	0.00	2.02
Pileated Woodpecker	0.22	0.30	0.00	0.50	0.33	0.50	0.30
Alder Flycatcher	0.11	0.00	0.00	0.00	0.00	0.00	0.02
Least Flycatcher	0.33	0.00	0.14	0.00	0.00	0.00	0.09
Northern Shrike	0.00	0.00	0.00	0.00	0.17	0.17	0.05
Blue-headed Vireo	0.78	1.60	1.29	0.00	0.00	0.00	0.73
Red-eyed Vireo	9.44	3.40	2.29	0.00	0.00	0.00	3.07
Gray Jay	0.00	0.20	0.14	0.17	0.17	0.50	0.18
Blue Jay	8.78	7.30	6.14	4.33	3.33	3.67	5.98
American Crow	0.00	0.40	0.14	0.17	0.17	1.50	0.36
Common Raven	2.44	3.80	3.71	3.17	7.67	5.17	4.14
Black-capped Chickadee	7.33	6.10	6.29	9.33	9.00	6.67	7.30
Boreal Chickadee	1.89	1.10	1.00	2.33	2.50	3.17	1.89
Red-breasted Nuthatch	3.00	3.40	1.43	1.00	0.50	0.17	1.84
White-breasted Nuthatch	0.00	0.10	0.29	0.00	0.17	0.00	0.09
Brown Creeper	0.00	0.10	0.14	0.00	0.00	0.33	0.09
Winter Wren	0.00	0.00	0.29	0.00	0.00	0.00	0.05
Golden-crowned Kinglet	0.22	0.70	1.14	2.33	2.33	4.50	1.64
Ruby-crowned Kinglet	0.89	1.90	2.86	3.50	2.83	0.00	1.93
Swainson's Thrush	0.11	0.10	0.14	0.00	0.00	0.00	0.07
Hermit Thrush	0.33	0.80	1.00	2.17	1.50	0.50	0.98
American Robin	3.44	1.10	1.57	2.50	30.33	13.00	7.45
Gray Catbird	0.11	0.00	0.00	0.00	0.00	0.00	0.02
Bohemian Waxwing	0.00	0.00	0.00	0.00	0.33	0.33	0.09
Cedar Waxwing	0.56	0.10	0.00	0.00	0.00	0.00	0.14

Tennessee Warbler	0.33	0.00	0.00	0.00	0.00	0.00	0.07
Nashville Warbler	0.11	0.00	0.29	0.00	0.00	0.00	0.07
Northern Parula	2.00	0.60	0.43	0.17	0.00	0.00	0.64
Chestnut-sided Warbler	0.11	0.00	0.14	0.00	0.00	0.00	0.05
Magnolia Warbler	5.44	1.80	1.71	0.17	0.00	0.00	1.82
Cape May Warbler	0.22	0.00	0.00	0.00	0.00	0.00	0.05
Black-throated Blue Warbler	1.11	0.10	0.14	0.00	0.00	0.00	0.27
Yellow-rumped Warbler	2.78	2.40	2.86	14.17	5.67	0.83	4.39
Black-throated Green Warbler	6.33	2.80	1.29	0.50	0.00	0.00	2.20
Blackburnian Warbler	0.44	0.10	0.00	0.00	0.00	0.00	0.11
Palm Warbler	0.00	0.00	0.29	0.33	0.17	0.17	0.14
Bay-breasted Warbler	0.11	0.00	0.00	0.00	0.00	0.00	0.02
Blackpoll Warbler	0.11	0.40	0.29	0.00	0.00	0.00	0.16
Black-and-White Warbler	0.67	0.50	0.43	0.00	0.00	0.00	0.32
American Redstart	0.44	0.00	0.00	0.00	0.00	0.00	0.09
Ovenbird	2.00	0.70	1.00	0.00	0.00	0.00	0.73
Mourning Warbler	0.33	0.20	0.00	0.00	0.00	0.00	0.11
Common Yellowthroat	4.67	3.80	2.57	1.00	0.00	0.00	2.36
Wilson's Warbler	0.11	0.00	0.00	0.00	0.00	0.00	0.02
Fox Sparrow	0.00	0.00	0.00	0.00	0.17	0.00	0.02
Song Sparrow	0.56	1.40	0.86	3.00	1.00	0.83	1.23
Lincoln's Sparrow	0.33	0.20	0.00	0.00	0.00	0.00	0.11
Swamp Sparrow	0.22	0.10	1.00	0.83	0.67	0.00	0.43
White-throated Sparrow	3.00	5.80	5.71	10.00	6.50	2.17	5.39
White-crowned Sparrow	0.00	0.00	0.14	0.00	0.17	0.00	0.05
Dark-eyed Junco	3.22	5.50	7.86	6.33	5.00	10.00	6.07
Red-winged Blackbird	0.00	0.00	0.00	0.00	0.00	0.17	0.02
Rusty Blackbird	0.00	0.00	0.00	0.00	0.33	0.00	0.05
Common Grackle	2.00	0.00	0.00	0.00	0.00	0.00	0.41
Red Crossbill	0.00	0.00	0.00	0.00	0.00	2.00	0.27
White-winged Crossbill	3.11	3.50	2.00	0.67	1.67	6.67	2.98
Pine Grosbeak	0.00	0.20	0.00	0.00	0.17	0.67	0.16
Purple Finch	1.33	1.40	1.29	2.17	1.33	0.83	1.39
Common Redpoll	0.00	0.00	0.00	0.00	0.00	0.83	0.11
Pine Siskin	0.56	0.30	0.14	0.00	0.33	0.83	0.36
American Goldfinch	2.44	1.90	3.14	3.17	0.17	0.50	1.95
Evening Grosbeak	0.00	0.20	0.00	0.00	1.17	11.00	1.70

Table 2. Mean Total Birds per Transect in the 50-m Band by Wind Direction and Speed during the Autumn Migration

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WindSpeed	WindDirection									
	N	NE	E	SE	S	SW	W	NW	Calm	Total
0 km/hr									86.88	86.88
1-6 km/hr							61.50	61.00		61.25
7-11 km/hr	61.33			34.00		41.50	72.00	83.00		61.10
12-19 km/hr	54.00					39.00	47.00	37.33		42.00
20-29 km/hr	9.00					42.50	31.25	31.00		31.25
30-39 km/hr	12.00				19.00	29.00	31.00	59.00		30.29
40-50 km/hr	18.00									18.00
Total	39.57	0.00	0.00	34.00	19.00	39.33	44.33	54.44	86.88	51.89

Table 3. Percent Occurrence of Wind Direction and Speed Combinations per Transect during the Autumn Migration

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WindSpeed	WindDirection									
	N	NE	E	SE	S	SW	W	NW	Calm	Total
0 km/hr									18.18	18.18
1-6 km/hr							4.55	4.55		9.09
7-11 km/hr	6.82			2.27		4.55	4.55	4.55		22.73
12-19 km/hr	2.27					2.27	2.27	6.82		13.64
20-29 km/hr	2.27					4.55	9.09	2.27		18.18
30-39 km/hr	2.27				2.27	2.27	6.82	2.27		15.91
40-50 km/hr	2.27									2.27
Total	15.91			2.27	2.27	13.64	27.27	20.45	18.18	100.00

Table 4. Habitat Types

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Type No.	Type	Description	Primary Species	Secondary Species	No. of Point Counts	No. of Segments
1	Clearcut, Regenerating, and/or Early Succession	Disturbed by forestry practices in recent years	Spruce-Fir, Red Maple, Grey Birch, White Birch	Trembling Aspen, Pin Cherry	7	3
2	Clearcut, Regenerating and/or Early Succession alongside Mature Deciduous	Disturbed by forestry in recent years, surrounded on at least one side by mature deciduous forest	Spruce-Fir, Red Maple, Grey Birch, White Birch And Sugar Maple, Yellow Birch, Beech	Trembling Aspen, Pin Cherry And Striped Maple	4	3
3	Mid-to-Late Succession	A mixed age, mixed (coniferous and deciduous) forest	Spruce-Fir, Sugar Maple, Red Maple, Yellow Birch, White Birch	Grey Birch, Beech	5	2
4	Mature Coniferous	Conifers comprise greater than 75% of the trees with many of harvestable size	Spruce-Fir, Red Pine	Sugar Maple, Yellow Birch, Grey Birch	4	2
5	Mature Deciduous	Deciduous trees comprise greater than 75% of the trees and most are of harvestable size	Sugar Maple, Yellow Birch, Beech	Striped Maple, White Birch, Spruce-Fir	4	2

Table 5. Mean Total Birds in 50-m Band by Habitat Type for Segments and Point Counts during the Autumn Migration

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Habitat Type	Segments	Point Counts
Clearcut, Regeneration, and Early Succession	25.00	3.83
Clearcut, Regeneration, and Early Succession with Mature Deciduous	14.88	2.16
Mid to Late Succession; Mixed Age and Mature Mixed Forest	15.14	2.47
Mature Coniferous	16.55	2.86
Mature Deciduous	12.09	1.61
Total	17.27	2.74

Table 6. Mean Total Species in 50-m Band by Habitat Type for Segments and Point Counts during the Autumn Migration

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Habitat Type	Segments	Point Counts
Clearcut, Regeneration, and Early Succession	8.58	2.44
Clearcut, Regeneration, and Early Succession with Mature Deciduous	5.85	1.36
Mid to Late Succession; Mixed Age and Mature Mixed Forest	6.91	1.71
Mature Coniferous	7.55	1.93
Mature Deciduous	5.32	1.20
Total	6.90	1.82

Table 7. Mean Abundance of Species Showing Significant Habitat Relationships at the 95% Confidence Level and Their Associated Habitat Types at the 95% Confidence Level for Segments and Point Counts in the 50-m Band during the Autumn Migration

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	Clearcut, Regeneration, and Early Succession		Clearcut, Regeneration, and Early Succession with Mature Deciduous		Mid to Late Succession; Mixed Age and Mature Mixed Forest		Mature Coniferous		Mature Deciduous	
	Seg	PC	Seg	PC	Seg	PC	Seg	PC	Seg	PC
Downy Woodpecker	0.03		0.06		0.00		0.00		0.18	
Northern Flicker	0.70		0.15		0.00		0.05		0.00	
Red-eyed Vireo	0.48	0.03	0.61	0.18	0.91	0.20	0.36	0.02	1.95	0.30
Black-capped Chickadee	3.79		1.52		2.95		0.86		1.91	
Boreal Chickadee	1.06	0.12	0.15	0.03	0.55	0.04	1.27	0.27	0.50	0.00
White-breasted Nuthatch		0.00		0.05		0.00		0.00		0.00
Golden-crowned Kinglet	0.42	0.04	0.12	0.02	0.91	0.07	1.32	0.27	0.23	0.07
Ruby-crowned Kinglet	1.61	0.29	0.33	0.00	0.23	0.04	0.64	0.20	0.09	0.00
Hermit Thrush	0.30		0.03		0.41		0.32		0.68	
Yellow-rumped Warbler	0.45		0.55		0.27		1.18		0.14	
Palm Warbler	0.18		0.00		0.00		0.00		0.00	
Black-and-White Warbler	0.12		0.03		0.00		0.32		0.09	
Ovenbird	0.03		0.15		0.18		0.09		0.91	
Common Yellowthroat	2.12	0.45	0.67	0.05	0.18	0.02	0.36	0.02	0.00	0.00
Song Sparrow	1.15	0.23	0.90	0.05	0.50	0.05	0.09	0.00	0.00	0.00
Swamp Sparrow	0.42	0.12	0.06	0.02	0.09	0.00	0.00	0.00	0.00	0.00
White-throated Sparrow	3.15	0.61	2.06	0.25	0.55	0.11	1.68	0.32	0.05	0.00
Purple Finch	0.24		0.00		0.00		0.00		0.00	

- Positively different from all four other habitat types at 95% level of probability
- Positively different from three habitat types at 95% level of probability
- Positively different from two habitat types at 95% level of probability
- Positively different from one habitat type at 95% level of probability

Table 8. Mean Abundance of Species Showing Significant Habitat Relationships at the 95% Confidence Level and Their Associated Habitat Types at the 90% Confidence Level for Segments and Point Counts in the 50-m Band during the Autumn Migration

[Back to Text]

	Clearcut, Regeneration, and Early Succession		Clearcut, Regeneration, and Early Succession with Mature Deciduous		Mid to Late Succession; Mixed Age and Mature Mixed Forest		Mature Coniferous		Mature Deciduous	
	Seg	PC	Seg	PC	Seg	PC	Seg	PC	Seg	PC
Downy Woodpecker	0.03		0.06		0.00		0.00		0.18	
Northern Flicker	0.70		0.15		0.00		0.05		0.00	
Red-eyed Vireo	0.48	0.03	0.61	0.18	0.91	0.20	0.36	0.02	1.95	0.30
Black-capped Chickadee	3.79		1.52		2.95		0.86		1.91	
Boreal Chickadee	1.06	0.12	0.15	0.03	0.55	0.04	1.27	0.27	0.50	0.00
White-breasted Nuthatch		0.00		0.05		0.00		0.00		0.00
Golden-crowned Kinglet	0.42	0.04	0.12	0.02	0.91	0.07	1.32	0.27	0.23	0.07
Ruby-crowned Kinglet	1.61	0.29	0.33	0.00	0.23	0.04	0.64	0.20	0.09	0.00
Hermit Thrush	0.30		0.03		0.41		0.32		0.68	
Yellow-rumped Warbler	0.45		0.55		0.27		1.18		0.14	
Palm Warbler	0.18		0.00		0.00		0.00		0.00	
Black-and-White Warbler	0.12		0.03		0.00		0.32		0.09	
Ovenbird	0.03		0.15		0.18		0.09		0.91	
Common Yellowthroat	2.12	0.45	0.67	0.05	0.18	0.02	0.36	0.02	0.00	0.00
Song Sparrow	1.15	0.23	0.90	0.05	0.50	0.05	0.09	0.00	0.00	0.00
Swamp Sparrow	0.42	0.12	0.06	0.02	0.09	0.00	0.00	0.00	0.00	0.00
White-throated Sparrow	3.15	0.61	2.06	0.25	0.55	0.11	1.68	0.32	0.05	0.00
Purple Finch	0.24		0.00		0.00		0.00		0.00	

Positively different from all four other habitat types at 90% level of probability

Positively different from three habitat types at 90% level of probability

Positively different from two habitat types at 90% level of probability

Positively different from one habitat type at 90% level of probability

Table 9. Mean Abundance of Additional Species Showing Significant Habitat Relationships at the 95% Confidence Level and Their Associated Habitat Types at the 90% Confidence Level for Segments and Point Counts at All Distances during the Autumn Migration

[Back to Text]

	Clearcut, Regeneration, and Early Succession		Clearcut, Regeneration, and Early Succession with Mature Deciduous		Mid to Late Succession; Mixed Age and Mature Mixed Forest		Mature Coniferous		Mature Deciduous	
	Seg	PC	Seg	PC	Seg	PC	Seg	PC	Seg	PC
Red-tailed Hawk	0.00	0.05	0.12	0.00	0.00	0.00	0.00	0.00	0.05	0.00
Pileated Woodpecker	0.24	0.08	0.09	0.00	0.00	0.00	0.09	0.05	0.00	0.00
Blue Jay	3.25	0.69	1.45	0.30	1.55	0.33	2.45	0.43	0.95	0.20
Common Raven	1.94	0.64	1.42	0.25	1.45	0.31	0.59	0.18	1.18	0.36
White-winged Crossbill	2.70	0.31	0.45	0.00	0.27	0.18	0.82	0.34	0.14	0.00
Pine Siskin	0.27	0.04	0.12	0.02	0.00	0.00	0.14	0.02	0.00	0.00

Positively different from all four other habitat types at 95% level of probability
Positively different from three habitat types at 95% level of probability
Positively different from two habitat types at 95% level of probability
Positively different from one habitat type at 95% level of probability

Table 10. Hermit Thrush Nocturnal Passage Counts during the Autumn Migration
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Day	Month	Start Time	Listening Point	Elevation (m)	Night Wind Direction	Night Wind Speed (km/hr)	Current Wind Direction	Current Wind Speed	Temp.	Sound Count
3	9	530	2	200	SW	12-19	W	40-50	10	0
11	9	541	2	200	SE	12-19	SE	1-6	12	13
14	9	544	6	230	SW	7-11	Calm	0	1	79
15	9	546	2	200	S	12-19	SE	20-29	11	0
18	9	549	6	230	S	7-11	Calm	0	1	1
19	9	550	2	200	SW	7-11	W	12-19	7	5
23	9	555	6	230	SW	12-19	W	30-39	16	0
25	9	558	2	200	NW	30-39	NW	30-39	9	0
26	9	559	5	240	SW	12-19	W	20-29	18	4
1	10	605	6	230	SW	7-11	Calm	0	-3	89
5	10	610	4	210	W	12-19	NW	7-11	8	44
7	10	613	6	230	NW	20-29	NW	30-39	8	0
14	10	622	6	230	SW	7-11	Calm	0	2	57
18	10	627	4	210	W	12-19	Calm	0	1	12
19	10	629	6	230	S	7-11	Calm	0	-3	14
23	10	634	4	210	SW	12-19	SW	20-29	10	0

Table 11. Summary of Diurnal Passage of Raptors during the Autumn Migration
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Species	Date Range	Time Range (hrs)	Median Time of Observation (hrs)	No. of Observations	% Time Blocks Observed	Mean No. Per Observation
Osprey	17 Sep - 3 Oct	1000-1200	1100	2	1.54%	1.00
Bald Eagle	29 Aug - 23 Oct	0830-1500	1130	29	16.92%	1.10
Northern Harrier	30 Aug	1000	1000	1	0.77%	1.00
Sharp-shinned Hawk	30 Aug - 15 Oct	0730-1600	0945	12	8.46%	1.17
Northern Goshawk	15 Oct	0800	0800	1	0.77%	1.00
Red-tailed Hawk	3 Sep - 10 Oct	0730-1500	1130	18	12.31%	1.11
American Kestrel	8 Sep - 17 Sep	1100-1330	1130	7	5.38%	1.14
Merlin	4 Oct	1300	1300	1	0.77%	1.00
Peregrine Falcon	6 Sep	1030	1030	1	0.77%	1.00

Table 12. Summary of the Diurnal Passage of Water Birds during the Autumn Migration

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Species	Date Range	Time Range (hrs)	Median Time of Observation (hrs)	No. of Observations	% Time Blocks Observed	Mean No. Per Observation
Canada Goose	6 Sep	930	0930	1	0.77%	8.00
Duck sp.	12 Oct	0730	0730	1	0.77%	12.00
Double-crested Cormorant	8 Sep - 26 Sep	0730-1100	0800	3	2.31%	2.33
Herring Gull	14 Sep - 23 Oct	0800-1430	1100	7	4.62%	2.57
Great Black-backed Gull	6 Oct	0800	0800	1	0.77%	6.00

Table 13. Summary of the Diurnal Passage of Woodpeckers and Passerines during the Autumn Migration

[Back to Text]

Species	Date Range	Time Range (hrs)	Median Time of Observation (hrs)	No. of Observations	% Time Blocks Observed	Mean No. Per Observation
None	1 Oct - 20 Oct	0700-1400	0930	11	8.46%	0.00
Downy Woodpecker	31 Aug - 2 Oct	1000-1030	1015	2	1.54%	1.00
Hairy Woodpecker	18 Sep	1100-1100	1100	1	0.77%	1.00
Northern Flicker	10 Sep - 18 Oct	0730-1230	1030	6	3.85%	1.00
Pileated Woodpecker	18 Sep - 19 Oct	1100-1230	1100	3	2.31%	1.00
Northern Shrike	23 Oct	1000-1000	1000	1	0.77%	1.00
Blue-headed Vireo	2 Oct	1030-1030	1030	1	0.77%	1.00
Red-eyed Vireo	26 Sep	0830-0830	0830	1	0.77%	1.00
Gray Jay	23 Sep	1000-1000	1000	1	0.77%	1.00
Blue Jay	3 Sep - 23 Oct	0830-1630	1100	35	22.31%	1.29
Common Raven	30 Aug - 23 Oct	0730-1630	1030	86	43.08%	1.67
Black-capped Chickadee	17 Sep - 23 Oct	0730-1500	0945	8	6.15%	4.38
Boreal Chickadee	26 Sep	0830-0830	0830	1	0.77%	1.00
Red-breasted Nuthatch	26 Sep	0800-0800	0800	1	0.77%	1.00
White-breasted Nuthatch	2 Oct - 18 Oct	1030-1030	1030	2	1.54%	1.00
Golden-crowned Kinglet	26 Sep	0830-0830	0830	1	0.77%	2.00
Ruby-crowned Kinglet	26 Sep	0800-0830	0815	2	1.54%	1.00
American Robin	3 Sep - 23 Oct	0730-1530	1045	28	19.23%	3.57
American Pipit	3 Oct	1030-1030	1030	1	0.77%	1.00
Cedar Waxwing	5 Sep - 25 Sep	0900-1030	0945	2	0.77%	1.50
Nashville Warbler	26 Sep	0800-0800	0800	1	0.77%	1.00
Magnolia Warbler	26 Sep	0830-0830	0830	1	0.77%	2.00
Yellow-rumped Warbler	30 Aug - 11 Oct	0730-1230	1000	36	23.85%	1.61
Black-throated Green Warbler	31 Aug - 2 Oct	1030-1030	1030	1	0.77%	1.00
Palm Warbler	14 Oct	1030-1030	1030	1	0.77%	1.00
Warbler species	29 Aug - 6 Oct	0730-1130	0900	14	8.46%	1.50
Scarlet Tanager	19 Sep	1000-100	1000	1	0.77%	1.00
Lincoln's Sparrow	2 Oct	1030-1030	1030	1	0.77%	3.00
White-throated Sparrow	26 Sep -2 Oct	0830-1100	1030	3	2.31%	1.33
Dark-eyed Junco	29 Aug - 23 Oct	0730-1230	1030	20	15.38%	8.25
Rose-breasted Grosbeak	10 Sep	1130-1130	1130	1	0.77%	1.00
Bobolink	8 Sep	1000-1000	1000	1	0.77%	1.00
Red-winged Blackbird	22 Sep	0830-0830	0830	1	0.77%	1.00
Purple Finch	29 Aug - 19 Oct	0830-1300	1030	20	13.85%	1.30
Red Crossbill	15 Oct - 23 Oct	0730-1030	0800	3	2.31%	1.00
White-winged Crossbill	14 Sep - 19 Oct	0900-1130	1030	5	3.85%	2.60
Pine Siskin	19 Sep - 18 Oct	1000-1230	1045	4	3.08%	1.75
American Goldfinch	30 Aug - 23 Oct	0730-1130	1000	25	16.92%	2.08
Evening Grosbeak	29 Aug - 23 Oct	1030-1500	1115	4	3.08%	5.50
Passerine species	29 Aug - 23 Oct	0730-1630	1030	30	20.00%	1.80

Table 14. Matrix of Flight Direction and Wind Direction for Woodpeckers and Small to Medium-Sized Passerines in Diurnal Passage during the Autumn Migration

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		Wind Direction								
Species	Flight Direction	Calm	E	N	NW	W	SW	S	SE	Grand Total
Woodpeckers	E				2	1				3
	N				1					1
	W				2	1		1	1	5
	S				1	1	1			3
Woodpeckers Total					6	3	1	1	1	12
Blue Jay	E			2	1	7	1			11
	N	1		1			2			4
	W			4	4	5	1			14
	S	2				4				6
Blue Jay Total		3		7	5	16	4			35
American Robin	E				1	1		1	1	4
	N				2	1	1			4
	W	1		2	2	7	1		2	15
	S				1	1	2	1		5
American Robin Total		1		2	6	10	4	2	3	28
Warblers	?				2		3		1	6
	E			1	1	1	2			5
	N				2	2				4
	W	2		6	3	15	3		3	32
	S		1		1	4	1			7
Warblers Total		2	1	7	9	22	9		4	54
Finches	?		1	4	3	5	10	1		24
	E			1	1	3		1		6
	N			3	3	8		1		15
	W	1			2	3	4		1	11
	S			1	1	2		1		5
Finches Total		1	1	9	10	21	14	4	1	61
Other Passerines	?					2	1			3
	E			1	4	4	1	2	1	13
	N				1	3				4
	W	1		2	7	21	5		2	38
	S				1	15	3	1	2	22
Other Passerines Total		1		3	13	45	10	3	5	80
None	None	1		2	1	4	1		2	11
None Total		1		2	1	4	1		2	11
Grand Total		9	2	30	50	121	43	10	16	281

Table 15. Matrix of Flight Direction and Wind Speed for Woodpeckers and Small to Medium-Sized Passerines in Diurnal Passage during the Autumn Migration
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		Wind Speed								
Species	Flight Direction	0 km/hr	1-6 km/hr	7-11 km/hr	12-19 km/hr	20-29 km/hr	30-39 km/hr	40-50 km/hr	51-62 km/hr	Grand Total
Woodpeckers	E		2		1					3
	N			1						1
	W		2		1	2				5
	S		1	1		1				3
Woodpeckers Total			5	2	2	3				12
Blue Jay	E		1	4	4	2				11
	N	1			2		1			4
	W		4	7	1	1	1			14
	S	2	1	1	2					6
Blue Jay Total		3	6	12	9	3	2			35
American Robin	E		1	1	1	1				4
	N		1	1	2					4
	W	1		2	6	3	1		2	15
	S		1		2	1		1		5
American Robin Total		1	3	4	11	5	1	1	2	28
Warblers	?				2	3	1			6
	E			3	2					5
	N				2		1	1		4
	W	2	3	3	20	3	1			32
	S		1	4	1	1				7
Warblers Total		2	4	10	27	7	3	1		54
Finches	?		3	7	8	5	1			24
	E		2		1	3				6
	N			1	9	1	4			15
	W	1	1	4	2	3				11
	S				4		1			5
Finches Total		1	6	12	24	12	6			61
Other Passerines	?			1		2				3
	E		2	1	7	1	2			13
	N				1	2		1		4
	W	1	3	6	24	3	1			38
	S		1	4	6	11				22
Other Passerines Total		1	6	12	38	19	3	1		80
None	None	1	1		3		3	3		11
None Total		1	1		3		3	3		11
Grand Total		9	31	52	114	49	18	6	2	281

Table 16. Mean Birds per Hectare by Species and Habitat Type at < 50 m (Non-zero values in red) during the Winter

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	Clearcut, regeneration & early succession	Clearcut, regeneration & early succession with mature deciduous	Mid to late succession	Mature coniferous	Mature deciduous	Residential or agricultural	Total
Ruffed Grouse	0.00	0.00	0.01	0.00	0.03	0.00	0.01
Rock Pigeon	0.00	0.00	0.00	0.00	0.00	0.27	0.03
Barred Owl	0.00	0.00	0.00	0.00	0.03	0.00	0.01
Downy Woodpecker	0.00	0.00	0.00	0.11	0.16	0.00	0.05
Hairy Woodpecker	0.00	0.00	0.00	0.02	0.15	0.00	0.03
Gray Jay	0.10	0.00	0.00	0.04	0.00	0.00	0.03
Blue Jay	0.00	0.10	0.03	0.00	0.00	0.07	0.03
Black-capped Chickadee	0.32	0.40	0.39	0.23	1.13	0.53	0.47
Boreal Chickadee	0.03	0.00	0.00	0.38	0.00	0.00	0.09
Red-breasted Nuthatch	0.03	0.00	0.00	0.00	0.02	0.00	0.01
White-breasted Nuthatch	0.00	0.00	0.00	0.00	0.16	0.00	0.02
Golden-crowned Kinglet	0.07	0.05	0.01	0.22	0.08	0.00	0.08
Pine Grosbeak	0.00	0.25	0.61	0.00	0.00	0.00	0.17
Common Redpoll	0.00	0.00	0.02	0.00	0.00	0.00	0.01

Table 17. Species Observed by Habitat Type at >50 m or Flying during the Winter

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	Clearcut, regeneration, and early succession	Clearcut, regeneration, and early succession with mature deciduous	Mid to late succession	Mature coniferous	Mature deciduous	Residential or agricultural
Downy Woodpecker					X	
Hairy Woodpecker	X	X		X	X	
Pileated Woodpecker					X	
Gray Jay			X			
Blue Jay	X	X		X		X
Common Raven	X	X		X	X	X
American Crow			X	X	X	X
Black-capped Chickadee			X			
Pine Grosbeak		X	X	X		
White-winged Crossbill	X					
Common Redpoll		X	X	X		X
American Goldfinch	X					

Table 18. Mean Number of Each Species per Transect at All Distances by 10-day Period during the Spring Migration

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Species	April 1-10	April 11-20	April 21-30	May 1-10	May 11-20	May 21-30	May 31-June 9	Total
American Black Duck	0.00	0.00	0.00	0.17	0.25	0.13	0.00	0.10
Green-winged Teal	0.00	0.00	0.00	0.00	0.13	0.25	0.00	0.08
Ruffed Grouse	0.00	1.60	2.80	2.17	1.38	1.75	0.50	1.58
Common Loon	0.00	0.00	0.00	0.00	0.13	0.00	0.17	0.05
Red-tailed Hawk	0.00	0.20	0.00	0.17	0.00	0.13	0.33	0.13
Broad-winged Hawk	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.03
Sharp-shinned Hawk	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.08
American Kestrel	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.05
Merlin	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.03
Herring Gull	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.03
Mourning Dove	1.50	0.20	0.20	0.00	0.00	0.00	0.17	0.15
Barred Owl	0.00	0.20	0.60	0.17	0.00	0.00	0.00	0.13
Ruby-throated Hummingbird	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.15
Belted Kingfisher	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.03
Yellow-bellied Sapsucker	0.00	5.40	11.60	9.50	6.13	4.63	7.83	6.88
Downy Woodpecker	0.00	0.40	0.40	0.17	0.38	0.25	0.17	0.28
Hairy Woodpecker	4.50	2.20	3.20	2.33	2.50	1.75	3.50	2.63
Black-backed Woodpecker	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.03
Northern Flicker	0.00	2.80	7.40	6.50	2.88	2.63	3.00	3.80
Pileated Woodpecker	0.50	0.60	0.40	0.17	0.25	0.25	0.33	0.33
Olive-sided Flycatcher	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.18
Eastern Wood Pewee	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.05
Yellow-bellied Flycatcher	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.03
Alder Flycatcher	0.00	0.00	0.00	0.00	0.00	0.38	4.83	0.80
Least Flycatcher	0.00	0.00	0.00	0.00	1.13	3.63	5.67	1.80
Blue-headed Vireo	0.00	0.00	0.00	1.00	3.63	4.75	3.67	2.38
Red-eyed Vireo	0.00	0.00	0.00	0.00	0.00	2.25	12.00	2.25
Tree Swallow	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.03
Blue Jay	1.50	1.20	1.80	2.00	1.88	3.50	3.33	2.33
American Crow	1.00	1.60	0.40	1.33	0.13	0.13	0.50	0.63
Common Raven	2.00	1.80	1.40	1.83	1.25	1.63	1.17	1.53
Black-capped Chickadee	3.50	5.00	2.80	4.33	1.75	4.88	1.83	3.40
Boreal Chickadee	0.50	3.00	0.60	1.17	1.13	0.88	0.83	1.18
Red-breasted Nuthatch	0.00	0.00	0.00	0.17	0.00	0.13	0.17	0.08
White-breasted Nuthatch	1.00	0.20	0.60	0.00	0.25	0.13	0.00	0.23
Winter Wren	0.00	0.00	0.20	0.33	0.25	0.13	0.17	0.18
Golden-crowned Kinglet	0.00	0.20	0.00	0.33	0.13	0.00	0.00	0.10
Ruby-crowned Kinglet	0.00	0.40	4.80	8.83	6.00	3.50	4.00	4.48
Swainson's Thrush	0.00	0.00	0.00	0.00	0.00	0.75	2.67	0.55
Hermit Thrush	0.00	0.00	2.20	9.33	2.63	4.75	6.33	4.10
American Robin	16.00	25.60	17.60	15.17	9.13	10.00	16.83	14.83
Gray Catbird	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.03

Cedar Waxwing	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.03
Tennessee Warbler	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.10
Nashville Warbler	0.00	0.00	0.00	0.00	0.00	1.38	1.33	0.48
Northern Parula	0.00	0.00	0.00	0.00	1.13	3.50	4.17	1.55
Chestnut-sided Warbler	0.00	0.00	0.00	0.00	0.13	1.00	1.83	0.50
Magnolia Warbler	0.00	0.00	0.00	0.00	1.63	11.00	13.50	4.55
Black-throated Blue Warbler	0.00	0.00	0.00	0.00	0.38	0.75	1.00	0.38
Yellow-rumped Warbler	0.00	0.00	3.20	8.00	6.88	3.75	1.00	3.88
Black-throated Green Warbler	0.00	0.00	0.00	0.17	5.88	16.00	12.67	6.30
Blackburnian Warbler	0.00	0.00	0.00	0.00	0.13	1.00	0.67	0.33
Palm Warbler	0.00	0.00	0.20	0.50	0.38	0.63	0.17	0.33
Blackpoll Warbler	0.00	0.00	0.00	0.00	0.00	0.38	0.17	0.10
Black-and-White Warbler	0.00	0.00	0.00	0.33	2.63	3.13	2.83	1.63
American Redstart	0.00	0.00	0.00	0.00	0.13	0.75	4.17	0.80
Ovenbird	0.00	0.00	0.00	0.00	8.00	17.38	10.67	6.68
Mourning Warbler	0.00	0.00	0.00	0.00	0.00	0.00	1.17	0.18
Common Yellowthroat	0.00	0.00	0.00	0.00	0.75	5.50	7.33	2.35
Wilson's Warbler	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.03
Fox Sparrow	1.00	0.60	0.00	0.00	0.00	0.00	0.00	0.13
Song Sparrow	1.00	8.40	4.40	3.67	3.25	2.50	2.83	3.78
Lincoln's Sparrow	0.00	0.00	0.00	0.00	0.88	2.25	2.67	1.03
Swamp Sparrow	0.00	0.00	0.40	1.50	0.50	0.25	0.33	0.48
White-throated Sparrow	0.00	0.00	5.20	23.17	22.75	19.63	20.33	15.65
Dark-eyed Junco	11.50	14.20	5.40	5.83	4.38	5.63	3.17	6.38
Rose-breasted Grosbeak	0.00	0.00	0.00	0.00	0.00	0.25	0.17	0.08
Red-winged Blackbird	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.03
Common Grackle	0.50	2.60	0.40	0.83	0.13	1.13	0.83	0.90
Pine Grosbeak	1.00	0.40	0.00	0.00	0.13	0.00	0.00	0.13
Purple Finch	0.00	0.00	1.00	6.83	6.00	3.88	3.50	3.65
Common Redpoll	0.50	0.20	0.00	0.00	0.00	0.00	0.00	0.05
Pine Siskin	0.50	0.00	0.00	0.17	0.00	0.38	1.33	0.33
American Goldfinch	0.00	0.00	0.20	0.33	1.63	2.88	1.83	1.25
Evening Grosbeak	2.00	1.20	2.20	1.00	1.88	0.75	0.83	1.33

Table 19. Mean Total Birds per Transect Segment at <50m by Previous Night Wind Direction and Speed during the Spring Migration

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Wind	Wind Direction								
Speed	N	NE	E	SE	S	SW	W	NW	Total
1-6 km/hr			11.67	12.67		10.67			11.57
7-11 km/hr			10.33		13.48	7.44	9.17		11.20
12-19 km/hr			10.00	22.00	10.56	10.73	12.50	10.00	12.46
20-29 km/hr		10.67				4.00	9.83		9.17
30-39 km/hr		7.00							7.00
Total		9.44	10.47	18.89	12.60	9.07	11.00	10.00	11.30

Table 20. Number of Transect Segments for Each Combination of Previous Night Wind Direction and Speed during the Spring Migration

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Wind	Wind Direction								
Speed	N	NE	E	SE	S	SW	W	NW	Total
1-6 km/hr			3	3		3			9
7-11 km/hr			6		21	9	6		42
12-19 km/hr			6	6	9	15	12		48
20-29 km/hr		6				3	6	3	18
30-39 km/hr		3							3
Total		9	15	9	30	30	24	3	120

Table 21. Mean Abundance of Species Showing Significant Habitat Relationships at the 95% Confidence Level and Their Associated Habitat Types at the 95% Confidence Level for Transect Segments at <50m and Point Counts at All Distances during the Spring Migration

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	Clearcut, Regeneration, and Early Succession		Clearcut, Regeneration and Early Succession with Mature Deciduous		Mid to Late Succession; Mixed Age and Mature Mixed Forest		Mature Coniferous		Mature Deciduous	
Species	Seg <50m	PC All	Seg <50m	PC All	Seg <50 m	PC All	Seg <50m	PC All	Seg <50m	PC All
Northern Flicker		0.24		0.13		0.04		0.05		0.03
Alder Flycatcher		0.19		0.00		0.02		0.03		0.00
Least Flycatcher		0.00		0.15		0.10		0.00		0.20
Blue-headed Vireo	0.07		0.10		0.30		0.05		0.60	
Red-eyed Vireo		0.09		0.35		0.10		0.03		0.13
Boreal Chickadee	0.17	0.06	0.17	0.00	0.05	0.02	1.10	0.40	0.00	0.00
Ruby-crowned Kinglet	0.43	0.30	0.17	0.05	0.90	0.40	1.15	0.40	0.54	0.18
Northern Parula	0.07	0.03	0.17	0.03	0.30	0.08	0.10	0.03	0.80	0.25
Black-throated Blue Warbler	0.03	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.50	0.25
Black-throated Green Warbler		0.17		0.15		0.42		0.73		0.33
Blackburnian Warbler	0.00		0.00		0.40		0.05		0.20	
Palm Warbler	0.17		0.00		0.05		0.00		0.00	
Black-and-white Warbler		0.09		0.13		0.32		0.03		0.03
Song Sparrow	1.50	0.49	0.03	0.05	0.15	0.04	0.15	0.00	0.00	0.00
Lincoln's Sparrow	1.00	0.26	0.07	0.00	0.00	0.02	0.05	0.00	0.00	0.00
Swamp Sparrow	0.33	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White-throated Sparrow	2.60	1.01	0.87	0.30	0.75	0.42	0.35	0.25	0.40	0.25

Positively different from all four other habitat types at 95% level of probability

Positively different from three habitat types at 95% level of probability

Positively different from two habitat types at 95% level of probability

Positively different from one habitat type at 95% level of probability

Table 22. Nocturnal Passage Counts during the Autumn Migration

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Day	Month	Start Time	Listening Point	Elevation m	Night Wind Direction	Night Wind Speed km/hr	Current Wind Direction	Current Wind Speed km/hr	Temp.	Species	Sound Count
4	5	04:52	5	240	E	12-19	Calm	0	1	Hermit Thrush	6
8	5	04:46	5	240	S	7-11	Calm	0	5	Hermit Thrush	4
13	5	04:40	4	210	NE	20-29	NE	12-19	1	Passerine species	1
19	5	04:33	6	230	S	12-19	S	20-20	11	Hermit Thrush	3
26	5	04:27	5	240	S	12-19	SW	40-50	11	Passerine species	1

Table 23. Summary of Occurrence and Abundance of Birds in Diurnal Passage during the Spring Migration

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Species	Date Range	Time Range (hrs)	Median Time of Observation (hrs)	No. of Observations	% Time Blocks Observed	Mean No. Per Observation
Common Merganser	15-May	0854	0854	1	2.00%	2
Common Loon	13-May	0901	0901	1	2.00%	1
Double-crested Cormorant	28-May	0927	0927	1	2.00%	1
Great Blue Heron	07-Apr	0730	0730	1	2.00%	1
Osprey	19 Apr-17 May	0910-0954	0932	2	4.00%	1.50
Bald Eagle	8 Apr-26 May	0830-1116	1026	8	16.00%	1.00
Sharp-shinned Hawk	19 Apr-12 May	0848-0910	0910	3	6.00%	1.33
Northern Goshawk	18-May	0946	0946	1	2.00%	1.00
Red-tailed Hawk	19 Apr-3 Jun	0854-1300	0946	12	24.00%	1.08
American Kestrel	4 May-2 Jun	0902-1016	0929	4	8.00%	1.50
Hairy Woodpecker	25-May	0920-0957	0938	2	4.00%	1.00
Northern Flicker	2 May-18 May	0900-1614	0930	4	8.00%	1.00
Pileated Woodpecker	19 May-2 Jun	0901-0902	0901	2	4.00%	1.00
Tree Swallow	13-May	0901	0901	1	2.00%	1.00
Blue Jay	7 Apr-4 May	0900-0956	0928	2	4.00%	1.00
Common Raven	7 Apr-25 May	0730-1300	0953	17	34.00%	1.18
American Crow	21 Apr-28 May	0915-0927	0915	3	6.00%	2.67
American Robin	7 Apr-18 May	0730-1116	0842	8	16.00%	1.63
Savannah Sparrow	07-May	0940	0940	1	2.00%	1.00
Bobolink	28-May	0927	0927	1	2.00%	2.00
Common Grackle	7 Apr-18 May	0730-1016	0853	2	4.00%	3.50
Purple Finch	15 May-28 May	0854-0927	0910	2	4.00%	1.50
Common Redpoll	07-Apr	0900	0900	2	4.00%	1.00
Pine Siskin	13 May-20 May	0901-0907	0901	3	6.00%	1.00
American Goldfinch	13 May-30 May	0901-0957	0932	6	20.00%	1.33
Evening Grosbeak	21 Apr-24 May	0850-0924	0910	7	14.00%	1.14
Passerine species	8 May-4 Jun	0613-0957	0903	8	16.00%	2.38
None	16 Apr-6 Jun	0709-1131	0924	12	24.00%	0.00

Table 24. Flight Direction of Woodpeckers and Small to Medium Passerines in Diurnal Passage during the Spring Migration

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Species	Undetermined	E	N	NE	NW	S	SE	W	Total
Hairy Woodpecker			1					1	2
Northern Flicker			1	1		1		1	4
Pileated Woodpecker		1						1	2
Tree Swallow		1							1
Blue Jay			1		1				2
American Robin		5		7			1		13
Savannah Sparrow				1					1
Bobolink			2						2
Common Grackle		4		3					7
Purple Finch	1	2							3
Common Redpoll	2								2
Pine Siskin	3								3
American Goldfinch	5				2	1			8
Evening Grosbeak	3			1			4		8
Passerine Species		14	1	2		1	1		19
Total	14	27	6	15	3	3	6	3	77

Table 25. Summary of Early Breeding Season by Species

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Species	Breeding Start Week	Mean	Max.	Sum	Frequency	Rank
White-throated Sparrow	May 15	2.71	6	65	91.70%	1
American Robin	May 1	2.54	6	61	91.70%	2
Ovenbird	May 22	1.88	8	45	87.50%	3
Yellow-rumped Warbler	May 8	1.58	5	38	83.30%	4
Dark-eyed Junco	May 1	1.29	4	31	79.20%	5
Magnolia Warbler	May 22	1.21	4	29	75.00%	6
Blue Jay	May 1	1.17	5	28	62.50%	7
Black-capped Chickadee	May 1	1.13	3	27	70.80%	8
Hermit Thrush	May 15	0.96	3	23	66.70%	9
Yellow-bellied Sapsucker	May 22	0.79	2	19	66.70%	10
Song Sparrow	May 1	0.79	3	19	45.80%	11
Northern Flicker	May 1	0.75	2	18	54.50%	12
Common Raven	Mar 1	0.75	3	18	54.20%	13
Hairy Woodpecker	May 1	0.71	2	17	66.70%	14
Common Yellowthroat	May 22	0.71	3	17	45.80%	15
Blue-headed Vireo	May 22	0.63	2	15	41.70%	16
Purple Finch	May 22	0.54	2	13	41.70%	17
American Crow	April 8	0.46	2	11	41.70%	18
Ruffed Grouse	April 22	0.42	2	10	29.20%	19
Ruby-crowned Kinglet	May 8	0.38	2	9	33.30%	20
American Redstart	May 22	0.29	2	7	25.00%	21
Common Grackle	April 22	0.29	4	7	16.70%	22
Nashville Warbler	May 22	0.25	2	6	20.80%	23
Downy Woodpecker	May 8	0.17	1	4	16.70%	24
Pine Siskin	April 22	0.17	1	4	16.70%	25
Barred Owl	Mar 22	0.13	1	3	12.50%	26
Swainson's Thrush	May 22	0.13	1	3	12.50%	27
Palm Warbler	May 15	0.13	2	3	8.30%	28
American Kestrel	April 22	0.08	2	2	4.20%	29
Pileated Woodpecker	April 22	0.08	1	2	8.30%	30
Boreal Chickadee	May 15	0.08	1	2	8.30%	31
Swamp Sparrow	May 15	0.08	1	2	8.30%	32
American Black Duck	April 1	0.04	1	1	4.20%	33
Common Loon	May 8	0.04	1	1	4.20%	34
Red-tailed Hawk	April 15	0.04	1	1	4.20%	35
Merlin	May 15	0.04	1	1	4.20%	36
Black-backed Woodpecker	May 15	0.04	1	1	4.20%	37
Tree Swallow	May 8	0.04	1	1	4.20%	38
White-breasted Nuthatch	May 1	0.04	1	1	4.20%	39
Pine Grosbeak	May 15	0.04	1	1	4.20%	40

Table 26. Mean Abundance of Early Breeding Species Showing Significant Habitat Relationships and Their Preferred Habitat Types at the 95% Confidence Level for Point Counts at All Distances

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Species	Clearcut, Regeneration, and Early Succession	Clearcut, Regeneration and Early Succession with Mature Deciduous	Mid to Late Succession; Mixed Age and Mature Mixed Forest	Mature Coniferous	Mature Deciduous
Northern Flicker	1.71	0.50	0.40	0.25	0.25
Blue-headed Vireo	0.14	0.50	1.40	0.00	1.25
Boreal Chickadee	0.00	0.00	0.00	0.50	0.00
American Redstart	0.00	0.25	0.40	0.00	1.00
Ovenbird	1.00	2.50	2.00	0.50	4.00
Common Yellowthroat	1.71	0.75	0.40	0.00	0.00
Song Sparrow	1.57	0.00	1.40	0.25	0.00
White-throated Sparrow	5.00	2.25	2.40	1.25	1.00
Dark-eyed Junco	1.00	2.00	2.20	0.50	0.75

Positively different from all four other habitat types at 95% level of probability

Positively different from three habitat types at 95% level of probability

Positively different from two habitat types at 95% level of probability

Positively different from one habitat type at 95% level of probability

Table 27. Summary of Peak Breeding Season by Species

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Species	Breeding Start Week	Mean	Max.	Sum	Frequency	Rank
Red-eyed Vireo	Jun-08	1.44	5	267	73.70%	1
White-throated Sparrow	May-15	1.25	8	256	57.40%	2
American Robin	May-01	1.12	5	229	60.80%	3
Ovenbird	May-22	1.00	6	204	59.30%	4
Black-throated Green Warbler	Jun-01	0.87	5	178	56.90%	5
Magnolia Warbler	May-22	0.52	3	106	39.20%	6
Swainson's Thrush	May-22	0.39	4	79	26.50%	7
Dark-eyed Junco	May-01	0.38	3	77	29.90%	8
Alder Flycatcher	Jun-08	0.40	4	75	24.70%	9
Hermit Thrush	May-15	0.36	4	74	27.90%	10
Common Yellowthroat	May-22	0.29	3	60	22.50%	11
American Redstart	May-22	0.28	3	57	23.50%	12
Ruby-crowned Kinglet	May-08	0.27	3	55	2.30%	13
Song Sparrow	May-01	0.24	4	48	13.70%	14
Black-and-white Warbler	Jun-01	0.24	2	48	22.10%	15
Yellow-bellied Sapsucker	May-22	0.23	2	47	19.60%	16
Least Flycatcher	Jun-01	0.23	3	46	15.20%	17
Blue-headed Vireo	May-22	0.20	2	40	17.20%	18
Blue Jay	May-01	0.19	3	39	13.20%	19
Mourning Warbler	Jun-15	0.23	3	37	17.20%	20
Yellow-rumped Warbler	May-08	0.18	4	36	12.30%	21
Northern Parula	Jun-01	0.17	2	34	14.20%	22
Hairy Woodpecker	May-01	0.14	2	28	12.70%	23
Purple Finch	May-22	0.13	2	27	12.30%	24
Black-capped Chickadee	May-01	0.12	2	25	10.30%	25
Cedar Waxwing	Jun-08	0.13	5	25	7.00%	26
Common Grackle	Apr-22	0.10	10	20	2.50%	27
Lincoln's Sparrow	Jun-08	0.09	2	17	8.10%	28
Chestnut-sided Warbler	Jun-01	0.08	3	16	6.90%	29
American Crow	Apr-08	0.07	4	14	5.40%	30
Swamp Sparrow	May-15	0.07	4	14	3.90%	31
Nashville Warbler	May-22	0.06	2	13	5.90%	32
White-winged Crossbill	Feb-01	0.06	12	12	0.50%	33
Northern Flicker	May-01	0.05	2	10	4.40%	34
Common Raven	Mar-01	0.04	2	9	3.40%	35
Olive-sided Flycatcher	Jun-08	0.05	1	9	4.80%	36
Yellow-bellied Flycatcher	Jun-15	0.06	1	9	5.50%	37
Boreal Chickadee	May-15	0.04	2	8	2.90%	38
Red-winged Blackbird	May-08	0.04	8	8	0.50%	39
Blackburnian Warbler	Jun-15	0.05	1	8	4.90%	40
American Goldfinch	Jun-22	0.08	2	8	6.30%	41
Gray Jay	Apr-01	0.03	4	7	1.50%	42
Tree Swallow	May-08	0.03	4	6	1.50%	43
Black-throated Blue Warbler	Jun-08	0.03	1	6	3.20%	44
Evening Grosbeak	Jun-15	0.04	2	6	3.10%	45

Winter Wren	May-22	0.02	1	4	2.00%	46
Eastern Wood-Pewee	Jun-08	0.02	1	4	2.20%	47
Pine Siskin	Apr-22	0.01	3	3	0.50%	48
Red-tailed Hawk	Apr-15	0.01	1	3	1.50%	49
Belted Kingfisher	May-22	0.01	1	3	1.50%	50
Northern Waterthrush	May-22	0.01	1	3	1.50%	51
Ruby-throated Hummingbird	Jun-08	0.02	1	3	1.50%	52
White-breasted Nuthatch	May-01	0.01	1	2	1.00%	53
Mourning Dove	May-15	0.01	1	2	1.00%	54
Yellow Warbler	May-22	0.01	2	2	0.50%	55
Bay-breasted Warbler	Jun-08	0.01	1	2	1.10%	56
Chimney Swift	Jun-15	0.01	2	2	0.60%	57
Pileated Woodpecker	Apr-22	0.00	1	1	0.50%	58
Common Loon	May-08	0.00	1	1	0.50%	59
Ring-necked Duck	May-15	0.00	1	1	0.50%	60
Spruce Grouse	May-08	0.00	1	1	0.50%	61
Wilson's Snipe	May-01	0.00	1	1	0.50%	62
Eastern Kingbird	Jun-01	0.00	1	1	0.50%	63
Red-breasted Nuthatch	May-15	0.00	1	1	0.50%	64
Tennessee Warbler	May-22	0.00	1	1	0.50%	65

Table 28. Mean Abundance of Peak Breeding Species Showing Significant Habitat Relationships and Their Preferred Habitat Types at the 95% Confidence Level for Point Counts at All Distances

[Back to Text]

Species	Clearcut, regeneration, and early succession	Clearcut, regeneration, and early succession with mature deciduous	Mid to late succession	Mature coniferous	Mature deciduous	Residential and agricultural
Red-eyed Vireo	0.95	1.74	1.20	0.53	2.20	1.00
White-throated Sparrow	2.79	1.61	1.22	0.81	0.34	1.00
American Robin	1.57	1.11	1.30	0.96	0.53	2.83
Ovenbird	0.39	1.13	0.73	0.57	1.94	0.00
Black-throated Green Warbler	0.75	0.61	1.02	2.05	0.51	0.33
Magnolia Warbler	0.68	0.34	0.75	1.10	0.04	0.17
Alder Flycatcher	1.52	0.44	0.28	0.37	0.00	0.67
Common Yellowthroat	0.71	0.68	0.11	0.05	0.06	0.50
American Redstart	0.21	0.34	0.23	0.05	0.47	0.00
Ruby-crowned Kinglet	0.50	0.00	0.38	0.52	0.09	0.33
Song Sparrow	0.82	0.32	0.06	0.05	0.00	1.33
Yellow-bellied Sapsucker	0.25	0.53	0.14	0.24	0.11	0.17
Least Flycatcher	0.00	0.55	0.11	0.00	0.38	0.00
Mourning Warbler	0.24	0.66	0.09	0.06	0.17	0.00
Yellow-rumped Warbler	0.18	0.00	0.28	0.57	0.00	0.17
Common Grackle	0.00	0.03	0.13	0.05	0.00	1.67
Chestnut-sided Warbler	0.21	0.18	0.02	0.00	0.00	0.33
Common Raven	0.00	0.05	0.02	0.00	0.09	0.33
Olive-sided Flycatcher	0.10	0.03	0.07	0.00	0.00	0.33
Yellow-bellied Flycatcher	0.00	0.00	0.11	0.18	0.00	0.00
Boreal Chickadee	0.00	0.00	0.06	0.19	0.00	0.00
American Goldfinch	0.36	0.13	0.03	0.00	0.00	0.33
Tree Swallow	0.00	0.00	0.02	0.00	0.02	0.67
Black-throated Blue Warbler	0.00	0.03	0.00	0.00	0.11	0.00
Red-tailed Hawk	0.04	0.00	0.02	0.00	0.00	0.17
Belted Kingfisher	0.00	0.03	0.00	0.00	0.02	0.17
Ruby-throated Hummingbird	0.00	0.00	0.00	0.11	0.02	0.00
Yellow Warbler	0.00	0.00	0.00	0.00	0.00	0.33
Ring-necked Duck	0.00	0.00	0.00	0.00	0.00	0.17

(magenta)	Positively different from all five other habitat types at 95% level of probability
(cyan)	Positively different from four other habitat types at 95% level of probability
(green)	Positively different from three habitat types at 95% level of probability
(orange)	Positively different from two habitat types at 95% level of probability
(yellow)	Positively different from one habitat type at 95% level of probability

Table 29. Rank Comparison of Breeding Birds between Early Breeding and Peak Breeding Seasons

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Species	Early Breeding Rank	Equivalent Peak Breeding Rank
White-throated Sparrow	1	1
American Robin	2	2
Ovenbird	3	3
Yellow-rumped Warbler	4	15
Dark-eyed Junco	5	6
Magnolia Warbler	6	4
Blue Jay	7	14
Black-capped Chickadee	8	18
Hermit Thrush	9	7
Yellow-bellied Sapsucker	10	12
Song Sparrow	11	11
Northern Flicker	12	23
Common Raven	13	24
Hairy Woodpecker	14	16
Common Yellowthroat	15	8
Blue-headed Vireo	16	13
Purple Finch	17	17
American Crow	18	20
Ruffed Grouse	19	
Ruby-crowned Kinglet	20	10
American Redstart	21	9
Common Grackle	22	19
Nashville Warbler	23	22
Downy Woodpecker	24	
Pine Siskin	25	27
Barred Owl	26	
Swainson's Thrush	27	5
Palm Warbler	28	
American Kestrel	29	
Pileated Woodpecker	30	30
Boreal Chickadee	31	25
Swamp Sparrow	32	21
American Black Duck	33	
Common Loon	34	31
Red-tailed Hawk	35	28
Merlin	36	
Black-backed Woodpecker	37	
Tree Swallow	38	26
White-breasted Nuthatch	39	29
Pine Grosbeak	40	

Table 30. Breeding Status of Birds in the Study Area (Legend Below)

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Species	Observed	Possible Breeding	Probable Breeding	Confirmed Breeding
Wood Duck		H		
American Black Duck			T	
Green-winged Teal		H		
Ring-necked Duck			P	
Common Merganser			A	
Ruffed Grouse			T	
Spruce Grouse		H		
Common Loon	X			
Great Blue Heron	X			
Bald Eagle		H		
Osprey		H		
Northern Goshawk			T	
Red-tailed Hawk			A	
Broad-winged Hawk		H		
American Kestrel			T	
Merlin		H		
Herring Gull	X			
Wilson's Warbler		S		
American Woodcock			T	
Black-billed Cuckoo		S		
Mourning Dove		S		
Great Horned Owl		S		
Barred Owl			T	
Northern Saw-whet Owl		S		
Chimney Swift		H		
Ruby-throated Hummingbird		H		
Belted Kingfisher		H		
Yellow-bellied Sapsucker				FY
Downy Woodpecker			T	
Hairy Woodpecker				DD
Black-backed Woodpecker		H		
Northern Flicker			T	
Pileated Woodpecker			T	
Olive-sided Flycatcher			T	
Eastern Wood Pewee			T	
Yellow-bellied Flycatcher		S		
Alder Flycatcher			T	
Least Flycatcher			T	
Eastern Kingbird		H		
Blue-headed Vireo				DD
Red-eyed Vireo				CF
Gray Jay				FY
Blue Jay			T	
American Crow			T	
Common Raven			T	
Tree Swallow				AE

Black-capped Chickadee			CF
Boreal Chickadee		T	
Red-breasted Nuthatch		T	
White-breasted Nuthatch		T	
Winter Wren		T	
Golden-crowned Kinglet	S		
Ruby-crowned Kinglet		D	
Swainson's Thrush			FY
Hermit Thrush			CF
American Robin			CF
Cedar Waxwing		T	
European Starling			FY
Tennessee Warbler	S		
Nashville Warbler		T	
Northern Parula			CF
Yellow Warbler		T	
Chestnut-sided Warbler			CF
Magnolia Warbler			CF
Cape May Warbler			FY
Black-throated Blue Warbler			CF
Yellow-rumped Warbler			CF
Black-throated Green Warbler			CF
Blackburnian Warbler		T	
Palm Warbler		T	
Bay-breasted Warbler	H		
Black-and-White Warbler		T	
American Redstart			CF
Ovenbird			CF
Northern Waterthrush	S		
Mourning Warbler			CF
Common Yellowthroat			DD
Canada Warbler		P	
Rose-breasted Grosbeak	S		
Chipping Sparrow	S		
Song Sparrow			FY
Lincoln's Sparrow			CF
Swamp Sparrow		T	
White-throated Sparrow			FY
Dark-eyed Junco			FY
Red-winged Blackbird	H		
Common Grackle			CF
Pine Grosbeak	H		
Purple Finch			NB
White-winged Crossbill	H		
Pine Siskin	H		
American Goldfinch		T	
Evening Grosbeak		T	

Breeding Codes

OBSERVED (Ob):

X - Species observed in its breeding season (no breeding evidence)

POSSIBLE (Po):

H - Species observed in its breeding season in suitable nesting habitat

S - Singing male(s) present, or breeding calls heard, in suitable nesting habitat in breeding season

PROBABLE (Pr):

P - Pair observed in suitable nesting habitat in nesting season

T - Permanent territory presumed through registration of territorial song, or the occurrence of an adult bird, at the same place, in breeding habitat, on at least two days a week or more apart, during its breeding season

D - Courtship or display, including interaction between a male and a female or two males, including courtship feeding or copulation

V - Visiting probable nest site

A - Agitated behaviour or anxiety calls of an adult

B - Brood Patch on adult female or cloacal protuberance on adult male

N - Nest-building or excavation of nest hole by wrens and woodpeckers

CONFIRMED (Conf):

NB - Nest-building or carrying nest materials, for all species except wrens and woodpeckers

DD - Distraction display or injury feigning

NU - Used nest or egg shells found (occupied or laid within the period of the survey)

FY - Recently fledged young (nidicolous species) or downy young (nidifugous species), including incapable of sustained flight

AE - Adults leaving or entering nest site in circumstances indicating occupied nest

FS - Adult carrying faecal sac

CF - Adult carrying food for young

NE - Nest containing eggs

NY - Nest with young seen or heard

Table 31. Species of Birds Flying at 50-125 m above the Observation Point at All Diurnal Passage Observation Points during the Autumn Migration

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		Passed Through Swept Area		
Species	Data	No	Yes	Grand Total
Osprey	N	1	1	2
	%	50.00%	50.00%	100.00%
Bald Eagle	N	18	11	29
	%	62.07%	37.93%	100.00%
Sharp-shinned Hawk	N	8	4	12
	%	66.67%	33.33%	100.00%
Red-tailed Hawk	N	12	6	18
	%	66.67%	33.33%	100.00%
American Kestrel	N	5	2	7
	%	71.43%	28.57%	100.00%
Merlin	N		1	1
	%	0.00%	100.00%	100.00%
Peregrine Falcon	N		1	1
	%	0.00%	100.00%	100.00%
Herring Gull	N	5	2	7
	%	71.43%	28.57%	100.00%
Common Raven	N	67	19	86
	%	77.91%	22.09%	100.00%
American Robin	N	24	4	28
	%	85.71%	14.29%	100.00%
American Pipit	N		1	1
	%	0.00%	100.00%	100.00%
Yellow-rumped Warbler	N	29	2	31
	%	93.55%	6.45%	100.00%
Warbler Species	N	11	2	13
	%	84.62%	15.38%	100.00%
Bobolink	N		1	1
	%	0.00%	100.00%	100.00%
Passerine Species	N	27	2	29
	%	93.10%	6.90%	100.00%
Total N		207	59	266
Total %		77.82%	22.18%	100.00%

Table 32. Observations of Bald Eagle and Common Raven Flying at 50-125 m above the Observation Point at Points 5, 2, and 4 during the Autumn Migration

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			Passed Swept Area		
Species	Observation Point	Data	No	Yes	Grand Total
Bald Eagle	5	N	9	6	15
		%	60.00%	40.00%	100.00%
	2	N	4	2	6
		%	66.67%	33.33%	100.00%
	4	N	5	3	8
		%	62.50%	37.50%	100.00%
Bald Eagle N			18	11	29
Bald Eagle %			62.07%	37.93%	100.00%
Common Raven	5	N	28	10	38
		%	73.68%	26.32%	100.00%
	2	N	6	4	10
		%	60.00%	40.00%	100.00%
	4	N	31	5	36
		%	86.11%	13.89%	100.00%
Common Raven N			65	19	84
Common Raven %			77.38%	22.62%	100.00%
Total N			83	30	113
Total %			73.45%	26.55%	100.00%

Table 33. The Status of Species of Concern by Conservation Agency (Legend below)

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Species	COSEWIC Status	SARA Status	NSESA Status	DNR Status	PIF Priority Species
Spruce Grouse					X
Common Loon				Yellow	
Northern Goshawk				Yellow	
Peregrine Falcon	Special Concern	Threatened	Vulnerable	Red	
American Woodcock					X
Chimney Swift	Threatened		Endangered	Yellow	
Olive-sided Flycatcher	Threatened			Yellow	X
Gray Jay				Yellow	
Boreal Chickadee				Yellow	
Chestnut-sided Warbler					X
Cape May Warbler					
Black-throated Blue Warbler					X
Blackburnian Warbler					X
Bay-breasted Warbler					X
Canada Warbler	Threatened			Yellow	X
Bobolink				Yellow	
Rusty Blackbird	Special Concern			Yellow	
Red Crossbill					X

Committee on the Status of Endangered Wildlife in Canada (COSEWIC)

Endangered = A wildlife species that is facing imminent extirpation or extinction

Threatened = A wildlife species likely to become an endangered species if nothing is done to reverse the factors leading to its extirpation or extinction

Special Concern = A wildlife species that may become a threatened or endangered species because of a combination of biological characteristics and identified threats

Species at Risk Act - Federal (SARA)

Classifications the same as for COSEWIC

Nova Scotia Endangered Species Act (NSESA)

Vulnerable = A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events

Partners in Flight (PIF)

Priority Species = A species may be considered a priority for several different reasons, including global threats to the species, high concern for regional or local populations, or responsibility for conserving large or important populations of the species.

Table 34. Status of Species of Concern in the Study Area

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Species	Status in Study Area
Spruce Grouse	Observed once in breeding season, breeding status=possible
Common Loon	Observed in flight only; 3 observations in the spring and twice in the breeding season; breeding status=possible
Northern Goshawk	One observation in autumn; 2 observations in breeding season; breeding status=probable
Peregrine Falcon	One observation in autumn
American Woodcock	10 flight display sites found in breeding season; nocturnal passage descent noted on four occasions in autumn; breeding status=probable
Chimney Swift	One observation in breeding season; breeding status=possible
Olive-sided Flycatcher	8 observations during spring migration; 12 observations during breeding period; breeding status=probable
Gray Jay	5 observations in autumn; 3 observations in winter, 1 observation in spring, 3 observations in breeding period; breeding status=confirmed
Boreal Chickadee	Numerous observations in all seasons; uncommon to common inhabitant of late successional and mature coniferous forest
Chestnut-sided Warbler	Common spring and fall migrant; uncommon to common breeder in early successional forest; breeding status=confirmed
Cape May Warbler	One family group seen in late May 2007; breeding status=confirmed
Black-throated Blue Warbler	Uncommon autumn and spring migrant; uncommon breeder in mature deciduous; breeding status=confirmed
Blackburnian Warbler	Uncommon migrant in autumn and spring, uncommon to common breeder in late successional forest; breeding status=probable
Bay-breasted Warbler	Uncommon migrant in autumn, rare in breeding season with two observations; breeding status=possible
Canada Warbler	Seen on two occasions in breeding season of 2007 including one pair; adult male seen at same location of pair in 2008. Another pair seen in spring migration; breeding status=probable
Bobolink	Seen once in diurnal passage in both autumn and spring
Rusty Blackbird	One observation in autumn
Red Crossbill	3 observations in autumn diurnal passage