AN EXAMINATION OF FOREST-DWELLING BIRDS IN RECREATIONAL AREAS WITHIN THUNDER BAY, ON.

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ABSTRACT

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Forest-dwelling birds hold various social, economic, and ecological values. This study aims to identify the habitat elements that recreational areas provide or lack for various forest birds. Three recreational areas across Thunder Bay, Ontario were visited in order to gain insight about the effects these areas have on avifauna. The study areas include: Thunder Bay Spacing Trials, Cascades Conservation Area and Kakabeka Falls Provincial Park. These sites were chosen based on their recreational value, size and location. Thunder Bay Spacing trials represents a homogenized recreational forest in comparison to the other two forests which are heterogeneous in structure. Observations of species, weather, time and date, and forest structure were all noted during each trial. Sampling techniques, duration of visits and the presence of a flowing water body remained constant amongst all sites. The relationship between bird observations and weather, bird presence based on forest structure (homogeneous and heterogeneous) and the anthropogenic qualities of each site were all investigated. From the results, there was a slight relationship between bird availability and weather. The bird and tree species composition of each site varied significantly, as well as the total number of species observed at each site.

Keywords: forest-dwelling birds, biodiversity, recreational areas, conservation, habitat, forest structure, weather, anthropogenic, bird presence

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INTRODUCTION

Boreal forest birds are a critical component to Northwestern Ontario ecosystems. The boreal forest is 310 million hectares in area that exists within the 545 million hectares of the boreal region (CEDC n.d.). In Ontario, birds contribute significantly to biodiversity, and are considered the best-known wildlife in the province of Ontario (Heagy & McCracken 2004). Birds of the boreal forest play keystone roles in forest ecosystems (Versluijs et al. 2017) and are valued for various reasons, such as being highly visible and providing naturalists and bird watchers satisfaction, holding cultural significance, and by contributing to the economy (Heagy & McCracken 2004). In Ontario, many recreational activities are based around avifauna, which involve over five million people and generate over one billion dollars to Ontario’s economy annually.

Habitat loss and fragmentation are considered threats to survival, affecting 58% of bird species, and are responsible for 20% of bird extinctions (St-Laurent et al. 2009). Bird Studies Canada suggests that conservation of birds will in turn result in the conservation of various other wildlife species and habitat (Heagy & McCracken 2004). Forest-dwelling birds are crucial for providing natural ecological services as well, such as pollination of plants, insect control and seed dispersal. Birds are often used as indicators of biodiversity due to their high sensitivity to change in environment (Martinez-Jauregui et al. 2016).

There are 340 provincial parks protected within Ontario, as well as various other reserves, conservation areas, plantations etc. suited for recreational use (Ontario Parks n.d.). Disturbance from recreational trails has been directly linked to declining biodiversity of native species in some protected areas (Thompson 2015). However, providing public natural areas are crucial to society and raising awareness of conservation of biodiversity. Many governments have adopted policies in order to maintain biodiversity in protected areas while allowing public access. Acts like the Canada National Parks Act aim to balance the needs between human-use and conserving biodiversity of Canadian fauna. However, protected area managers are in desperate need of information on the use of habitat by native biota within these areas to support decision making.

According to Bird Studies Canada, within Thunder Bay and district, 368 bird species have been observed and recorded as of December 31st, 2016 (Lepage 2017). This list comprises 45 clades, including landbirds, shorebirds, waterbirds and waterfowl. All of the species on the list are labelled as either a permanent resident, summer resident, winter resident, spring/fall migrant, casual in the District of Thunder Bay, accidental in the District of Thunder Bay, or extinct/extirpated. Of the 368 species, 36 are considered permanent residents and 12 more are winter residents.

This study addresses three recreational areas across Thunder Bay managed under different authorities and observes differences in bird presence and diversity in each environment. One is a large plantation, relatively homogeneous in structure, the second is a conservation area located within city limits, and the third is a provincial park known for its significant tourist attractions. Respectively, the areas are the Thunder Bay Spacing Trial, Cascades Conservation Area, and Kakabeka Falls Provincial Park. The Thunder Bay Spacing Trials site is expected to have the lowest permanent and winter resident bird species diversity of all three sites.

With an increasing human interest in nature, and further development of recreational forest areas, the effects these areas have on avifauna diversity must be explored. The objectives of this study were to (1) examine the presence and diversity of forest-dwelling birds in three different recreational areas (2) identify if there is a relationship between bird activity and weather and (3) examine the structural composition of the three recreational areas studied and how it may affect forest-dwelling birds. It was predicted that the presence and diversity of forest birds would be greater at Cascades Conservation Area and Kakabeka Falls Provincial Park due to their heterogeneity in forest structure. However, conifer-dominated stands were predicted to encourage bird inhabitants because of the available winter cover, opposite to deciduous stands. It was also predicted that birds would be less active during days with cold temperatures and high wind speeds. The results from investigating these ideas will be considered to produce logical deductions about the impact of recreational use and forest structure on avifauna habitat.

LITERATURE REVIEW

Weather

Atmospheric processes have an impact on all life forms, especially those that use flight (Elkins 1983). Weather affects the degree of mobility of individual birds. Temperature and movement of air significantly affect aerial feeders and may affect their ability to search for or locate food. Birds that rely on the use of airspace will be affected most by changing atmospheric conditions and success in flight is often determined by air movements. On the other hand, birds are well adapted to coping with changing environmental conditions like temperature, rainfall and humidity.

Thermals are air up-currents resulting from convection; they provide lift for many species and aid to reduce the degree of sinking, which would often occur as a result of gravity (Elkins 1983). This activity is called “static soaring” and it reduces the amount of strain on birds as well as the amount of energy spent. For a large bird, energy consumption may be reduced by a factor of 23 by soaring instead of flapping. Production of thermals depends on soil conditions (dampness, reflectivity and moisture content), reflectivity of the sun’s incident rays, and speed of airflow across the surface of the ground. For this reason, forests produce very weak thermals. Thermals are created just as the sun raises the surface temperature, but cloud cover can inhibit the production and maintenance of thermals. In Coto Donana, Spain, raptor soaring increased along with a morning rise in air temperature and decreased around mid-afternoon after temperatures fell. Strong winds may also affect thermal strength.

For large soaring birds, thermal formation is so heavily relied on that it directly controls their diurnal cycles. At high altitudes, thermals will form whenever cool air flows over a warmer water surface.

<u>Food Availability</u>

Flight is an exhausting exercise that continuously drains energy resources, which is why energy spent flying must be compensated by the food acquired from the birds' journey (Elkins 1983). Breeding, moulting and migration are likewise energy-costly processes that require an even greater intake of energy and thus, more food.

Season is a significant factor in availability of food for birds. Winter is especially significant as food availability is impacted by variations in the weather (Renner et al. 2012). A study assessing food preferences in winter bird communities in Germany, from November to April, showed that snow cover affects the amount of activity at feeding stations and extremely low temperatures increased activity around them. During winter in the northern temperate zone, birds face a reduced supply of food quality and quantity, as arthropod populations are limited or unavailable. Snow cover reduces foraging opportunities and shorter days limit the available time to forage. Birds that are faced with extreme temperatures expend more energy and are required to conserve more energy. Birds deal with this task in three ways: (1) avoiding areas with low food availability, (2) reducing the amount of energy spent, and (3) optimizing foraging time by focusing on high quality foods.

Birds will choose habitat based on availability and quality of food regardless of weather conditions (Renner et al. 2012). Lower shrub layers on the forest floor are important for forage and protection (Heyman 2010). Renner et al. (2012) state that food availability and habitat quality are closely linked to forest structure and accept that food sources differ depending on species composition and the structure of the forest. For instance, in spruce forests, there is a high quantity of low-quality food sources and minimal understory. Paths, tracks and roads are sometimes beneficial to forest birds, as they provide areas of near-bare ground where it may be easier to spot insects, seeds, and other small food sources (Goodwin 1978).

Habitat, food and stand structural preferences are associated with the adaptability of an avian species to changes in environment. These characteristics of common winter residents within Thunder Bay are summarized, and their adaptability to change is ranked from low to high (Table 1). The scale designation is assigned to each species based on historic events, their life history and their conservation status. Generally, the lower the adaptability a species has to disturbance, the less it should be seen in highly disturbed environments (recreational areas; plantations).

Table 1. A summary of the characteristics and requirements of the species observed throughout the study

Species	Habitat	Food Preferences	Adaptability to anthropogenic disturbance	Stand structural preferences & Comments
Pileated Woodpecker *(Dryocopus pileatus)* (Naylor et al 1996)	Nest in dead or decaying trees Dense, mature and productive forest Prefers aspen & other hardwood forest	Insects from dead or decaying stems Nuts and fruits	L	Prefer large diameter trees (25+ cm, 40+ optimally) Dense, mature and productive forest with 60%+ canopy closure Forest-interior species
Ruffed Grouse (*Bonasa umbellus*) (DNR 2009)	Deciduous and mixed deciduous-coniferous forests, with a significant aspen component	Succulent plant materials, fruit and insects	H	Young deciduous forest High percentage of aspen in forest composition
Spruce Grouse (*Falcipennis canadensis*) (WDNR 2013)	Coniferous forest with many shrub layers (blueberry, trailing arbutus, ericaceous vegetation)	Conifer needles serve as year-round food source	M	Conifer specialist (prefer jackpine and spruce forest) adjacent to early sucessional forest Jack pine of 4-7 metres in height Black spruce, white spruce, tamarack and jack pine are important

Species	**Habitat**	**Food Preferences**	**Adaptability to anthropogenic disturbance**	**Stand structural preferences & Comments**
Bald Eagle (*Haliaeetus leucocephalus*) (OMNR 1987)	Large continuous areas of mixed or deciduous forest in close proximity to lakes or rivers	Fish	L	Stands with 30% to 50% canopy cover Tall living white pine (for nests)
Great Horned Owl (*Bubo virginianus*) (Cornell n.d.)	Nearctic range Inhabits forests, fens, pastures	Small to medium-sized mammals	H	Prefers areas adjacent to open areas, fragmented land, second-growth forests, swamps and agricultural areas
Downy Woodpecker (*Picoides pubescens*) (Schroeder 1982)	Inhabits deciduous woodland, riparian forests, urban parks and residential areas	Insects	H	Snag trees for nesting
Hairy Woodpecker (*Picoides villosus*) (Audubon n.d.)	Inhabits mature forest, wooded parks and other urban environments Use decaying trees as nesting and forage sites	Insects primarily; but also berries, seeds and nuts	M	Displays preference for large-diameter, mature trees

Species	**Habitat**	**Food Preferences**	**Adaptability to anthropogenic disturbance**	**Stand structural preferences & Comments**
Black-Backed Woodpecker (*Picoides arcticus*) (Tremblay et al 2016)	Inhabits a variety of forest types within the boreal forest	Insects	L	prefers mature and old-growth conifer and mixed wood forest types, as well as recently burned forests
Blue jay (*Cyanocitta cristata*) (Cadman et al 2007)	Forest with significant edge habitat, river valleys, orchards, residential and urban areas	Insects	H	Edge habitat Areas with ornamental conifers, mature oak, maple and other mast-producing trees
Bank Swallow (*Riparia riparia*) (OMNRF 2017)	Nests in aggregate pits or natural banks along water courses and lakeshores	Insects, aquatic invertebrates	M	Vertical or nearly vertical structure of appropriate substance to nest in
Black-capped Chickadee (*Poecile atricapillus*) (Foote et al 2010)	Various forest areas, woodlots and urban areas across the boreal region	Insects	H	Mixed wood/conifero us forest
Boreal Chickadee (*Poecile hudsonica*) (BSI 2015)	Broadly distributed across Ontario Coniferous forest and some mixed woodlands	Insects, spiders, pupae and eggs; occasionally fruit	M	Often dwelling in the interior of dense spruces

Species	**Habitat**	**Food Preferences**	**Adaptability to anthropogenic disturbance**	**Stand structural preferences & Comments**
Red-Breasted Nuthatch (*Sitta canadensis*) (Ghalambor & Martin 1999)	Dense coniferous forest	Insects, seeds	H	Prefers high spruce and fir composition and mature conifer (associated with plantations)
Chipping Sparrow (*Spizella passerina*) (Middleton 1998)	Open woodlands, borders of forest openings, edges. of rivers and lakes and brushy, weedy fields.	Insects, seeds	H	Uses open areas for foraging
Song Sparrow (*Melospiza melodia*) (Bird Web n.d.)	Inhabits open shrubby habitat, along rivers or lakeshores and urban areas	Insects, seeds	H	Forest areas with significant shrub layer
House Sparrow (*Passer domesticus*) (Mayntz 2017)	Nest in buildings and other structures, natural cavities, nest boxes and previously	Insects, seeds	H	Highly adapted to urban and agricultural habitats

Species	Habitat	Food Preferences	Adaptability to anthropogenic disturbance	Stand structural preferences & Comments
	inhabited nests			
Common merganser (*Mergus merganser*) (Pearce et al 2015)	Nest near large rivers or lakes	Fish	M	Indicator of environmental health, contaminant and acidification level of water bodies
White-breasted nuthatch (*Sitta canadensis*) (Cornell n.d.)	Mature woods and woodland edges	insects	M	Deciduous stands

Forest Management

Vegetation structure and avifauna have a strong relationship with one another. Changes in song perches as well as nesting sites have a direct impact on the use of managed habitat by birds that occupy narrow niches (Woodcock et al. 1997). This study examining the effects of conifer release on breeding songbird populations also concluded that untreated forest patches offered substantial habitat and their presence appeared to be a significant factor in maintaining bird diversity; silviculture applied to reduce ground vegetation significantly affected bird populations by decreasing the availability of nesting material and foraging space. In this same study, it became evident that male passerine species held strong ties to an individual site even after disturbance. Some silviculture, for example gap cutting, increases forest bird diversity, as it creates a mosaic of forest successional stages (Versluijs et al. 2017).

Generally, higher density of woody and herbaceous vegetation allows for a greater diversity and abundance of insects, which in turn supply a significant amount of food for a variety of wildlife species (Ketzler et al. 2017). Forests with significant complexity, well-developed understory, deadwood, large-diameter trees and presence of deciduous trees offer superior resources, nesting opportunities and cover from predators (Versluijs et al. 2017). Forests managed to become a simpler system provide limited forage for boreal birds. Simplification of forest vegetation may also increase the risk of predation. Unfortunately, spaced plantations with a simpler structure are more commonly being used to restore biodiversity in forest landscapes (Martinez-Jauregui et al. 2016). Tree plantations are common for wood production and recreational areas and occupy a large portion of the boreal forest.

Habitat heterogeneity is a significant value in determining species richness (Honkanen et al. 2009). Plantations are generally more homogeneous in structure, as they have fewer woody species and the trees are often at regular spacing and even in age (Martinez-Jauregui et al. 2016). Forest plantations support lower biodiversity than natural forests when species composition is generally homogenized. Many environments in Sweden, where forests are extremely homogenized, face declines in biodiversity as a result of human-induced habitat loss and increased fragmentation of forest stands at a multi-scale level (Versluijs et al. 2017). Understory clearance is a common occurrence in urban woodlands, performed to increase the recreational value or aesthetic (Heyman 2010).

Anthropogenic Value & Impact

According to Goodwin (1978), many birds have been able to thrive alongside humans, sometimes as a result of the changes we make to ecosystems. However, disturbance from recreational trails has been directly linked to declining biodiversity of native species in protected areas (Thompson 2015). At the same time, providing public natural areas is crucial to society and to raising awareness of the importance of conservation of biodiversity. Although many recreational areas are designed to prevent habitat loss, they may not be effective at conserving native wildlife.

Along with the land use surrounding a recreational area that may threaten wildlife species, the presence of humans can add additional stress for many species (Thompson 2015). The main purpose of provincial parks, nature reserves or conservation areas is to inhibit loss of biodiversity in an ecosystem (Versluijs et al. 2017). Many governments have adopted policies in order to maintain biodiversity in protected areas while allowing public access (Thompson 2015). Acts such as the *Canada National Parks Act* aim to balance the needs of people with conserving Canadian fauna. However, protected area managers often lack information on the effect of recreation on native biota within these areas to support decision making.

METHODOLOGY

STUDY AREA DESCRIPTIONS

Thunder Bay Spacing Trial

The Thunder Bay Spacing Trial, established in 1951, is located southwest of Thunder Bay over a glaciolacustrine plain that was previously used for agricultural purposes (McClain et al. 1994). It is located on 25th Side Road, off of Arthur Street West (48°22' N, 89°23' W; Figure 1). The site has a fresh soil moisture regime, rapid drainage, and soil textures consisting of fine sandy loams over sandy clay loam deeper than 160 cm; the ideal qualifications for a tree plantation (McClain et al. 1994).

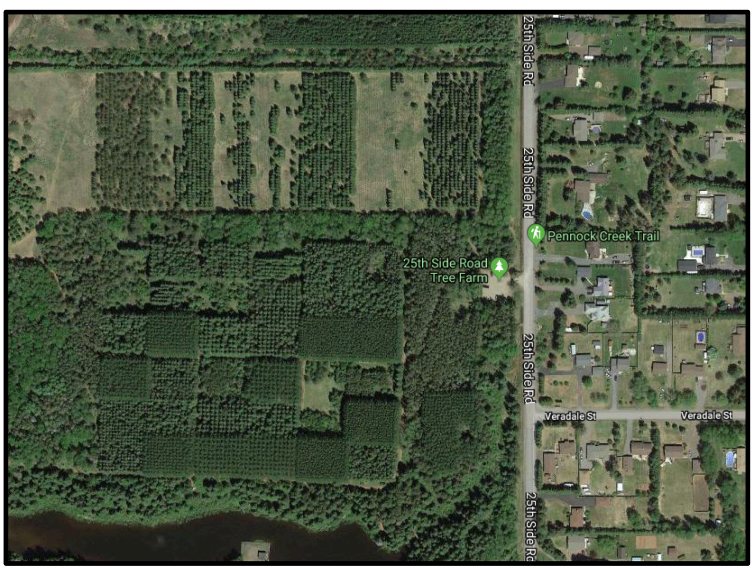


Figure 1. The Thunder Bay Spacing Trial (Google Maps 2018)

The initial spacing trial area (planted in 1951) is 8 hectares in area and consists of black spruce (*Picea mariana* (Mill.) B.S.P.), white spruce (*P. glauca* (Moench) Voss), red pine (*Pinus resinosa* Ait.) and jack pine (*P. banksiana* Lamb.) planted at spacings of 1.8 m, 2.7 m, and 3.6 m (McClain et al. 1994).

Many other trials that vary in age have been established since, surrounding the initial plantation. For example, the Nelder Spacing Trial (Figure 2) was initiated in 1995 and 1996 and consists of black spruce, Norway spruce (*Picea abies* (L.) H. Karst.), white spruce, tamarack (*Larix laracina* (Du Roi) K. Koch), white birch (*Betula papyrifera* Marshall) and balsam fir (*Abies balsamea* (L.) Mill). There are additional experiments demonstrated throughout the site, such as the 'Vegetation Management Alternatives Demonstration Area', which experimented by planting jack pine and black spruce in different media, including plastic and straw mulches.

Number of seedlings per plot (approximately 1,300 m^2) varies with spacing, resulting in 414, 180, and 108 seedlings corresponding to the 1.8-m, 2.7-m, and 3.6-m spacing Trial (McClain et al. 1994). Some Trials are mixed, and others are monoculture (Figure 3). Trees planted in monoculture at 2.7-m spacing include: white birch, white pine, jack pine, tamarack, white spruce, red pine and black spruce.

Figure 2. Nelder Spacing trials (1995/96). Photograph by Johns (2018).

Figure 3. Monoculture Trial planted at 2.7 m spacing in 1995/96. Photograph by Johns (2018).

The initial goal of the plantation was to test how tree spacing affects tree growth (McClain et al. 1994). Many of the planted areas are divided by natural forest that has been left unmanaged. The general species composition of these areas is hardwood dominated mixed-wood with trembling aspen (*Populus tremuloides* Michx.) and white birch being the most prevalent trees. These planted areas, as well as the unmanaged forest, often fall adjacent to man-made trails. The Pennock Creek Trail that runs throughout the Thunder Bay Spacing Trial and is 5 km in length (Figure 4).

Figure 4. Map of the Thunder Bay Spacing Trial. The empty squares signify where white pine (*Pinus strobus* L.) that was planted initially but was removed in 1965 due to severe white pine weevil (*Pissodes strobi* (Peck)) attack, as well as white pine blister rust (*Cronartium ribicola* Fischer) damage (McClain et al. 1994). Photograph by Johns (2018).

<u>Kakabeka Falls Provincial Park</u>

Kakabeka Falls Provincial Park, established in 1957, is located 32 km west of Thunder Bay (Figure 5). It was classified as a Natural Environment Park in 1967, because of the its provincially significant natural features and historical and recreational values (Ontario Parks 2001). Kakabeka Falls is derived from the Ojibwa meaning *thundering water* and it is the second tallest waterfall in Ontario at 39 m.

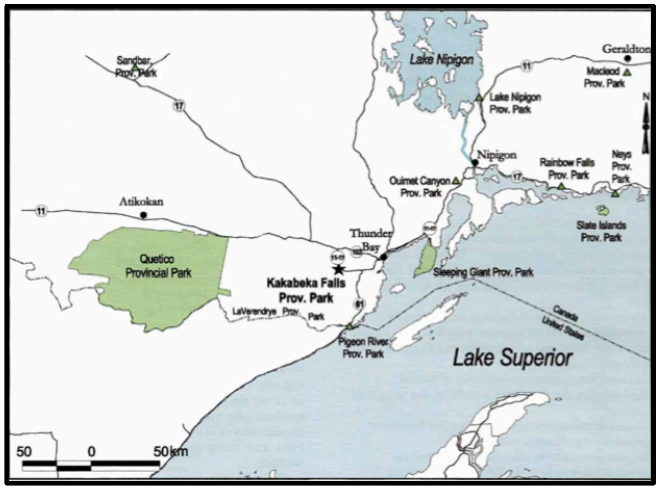


Figure 5. Location of Kakabeka Falls Provincial Park (Ontario Parks)

The park is situated within the northern limit of the Quetico section of the Great Lakes-St. Lawrence Forest Region and adjacent to the southern portion of the Superior section of the Boreal Forest Region, so it includes vegetation representative of both forest regions (Figure 5). The canopy generally consists of trembling aspen, white birch, and jack pine (Ontario Parks 2001). White spruce and balsam fir are present at higher elevations, and black spruce grows in lower areas. This species composition typically results from disturbances like logging, fire or agriculture.

The Kakabeka Falls area provides habitat for various wildlife species such as: moose (*Alces alces* L.), white-tailed deer (*Odocoileus virginianus* Zimmermann), North American beaver (*Castor canadensis* Kuhl), red fox (*Vulpes vulpes* L.), snowshoe hare (*Lepus americanus* Erxleben), raccoon (*Procyon lotor* L.), North American porcupine (Erethizon dorsatum L.), American black bear (*Ursus americanus* Pallus), striped skunk (*Mephitis mephitis* Schreber) and Eastern chipmunk (*Tamias striatus* L.), as well as many amphibians (Ontario Parks 2001). Typical avifauna of the park includes: the common raven (*Corvus corax* L.), ruffed grouse (*Bonasa umbellus* L.), wood warblers and thrushes. Eighteen fish species also inhabit the area below the falls.

An extensive trail system runs throughout Kakabeka Falls Provincial Park (Figure 6). There are six identified trails: The Poplar Point trail (3.6 km), the River Terrace loop (3.6 km), the Beaver Meadows trail (5.6 km), the Contact trail (1.0 km), the Little Falls trail (3.0 km), and the Mountain Portage trail (1.2 km). These routes provide various recreational opportunities, including to view avifauna, and they increase tourism in Kakabeka Falls Provincial Park.

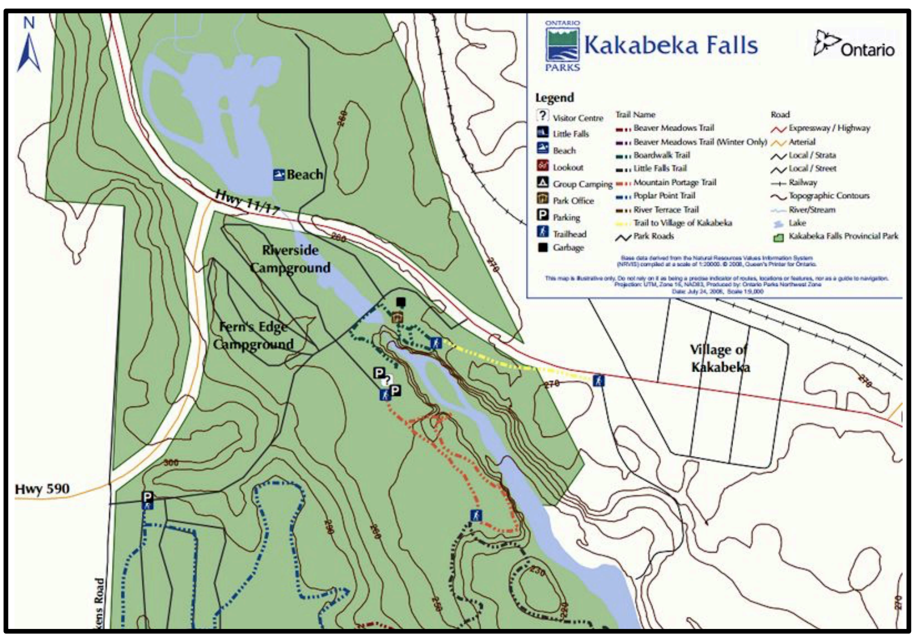


Figure 6. Trail system of Kakabeka Falls Provincial Park (Ontario Parks 2014).

<u>Cascades Conservation Area</u>

Situated within the city of Thunder Bay, Cascades Conservation Area is one of the 8 areas in the region managed by the Lakehead Region

Conservation Authority. The entire area is 162 hectares in size, with 5.5 km in trails (Figure 8). Cascades Conservation Area is located about 3.5 km north of the Thunder Bay Expressway (Hwy 11/17) at the end of Balsam Street (Figure 7). It is a popular recreational attraction to the public because of the spectacular rapids along the Current River (LRCA n.d.). The forest composition of the area is predominantly hardwood, with poplar and birch the most common trees.

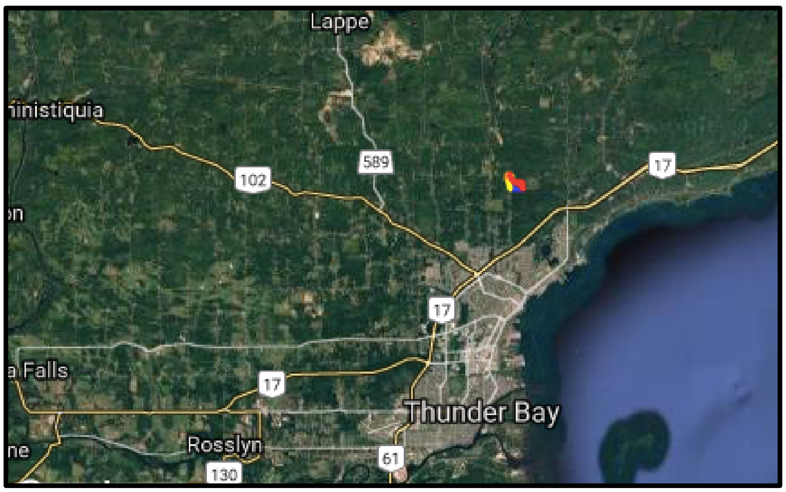


Figure 7. Location of Cascades Conservation Area (Google Maps 2018).

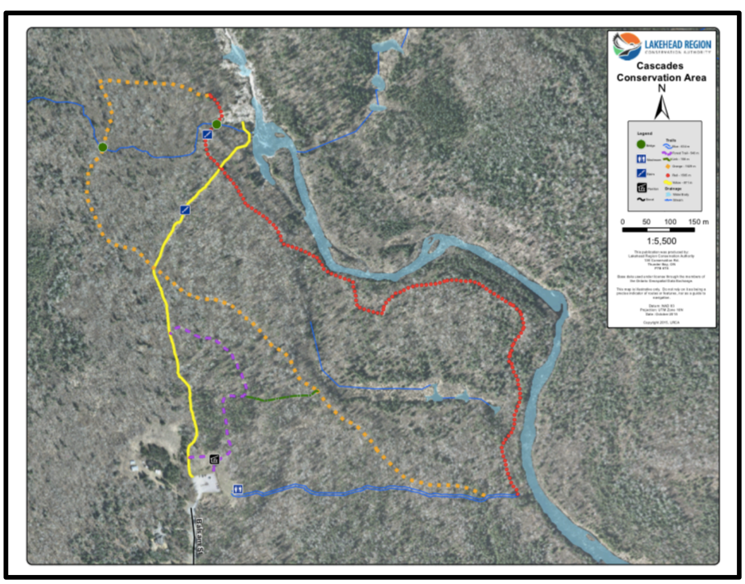


Figure 8. Map of Cascades Conservation Area & trail system (LRCA n.d.)

FIELD SITE METHODOLOGY

Site Characteristics

Information on site characteristics was gathered by visual observation and through modified point sampling ($2m^2$/ha wedge prism) to determine diameter distribution of the trees on site, and the density and basal area of the stands studied. Within the Thunder Bay Spacing Trial, literature as well as signs posted around the area offered additional information on species composition, spacing, basal and diameter of some of the stands. Five sample plots were located randomly at each site at least 6 m from a trail. Diameter and species of each stem in each plot was recorded.

Bird Presence

Two hours per visit were spent observing bird species by walking all of the trails available. Species presence was recorded from visual observation (using binoculars) and from photographs used to aid identification. Attention to calls and songs was also used for identification. Birds circling overhead or flying by but not using the forest area were not recorded. Only birds active within or using the forested area, which included perching, flying from tree to tree, etc. were recorded.

There were twenty visits completed: ten to the Thunder Bay Spacing Trial, five to Cascades Conservation Area, and five to Kakabeka Falls Provincial Park. The two mixed-forest areas combined thus received the same total of ten visits as did the Thunder Bay Spacing Trial. The majority of the visits took place on different days.

Additional Information

Temperature (°C), wind speed (km/hour), time, date, and length of the trip were all recorded for each visit to each location. Any additional observations that may be attributed to presence or absence of birds were also recorded; observation of nests, presence of bird feeders/houses, other animals observed, etc. (Table 1). Additional signs of wildlife presence were recorded each visit as it may have reflected the quality of the site. Objects like bird feeders or houses were recorded for each location, as they can increase attraction to the site and result in an inaccurate representation of the overall quality of the site.

Data Analysis

After each visit, tree species, weather, time and date, bird species and quantity of individuals observed was entered into a Microsoft Excel spreadsheet. Density and basal area was calculated in Microsoft Excel for each plot in each location from published factors. From the field-collected data, bird species diversity along with the total number of individuals per study area was compared and contrasted amongst all sites.

RESULTS

Wind speed and temperature fluctuated substantially across the ten trials at the Thunder Bay Spacing Trial site (Table 2), along with the number of bird observations. As the dates proceed further into the winter season, the temperatures generally remain below 0°C.

Table 2. A summary of the weather conditions and number of birds observed at the Thunder Bay Spacing Trial, organized by date and trial number.

Thunder Bay Spacing Trial						
Trial	Date (YYYY-MM-DD)	Weather	Temperature (°C)	Wind (km/hr)	Time Duration	No. of Birds Observed
1	2017-10-13	15 °C, Sunny, wind: 21km/hr	15	21	12:00-14:00	15
2	2017-10-22	12°C, Cloudy, wind: 18km/hr	12	18	12:15-14:00	0
3	2017-10-28	1°C, Mostly cloudy, wind: 19km/hr	1	19	13:00-15:00	13
4	2017-11-24	(-)1°C, Cloudy, wind: 10km/hr	-1	10	12:00-14:00	11
5	2017-12-18	1°C, Cloudy, wind: 10km/hr	1	10	14:00-16:15	2
6	2018-02-10	(-)15°C, Sunny, wind: 13km/hr	-15	13	12:00-14:00	5
7	2018-02-17	(-)4°C, Partly cloudy, wind: 26km/hr	-4	26	15:00-17:00	2
8	2018-03-03	(-)3°C, Cloudy, wind: 5km/hr	-3	5	14:45-16:45	2
9	2018-03-07	(-)3°C, Mostly cloudy, wind: 21km/hr	-3	21	15:30-17:30	5
10	2018-03-29	(-)5°C, Partly cloudy, wind: 19km/hr	-5	19	13:20-15:20	4

Temperature and bird observations fluctuated across the five trials at Cascades Conservation Area (Table 3). Bird observations remained generally low aside from the first trial date where 15 individuals were observed congregated around the bird feeder.

Table 3. A summary of the weather conditions and number of birds observed at Cascades Conservation Area, organized by date and trial number.

Cascades Conservation Area						
Trial	Date (YYYY-MM-DD)	Weather	Temperature (°C)	Wind (km/hr)	Time Duration	No. of Birds Observed
1	2018-03-07	(-)6°C, Snow showers, wind: 21km/hr	-6	21	13:00-15:00	15
2	2018-03-10	0°C, Partly cloudy, wind: 10km/hr	0	10	14:30-16:30	5
3	2018-03-14	(-)6°C, Partly cloudy, wind: 16km/hr	-6	16	14:45-16:00	0
4	2018-03-16	1°C, Sunny, wind: 14km/hr	1	14	15:00-17:00	4
5	2018-03-18	(-)2°C, Cloudy, wind: 19km/hr	-2	19	13:50-15:50	2

At Kakabeka Falls Provincial Park, the wind speed was cumulatively lower than any 5 trials of the other sites, however, temperatures remained below 0°C except for one trial where temperature was 3°C (Table 4). Bird observations did not exceed 9 individuals in one trial over the five visits.

Table 4. A summary of the weather conditions and number of birds observed at Kakabeka Falls Provincial Park, organized by date and trial number

Kakabeka Falls Provincial Park						
Trial	Date (YYYY-MM-DD)	Weather	Temperature (°C)	Wind (km/hr)	Time Duration	No. of Birds Observed
1	2017-11-06	(-)2°C, Partly cloudy, wind: 21 km/hr	-2	21	14:00-16:00	7
2	2017-11-14	3°C, Cloudy, wind: 10km/hr	3	10	15:00-17:00	3
3	2018-02-24	(-)7°C, Sunny, wind: 8km/hr	-7	8	13:30-15:30	8
4	2018-03-03	(-)3°C, Cloudy, wind: 5km/hr	-3	5	12:00-14:00	6
5	2018-03-14	(-)6°C, Partly cloudy, wind: 16 km/hr	-6	16	16:30-18:00	4

Bird observations generally decreased as temperature decreased at the Thunder Bay Spacing Trial site (Figure 9). Wind speed and temperature decreased at a somewhat similar rate from Trial 1 to Trial 5 but differed significantly from that point on. Ultimately, bird observations were highest on the initial trial date (Trial 1) where temperature reached 15°C. At Cascades Conservation Area, temperature and wind speed reflect each other very similarly on an imaginary horizontal axis (Figure 10). Bird observations were greatest during Trial 1, where wind speed was 21 km/hr and temperature reached -6°C. Aside from the break in pattern at Trial 3, the number of bird observations follow a slow decline, but wind and temperature continue to fluctuate. The number of bird observations at Kakabeka Falls Provincial Park do not exhibit an increasing or decreasing pattern (Figure 11). Bird observations are not greatest when the temperature is the highest of all five trials. In contrast, the number of bird observations is greatest when temperature is the lowest of all five trials, reaching -7°C.

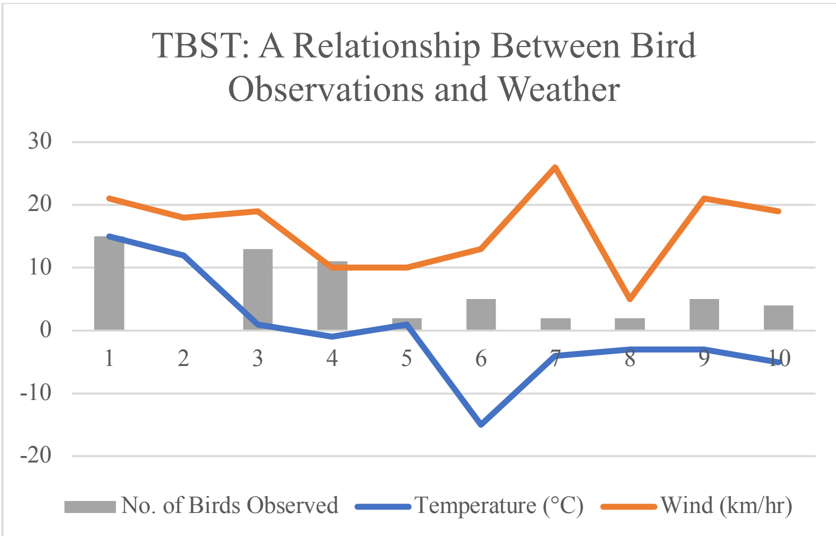


Figure 9. Relationship between weather and bird observations at the Thunder Bay Spacing Trials

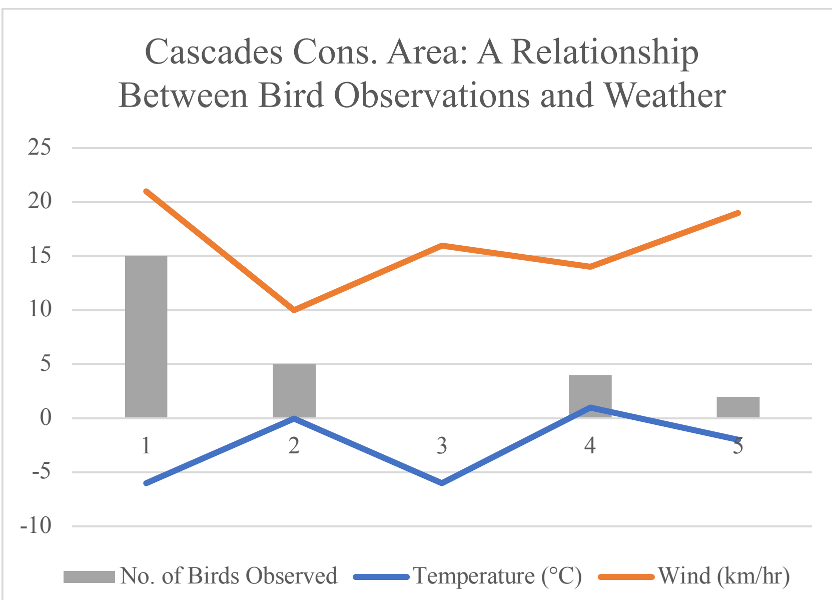


Figure 10. Relationship between weather and bird observations at Cascades Conservation Area

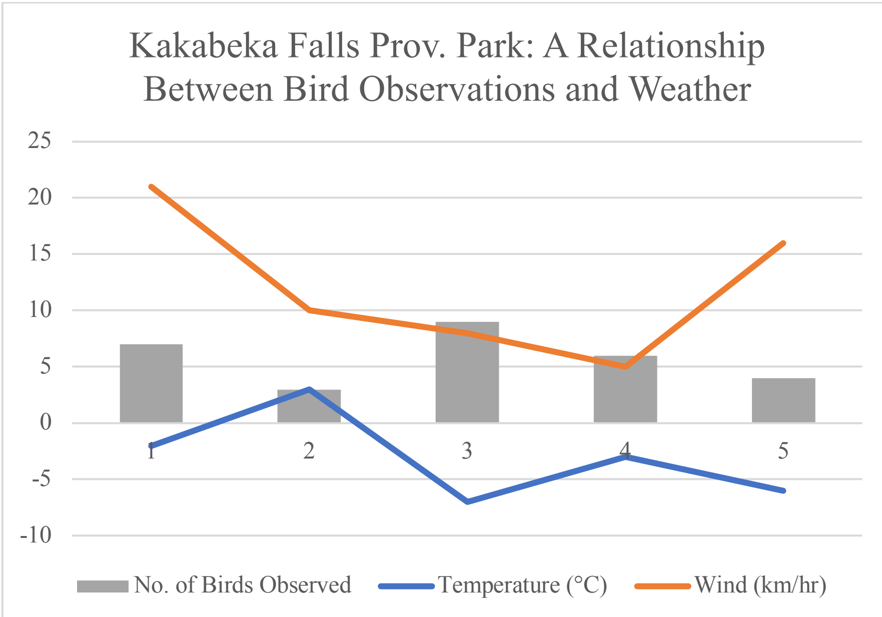


Figure 11. Relationship between weather and bird observations at Kakabeka Falls Provincial park

Cascades Conservation Area (CCA) had the greatest tree diameter of all three sites averaging to 26.6 cm (Figure 12). Thunder Bay Spacing Trial had the second greatest average diameter of 23.2 cm, and Kakabeka Falls Provincial Park had an average diameter of 18.8 cm of all stems sampled.

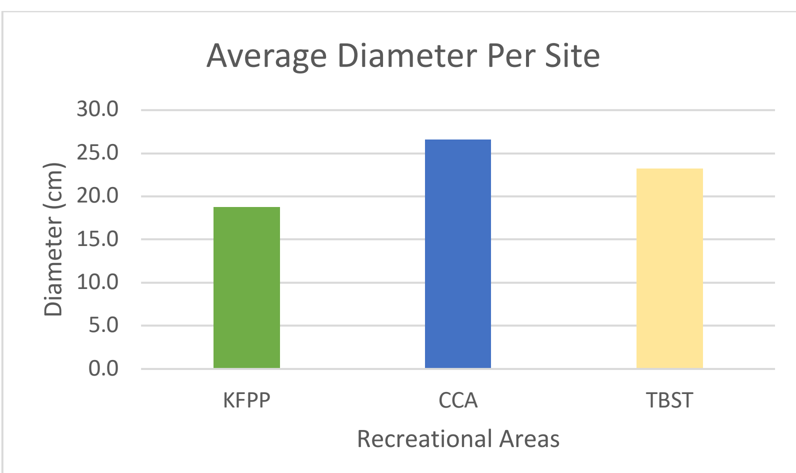


Figure 12. Average diameter of trees sampled at Kakabeka Falls Provincial Park (KFPP), Cascades Conservation Area (CCA) and Thunder Bay Spacing Trial (TBST).

Of the ten trials within the homogeneous forest (Thunder Bay Spacing Trial site), there were 59 individuals observed, surpassing the 54 individuals observed at over the ten trials at the heterogeneous forests (Cascades Conservation Area and Kakabeka Falls Provincial Park) (Figure 13).

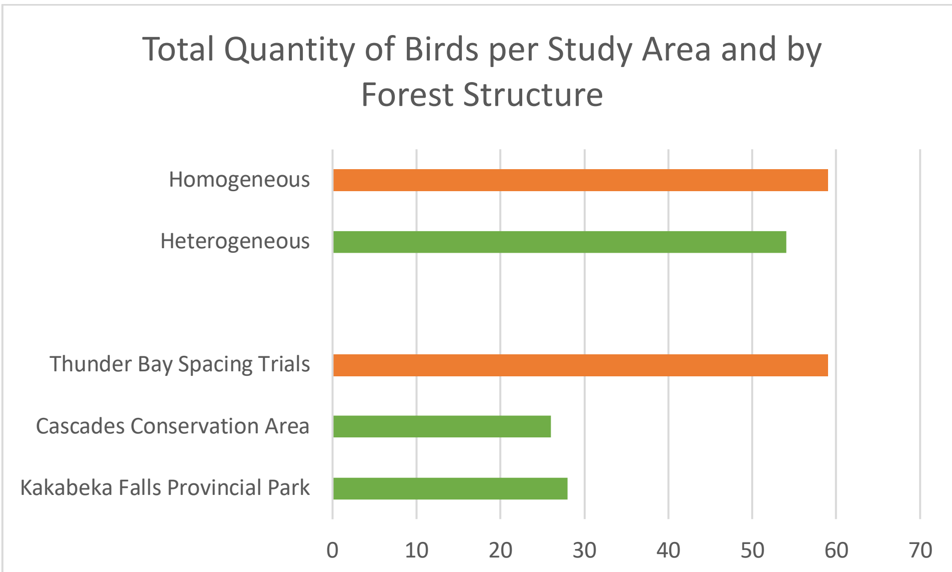


Figure 13. Total quantity of birds observed per study area and by forest structure

The Thunder Bay Spacing Trial had the greatest diversity of species with a total of 12 species observed over the ten trials (figure 14). Similarly, Kakabeka Falls Provincial Park had the second greatest diversity of species with 11 species observed in total over only 5 trials. Cascades Conservation Area had the least number of species across five trials, of all three sites, with 4 different species observed in total.

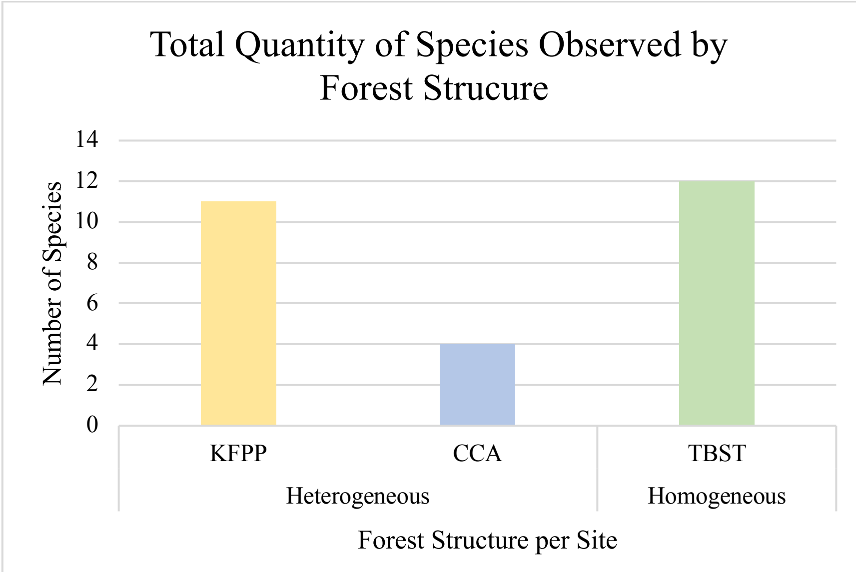
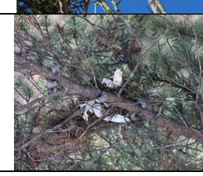


Figure 14. Total number of bird species observed at each site

At the Thunder Bay Spacing Trial site, there were numerous red squirrels, chipmunks, and dead animal remains suggesting that there is a variety of wildlife in the area (Table 4). There were various man-made bird houses around the property. At Cascades Conservation Area, there were a variety of signs of wildlife/avifauna presence; cavities in trees and holes bored into tree stems. Additionally, off of a main trail, there was a bird feeder with an abundance of sunflower seeds. Kakabeka Falls Provincial Park also had many red squirrels and signs of birds nesting in the area, around the site.

Table 4. Examples of observations and photograph evidence. Photographs by Johns (2017/2018).

SITE	SIGN	EVIDENCE
THUNDER BAY SPACING TRIAL	Other wildlife; red squirrel(s), animal remains	
	Man-made bird houses	
CASCADES CONSERVATION AREA	Holes bored into tree; cavity tree	
	Bird feeder with sunflower seeds	
KAKABEKA FALLS PROVINCIAL PARK	Other wildlife; red squirrel(s)	
	Nest(s)	

DISCUSSION

Throughout the course of this study, many variables were assumed to have an impact on the availability of birds in the three recreational areas in focus: Thunder Bay Spacing Trial, Cascades Conservation Area and Kakabeka Falls Provincial Park. The premise of the study was to assess the effects of recreational forest areas on avifauna by studying the degree of forest management disturbance, anthropogenic disturbance, the structure of each forest and other variables that may affect the availability of a species on site, like habitat preferences and bird behaviour. Due to the nature of field work, the effects of weather also needed to be considered. There were many limitations and complications with a study of this nature, and these reasons are discussed below.

Weather

As all life forms are affected by atmospheric processes, the effect of weather on bird activity and probability of observation needed to be explored in this study (Elkins 1983). Flying and locomotion requires energy, and unless the individual is expecting to reap benefit from the travel, equal to or greater than the energy spent, the bird may remain motionless deep within the forest to prevent heat and energy loss (Elkins 1983). Birds that are faced with extreme temperatures expend more energy and are required to conserve more (Renner et al 2012). This would reduce the probability of being observed significantly. Additionally, aerial feeders are more significantly impacted by changes in temperature and air movement, inclining certain species to remain active more so than others (Elkins 1983).

For each trial, two components, wind speed and temperature, were recorded for an estimate of weather (Table 2). Based on the biology and behaviour of birds, the results should show a steady decline in bird observations throughout the data records; as temperature declines, birds would not be as active as they would in warmer temperatures. However, this relationship between birds and weather is not entirely justified from the findings of this study. For example, regarding the Thunder Bay Spacing Trial site data shown in figure 9, there is no consistent pattern that suggests greater wind speeds or lower temperatures limit the activity of avifauna; in trial 2, there were 0 birds observed, although temperature reached 12°C whereas the temperature in trial 6 was -15°C, but more individuals were observed.

Thus, the results shown in figures 9, 10 and 11 make it difficult to solidify the relationship between bird activity and weather. From the Thunder Bay Spacing Trial results, it appears that as temperatures decreased, there was a general, but slow, decline in the number of bird observations. The results of the Trial within Cascades Conservation Area (see figure 10.) did not illustrate an obvious correlation of bird activity and weather, as Trial 1 reached the greatest wind speeds and the lowest temperature but had the greatest number of bird observations of all five Trial. In regard to Kakabeka Falls Provincial Park, the number of bird observations did not exceed 10 throughout all five trials. During Trial 2, the temperature was the highest, but held the least number of bird observations, suggesting that temperature is not as influential as it was expected to be.

Another variable that must be considered when interpreting the results from this study is food availability. During winter months, birds face a reduced supply of food quality and quantity as arthropod populations are limited or unavailable (Renner et al 2012). Also, snow cover and shorter days limit the available opportunity for forage (Renner et al 2012).

For instance, a study assessing food preferences in winter bird communities in Germany, from November to April, showed that snow cover affects the amount of activity at food stations, and extremely low temperatures increased activity around the food stations (Renner et al 2012). At Cascades Conservation Area, trial 1 held the greatest observations, but the majority of the birds were observed congregated at a bird feeder, where there was an abundance of sunflower seeds available. Presence of a food source (natural or human-made) is a possible clause why birds may or may not be observed in separate areas of the same location. Furthermore, if the area with the bird feeder and the individuals was not located, this would have decreased the number of bird observations in that day significantly, and further altered the results from Cascades Conservation Area.

Birds will choose habitat based on availability and quality of food, in varying weather conditions (Renner et al 2012). From this information, it can be deduced that the Thunder Bay Spacing Trial site, a forest homogeneous in structure, might have a greater availability and/or quality of food in inclement weather, than the two heterogeneous forests (Cascades Conservation Area and Kakabeka Falls Provincial Park) combined (Figure 13). As the majority of birds observed at Cascades Conservation Area were located in close proximity to the bird feeder, and little were observed elsewhere, it may be fair to assume the forest from this site offers limited natural forage for boreal forest birds.

Forest Management Disturbance

Although the main purpose of provincial parks, nature reserves or conservation areas is to inhibit loss of biodiversity in an ecosystem while encouraging public use, the degree of management in recreational areas may influence the availability of bird species who prefer natural forest (Versluijs et al 2017). Many environments face declines in biodiversity as a result of human-induced habitat loss, increased fragmentation as well as homogenisation of forest stands at a multi-scale level. With a higher intensity of management in a forest, the vertical structure and forest layers may be compromised, which may reduce the amount of resources and/or habitat for various forest-dwelling species.

The difference in forest structure and management of Thunder Bay Spacing Trial to the two other sites, needed to be acknowledged. Avifauna and vegetation structure have a strong relationship with one another, and changes in forest structure can significantly impact those with a narrow niche (Woodcock et al 1997). It has been observed that the presence of untreated forest patches in between conifer release treatments offered considerable habitat for songbird populations and contributed to maintaining biodiversity in the area. The Thunder

Bay Spacing Trial site had a parallel structure; segments of highly managed, homogeneous forest surrounded by fragments of undisturbed and untreated natural forest. Since the Thunder Bay Spacing Trial is observed to have the highest bird count of all three sites, it is possible to assume that the patches of non-homogeneous forest throughout the plantation offered refuge and habitat for various bird species.

There is a clearly supported relationship between richness of ground vegetation and presence of avifauna. Birds often seek cover or find nesting material and forage within the lower shrub layer (Woodcock et al 1997). Because of the higher degree of management that is associated with a plantation, it is logical to believe that the Thunder Bay Spacing Trial site would have less individuals occupying the area in total, opposed to the natural and lightly disturbed forests of Cascades Conservation Area and Kakabeka Falls Provincial Park. Plantations are generally more homogeneous in structure, resulting in a lesser diversity of woody species, and the stems are often planted at regular spacing and are even in age (Martinez-Jauregui et al. 2016). Logically, one could assume that fewer bird species would occupy the Spacing Trial site. In contrast to predictions, the Spacing Trial location displayed the greatest diversity of bird species of all three sites (Figure 14). Therefore, opposite to literary evidence, the Spacing Trial seemed to have offered adequate habitat for bird species, regardless of the difference in condition or richness of the lower forest layers.

Forest Structure

To assess the impacts recreational forest area has on avifauna habitat, the composition of the recreational forest must be considered.

For this study, components of forest structure used to gain insight on each forest include density and basal area of the forest, species composition, diameter of stems and other observable characteristics of the forest.

Two obvious differences between the sites are the heterogeneous composition of Cascades Conservation Area and Kakabeka Falls Provincial Park, and the homogeneous structure of the Thunder Bay Spacing Trial. The stems in Cascades Conservation Area as well as Kakabeka Falls Provincial park were mixed in species and varied in age, height, and diameter. Whereas the Thunder Bay Spacing Trial has a series of stands generally uniform in species, age, height and diameter. To ignore the structure of the recreational forest would allow a larger margin for inaccuracy in making conclusions about each site, as all three sites vary significantly.

Four of the plots performed in the Thunder Bay Spacing Trial site were located within a planted stand. The final plot was taken in the mixedwood forest segregating the uniform stands. From the results, it is apparent that the Spacing Trial is majorly coniferous in species composition, aside from the hardwood-dominated mixedwood patches throughout the site. All of the homogeneous stands vary in spacing; 2.7 metre, 1.8 metre, 3.6 metre, etc. Density refers to the number of stems per hectare and varies as tree spacing changes. The variety of density within the Spacing Trial site allows for an appeal to various different species with different habitat preferences. For example, the Great Horned owl (*Bubo virginianus*) was found perched on a branch within the 3.6 metre-spaced red pine (*Pinus resinosa*) stand; the clear view of the ground and the ability to fly in between trees with ease (having a vast wingspan) might offer suitable hunting habitat for this species. In contrast, the spruce grouse (*Falcipennis canadensis*) was spotted in the mixedwood forest adjacent to the planted stands, where the downed woody debris and herbaceous vegetation that is associated with the unmanaged forest patch may have offered cover and protection when threatened.

In Kakabeka Falls Provincial Park, trembling aspen appears to be the dominant species of all five plots. The hardwood dominated forest differs from the composition of the Thunder Bay Spacing Trial site significantly. However, the diversity of bird species recorded on site fell just under the diversity of species at the Spacing Trial site, with half the number of visits (Kakabeka Falls Prov. Park = 5 visits, Thunder Bay Spacing Trial = 10 visits; figure 14). This data suggests that the deciduous component might appeal to a variety of species, over a conifer-dominated stand. When deciduous leaves are shed as cooler months approach, this decreases the cover a canopy provides with all if its foliage. A prediction that birds might occupy softwood-dominated stands more in the winter (for cover from harsh temperature and precipitation) was suggested. However, there does not appear to be an obvious pattern of individuals or species preferentially occupying coniferous stands over hardwood-dominated forest in inclement weather, according to the results of this study.

The forest of Cascades Conservation Area was found to have numerous large-diameter trees (Figure 12), with a minor coniferous component. This site had the lowest density of stems per hectare of all three sites, and also had the least species observed on site (Figure 14). There are two explanations behind these results: Firstly, density of stems can be attributed to habitat selection depending on species, and secondly, available energy may be attributed to the results found from this study. For instance, a study performed in Finland by Honkanen and colleagues assessed the relationship of energy, area and habitat heterogeneity on species richness and found that energy was the main factor in determining species richness of boreal forest birds (2009). From this information, it could be assumed that there are limited energy sources found within the forest of Cascades Conservation Area, in contrast to the other two sites.

The average density of stems per hectare of all five plots per site is highest at the Thunder Bay Spacing Trial location. Kakabeka Falls Provincial Park falls second, and Cascades Conservation Area has the lowest density of all three sites. The species composition of all three sites vary, but the heterogeneous forests (Cascades and Kakabeka) are hardwood-dominated (white birch and trembling aspen), whereas the homogeneous forest (Thunder Bay Spacing Trial) is majorly coniferous. This is important to identify as some forest-dwelling birds show a strong preference based on tree composition. For example, ruffed grouse (*Bonasa umbellus*) is majorly associated with forests that have a high percentage of aspen, and other hardwood species. This preference was apparent as the ruffed grouse observed in this study was found at Kakabeka Falls Provincial Park, where there is a significant aspen component within the forest.

Bird Presence

When grouped by forest type, the heterogeneous forest and homogeneous forest do not differ dramatically in presence of individuals. However, Thunder Bay Spacing Trial (the homogeneous forest) had the greatest number of individuals over the 10 total Trial.

Many bird species were repeated across all three sites, although there were various species, like the bank swallow (*Riparia riparia*), that would be extremely unlikely to observe in any of locations except for Kakabeka Falls Provincial Park. The presence of species observed at each site were not always expected but understood. For instance, the house sparrow (*Passer domesticus*) was observed at Thunder Bay Spacing Trial and Cascades Conservation Area. This pattern is likely a result of the urbanization adjacent to these areas, as house sparrows are highly adapted to living in urban environments and use this to their advantage (Mayntz 2017). Species like the boreal chickadee, however, were not expected to be seen, as they are a quieter and more elusive than the black-capped chickadee. Although, these individuals were almost never spotted flying around, but hidden within tree branches. On the other hand, the black-capped chickadee was easily the most observed species of all three sites combined. Because of their suitability to a variety of forest habitats, it is reasonable why this species was most commonly observed.

Bird Species Diversity

In terms of segregating the sites by forest structure, the 10 total Trial of the heterogeneous forests combined have greater diversity than the 10 Trial at Thunder Bay Spacing Trial – the homogeneous forest (Figure 14). Evaluating the sites alone, regardless of forest structure, Kakabeka Falls had the greatest diversity of birds for the number of Trial. The Spacing Trial had two times the number of visits that Kakabeka Falls had, but the total species recorded only differs by one. It is understandable that Kakabeka Falls Provincial Park would have the greatest diversity of birds observed within, as the forest is complex and more remote than the other two sites. For instance, Thunder Bay Spacing Trial is in close proximity to housing and busy traffic ways, Cascades is located within the city of Thunder Bay, but Kakabeka is a vast area, less susceptible to anthropogenic disturbance. The tree species composition is extensive, although hardwood-dominated, and various softwoods and hardwood species are present. The greater diversity of tree species expands potential habitat for a variety of avifauna. There was a substantial diversity of species at Thunder Bay Spacing Trial as well, however, the two cannot accurately be compared as the number of Trial is greater at the Spacing Trial site. Cascades Conservation Area seems to have the least bird species diversity of all three sites. The lack of canopy and tree species might be responsible for the lack in diversity within the Cascades Conservation Area forest.

LIMITATIONS OF THE STUDY

Observer Error/Bias

Over the course of this study, it became evident that there were many variables that had potential to impact results, aside from the those identified and explored. With the short period of field work, and limited tools and equipment, greater potential for error was introduced.

As this study did not involve any song meters, trail cameras, mist nets, or any other physical technology, all information was gathered via sight and sound observation. Firstly, this is difficult as observer error and observer bias may come into play. For instance, identification via sight or sound is not always 100% guaranteed, especially when the evidence is based on one individual's observation. To compensate for this type of error, photos were taken whenever possible to solidify identification. Secondly, when field work is dependent on a single individual, preference of visit times or availability for data collection might be influenced by other factors like weather conditions, for example.

Although all three sites were recreational areas and they all included a presence of a water body and an extensive trail system throughout the area, the characteristics of the site might be too influential to make deductions on 'recreational areas' as a whole. Many of the qualities of the site differed – like forest structure and size, but something that was hard to account for was anthropogenic disturbance. Yes, it was assumed that all three areas held social value and were frequently visited by the public, but degree of human disturbance might influence availability of birds significantly and is hard to measure. Additionally, location and surrounding features might influence bird activity in the area, or perhaps deter certain species more than others, as disturbance from recreational trails has been linked to decreasing biodiversity within an area (Thompson 2015). For instance, the Spacing Trial often has trucks, belonging to the MNRF, that frequently drive throughout the wide "trails" of the Spacing Trial site, contributing to anthropogenic noise and disturbance. At Kakabeka Falls Provincial Park, people ride snowmobiles throughout the trail system, increasing noise levels significantly. Similar to all of the sites, Cascades Conservation Area is dog-friendly, and any individuals may walk their dogs off-leash and allow them to veer off trail into the woody areas. Many of these ideas are hard to account for and may seem insignificant but might influence bird availability in each area. The additional observations that were deemed significant throughout the Trial were recorded (Table 4). At the Thunder Bay Spacing Trial site, there was an abundance of red squirrels, hunted grouse remains and man-made bird houses scattered throughout the property. These observations suggest that, firstly, there is an abundance of wildlife other than avifauna existing in or around the site, which suggests that the Spacing Trial might offer adequate habitat for a variety of species. Secondly, the man-made bird houses introduce another idea of assisted or artificial habitat and encourage birds to reside in the area, which might give an inaccurate representation of the quality of the site itself. At Cascades Conservation Area, there were obvious signs of woodpeckers, and other cavity-nesting animals. Cascades has a variety of large-diameter, old or decaying stems which offer forage and habitat for many species. At the Cascades Conservation Area site, there was a bird feeder just off of the trail, which encourages bird activity within the site, around the feeder. As this human-implemented object assists the site in providing adequate energy sources, it gives a false representation of the use of the forest by avifauna. Kakabeka Falls Provincial Park also showed signs of other small mammals, and obvious signs of use by birds (ie. nests in trees). This additional information was important because it may be responsible or correlated to the presence of avifauna on a site.

The Nature Of Birds

Another major complication that was ignored in this study was the behaviour and nature of birds. Birds are designed to travel great distances in short periods of time. As a result, birds are frequently moving and often do not remain stationary for long periods of time, unless to conserve energy. This makes avifauna hard to identify and increases the potential for replication in a study. For instance, a single black-capped chickadee could be perceived as multiple individuals if it were to move around to different locations, and the individual bird could be recorded numerous times, suggesting a greater abundance of birds at a site, when this may not be the case.

Generally, birds are elusive in nature and some, like the boreal chickadee (*Poecile hudsonica*), are quite inconspicuous (Foote et al 2010). Without a mark-recapture approach, it is extremely difficult to distinguish different individuals of the same species or observe their presence at all.

Additionally, many birds have adapted well to changes in environment (Elkins 1983). For example, the house sparrow thrives alongside man, and has adapted well to urban areas, as it builds nests in buildings and other structure (Mayntz 2017). Seeing a house sparrow on site is not necessarily an indication of high quality habitat. It was identified that birds have an ability to adapt and their presence is not always attributed to site quality.

That being said, many species that were deemed sensitive to disturbance were observed in this study. The Thunder Bay Spacing Trial and Kakabeka Falls Provincial Park had the greatest number of species in comparison to Cascades Conservation Area. From this information, it is possible to assume that Thunder Bay Spacing Trial and Kakabeka Falls Provincial Park have success in maintaining biodiversity. It was not surprising to see certain species like blue jay, chipping sparrow, and hairy woodpecker, as these species are well-adapted to disturbances. Assuming the same protocol for observing all avian species seems to give a narrow perspective on the total bird population in an area, as all species are different in their behaviour, preferences and habitat requirements.

Field Work Improvements

There are various components to field work that must be acknowledged. In this study, ~2 hours were spent for observations each trial session, for 5-10 Trial. The field work commenced October 13th, 2017 and ended March 29th, 2018. Five Trial were performed at Kakabeka Falls Provincial Park, five Trial at

Cascades Conservation Area and ten Trial were performed at the Thunder Bay Spacing Trial.

There are numerous improvements that could be made to the field data collection component to this study. For instance, the length of study or number of replications in the study are not adequate enough, nor the duration of each trial, to make confident deductions about habitat and bird availability, or bird availability and weather. Some sites were visited more during different seasons, which impacts results significantly; the Spacing Trial was visited first, during warmer temperatures in October (Table 2), and the bird observations during these times contributed tremendously to the total bird count of the site. Also, trial commencement was not consistent, but should have, ideally, remained the same time of day for each trial, as some species might be more active at different times of day.

Having a fourth site (a second plantation) that was as recreationally appreciated as the Spacing Trial site would have been ideal for the credibility of the study. The Spacing Trial was, therefore, visited ten times instead of five, in order to have the same amount of Trial in each forest type (heterogeneous and homogeneous). Having a fourth site would have increased the opportunity for more data and would have gained additional insight on the effect of recreational plantations on avifauna. Unfortunately, this was not available.

Another modification that could have been added to the study would be a ‘control’ forest – a natural, undisturbed and unmanaged forest that could be visited just as much as the other sites. Having a control forest to compare to would allow for conclusions to be made about the impact of recreational areas on avifauna in relation to a natural forest area. For this study, presence of birds was used to assess whether a site had detrimental impacts on avian species. This approach could have been more reliable.

Therefore, more invasive or active methods, a greater length of study, more frequent and longer visits, a consistent time of day, a fourth site, and a control forest would be essential additions to this study if it were to be repeated once more.

Assessing Habitat

Ultimately, it is hard to assess habitat as a whole, as there are so many components and influential factors associated with it and many species differ in habitat preferences. For instance, perhaps density could be isolated as the variable to be compared to bird availability. There are numerous factors to take into account when performing a study of this nature but maintaining as many constant variables would improve the credibility of results immensely. This idea is supported by Robert S. Rempel when he states, “there is no a priori justification to use stand characteristics as the sole means of characterizing a songbird’s habitat needs” (2007). He also says that “Stand-scale analyses ignore the influence of adjacent stand conditions and the landscape (matrix) content in which the stand lies, including the influence of local and landscape-scale homogeneity and heterogeneity on habitat quality” (Rempel 2017).

CONCLUSION

The objectives of this study were to (1) examine the presence and diversity of forest-dwelling birds in three different recreational areas (2) identify if there is a relationship between bird activity and weather and (3) examine the structural composition of the three recreational areas studied and how it may affect forest-dwelling birds. After retrieving the results, it is evident that there is a presence of forest birds at all three sites, but some more than others. It was identified that there were a variety of factors that may have contributed to these results including: weather, time, recreation attraction, season, duration, frequency, observer error/bias and location. It was difficult to identify a relationship between bird activity and weather, as there wasn't an obvious pattern generated from the results of this short-term study. Lastly, forest structure is most likely attributed to presence of birds, however, the preconceived idea that more homogeneous stands would deter avifauna did not appear to be truthful. The use of conifer-dominated stands in winter, however, was apparent. This study aimed to evaluate habitat in recreational areas to gain insight for forest managers of the effects of forest management on avifauna. Non-invasive methods of data were used to achieve results from this study, but many errors were presented during this time. Ultimately, it appears that forest birds are able to adapt to a variety of environments and, from this study, it seems that none of these environments were not managed intensely enough to deter forest-dwelling birds entirely.

LITERATURE CITED

Audubon. n.d. Hairy woodpecker (*Picoides villosus*). National Audubon Society. Retrieved from: https://www.audubon.org/field-guide/bird/hairy-woodpecker

Bird Web. n.d. Song Sparrow (*Melospiza melodia*). Seattle Audubon Society. Retrieved from: http://www.birdweb.org/birdweb/bird/song_sparrow

Boreal Songbird Initiative (BSI). 2015. Boreal chickadee (*Poecile hudsonica*). Retrieved from: https://www.borealbirds.org/bird/boreal-chickadee.

Cadman, M.D., D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Courturier. 2007. Atlas of the Breeding Birds of Ontario, 2001-2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto, Ontario. 706 pp.

Community Economic Development Commission, Thunder Bay. n.d. The Boreal Forest. Retrieved from: http://www.thunderbay.ca/Assets/CEDC/docs/Forestry_Sector.pdf

Cornell Lab of Ornithology. Great horned owl, life history. The Cornell Lab of Ornithology, Cornell University. Retrieved from: https://www.allaboutbirds.org/guide/Great_Horned_Owl/lifehistory

Cornell Lab of Ornithology. White-breasted nuthatch. The Cornell Lab of Ornithology, Cornell University. Retrieved from: https://www.allaboutbirds.org/guide/White-breasted_Nuthatch/id

DNR. 2009. Managing your woodlands for ruffed grouse. State of Minnesota Department of Natural Resources. Retrieved from: http://files.dnr.state.mn.us/assistance/backyard/privatelandhabitat/managing_woodland_ruffed_grouse_flat.pdf

Elkins, N. 1983. Weather and Bird Behaviour. T & A D Poyser Ltd., Staffordshire, England. 239 pp.

Foote, J. R., D. J. Mennill, L. M. Ratcliffe, and S. M. Smith. 2010. Black-capped Chickadee (*Poecile atricapillus*), version 2.0. In the Birds of North America (A. F. Poole, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bna.39. Retrieved from: https://birdsna.org/Species-Account/bna/species/039/articles/introduction

Ghalambor, C. K. and T. E. Martin. 1999. Red-breasted Nuthatch (*Sitta canadensis*), version 2.0. In the Birds of North America (A. F. Poole and

F. B. Gill, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bna.459. Retrieved from: https://birdsna.org/Species-Account/bna/species/459/articles/introduction

Goodwin, D. 1978. Birds of Man's World. British Museum (Natural History), Cornell University Press., Ithaca, New York. 183 pp.

Heagy, A.E. and J.D. McCracken. 2004. Monitoring the state of Ontario's migratory landbirds. Bird Studies Canada. Retrieved from: http://www.bsc-eoc.org/download/StateofONbirds.pdf

Heyman, E. 2010. Clearance of understory in urban woodlands: Assessing impact on bird abundance and diversity. *Forest Ecology and Management*, 260, 125-131. doi:10.1016/j.foreco.2010.04.011

Honkanen, M., J-M. Roberge, A. Rajasarkka, and M. Monkkonen. 2009. Disentangling the effects of area, energy and habitat heterogeneity on boreal forest bird species richness in protected areas. Blackwell Publishing Ltd. Global Ecology and Biogeography. 61-71 pp.

Ketzler, L. P., C.E. Comer, and D.J. Twedt. 2017. Nocturnal insect availability in bottomland hardwood forests managed for wildlife in the Mississippi Alluvial Valley. *Forest Ecology and Management* 391, 127-134. doi:10.1016/j.foreco.2017.02.009

Lakehead Region Conservation Authority (LRCA). n.d. Cascades. Lakehead Region Conservation Authority. Retrieved from: http://www.lakeheadca.com/conservation/conservation-areas/cascades

Lepage, D. 2017. Bird checklists of the World, Thunder Bay., Avibase - the world bird database. Bird Studies Canada.

Martinez-Jauregui, M., M. Diaz, D. Sanchez de Ron, and M. Solino. 2016. Plantation of natural recovery? Relative contribution of planted and natural pine forests to the maintenance of regional bird diversity along ecological gradients in Southern Europe. *Forest Ecology and Management* 388, 183-192.

Mayntz, M. 2017. House sparrow (*Passer domesticus*). The Spruce. Retrieved from: https://www.thespruce.com/house-sparrow-387273

McClain, K. M., D. M. Morris, S. C. Hills, and L. J. Buse. 1994. The effects of initial spacing on growth and crown development for planted northern conifers: 37-year results. Forestry Chronicle 70(2): 174-177.

Middleton, A. L. 1998. Chipping Sparrow (*Spizella passerina*), version 2.0. In the Birds of North America (A. F. Poole and F. B. Gill, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bna.334. Retrieved from: https://birdsna.org/Species-Account/bna/species/chispa/introduction

OMNRF. 1987. Bald Eagle habitat management guidelines. Ontario Ministry of Natural Resources. Retrieved from: https://dr6j45jk9xcmk.cloudfront.net/documents/2789/guide-bald-eagle.pdf

OMNRF. 2017. Best management practices for the protection, creation and maintenance of bank swallow habitat in Ontario. Ontario Ministry of Natural Resources and Forestry. Retrieved from: https://www.ossga.com/multimedia/2017-03-27-100504-95129/bansbmpenpdffinalv.1.117mar17.pdf

Ontario Parks. 2001. Kakabeka Falls park management plan. Government of Ontario. Retrieved from: http://files.ontario.ca/environment-and-energy/parks-and-protected-areas/mnr_bpp0146.pdf

Ontario Parks. 2014. Kakabeka Falls trail map. Government of Ontario. Retrieved from: http://www.superiortrails.com/2014images/kakabekamap.jpg

Ontario Parks. n.d. Ontario parks: 125 years. Government of Ontario. Retrieved from: http://www.ontarioparks.com/op125.

Ontario, 2017. 37 pp. Retrieved from: https://www.ossga.com/multimedia/2017-03-27-100504-95129/bansbmpenpdffinalv.1.117mar17.pdf

Pearce, J., M. L. Mallory, and K. Metz. 2015. Common Merganser (*Mergus merganser*), version 2.0. In the Birds of North America (A. F. Poole, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bna.442. Retrieved from: https://birdsna.org/Species-Account/bna/species/commer/introduction

Ontario Ministry of Natural Resources and Forestry (OMNRF). 2017. Best management practices for the protection, creation and maintenance of bank swallow habitat in Ontario. Queen's Printer for Ontario, 2017. 37 pp. Retrieved from: https://www.ossga.com/multimedia/2017-03-27-100504-95129/bansbmpenpdffinalv.1.117mar17.pdf

Rempel, R. S. 2007. Selecting focal songbird species for biodiversity conservation assessment: response to forest cover amount and configuration. Avian Conservation and Ecology. Center for Northern Forest Research, Ontario Ministry of Natural Resources.

Renner S. C., S. Baur, A. Possler. J. Winkler, E.K.V. Kalko, et al. 2012. Food Preferences of Winter Bird Communities in Different Forest Types. PLoS ONE 7(12): e53121. doi:10.1371/journal.pone.0053121

Schroeder, R. L. 1982. Habitat suitability index models: Downy woodpecker. U.S. Dept. Int., Fish Wildlife Service. FWS/OBS-821l0.38. 10 pp. Retrieved from: https://www.nwrc.usgs.gov/wdb/pub/hsi/hsi-038.pdf

St-Laurent, M., C. Dussault, J. Ferron, and R. Gagnon. 2009. Dissecting habitat loss and fragmentation effects following logging in boreal forest: Conservation perspectives from landscape simulations. *Biological Conservation* 142(10), 2240-2249. doi:10.1016/j.biocon.2009.04.025

Styring, A. R., R. Ragai, J. Unggang, R. Stuebing, P.A. Hosner, and F.H. Sheldon. 2011. Bird community assembly in Bornean industrial tree plantations: Effects of forest age and structure. *Forest Ecology and Management* 261(3), 531-544. doi:10.1016/j.foreco.2010.11.003

Thompson, B. 2015. Recreational trails reduce the density of ground-dwelling birds in protected areas. Environmental Management. Springer Science + Business Media. 1181-1190 pp.

Tremblay, J. A., R. D. Dixon, V. A. Saab, P. Pyle, and M. A. Patten. 2016. Black-backed Woodpecker (*Picoides arcticus*), version 3.0. In the Birds of North America (P. G. Rodewald, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bna.bkbwoo.03

Versluijs, M., S. Eggers, J. Hjältén, T. Löfroth, and J. Roberge. 2017. Ecological restoration in boreal forest modifies the structure of bird assemblages. *Forest Ecology and Management* 401, 75-88. doi:10.1016/j.foreco.2017.06.055

Wisconsin Department of Natural Resources (WDNR). 2013. Wisconsin Spruce Grouse Species Guidance. Bureau of Natural Heritage Conservation, Wisconsin Department of Natural Resources, Madison, Wisconsin. Retrieved from: https://dnr.wi.gov/files/PDF/pubs/er/ER0696.pdf

Woodcock, J., J.P. Ryder, R.A. Lautenschlager, and W.F. Bell. 1997. Indirect effects of conifer release alternatives on songbird populations in northwestern Ontario. *Forestry Chronicle* 73(1), 107-112. doi:10.5558/tfc73107-1

APPENDICES

Table A *1*. Diameter, species composition, basal area and density of each plot for the Thunder Bay Spacing Trial site

Thunder Bay Spacing Trials									
Plot 1 (2.7 m)		Plot 2 (1.8 m)		Plot 3 (3.6 m)		Plot 4		Plot 5	
Species	DBH (cm)	Species	DBH (cm)	Species	DBH (cm)	Species	DBH (cm)	Species	DBH (cm)
Pinus resinosa	/	*Picea mariana*	/	*Pinus resinosa*	31	*Pinus banksiana*	17.3	*Populus tremuloides*	21.3
'	/	'	/	*Pinus resinosa*	27.5	*Pinus banksiana*	16.5	*Populus tremuloides*	24.0
'	/	'	/	*Pinus resinosa*	23.4	*Pinus banksiana*	23	*Populus tremuloides*	20.5
'	/	'	/	*Pinus resinosa*	25.6	*Pinus banksiana*	19.5	*Populus tremuloides*	18.3
'	/	'	/	*Pinus resinosa*	20.0	*Pinus banksiana*	16.7	*Populus tremuloides*	26.0
'	/	'	/	*Pinus resinosa*	19.7	*Pinus banksiana*	18.6	*Betula papyrifera*	14.7
'	/	'	/	*Pinus resinosa*	21.5	*Pinus banksiana*	21.4	*Betula papyrifera*	17
'	/	'	/	*Pinus resinosa*	30.5				
'	/	'	/	*Pinus resinosa*	31.5				
'	/	'	/	*Pinus resinosa*	29.5				
'	/	'	/						
'	/	'	/						
'	/	'	/						
'	/	'	/						
'	/	'	/						
'	/	'	/						
'	/	'	/						
Average diameter (cm)	27.4	Average diameter (cm)	17.4 cm	Average diameter (cm)	26.02	Average diameter (cm)	19.0	Average diameter (cm)	20.3
Average plot radius (m):	9.7	Average plot radius (m):	6.2	Average plot radius (m):	9.2	Average plot radius (m):	6.7	Average plot radius (m):	7.2
Average plot size (m^2):	294.7	Average plot size (m^2):	118.9	Average plot size (m^2):	265.8	Average plot size (m^2):	141.7	Average plot size (m^2):	161.1
Average plot size (ha):	0.029	Average plot size (ha):	0.012	Average plot size (ha):	0.027	Average plot size (ha):	0.014	Average plot size (ha):	0.016
Basal area/ha (m^2):	73.4	Basal area/ha (m^2):	37.7	Basal area/ha (m^2):	20	Basal area/ha (m^2):	14	Basal area/ha (m^2):	14
Density (stems/ha)	1372	Density (stems/ha)	3086	Density (stems/ha)	412.2	Density (stems/ha)	514.2	Density (stems/ha)	480.6

Table A *2*. Diameter, species composition, basal area and density of each plot for the Thunder Bay Spacing Trial site

Kakabeka Falls Provincial Park									
Plot 1		Plot 2		Plot 3		Plot 4		Plot 5	
Species	DBH (cm)	Species	DBH (cm)	Species	DBH (cm)	Species	DBH (cm)	Species	DBH (cm)
Abies balsamea	21.1	*Abies balsamea*	18.3	*Abies balsamea*	11.0	*Pinus banksiana*	26.0	*Picea glauca*	11.3
Abies balsamea	19.0	*Abies balsamea*	23.0	*Abies balsamea*	14.6	*Pinus banksiana*	29.3	*Picea glauca*	14.0
Abies balsamea	17.0	*Abies balsamea*	17.4	*Populus tremuloides*	25.5	*Pinus banksiana*	15.4	*Picea glauca*	12.1
Abies balsamea	12.4	*Abies balsamea*	12.0	*Populus tremuloides*	22.6	*Pinus banksiana*	21.0	*Pinus strobus*	31.5
Abies balsamea	26.2	*Picea glauca*	17.8	*Populus tremuloides*	22.0	*Pinus banksiana*	24.5	*Pinus strobus*	24.5
Picea glauca	24.0	*Picea glauca*	16.5	*Picea mariana*	18.5	*Picea mariana*	16.6	*Populus tremuloides*	13.1
Picea glauca	23.0	*Populus tremuloides*	17.5	*Picea mariana*	16.0	*Picea mariana*	16.5	*Thuja occidentalis*	11.0
Populus tremuloides	19.6	*Populus tremuloides*	18.0			*Picea mariana*	13.3	*Thuja occidentalis*	12.4
Populus tremuloides	18.5	*Populus tremuloides*	23.5			*Populus tremuloides*	17.5		
Populus tremuloides	22.0	*Populus tremuloides*	21.0						
Populus tremuloides	17.7	*Populus tremuloides*	18.5						
Populus tremuloides	23.3								
Populus tremuloides	16.0								
Populus tremuloides	20.5								
Populus tremuloides	14.0								
Average diameter (cm)	19.6	Average diameter (cm)	18.5	Average diameter (cm)	18.6	Average diameter (cm)	20.0	Average diameter (cm)	16.2
Average plot radius (m):	6.9	Average plot radius (m):	6.5	Average plot radius (m):	6.6	Average plot radius (m):	7.1	Average plot radius (m):	5.7
Average plot size (m^2):	151.1	Average plot size (m^2):	134.4	Average plot size (m^2):	135.8	Average plot size (m^2):	157.2	Average plot size (m^2):	103.5
Average plot size (ha):	0.015	Average plot size (ha):	0.013	Average plot size (ha):	0.014	Average plot size (ha):	0.016	Average plot size (ha):	0.010
Basal area/ha (m^2):	30.0	Basal area/ha (m^2):	22.0	Basal area/ha (m^2):	14.0	Basal area/ha (m^2):	18.0	Basal area/ha (m^2):	16.0
Density (stems/ha)	1126.6	Density (stems/ha)	899	Density (stems/ha)	645.4	Density (stems/ha)	687.9	Density (stems/ha)	1095.8

Table A *3*. Diameter, species composition, basal area and density of each plot for the Thunder Bay Spacing Trial site

Cascades Conservation Area									
Plot 1		Plot 2		Plot 3		Plot 4		Plot 5	
Species	DBH (cm)	Species	DBH (cm)	Species	DBH (cm)	Species	DBH (cm)	Species	DBH (cm)
Betula papyrifera	34.0	*Betula papyrifera*	25.7	*Betula papyrifera*	18.1	*Betula papyrifera*	33.6	*Betula papyrifera*	19.0
Betula papyrifera	30.5	*Betula papyrifera*	28.0	*Betula papyrifera*	24.0	*Betula papyrifera*	23.5	*Betula papyrifera*	23.0
Betula papyrifera	20.7	*Picea glauca*	23.9	*Picea mariana*	24.3	*Betula papyrifera*	26.6	*Betula papyrifera*	21.1
Betula papyrifera	22.0	*Pinus banksiana*	26.8	*Picea mariana*	21.0	*Picea glauca*	19.5	*Betula papyrifera*	20.0
Pinus banksiana	43.5	*Pinus banksiana*	32.1	*Pinus banksiana*	19.0	*Picea mariana*	24.0	*Populus tremuloides*	24.0
Pinus banksiana	50.1	*Pinus banksiana*	23.1	*Pinus banksiana*	23.0	*Pinus banksiana*	18.0	*Populus tremuloides*	26.5
Pinus banksiana	26.6	*Pinus banksiana*	23.0	*Populus tremuloides*	23.4	*Pinus banksiana*	21.3	*Populus tremuloides*	32.6
Pinus banksiana	24.0	*Populus tremuloides*	27.0	*Populus tremuloides*	30.5	*Populus tremuloides*	30.8	*Populus tremuloides*	28.2
Pinus banksiana	23.5	*Populus tremuloides*	32.7	*Populus tremuloides*	28.7	*Populus tremuloides*	32.0	*Populus tremuloides*	25.0
Pinus banksiana	22.5			*Populus tremuloides*	31.3			*Populus tremuloides*	34.5
Pinus banksiana	36.8							*Populus tremuloides*	14.6
Pinus banksiana	36.2								
Populus tremuloides	31.0								
Average diameter (cm)	30.9	Average diameter (cm)	26.9	Average diameter (cm)	24.3	Average diameter (cm)	25.5	Average diameter (cm)	24.4
Average plot radius (m):	10.9	Average plot radius (m):	9.5	Average plot radius (m):	8.6	Average plot radius (m):	9.0	Average plot radius (m):	8.6
Average plot size (m^2):	374.3	Average plot size (m^2):	284.5	Average plot size (m^2):	232.4	Average plot size (m^2):	254.8	Average plot size (m^2):	233.9
Average plot size (ha):	0.0	Average plot size (ha):	0.0	Average plot size (ha):	0.0	Average plot size (ha):	0.0	Average plot size (ha):	0.0
Basal area/ha (m^2):	26.0	Basal area/ha (m^2):	18.0	Basal area/ha (m^2):	20.0	Basal area/ha (m^2):	18.0	Basal area/ha (m^2):	22.0
Density (stems/ha)	426.4	Density (stems/ha)	330.4	Density (stems/ha)	472.3	Density (stems/ha)	402.3	Density (stems/ha)	557.6