

FINAL REPORT

**AVIAN MONITORING STUDIES AT THE BUFFALO RIDGE, MINNESOTA WIND
RESOURCE AREA: RESULTS OF A 4-YEAR STUDY**

Prepared For:

Northern States Power Company
414 Nicollet Mall, 8th Floor
Minneapolis, Minnesota 55401

Prepared By:

Gregory D. Johnson, Wallace P. Erickson, M. Dale Strickland, Maria F. Shepherd and
Douglas A. Shepherd

Western EcoSystems Technology, Inc.
2003 Central Avenue
Cheyenne, Wyoming 82001

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EXECUTIVE SUMMARY

Wind has been used to commercially produce energy in the U.S. since the early 1970's. Recent advances in wind turbine technologies have reduced costs associated with windpower production, improving the economics of wind energy. As a result, wind energy plants have been constructed in 15 states in the U.S. Although generally considered environmentally friendly, an unexpected impact associated with wind energy, especially in California, has been the deaths of birds colliding with turbines and other wind plant features. In comparison to other structures such as TV towers and radio towers, however, overall incidence of bird mortality in wind generation facilities is small. Results of monitoring studies conducted in Europe and California indicate that raptors (birds of prey), passerines (songbirds), shorebirds and waterfowl are the most susceptible to turbine collisions. Several factors, including avian abundance and composition, geographic area, prey abundance and wind plant characteristics, determine the potential for avian mortality.

In 1994, Northern States Power Company (NSP) initiated a windpower development project that may eventually produce 425 megawatts (MW) of electricity. The first phase (P1) was developed by Kenetech Windpower, Inc. (Kenetech) in 1994 and consists of a 25-megawatt (MW) wind plant comprised of 73 turbines on Buffalo Ridge, Minnesota. The second phase (P2) consists of a 107.25 MW wind plant comprised of 143 turbines. This facility was completed by Enron Corporation in 1998, and is the world's largest single wind farm project. The third phase (P3) consists of a 103.5 MW wind plant comprised of 138 turbines. This facility was completed by Enron in 1999.

Results of a biological reconnaissance of the Buffalo Ridge Wind Resource Area (WRA) conducted prior to windpower development indicated that there was relatively low potential for avian mortality to occur on this site because Buffalo Ridge was not in a major waterfowl staging area or migration route, and that passerines usually migrate at altitudes above the turbine blades. Radar studies of nocturnal avian migrants also showed that abundance of migrants was relatively lower on Buffalo Ridge than other areas sampled in west-central and southwestern Minnesota. Results of pilot avian monitoring studies conducted by South Dakota State University in 1994 and 1995 following construction of the first wind plant indicated that avian and bat mortality within the wind development area was relatively low. In 1996, Western EcoSystems Technology (WEST, Inc.) was contracted by Northern States Power Company (NSP) to develop an avian monitoring protocol for the Buffalo Ridge WRA and to implement the protocol beginning with the 1996 field season.

Buffalo Ridge is a 62-mile-long segment of the Bemis Moraine located in Lincoln and Pipestone Counties in southwest Minnesota and Brookings County, South Dakota. Habitats in the study area consist primarily of agricultural crops including corn, soybeans, small grains and hay; pasture; and Conservation Reserve Program (CRP) fields. So far, there are three major phases of wind development within the WRA. In addition to those study sites within the WRA, a permanent reference area not scheduled for windpower development was selected along Buffalo Ridge northwest of the WRA in Brookings County, South Dakota.

The primary goals of this study were to evaluate risk to birds from each phase of development and the cumulative risk to birds from all windpower development in the WRA. The secondary goal was to provide information that can be used to reduce the risk to birds from subsequent developments. This monitoring study used the before/after and control/impact (BACI) design. The design and analysis used a "weight of evidence" approach to assess effects of the project on species of concern.

One hundred meter radius point count surveys were conducted to estimate species composition, relative abundance, habitat use, flight behavior and relative risk during the period 15 March to 15 November, 1996-1999 at turbine locations and at randomly selected stations within the WRA. Raptor and other large bird (RLB) 0.8-km radius point count surveys were conducted at randomly located points throughout the WRA to estimate the same parameters for these birds. Carcass searches were conducted at turbine locations and at randomly selected plots throughout the WRA to estimate number of avian and bat mortalities attributable to wind turbine collisions for the entire Buffalo Ridge WRA, and to relate the mortalities by species to the relative abundance of each species, turbine characteristics, habitat and other parameters to aid in determining relative risk to that species. An estimate of the total number of avian and bat fatalities in each phase of the wind development area was made.

Researchers documented 218 species of birds in the Buffalo Ridge study area during the 4-year study. Six of the species observed are listed as threatened by the State of Minnesota and/or U.S. Fish and Wildlife Service. Observations consisted of six peregrine falcons, 51 bald eagles, three Wilson's phalaropes, 16 loggerhead shrikes, two horned grebes and one common tern. Most of these birds were observed during the spring or fall migration and were likely migrants. Two pairs of loggerhead shrikes were documented breeding in the study area.

During the study, 164 species were identified during sightings of 25,471 groups totaling 70,727 birds while conducting point count surveys on all four study areas on Buffalo Ridge. Avian richness was highest in the summer (1 June - 15 August), followed by spring (15 March - 31 May) and fall (16 August - 15 November), whereas avian abundance was highest in the fall and lowest in the summer. The three most abundant bird groups during the spring period were blackbirds, longspurs, and sparrows. Blackbirds, sparrows and swallows were most abundant in summer, and blackbirds, longspurs, and sparrows were most abundant in fall.

Sixty-two species were identified during sightings of 3,546 groups totaling 20,035 birds while conducting RLB surveys in the Buffalo Ridge study area. Avian richness was highest in the spring, whereas avian abundance was highest in the fall. The three most abundant RLB groups on Buffalo Ridge during the spring were waterfowl, waterbirds, and shorebirds. In summer, the three most abundant groups were raptors, waterbirds, and waterfowl, and in fall, the three most abundant groups were waterbirds, waterfowl and corvids.

Observations were made of 15,247 flying flocks comprised of 55,607 birds during point count surveys on Buffalo Ridge. Mean flight height was lowest for wrens (1.8 m), upland gamebirds (2.3 m) and sparrows (6.0 m). Highest mean flight heights were recorded for waterfowl (46.9 m), waterbirds (44.3 m) and blackbirds (17.2 m). Flight height data were examined separately for the P1 turbines (Turbine A) and P2/P3 turbines (Turbine B) on Buffalo Ridge due to different turbine heights. For Turbine A, 20.1% of flying birds were within the rotor-swept height (19.5-52.5 m), whereas 11.3% were observed flying within the rotor-swept height of Turbine B (26-74 m). Bird groups most often observed flying within the rotor-swept height were waterbirds, waterfowl, longspurs, raptors, and corvids. There were no significant differences in flight height as a function of habitat or presence or absence of turbines.

Observations were made of 3,156 flying flocks comprised of 18,144 birds during RLB surveys on Buffalo Ridge. Mean flight height was highest for waterfowl (73.4 m), followed by waterbirds (36.3

m), raptors (26.6 m), shorebirds (21.5 m) and corvids (13.5 m). Forty-five percent of flying birds were within the rotor-swept height of Turbine A, and 36% were within the rotor-swept height of Turbine B. Bird groups most often observed flying within the rotor-swept height during RLB surveys were shorebirds, waterbirds, raptors and waterfowl. Flight height data collected during daylight hours indicate the larger Turbine B may pose less risk to some groups of birds than the smaller Turbine A.

Turbine exposure indices based on mean abundance adjusted for visibility bias, proportion of daily activity budget spent flying, and proportion of flight heights within the rotor-swept height of turbines were calculated for all species observed during surveys. For point count survey data, species with the highest exposure to turbines, depending on season, were lapland longspur, red-winged blackbird, horned lark, cliff swallow, barn swallow, and European starling. Using data collected during RLB surveys, species with the highest exposure index, depending on season, were mallard, Franklin's gull, Canada goose, and double-crested cormorant. This analysis was based on observations of birds during the daylight period and did not take into consideration flight behavior or abundance of nocturnal migrants. This analysis also does not account for differences among species in their ability to detect and avoid turbines, habitat selection, turbine characteristics, and other factors that may influence exposure to turbines; therefore, actual risk may be higher or lower than predicted by this index.

Based on point count survey data, avian relative use over the entire Buffalo Ridge study area was highest in woodland habitat (1381/km²), followed by wetland (787), pasture (365), hayfields (351), CRP (256) and croplands (184). Relative use of woodland and wetland was significantly higher than cropland and CRP; there were no significant differences in use among CRP, pasture, and hayfields. For larger birds recorded during RLB surveys, highest use occurred in wetlands (76.3/km²), followed by cropfields (10.9), pasture (7.0) and CRP (6.1); however, there were no significant differences in use among habitats. Effects of distance to the nearest wetland and woodland on avian use were modeled using stepwise linear regression. Results of the analysis indicated a significant ($p < 0.05$) relationship between avian use and distance to the nearest wetland for waterfowl, upland gamebirds, sparrows and finches. A significant ($p < 0.05$) relationship between avian use at the plot and distance to the nearest woodland was found for several groups, including doves, woodpeckers, swallows, blackbirds, wrens, corvids, vireos/warbblers, and thrushes.

The BACI analysis of both point count and RLB survey data indicated that use of the wind development areas following construction was lower than expected for several groups and species of birds. Seven of 22 species of grassland breeders showed reduced use near turbines. The area of reduced use occurred primarily in close proximity (i.e., ≤ 100 m) to turbines; however, the area of reduced use was larger for certain avian groups during some seasons. On a large-scale basis (i.e., within the entire WRA), reduced use by birds associated with windpower development appears to be relatively minor and would not likely have any population consequences on a regional level. A positive effect of reduced avian use around turbines would be reduced potential for collision mortality. Lower avian use where turbines are present may be due to avoidance of turbine noise, maintenance activities, and less available habitat due to the presence of maintenance roads and cleared gravel pads surrounding turbines. Another potential factor in the lowered avian use noted at turbine plots is that turbine noise may reduce observer detection rates of birds, especially those that observers detected by sound only.

During the 4-year study, 5,322 fatality searches were conducted on study plots, 2,482 (46.6%) of which were conducted on plots without turbines to estimate reference mortality in the study area, and 2,840 (53.4%) of which were conducted on plots associated with operational turbines. Thirty-one avian fatalities comprised of 15 species were found on reference plots during the study period, and 55 avian fatalities comprised of at least 31 species were found associated with operational wind plant features. Avian fatalities associated with turbines were comprised of 76.4% passerines, 9.1% waterfowl, 5.5% waterbirds, 5.5% upland gamebirds, 1.8% raptors and 1.8% shorebirds.

A total of 184 bat fatalities were found in 1998 and 1999 within the three wind development areas. All bat mortalities were found associated with turbines and appeared turbine-related. Most bats were tree bats, with hoary bat being the most common fatality.

Overall searcher efficiency averaged 38.7%, and mean length of stay for carcasses before being removed or consumed by scavengers was 7.01 days for birds and 10.36 days for bats. Based on the number of turbine-related casualties found per search adjusted for searcher efficiency and scavenger removal rates, total avian mortality in the P1 wind development area was estimated to average 72 per 8-month field season during the 4-year study. The resulting estimated annual mean fatality rate was 0.98 birds per turbine. In the P2 study area, total avian mortality was estimated to be 265 in 1998 and 383 in 1999, for a 2-year average of 2.27 fatalities per turbine. In the P3 wind plant, total avian mortality in 1999 was estimated to be 613, which equates to 4.45 fatalities per turbine.

Total bat mortality in the P1 study area was estimated to be 19 in 1999 (0.26/turbine). In the P2 study area, total bat mortality was estimated to be 231 in 1998 and 277 in 1999, which equates to a 2-year average of 1.78 bats killed per turbine in the P2 wind development area per year. The total bat fatality estimate for the P3 wind plant in 1999 was 282 (2.04/turbine).

For all reference plots combined, mean number of avian fatalities found per study plot per year was 1.10. In the P1 study area, the estimated mean number of bird fatalities per turbine per year was actually lower than the estimated mean number of bird fatalities per reference plot per year. Estimated mean number of avian fatalities per turbine in the P2 study area was approximately 2.1 times that of natural mortality, and the estimated mean number of avian fatalities per turbine per year in the P3 study area was approximately 4.0 times that of expected natural mortality in the study area.

Compared to several other wind plants in the U.S., avian mortality appears to be low on Buffalo Ridge. Our data indicate that wind plant-related avian mortality on Buffalo Ridge primarily involves nocturnal migrants. Mortality of resident breeding birds appears very low, involves primarily common species, and would not likely have any population consequences within the Buffalo Ridge WRA. Based on the estimated number of birds that migrate through Buffalo Ridge each year, the number of wind plant related avian fatalities at Buffalo Ridge is likely inconsequential from a population standpoint. Information on bat abundance, behavior or habitat use at Buffalo Ridge is currently lacking.

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INTRODUCTION

Wind has been used to commercially produce energy in the U.S. since the early 1970's (AWEA 1995). Recent advances in wind turbine technologies have reduced costs associated with windpower production, improving the economics of wind energy (Hansen *et al.* 1992). As a result, commercial wind energy plants have been constructed in 15 states, and additional projects are planned for in another six states in the U.S. (Anderson *et al.* 1999). To date, most windpower development in the U.S. has occurred in California, but greater than 90% of the windpower potential in the U.S. exists within 12 midwestern and western states (Iowa, Minnesota, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, New Mexico, Colorado, Wyoming and Montana) (Weinberg and Williams 1990).

An estimated 5 to 80 million birds die annually in the U.S. by colliding with manmade objects (Avery *et al.* 1980, Banks 1979, Jaroslow 1979). Although generally considered environmentally friendly, windpower has been associated with the deaths of birds colliding with turbines and other wind plant structures, especially in California (Orloff and Flannery 1992). Compared to other structures, such as communication towers and power lines, however, overall incidence of bird mortality in wind generation facilities is small (AWEA 1995). The range of avian mortality from turbine collisions is 0 to 37 birds per turbine per year in the U.S. and Europe (Howell and Noone 1992, Winkelman 1992a). Studies indicate that raptors and passerines are the most susceptible to turbine collisions in the U.S., whereas waterfowl and shorebirds appear to be most susceptible in Europe (AWEA 1995). Most European wind plants are in coastal areas, whereas most U.S. wind plants are in interior areas.

Early wind energy facilities in the U.S. were placed without regard to level of avian use, and some of these sites are located where birds are abundant and the risk of turbine collisions is high (AWEA 1995). As a result, extensive mortality has been reported at some wind generation facilities. In the Altamont Pass area near Livermore, California, where more than 7,000 turbines exist within the Wind Resource Area (WRA), an estimated 567 raptors were killed over a 2-year period by colliding with turbines (Orloff and Flannery 1992). Researchers estimated 6,800 birds were killed annually at the San Geronio, California wind facility based on 40 dead birds found while monitoring nocturnal migrants. Because most of these birds were passerines and large numbers of passerines migrate through this area, the authors concluded that this level of mortality was biologically insignificant (McCrary *et al.* 1986). Studies conducted on other wind generation facilities have shown that this level of mortality does not routinely occur (e.g., Johnson *et al.* 2000a, Erickson *et al.* 2000). Numerous factors, including avian abundance and composition, presence of migration corridors, geographic area, landscape features, prey abundance and wind plant features, determine the potential for avian mortality (Nelson and Curry 1995, Orloff 1992).

In 1994, Kenetech Windpower, Inc. (Kenetech) completed development of a 73 turbine 25-megawatt (MW) wind plant on Buffalo Ridge, Minnesota. In 1998, construction of 143 additional turbines capable of generating 107.25 MW was completed by Enron Corporation. Another facility capable of generating 103.5 MW was completed by Enron in the summer of 1999. The Buffalo Ridge wind development area is currently the largest in operation outside of California, and the 107.25 MW Enron development completed in 1998 is considered the largest single wind plant in the world. A

biological reconnaissance of the Buffalo Ridge WRA was conducted prior to initiation of the windpower facility (Nelson 1993). Based on this reconnaissance, the author concluded that there was relatively low potential for avian mortality to occur on this site. This conclusion was based on the finding that Buffalo Ridge is not located in a major waterfowl staging area or along significant waterfowl migration routes and that migrating passerines generally fly at heights well above turbines. Additional conclusions of the biological reconnaissance indicated that (1) impact of a windpower facility on migrant birds would likely be related to their abundance and migration heights, and would likely vary considerably among sites, and that (2) certain species of raptors could be susceptible to collision with turbines at Buffalo Ridge, including one common species (red-tailed hawk), and six other less common species that migrate through the area.

The University of Minnesota, Duluth campus, was contracted by Northern States Power Company (NSP) to conduct nighttime radar studies of avian use in the project area. Data were collected in the fall of 1996 (12 September to 29 October) and spring of 1997 (26 March to 12 May) near Marshall (8 sites), Benson (6 sites), and Elbow Lake, Minnesota (6 sites). Two of the Marshall sites were located on Buffalo Ridge. Radar detections of migrating birds were conducted at 1.4 km and 5.6 km radii. Birds as small as passerines could be detected at the 1.4 km radius, whereas only birds approaching the size of gulls or larger could be detected at the 5.6 km radius. Migratory bird activity in this area was quite variable. In general, however, bird detections at the Buffalo Ridge sites were lower than the other six Marshall sites as well as the Benson and Elbow Lake sites. In the fall of 1996, mean number of detections for both 1.4-km and 5.6-km radius surveys combined was 366/hr at the two Buffalo Ridge sites. This compares to a mean of 378/hr at the other six Marshall sites, 559/hr at Benson, and 686/hr at Elbow Lake. In the spring of 1997, mean detection rate was 475/hr at Buffalo Ridge, compared to 540/hr at the other Marshall sites, 543/hr at Benson, and 376/hr at Elbow Lake (Hawrot and Hanowski 1997). These data indicate that Buffalo Ridge receives comparably less use by nocturnal migrants than other areas sampled in west-central and southwestern Minnesota.

Near the completion of the first 25 MW phase of the facility in 1994, South Dakota State University (SDSU) was contracted by Kenetech to conduct avian research on the Buffalo Ridge WRA. The purpose of their research was to develop and conduct a systematic avian monitoring program to measure seasonal movements, relative abundance, temporal flight patterns, and incidence of nesting and avian mortality associated with the Buffalo Ridge WRA. Field research in 1994 and 1995 indicated that wind plant-related avian and bat mortality was relatively low on Buffalo Ridge. Results of research conducted by SDSU at Buffalo Ridge have previously been presented (Higgins *et al.* 1995, Higgins *et al.* 1996, Leddy 1996, Leddy *et al.* 1999, Leddy *et al.* in press, Osborn *et al.* 1996, Osborn *et al.* 1998, Osborn *et al.* 2000, Usgaard *et al.* in press).

In 1996, Western EcoSystems Technology (WEST, Inc.) was contracted by Northern States Power Company (NSP) to develop an avian monitoring protocol for the Buffalo Ridge WRA. This protocol (Strickland *et al.* 1996) was developed and peer-reviewed by numerous individuals representing the wind energy industry, U.S. Fish and Wildlife Service, Minnesota Department of Natural Resources, and the Audubon Society prior to finalization. This report presents final results of a 4-year avian monitoring study conducted by WEST from 1996 to 1999 under the avian monitoring protocol developed for Buffalo Ridge, Minnesota. Most previous studies of windpower/avian interactions have emphasized assessing effects on raptors. Due to relatively low abundance of raptors on Buffalo

Ridge, and based on conversations with Minnesota Department of Natural Resources personnel, this study emphasized assessing effects of windpower on passerines, waterbirds, and waterfowl. Although this study was designed primarily to assess effects of windpower development on birds, data collected during fatality searches also allowed this study to address windpower-related impacts to bats.

STUDY AREA

The study area consists of a large portion of Buffalo Ridge, a 62-mile-long segment of the Bemis Moraine located in Lincoln and Pipestone Counties in southwest Minnesota and Brookings County, South Dakota (Figure 1). Buffalo Ridge is located in the Coteau des Prairies, a major physiographic landform consisting of terminal moraines and stream-dissected lands (Coffin and Pfannmuller 1988). The ridge runs diagonally from southeast to northwest and separates the Missouri and Mississippi River watersheds. Elevations in the study area range from 546 m to 610 m above sea level (Nelson 1993). Vegetation types in the study area consist primarily of agricultural crops including corn, soybeans, small grains and hay; pasture; and Conservation Reserve Program (CRP) grasslands. Most CRP fields were planted to a mixture of smooth brome and alfalfa or to monocultures of switchgrass. Much of the land enrolled in the CRP program at the start of the study in 1996 was put back into crop production during the 4-year study period. Relatively minor vegetation types in the study area include deciduous woodlots associated with farmsteads, wooded ravines, and wetlands.

The WRA currently consists of three major phases of development (Figure 1). Phase I (denoted P1), constructed by Kenetech in 1994, consists of 73 Model 33 M-VS turbines and related facilities, including distribution lines, meteorological towers, communication systems, transformers, substations, roads, and operations and maintenance facilities. Turbines in P1 are arranged in 10 strings with 3 to 20 turbines per string. None of the turbines in P1 have any lighting. Turbines are spaced from 91 m to 183 m apart. P1 is located in the approximate center of the WRA (Figure 2), and generates 25 MW of electricity. The Kenetech Model 33 M-VS turbine operates at wind speeds of 9 to 65 mph. Phase II (denoted P2), consisting of 143 Zond Model Z-750 turbines and related facilities sufficient to generate 107.25 MW of electricity, was completed by Enron Corporation in July 1998. P2 consists of 26 strings of turbines, with 2 to 12 turbines per string spaced at intervals ranging from approximately 100 m to 200 m. The three turbines comprising the most southern and northern turbine string have Federal Aviation Administration (FAA) lighting. The Enron turbine operates at wind speeds of 8 to 65 mph. P2 is located in the northwestern portion of the WRA (Figure 3). Phase III (P3) facilities capable of generating an additional 103.5 MW were completed by Enron in the southeast portion of the WRA in June 1999 (Figure 4). This facility consists of 138 Zond Model Z-750 turbines. P3 consists of 36 strings of turbines, with 2 to 13 turbines per string spaced at intervals ranging from approximately 250 m to 500 m. Every other turbine within the P3 windplant has FAA lighting. In addition to the 354 turbines within the three major windpower developments included in this study, several small developments totaling an additional 55 turbines have recently been completed on Buffalo Ridge. For study purposes, a permanent reference area not scheduled for windpower development was selected along Buffalo Ridge northwest of the WRA in Brookings County, South Dakota (Figure 5).

Habitats within the 100-m radius (total size = 3.14 ha) of randomly-selected avian survey points in each of the four study sites (see below) were classified and their proportions averaged to estimate habitat composition of each study area as well as for all of Buffalo Ridge. For the entire Buffalo Ridge study area, cropland was the major habitat, ranging from 47.7% of the study area in 1996 to 59.5% in 1998. The mean percent of each study area comprised of cropland during the 4-year study ranged from 50.7% in P2 to 68.6% in P1. Over the entire study period, soybeans were the most common crop, comprising 50.5% of all cropland. Corn comprised 42.0% of all cropland. Small grains (e.g., wheat, barley, oats) comprised 7.2% of all cropland, and the remaining 0.4% was comprised of minor crops such as buckwheat.

After cropland, pasture was the next most abundant habitat, ranging from 20.5% of the entire Buffalo Ridge study area in 1996 to 22.9% in 1999. P1 had the lowest percent pasture (9.0%) and P3 had the highest percent pasture (27.2%). CRP grasslands were the third most abundant habitat type. CRP grasslands were most common at the start of the study in 1996, when they comprised 13.9% of all habitat types on Buffalo Ridge. The amount of CRP on Buffalo Ridge was reduced by 69% from 1996 to 1998, when CRP comprised only 4.3% of the study area. Additional acreage was put into the CRP program in 1999, when this habitat comprised 6.2% of the study area (Figure 6). Most CRP occurred in the P2 study area (4-year mean = 13.6%), and the least amount of CRP was in the Reference Area (4-year mean = 3.3%). The largest reductions in CRP grasslands over the study period occurred in the P1 and P2 study areas. In the P1 study area, CRP was reduced from 18.6% in 1996 to 4.6% in 1999. In the P2 study area, CRP was reduced from 26.0% in 1996 to 4.5% in 1998, then increased to 11.4% in 1999.

Percent of the Buffalo Ridge study area comprised of hayfields ranged from 5.2% in 1999 to 10.0% in 1997. The P1 area had the smallest acreage in hayfields (4-year mean = 2.0%), and the Reference Area had the largest acreage in hayfields (4-year mean = 9.9%). For all of Buffalo Ridge, woodlots (natural and farmstead) averaged approximately 4.8% of the study area, and wetlands averaged 1.5%. Percent of each study area comprised of woodlots ranged from 4.3% in the Reference Area to 6.7% in the P3 study area. The proportion of each area comprised of wetlands ranged from 0.4% in the P1 area to 2.0% in the P2 study area (Figure 6). Descriptions of vegetation, including vertical density and vegetation height, have previously been described for cropland, pasture, and CRP habitats occurring within the Buffalo Ridge study area (Leddy 1996).

METHODS

Experimental Design

The primary goals of monitoring windpower development are to evaluate risk to birds from each phase of development and the cumulative risk to birds from all windpower development in the WRA. The secondary goal of monitoring is to provide information that can be used to reduce risk

to birds from subsequent developments (Strickland *et al.* 1996). This monitoring study used the Before/After - Control/Impact (BACI) design (Green 1979). This monitoring study also provided data compatible with numerous other windpower projects in operation or under development. Finally, this monitoring study assessed risk based on a weight of evidence approach.

The sampling design was a BACI modification of a protocol proposed by Anderson *et al.* (1996a) where avian use and mortality are measured on plots located at varying distances from turbines. Modifications to Anderson's protocol followed the sampling Protocol A proposed by Manly *et al.* (1993), where use of sampling frames allow for mortality estimation for the entire wind development area and reference areas and an estimate of avian use standardized by unit area and unit effort. Estimates of relative risk by species, mortality attributable to the wind development area, and other parameters that can be measured by Anderson's approach also were measured during this study.

The BACI design combined collection of data before and after the P2 and P3 windpower developments with collection of data from the P1 development and multiple control areas. An attempt was made to find a permanent control area as similar as possible, both physically and biologically, to the current wind development sites. Perfect control areas for the wind development area do not exist; thus, control areas are termed reference areas. Four areas were included in the study, including the P1, P2, and P3 wind development areas and the Reference Area. Data collected on the P2 site in 1996 and 1997 and the P3 site in 1996, 1997, and 1998 served as reference data for the P1 site prior to development of the P2 and P3 sites and also served as preconstruction data for the P2 and P3 developments. By sampling both reference and wind development areas before and after windpower development, both temporal and spatial controls are used, optimizing impact assessment capabilities (Green 1979). Analyses under the BACI design were used to compare the P2 and P3 sites to the reference data both prior to and after windpower development because at least two years of preconstruction data were available.

The monitoring protocol used for this study was a product of interaction among scientists, industry representatives, the utility company, agency professionals and conservation groups concerned with potential effects of windpower development on wildlife in Minnesota. Monitoring activities combined relatively intensive surveys of species of primary concern with relatively less intensive surveys of species of reduced concern. The design and analysis used a "weight of evidence" approach to assess effects of the project on species of concern. A number of hypotheses, derived from the goals and objectives contained in the monitoring plan, were tested with data accumulated during the study. Estimates of direct mortality can be made in a given year through fatality searches, but tests of other parameters (e.g., avoidance of wind plant by avian species) for any given year may have relatively little power to detect an effect of windpower on population levels of species of concern. However, the trend of effects (if any) was examined to determine if effects were of a magnitude warranting additional, more detailed study. The weight of evidence approach emphasizes detection of biological significance when statistical significance is marginal. Important differences are indicated by effects which have potential biological importance but may have marginal statistical confidence.

The monitoring plan did not provide estimates of population parameters but did provide indices of population parameters. Depending on the avian resource of concern, evaluations of wind energy

development effects included effects on individuals (e.g., reduction or increase in use of the area occupied by the turbines) and population effects such as mortality (e.g., death due to collision with a turbine). Several outcomes were possible from interpreting results of the avian studies. For example, if there was a decline in avian use of the P2 site after construction of turbines without a similar decline on the reference area(s), this might be interpreted as evidence of an effect of windpower development on birds. A decline in use of both the reference and wind development area in the absence of turbine-related mortality may be interpreted as a population response unrelated to windpower.

This monitoring effort was designed to obtain data on avian species thought to be at risk from wind energy development. Passerines and shorebirds were of primary concern because of their abundance in the area and because of the presence of several species of concern (e.g., loggerhead shrike and Wilson's phalarope). Raptors, with the exception of the burrowing owl, were of reduced concern, primarily because the most common breeding species is the ubiquitous red-tailed hawk. Mortality was measured through conducting fatality searches at turbines in existing windpower production areas and in reference areas. Relative use of birds was measured through standardized surveys conducted during daylight hours each season. Seasons were defined as (1) spring migration (March 15 - May 31); (2) breeding season (June 1 - August 15); and (3) fall migration (August 16 - November 15). Two types of surveys were conducted. The first method involved making point counts of birds for a short duration (5 minutes) from a large number of points across the study areas. Passerines and other smaller birds were the primary targets of these surveys because they have smaller home ranges and cannot be detected at large distances; however, all species of birds were recorded. The second method involved making counts of birds for a longer duration (30 minutes) from a few points with large viewsheds in each study area. Raptors and other larger birds (RLB) were the targets of these surveys because they can be detected from larger distances and were fairly uncommon within the study area compared to passerines.

Point Count Surveys

The objective of point count surveys was to develop estimates of avian use, species composition, relative abundance, spatial use and flight behavior within all three development areas and the permanent reference area. Point count surveys were used to estimate relative density and use of all avian species on the study areas. Survey points were randomly spread across study areas to ensure representative samples (Figures 2-5). Use was measured by counting birds observed within 100-m radius sample plots. We assumed use was influenced by biological and physical characteristics of the site and/or the home range of the species. Each bird detected during counts was located in relation to existing or measured information regarding the physical and biological characteristics of the site.

A systematic sample of 21 turbine locations in the P1 study area and 40 turbine locations in the P2 study area were selected as point count stations for measuring avian use. No avian survey points were located at turbine plots in the P3 study area because this facility did not become operational until near the end of the study in July 1999, and post-construction data suitable for the BACI analysis would not have been available. In addition to turbine points, a systematic sample of survey points was selected from an area within 100 m to 300 m of public road rights-of-way; 11 within P1,

31 in P2, 25 in P3, and 29 in the Reference Area (Figures 2-5). A random number was selected to determine whether the east-west or north-south running roads were used for locating points. A random starting point was used to locate the first point along each north-south or east-west road, with subsequent points located equidistant apart along the road and within the boundary of the study area. The actual point count stations were offset from the road edge by a random distance between 100 m and 300 m perpendicular to the left or right of the road. Points were located away from roads to ensure they were placed in areas representative of most turbine locations in the study areas.

Throughout the study, the same points established in 1996 were sampled every year except for turbine plots in the P1 study area, where a new sample of 21 turbines was selected each subsequent year. A new sample of turbine plots was selected each year of the study at this site to increase the probability of selecting potential “problem” turbines that may have higher mortality associated with them due to their location or habitat. New turbine locations were not selected in the P2 study area each year because data should be collected at the same points prior to and following construction for a robust BACI analysis.

A circular plot method was used for avian point count surveys (Reynolds *et al.* 1980). Observations on each point were made once every two weeks from 15 March to 15 November each year of the study. Surveys were conducted between ½ hour before sunrise and four hours after sunrise. At each point, observers recorded all birds detected by sight or sound for a 5-minute period. To assist with assessing potential effects of turbine noise on bird detection rates, which has implications for comparing avian use with the BACI design (Anderson *et al.* 1997), the method for detecting each bird observed (i.e., sight only, sound only, both sight and sound) was recorded. When conducting surveys at turbine plots, the observer rotated around the base of the turbine during the survey period to ensure that birds on all sides of the turbine had an equal probability of being detected. Data recorded for each observation included time, species, number, estimated distance from the observer, activity, habitat, flight direction, and estimated flight height to the nearest meter. Biologists were trained in flight height estimation by estimating flight heights of birds flying near turbines of known height. For data analysis, these flight heights were categorized to correspond to the height below, within, and above the space occupied by turbine blades. Weather data (temperature, wind speed and direction, cloud cover, precipitation) also were recorded each visit.

Raptor/Large Bird (RLB) Surveys

The objective of the RLB use surveys was to estimate spatial and temporal use by large bird species of interest on Buffalo Ridge as a whole and within each of the four study areas. Groups of birds recorded during RLB surveys included raptors, corvids (limited to crows), waterbirds (e.g., cormorants, pelicans, gulls, waders), waterfowl and shorebirds. Avian use is considered an index to density (number of individuals per unit area) of species using the study areas. Use was measured by making counts of birds observed within sample plots, and keeping track of the duration of time spent within the boundaries of the plot. Each bird detected during counts was located in relation to existing or measured information regarding the physical and biological characteristics of the site. This survey concentrated on raptors, waterfowl, and other less frequently observed large birds, but all larger species detected within the plot were recorded with the exception of rock dove; this ubiquitous species was recorded only during point count surveys.

Six RLB observation stations each were located within the P2 (Figure 3), P3 (Figure 4), and permanent Reference Area (Figure 5) using a systematic sampling procedure with a random starting point for the first location. When necessary, during a preliminary field visit to each point, the location of the center of the point was adjusted to the nearest location with an unobstructed view out to 0.8 km in at least 270^B. Only two observation stations were located within the P1 study area (Figure 2); these stations were the same ones surveyed by Higgins *et al.* (1995). The P1 study area is much smaller (8.5 mi²) than the other three study areas (25-38 mi² each).

Each RLB observation station consisted of a 0.8-km radius circle centered on an observation point. Landmarks and other prominent topographic features were located to help identify the 0.8-km boundary of each station. Observations of birds beyond the 0.8-km radius also were recorded, but were analyzed separately from data collected within the plot. Observations were made once every two weeks from 15 March to 15 November. Observation times were rotated to cover all daylight hours. Each station was visited twice each sampling day, once during the morning (0800-1200) and once during the afternoon (1200-1600). Efforts were made to ensure each station was surveyed about the same number of times during each period of the day each season.

During each visit, continuous counts of birds during a 30-minute interval were made to establish use of the plot by species. All sightings were recorded on data sheets at the time of observation. A unique observation number was assigned to each sighting to identify the location of first observation on the map. The date, plot number, begin and end times of the observation period, and species were recorded. Weather data (temperature, wind speed and direction, cloud cover, precipitation) were recorded each visit.

Location of first sighting and direction of travel were mapped in the field. The flight height of each bird was estimated to the nearest meter. For data analysis, these flight heights were categorized to correspond to the height below, within, and above the space occupied by turbine blades. Flight pattern (including perching) and flight height were recorded at the time of first observation and every five minutes of the survey (5, 10, 15, 20, 25 and 30 minutes). For example, if a red-tailed hawk was detected eight minutes into the survey and remained in the survey area for five minutes, the flight pattern and flight height of this hawk were recorded at first observation and 10 minutes into the survey. The habitat traversed by the bird also was identified in a similar fashion. Any comments or unusual observations were recorded on the data form.

Avian Survey Data Analysis

Avian Use

Species lists were generated by study period and study area. The number of birds seen during each point count survey was standardized to a unit area and unit time surveyed. The point count survey data are reported as the number of birds detected during a 5-minute interval per 0.031 km² (100-m radius viewshed for each station). For RLB surveys, the standardized unit time was 60 minutes, as both the morning and afternoon survey data were combined for each plot, and the standardized unit area was 2.01 km² (800-m radius viewshed for each station).

Point estimates were tabulated and plotted to illustrate and compare differences in avian use between (1) species, (2) seasons, (3) years, (4) turbine and non-turbine sites, (5) habitat, (6) flight height categories, and (7) study areas. Differences were considered significant if 90% or 95% Confidence Intervals (CI) (depending on the test) placed around the estimates being compared did not overlap. Station to station variability was used to estimate precision of the estimates. For all analyses, the sample size for comparisons of avian use was the number of plots, with repeated visits to the plots considered as subsamples.

Adjustments for visibility bias (Buckland *et al.* 1993) were estimated by species when data were sufficient using the program DISTANCE (Laake *et al.* 1993). Pooling of data across some species was required when low numbers precluded estimating visibility bias for individual species. Species were pooled into groups that exhibited similar detectability.

Effects of Windpower Development on Use

A Before/After - Control/Impact (BACI) analysis was used to test for effects of windpower development in the P2 and P3 study areas, where both pre- and post-construction data were available. The analysis examined both small-scale effects, which were defined as effects occurring at plots with turbines, and large-scale effects, which were defined as effects occurring at non-turbine plots within the wind development areas (i.e., roadside point count survey and RLB survey plots). Small-scale effects could only be assessed in the P2 study area, where both pre and post-construction avian use estimates were available at turbine plots. To assess small-scale effects of turbines in the P2 study area, avian use estimates (#/survey) for reference (non-turbine) plots in all four study areas following turbine construction in the P2 study area were divided by use estimates for the same reference plots prior to turbine construction. This reference post-to pre-construction ratio was then divided into the corresponding post-to pre-construction ratio for the P2 turbine plots. For example, if mean use of swallows on all reference plots was 2.0/survey prior to turbine construction and 3.0/survey following turbine construction, then the reference ratio for the post- to pre-construction periods is $3.0/2.0 = 1.5$. If mean use by swallows at turbine plots in the P2 study area was 2.4/survey prior to construction and 2.0 after construction, then the post- to pre-construction ratio would be $2.0/2.4 = 0.83$. The effect estimate was then calculated as the ratio of the P2 turbine ratio to the reference ratio ($0.83/1.55 = 0.56$). Post-construction effect estimates were calculated separately by season for the 1998 and 1999 P2 turbine plot data. Effect estimates were calculated for taxonomic groups and for avian species that breed in grasslands. The latter group was included to address the Minnesota DNR's concern over potential impacts of windpower development on breeding grassland birds.

A 90% bootstrap confidence interval (Manly 1991) was obtained for the effect estimate, and significant changes relative to the reference sites were indicated when the confidence interval did not capture the value 1. An effect estimate <1 indicates a negative effect due to the turbines/wind plant, whereas an effect estimate >1 indicates a positive effect. By using post/pre wind plant construction ratios in both wind plant and reference areas, any changes in habitat occurring over time are accounted for in the effects analysis if habitat changes are similar between wind plant and reference areas.

Large-scale effects were assessed using the BACI analysis for both the P2 and the P3 study areas, where roadside point count and RLB surveys were conducted at the same plots both prior to and following wind plant development. The analysis was similar to that described for small-scale effects, except that the only reference data available for the BACI analysis were data collected in the Reference Area. To further assess potential large-scale wind development effects, linear regression models were used to examine the relationship between avian use and distance to the nearest turbine from all non-turbine (roadside) plots in all three wind development areas.

Effects of turbines on birds within 100 m were also determined by comparing the mean distance to observations at turbine plots and non-turbine plots. If birds were avoiding turbines, mean distance to observations should be longer at turbine than at non-turbine plots, because most birds would be further away from the observer standing at the base of a turbine. The effect of whether or not the turbine was running on estimated bird use at the plot was determined for all birds recorded during surveys as well as for all birds detected only by sound. The purpose of this analysis was to determine if turbine noise interfered with the ability of observers to detect singing birds and to determine if birds may avoid turbines when they are running. Use data (#/survey by avian group) collected when turbines were running were subtracted from use data collected when turbines were off (matched pairs analysis). If turbine activity does not affect use, then one would expect the resulting number to be 0. A 90% CI was placed around the difference. If the 90% CI was positive (did not include 0), the reduced use when turbines were running was considered significant.

Turbine Exposure Index

A relative index to turbine exposure (E) was calculated for all bird species observed in the P1, P2, and P3 study areas by season using the following formula:

$$E = A * P_f * P_t$$

where E is defined to be the probability of exposure to turbine collision, A = mean abundance for species i adjusted for visibility bias, P_f = proportion of all observations of species i where activity was recorded as flying (an index to the approximate percentage of time species i spends flying during the daylight period), and P_t = proportion of all flight height observations of species i within the rotor-swept height of the turbines. P_t was calculated for two turbine types in use on Buffalo Ridge. Turbine A is installed on top of a 120-foot (36-m) tubular tower and has a blade diameter of 108 feet (33 m). Maximum height of the wind turbine at the tip of the blade is 174 feet (52.5 m). The rotor-swept height of Turbine A is 19.5 to 52.5 m above ground. Turbine B is installed on top of a 164-foot (50-m) tubular tower. Two blade diameters are in use. One is 151 feet (46 m), and the other is 157.5 feet (48 m). Therefore, the rotor-swept height of Turbine B is either 26 m to 74 m or 27 m to 73 m above ground. The rotor-swept height of 26 m to 74 m above ground was used in all avian flight height analyses involving Turbine B because this area encompasses both rotor diameters.

Habitat Use

Using avian observation data by habitat at the point count, avian densities were estimated to relate habitat characteristics to avian use. These estimates may be useful in developing a data level in a Geographical Information System (GIS) indicating those regions within a development area that

have the highest probability of use by a given species, information that may be useful when siting turbines in future phases.

The proportion of each habitat type occurring within each 0.031 km² area (point count surveys) or 2.01 km² area (RLB surveys) was recorded each survey. Habitat was recorded for each bird detected during surveys. For all avian groups except swallows and raptors, densities were calculated using only observations of perched birds or birds flying ≤ 5 m high. We used the 5 m flight height criteria as we assumed a majority of the birds flying > 5 m high may not have been definitively using a particular habitat. For calculating the density of swallows, all perched as well as all flying birds were included in the density estimates, regardless of flight height. All flying swallows were included in the habitat analyses because these birds forage primarily while flying, and habitat likely influences availability of insect prey. For calculating density of raptors, all raptors either perched or flying ≤ 20 m high were included in the estimates. Raptors flying ≤ 20 m high were included in the density estimates because many of these birds were actively foraging, and prey availability is a function of habitat. Density by species was calculated for all species with ≥ 25 observations during the study.

Stepwise linear regression models were used to determine what factors appear to be most related to the magnitude of use by birds at point count survey plots. Independent variables considered were indicator variables for the type of plot (turbine vs. non-turbine); proportions of crop, CRP, hay, and pasture within the plot; indicator variables for presence/absence of woodlots and wetlands within the plot; and variables for distance from the plot to the nearest wetland and woodland. Distances to the nearest wetland and woodland were included in the model because these two habitat types receive substantially more use by birds than other habitats in the study area, and could influence magnitude of avian use in adjacent areas. We used a modification of Akaike's information criterion (Akaike 1974, Anderson *et al.* 1994) for the model selection criteria, which is a function of model fit, number of parameters, and sample size. Data collected at the point (bird use, habitat, distance to nearest wetland and woodland, and type of plot) were used in the linear regression analyses. Coefficients for parameters in the "best" model indicate the relationship between the variables and magnitude of use by a species or avian group at a station. For example, positive coefficients for the habitat variables indicate that avian use at a station increases with increasing proportions of the habitat variables. A negative coefficient for the habitat indicator variables or the type of plot indicator variable would indicate that avian use is less when that habitat occurs or when a turbine is in the plot.

Habitat Characteristics Associated with Fatalities

Stepwise linear regression models were also used to evaluate effects of habitat on the probability of occurrence of both bat and avian mortality at survey plots. Incidence of mortality was assumed to be related to use of the study area. Independent variables considered were the same as those considered in the habitat use analyses. We again used a modification of Akaike's information criterion for the model selection criteria. Data collected at the point (mortality presence/absence, habitat, distance to nearest wetland and woodland) were used in the linear regression analyses.

General Wildlife Observations

In addition to standardized point count and RLB surveys, biologists also recorded observations of birds on the Buffalo Ridge study area while driving between survey points and between study sites. Emphasis was placed on recording rare species not previously recorded during standardized surveys, unusual observations of bird concentrations or behavior, and any species listed as threatened or endangered by the U.S. Fish and Wildlife Service or State of Minnesota.

Fatality Searches

One primary indication of windpower impact to bird and bat populations is mortality caused by windpower facilities. Mortality was measured by estimating the number of bird and bat fatalities in the wind development area whose death could be related to turbines. All avian and bat fatalities located within areas surveyed, regardless of species, were recorded and a cause of death determined, if possible, based on field examination and necropsy results. An estimate of the total number of fatalities was made. Total number of fatalities was estimated by adjusting for "length of stay" (scavenging) and searcher efficiency bias.

Objectives of fatality searches were to (1) estimate the number of mortalities attributable to wind turbine collisions for the entire Buffalo Ridge WRA, and (2) relate the mortalities by species to the relative abundance of each species and other parameters such as turbine characteristics and habitat to aid in determining relative risk to that species.

Fatality searches were conducted in all four study sites on Buffalo Ridge. Fatality searches were initiated in the P2 and P3 study areas prior to turbine construction to estimate pre-construction natural mortality. Searches were conducted at each of the 21 avian point count stations centered at a turbine within the P1 study area and at each of the 40 avian point count stations centered at a turbine location within the P2 study area. Searches were conducted at 30 randomly selected turbines in the P3 study area in 1999. Searches also were conducted at a systematic sample of 50% of the avian point count stations located within the 100 m to 300 m buffer of roads (6 in P1, 16 in P2, 13 in P3 and 14 in REF). Stations to be sampled for mortalities were flagged at the time of the first point count survey.

Biologists trained in proper search techniques conducted the searches. From 1996 to 1998, a 126 m X 126 m (1.59 ha) square plot was centered around each turbine for conducting fatality searches to ensure all areas within 63 m of the turbine were searched. The 63 m distance was set conservatively, as avian fatalities have rarely been documented up to 63 m from turbines at other wind plants. Data on distance to turbine for both avian and bat mortalities collected from 1996 to 1998 indicated that the 63 m search radius was likely much larger than required to adequately evaluate avian and bat mortality associated with turbines. All of the 16 turbine-related avian fatalities found by WEST during the first three years of the study were within 33 m of a turbine, and the mean distance was 12.5 m. All of the 78 dead bats found in 1998 were within 26.5 m of a turbine, and the mean distance was 9.4 m. In 1994 and 1995, all 10 apparently turbine-related bird mortalities found by Higgins *et al.* (1996) on the P1 study area were within 43.9 m of a turbine, and the mean distance was 17.2 m. The 13 turbine-related bats found by SDSU researchers in 1994 and 1995 were all within 39.0 m of a turbine, and the mean distance was 18.3 m. During trials to establish size of search plots in the P1 wind development area on Buffalo Ridge, Higgins *et al.*

(1996) either dropped or threw 35 birds of varying species from the tops of the Kenetech turbines. The distance these birds landed from turbines ranged from 8.2 m for birds dropped to 28.5 m for birds thrown. The mean distance that birds landed from turbines was 19.8 m for small birds and 16.2 m for medium-sized birds. Data collected on 139 suspected turbine-related avian mortalities at a wind development area in California support the data collected at Buffalo Ridge. The mean distance to the nearest turbine for the 139 avian mortalities was 24.1 m, and 77% of all turbine-related casualties were found within 30.5 m of a turbine. Only 4% of the fatalities were found at distances greater than 61 m from a turbine (Orloff and Flannery 1992). Based on the above data, in 1999, the fatality search plot was reduced in size so that it covered all areas within 50 m of a turbine, rather than 63 m. Reducing the size of each fatality search plot allowed for more turbines to be searched within a given time period.

A square plot, rather than a circular plot, was used to facilitate marking search boundaries and conducting the search. Transects were initially set at 6 m apart in the area to be searched, and the searcher initially walked at a rate of approximately 30-45 m/min along each transect searching both sides out to 3 m for casualties (Johnson *et al.* 1993). Search radius and speed were adjusted by habitat type. On average, approximately 30 to 45 minutes were spent searching each plot.

Searches of randomly selected turbines were conducted once every two weeks to locate and collect any fatalities found under turbines; however, casualties found at other times and places also were recorded. For all casualties found, data recorded included species, sex, age, date and time collected, location, distance to nearest turbine, condition, and any comments regarding possible causes of death. The condition of each fatality found was recorded using the following condition categories:

- C Intact - carcass that is completely intact, is not badly decomposed, and shows no sign of being fed upon by a predator or scavenger.
- C Scavenged - entire carcass that shows signs of being fed upon by a predator or scavenger or a portion(s) of a carcass in one location (e.g., wings, skeletal remains, legs, pieces of skin, etc.).
- C Feather Spot - 10 or more feathers at one location indicating predation or scavenging.

All casualties located were photographed as found and mapped on a detailed map of the study area that showed location of wind turbines and associated facilities such as power lines and towers. Casualties found were labeled with a unique number, bagged and frozen. A copy of the data sheet for each carcass was maintained, bagged and frozen with the carcass at all times. Gross necropsies of all intact, suitable avian fatalities found associated with a turbine were conducted by Dr. Elizabeth Williams of the Wyoming State Veterinary Laboratory, Laramie, Wyoming. All bat fatalities found during the study were apparently turbine-related and laboratory necropsies were not conducted.

The estimated average number of fatalities detected per turbine (\bar{c}) was calculated by:

$$\bar{c} = \frac{\sum_{i=1}^k c_i}{k}$$

where c_i is the number of fatalities detected at turbine i for the period of study, and k is the number of turbines searched. The variance was calculated by:

$$V(\bar{c}) = \frac{1}{k} \left(\frac{\sum_{i=1}^k (c_i - \bar{c})^2}{k-1} \right)$$

The estimated total number of detectable fatalities (C) was calculated by:

$$C = k(\bar{c})$$

with variance

$$Var(C) = k^2(var(\bar{c})).$$

Fatality Search Biases

Estimation of Carcass Removal

The objective of the carcass removal trials was to estimate length of time avian mortalities remained in the search area. Carcass removal studies were conducted in the same areas and habitats where fatality searches occurred on randomly-selected turbine locations and reference plots in all four study areas. Carcass removal trials were conducted within each of the following seasons: (1) spring migration (March 15 - May 31); (2) breeding season (June 1 - August 15); and (3) fall migration (August 16 - November 15). Trials were spread over most of the season to incorporate effects of varying weather, climatic conditions, and scavenger densities.

During the entire study, 49 carcass removal trials were conducted with birds. Each trial consisted of monitoring the fate of approximately 15 birds of varying composition. Carcasses were selected to represent a variety of avian species and size classes. Adult female mallards were used to represent large birds such as raptors and waterfowl; adult northern bobwhite and adult rock doves were used to simulate medium sized birds such as small raptors, small ducks, and shorebirds; and juvenile mallards, juvenile northern bobwhites, and adult house sparrows and adult European starlings were used to represent small birds such as passerines. An additional four trials were conducted with bat carcasses. The fate of 10 bat carcasses was monitored during each trial to

determine if removal rates for bats differed from that of birds of similar size. Bats used for the trials were intact fresh bats found dead during the study.

Carcasses were placed in a variety of postures to simulate a range of conditions. They were (1) placed in an exposed posture (e.g., thrown over the left shoulder while standing under a turbine); (2) hidden to simulate a crippled bird or bat (e.g., placed beneath a shrub or tuft of grass); and (3) partially hidden. An equal proportion of carcasses were included in each of the above categories. Carcasses were checked for up to 14 days to determine scavenger removal rates and were removed at the end of the 14-day period. Carcasses were marked discreetly with black electrical tape on the feet so searchers could recognize the carcass as experimental and leave it at the location found. Estimates of carcass removal were used to adjust fatality counts for removal bias. Carcass removal includes removal by predation or scavenging or removal by other means such as being plowed into a field.

The length of time a carcass remained in the study area before it was removed was denoted as t_i . Mean length of time a carcass remained at the site before it was removed (\bar{t}) was calculated by:

$$\bar{t} = \frac{\sum_{i=1}^k t_i}{k}$$

where k is the number of carcasses where t_i was obtained. The variance, $V(\bar{t})$, was calculated using the usual variance of a mean formula:

$$V(\bar{t}) = \frac{1}{k} \left(\frac{\sum_{i=1}^k (t_i - \bar{t})^2}{k-1} \right)$$

Carcass removal statistics were estimated by study site, season, habitat type, and size class of bird.

Estimation of Searcher Efficiency

The objective of searcher efficiency trials was to estimate the percentage of avian mortalities found by searchers. Searcher efficiency trials were conducted in the same areas fatality searches occurred. Sixty trials were conducted over the course of the study. Searcher efficiency was estimated by season and major habitat (gravel pad, crop, CRP, noncrop habitats). Crop types represented included corn, corn stubble, soybeans, soybean stubble, alfalfa, grass hay, cut hay, wheat stubble, plowed field and fallow field. Noncrop habitats consisted of snow, pasture, woodlots, wetlands and gravel roads/turbine pads. Estimates of searcher efficiency were used to adjust the number of carcasses found, correcting for detectability bias. Carcasses used for searcher efficiency trials had the same composition as those used for carcass removal trials. Searcher efficiency trials were not conducted with bats as we assumed detectability of bats was similar to that of small birds with similar colors.

Personnel conducting searches did not know the location of searcher efficiency carcasses. All carcasses were placed at random locations within areas being searched for fatalities prior to the search on the same day. Carcass placement was spread over the entire season to incorporate effects of varying weather and vegetation growth. Carcasses were placed in a variety of postures to simulate a range of conditions as was done for carcass removal trials.

Each carcass was discreetly marked (see scavenger removal studies) so that it could be identified as a study carcass after it was found. The number, location and habitat of the detectability carcasses found during fatality searches were recorded. The number of carcasses available for detection during each trial was determined immediately after the trial by the person responsible for distributing the carcasses. Carcasses not found by the searcher were removed following the fatality search effort for that day.

Searcher efficiency was expressed as p , the estimated proportion of detectability carcasses found by searchers. Results of searcher efficiency trials were used to evaluate effectiveness of the fatality search effort and to make adjustments for the final estimate of the total number of fatalities. The variance, $V(p)$, was calculated by the formula:

$$V(p) = p^2 \left(\frac{V(f)}{f^2} + \frac{V(k)}{k^2} - 2\rho \frac{se(f)se(k)}{f(k)} \right)$$

where k is the total number of carcasses placed, f is the number of carcasses found, and ρ is the correlation between k and f across trials. A different searcher efficiency rate was estimated for each habitat and carcass size class.

Estimating the Total Number of Fatalities

The estimate of the total number of avian and bat fatalities consisted of the three components discussed previously: (1) the estimate and associated variance for the number of fatalities detected during the study period, (2) the estimate and associated variance for the mean length of time fatalities remained in the study area before being removed, and (3) the estimate and associated variance for the searcher efficiency rate. To calculate mortality for the entire study period, values used for searcher efficiency and mean length of stay were weighted based on relative proportions of each habitat type in the study area, and averaged across all three seasons. Bat mortality was restricted primarily to summer and early fall; therefore, only searcher efficiency and scavenger removal data collected during this time period were used to estimate total bat mortality. Because the vast majority of bats killed by turbines appeared to have dropped within the cleared area surrounding turbines, the mortality estimate was weighted on searcher efficiency data collected in this type of habitat. The cleared area around turbines was approximately 0.04 acres in P1, 0.11 acres in P2, and 0.25 acres in P3. The total area searched around each turbine was 3.92 acres from 1996 to 1998 and 2.47 acres in 1999. Therefore, percent of the search area comprised of gravel pad from 1996 to 1998 was 1.0% in P1 and 2.8% in P2 (P3 turbines were not searched until 1999). In 1999, the percent of each search area comprised of gravel pad was 1.6% in P1, 4.5% in P2, and 10.1% in P3. We believe that searcher efficiency data collected using small dark brown or black birds (i.e.,

juvenile mallard, juvenile bobwhite, adult house sparrow, adult European starling) was appropriate for estimating detection rates for bats. Scavenger removal of bats was determined with 40 fresh bat carcasses collected during the study in 1999. Searcher efficiency and scavenger removal data collected from 1996 through 1999 were combined to increase sample size and improve the total mortality estimates.

The estimated total number of fatalities for the wind development area, m , for the time frame between searches was calculated by:

$$m = \frac{N(I(C))}{k(\bar{t}(p))}$$

where N is the total number of turbines, I is the interval between searches in days, C is the total number of fatalities found for the period of study, k is the number of turbines sampled, t is the mean length of time fatalities remain in the study area before being removed, and p is the searcher efficiency.

The variance was calculated using the variance of a product formula (Goodman 1960) and the variance of a ratio formula (Cochran 1977). The variance of the product t and p is:

$$V(\bar{t}(p)) = \bar{t}^2(V(p) + p^2(V(\bar{t})) + V(\bar{t})(V(p)))$$

From this, the variance of m is:

$$V(m) = \frac{N^2}{n^2} (I^2(m^2) \left[\frac{V(\bar{t}(p))}{\bar{t}^2(\bar{p}^2)} + \frac{V(\bar{c})}{\bar{c}^2} \right])$$

The standard error of m was calculated by

$$SE(m) = \sqrt{Var(m)}$$

An approximate 90% confidence interval around m is:

$$m \pm 1.67(SE(m))$$

Quality Assurance/Quality Control

QA/QC measures were implemented at all stages of the study, including field data collection, data entry, data analysis, and report preparation. Observers were trained in the methods used and tested

on their ability to identify avian species, to estimate size of large flocks, and to estimate distance to and flight heights of birds. At the end of each survey day, each observer was responsible for inspecting his or her data forms for completeness, accuracy, and legibility. The study team leader periodically reviewed data forms to insure completeness and legibility. Data were entered into electronic files by a professional data entry firm (National Conversion Systems, Inc., Vienna, VA) and verified through double entry. The final data files were compared to the raw data forms and any errors detected were corrected. Any irregular codes detected, or any unclear or ambiguous data were discussed with the observer and study team leader. All changes made to the raw data were documented for future reference. After the data had been keyed and verified, the study team leader checked a 5% sample of data forms against the final computer file. Any problems identified in later stages of analysis were traced back to the raw data forms, and appropriate changes in all steps were made. Standard operating procedures (SOPs) detailing the step by step procedures to be followed by field biologists for fatality searches, fatality search bias trials, point count surveys, and RLB surveys were prepared prior to data collection.

RESULTS AND DISCUSSION

General Wildlife Observations

Researchers documented 218 species of birds in the Buffalo Ridge study area from 15 March through 15 November 1996-1999 during avian surveys and general wildlife observations (Appendix A). Forty-three (20%) of the 218 species were not recorded during standardized point count or RLB surveys (Appendix A). Many of these species were relatively rare in the study area or occupied minor habitat types not surveyed during standardized surveys. The majority of these species were waterfowl, gulls, herons and shorebirds associated with Lake Benton (Figure 2) and passerines associated with larger tracts of deciduous forest. Some species on the periphery of their normal range (see Janssen 1987) such as Say's phoebe (scientific names are provided in Appendix A), ferruginous hawk, California gull, and mountain bluebird also were observed. Other notable sightings included observations in the P2 study area of 35 and 32 migrating red-tailed hawks throughout the day on 27 and 31 March 1997, respectively. Researchers also documented the first breeding record for Le Conte's sparrow in southwest Minnesota.

Endangered, Threatened and Special Concern Species

No species currently listed as endangered by the U.S. Fish and Wildlife Service or State of Minnesota were observed in the study area over the four-year study. Six species listed as threatened were observed, including the federally threatened bald eagle and state threatened peregrine falcon, common tern, Wilson's phalarope, horned grebe, and loggerhead shrike (Minnesota Department of Natural Resources 1996). Fifty-one bald eagles were observed during the study. Total number observed per year ranged from two in 1996 to 21 in 1997. Forty-two were observed during the

spring migration and the remaining nine were observed during the fall migration (Table 1). Most of the bald eagles (35) were observed during general wildlife observations, but 14 were observed during RLB surveys and two were observed while conducting point count surveys. Most of the observations were in the P2 study area (19), followed by the P1 area (8), the P3 area (7) and the Reference Area (5). Twelve were observed near Lake Benton but not within any of the wind development areas. Six peregrine falcons were observed while conducting the study, two in 1996, three in 1997, and one in 1998. Four of the peregrines were observed during fall migration and two were observed during spring migration (Table 1). Three of the peregrine falcons were observed during general wildlife observations, one was observed during a point count survey, and two were observed during RLB surveys. One of the peregrines was observed near Lake Benton outside any of the wind development areas and one was observed in the Reference Area. The other observations occurred in the P2 and P3 study areas (2 each).

One common tern was observed during an RLB survey in the P3 study area on 21 April 1998. Two horned grebes were observed on Lake Benton on 29 April 1998. Sixteen loggerhead shrikes were observed during the study, four in 1996, six in 1998, and six in 1999. Two were observed while conducting point count surveys and 14 were observed during general wildlife observations. Loggerhead shrikes were observed in the P2 study area (8), P3 study area (7), and P1 study area (1). Six of the shrikes were observed during spring migration and the remaining ten were observed during the breeding season. Two individual shrikes were observed the first week of June and did not appear to be breeding. Two adults and two nestlings were observed in June 1998 in the P2 study area, and two adults with a nest were observed in the P3 study area in June 1999. Of the three Wilson's phalaropes observed during the study, two were observed in the P3 study area on 5 May 1997, and one was observed in the P3 study area on 3 June 1998. With the exception of the two nesting records for loggerhead shrike, virtually all threatened species were observed during the spring or fall migration and were likely migrants through the study area; no evidence of breeding by bald eagle, peregrine falcon, common tern, horned grebe, or Wilson's phalarope was documented in the study area.

Five species listed as species of special concern by the State of Minnesota (Minnesota Department of Natural Resources 1996) were also observed during the study, including short-eared owl, Franklin's gull, American white pelican, marbled godwit, and Forster's tern. One short-eared owl was observed in the P2 study area during a point count survey on 13 October 1997. A lone marbled godwit was observed flying over the P1 study area on 29 April 1997. Franklin's gulls were one of the more common species observed in the study area. Over the four-year study, 999 were observed during point count surveys and 6,606 were observed during RLB surveys. Nearly 90% of all Franklin's gulls were observed in the fall. Five percent of the observations occurred during the spring migration and 5% occurred during late summer. American white pelicans were also frequently observed on Buffalo Ridge. Over the 4-year study, 24 were observed during point count surveys and 428 were observed during RLB surveys. Most (64%) were observed in the fall, 17% were observed in the spring and 18% were observed during the summer. Nine Forster's terns were observed during point count surveys, and five were observed during RLB surveys. All Forster's terns were observed in the spring migration. No evidence of breeding by species of special concern was documented within any of the study areas during the study.

Avian Abundance and Species Composition

Point Count Surveys

Over the 4-year study, 164 species were documented during sightings of 25,471 groups totaling 70,727 birds while conducting point count surveys on all four study areas on Buffalo Ridge (Appendix B). The number of birds observed by species used to obtain use and composition estimates are presented in Appendix C. For all four study areas combined, 142 species were observed in spring (15 March - 31 May), 94 were observed in summer (1 June - 15 August), and 119 were observed in the fall (16 August - 15 November) (Table 2). During the entire study period, the greatest number of species was observed in the P2 study area (138), followed by the Reference Area (116), P3 study area (110), and P1 study area (93).

For the entire Buffalo Ridge study area, avian use (mean number per survey) was highest in the fall (8.99/survey), followed by spring (6.59), and summer (6.06). The highest use occurred in the P3 study area in fall (10.32/survey), and the lowest use was recorded in the P1 study area in spring (3.86/survey) (Table 2).

The mean number of species observed per survey was used as an index to avian richness. Avian richness was highest in the summer (3.11 species/survey), followed by spring (2.43), and fall (1.52). The highest avian richness of any study area and season occurred in the P3 study area in summer (3.68 species/survey), and the lowest occurred in the P1 study area in fall (1.03 species/survey) (Table 2).

Data collected in 1996 and 1997 prior to initiation of the windpower developments in the P2 and P3 study areas were used to compare avian abundance and richness among seasons and study areas. Data collected in 1998 and 1999 were not used due to potential for wind plant-related effects. Based on these data, both fall and spring avian richness were significantly ($p < 0.10$) lower than during the summer. There was no significant difference ($p \geq 0.10$) in avian richness between the P2, P3 and Reference areas; however, the P1 study area had significantly lower ($p < 0.10$) richness than the other three areas during all three seasons (Figure 7). For all four study areas combined, avian relative abundance was significantly higher ($p < 0.10$) in the fall than in the spring or summer. This same pattern was observed in each of the individual study areas except the Reference Area, where avian abundance was highest in the spring. For all species combined, there was no significant difference ($p \geq 0.10$) in avian relative abundance between the P2, P3 and Reference areas all three seasons. The P1 study area had significantly ($p < 0.10$) lower avian relative abundance than the other three study areas in the spring and summer; however, in the fall, only the P2 site had significantly higher relative abundance than the P1 site (Figure 8).

Although patterns varied among study sites, waterbirds (species included in each group are provided in Appendix D) were in general most numerous in fall and least numerous in summer. Waterfowl abundance was highest in the spring and lowest in the summer, while shorebird abundance was highest and similar in the spring and summer. Raptor abundance was similar throughout the year. Dove abundance was highest in fall and lowest during the

spring. Passerine abundance was highest in fall and lower but similar in the spring and summer.

The three most abundant avian groups for all four study areas combined during the spring period were blackbirds (2.43/survey), longspurs (including horned larks) (1.04/survey), and sparrows (1.03/survey) (Table 3). Blackbirds comprised 37%, and longspurs and sparrows each comprised 16% of all observations in spring (Table 3). The five most abundant species observed on Buffalo Ridge in spring were red-winged blackbird (1.18/survey), lapland longspur (0.76), brown-headed cowbird (0.39), common grackle (0.34), and horned lark (0.27) (Table 4). Red-winged blackbirds and lapland longspurs were the two most abundant species on all four study areas in spring except the P1 study area (red-winged blackbird and common grackle); however, differences existed in abundance of other species among study areas (Table 4). Based on frequency of occurrence (percent of surveys each species was recorded), the most frequently occurring species on Buffalo Ridge in spring were red-winged blackbird (29.0% of surveys), western meadowlark (21.3%), brown-headed cowbird (17.1%), savannah sparrow (12.7%), and common grackle (11.3%) (Table 5). These species were in general the most frequently occurring in each individual study area as well, although some differences did exist between areas (Table 5).

In summer, for all four study areas combined, blackbirds remained the most abundant group (1.68/survey), followed by sparrows (1.49) and swallows (1.05) (Table 3). Blackbirds comprised 28%, sparrows comprised 25%, and swallows comprised 17% of all observations in summer (Table 3). The most abundant species were barn swallow (0.76/survey), red-winged blackbird (0.62), common grackle (0.33), European starling (0.32), and brown-headed cowbird (0.29). Barn swallows and red-winged blackbirds were the two most abundant species on each of the four study areas in summer (Table 4). Species most frequently observed during summer surveys were barn swallow (29.1% of surveys), red-winged blackbird (26.2%), western meadowlark (17.8%), savannah sparrow (16.3%), and brown-headed cowbird (14.5%) (Table 5).

During fall surveys, blackbirds (3.08/survey), longspurs (2.04), and sparrows (1.05) were the three most abundant groups, comprising 34%, 23% and 12% of all observations, respectively (Table 3). The five most numerous species on Buffalo Ridge were lapland longspur (1.16/survey), European starling (0.97), horned lark (0.86), red-winged blackbird (0.72), and barn swallow (0.52); however, differences did occur among study areas (Table 4). The most frequently observed species in fall were barn swallow (14.1% of surveys), European starling (9.9%), mourning dove (9.5%), horned lark (9.4%) and western meadowlark (8.6%) (Table 5).

Raptor/Large Bird (RLB) Surveys

Sixty-two species were identified during sightings of 3,546 groups totaling 20,035 birds while conducting RLB surveys in the Buffalo Ridge study area from 15 March through 15 November 1996-1999 (Appendix E). The number of birds observed by species used to obtain use and composition estimates are presented in Appendix C. For all four study areas combined, 56 species were observed in spring, 26 were observed in summer, and 44 were

observed in the fall (Table 2). Over the entire survey period, the greatest number of species was observed in the P2 study area (53), followed by the Reference Area (48), P3 study area (44), and P1 study area (23). Avian richness was higher in the spring (2.47 species/survey) than in the fall (1.88 species/survey) or summer (1.59 species/survey) (Table 2). The highest avian richness of any study area and period occurred in the P2 area in spring (2.93 species/survey). The lowest richness occurred during the summer in all four study areas (Figure 9).

For all four study areas combined, mean number of birds observed per survey was highest in the fall (22.84/survey) and slightly lower in the spring (15.87/survey); relative abundance in the summer (5.24/survey) was far lower. Abundance of waterbirds was much higher in the fall than during spring and summer. Waterfowl abundance was highest in the spring and lowest in the summer. Shorebirds were most numerous in spring and least numerous in the fall. Raptor and upland gamebird abundance generally remained constant throughout the survey period. Abundance of corvids was highest in the fall and similar in the spring and summer (Figure 10).

The three most abundant bird groups for all four study areas combined during the spring period were waterfowl (9.40/survey), waterbirds (2.16/survey), and shorebirds (1.60/survey); these groups comprised 59%, 14% and 10% of all birds observed, respectively (Table 6). The five most abundant species observed on Buffalo Ridge in the spring were snow goose (2.96/survey), Canada goose (2.73/survey), mallard (2.04/survey), American crow (1.16/survey) and Franklin's gull (1.06/survey) (Table 7). Snow geese were the most abundant species in the P1 and P3 study sites, whereas Canada geese were the most abundant in the P2 study area and Reference Area. Based on frequency of occurrence, the most frequently occurring species on Buffalo Ridge in spring were American crow (38.7% of surveys), mallard (38.5%), red-tailed hawk (32.3%), northern harrier (30.0%), and Canada goose (12.7%) (Table 8). These species were in general the most frequently occurring in each individual study area as well, although some differences did exist between areas (Table 8).

In summer, for all four study areas combined, raptors were the most abundant group (1.34/survey), followed by waterbirds (1.20/survey) and waterfowl (1.16/survey) (Table 6). Raptors comprised 26%, waterbirds comprised 23% and waterfowl comprised 22% of all birds observed. The most abundant species in summer were American crow (1.10/survey), Franklin's gull (0.84), mallard (0.80), red-tailed hawk (0.54), and northern harrier (0.35) (Table 7). Species most frequently observed during summer surveys were red-tailed hawk (33.4% of surveys), American crow (29.7%), northern harrier (19.9%), Swainson's hawk (16.4%), and mallard (15.1%) (Table 8).

During fall surveys, waterbirds had far greater abundance than any other group (14.64/survey), followed by waterfowl (4.29), and corvids (limited to American crow (1.96). These groups comprised 64%, 19%, and 9% of all observations, respectively (Table 6). The five most numerous species were Franklin's gull (11.59/survey), American crow (1.96), Canada goose (1.87), double-crested cormorant (1.64), and mallard (1.40). Franklin's gull

was the most numerous species in all four study areas in fall (Table 7). The most frequently observed species in fall were red-tailed hawk (45.0% of surveys), American crow (33.0%), northern harrier (20.6%), American kestrel (13.0%), and Swainson's hawk (10.5%) (Table 8).

Differences in mean abundance and frequency of occurrence among species in both the point count and RLB survey data primarily reflect differences in flocking behavior among species. Many of the most abundant species were seen on few surveys, but tended to occur in large flocks when they were observed, especially waterbirds, waterfowl, and some species of passerines (Appendix F). For example, Franklin's gulls and lapland longspurs were some of the most abundant species in some seasons and study areas, yet their frequency of occurrence was relatively low. The mean flock size for Franklin's gull observed during RLB surveys was 57.9, and flocks of up to 550 individuals were observed. The mean flock size for lapland longspur observed during point count surveys was 33.4, and one flock estimated to contain 750 individuals was observed (Appendix F). Other species, such as most raptors, were observed much more frequently than waterbirds and waterfowl, but were often observed as lone individuals or very small groups, making their overall abundance much lower than those species that tended to occur in large flocks (Appendix F).

Avian abundance and richness were lower in the P1 study area than other study sites for all seasons combined. Lower avian abundance and richness in the P1 area are most likely due to its size in relation to the other study sites. The P1 area is 8.5 square miles, much smaller than the P2 (28.8 mi²), P3 (25.3 mi²) and Reference Area (38.0 mi²) (Figure 1). Due to the much smaller size of the P1 study area, only two RLB survey plots and 11 roadside point count survey plots were established in this study area, compared to 6 RLB survey points and ≥ 25 roadside point count survey plots in each of the other three study areas. Because the other sites are much larger and had more survey plots, avian abundance and richness were likely higher simply because a larger geographical area and a greater variety of habitat types were surveyed.

Flight Height

Point Count Surveys

Over the 4-year study, 15,247 flocks comprised of 55,607 birds were observed flying during point count surveys on Buffalo Ridge (Appendix G). Mean flight height for all species combined was 16.0 m. Mean flight height was lowest for wrens (1.8 m), upland gamebirds (2.3 m), sparrows (6.0 m) and swallows (6.2 m). Highest mean flight heights were recorded for waterfowl (46.9 m), followed by waterbirds (44.3 m) and blackbirds (17.2 m) (Table 9).

Flight height data were examined separately for two different rotor-swept heights (Turbine A and Turbine B) due to different turbine sizes and rotor-swept heights present in the P1 and P2/P3 study areas. The 33 m diameter rotor-swept height of Turbine A is 19.5 m to 52.5 m above ground, whereas the 48 m rotor-swept height of the larger Turbine B is 26 m to 74 m above ground. For Turbine A, 75.7% of all flying birds observed were below the rotor-swept height, 20.1% were within the rotor-swept height, and 4.2% were above the rotor-swept height (Table 10). For Turbine B, 85.7% of birds observed flying were below the

rotor-swept height, 11.3% were within the rotor-swept height, and 3.0% were above the rotor-swept height (Table 10).

For all species combined, a significantly ($p < 0.05$) smaller proportion of birds was observed within the rotor-swept height of Turbine B than Turbine A. Avian groups that had a significantly ($p < 0.05$) higher proportion of flight heights within the rotor-swept height of Turbine A than Turbine B were raptors, doves and passerines. There was no significant difference in the proportion of flight heights within the rotor-swept height of Turbine A and B for shorebirds, waterbirds, waterfowl, and corvids (Figure 11).

Bird groups most often observed flying within the turbine rotor-swept height were waterbirds (71.4% within rotor-swept height of Turbine A, 69.9% within rotor-swept height of Turbine B), waterfowl (46.7% Turbine A, 36.7% Turbine B), longspurs (31.0% Turbine A, 15.1% Turbine B), raptors (25.0% Turbine A, 10.0% Turbine B), and corvids (24.5% Turbine A, 12.1% Turbine B) (Table 10). For species with ≥ 25 flying flocks recorded during surveys, the five with the greatest proportion of observations within the rotor-swept height of Turbine A were double-crested cormorant (98%), Franklin's gull (86%), Canada goose (61%), Swainson's hawk (50%), and common snipe (47%). For Turbine B, species with the greatest proportion of observations within the rotor-swept height were the same, including double-crested cormorant (84%), Franklin's gull (53%), Canada goose (36%), Swainson's hawk (28%), and common snipe (20%) (Appendix G). Several common species were never observed flying at the rotor-swept height of either turbine, including ring-necked pheasant, western kingbird, vesper sparrow, savannah sparrow, and song sparrow.

In other avian/windpower interaction studies, habitat and/or topographical features have been found to correlate with flight heights of birds using those habitats, especially raptors (Johnson *et al.* 2000b). The proportion of all birds observed flying within the rotor-swept height of turbines was highest when they were observed in cropland and lowest when they were observed in wetlands, but there were no significant ($p \geq 0.05$) differences in flight heights among habitats for any of the avian groups analyzed (Figure 12). Because habitat does not appear to be related to bird flight heights at the Buffalo Ridge study area, there is no justification for placing turbines in certain habitats to reduce the potential for collision mortality based on this parameter. Using point count survey data, flight height also was examined as a function of turbine presence or absence to determine potential influence of turbines on flight height. Mean flight height at plots with turbines was similar ($p \geq 0.05$) to mean flight height at plots without turbines for all avian groups (Figure 13), suggesting that birds are not changing their flight heights in response to turbine presence.

Raptor/Large Bird (RLB) Surveys

Observations were made of 3,156 flying flocks comprised of 18,144 birds during RLB surveys on Buffalo Ridge from 1996 to 1999 (Appendix C). The average flight height of all species combined was 43.1 m. Mean flight height was highest for waterfowl (73.4 m), followed by waterbirds (36.3 m), raptors (26.6 m), shorebirds (21.5 m), and corvids (13.5 m). The lowest mean flight height was for upland gamebirds (1.6 m) (Table 9).

Based on dimensions of Turbine A, 20.9% of all birds were flying below the rotor-swept height, 45.1% were within the rotor-swept height, and 34.0% were above the rotor-swept height. For Turbine B, 35.7% of all flying birds observed were below the rotor-swept height, 35.6% were within the rotor-swept height, and 28.7% were above the rotor-swept height (Table 10). There was no significant difference ($p \geq 0.05$) between the proportion of birds flying within the rotor-swept height of Turbine A and Turbine B for any of the avian groups observed during RLB surveys (Figure 14).

Bird groups most often observed flying within the rotor-swept height were shorebirds (81% within rotor-swept height of Turbine A, 55% within rotor-swept height of Turbine B), waterbirds (58% Turbine A, 45% Turbine B), raptors (44% Turbine A, 28% Turbine B), and waterfowl (29% for both Turbine A and B) (Table 10). For species with observations of at least 25 flying flocks, the five with the greatest proportion of observations within the rotor-swept height of Turbine A were great blue heron (70%), double-crested cormorant (66%), sharp-shinned hawk (62%), Swainson's hawk (59%), and red-tailed hawk (58%). For Turbine B, species with the greatest proportion of observations within the rotor-swept height were double-crested cormorant (61%), American white pelican (52%), ring-billed gull (48%), Swainson's hawk (45%), and Franklin's gull (43%) (Appendix G).

Flight height data collected during point count surveys over the four-year period during daylight hours indicate that the larger Turbine B may pose less risk than the smaller Turbine A to some groups of birds. Although flight height data indicate potentially more risk associated with Turbine A, turbine fatality rates from this study (see below) were higher for Turbine B than Turbine A. No relationship between avian mortality and height of turbines was found at Altamont Pass in California, where numerous turbine types exist within the WRA (Orloff and Flannery 1996).

Calculated differences in risk between turbine types were based only on the rotor-swept height, not the rotor-swept area, which also may influence risk (Howell 1997). The rotor-swept area of Turbine A, with 33-m diameter blades, is 3,419.5 m², whereas the rotor-swept area of Turbine B, with 48-m diameter blades, is 7,234.6 m² (2.1:1 ratio). Fewer birds may fly through a wind development area at the rotor-swept height of Turbine B, but the exposure to those birds that do may be higher than for Turbine A because the rotor-swept area of Turbine B is over two times as large. Results of avian mortality studies at California wind plants have been mixed, with one study showing no correlation between the size of rotor-swept areas and associated avian mortality (Howell 1997), and another study showing a statistically significant association between rotor-swept area and avian mortality (Orloff and Flannery 1996). A mathematical model designed to predict the magnitude of avian collisions concluded that increasing rotor diameter should result in a decrease in avian mortality due to lowered tip speed ratio (Tucker 1996a, Tucker 1996b). Caution must be used when comparing data collected on Buffalo Ridge to other areas, as flight height characteristics are study area and species specific and these data may not be applicable in other geographic areas. In addition, all flight height data were collected during the day, and diurnal avian flight heights certainly differ from flight heights of nocturnal migrants.

Turbine Exposure Indices

Point Count Surveys

Relative exposure indices, defined as the probability of being exposed to collision with a turbine, were calculated for all species observed during point count and RLB surveys (Appendix H) based on mean abundance adjusted for visibility bias, proportion of daily activity budget spent flying, and proportion of flight heights within the rotor-swept height of both turbine types. Based on this index for both turbine types combined, species with the highest probability of exposure to turbine collision during spring were lapland longspur, red-winged blackbird, horned lark, common grackle, mallard and snow goose. During the summer, species with the highest exposure index were red-winged blackbird, horned lark, cliff swallow, barn swallow, and common grackle. During the fall, lapland longspur, horned lark, red-winged blackbird, European starling, Franklin's gull and double-crested cormorant had the highest exposure index (Table 11).

Raptor/Large Bird (RLB) Surveys

Based on our exposure index, species with the highest probability of exposure in spring were Canada goose, mallard, Franklin's gull, double-crested cormorant and pectoral sandpiper (Table 12). During the summer, Franklin's gull, mallard, American crow, Swainson's hawk, and American white pelican had the highest exposure index. Species with the highest exposure index in fall were Franklin's gull, double-crested cormorant, Canada goose, mallard, and ring-billed gull (Table 12).

This analysis may provide insight into what species might be the most likely turbine casualties. However, this index only considers relative probability of exposure based on abundance, proportion of daily activity budget spent flying, and flight height of each species. This analysis is based on observations of birds during the daylight period and does not take into consideration flight behavior or abundance of nocturnal migrants. It also does not take into consideration varying ability among species to detect and avoid turbines, habitat selection and other factors that may influence exposure to turbine collision; therefore, the actual risk may be lower or higher than indicated by these data. For example, in the Altamont Pass WRA in California, mortality among the five most common species was not related to their abundance. American kestrels, red-tailed hawks, and golden eagles were killed more often, and turkey vultures and common ravens were killed less often than predicted based on abundance (Orloff and Flannery 1992). Similarly, at the Tehachapi Pass WRA in California, common ravens were found to be the most common large bird in the WRA, yet no fatalities for this species were documented during intensive studies (Anderson *et al.* 1996b).

Habitat Use

Point Count Surveys

Total avian use (number observed/km²) over the entire Buffalo Ridge study area was highest in woodland habitat (1381/km²), followed by wetlands (787), pasture (365), hayfields (351) and CRP (256); avian density was lowest in croplands (184/km²) (Table 13). Use of woodlands was significantly ($p < 0.05$) higher than any other habitat type. Density in both woodlands and wetlands was significantly higher than cropland and CRP. There was no significant difference in avian use among CRP, hayfields, and pasture (Figure 15). Use of

cropland was not significantly lower than use of CRP and hayfields, but was significantly lower than use of pasture.

Based on the linear regression analysis, if woodlands were present within a plot, significantly higher use was recorded for several groups, including chickadees/nuthatches, corvids, doves, finches, orioles/tanagers, sparrows, swallows, thrushes, warblers/vireos, woodpeckers and wrens (Table 14). These results support those of Leddy (1996), who found that density of singing male passerines during May and June 1995 at Buffalo Ridge also was highest in woodlands (502/km²); wetlands were not evaluated in that study. Avian groups not positively associated with presence of woodland within the survey plot were blackbirds, upland gamebirds, longspurs, shorebirds, waterbirds and waterfowl. If wetlands were present within the survey plot, significantly higher use was recorded for blackbirds, shorebirds, and swallows (Table 14). Higher use of wetlands and woodlands is expected; habitat structure and diversity are much higher in woodlands and wetlands than in monocultures (i.e., hayfields, croplands).

Several individual habitats that comprise only minor portions of the study area received high use by birds. For example, the habitat with the highest use was gravel mine (1,342/km²) due to the abundance of colonial nesting bank swallows using this habitat. Other habitat types with relatively high use were native trees/tree rows (583/km²), residential woodlots (471), wetlands (444) and bare ground (256). High use of bare ground was primarily due to extensive use by two of the most abundant species in the study area during the spring and fall, lapland longspurs and horned larks. Of the major crops produced in the study area, highest use occurred in cut hay (210/km²), wheat stubble (138) and alfalfa (134). Winter wheat fields received the lowest use (20/km²), followed by cornfields (67) and soybean fields (84) (Appendix I).

Based on 1996 through 1999 survey data for the period 15 March to 15 November, the three groups with the highest use of CRP were sparrows (107/km²), swallows (68), blackbirds (37) and wrens (17) (Table 13). Species with highest use of CRP were barn swallow (47.2/km²), bobolink (27.9), red-winged blackbird (23.8), savannah sparrow (19.1), sedge wren (16.4), and western meadowlark (13.4) (Appendix J). Groups with highest use of crop fields were swallows (52/km²), blackbirds (41), sparrows (32) and longspurs (32). Species with the highest density in cropfields included barn swallow (42.3/km²), red-winged blackbird (23.0), horned lark (13.1), lapland longspur (12.2), European starling (12.0), and brown-headed cowbird (10.8). Hayfields were used most by swallows (117/km²), sparrows (105), blackbirds (62) and longspurs (22). Barn swallows had the highest densities in hayfields (100.1/km²). Other species with relatively high densities in hayfields included European starling (53.1/km²), savannah sparrow (25.5), red-winged blackbird (23.7), western meadowlark (19.1), lapland longspur (16.8), brown-headed cowbird (16.1) and bobolink (14.9).

Birds using pasture the most were swallows (132/km²), sparrows (105), blackbirds (62), and shorebirds (16). Species with highest densities in pastures included barn swallow (95.8/km²), red-winged blackbird (40.0), western meadowlark (38.0), European starling (30.3), cliff

swallow (26.0), savannah sparrow (19.2), brown-headed cowbird (15.2), killdeer (13.9) and grasshopper sparrow (10.3) (Appendix J). Groups with the highest use of woodlands were sparrows (526/km²), blackbirds (237), swallows (165) and warblers/vireos (98). Numerous species had high densities in woodlands. Those species with the highest densities included European starling (226.5/km²), barn swallow (140.4), American robin (116.1), song sparrow (103.2), common grackle (85.9), and brown-headed cowbird (79.3). In wetlands, blackbirds had the highest use (287/km²), followed by sparrows (201), swallows (100) and waterfowl (68) (Table 13). Species with the highest use of wetlands were red-winged blackbird (550.6/km²), song sparrow (69.9), barn swallow (53.4), cliff swallow (37.2), mallard (36.9), and sedge wren (33.3) (Appendix J).

Raptor/Large Bird (RLB) Surveys

For larger birds recorded during RLB surveys, the highest use (number observed/km²) by all birds occurred in wetlands (76.3/km²), followed by croplands (10.9), pasture (7.0) and CRP (6.1). Lowest use occurred in hayfields (3.4) (Table 13). Due to variability in the data, there were no significant differences in avian use among habitats. Avian groups with the highest use of CRP were waterbirds (2.06/km²), waterfowl (1.44), and raptors (1.27). In cropland, highest use was by waterbirds (4.95/km²), followed by waterfowl (3.57) and corvids (1.03). High use of cropland by waterbirds primarily reflected high use of plowed fields by gulls. The only group with high (>1.0/km²) use of hayfields was waterbirds (2.92/km²). In pastures, waterbirds (3.43/km²) and waterfowl (1.77) were the only groups with use estimates \geq 1.0/km². Groups with relatively high use of woodlands were corvids (2.08/km²) and raptors (1.47). The three groups with the highest use of wetlands were waterfowl (57.9/km²), waterbirds (12.9), and shorebirds (4.2) (Table 13). Grazed pasture received more use by large birds (19.2/km²) than did ungrazed pasture (11.3). Of the major crops produced in the study area, highest use occurred in corn (22.4/km²), soybean stubble (11.2) and grass hayfields (10.4); lowest use occurred in alfalfa stubble (0.84), wheat stubble (0.29), and corn stubble (0/km²) (Appendix I).

Avian habitat use data indicate that habitats with the highest potential for avian interactions with turbines are wetlands and woodlands. Use of wetlands is approximately double, and use of woodlands is approximately four times that of any other habitat in the study area. These habitats comprise a small proportion of available habitat in the Buffalo Ridge WRA and avian risk may be reduced by siting turbines away from these habitats. CRP, pasture, hayfields and croplands have relatively similar and substantially less use by birds than wetlands and woodlands. Based on data collected to date, croplands and CRP have the lowest use of all habitat types, and avian risk may be reduced by siting turbines in these habitats.

Landscape Effects on Avian Use

Results of the stepwise linear regression analysis indicated a significant ($p < 0.05$) negative relationship between avian use and distance to the nearest wetland for sparrows, finches, upland gamebirds, and waterfowl. A negative relationship indicates that use of the plot by these groups decreased with increasing distance to the nearest wetland (Table 14). A significant ($p < 0.05$) negative relationship between avian use at the plot and distance to the nearest woodland was found

for several groups, including doves, woodpeckers, swallows, blackbirds, corvids, warblers/vireos, thrushes, chickadees/nuthatches, finches and wrens (Table 14). The coefficient for distance to woodland also was negative, indicating that use of the plot by these bird groups decreased with increasing distance to the nearest woodland (Table 14). These results support the conclusion that siting turbines away from wetlands and woodlands would likely reduce risk to birds in the project area.

Potential Windpower Development Area Effects on Avian Use by Taxonomic Group

Small-scale Effects

Trends in use for birds recorded during point count surveys over the 4-year study period varied by season, study area, and avian group (Figure 8). In the P2 study area, the BACI analysis was used to examine effects by season in both 1998 and 1999. Avian groups with lower than expected abundance at turbine plots varied by season as well as by year (1998 or 1999) (Table 15). The BACI analysis indicated that avian use of turbine point count plots within the P2 study area at some time period (season/year combination) following turbine construction was lower than expected for 11 avian groups, including waterbirds, raptors, upland gamebirds, woodpeckers, sparrows, swallows, warblers/vireos, finches, longspurs, wrens, and passerines placed in the “other” group category (see Appendix D for species included in this group). Post construction use by all passerines combined was lower than expected in the summer and fall of 1998 and all three seasons in 1999 (Table 15). There also appeared to be a negative windpower development effect on avian richness at turbine plots in the P2 study area all seasons in both 1998 and 1999 (Figure 7).

No apparent turbine-related negative effects on use were detected at any time period following construction for nine avian groups, including waterfowl, shorebirds, doves, flycatchers, corvids, blackbirds, chickadees/nuthatches, tanagers/orioles, and thrushes (Table 15). Relative to reference plots, the BACI analysis also indicated significantly ($p < 0.10$) higher than expected use of turbine plots following construction for some groups of birds at certain time periods, including corvids in the spring of 1998 and 1999, warblers/vireos and waterfowl in the spring of 1998, and longspurs/larks in the summer of 1998.

For all seasons and years combined, there were a total of 120 comparisons conducted for the BACI analysis (20 avian groups X 3 seasons X 2 years). Out of these 120 comparisons, 78 (65%) showed no change in use following construction, 37 (31%) showed a significant decline in use, and five (4%) showed a significant increase in use relative to reference values. Overall, these results show that turbines do not affect use of the immediate area (100 m from turbine) by most groups (i.e., 65%) of birds. However, the presence of turbines does reduce use of the immediate area by several avian groups at certain seasons. By conducting 120 independent comparisons with a p value of 0.10, one would expect 10% of the comparisons, or 12, to be statistically significant even when the differences were not real. Although not all of the comparisons were independent, given the large number of comparisons, some of the significant effects indicated are likely due to chance alone and are not real effects. This may explain the five cases where significant increases in avian use

were indicated; however, windplant development may actually improve habitat for some species that prefer bare or disturbed ground (e.g., horned lark).

Linear regression was also used to assess effect of turbine presence on avian use for all avian groups detected during point count surveys at turbine plots within all three wind development areas. The model indicated a significant ($p < 0.05$) negative relationship between avian use and presence of turbines within the plot for waterfowl, shorebirds, upland gamebirds, woodpeckers, blackbirds, corvids, longspurs/larks, sparrows, swallows and thrushes (Table 14). A negative relationship for this variable indicates that avian use decreased when turbines were present. A significant positive relationship between use by doves and presence of turbines also was indicated.

Effects of turbines on birds within 100 m also were determined by comparing the mean distance to observations at turbine plots and non-turbine plots. If birds were avoiding turbines, mean distance to observations should be longer at turbine than at non-turbine plots, because most birds would be further away from the observer standing at the base of a turbine. This appears to possibly be the case with passerines. Although mean distance to passerine observations at turbine plots (58 m) was only slightly longer than mean distance to passerine observations at non-turbine plots (54 m), the difference was statistically significantly ($p < 0.05$). For large birds, no significant difference in distance to observations between turbine or non-turbine plots was noted (Figure 16).

Another potential cause of reduced avian use at turbine plots is that turbine noise may affect detection rates of birds by observers, as many birds are detected by sound alone, especially small, cryptic passerines (e.g., sparrows, sedge wren). During the study, we recorded whether or not turbines were running while conducting point count surveys. Data were analyzed by avian group for all birds detected as well as for all birds detected by sound alone. Based on this analysis, for all birds recorded during surveys, mean use of turbine plots by swallows (0.23/survey), finches (0.05/survey), and sparrows (0.69/survey) was significantly ($p < 0.05$) lower when turbines were running than when they were not running (0.45 swallows/survey, 0.13 finches/survey, 1.00 sparrows/survey). Turbine noise may have interfered with the observer's ability to detect finches and sparrows. The vast majority of swallows were detected by sight; therefore, it is unlikely that turbine noise greatly impaired the ability of observers to detect swallows. These data suggest that swallows and perhaps other birds may avoid turbines to a greater extent when the turbines are running than when they are off. Previous studies at Buffalo Ridge (Osborn *et al.* 1998) and in Europe (Winkelman 1992a) have found that rotating turbines appear to be more visible to birds than nonrotating turbines. In Europe, bird use around turbines was decreased by 36% when the turbines were off compared to 67% when the turbines were running (Winkelman 1985).

For birds detected primarily by sound, a significantly lower ($p < 0.05$) number of singing sparrows were detected when turbines were running (0.23/survey) than when turbines were not running (0.46/survey). No differences were found for any other avian group. Although sparrows may avoid turbines when they are running to some extent, the lower use estimates for singing sparrows when turbines are running suggest that interference due to turbine noise

may have reduced the ability of observers to detect these birds, and this may have contributed to reduced estimates of sparrow use at turbine plots. In some studies of windpower/avian interactions, researchers have elected not to record birds detected by sound only due to concerns with biases associated with turbine noise interference (Anderson *et al.* 1999).

Large-scale Effects

Point Count Survey Data

The BACI analysis was used to examine potential large-scale wind development effects at roadside plots within the P2 study area during both 1998 and 1999 and at roadside plots within the P3 study area in 1999. The BACI analysis indicated that avian use of non-turbine point count plots within the P2 study area at some time period (season/year combination) following turbine construction was lower than expected for 10 avian groups, including waterbirds, waterfowl, raptors, upland gamebirds, flycatchers, sparrows, blackbirds, tanagers/orioles, thrushes, and passerines placed in the “other” group category (see Appendix D). Use of the P2 study area by all passerines combined was lower than expected only in the spring of 1998, which was during wind plant construction but prior to the time that most turbines became operational. After completion of the wind plant, use of roadside plots by all passerines combined was similar to expected use (Table 16). No apparent turbine-related negative effects on use were detected at any time period following construction for the other 10 avian groups (shorebirds, doves, woodpeckers, chickadees/nuthatches, corvids, finches, longspurs/larks, swallows, warblers/vireos, and wrens) (Table 16). Relative to reference plots, the BACI analysis also indicated significantly ($p < 0.10$) higher than expected use of turbine plots following construction for some groups of birds at certain times, including chickadees/nuthatches and tanagers/orioles in the spring of 1998 and 1999, and blackbirds, finches, and flycatchers in the fall of 1999. There were no negative windpower development effects on avian richness at roadside plots in the P2 study area (Figure 7).

Of the 120 comparisons of avian use conducted for the BACI analysis using roadside point count data in the P2 study area, 95 groups (79%) showed no change in use following construction, 18 groups (15%) showed a significant decline in use, and seven groups (6%) showed a significant increase in use relative to reference area values. Overall, these data indicate minimal large-scale effects of windpower development on avian use of the P2 study area.

Avian use of non-turbine point count plots within the P3 study area following wind plant construction in 1999 was lower than expected for passerines in the “other” group in the summer, and for longspurs and raptors in the fall. The analysis also indicated that avian use was higher than expected for raptors and wrens in the spring and blackbirds in the fall. No change in use was indicated for any of the other groups. Use of the P3 study area by all passerines combined was similar to expected use during all three seasons (Table 16). There were also no negative windpower development effects on avian richness at roadside plots in the P3 study area (Figure 7). Because a similar number of groups showed significant

negative and positive changes in abundance relative to reference area values, no large-scale effects on avian use of the P3 study area following construction of the wind plant are indicated.

To further assess potential large-scale effects of wind plant operation, effect of distance from each non-turbine (roadside) point count survey plot to the nearest turbine and habitat on mean use (number/survey) at the roadside plot was investigated using linear regression. The “distance to turbine” variable was not included in the models selected as best using the AIC criteria for any of the 20 avian groups or for all passerines combined, indicating that there were no differences in avian use as a function of distance from turbine. This suggests that turbines do not significantly reduce use at the distances non-turbine plots were from turbines (range = 105 m - 5364 m).

Raptor/Large Bird Survey Data

Trends in use for birds recorded during RLB surveys over the 4-year study period also varied by season, study area and avian group (Figure 10). Post-construction use of RLB survey plots by large birds within the P2 study in spring was lower than expected for waterfowl in 1998 and 1999 and upland gamebirds in 1999. During the summer season, the only group with lower than expected abundance was raptors in both 1998 and 1999. In the fall, lower than expected use was indicated for crows in 1998 and 1999, and for raptors and waterfowl in 1999 (Table 17). The analysis also indicated higher than expected use for waterbirds in the summer of 1999. No change in use was indicated for any of the other groups. Avian richness at RLB survey plots was lower than expected in the spring of 1998 and 1999, but not during any of the other seasons (Figure 9). Forty-two comparisons of avian use were conducted with the RLB data collected in the P2 study area (7 groups X 3 seasons X 2 years). Of the 42 comparisons, 32 groups (76%) showed no change in use following construction, nine groups (21%) showed a significant decline in use, and one group (2%) showed a significant increase in use relative to reference area values (Table 17).

Post-construction use of RLB survey plots by large birds within the P3 study in 1999 was not significantly lower than expected use for any avian group. Significantly higher than expected use following wind plant construction and operation was indicated for crows and raptors in the spring. Avian richness was similar to expected in the fall of 1999 and was significantly higher than expected in the spring and summer of 1999.

The BACI analysis indicates negative effects on use by some large bird groups in the P2 wind development area and no negative effects on large bird use of the P3 study area. Taken together, it appears that large-scale effects of wind plant development and operation on large birds are relatively low and would not necessarily be associated with all wind development projects on Buffalo Ridge.

Potential Windpower Development Area Effects on Breeding Grassland Birds

Small-scale Effects

The 22 species of breeding grassland birds included in the BACI analysis were provided by the Minnesota DNR and are listed in Appendix D. Trends in use for grassland breeders recorded during point count surveys over the 4-year study period varied by year and study area (Figure 17). In the P2 study area, the BACI analysis was used to examine effects during the breeding season in both 1998 and 1999. The first year following construction (1998), the BACI analysis indicated that use of turbine point count plots was lower than expected for common yellowthroat and northern harrier (Table 18). However, use was greater than expected for horned lark and vesper sparrow. In 1999, two years following construction, use of turbine plots was lower than expected for bobolink, common snipe, common yellowthroat, grasshopper sparrow, ring-necked pheasant, savannah sparrow, and sedge wren, as well as for all grassland breeders combined (Table 18). No species showed significantly higher than expected use in 1999.

Large-scale Effects

The BACI analysis was used to examine potential large-scale wind development effects at roadside plots within the P2 study area during both 1998 and 1999 and at roadside plots within the P3 study area in 1999. The only grassland nesting species with lower than expected abundance at roadside plots during the breeding season was northern harrier at the P2 windplant in 1998. Use of the P2 and P3 windplants by northern harrier in 1999 was similar to expected use based on reference area values. No other significant effects were detected for any of the other 21 species examined (Table 19).

Based on all available data, it appears that windpower development does reduce use by some groups and species of birds. The area of reduced use occurs primarily in close proximity (≤ 100 m) to turbines. These results are similar to those of Osborn *et al.* (1998) who reported that birds at Buffalo Ridge avoid flying in areas with turbines, and Leddy (1996), who found that avian use was lower in plots with turbines than at non-turbine plots at Buffalo Ridge. Leddy (1996) attributed lower avian use where turbines were present to avoidance of turbine noise and maintenance activities and less available habitat due to the presence of maintenance roads and use of herbicides along maintenance roads. The cleared area around turbines was approximately 14 m in diameter in P1 (0.04 acres), 24 m in diameter in P2 (0.11 acres), and 36 m in diameter in P3 (0.25 acres). Presence of access roads and the large cleared areas surrounding turbines, especially in the P2 and P3 study areas, likely decrease habitat effectiveness for many bird species.

Although displacement effects related to windpower development have not been evaluated in detail in the U.S., several studies in Europe have addressed this issue. Many groups of birds, including waterfowl, shorebirds, waders, and passerines, have shown disturbance effects ranging from 250 m to as far as 800 m away from turbines (Peterson and Nohr 1989, Pederson and Poulsen 1991, Vauk 1990, Winkelman 1989, Winkelman 1990, Winkelman 1992b). Reductions in use of up to 95% have been recorded (Winkelman 1994). Disturbance to breeding birds appears negligible and was documented during only one study (Pedersen and Poulsen 1991). Most disturbance has involved feeding, resting, and migrating birds (Crockford 1992). For other avian groups or species or at other European wind plants, however, no displacement effects were observed (Karlsson 1983, Phillips 1994, Winkelman 1989, Winkelman 1990).

Results of avian mortality estimates (see below) indicate that any potential decrease in avian use of wind development areas following turbine construction is not likely caused by increased mortality rates due to turbine collisions. For several of the avian groups that showed decreased use following turbine construction, no representatives of these groups were found during fatality searches. Any decreased use of the wind development area documented during this study can likely be attributed primarily to the factors discussed above, including behavioral avoidance of turbines and maintenance activities, reduced habitat effectiveness within wind development areas due to presence of roads and turbine pads, and reduced ability of observers to detect singing birds at turbine plots.

Fatality Search Results

Reference Mortality

During the four-year study, 5,322 fatality searches were conducted on study plots, 2,482 (46.6%) of which were conducted on plots without turbines to estimate reference mortality in the study area, and 2,840 (53.4%) of which were conducted on plots associated with operational turbines in the P1, P2 and P3 study areas (Table 20). Thirty-one avian fatalities comprised of 15 species were found on reference plots during the study period (Table 21). Reference mortality consisted of eight upland gamebirds, seven doves, five sparrows, three waterfowl, three raptors, two blackbirds, one waterbird, one shorebird, and one unidentified bird (Appendix K). Fourteen of the 31 fatalities (45%) were feather spots, 13 (42%) were scavenged, and four (13%) were intact. Twenty-four of the 31 fatalities were found during scheduled fatality searches and the other seven were found while conducting other study activities (Appendix K). Only fatalities found during scheduled fatality searches were used to estimate mean number of fatalities per reference study plot.

Of the 31 fatalities found on reference plots, 10 were found in the Reference Area, three were found in the P1 study area on roadside plots, 12 were found in the P2 study area either on roadside plots (4) or proposed turbine sites prior to construction of turbines (8), and six avian mortalities were found on roadside plots in the P3 study area. The exact cause of death of many birds found in reference plots could not be determined; however, most birds appeared to have been killed by predators or vehicles (Appendix K).

Windpower-related Mortality

Birds

Fifty-five fatalities were found associated with operational wind development features in the P1, P2 and P3 study areas during the 4-year study (Table 21). The 55 mortalities found during the study represent at least 31 species of birds. Forty-two of the fatalities (76.4%) were passerines (Table 22). Passerine groups with the most fatalities were warblers (19), followed by sparrows (6), swallows (5), flycatchers (3), wrens (2) and blackbirds (2). The other passerine fatalities consisted of a ruby-crowned kinglet, western meadowlark, gray catbird, warbling vireo, and unidentified passerine. Other avian groups with more than one fatality included waterfowl (5), waterbirds (3), and upland gamebirds (3). Only one raptor (red-tailed hawk) and one shorebird (killdeer) were found during the study (Table 22). Species with more than one fatality included common yellowthroat (7), barn swallow (4), orange-crowned warbler (4), black-and-white warbler (3), and two of each of the

following species: pied-billed grebe, American coot, mallard, ring-necked pheasant, sedge wren, vesper sparrow, yellow warbler, and unidentified empidonax flycatcher (Table 22).

Forty fatalities (73%) were intact, 11 (20%) were scavenged, and four (7%) were dismembered. Thirty-eight of the fatalities were found during scheduled fatality searches and the remaining 17 were found while conducting other study activities (Appendix K). Only fatalities found during scheduled fatality searches were used to estimate mean number of fatalities per turbine and total wind development area mortality. Thirteen avian fatalities were found in the P1 study area from 1996 through 1999 and 22 were found in the P2 study area, including two birds that appeared to have collided with guy wires on meteorological towers prior to turbine construction and 20 birds that appeared to have collided with turbines in 1998 and 1999. Twenty avian fatalities were found associated with turbines in the P3 study area in 1999.

Dead birds were found from 0.3 m to 60.1 m away from turbines, and the mean distance was 14.8 m. Thirteen percent were found ≤ 10 m from a turbine, 57% were found from 10 m to 20 m, 15% were found from 20 m to 30 m, 4% were found from 30 m to 40 m, none (0%) were found from 40 m to 50 m, and one bird (2%) was found >50 m away from a turbine (60.1 m). Based on the distribution of bird fatalities surrounding turbines (Figure 18), the plot size established for searching was adequate to detect virtually all fatalities (see Gauthreaux 1996).

Necropsies conducted on suitable turbine-related fatalities indicated that injuries sustained by turbine casualties included fractured skulls, wings, necks, ribs, sternums and vertebrae; gashes; fragmentation of the liver and kidney; bruised muscle and abraded skin. Cause of mortality for turbine-related casualties was diagnosed as blunt trauma (E. Williams, Wyoming State Vet Lab, unpubl. necropsy reports). With the exception of four birds, all avian mortalities found at the Buffalo Ridge site were relatively intact. This is in contrast to avian mortalities collected at the Altamont Pass and Solano County Wind Resource Areas in California, where the majority of raptor injuries involved the body being torn in half or body parts being sheared off (Orloff and Flannery 1992). Differences in injuries may be due to the size of birds most frequently involved in collisions (passerines in Minnesota versus raptors in California) and differences in turbine characteristics between wind development areas.

Weather appeared to be strongly related to avian mortality. Of the 55 bird fatalities found associated with wind plant features during the study, 48 were estimated to have been dead for less than one week which allowed weather at the estimated time of death to be recorded. Thirty-one of the 55 mortalities may have occurred in association with thunderstorms, six may have occurred in association with fog, four may have occurred in association with gusty winds, and four possibly occurred in association with rain. Only three fatalities likely occurred when weather was apparently not a factor. Inclement weather has also been identified as a contributing factor in avian collisions with other obstacles, including power lines, buildings, and communications towers (Estep 1989, Howe *et al.* 1995). The largest single avian mortality event documented during this study occurred on 17 May 1999, when 14 fresh birds (11 warblers, two flycatchers, one vireo) were found underneath two adjacent turbines in the P3 wind plant. A severe thunderstorm the previous night may have forced these birds to fly at lower than normal altitudes while migrating. Although migrating passerines generally fly at altitudes higher than 150 m (see Bonneville Power Associates

1987), migrants tend to fly lower during high winds, low clouds, and rain (Rogers *et al.* 1977). Presence of FAA lighting on turbines did not appear to be highly related to mortality. No mortalities were found associated with any of the lighted turbines within the P2 windplant. Of the 20 avian fatalities found within the P3 windplant in 1999, 8 were found at unlit turbines and 12 were found at lighted turbines.

Five of the 34 windpower-related mortalities (15%) whose age could be determined were juvenile birds. Immature birds may be more susceptible to turbine collisions than adults because they may not be as experienced at flying and maneuvering to avoid objects. At a California wind development area, juvenile birds (mostly raptors) comprised a much higher proportion of turbine fatalities than one would expect based on their relative abundance (Orloff and Flannery 1992). Other studies in California have found no relationship between age and susceptibility to collision (Estep 1989). Most of the fatalities on Buffalo Ridge occurred during the spring migration when passerines would be considered adults.

Bird fatalities were fairly widespread throughout the P1 and P2 wind plants. Over the 4-year study, all 73 turbines within the P1 study area were searched for fatalities. Bird fatalities were found at 10 of the 73 turbines during formal fatality searches and at an additional two turbines while conducting other study activities. Multiple fatalities (2) were found only at one of the turbines (Turbine 5549). For combined data from 1998 and 1999, dead birds were found at 13 of the 40 turbine plots randomly selected for fatality searches in the P2 study area, and incidental fatalities were found at an additional four turbines. The only turbine with multiple fatalities was Turbine #3, where four passerines were found on the same day (20 May 1999). In the P3 wind plant, bird fatalities were restricted to four of the 30 turbines randomly selected for sampling in 1999, and fatalities were found at an additional three turbines while conducting other study activities. Most (70%) of the avian mortality documented at the P3 site in 1999 occurred on 17 May 1999, when 14 avian fatalities were found at two adjacent turbines (Turbine #8 and #9); no other turbines within the P3 study area had more than one fatality during the study (Appendix K).

Twenty-three (42%) of the avian fatalities were found at turbines in plowed fields during the spring. Nine fatalities (16%) were found at turbines placed in CRP fields, eight (15%) were found at turbines placed within soybean fields, six (11%) were found in pastures, five (9%) were found at turbines placed within corn fields, and one each were found associated with small grain and alfalfa fields. Effects of habitat within the plot and distance from the plot to the nearest wetland and woodland on the presence/absence of avian mortalities at the plot were compared using t-tests. Turbines with avian mortality were significantly ($p=0.05$) closer to wetlands (436 m) than turbines without avian mortality (594 m). Turbines with avian mortality also had significantly ($p = 0.06$) less crop (42%) within 100 m of the turbine than turbines without mortality (58% crop). There was no significant difference between any of the other habitat variables or distance to woodland variable. This analysis supports our previous conclusion that avoiding wetlands when siting turbines may lead to reduced avian mortality. Distance to wetland may be more important than distance to woodland, as distance to woodland was not significantly different between those turbines with avian mortality and those turbines without documented avian mortality. Although avian densities in crop fields were statistically similar to densities in CRP and hayfields, actual density in cropfields was the lowest among all habitats on Buffalo Ridge. Therefore, it is not surprising that significantly fewer avian

fatalities were found at turbines that had a higher proportion of adjacent cropfields than noncrop habitat types.

Seventy-three percent of all avian fatalities were found outside the breeding season (Figure 19). Based on the species, date found, and habitat, it appears that avian migrants were most prone to turbine collision on Buffalo Ridge. Most of these birds were likely nocturnal migrants that collided with wind plant features at night. Of the 55 fatalities found during the 4-year study, 39 (71%) were likely migrants through the area, 11 (20%) were likely birds that were breeding in the study area, and five (9%) were likely permanent residents. Because most fatalities found during the study were likely nocturnal migrants, it is not known if these groups and species are more susceptible than others or if the fatality data are proportional to the abundance of these birds during the migration period.

There was some correlation between species of turbine fatalities during the breeding season and the turbine exposure index we developed. Three barn swallow fatalities were found during this time period, and the exposure index for barn swallow in summer was ranked #5 of 94 species. Other breeding season fatalities with relatively high exposure indices included one common grackle, with an exposure index of #4 of 94 species, one mallard, with an exposure index ranked #2 of 26 species (RLB data) and #20 of 94 species (point count data), and one dickcissel, with an exposure index ranked #28 of 94 species. The other seven species found during the breeding season had an exposure index of 0, primarily because these species either had very low use of the study areas, were rarely observed flying, or tended to fly at heights above or below the rotor-swept height of turbines. Some of the passerines were found in early June and may have also been late migrants rather than local breeders.

There was little correlation between the exposure index and species of fatalities found during the spring and fall periods. Of the 17 species of fatalities found in spring, 13 had exposure indices of 0, primarily due to low abundance during diurnal surveys. The other four included mallard, with an exposure index of #2 of 57 species (RLB data) and #5 of 143 species (point count survey data), European starling, with an exposure index of #10/143 species, barn swallow, with an exposure index of #17/143, and American coot, with an exposure index of #65/143 (point count data) or 0 (RLB data). Of the eight species of fatalities found in fall, the exposure index was 0 for all but purple martin, which had an exposure index of #39 of 119 species.

Low correlation between the exposure index and most species of fatalities found in the spring and fall provides further evidence that nocturnal migrants comprised the majority of avian fatalities on Buffalo Ridge during these time periods. The exposure index was developed using data on avian abundance and flight behavior collected during daylight hours, which likely differ substantially from abundance and flight behavior of nocturnal migrants.

Bats

In 1994 and 1995, SDSU researchers found 13 bat mortalities in association with turbines in the P1 study area (Higgins *et al.* 1996, Osborn *et al.* 1996). No further bat mortality was documented during searches conducted at this site in 1996 and 1997 (Johnson *et al.* 1997, Johnson *et al.* 1998). In 1998, however, two dead bats were found in the P1 study area and 76 dead bats were collected

in the P2 study area, where the wind plant became operational in the summer of 1998 (Johnson *et al.* 1999). In 1999, 106 dead bats were found, including five in the P1 wind plant, 57 in the P2 wind plant, and 44 in the P3 wind plant that became operational in the summer of 1999 (Table 21). All bat mortalities were found associated with turbines and appeared turbine-related. Injuries sustained by bats included fractured wings, legs, and necks; head wounds; abrasions and abdominal injuries (Appendix L). Bat fatalities were found during the period from 20 May to 19 October; however, most (97%) were found from 15 July to 15 September (Figure 19). One hundred fifteen (63%) of the 184 bats found in 1998 and 1999 were located during scheduled fatality searches; the remainder were found while conducting other study activities. Only fatalities found during scheduled fatality searches were used to estimate mean number of fatalities per turbine and total wind development area mortality.

Bat fatalities were fairly widespread throughout the wind plants. For combined data from 1998 and 1999, dead bats were found at 33 of the 40 turbine plots randomly selected for fatality searches in the P2 study area, and incidental fatalities were found at an additional 31 turbines. In the P3 wind plant, bat fatalities were found at 20 of the 30 turbines randomly selected for sampling in 1999, and fatalities were found at an additional eight turbines while conducting other study activities. The largest number of bats found at any one turbine was eight at Turbine 138 in the P2 study area (Appendix L).

Seventy of the bats (38%) were intact, 111 (60%) were scavenged, one (0.5%) was dismembered and two (1%) were found with injuries but were not captured. Virtually all scavenging of bat carcasses was done by insects. The vast majority of bats were found on the cleared area or access road surrounding turbine pads. These cleared areas average approximately 14 m in diameter at P1 turbine sites, 24 m in diameter at P2 turbine sites, and 36 m in diameter at P3 turbine sites. Distances bats were found from turbines ranged from 0.3 m to 34.8 m, and the average was 10.1 m. Fifty-four percent of all bats were found ≤ 10 m from a turbine, 43% were found from 10 m to 20 m, 3% were found from 20 m to 30 m, and one (0.5%) was found >30 m from a turbine (34.8 m). Although dead bats in CRP or crop fields would be much harder to detect than bats on a cleared gravel pad or road, the overwhelming number of bats found on the cleared areas surrounding the turbine indicate that most bats killed by turbines likely fell within this zone. Based on distribution of bat fatalities surrounding turbines (Figure 18), the 100 m X 100 m search plot was more than adequate to detect all bat fatalities associated with turbines (Gauthreaux 1996).

Twenty-one of the 184 bats found were too decomposed to allow for positive identification. Of the remaining 163 bats, 108 (66%) were hoary bats (*Lasiurus cinereus*), 37 (23%) were red bats (*Lasiurus borealis*), six (4%) were silver-haired bats (*Lasionycteris noctivagans*), six (4%) were eastern pipistrelles (*Pipistrellus subflavus*), five (3%) were little brown bats (*Myotis lucifugus*) and one (0.6%) was a big brown bat (*Eptesicus fuscus*) (Appendix L). With the exception of eastern pipistrelle, which is a protected species of special concern in Minnesota (Minnesota Department of Natural Resources 1996), all species of bats found associated with turbines appear to be relatively common in the state and have no legal protection.

In 1998, 37 bats were sexed by St. Cloud State University, but age data were not collected. Of the 27 hoary bats examined, 17 (63%) were males and 10 (37%) were females. Four of seven red bats

were males and three were females. All three silver-haired bats examined were males. In 1999, 21 bats were both sexed and aged by St. Cloud State University. Of the eight hoary bats examined, six were adults (5 %, 1 &) and two were juveniles (1 %, 1 &). The large percentage of hoary bats comprised of adult males is surprising. Hazard (1982) reports that in Minnesota most adult hoary bats are females because most males that migrate north concentrate in the Far West. Four of the 11 red bats examined were adults (3 %, 1 &), and seven were juveniles (3 %, 3 &, 1 unknown). The one big brown bat examined was an adult male and the one silver-haired bat in the sample was an adult female.

Food items in the stomachs were determined for 17 bats. For all species combined, the most common food item consumed by bats was beetles (Coleoptera), present in 13 bats, followed by butterflies & moths (Lepidoptera), present in nine bats, and true bugs (Homoptera), true flies (Diptera) and caddisflies (Trichoptera), all three of which had been consumed by seven of the bats. Food items of lesser importance included true bugs (Hemiptera), lacewings (Neuroptera), and bees/wasps (Hymenoptera) (Table 23). Virtually all bats appeared well-fed indicating recent feeding activity.

As with birds, weather conditions appeared to be related to bat mortality within the wind development area. Of the 184 bats found, 141 appeared to have been dead for less than one week which allowed weather at the approximate time of death to be estimated. Twenty-six bats were found following thunderstorms with gusty winds, 49 were found following periods of rain and/or fog, 18 were found following combinations of gusty winds, rain, and fog, and five were found following periods of gusty winds. Forty-three bats were found when severe weather was apparently not a factor. Inclement weather has also been associated with migratory bat collisions with buildings and lighthouses (Van Gelder 1956).

The majority of dead bats were found near turbines placed in soybeans (60), followed by cornfields (46), CRP (27) and pasture (24) (Appendix L). Effects of habitat within the plot and distance from the plot to the nearest wetland and woodland on the presence/absence of bat mortalities at the plot were examined using t-tests. Turbines with bat mortality were significantly ($p=0.089$) closer to wetlands (500 m) than turbines without bat mortality (600 m). Turbines with bat mortality also had significantly ($p = 0.001$) less CRP (9%) within 100 m of the turbine than turbines without mortality (31% CRP). There was no significant difference between any of the other habitat variables or distance to woodland variable. This analysis indicates that placing turbines away from wetlands may also reduce bat mortality. Insect abundance may be correlated with distance to wetland, where many flying insects (e.g., caddisflies) originate. This analysis also indicates that bat use may be higher in habitats other than CRP grasslands. Flying insect abundance may be lower within CRP grasslands than other habitat types. Additional research would be required to obtain more definitive data on the relationship between habitat and bat abundance.

No data on habitat use or behavior of bats in the Buffalo Ridge study area were collected as part of wind development area monitoring activities. Hoary, red and silver-haired bats all roost in deciduous trees (Nordquist 1997). Eastern pipistrelles and little brown bats also roost in trees, but may roost in other habitats including under rocks and in wood piles, buildings and other structures (Fitzgerald *et al.* 1994). Bat roost sites in the project area likely include residential woodlots as

well as native stands of trees and shelterbelts. The hoary, red, and silver-haired bats are all migratory species. The eastern pipistrelle and little brown bat spend the winter in hibernacula, but the little brown bat may migrate several hundred miles to hibernate (Hazard 1982). Both hoary and red bats migrate north in May and June. Hoary bats begin their southward movement in late August or early September, whereas red bats migrate south from September through November. The hoary bat ranges widely and can often be found far from trees (Hazard 1982). According to Fitzgerald *et al.* (1994), hoary and red bats typically forage from treetop level to within a meter of the ground, but Clark and Stromberg (1987) report that these bats may circle to high altitudes while feeding. The red bat is known for erratic flight behavior upon first flight in the evening, when it will often fly at altitudes well above treetop level. Silver-haired bats spend most of their time foraging at heights less than 6 m, and little brown bats generally forage at heights of 3 to 6 m.

Because no data on bat abundance are available for the Buffalo Ridge study area, potential population effects of windpower-related mortality cannot be quantified. However, more bat fatalities were found at the P2 study area in 1999 than in 1998. If bat mortality within the wind plant in 1998 had significantly reduced the population, then one might expect lower mortality the following year simply because there would be fewer bats in the area. The fact that even more bat fatalities were found in 1999 suggests that wind plant-related mortality may not be high enough to result in substantial population declines or that most bats killed were migrants rather than resident breeders. Further work would be required to adequately evaluate effects of wind development on bat populations.

Bat mortality at Buffalo Ridge is not unique among wind plants. Previous studies have documented bats colliding with other man-made structures, including buildings, lighthouses, and television towers (Van Gelder 1956, Crawford and Baker 1981). Wind plant-related bat mortality was first documented in Australia, where 22 white-striped mastiff-bats (*Tadarida australis*) were found at the base of turbines over a 4-year period (Hall and Richards 1972). At a 41.4 MW wind plant on Foote Creek Rim in Carbon County, Wyoming, 45 dead bats were found in 1999, resulting in a total mortality estimate of 171 (Johnson *et al.* 2000a), and at a 24.9 MW wind plant on Vansycle Ridge in Umatilla County, Oregon, 10 dead bats were found in 1999, resulting in a total mortality estimate of 28 (Erickson *et al.* 2000). In the summer of 1999, 35 dead bats were found within a 31-turbine windfarm in Wisconsin (Steve Ugoretz, Wisconsin Department of Natural Resources, pers. commun.). Total mortality has not yet been estimated in that study (Shawn Puzen, Wisconsin Public Service Corporation, pers. commun.). Small numbers of dead bats have also been found at wind plants in California (Howell 1997, Howell and Didonato 1991, Orloff and Flannery 1992, Anderson *et al.* 2000, Thelander and Ruge 2000,) and Colorado (Ron Ryder, Colorado State University, pers. commun.). As was the case in Minnesota, most bat fatalities found at other wind plants have been tree bats, with hoary, red and silver-haired bats being the most prevalent fatalities.

The cause of bat collisions with wind turbines or other man-made structures is not well understood (Osborn *et al.* 1996). According to Van Gelder (1956), most bat collisions at other man-made structures occur during migration and are normally associated with inclement weather and avian collision mortalities. Based on this, he hypothesized that inclement weather forced migrating birds to fly lower, and the birds somehow confused migrating bats. At a communication tower in Florida, however, bat fatalities were largely found in the absence of associated avian mortalities (Crawford

and Baker 1981). Based on the timing of bat migrations and lack of any bat mortality during the breeding season, much of the bat mortality at Buffalo Ridge likely involved migrating bats; however, some of the mortality occurring in July and early August may have involved resident bats. Resident bats may visually navigate between well known roosting, watering and feeding sites without echolocating (Osborn *et al.* 1996). If bats move through windfarms on Buffalo Ridge by sight only, then causes of bat mortality would be similar to causes of avian mortality at wind plants.

None of the turbines at the P1 windplant on Buffalo Ridge are lighted. At the P2 windplant, only six of the 143 turbines are lighted (3 at each end of the windplant). Every other turbine within the P3 windplant is lighted due to its proximity to the Pipestone airport. Lights on turbines may attract flying nocturnal insects and increase the probability of bat collisions. However, presence of FAA lighting on turbines did not appear to be highly related to bat mortality. Thirty-four of the 184 dead bats (18%) were found at lighted turbines, which is similar to the proportion of turbines in the WRA that are lighted (22%). In the P3 windplant, 26 bats were found at lighted turbines and 15 were found at unlit turbines. Although not documented, Osborn *et al.* (1996) suggested that bats may possibly roost temporarily on the catwalk or other external turbine structures. Additional research would be required to adequately evaluate causes of wind plant- related bat mortality on Buffalo Ridge.

Fatality Search Biases

Searcher Efficiency

During the four-year study, 839 birds were placed for searcher efficiency trials (Table 24). Searcher efficiency remained fairly consistent between years and varied by size class of bird and habitat type (Table 25). For all habitats combined, 29.4% of the small birds (house sparrow, European starling, juvenile mallard, juvenile northern bobwhite), 39.6% of the medium sized birds (rock dove, adult bobwhite), and 48.8% of the large birds (adult hen mallard) were detected. Detection rates for all size classes combined ranged from 16.7% in wetlands to 75.0% in snow. For the major habitats, detection rates averaged 35.8% in crop fields, 28.6% in CRP, 40.9% in pasture, and 33.3% in hayfields. Overall detection rates for all bird size classes and habitats combined was 38.7% (Table 25).

Carcass Removal Rates

Forty bat and 735 bird carcasses were used for scavenger removal trials during the study (Table 24). For birds, the mean length of time that carcasses remained in the study area prior to removal varied with study site, carcass size, habitat type, and season (Appendix M). Mean length of stay in each study area ranged from 5.10 days in the P1 study area to 8.02 days in the P2 study area (Table 26). Large carcasses lasted the longest (mean = 8.50 days), followed by medium-sized (7.99 days) and small carcasses (4.69 days). Carcasses lasted the shortest period in snow (mean length of stay = 2.09 days) and wetlands (5.59 days), and lasted the longest in CRP (8.55 days) and woodland (9.81 days). Mean length of stay was longest in the fall (9.72 days), followed by summer (6.81 days) and spring (4.30) (Table 26). The overall mean length of stay for all bird carcasses in the Buffalo Ridge study areas was 7.01 days. In addition to raptors and crows, other species observed in the project area that may have scavenged bird carcasses included coyote (*Canis latrans*), red fox (*Vulpes vulpes*), domestic dog (*Canis familiaris*), domestic cat (*Felis catus*), raccoon (*Procyon lotor*), mink (*Mustela*

vison), striped skunk (*Mephitis mephitis*), badger (*Taxidea taxus*), long-tailed weasel (*Mustela frenata*), least weasel (*Mustela nivalis*) and ground squirrels (*Spermophilus* spp.). During summer, the main cause of carcass removal was scavenging by insects, primarily maggots and carrion beetles.

Bat carcasses were monitored only in the summer and fall seasons when most bat mortality occurred. Bat carcasses lasted an average of 10.36 days during this time period. Virtually all scavenging of bat carcasses was done by insects.

Estimation of the Number of Turbine-Related Fatalities

Birds

Estimated total avian mortality over the 8-month study period in the P1 wind development area ranged from 36 in 1999 (90% CI = 1 - 87) to 106 (90% CI= 24-187) in 1996 (Table 27). The average number of turbine fatalities per 8-month period in the P1 wind development area over the 4-year study period was estimated to be 72 (90% CI = 36 to 108). Mean number of birds killed per turbine over the 8-month study period in the P1 study area was estimated to range from 0.50/turbine in 1999 to 1.45/turbine in 1996, with a 4-year average of 0.98/turbine. For the P2 wind development area, mortality estimates based on the number of birds found in 1998 were extrapolated assuming that all 143 turbines were operational during the entire 8-month study interval. Although some turbines became operational in early spring 1998, all the turbines were not in use until late summer 1998. Therefore, the mortality estimate for 1998 is likely higher than actual mortality, but should be representative of expected mortality if all 143 turbines were operational during the entire 8-month study period. The total mortality estimate for the P2 study area was 265 (90% CI = 103 - 481) in 1998 and 383 (90% CI = 85 - 681) in 1999, for a 2-year average of 324 (90% CI = 175 - 473). Estimated mean number of bird fatalities per turbine in the P2 study area was 1.85/turbine in 1998 and 2.68/turbine in 1999, for a 2-year average of 2.27/turbine (Table 27).

In the P3 wind development area, total avian mortality was estimated to be 613 (90% CI = 132 - 1093) in 1999. The mean number of avian fatalities per turbine was estimated to be 4.45 during the 8-month study interval (Table 27). As was the case with analysis of P2 mortality data in 1998, the number of fatalities in the P3 study area in 1999 was estimated under the assumption that all 138 turbines were operational during the entire 8-month study period. Many of the turbines did not become operational until the summer of 1999.

Although most of the avian fatalities found on turbine plots during standardized searches appeared to be attributable to wind turbines, cause of death for some of the fatalities could not be determined. Therefore, the possibility exists that not all fatalities found on turbine plots were caused by turbine collisions. In the P1 study area, the estimated mean number of bird fatalities per turbine per year (0.98) was actually lower than the estimated mean number of bird fatalities per reference plot per year over the 4-year study (1.10) (Table 28). Estimated mean number of avian fatalities per turbine was 2.27 in the P2 study area (1998 and 1999 combined), which is approximately 2.1 times that of natural mortality. The estimated mean number of avian fatalities per turbine per year was 4.45 in the P3 study area (1999 only), which is approximately 4.0 times that of expected natural mortality in the study area (Table 27).

Bats

An estimate of total bat mortality in the P1 study area could not be made in 1998 because neither of the two dead bats found were located on fatality search plots. Although bat mortality did occur within this wind development area in 1998, the fact that only two bats were found within the study area, and that no bats were found during scheduled fatality searches, indicates that bat mortality in the P1 study area was minimal in comparison to the P2 study area. In 1999, three bats were found during scheduled fatality searches in the P1 study area. Total bat mortality was estimated to be 19 (90% CI = 4 to 33) in 1999, and the mean number killed per turbine was estimated to be 0.26 (Table 29).

Estimated total bat mortality in the P2 study area was 231 in 1998 (90% CI = 172 - 290) and 277 (90% CI = 219 - 335) in 1999, for a 2-year average of 254 (90% CI = 213 - 295). Both the 1998 and 1999 bat fatality estimates were calculated using scavenger removal data for bats collected in 1999. Mean number of bat fatalities per turbine during the study period was estimated to be 1.62 in 1998 and 1.94 in 1999, for a 2-year average of 1.78. The estimated total bat mortality in the P3 study area in 1999 was 282 (90% CI = 199 - 365), which equates to a mean of 2.04 bats killed per turbine (Table 29).

CONCLUSIONS

Habitats in the permanent Reference Area selected on Buffalo Ridge in South Dakota were quite similar to the wind development areas. In 1996 and 1997, habitat composition on the Reference Area was not significantly different from that of the study areas comprising the P1, P2, and P3 windpower developments, with the lone exception that the P2 study area had a significantly higher proportion of CRP. Due to a reduction in CRP habitats in the P2 study area, there were no significant differences in habitat composition among all four study areas in 1998 and 1999. Data collected prior to initiation of windpower development in the P2 and P3 study areas indicated that there was no significant difference in either avian abundance or richness between the P2, P3 and Reference areas. Due to its much smaller size, both richness and abundance were significantly lower in the P1 study area than the other three study areas. The permanent Reference Area provided a suitable reference for this study, and is recommended as a reference area if any future wildlife monitoring activities are conducted at Buffalo Ridge.

Birds

During extensive avian surveys across Buffalo Ridge over the last four years, no species classified as endangered by the U.S. Fish and Wildlife Service or State of Minnesota were observed in the study area. Six species classified as state or federal threatened were observed, but appear to be relatively uncommon in this area. Most use of the Buffalo Ridge area by these species occurs during migration; only two pairs of loggerhead shrikes were documented breeding in the study area. Five avian species of state concern were observed in the study area. Franklin's gulls were abundant in the study area, and American white pelicans were fairly common. The other species were rarely observed. No fatalities of species classified as endangered, threatened or special concern were

documented during the study period, and wind development along Buffalo Ridge is not likely to jeopardize any of these species.

Although flight height data collected during the daylight period indicate that the larger Turbine B may pose less risk to some groups of birds than the smaller Turbine A, mortality data indicate that avian mortality rates per turbine are higher for Turbine B. Higher mortality at wind plants where Turbine B is in use likely supports our conclusion that nocturnal migrants are the primary avian group at risk on Buffalo Ridge, as the taller the structure, the greater the potential risk to nocturnal migrants (McCrary *et al.* 1984). Higher mortality associated with Turbine B also may be attributable to the much larger rotor-swept area of Turbine B than Turbine A. Mortality data collected during this study suggest that the smaller (i.e., shorter) turbines have lower avian mortality.

Avian relative abundance on Buffalo Ridge is much higher in wetland and woodland habitats than in other major habitat types. For several groups of birds, there is also a significant relationship between abundance and distance to the nearest wetland or woodland. Avian mortality also increased with decreased distance to wetlands. Data collected during the 4-year study suggest that avian mortality would be reduced if turbines are sited as far away from woodlands and wetlands as possible.

Based on differences in avian densities among habitats on Buffalo Ridge, Leddy *et al.* (1999) suggested that land adjacent to turbines be maintained as cropland or pasture to reduce avian risk. CRP habitats are selected for by several species of grassland birds, and the abundance of CRP habitat in the Midwest has been credited with substantially increasing populations of numerous breeding species (Johnson and Schwartz 1993). Although croplands have the lowest avian use, our data indicate little difference in use among cropland, CRP and pasture. Furthermore, data collected during this study indicate that turbines placed in CRP habitats do not cause unacceptable levels of avian mortality. Therefore, conversion of CRP currently adjacent to operational turbines into crop fields or pasture may not be warranted. Permanently maintaining habitats adjacent to turbines in CRP could mitigate avian losses caused by turbines if increases in density of grassland species that select CRP habitats offset any decreases in avian abundance caused by turbine avoidance or turbine collisions.

The BACI analysis of both point count and RLB survey data indicated that use of the wind development areas following construction is lower than expected for several groups of birds. The area of reduced use occurs primarily in close proximity (i.e., ≤ 100 m) to turbines; however, the area of reduced use is larger for certain avian groups during some seasons. On a large-scale basis, reduced use by birds associated with windpower development appears to be relatively minor and would not likely have any population consequences on a regional level. One positive effect of reduced avian use around turbines would be reduced potential for collision mortality (Crockford 1992).

Over the course of the study, 24 avian fatalities were found while conducting 2,482 fatality searches on reference study plots. Approximately 45 minutes were spent searching each plot; therefore, one reference mortality was found for every 78 person-hours of searching. Based on the extreme effort required to document reference area mortality, we now feel that this study component is probably

not warranted. Although some of the avian fatalities found associated with turbines may not have been caused by collisions, data collected through field examinations and laboratory necropsies indicate that most of the fatalities were likely turbine-related. If future avian mortality studies are conducted on Buffalo Ridge, conservative estimates of mortality should be made assuming all fatalities found associated with turbines are turbine-related. The amount of natural mortality occurring in the study area is so small that attempting to correct fatality estimates for natural mortality is not warranted.

Compared to several other wind plants in the U.S., data collected from 1996-1999 indicate that avian mortality is relatively low on Buffalo Ridge. At the P1 wind plant, no turbine-related avian mortalities were found in 1994 and seven were found in 1995 (Higgins *et al.* 1996). Our mortality estimates indicate an average mortality rate over the last four years of 0.98 birds/turbine in the P1 wind development area during the period 15 March to 15 November. Using this average, an estimated 72 avian fatalities may occur annually at this wind plant. The estimated number of bird fatalities per turbine in the P2 study area was 1.85 in 1998 and 2.68 in 1999. The estimated mortality rate for the P3 wind development area in 1999 was 4.45/turbine. Turbines used in the P2 and P3 area are typical of the large, newer-generation turbines currently being used on most wind plants throughout the U.S., and future windpower developments on Buffalo Ridge will likely have similar turbines. An average of the three turbine fatality estimates for this turbine type (two samples in P2 and one sample in P3) yields an estimate of 2.99 birds per turbine. Based on this average, annual mortality would be approximately 840 birds per year in the P2 and P3 wind plants combined.

For every additional 100 turbines built on Buffalo Ridge in the future, an additional annual mortality of approximately 300 birds would be expected. Composition of future fatalities at Buffalo Ridge would likely be similar to that presented in Table 22.

Our data indicate that wind plant-related avian mortality on Buffalo Ridge primarily involves nocturnal migrants. Mortality of resident breeding birds appears very low, involves primarily common species, and would not likely have any population consequences within the Buffalo Ridge WRA. The estimated number of migrant fatalities can be put into perspective by examining the radar data collected on Buffalo Ridge by Hawrot and Hanowski (1997). Based on these data, an estimated 277 birds per hour passed by within a 1.4 km radius of the radar stations in the fall of 1996, and an estimated 260 birds per hour passed within a 1.4 km radius of the radar stations in the spring of 1997. Data were collected and averaged over a 14-hour period. Extrapolating the hourly estimates to the 14-hour sampling interval yields an estimate of 3,640 migrants/day during the spring migration and 3,878 migrants/day during the fall migration. Further extrapolation to cover the 48-day time periods included in each of the radar samples (26 March to 12 May and 12 September to 29 October) yields a total estimate of 174,720 migrants in the spring and 186,144 migrants in the fall within a 1.4 km radius (2.8 km wide front) of any given point on Buffalo Ridge. From east to west, the total width of the wind development (all three phases) on Buffalo Ridge is approximately 27.2 km. Assuming the radar collected are fairly representative of all of Buffalo Ridge, then the mean number of migrants potentially exposed to turbine collisions on Buffalo Ridge would be approximately $27.2 \text{ km} / 2.8 \text{ km} \times 174,720 = 1,697,280$ in the spring and $27.2 \text{ km} / 2.8 \text{ km} \times 186,144 = 1,808,256$ in the fall, or approximately 3,505,536 birds per year. Given this estimate, the number of avian migrant wind plant related fatalities on Buffalo Ridge is likely inconsequential from a population standpoint.

Bats

Due to its location, habitat, turbine characteristics, or a combination of these factors, bat mortality occurring at the P1 wind plant is minor in comparison to the P2 and P3 wind development areas. The estimated number of bat fatalities per turbine in the P2 study area was 1.62 in 1998 and 1.94 in 1999. The estimated mortality rate for the P3 wind development area in 1999 was 2.04/turbine. An average of the three turbine fatality estimates for the newer-generation turbine types used in the P2 and P3 wind development areas results in an estimate of 1.87 bat fatalities per turbine. Based on this average, annual mortality would be approximately 525 bats per year in the P2 and P3 wind plants combined. For every additional 100 turbines built on Buffalo Ridge in the future, an additional annual mortality of approximately 187 bats would be expected. Bat mortality also increased with decreased distance to wetlands, and mortality may be reduced if turbines are sited as far away from woodlands and wetlands as possible. Future research would be required to assess effect of the mortality on bat populations within the study area.

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Table 1. Observations of threatened and special concern species on Buffalo Ridge study area, 15 March to 15 November, 1996-1999.

Species	Status	Number Observed per Season			Total
		Spring Migration (3/15-5/31)	Breeding Season (6/1-8/15)	Fall Migration (8/16-11/15)	
Bald Eagle	Federal Threatened State Species of Concern	42	0	9	51
Peregrine Falcon	State Threatened	2	0	4	6
Wilson's Phalarope	State Threatened	2	1	0	3
Loggerhead Shrike	State Threatened	6	10 ^a	0	16
Common Tern	State Threatened	1	0	0	1
Horned Grebe	State Threatened	2	0	0	2
Short-eared Owl	State Species of Concern	0	0	1	1
Franklin's Gull	State Species of Concern	422	405	6,778	7,605
Forster's Tern	State Species of Concern	14	0	0	14
American White Pelican	State Species of Concern	78	83	291	452
Marbled Godwit	State Species of Concern	1	0	0	1

^a Includes observation of 2 adults and 2 nestlings in P2 study area in June 1998; two adults were also observed with nest in P3 study area in June 1999.

Table 2. Avian abundance and richness by season on Buffalo Ridge (BR), Phase I (P1), Phase II (P2), Phase III (P3), and Reference Area (REF), 15 March to 15 November 1996-1999.

Point Count Survey Data					
Season	Study Area				REF
	BR	P1	P2	P3	
Spring					
No. Species	142	77	112	81	97
Mean No./Survey ^a	6.59	3.86	6.82	7.16	8.52
Mean No. Species/Survey	2.43	1.70	2.40	2.82	2.99
Summer					
No. Species	94	56	71	69	66
Mean No./Survey	6.06	4.28	5.87	7.56	7.20
Mean No. Species/Survey	3.11	2.41	3.08	3.68	3.50
Fall					
No. Species	119	62	96	73	82
Mean No./Survey	8.99	7.25	9.62	10.32	8.34
Mean No. Species/Survey	1.52	1.03	1.51	1.83	1.80

RLB Survey Data					
Season	Study Area				REF
	BR	P1	P2	P3	
Spring					
No. Species	56	19	42	35	44
Mean No./Survey ^b	15.87	20.91	17.19	11.10	17.64
Mean No. Species/Survey	2.47	2.19	2.93	2.33	2.23
Summer					
No. Species	26	10	22	18	15
Mean No./Survey	5.24	2.44	7.33	5.92	3.41
Mean No. Species/Survey	1.59	1.18	1.85	1.68	1.36
Fall					
No. Species	44	18	34	27	27
Mean No./Survey	22.84	20.95	27.63	23.05	18.47
Mean No. Species/Survey	1.88	1.72	2.11	1.85	1.72

^a Mean number/point count survey was defined as the number of birds observed per observation point per 5-minute period.

^b Mean number/RLB survey was defined as the number of birds observed per observation point per survey day (60-minute period).

Table 3. Mean abundance, percent composition, and percent frequency of occurrence of avian groups observed during point count surveys on the Buffalo Ridge study area, March to November, 1996-1999^a.

Group	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Waterbirds	0.07	0.03	0.49	1.08	0.57	5.44	2.07	1.09	1.89
Waterfowl	0.50	0.06	0.21	7.61	1.05	2.33	12.17	2.39	1.76
Shorebirds	0.32	0.25	0.15	4.85	4.07	1.62	12.32	12.96	5.06
Upland Gamebirds	0.04	0.03	0.09	0.52	0.56	1.04	2.60	1.43	1.93
Doves	0.17	0.40	0.45	2.57	6.60	5.00	8.17	17.40	12.99
Raptors	0.07	0.07	0.08	1.06	1.10	0.87	5.17	5.38	6.74
Woodpeckers	0.05	0.06	0.06	0.80	0.97	0.61	4.31	4.48	4.03
Swallows	0.32	1.05	0.60	4.83	17.37	6.64	11.76	35.33	15.00
Flycatchers	0.03	0.09	0.03	0.37	1.41	0.37	2.07	5.55	1.64
Finches	0.10	0.18	0.11	1.50	2.97	1.27	3.65	10.51	4.90
Blackbirds	2.43	1.68	3.08	36.92	27.80	34.24	51.12	49.34	19.68
Corvids	0.13	0.12	0.26	1.89	1.98	2.91	5.83	5.36	8.36
Tanagers/Orioles	<0.01	<0.01	<0.01	0.07	0.07	<0.01	0.41	0.30	0.03
Vireos/Warblers	0.05	0.11	0.03	0.82	1.77	0.35	3.10	9.52	1.41
Sparrows/sparrowlikes	1.03	1.49	1.05	15.66	24.53	11.65	48.15	62.10	29.68
Longspurs	1.04	0.15	2.04	15.73	2.43	22.72	11.45	7.95	12.12
Chickadees/Nuthatches	0.01	0.01	0.02	0.14	0.12	0.20	0.78	0.55	0.96
Wrens	0.03	0.16	0.02	0.49	2.56	0.25	2.43	12.12	1.74
Thrushes	0.19	0.11	0.21	2.88	1.87	2.28	10.38	7.81	5.90
Other	0.01	0.01	0.02	0.20	0.20	0.20	0.26	0.84	0.29
TOTAL	6.59	6.06	9.00	100.00	100.0	100.00	--	--	--

^aMean abundance = mean number observed /5-minute count; Percent Composition = percent of all observations comprised of group *i*; Frequency of Occurrence = percent of all surveys where group *i* was recorded.

Table 3 (Continued). Mean abundance, percent composition, and percent frequency of occurrence of avian groups observed during point count surveys on the Buffalo Ridge study area, March to November, 1996-1999^a.

Group	Phase I								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Waterbirds	0.04	0.05	0.14	0.98	1.24	1.99	1.04	1.25	1.23
Waterfowl	0.23	0.03	0.01	5.97	0.69	0.15	6.49	1.74	0.33
Shorebirds	0.16	0.10	0.09	4.05	2.24	1.20	6.49	6.72	2.64
Upland Gamebirds	0.03	0.02	0.06	0.67	0.52	0.86	2.34	0.87	1.16
Doves	0.13	0.37	0.27	3.35	8.58	3.71	6.69	17.90	11.09
Raptors	0.02	0.04	0.03	0.54	0.83	0.37	2.08	2.63	2.54
Woodpeckers	0.03	0.03	0.02	0.88	0.75	0.29	3.13	2.77	1.75
Swallows	0.14	0.63	0.37	3.60	14.65	5.09	6.28	22.44	10.99
Flycatchers	0.01	0.02	0.01	0.30	0.39	0.17	0.78	1.38	0.60
Finches	0.04	0.11	0.10	0.95	2.49	1.41	2.34	7.64	5.05
Blackbirds	1.68	1.36	4.40	43.44	31.78	60.65	43.66	49.55	18.69
Corvids	0.08	0.07	0.15	2.04	1.66	2.02	5.00	4.15	5.36
Tanagers/Orioles	<0.01	<0.01	<0.01	0.03	0.03	0.02	0.13	0.13	0.16
Vireos/Warblers	0.03	0.13	0.01	0.81	3.08	0.20	1.82	10.94	0.98
Sparrows/sparrowlikes	0.59	0.97	0.52	15.19	22.70	7.14	32.83	49.61	19.45
Longspurs	0.45	0.07	0.86	11.54	1.69	11.91	9.19	5.38	6.72
Chickadees/Nuthatches	0	0.01	0.01	0	0.15	0.11	0	0.47	0.47
Wrens	0.05	0.19	0.02	1.35	4.36	0.26	3.26	13.35	1.36
Thrushes	0.17	0.09	0.16	4.27	1.98	2.24	7.60	5.38	4.41
Other	<0.01	0.01	0.02	0.03	0.18	0.22	0.13	0.78	0.11
TOTAL	3.86	4.28	7.25	100.00	100.0	100.00	--	--	--

^aMean abundance = mean number observed /5-minute count; Percent Composition = percent of all observations comprised of group *i*; Frequency of Occurrence = percent of all surveys where group *i* was recorded.

Table 3 (Continued). Mean abundance, percent composition, and percent frequency of occurrence of avian groups observed during point count surveys on the Buffalo Ridge study area, March to November, 1996-1999^a.

Group	Phase II								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Waterbirds	0.09	0.02	0.49	1.24	0.30	5.08	3.03	0.98	2.20
Waterfowl	0.54	0.10	0.30	7.95	1.74	3.07	15.42	3.36	2.59
Shorebirds	0.29	0.27	0.16	4.29	4.51	1.63	12.63	14.33	6.03
Upland Gamebirds	0.05	0.02	0.10	0.68	0.39	1.03	3.46	1.47	2.18
Doves	0.16	0.40	0.53	2.31	6.80	5.51	7.60	15.54	12.86
Raptors	0.10	0.08	0.08	1.52	1.27	0.87	6.60	6.11	7.17
Woodpeckers	0.04	0.05	0.04	0.61	0.77	0.39	3.12	3.22	2.89
Swallows	0.27	1.09	0.63	4.00	18.54	6.56	11.84	37.78	15.49
Flycatchers	0.02	0.08	0.04	0.32	1.39	0.38	2.01	5.11	1.71
Finches	0.11	0.17	0.11	1.60	2.94	1.17	3.58	9.75	4.87
Blackbirds	2.55	1.29	2.93	37.46	21.94	30.51	44.44	41.70	17.99
Corvids	0.11	0.11	0.21	1.59	1.80	2.19	4.66	4.67	7.20
Tanagers/Orioles	0.01	<0.01	0	0.07	0.04	0	0.44	0.23	0
Vireos/Warblers	0.05	0.10	0.03	0.77	1.62	0.27	3.12	8.44	1.54
Sparrows/sparrowlikes	1.14	1.69	1.13	16.70	28.76	11.75	51.31	66.57	29.80
Longspurs	1.09	0.18	2.57	15.96	3.03	26.76	12.45	8.79	14.52
Chickadees/Nuthatches	0.01	0.01	0.01	0.11	0.13	0.14	0.58	0.53	0.70
Wrens	0.02	0.16	0.02	0.31	2.64	0.21	1.58	12.43	1.73
Thrushes	0.14	0.07	0.20	2.11	1.26	2.12	8.65	5.66	4.86
Other	0.03	0.01	0.03	0.38	0.14	0.35	0.31	0.68	0.61
TOTAL	6.82	5.87	9.62	100.00	100.0	100.00	--	--	--

^aMean abundance = mean number observed /5-minute count; Percent Composition = percent of all observations comprised of group *i*; Frequency of Occurrence = percent of all surveys where group *i* was recorded.

Table 3 (Continued). Mean abundance, percent composition, and percent frequency of occurrence of avian groups observed during point count surveys on the Buffalo Ridge study area, March to November, 1996-1999^a.

Group	Phase III								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Waterbirds	0.13	0.08	0.88	1.79	1.05	8.52	1.38	1.47	2.27
Waterfowl	0.47	0.04	0.43	6.51	0.50	4.13	12.12	1.73	2.11
Shorebirds	0.45	0.30	0.14	6.27	3.91	1.31	14.88	11.70	5.39
Upland Gamebirds	0.03	0.03	0.07	0.36	0.40	0.63	1.60	1.60	1.69
Doves	0.24	0.48	0.49	3.29	6.35	4.77	10.38	21.60	16.16
Raptors	0.04	0.09	0.09	0.54	1.17	0.89	3.90	7.30	7.62
Woodpeckers	0.06	0.04	0.07	0.86	0.58	0.70	5.08	3.37	5.30
Swallows	0.35	1.21	0.68	4.88	16.05	6.61	14.67	43.40	18.61
Flycatchers	0.01	0.07	0.03	0.15	0.93	0.24	0.90	4.77	1.29
Finches	0.06	0.22	0.09	0.82	2.93	0.82	4.20	12.53	4.83
Blackbirds	2.86	2.59	2.84	39.95	34.22	27.49	65.68	60.53	27.23
Corvids	0.19	0.21	0.44	2.69	2.76	4.26	7.70	7.33	11.18
Tanagers/Orioles	0	0.01	0	0	0.12	0	0	0.53	0
Vireos/Warblers	0.04	0.14	0.07	0.53	1.81	0.68	3.40	12.37	1.77
Sparrows/sparrowlikes	1.09	1.61	1.02	15.24	21.26	9.86	50.72	65.23	35.59
Longspurs	0.85	0.11	2.80	11.89	1.39	27.11	9.77	6.93	12.47
Chickadees/Nuthatches	0.01	0	0.02	0.09	0	0.19	0.33	0	1.05
Wrens	0.03	0.16	0.03	0.35	2.16	0.30	2.10	12.47	2.31
Thrushes	0.26	0.15	0.15	3.63	2.04	1.47	13.57	9.93	6.27
Other	0.01	0.03	0	0.14	0.36	0	0.60	0.87	0
TOTAL	7.16	7.56	10.32	100.00	100.0	100.00	--	--	--

^aMean abundance = mean number observed /5-minute count; Percent Composition = percent of all observations comprised of group *i*; Frequency of Occurrence = percent of all surveys where group *i* was recorded.

Table 3 (Continued). Mean abundance, percent composition, and percent frequency of occurrence of avian groups observed during point count surveys on the Buffalo Ridge study area, March to November, 1996-1999^a.

Group	Reference Area								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Waterbirds	0.02	0.01	0.54	0.27	0.18	6.42	1.39	0.81	1.56
Waterfowl	0.74	0.03	0.04	8.64	0.43	0.44	10.78	1.39	1.08
Shorebirds	0.46	0.33	0.20	5.35	4.64	2.37	16.21	17.96	5.26
Upland Gamebirds	0.02	0.08	0.14	0.26	1.10	1.66	1.62	1.80	2.36
Doves	0.18	0.37	0.43	2.15	5.14	5.10	9.28	17.64	12.63
Raptors	0.07	0.06	0.11	0.78	0.88	1.35	6.35	5.03	9.65
Woodpeckers	0.10	0.14	0.12	1.11	1.89	1.39	7.94	10.42	8.17
Swallows	0.61	1.31	0.70	7.09	18.16	8.39	15.34	36.87	15.10
Flycatchers	0.06	0.19	0.06	0.70	2.59	0.71	4.84	12.07	2.99
Finches	0.18	0.24	0.16	2.15	3.37	1.89	4.91	13.73	4.89
Blackbirds	2.56	2.19	2.15	30.00	30.46	25.80	63.03	57.33	17.96
Corvids	0.16	0.13	0.35	1.84	1.80	4.23	8.06	6.60	11.88
Tanagers/Orioles	0.01	0.01	0	0.13	0.10	0	1.11	0.45	0
Vireos/Warblers	0.10	0.08	0.03	1.21	1.14	0.36	4.37	7.91	1.28
Sparrows/sparrowlikes	1.23	1.48	1.47	14.38	20.59	17.67	55.69	62.93	35.66
Longspurs	1.71	0.20	1.49	20.02	2.75	17.80	13.00	9.81	12.26
Chickadees/Nuthatches	0.03	0.01	0.04	0.33	0.19	0.45	2.65	1.21	2.04
Wrens	0.04	0.11	0.03	0.50	1.56	0.31	3.91	9.73	1.70
Thrushes	0.26	0.20	0.31	3.07	2.82	3.66	14.80	13.79	9.71
Other	0	0.01	0	0	0.20	0	0	1.27	0
TOTAL	8.53	7.20	8.34	100.00	100.0	100.00	--	--	--

^aMean abundance = mean number observed /5-minute count; Percent Composition = percent of all observations comprised of group *i*; Frequency of Occurrence = percent of all surveys where group *i* was recorded.

Table 4. Five most abundant bird species (based on mean number per 5-minute survey) observed during point count surveys on Buffalo Ridge, 15 March to 15 November 1996-1999.

Study Area	Spring		Summer		Fall	
	Species	#/survey	Species	#/survey	Species	#/survey
Buffalo Ridge	Red-winged Blackbird	1.18	Barn Swallow	0.76	Lapland Longspur	1.16
	Lapland Longspur	0.76	Red-winged Blackbird	0.62	European Starling	0.97
	Brown-headed Cowbird	0.39	Common Grackle	0.33	Horned Lark	0.86
	Common Grackle	0.34	European Starling	0.32	Red-winged Blackbird	0.72
	Horned Lark	0.27	Brown-headed Cowbird	0.29	Barn Swallow	0.52
Phase I	Red-winged Blackbird	0.72	Barn Swallow	0.59	European Starling	1.55
	Common Grackle	0.40	Red-winged Blackbird	0.57	Red-winged Blackbird	1.09
	Brown-headed Cowbird	0.31	Common Grackle	0.29	Lapland Longspur	0.65
	Horned Lark	0.29	Brown-headed Cowbird	0.28	Barn Swallow	0.34
	American Robin	0.15	Mourning Dove	0.26	Common Grackle	0.25
Phase II	Red-winged Blackbird	1.31	Barn Swallow	0.78	Horned Lark	1.34
	Lapland Longspur	0.77	Red-winged Blackbird	0.53	Lapland Longspur	1.21
	Brown-headed Cowbird	0.32	Savannah Sparrow	0.29	Red-winged Blackbird	0.81
	Horned Lark	0.31	Bobolink	0.29	European Starling	0.67
	Western Meadowlark	0.29	Mourning Dove	0.24	Barn Swallow	0.52
Phase III	Red-winged Blackbird	1.44	Barn Swallow	0.87	Lapland Longspur	2.29
	Lapland Longspur	0.73	Red-winged Blackbird	0.80	European Starling	1.15
	Common Grackle	0.54	European Starling	0.69	Barn Swallow	0.64
	Brown-headed Cowbird	0.33	Common Grackle	0.53	Franklin's Gull	0.58
	Western Meadowlark	0.29	Brown-headed Cowbird	0.35	Horned Lark	0.46
Reference Area	Lapland Longspur	1.42	Barn Swallow	0.79	European Starling	0.88
	Red-winged Blackbird	1.16	Red-winged Blackbird	0.72	Horned Lark	0.82
	Brown-headed Cowbird	0.69	Common Grackle	0.44	Lapland Longspur	0.65
	Barn Swallow	0.47	Cliff Swallow	0.44	Barn Swallow	0.61
	Western Meadowlark	0.35	Brown-headed Cowbird	0.43	Red-winged Blackbird	0.43

Table 5. Five most commonly occurring bird species (based on percent frequency of occurrence) observed during point count surveys on Buffalo Ridge, 15 April to 15 November 1996-1999.

Study Area	Spring		Summer		Fall	
	Species	% freq.	Species	% freq.	Species	% freq.
Buffalo Ridge	Red-winged Blackbird	29.0	Barn Swallow	29.1	Barn Swallow	14.1
	Western Meadowlark	21.3	Red-winged Blackbird	26.2	European Starling	9.9
	Brown-headed Cowbird	17.1	Western Meadowlark	17.8	Mourning Dove	9.5
	Savannah Sparrow	12.7	Savannah Sparrow	16.3	Horned Lark	9.4
	Common Grackle	11.3	Brown-headed Cowbird	14.5	Western Meadowlark	8.6
Phase I	Red-winged Blackbird	23.2	Red-winged Blackbird	26.9	Barn Swallow	10.1
	Brown-headed Cowbird	15.0	Barn Swallow	21.2	Mourning Dove	8.9
	Common Grackle	11.9	Mourning Dove	14.5	European Starling	8.7
	Western Meadowlark	11.7	Brown-headed Cowbird	14.4	Horned Lark	4.8
	Vesper Sparrow	9.5	Sedge Wren	12.6	American Goldfinch	4.6
Phase II	Red-winged Blackbird	25.1	Barn Swallow	30.7	Barn Swallow	14.3
	Western Meadowlark	22.8	Red-winged Blackbird	22.1	Horned Lark	11.4
	Brown-headed Cowbird	14.2	Savannah Sparrow	20.0	European Starling	8.5
	Savannah Sparrow	13.9	Western Meadowlark	16.6	Mourning Dove	8.3
	Mallard	11.6	Grasshopper Sparrow	13.6	Western Meadowlark	8.1
Phase III	Red-winged Blackbird	41.5	Barn Swallow	35.9	Barn Swallow	18.4
	Western Meadowlark	24.6	Red-winged Blackbird	33.1	European Starling	14.0
	Common Grackle	19.9	Savannah Sparrow	23.7	Western Meadowlark	12.7
	Brown-headed Cowbird	19.9	Western Meadowlark	23.3	Mourning Dove	11.5
	Savannah Sparrow	18.3	Common Grackle	17.9	Horned Lark	9.8
Reference Area	Red-winged Blackbird	34.2	Red-winged Blackbird	28.8	Barn Swallow	14.0
	Western Meadowlark	25.4	Barn Swallow	28.4	Mourning Dove	11.4
	Brown-headed Cowbird	24.1	Western Meadowlark	22.9	European Starling	11.0
	Savannah Sparrow	13.3	Brown-headed Cowbird	19.1	Western Meadowlark	10.9
	Vesper Sparrow	13.3	Song Sparrow	18.4	Horned Lark	9.7

Table 6. Mean abundance, percent composition, and percent frequency of occurrence of avian groups observed during RLB surveys on the Buffalo Ridge study area, 15 March to 15 November 1996-1999^a.

Buffalo Ridge									
Group	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Waterbirds	2.16	1.20	14.64	13.62	22.91	64.10	19.08	12.29	21.29
Waterfowl	9.40	1.16	4.29	59.24	22.18	18.79	47.48	16.57	15.02
Shorebirds	1.60	0.43	0.21	10.11	8.19	0.91	12.81	9.06	3.22
Upland Game	0.07	0.01	0.05	0.47	0.12	0.21	3.42	0.64	2.04
Raptors	1.47	1.34	1.69	9.23	25.57	7.40	64.79	64.27	68.96
Corvids	1.16	1.10	1.96	7.29	21.02	8.58	38.71	29.66	32.96
TOTAL	15.87	5.24	22.84	100.00	100.00	100.00	--	--	--

Phase I									
Group	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Waterbirds	2.00	0.46	13.39	9.59	18.94	63.94	21.25	11.67	30.65
Waterfowl	15.18	0.20	4.57	72.62	8.19	21.82	47.08	11.25	10.12
Shorebirds	1.56	0.40	0.04	7.47	16.38	0.17	6.25	5.00	1.79
Upland Game	0.13	0	0	0.64	0	0	6.67	0	0
Raptors	1.40	0.98	1.80	6.68	40.27	8.60	61.67	63.33	69.35
Corvids	0.63	0.40	1.15	3.01	16.21	5.47	33.75	16.67	23.21
TOTAL	20.91	2.44	20.95	100.00	100.00	100.00	--	--	--

Phase II									
Group	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Waterbirds	3.57	1.60	18.43	20.76	21.87	66.71	23.19	15.21	29.68
Waterfowl	9.72	3.07	5.83	56.50	41.88	21.12	65.56	27.29	22.18
Shorebirds	0.99	0.34	0.32	5.76	4.58	1.17	12.22	8.54	5.93
Upland Game	0.08	0.01	0.05	0.44	0.11	0.18	3.47	0.83	2.58
Raptors	1.72	1.53	1.70	9.98	20.93	6.14	68.89	71.25	72.22
Corvids	1.12	0.78	1.28	6.50	10.63	4.64	33.26	22.92	25.54
TOTAL	17.20	7.33	27.62	100.00	100.00	100.00	--	--	--

^a Mean abundance = Mean number observed /60-minute count; Percent Composition = percent of all observations comprised of group *i*; Frequency of Occurrence = percent of all surveys where group *i* was recorded.

Table 6 (Continued). Mean abundance, percent composition, and percent frequency of occurrence of avian groups observed during RLB surveys on the Buffalo Ridge study area, 15 March to 15 November 1996-1999^a.

Group	Phase III								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Waterbirds	0.91	2.10	14.17	8.20	35.53	61.49	15.14	12.57	18.29
Waterfowl	6.15	0.40	3.83	55.42	6.77	16.62	38.47	13.96	11.39
Shorebirds	1.18	0.38	0.10	10.62	6.41	0.41	8.82	7.85	1.98
Upland Game	0.06	0.01	0.09	0.53	0.12	0.41	2.50	0.69	2.82
Raptors	1.46	1.25	1.68	13.19	21.04	7.29	68.06	59.51	67.20
Corvids	1.34	1.78	3.18	12.04	30.14	13.78	54.17	46.46	46.41
TOTAL	11.10	5.92	23.05	100.00	100.00	100.00	--	--	--

Group	Reference Area								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Waterbirds	2.06	0.14	11.73	11.66	4.20	63.52	18.19	9.31	12.76
Waterfowl	10.41	0.34	3.11	59.02	9.94	16.85	38.54	10.25	13.13
Shorebirds	2.66	0.58	0.26	15.06	17.10	1.43	19.58	12.13	2.22
Upland Game	0.07	0.01	0.01	0.39	0.18	0.08	3.19	0.60	1.39
Raptors	1.24	1.36	1.66	7.02	39.90	8.97	58.47	62.35	67.32
Corvids	1.19	0.98	1.69	6.76	28.68	9.15	30.35	23.95	30.20
TOTAL	17.64	3.41	18.47	100.00	100.00	100.00	--	--	--

^a Mean abundance = Mean number observed /60-minute count; Percent Composition = percent of all observations comprised of group *i*; Frequency of Occurrence = percent of all surveys where group *i* was recorded.

Table 7. Most abundant bird species (based on mean number per 60-minute survey) observed during RLB surveys on Buffalo Ridge, 15 March to 15 November 1996-1999.

Study Area	Spring		Summer		Fall	
	Species	#/survey	Species	#/survey	Species	#/survey
Buffalo Ridge	Snow Goose	2.96	American Crow	1.10	Franklin's Gull	11.59
	Canada Goose	2.73	Franklin's Gull	0.84	American Crow	1.96
	Mallard	2.04	Mallard	0.80	Canada Goose	1.87
	American Crow	1.16	Red-tailed Hawk	0.54	Double-crested Cormorant	1.64
	Franklin's Gull	1.06	Northern Harrier	0.35	Mallard	1.40
Phase I	Snow Goose	9.23	Swainson's Hawk	0.43	Franklin's Gull	7.52
	Canada Goose	5.19	American Crow	0.40	Mallard	3.80
	Double-crested Cormorant	0.92	American White Pelican	0.33	Double-crested Cormorant	3.51
	Pectoral Sandpiper	0.90	Red-tailed Hawk	0.26	American White Pelican	1.58
	American White Pelican	0.88	American Kestrel	0.20	American Crow	1.15
Phase II	Canada Goose	3.97	Mallard	2.22	Franklin's Gull	14.51
	Mallard	3.08	Franklin's Gull	1.04	Canada Goose	2.89
	Franklin's Gull	2.49	American Crow	0.78	Ring-billed Gull	2.15
	Snow Goose	1.40	Northern Harrier	0.65	Mallard	2.11
	American Crow	1.12	Canada Goose	0.60	American Crow	1.28
Phase III	Snow Goose	3.71	American Crow	1.78	Franklin's Gull	12.24
	Mallard	1.46	Franklin's Gull	1.74	American Crow	3.18
	American Crow	1.34	Red-tailed Hawk	0.39	Double-crested Cormorant	1.52
	Canada Goose	0.65	Northern Harrier	0.32	Canada Goose	1.23
	Red-tailed Hawk	0.59	American Kestrel	0.31	Unidentified Duck	0.97
Reference Area	Canada Goose	2.75	American Crow	0.98	Franklin's Gull	9.37
	Mallard	2.04	Red-tailed Hawk	0.79	Canada Goose	1.85
	Snow Goose	1.68	Swainson's Hawk	0.27	Double-crested Cormorant	1.74
	Greater White-fronted Goose	1.63	Upland Sandpiper	0.20	American Crow	1.69
	American Crow	1.19	Mallard	0.17	Red-tailed Hawk	0.86

Table 8. Most commonly occurring bird species (based on percent frequency of occurrence) observed during RLB surveys on Buffalo Ridge, 15 March to 15 November 1996-1999.

Study Area	Spring		Summer		Fall	
	Species	% freq.	Species	% freq.	Species	% freq.
Buffalo Ridge	American Crow	38.71	Red-tailed Hawk	33.43	Red-tailed Hawk	44.96
	Mallard	38.54	American Crow	29.66	American Crow	32.96
	Red-tailed Hawk	32.29	Northern Harrier	19.93	Northern Harrier	20.57
	Northern Harrier	30.04	Swainson's Hawk	16.35	American Kestrel	13.02
	Canada Goose	12.73	Mallard	15.14	Swainson's Hawk	10.45
Phase I	American Crow	33.75	Swainson's Hawk	30.00	Red-tailed Hawk	44.05
	Northern Harrier	27.92	Red-tailed Hawk	21.67	American Crow	23.21
	Red-tailed Hawk	27.08	American Crow	16.67	American Kestrel	17.86
	Mallard	25.83	American Kestrel	12.08	Swainson's Hawk	12.80
	Canada Goose	23.33	Mallard	11.25	Franklin's Gull	10.71
Phase II	Mallard	56.25	Red-tailed Hawk	36.25	Red-tailed Hawk	50.10
	American Crow	33.26	Northern Harrier	32.29	American Crow	25.54
	Red-tailed Hawk	32.92	Mallard	26.46	Northern Harrier	24.11
	Northern Harrier	31.53	American Crow	22.92	Mallard	12.28
	Swainson's Hawk	14.03	Swainson's Hawk	14.38	Franklin's Gull	11.65
Phase III	American Crow	54.17	American Crow	46.46	American Crow	46.41
	Red-tailed Hawk	37.43	Red-tailed Hawk	28.54	Red-tailed Hawk	38.77
	Northern Harrier	31.81	American Kestrel	20.90	Northern Harrier	21.55
	Mallard	30.90	Northern Harrier	17.78	Swainson's Hawk	15.44
	American Kestrel	13.89	Swainson's Hawk	15.28	American Kestrel	10.77
Reference Area	Mallard	32.71	Red-tailed Hawk	39.40	Red-tailed Hawk	46.33
	American Crow	30.35	American Crow	23.95	American Crow	30.20
	Red-tailed Hawk	28.26	Swainson's Hawk	14.83	Northern Harrier	20.93
	Northern Harrier	27.50	Northern Harrier	13.17	American Kestrel	16.96
	American Kestrel	10.28	Mallard	9.55	Swainson's Hawk	9.29

Table 9. Mean flight heights of birds observed during point count and RLB surveys.

Point Count Survey Data	
Group	Mean Flight Height (m)
Waterbirds	44.30
Waterfowl	46.93
Shorebirds	10.46
Upland Gamebirds	2.26
Doves	9.15
Raptors	15.13
Woodpeckers	7.72
Swallows	6.21
Flycatchers	8.38
Blackbirds	17.24
Corvids	13.87
Vireos/Warbblers	8.38
Sparrow/Sparrowlikes	5.95
Thrushes	11.83
Longspurs	15.67
Finches	11.59
Tanagers/Orioles	7.38
Wrens	1.75
Chickadees/Nuthatches	6.43
Other	15.43
All Passerines	13.88
All Birds	15.98

RLB Survey Data	
Group	Mean Flight Height (m)
Waterbirds	36.32
Waterfowl	73.35
Shorebirds	21.52
Upland Gamebirds	1.57
Raptors	26.61
Crows	13.53
Other	18.00
All Birds	43.13

Table 10. Percent of birds observed flying below, within and above the rotor-swept height of Turbine A and Turbine B^a.

Group	Point Count Surveys							
	# Flocks	# Individ.	Turbine A			Turbine B		
			Below	Within	Above	Below	Within	Above
Waterbirds	162	2279	10.2	71.4	18.4	24.5	69.9	5.6
Waterfowl	483	2167	31.7	46.7	21.6	47.7	36.7	15.6
Shorebirds	742	1607	82.1	17.5	0.4	92.2	7.7	0.1
Upland Gamebirds	60	271	100.0	0.0	0.0	100.0	0.0	0.0
Doves	1251	3029	91.8	8.2	0.0	98.6	1.4	0.0
Raptors	531	580	72.1	25.0	2.9	88.4	10.0	1.6
Woodpeckers	253	307	95.8	3.9	0.3	98.4	1.6	0.0
Swallows	2458	6216	95.4	4.2	0.3	97.3	2.7	0.0
Flycatchers	189	286	94.1	5.9	0.0	95.5	4.5	0.0
Blackbirds	4375	20491	76.6	17.1	6.3	87.1	7.4	5.5
Corvids	544	1467	75.5	24.5	0.1	87.9	12.1	0.0
Vireos/Warblers	44	66	93.9	6.1	0.0	100.0	0.0	0.0
Sparrow/Sparrowlikes	2107	4173	94.9	4.5	0.6	97.4	2.4	0.1
Thrushes	447	1021	85.2	13.1	1.7	91.2	7.1	1.7
Longspurs	971	10396	68.4	31.0	0.6	84.8	15.1	0.1
Finches	550	1053	87.4	12.3	0.3	94.0	6.0	0.0
Tanagers/Orioles	9	13	100.0	0.0	0.0	100.0	0.0	0.0
Wrens	23	28	100.0	0.0	0.0	100.0	0.0	0.0
Chickadees/Nuthatches	9	14	100.0	0.0	0.0	100.0	0.0	0.0
Other	39	143	65.7	34.3	0.0	93.7	6.3	0.0
All Passerines	11,745	45,346	79.5	17.3	3.1	89.3	8.1	2.6
All Birds	15,247	55,607	75.7	20.1	4.2	85.7	11.3	3.0

^a Turbine A: 0-19.5 m = below; 19.5-52.5 m = within; >52.5 m = above rotor-swept height.

Turbine B: 0 - 26 m = below; 26 - 74 m = within; >74 m = above rotor-swept height.

Table 10 (Continued). Percent of birds observed flying below, within and above the rotor-swept height of Turbine A and Turbine B^a.

RLB Surveys								
Group	# Flocks	# Individuals	Turbine A			Turbine B		
			Below	Within	Above	Below	Within	Above
Waterbirds	312	8157	13.6	57.5	28.9	32.1	45.4	22.5
Waterfowl	448	5450	6.6	28.6	64.8	13.0	29.2	57.8
Shorebirds	118	812	18.4	81.4	0.2	45.2	54.6	0.2
Upland Gamebirds	18	44	100.0	0.0	0.0	100.0	0.0	0.0
Raptors	1656	1881	43.4	43.5	13.1	61.6	28.3	10.1
Corvids	601	1796	72.5	25.5	1.9	88.5	10.2	1.4
All Birds	3,156	18,144	20.9	45.1	34.0	35.7	35.6	28.7

^a Turbine A: 0-19.5 m = below; 19.5-52.5 m = within; >52.5 m = above rotor-swept height.

Turbine B: 0 - 26 m = below; 26 - 74 m = within; >74 m = above rotor-swept height.

Table 11. Ten species with highest exposure to turbines in Buffalo Ridge WRA from point count survey data based on mean abundance, proportion of activity budget spent flying, and proportion of flight heights within rotor-swept height of turbines.

Spring			
Species	Exposure index ^a		Exposure index ^a
	Turbine A	Species	
Lapland Longspur	0.713	Lapland Longspur	0.295
Red-winged Blackbird	0.394	Horned Lark	0.190
Horned Lark	0.306	Red-winged Blackbird	0.156
Unidentified Blackbird	0.122	Snow Goose	0.056
Common Grackle	0.089	Common Grackle	0.051
Mallard	0.060	Unidentified Blackbird	0.044
Brown-headed Cowbird	0.058	Canada Goose	0.040
Snow Goose	0.056	Common Redpoll	0.039
Canada Goose	0.051	Greater White-fronted Goose	0.031
Yellow-headed Blackbird	0.050	Mallard	0.030

Summer			
Species	Exposure index ^a		Exposure index ^a
	Turbine A	Species	
Red-winged Blackbird	0.207	Horned Lark	0.103
Horned Lark	0.166	Red-winged Blackbird	0.082
Cliff Swallow	0.109	Cliff Swallow	0.061
Common Grackle	0.086	Barn Swallow	0.057
Barn Swallow	0.076	Common Grackle	0.049
European Starling	0.075	European Starling	0.044
Unidentified Blackbird	0.051	Bobolink	0.028
Brown-headed Cowbird	0.044	Bank Swallow	0.020
Bank Swallow	0.043	Unidentified Blackbird	0.018
American Goldfinch	0.036	Killdeer	0.015

Fall			
Species	Exposure index ^a		Exposure index ^a
	Turbine A	Species	
Lapland Longspur	1.093	Horned Lark	0.599
Horned Lark	0.965	Lapland Longspur	0.452
Unidentified Blackbird	0.503	Unidentified Blackbird	0.180
Red-winged Blackbird	0.239	Franklin's Gull	0.140
European Starling	0.226	European Starling	0.132
Franklin's Gull	0.194	Double-crested Cormorant	0.127
Double-crested Cormorant	0.123	Red-winged Blackbird	0.094
Canada Goose	0.059	Unidentified Gull	0.050
Common Grackle	0.054	Canada Goose	0.046
Barn Swallow	0.052	Barn Swallow	0.040

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Table 12. Ten species with highest exposure to turbines in Buffalo Ridge WRA from RLB survey data based on mean abundance, proportion of activity budget spent flying, and proportion of flight heights within rotor-swept height of the turbines.

Spring			
Species	Exposure index ^a		Exposure index ^a
	Turbine A	Species	
Canada Goose	0.831	Canada Goose	0.847
Mallard	0.602	Snow Goose	0.552
Franklin's Gull	0.506	Mallard	0.474
Double-crested Cormorant	0.355	Franklin's Gull	0.381
Pectoral Sandpiper	0.264	Double-crested Cormorant	0.326
American Crow	0.238	American Golden-Plover	0.215
American Golden-Plover	0.215	Pectoral Sandpiper	0.176
Snow Goose	0.189	American Crow	0.095
Black-bellied Plover	0.167	American White Pelican	0.084
Northern Pintail	0.091	Northern Pintail	0.068

Summer			
Species	Exposure index ^a		Exposure index ^a
	Turbine A	Species	
Franklin's Gull	0.399	Franklin's Gull	0.301
Mallard	0.235	Mallard	0.185
American Crow	0.227	American White Pelican	0.111
Swainson's Hawk	0.133	Swainson's Hawk	0.102
American White Pelican	0.107	American Crow	0.091
Pectoral Sandpiper	0.102	Canada Goose	0.086
Canada Goose	0.084	Pectoral Sandpiper	0.068
Great Blue Heron	0.062	Great Blue Heron	0.032
Northern Harrier	0.048	Northern Harrier	0.030
American Kestrel	0.034	Double-crested Cormorant	0.014

Fall			
Species	Exposure index ^a		Exposure index ^a
	Turbine A	Species	
Franklin's Gull	5.540	Franklin's Gull	4.173
Double-crested Cormorant	1.063	Double-crested Cormorant	0.975
Canada Goose	0.568	Canada Goose	0.579
Mallard	0.412	Mallard	0.324
American Crow	0.404	Ring-billed Gull	0.315
Ring-billed Gull	0.335	American White Pelican	0.277
American White Pelican	0.269	American Crow	0.161
Swainson's Hawk	0.103	Swainson's Hawk	0.078
Great Blue Heron	0.046	Snow Goose	0.060
American Kestrel	0.038	Great Blue Heron	0.024

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Table 13. Avian use (# observed/km²) by habitat type on the Buffalo Ridge Study area, 15 March to 15 November 1996-1999.

Group	Point Count Survey Data						
	CRP	Crop	Hay	Pasture	Woods	Wetlands	Other
Waterbirds	0.02	0.01	0.00	0.07	0.00	3.59	0.00
Waterfowl	0.73	0.70	0.24	0.54	0.00	67.54	0.00
Shorebirds	1.86	6.55	7.07	15.70	0.29	38.03	20.74
Upland Gamebirds	2.85	1.34	1.30	7.77	3.31	0.46	0.22
Doves	2.58	7.20	9.67	10.31	30.98	0.00	25.22
Raptors	1.58	0.97	2.52	2.57	13.35	1.72	0.25
Woodpeckers	0.85	1.02	0.94	2.10	38.35	1.75	0.41
Swallows	67.85	52.29	116.72	132.48	165.19	100.38	52.42
Flycatchers	0.87	0.71	1.51	4.26	20.94	1.20	0.62
Finches	4.77	2.03	3.62	7.84	58.38	11.10	2.71
Blackbirds	36.79	40.89	62.42	62.19	236.62	286.82	17.55
Corvids	0.45	1.14	2.78	1.12	21.87	0.00	0.58
Tanagers/Orioles	0.08	0.03	0.00	0.06	2.67	0.59	0.00
Vireos/Warblers	4.79	0.55	1.44	1.63	97.51	29.76	0.97
Sparrows/sparrowlikes	106.55	32.04	105.18	105.03	526.25	201.21	36.76
Longspurs	4.98	31.81	21.78	3.84	0.00	0.00	104.68
Chickadees/Nuthatches	0.00	0.03	1.01	0.00	34.72	0.77	0.25
Wrens	16.54	0.15	1.96	3.03	43.43	36.54	0.33
Thrushes	1.47	4.42	10.91	4.26	86.30	4.31	2.18
Other	0.00	0.03	0.20	0.07	0.73	0.78	0.00
TOTAL	255.63	183.90	351.25	364.87	1380.90	786.55	265.88

Table 13 (Continued). Avian use (# observed/km²) by habitat type on the Buffalo Ridge Study area, 15 March to 15 November 1996-1999.

RLB Survey Data							
Group	CRP	Crop	Hay	Pasture	Woods	Wetland	Other
Corvids	0.779	1.032	0.121	0.619	2.082	0.227	0.194
Upland Gamebirds	0.053	0.032	0.006	0.009	0.007	0.000	0.000
Raptors	1.271	0.856	0.154	0.824	1.466	0.978	0.236
Shorebirds	0.478	0.412	0.110	0.391	0.000	4.239	0.000
Waterbirds	2.061	4.953	2.922	3.427	0.128	12.888	0.093
Waterfowl	1.442	3.571	0.039	1.766	0.178	57.923	4.041
TOTAL	6.083	10.856	3.352	7.044	3.861	76.303	4.563

Table 14. Best linear regression models for estimating the magnitude of avian use by group in a survey plot as a function of the presence or absence of turbines, habitats within the plot, and distance to the nearest wetland or woodland^a.

Group	Plot Type									
	Intercept	(turbine vs non-turbine)	wetland indicator	woodland indicator	Dist. to wetland	Dist. to woodland	CRP	Crop	Pasture	Hay
Waterbirds	-0.132				0.241					0.011
Waterfowl	0.439	-0.2			-0.257					
Shorebirds	0.197	-0.092	0.107			0.279	-0.002		0.001	
Upland Gamebirds	0.057	-0.037			-0.04		0.0004			
Doves	0.368	0.155		0.135		-0.311	-0.002		0.001	
Woodpeckers	0.086	-0.027		0.097	0.023	-0.084	-0.0005	-0.0004		
Chickadees/Nuthatches	0.009			0.0387		-0.0276				
Blackbirds	2.819	-0.93	1.093			-2.05				
Corvids	0.195	-0.071		0.129		-0.204	-0.001			
Finches	0.071			0.055	-0.023	-0.073			0.0004	
Longspurs	0.537	-1.598				2.047			-0.013	
Orioles/Tanagers	0.003			0.008						
Sparrows	1.949	-0.526		0.51	-0.216			-0.11		
Swallows	0.584	-0.328	0.558	0.324		-0.351			0.006	
Thrushes	0.184	-0.076		0.31		-0.237				
Vireos/Warblers	0.135			0.121		-0.061		-0.0009	-0.0005	
Wrens	0.099			0.071		-0.056	0.0019	-0.0006		

^a Negative coefficients for the plot type variable indicate that avian use is less at a turbine plot than a non-turbine plot. Positive coefficients for the woods or wetland variables indicate use is higher at plots containing woods or wetlands. Negative coefficients for the distance to wetland and woodland variables indicate that avian use decreases as distance to woodland or wetland increases. Positive coefficients for the habitat variables indicate that avian use increases with proportion of that habitat within the plot.

Table 15. Significant post-construction positive or negative effects on avian use and richness at turbine plots within the Phase II Wind Development Area relative to reference (roadside) plots in all four study areas.

Group	Spring							
	Phase 2 - 1998				Phase 2 - 1999			
	Effect	90% CI		Sign ^a	Effect	90% CI		Sign ^a
Estimate	Lower	Upper	Estimate		Lower	Upper		
Blackbirds	0.83	0.39	1.52		0.62	0.29	1.15	
Chickadees/Nuthatches	1.36	0.76	2.24		1.44	0.61	2.97	
Corvids	4.22	1.44	9.69	+	16.46	2.29	47.37	+
Doves	1.13	0.34	2.56		0.81	0.20	2.05	
Finches	2.59	0.29	8.31		1.08	0.19	2.95	
Flycatchers	2.42	0.71	5.55		0.94	0.33	1.94	
Longspurs	1.01	0.20	2.64		1.10	0.24	2.88	
Other	0.22	0.04	0.64	-	0.52	0.25	0.97	-
Raptors	0.34	0.08	0.88	-	0.31	0.07	0.81	-
Shorebirds	0.90	0.31	1.96		1.04	0.36	2.28	
Sparrows	0.56	0.38	0.76	-	0.62	0.42	0.85	-
Swallows	2.05	0.92	3.77		0.86	0.26	1.78	
Tanagers/Orioles	1.04	0.47	1.84		0.80	0.34	1.47	
Thrushes	0.59	0.19	1.29		0.34	0.12	0.67	-
Upland Gamebirds	0.24	0.09	0.49	-	0.16	0.05	0.36	-
Vireos/Warbblers	4.35	1.12	9.96	+	1.93	0.40	5.10	
Waterbirds	0.16	0.02	0.57	-	0.35	0.10	0.85	-
Waterfowl	4.99	1.35	10.96	+	1.19	0.38	2.46	
Woodpeckers	0.40	0.10	0.96	-	0.20	0.07	0.44	-
Wrens	0.33	0.12	0.70	-	0.21	0.09	0.39	-
Passerines	0.78	0.50	1.12		0.67	0.44	0.98	-
# Species/Survey	0.83	0.71	0.97	-	0.63	0.52	0.74	-

^a a + sign indicates a significant (p<0.10) increase in use relative to reference values,

a - sign indicates a significant decrease in use relative to reference values

Table 15 (Continued). Significant post-construction positive or negative effects on avian use and richness at turbine plots within the Phase II Wind Development Area relative to reference (roadside) plots in all four study areas.

Group	Summer							
	Phase 2 - 1998				Phase 2 - 1999			
	Effect Estimate	90% CI Lower Upper		Sign ^a	Effect Estimate	90% CI Lower Upper		Sign ^a
Blackbirds	1.15	0.57	1.96		0.66	0.40	1.00	
Chickadees/Nuthatches	0.64	0.32	1.22		0.83	0.35	1.81	
Corvids	0.88	0.16	2.24		1.02	0.30	2.31	
Doves	0.65	0.23	1.34		1.14	0.50	2.18	
Finches	0.83	0.36	1.46		0.63	0.29	1.13	
Flycatchers	1.07	0.20	2.45		0.50	0.17	1.02	
Longspurs	2.57	1.11	4.87	+	1.96	0.82	3.80	
Other	0.55	0.15	1.34		0.56	0.23	1.13	
Raptors	0.17	0.06	0.35	-	0.32	0.08	0.72	-
Shorebirds	2.01	0.69	4.17		1.01	0.39	1.98	
Sparrows	0.66	0.45	0.93	-	0.51	0.38	0.68	-
Swallows	0.52	0.26	0.92	-	0.24	0.12	0.40	-
Tanagers/Orioles	0.95	0.51	1.57		0.72	0.44	1.14	
Thrushes	0.80	0.25	1.70		1.42	0.44	2.98	
Upland Gamebirds	0.61	0.15	1.50		0.15	0.05	0.37	-
Vireos/Warbblers	0.52	0.12	1.21		0.32	0.12	0.60	-
Waterbirds	3.98	0.86	10.32		0.65	0.17	1.61	
Waterfowl	1.06	0.10	3.46		0.57	0.08	1.61	
Woodpeckers	0.78	0.27	1.63		0.69	0.26	1.33	
Wrens	0.36	0.13	0.71	-	0.23	0.09	0.41	-
Passerines	0.68	0.52	0.86	-	0.44	0.36	0.53	-
# Species/Survey	0.73	0.60	0.86	-	0.59	0.50	0.68	-

^a a + sign indicates a significant (p<0.10) increase in use relative to reference values,

a - sign indicates a significant decrease in use relative to reference values

Table 15 (Continued). Significant post-construction positive or negative effects on avian use and richness at turbine plots within the Phase II Wind Development Area relative to reference (roadside) plots in all four study areas.

Group	Fall							
	Phase 2 - 1998				Phase 2 - 1999			
	Effect	90% CI		Sign ^a	Effect	90% CI		Sign ^a
Estimate	Lower	Upper		Estimate	Lower	Upper		
Blackbirds	1.13	0.42	2.29		0.51	0.20	1.08	
Chickadees/Nuthatches	1.05	0.54	1.88		0.57	0.29	1.02	
Corvids	0.54	0.15	1.19		0.51	0.16	1.07	
Doves	0.73	0.26	1.53		0.61	0.23	1.23	
Finches	0.28	0.08	0.60	-	0.46	0.18	0.86	-
Flycatchers	3.42	0.49	8.72		0.71	0.28	1.43	
Longspurs	0.25	0.09	0.50	-	0.49	0.18	1.06	
Other	8.58	0.32	32.00		1.53	0.14	5.49	
Raptors	0.52	0.23	0.93	-	0.30	0.14	0.50	-
Shorebirds	0.72	0.22	1.52		1.20	0.43	2.48	
Sparrows	0.45	0.28	0.70	-	0.44	0.25	0.74	-
Swallows	0.48	0.21	0.86	-	0.30	0.15	0.50	-
Tanagers/Orioles	0.74	0.42	1.00		1.00	1.00	1.00	
Thrushes	0.51	0.08	1.26		0.40	0.07	1.11	
Upland Gamebirds	0.19	0.05	0.44	-	0.29	0.03	0.84	-
Vireos/Warbblers	3.05	0.62	7.97		0.73	0.28	1.48	
Waterbirds	15.96	0.09	96.71		10.37	0.32	46.97	
Waterfowl	6.75	0.27	20.64		1.71	0.11	6.79	
Woodpeckers	0.22	0.12	0.36	-	1.00	0.43	1.91	
Wrens	1.03	0.47	1.94		0.78	0.35	1.56	
Passerines	0.46	0.27	0.73	-	0.32	0.19	0.49	-
# Species/Survey	0.61	0.50	0.74	-	0.61	0.49	0.73	-

^a a + sign indicates a significant (p<0.10) increase in use relative to reference values,

a - sign indicates a significant decrease in use relative to reference values

Table 16. Significant post-construction positive or negative effects on avian use and richness at non-turbine (roadside) plots within the Phase II and Phase III Wind Development Areas relative to non-turbine (roadside) plots in the Reference Area.

Group	Spring											
	Phase 2 - 1998				Phase 2 - 1999				Phase 3 - 1999			
	Effect	90% CI		Sign ^a	Effect	90% CI		Sign ^a	Effect	90% CI		Sign ^a
	Estim.	Lower	Upper		Estim.	Lower	Upper		Estim.	Lower	Upper	
Blackbirds	0.25	0.12	0.45	-	0.52	0.21	1.03		1.15	0.74	1.71	
Chickadees/Nuthatches	3.86	1.03	9.60	+	11.69	1.77	30.93	+	1.35	0.28	3.56	
Corvids	3.18	0.88	7.42		0.85	0.12	2.11		1.54	0.36	3.82	
Doves	1.21	0.45	2.50		2.04	0.67	4.52		1.05	0.23	2.63	
Finches	2.24	0.18	7.59		0.78	0.15	1.95		0.38	0.07	1.01	
Flycatchers	1.93	0.57	4.52		0.88	0.26	2.06		1.88	0.50	4.73	
Longspurs	0.40	0.02	1.16		4.01	0.15	12.00		0.50	0.03	1.68	
Other	16.02	0.56	46.93		0.80	0.52	1.00	-	4.19	1.00	7.40	
Raptors	0.38	0.13	0.79	-	0.76	0.24	1.68		7.95	2.09	17.81	+
Shorebirds	0.74	0.25	1.57		1.47	0.32	3.76		2.43	0.33	7.53	
Sparrows	0.67	0.41	1.00	-	0.53	0.31	0.80	-	0.83	0.51	1.23	
Swallows	2.90	0.94	6.06		1.94	0.36	4.98		2.14	0.43	5.56	
Tanagers/Orioles	2.77	1.01	5.66	+	4.53	1.01	11.14	+	2.03	0.75	4.21	
Thrushes	0.34	0.13	0.66	-	0.48	0.17	0.97	-	1.26	0.41	2.78	
Upland Gamebirds	1.57	0.40	3.87		1.10	0.20	3.08		1.94	0.22	5.84	
Vireos/Warbblers	1.34	0.30	3.65		1.94	0.33	5.35		3.56	0.58	10.01	
Waterbirds	0.05	0.00	0.19	-	0.10	0.02	0.28	-	1.45	0.12	5.12	
Waterfowl	0.83	0.15	2.20		1.53	0.12	4.88		4.75	0.35	16.67	
Woodpeckers	2.35	0.66	5.20		1.93	0.53	4.75		0.74	0.17	1.86	
Wrens	0.43	0.10	1.12		1.25	0.19	3.36		6.17	1.24	16.42	+
Passerines	0.38	0.22	0.62	-	0.77	0.39	1.30		1.03	0.65	1.52	
# Species/Survey	0.83	0.66	1.03		0.81	0.63	1.01		1.00	0.80	1.25	

^a a + sign indicates a significant (p<0.10) increase in use relative to reference values,
a - sign indicates a significant decrease in use relative to reference values

Table 16 (Continued). Significant post-construction positive or negative effects on avian use and richness at non-turbine (roadside) plots within the Phase II and Phase III Wind Development Areas relative to non-turbine (roadside) plots in the Reference Area.

Group	Summer											
	Phase 2 - 1998				Phase 2 - 1999				Phase 3 - 1999			
	Effect	90% CI		Sign ^a	Effect	90% CI		Sign ^a	Effect	90% CI		Sign ^a
Estim.	Lower	Upper		Estim.	Lower	Upper		Estim.	Lower	Upper		
Blackbirds	0.90	0.56	1.31		1.04	0.64	1.59		1.07	0.60	1.70	
Chickadees/Nuthatches	0.97	0.21	2.48		1.35	0.12	4.70		0.81	0.17	2.19	
Corvids	0.63	0.16	1.49		1.06	0.24	2.86		4.33	0.87	11.18	
Doves	0.79	0.31	1.49		0.63	0.25	1.23		0.81	0.37	1.46	
Finches	0.81	0.32	1.48		1.23	0.53	2.42		0.64	0.26	1.29	
Flycatchers	0.84	0.27	1.78		0.70	0.24	1.58		1.71	0.47	4.10	
Longspurs	2.94	0.78	6.32		2.98	0.86	6.52		1.78	0.59	3.90	
Other	1.27	0.19	3.85		1.84	0.47	4.62		0.21	0.06	0.54	-
Raptors	1.63	0.61	3.17		1.10	0.31	2.64		0.60	0.16	1.43	
Shorebirds	0.94	0.33	1.98		0.91	0.34	2.02		0.50	0.15	1.15	
Sparrows	1.26	0.76	1.96		0.84	0.54	1.22		0.89	0.58	1.32	
Swallows	0.83	0.48	1.32		1.12	0.50	2.05		1.09	0.50	1.98	
Tanagers/Orioles	1.66	0.48	3.70		2.28	0.62	5.14		1.95	0.37	5.04	
Thrushes	0.97	0.37	1.95		1.06	0.37	2.29		1.27	0.43	2.84	
Upland Gamebirds	1.26	0.18	3.83		5.31	0.31	18.05		3.75	0.22	13.21	
Vireos/Warbblers	0.72	0.27	1.43		1.17	0.45	2.33		1.56	0.60	3.15	
Waterbirds	4.10	0.53	12.47		4.24	0.55	14.65		0.70	0.02	2.36	
Waterfowl	0.27	0.04	0.77	-	0.57	0.04	1.95		0.42	0.03	1.50	
Woodpeckers	0.53	0.14	1.17		0.61	0.10	1.61		0.78	0.20	1.96	
Wrens	0.81	0.27	1.64		0.99	0.32	2.14		1.49	0.42	3.54	
Passerines	0.92	0.70	1.17		0.93	0.70	1.20		1.02	0.73	1.35	
# Species/Survey	0.90	0.74	1.07		0.90	0.71	1.10		0.91	0.74	1.13	

^a a + sign indicates a significant (p<0.10) increase in use relative to reference values,

a - sign indicates a significant decrease in use relative to reference values

Table 16 (Continued). Significant post-construction positive or negative effects on avian use and richness at non-turbine (roadside) plots within the Phase II and Phase III Wind Development Areas relative to non-turbine (roadside) plots in the Reference Area.

Group	Fall											
	Phase 2 - 1998				Phase 2 - 1999				Phase 3 - 1999			
	Effect Estim.	90% CI Lower Upper		Sign ^a	Effect Estim.	90% CI Lower Upper		Sign ^a	Effect Estim.	90% CI Lower Upper		Sign ^a
Blackbirds	0.96	0.39	1.91		4.79	1.43	10.31	+	4.23	1.61	8.65	+
Chickadees/Nuthatches	5.15	0.80	14.00		0.65	0.07	2.06		1.30	0.06	4.08	
Corvids	0.67	0.24	1.34		1.25	0.33	2.80		1.31	0.35	3.23	
Doves	0.69	0.24	1.49		1.31	0.36	3.18		2.34	0.77	5.09	
Finches	1.57	0.29	4.22		7.98	1.67	20.79	+	4.52	0.45	13.14	
Flycatchers	0.38	0.09	0.98	-	7.29	1.63	19.19	+	1.19	0.36	2.87	
Longspurs	1.11	0.24	2.88		0.84	0.15	2.47		0.28	0.05	0.76	-
Other	0.33	0.07	1.00		0.84	0.14	2.71		1.00	1.00	1.00	
Raptors	0.31	0.12	0.61	-	0.35	0.15	0.65	-	0.49	0.20	0.93	-
Shorebirds	0.99	0.25	2.30		4.30	0.86	11.89		5.89	0.89	16.04	
Sparrows	1.03	0.54	1.75		1.21	0.56	2.21		1.09	0.48	2.01	
Swallows	0.60	0.22	1.21		0.98	0.45	1.78		1.02	0.43	1.93	
Tanagers/Orioles	1.00	1.00	1.00		1.00	1.00	1.00	-	1.00	1.00	1.00	
Thrushes	0.77	0.21	1.82		0.22	0.04	0.56	-	0.39	0.08	1.05	
Upland Gamebirds	0.26	0.02	0.89	-	0.26	0.03	0.78	-	1.43	0.18	3.64	
Vireos/Warbblers	1.11	0.09	3.84		0.71	0.05	2.27		0.57	0.03	2.04	
Waterbirds	175.45	0.28	1089.3		65.40	0.02	131.14		1.82	0.00	7.82	
Waterfowl	1.64	0.03	6.75		0.23	0.01	0.72	-	2.96	0.04	9.52	
Woodpeckers	2.16	0.72	4.59		2.90	0.75	6.73		0.53	0.15	1.22	
Wrens	2.18	0.66	5.11		2.62	0.38	7.99		0.65	0.10	2.11	
Passerines	0.92	0.53	1.43		1.74	0.83	3.01		1.02	0.50	1.79	
# Species/Survey	0.90	0.70	1.15		0.90	0.67	1.18		0.98	0.73	1.27	

^a a + sign indicates a significant (p<0.10) increase in use relative to reference values,

a - sign indicates a significant decrease in use relative to reference values

Table 17. Significant post-construction positive or negative effects on avian use and richness at RLB survey plots within the Phase II and Phase III Wind Development Areas relative to the Reference Area.

Spring												
Group	Phase 2 - 1998				Phase 2 - 1999				Phase 3 - 1999			
	Effect	90% CI		Sign ^a	Effect	90% CI		Sign ^a	Effect	90% CI		Sign ^a
	Estim.	Lower	Upper		Estim.	Lower	Upper		Estim.	Lower	Upper	
Crows	0.47	0.18	1.00		0.87	0.13	2.33		3.08	1.28	6.06	+
Upland Gamebirds	6.49	0.05	24.42		0.18	0.00	0.60	-	2.02	0.01	8.40	
Raptors	0.75	0.44	1.17		0.87	0.49	1.39		2.88	1.23	5.39	+
Shorebirds	3.33	0.02	9.47		4.50	0.01	4.48		6.73	0.01	7.97	
Waterbirds	4.96	0.37	17.63		8.61	0.26	36.00		49.36	0.90	184.84	
Waterfowl	0.19	0.01	0.59	-	0.39	0.10	0.94	-	1.04	0.11	3.46	
# Species/survey	0.66	0.47	0.85	-	0.74	0.54	0.98	-	2.09	1.52	2.72	+

Summer												
Group	Phase 2 - 1998				Phase 2 - 1999				Phase 3 - 1999			
	Effect	90% CI		Sign ^a	Effect	90% CI		Sign ^a	Effect	90% CI		Sign ^a
	Estim.	Lower	Upper		Estim.	Lower	Upper		Estim.	Lower	Upper	
Crows	0.36	0.05	1.07		1.45	0.27	3.91		3.41	0.97	8.33	
Upland Gamebirds	1.61	0.20	4.33		1.00	1.00	1.00		2.29	0.70	5.18	
Raptors	0.60	0.32	1.00	-	0.45	0.21	0.83	-	1.35	0.63	2.54	
Shorebirds	5.99	0.10	19.87		0.57	0.01	2.45		0.85	0.01	3.35	
Waterbirds	6.55	0.19	22.03		60.08	2.45	250.39	+	59.78	0.18	243.54	
Waterfowl	0.39	0.00	1.29		8.55	0.09	37.08		3.96	0.23	23.08	
# Species/survey	0.86	0.54	1.32		0.81	0.56	1.15		1.57	1.16	2.10	+

Fall												
Group	Phase 2 - 1998				Phase 2 - 1999				Phase 3 - 1999			
	Effect	90% CI		Sign ^a	Effect	90% CI		Sign ^a	Effect	90% CI		Sign ^a
	Estim.	Lower	Upper		Estim.	Lower	Upper		Estim.	Lower	Upper	
Crows	0.12	0.01	0.34	-	0.28	0.03	0.70	-	0.76	0.25	1.67	
Upland Gamebirds	10.73	0.46	37.53		0.65	0.12	1.58		4.47	0.18	19.84	
Raptors	0.74	0.45	1.13		0.44	0.27	0.65	-	1.35	0.89	1.95	
Shorebirds	4.82	0.01	22.01		32.06	0.17	124.63		11.37	0.83	40.86	
Waterbirds	4.39	0.31	12.81		6.19	0.10	19.46		0.59	0.02	1.87	
Waterfowl	0.69	0.06	2.06		0.28	0.03	0.88	-	0.31	0.00	1.05	
# Species/survey	0.73	0.47	1.05		0.58	0.39	0.80	-	1.27	0.95	1.64	

^a a + sign indicates a significant (p<0.10) increase in use relative to reference values,
a - sign indicates a significant decrease in use relative to reference values

Table 18. Significant post-construction positive or negative effects on use of turbine plots by grassland breeders within the Phase II Wind Development Area relative to reference (roadside) plots in all four study areas.

Species	Phase 2 - 1998			Sign	Phase 2 - 1999			Sign
	Mean Effect	90% CI			Mean Effect	90% CI		
		Lower	Upper			Lower	Upper	
Bobolink	0.62	0.19	1.29		0.37	0.12	0.73	-
Brewer's Blackbird	0.49	0.05	1.33		1.16	1.00	1.42	
Brown-headed Cowbird	1.57	0.68	2.97		1.39	0.82	2.23	
Clay-colored Sparrow	1.63	0.35	3.97		1.94	0.59	4.25	
Common Snipe	0.59	0.31	1.01		0.52	0.28	0.88	-
Common Yellowthroat	0.38	0.12	0.78	-	0.28	0.10	0.52	-
Dickcissel	1.76	0.75	3.27		2.11	1.01	3.63	+
Field Sparrow	0.97	0.50	1.67		0.97	0.50	1.67	
Grasshopper Sparrow	0.63	0.28	1.14		0.38	0.16	0.69	-
Gray Partridge	1.44	0.41	3.26		0.47	0.12	1.18	
Horned Lark	2.89	1.17	5.87	+	1.93	0.86	3.76	
Lark Sparrow	1.00	1.00	1.00		0.86	0.64	1.00	
LeConte's Sparrow	1.00	1.00	1.00		1.00	1.00	1.00	
Loggerhead Shrike	1.00	1.00	1.00		0.82	0.57	1.00	
Northern Harrier	0.40	0.12	0.90	-	0.79	0.18	1.96	
Ring-necked Pheasant	0.41	0.07	1.28		0.28	0.05	0.78	-
Savannah Sparrow	1.04	0.53	1.77		0.32	0.13	0.59	-
Sedge Wren	0.58	0.19	1.28		0.48	0.20	0.96	-
Short-eared Owl	1.00	1.00	1.00		1.00	1.00	1.00	
Upland Sandpiper	0.97	0.33	2.27		0.81	0.36	1.50	
Vesper Sparrow	1.84	1.02	3.02	+	1.53	0.87	2.49	
Western Meadowlark	1.17	0.65	1.86		0.91	0.46	1.54	
Grassland species	0.93	0.76	1.12		0.70	0.60	0.81	-

^a a + sign indicates a significant ($p < 0.10$) increase in use relative to reference values,

a - sign indicates a significant decrease in use relative to reference values

Table 19. Significant post-construction positive or negative effects on grassland breeders at non-turbine (roadside) plots within the Phase II and Phase III Wind Development Areas relative to non-turbine (roadside) plots in the Reference Area.

Species	Phase 2 - 1998				Phase 2 - 1999				Phase 3 - 1999				
	Mean	90% CI		Mean	90% CI		Mean	90% CI		Mean	90% CI		Sign ^a
	Use	Lower	Upper	Use	Lower	Upper	Use	Lower	Upper	Use	Lower	Upper	Sign ^a
Bobolink	0.73	0.22	1.63	1.23	0.21	3.42	2.66	0.60	6.86				
Brewer's Blackbird	41.87	1.00	119.85	1.00	1.00	1.00	0.76	0.48	1.00				
Brown-headed Cowbird	0.91	0.41	1.68	0.64	0.29	1.18	0.96	0.49	1.58				
Clay-colored Sparrow	2.84	0.49	7.56	3.72	0.49	9.95	2.22	0.47	5.78				
Common Snipe	0.64	0.26	1.18	2.41	0.64	5.38	1.03	0.65	1.48				
Common Yellowthroat	0.67	0.23	1.37	1.28	0.44	2.79	1.92	0.75	3.97				
Dickcissel	2.98	0.96	6.24	2.73	0.97	5.62	1.49	0.66	2.80				
Field Sparrow	0.60	0.20	1.00	0.60	0.20	1.00	1.00	1.00	1.00				
Grasshopper Sparrow	1.13	0.32	2.65	1.79	0.47	4.30	1.74	0.48	4.05				
Gray Partridge	1.91	0.29	5.51	1.91	0.05	8.69	12.91	0.23	63.09				
Horned Lark	2.38	0.43	7.12	2.62	0.53	7.28	1.52	0.51	3.10				
Lark Sparrow	1.00	1.00	1.00	0.68	0.31	1.00	0.68	0.31	1.00				
LeContes Sparrow	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00				
Loggerhead Shrike	1.00	1.00	1.00	1.00	1.00	1.00	2.03	1.00	4.00				
Northern Harrier	0.22	0.09	0.46	-	1.22	0.23	3.05	0.88	0.20	2.24			
Ring-necked Pheasant	0.56	0.05	1.83	8.42	0.60	30.59	2.66	0.20	10.34				
Savannah Sparrow	0.74	0.35	1.32	0.85	0.28	1.86	1.44	0.51	3.44				
Sedge Wren	0.60	0.15	1.47	1.20	0.24	3.16	2.84	0.68	7.04				
Short-eared Owl	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00				
Upland Sandpiper	0.82	0.12	2.30	1.08	0.16	3.32	2.59	0.30	8.07				
Vesper Sparrow	1.92	0.78	3.67	2.26	0.97	4.27	1.47	0.63	2.76				
Western Meadowlark	1.74	0.83	3.14	1.91	0.93	3.36	1.41	0.72	2.45				
Grassland species	0.95	0.72	1.21	0.93	0.68	1.23	1.20	0.92	1.50				

^a a + sign indicates a significant (p<0.10) increase in use relative to reference values,
a - sign indicates a significant decrease in use relative to reference values

Table 20. Number of mortality searches conducted in the Buffalo Ridge project area, 1996-1999.

Study Area	Turbine Plots				Non-turbine Plots				Total
	1996	1997	1998	1999	1996	1997	1998	1999	1996-99
Phase I Wind Plant	294	360	339	369	88	102	87	39	1678
Phase II Wind Plant	0 ^a	0	450	656	274 ^b	311 ^b	292 ^b	38	2021
Phase III Wind Plant	0	0	0	372	183	213	120	45	933
Permanent Reference Area	0	0	0	0	209	239	135	107	690
TOTAL	294	360	789	1397	754	865	634	229	5322

^a no turbines present

^b Includes roadside plots and turbine plots prior to turbine development

Table 21. Avian and bat mortality associated with the Buffalo Ridge, Minnesota windpower development.

Year	Phase I Wind plant				Phase II Wind plant				Phase III Wind plant				Reference Area	
	Wind plant Mortality		Reference Mortality		Wind plant Mortality		Reference Mortality		Wind plant Mortality		Reference Mortality		Reference Mortality	
	Birds	Bats	Birds	Bats	Birds	Bats	Birds	Bats	Birds	Bats	Birds	Bats	Birds	Bats
1996	3	0	2	0	na ^a	na	1	0	na	na	1	0	2	0
1997	3	0	0	0	2 ^b	na	7	0	na	na	4	0	4	0
1998	4	2	1	0	6	76	2	0	na	na	1	0	3	0
1999	3	5	0	0	14	57	2	0	20	44	0	0	1	0
Total	13	7	3	0	22	133	12	0	20	44	6	0	10	0

^a na = not applicable, windplant became operational in 1998 (Phase II) and 1999 (Phase III)

^b Two mortalities associated with collisions with meteorological towers, no turbines present in P2 until 1998.

Table 22. Composition of windplant-related avian fatalities found on Buffalo Ridge, 1996-1999.

Avian Group	Number of fatalities	Percent of fatalities
Passerines	42	76.4
Warblers	19	34.5
Common Yellowthroat	7	12.7
Orange-crowned Warbler	4	7.3
Black-and-white Warbler	3	5.5
Yellow warbler	2	3.6
Yellow-rumped Warbler	1	1.8
Magnolia Warbler	1	1.8
Blackpoll Warbler	1	1.8
Sparrows	6	10.9
Vesper Sparrow	2	3.6
Chipping Sparrow	1	1.8
Lincoln's Sparrow	1	1.8
House Sparrow	1	1.8
Dickcissel	1	1.8
Swallows	5	9.1
Barn Swallow	4	7.3
Purple Martin	1	1.8
Flycatchers	3	5.5
Empidonax Flycatcher	2	3.6
Least Flycatcher	1	1.8
Blackbirds	2	3.6
European Starling	1	1.8
Common Grackle	1	1.8
Other	7	12.7
Sedge Wren	2	3.6
Warbling Vireo	1	1.8
Ruby-crowned Kinglet	1	1.8
Western Meadowlark	1	1.8
Gray Catbird	1	1.8
Unidentified Passerine	1	1.8
Waterfowl	5	9.1
Mallard	2	3.6
Blue-winged Teal	1	1.8
American Coot	2	3.6
Waterbirds	3	5.5
Pied-billed Grebe	2	3.6
Herring Gull	1	1.8
Upland Gamebirds	3	5.5
Ring-necked Pheasant	2	3.6
Gray Partridge	1	1.8
Raptors	1	1.8
Red-tailed Hawk	1	1.8
Shorebirds	1	1.8
Killdeer	1	1.8
TOTAL	55	100.0

Table 23. Food items present in the stomachs of 17 bat mortalities collected during the study.

Order	Common Name	Number of bat stomachs with food item present				
		Hoary (n=10)	Red (n=4)	Silver-haired (n=2)	Big brown (n=1)	Total (n=17)
Coleoptera	Beetles	8	3	1	1	13
Lepidoptera	Moths & Butterflies	5	3	1	0	9
Homoptera	Leafhoppers	3	2	2	0	7
Diptera	True Flies	7	0	0	0	7
Trichoptera	Caddisflies	5	1	1	0	7
Neuroptera	Lacewings	5	0	0	0	5
Hemiptera	True Bugs	2	0	0	0	2
Hymenoptera	Ants/Bees/Wasps	1	0	0	0	1

Table 24. Composition and number of carcasses used in searcher efficiency and scavenger removal trials, 1996-1999.

Carcass Type	Age	Size Class Represented	Searcher Efficiency Trials	Scavenger Removal Trials
Hen Mallard	Adult	Large	260	231
Subtotal Large			260	231
Bobwhite	Adult	Medium	134	114
Rock Dove	Adult	Medium	139	129
Subtotal Medium			273	243
Bobwhite	Juvenile	Small	90	96
Mallard	Juvenile	Small	145	91
House Sparrow	Adult	Small	64	67
Starling	Adult	Small	7	7
Hoary Bat	Adult	Small	0	40
Subtotal Small			306	301
TOTAL			839	775

Table 25. Number of birds detected during searcher efficiency trials conducted on the Buffalo Ridge study areas, March through November, 1996 - 1999.

Size Class of Bird ^a	Habitat Type								Total
	Crop	CRP	Pasture	Hay	Plowed/ bare ground	Woodland	Wetland	Snow	
Small	19/89 (21.3%)	13/74 (17.6%)	13/44 (29.5%)	4/22 (18.2%)	34/58 (58.6%)	3/8 (37.5%)	0/2 (0.0%)	4/9 (44.4%)	90/306 (29.4%)
Medium	38/96 (39.6%)	19/63 (30.2%)	19/47 (40.4%)	10/24 (41.7%)	12/25 (48.0%)	3/9 (33.3%)	½ (50.0%)	6/7 (85.7%)	108/273 (39.6%)
Large	40/86 (46.5%)	27/69 (39.1%)	22/41 (53.7%)	9/23 (39.1%)	15/19 (78.9%)	6/12 (50.0%)	0/2 (0.0%)	8/8 (100.0%)	127/260 (48.8%)
Total	97/271 (35.8%)	59/206 (28.6%)	54/132 (40.9%)	23/69 (33.3%)	61/102 (59.8%)	12/29 (41.4%)	1/6 (16.7%)	18/24 (75.0%)	325/839 (38.7%)

^a Small birds represented by adult house sparrows, adult European starlings, juvenile mallards and juvenile northern bobwhite; medium sized birds represented by rock doves and adult northern bobwhite; large birds represented by adult female mallards.

Table 26. Mean length of stay (days) for carcasses placed to monitor scavenger removal rates.

Study Area		Carcass Size Class ^a		Habitat Type		Season	
P1	5.10	Large	8.50	Crop ^b	6.67	Spring	4.30
P2	8.02	Medium	7.99	CRP	8.55	Summer	6.81
P3	7.12	Small	4.69	Hayfield	7.39	Fall	9.72
REF	7.78			Pasture	7.02		
ALL	7.01			Snow	2.09		
				Wetland	5.59		
				Woods	9.81		
				Bare ground	5.85		

^a Small birds represented by adult house sparrows, adult European starlings, juvenile mallards and juvenile northern bobwhite; medium sized birds represented by rock doves and adult northern bobwhite; large birds represented by adult female mallards.

^b Crop types represented included corn, corn stubble, soybean, soybean stubble, wheat stubble, and plowed field.

Table 27. Estimates of turbine-related avian mortality for the Buffalo Ridge wind resource area, March through November 1996-1999.

Phase I Study Area

Year	Carcass Size	Total Mortality Estimate	90% Confidence Interval	No. Fatalities per Turbine per Year	90% Confidence Interval
1996	Small	106	24 - 187	1.45	0.33 - 2.57
	Medium	0	na	0	na
	Large	0	na	0	na
	TOTAL	106	24 - 187	1.45	0.33 - 2.57
1997	Small	36	1 - 85	0.49	0.04 - 1.17
	Medium	15	1 - 35	0.20	0.04 - 0.48
	Large	14	1 - 34	0.19	0.04 - 0.47
	TOTAL	65	7 - 122	0.88	0.09 - 1.67
1998	Small	61	2 - 120	0.84	0.02 - 1.65
	Medium	19	1 - 44	0.26	0.04 - 0.62
	Large	0	na	0	na
	TOTAL	80	15 - 145	1.10	0.21 - 1.99
1999	Small	36	1 - 87	0.50	0.05 - 1.20
	Medium	0	na	0	na
	Large	0	na	0	na
	TOTAL	36	1 - 87	0.50	0.05 - 1.20
1996-1999 Mean	Small	60	29 - 91	0.82	0.40 - 1.24
	Medium	9	1 - 17	0.12	0.01 - 0.23
	Large	4	1 - 8	0.05	0.01 - 0.12
	TOTAL	72	36 - 108	0.98	0.42 - 1.54

Table 27 (Continued). Estimates of turbine-related avian mortality for the Buffalo Ridge wind resource area, March through November 1996-1999.

Phase II Study Area

Year	Carcass Size	Total Mortality Estimate	90% Confidence Interval	No. Fatalities per Turbine per Year	90% Confidence Interval
1998	Small	244	96 - 393	1.71	0.67 - 2.75
	Medium	21	1 - 50	0.14	0.05 - 0.35
	Large	0	na	0	na
	TOTAL	265	103 - 481	1.85	0.55 - 3.20
1999	Small	326	74 - 578	2.28	0.52 - 4.04
	Medium	0	na	0	na
	Large	57	11 - 103	0.40	0.08 - 0.72
	TOTAL	383	85 - 681	2.68	0.63 - 4.73
1998-1999 Mean	Small	285	139 - 431	2.00	1.41 - 2.58
	Medium	11	1 - 25	0.07	0.01 - 0.13
	Large	29	6 - 51	0.20	0.11 - 0.29
	TOTAL	324	175 - 473	2.27	1.67 - 2.86

Phase III Study Area

Year	Carcass Size	Total Mortality Estimate	90% Confidence Interval	No. Fatalities per Turbine per Year	90% Confidence Interval
1999	Small	613	132 - 1093	4.45	0.11 - 8.78
	Medium	0	na	0	na
	Large	0	na	0	na
	TOTAL	613	132 - 1093	4.45	0.11 - 8.78

Table 28. Estimates of mean number of avian fatalities found per fatality search on reference plots in the Buffalo Ridge study area, March through November 1996-1999.

Year	Carcass Size	No. per Search Plot per Year	90% Confidence Interval
1996	Small	0.60	0.03 - 1.17
	Medium	0.10	0.02 - 0.26
	Large	0.13	0.02 - 0.29
	TOTAL	0.83	0.22 - 1.44
1997	Small	1.14	0.42 - 1.87
	Medium	0.45	0.11 - 0.79
	Large	0.22	0.04 - 0.40
	TOTAL	1.81	0.98 - 2.64
1998	Small	0.32	0.02 - 0.77
	Medium	0.16	0.02 - 0.43
	Large	0.17	0.02 - 0.41
	TOTAL	0.65	0.07 - 1.23
1996-98 Mean	Small	0.69	0.34 - 1.03
	Medium	0.24	0.08 - 1.39
	Large	0.17	0.06 - 0.29
	TOTAL	1.10	0.70 - 1.49

Table 29. Estimates of turbine-related bat mortality for the Buffalo Ridge wind resource area, March through November 1996-1998.

Phase I Study Area				
Year	Total Mortality Estimate	90% Confidence Interval	No. Fatalities per Turbine per Year	90% Confidence Interval
1999	19	4 - 33	0.26	0.06 - 0.46
Phase II Study area				
Year	Total Mortality Estimate	90% Confidence Interval	No. Fatalities per Turbine per Year	90% Confidence Interval
1998	231	172 - 290	1.62	1.21 - 2.03
1999	277	219 - 335	1.94	1.53 - 2.35
1998-1999 Mean	254	213 - 295	1.78	1.61 - 1.95
Phase III Study area				
Year	Total Mortality Estimate	90% Confidence Interval	No. Fatalities per Turbine per Year	90% Confidence Interval
1999	282	199 - 365	2.04	1.46 - 2.62

Figure 1. Location of the Phase I, Phase II, Phase III and Reference areas on Buffalo Ridge.

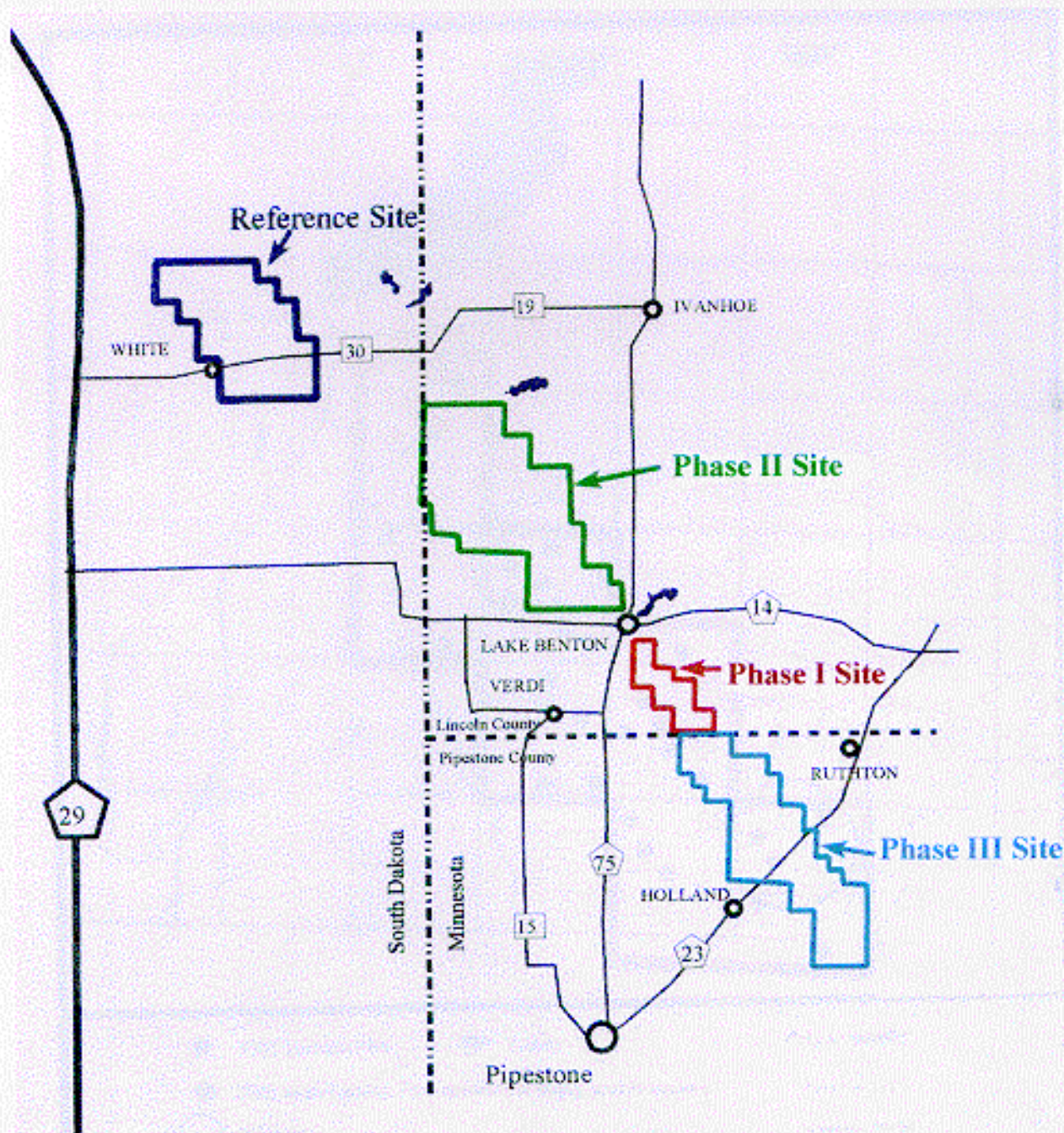


Figure 2. Phase I study area and locations of sample plots.

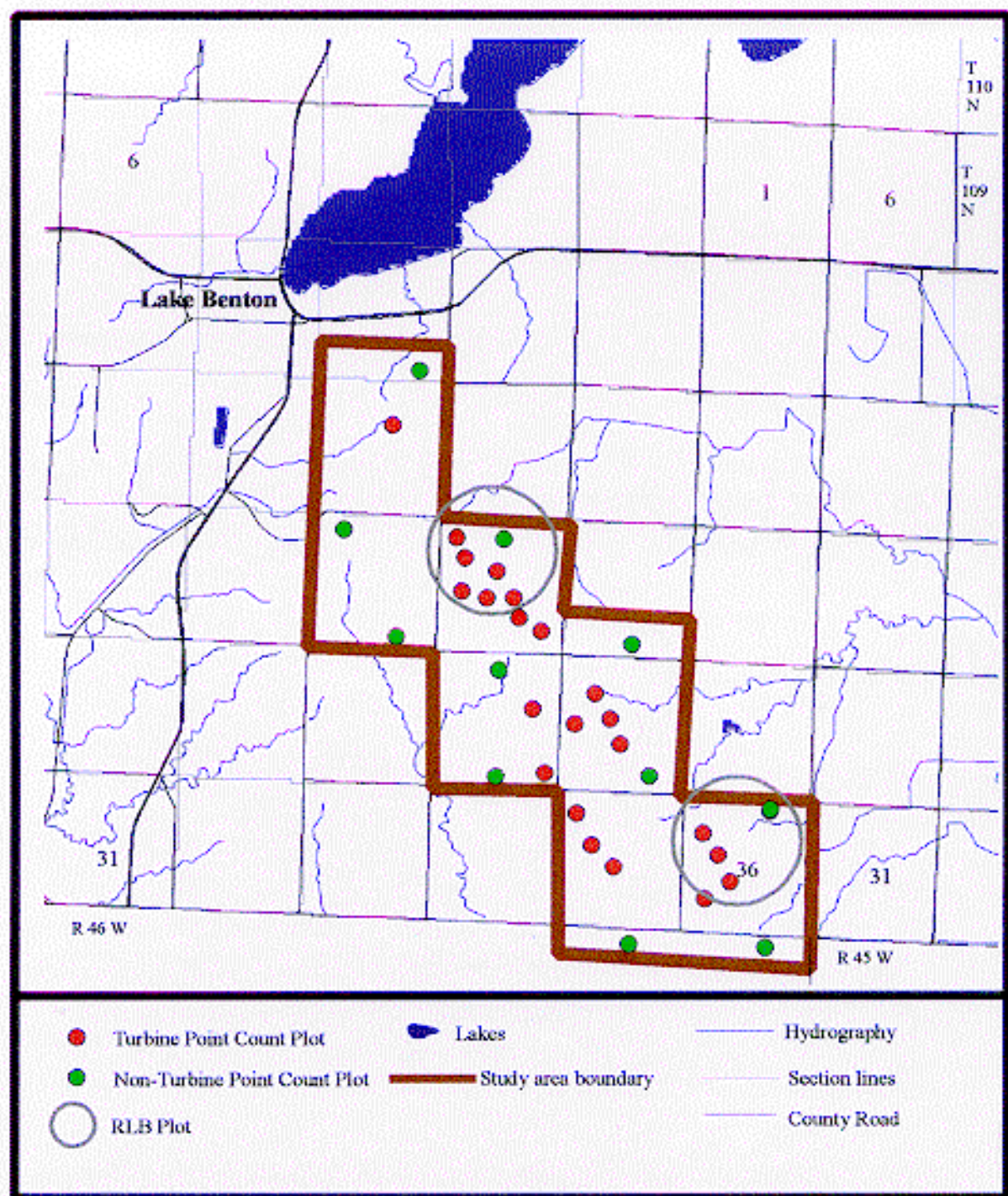


Figure 3. Phase II study area and locations of sample plots.

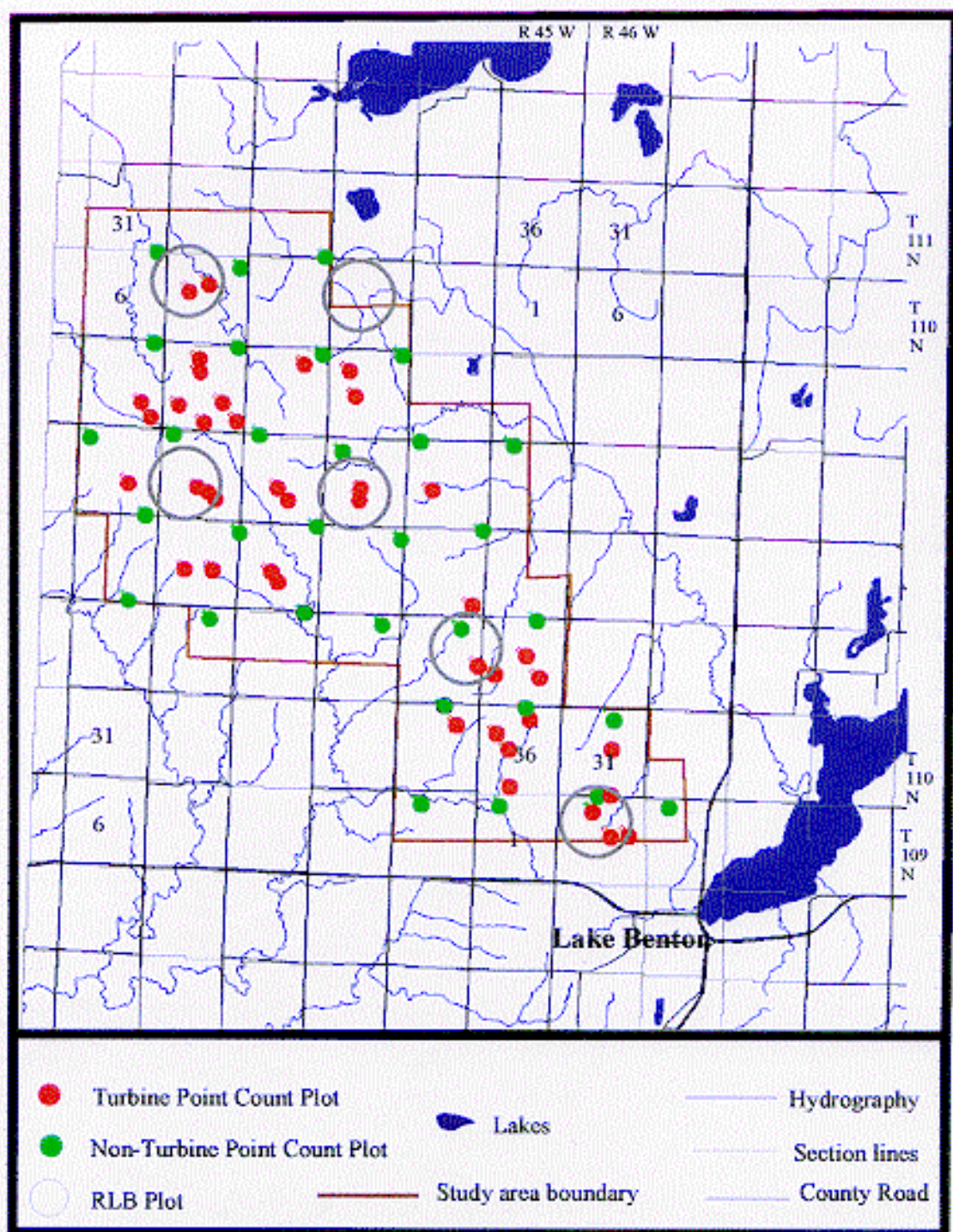


Figure 4. Phase III study area and locations of sample plots.

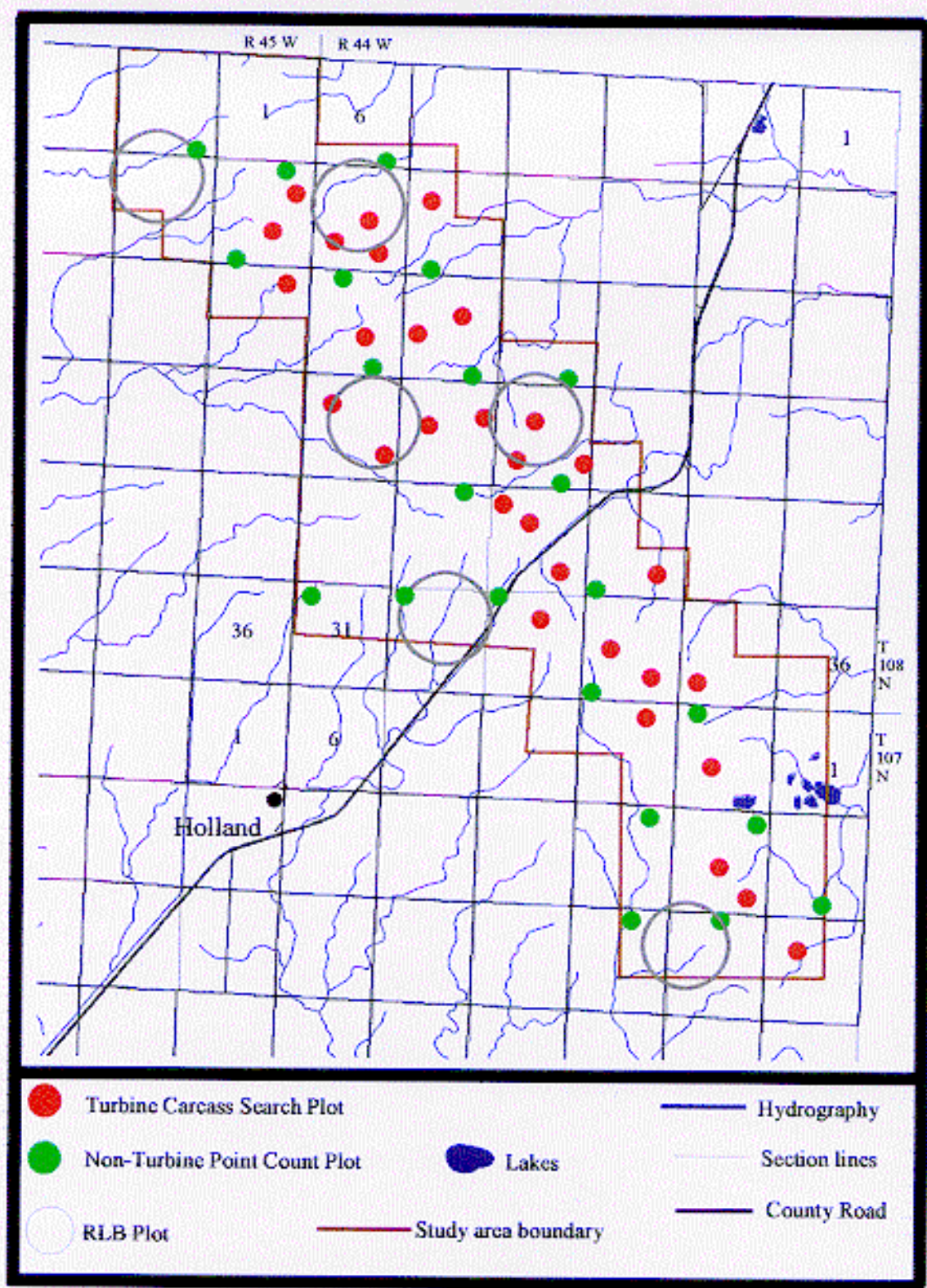


Figure 5. Permanent Reference Area and locations of sample plots.

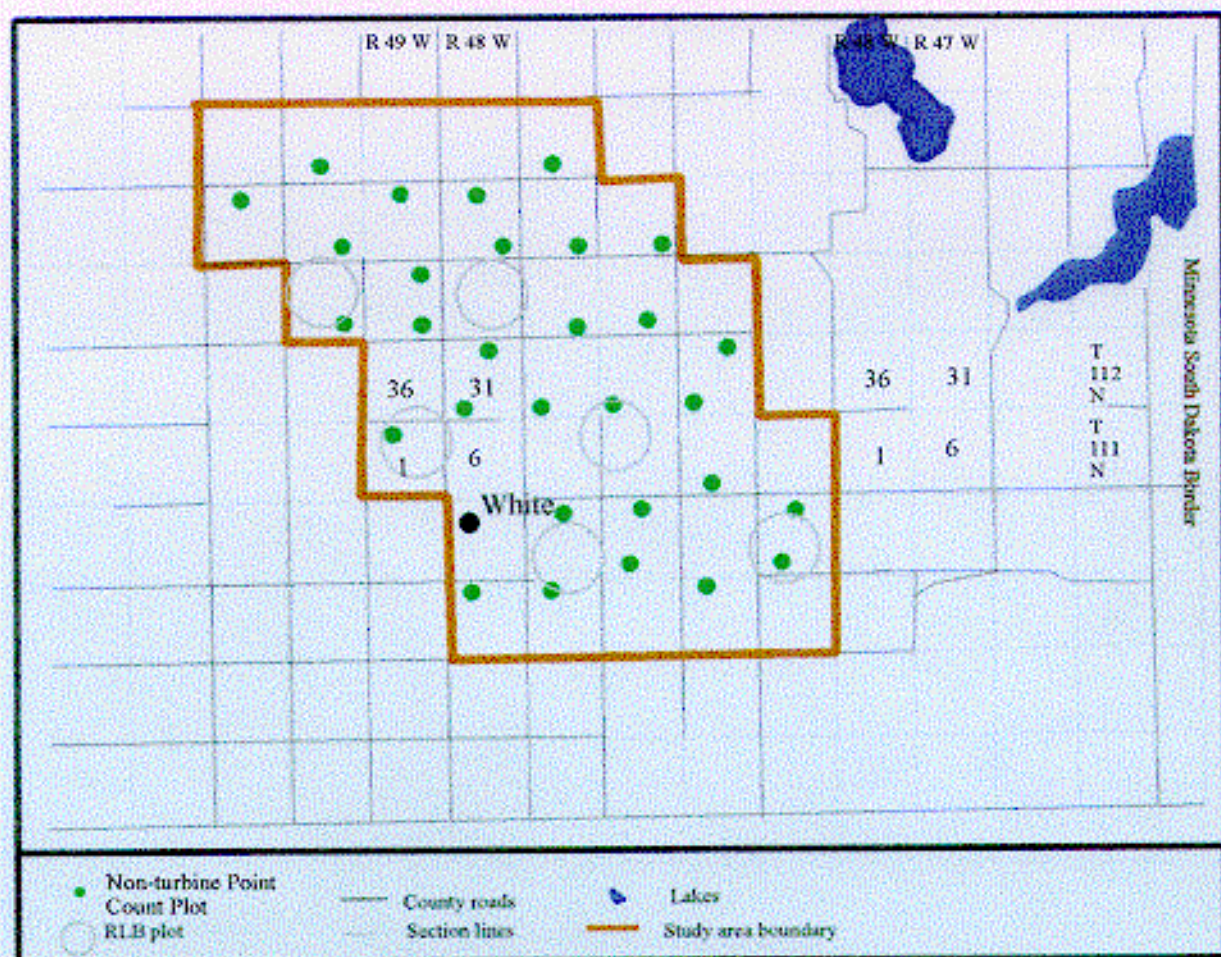
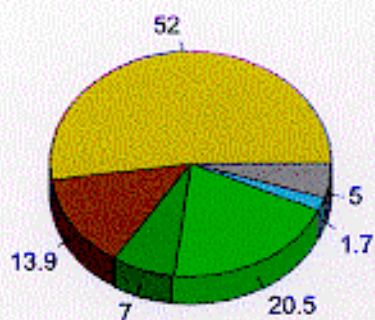


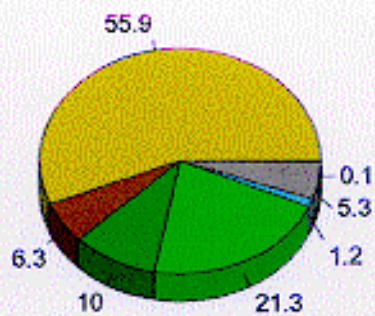
Figure 6. Habitat composition on Buffalo Ridge and the P1, P2, P3 and Reference study areas.

BUFFALO RIDGE HABITAT

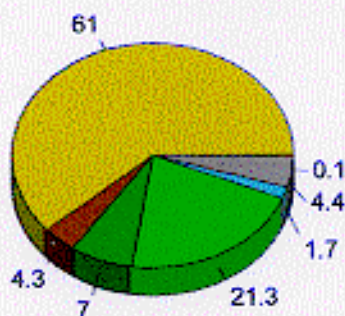
1996



1997



1998



1999

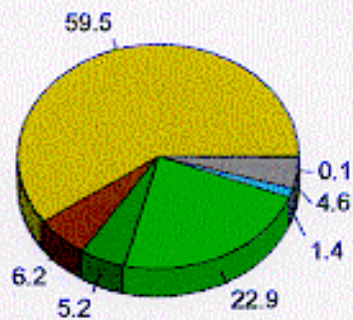
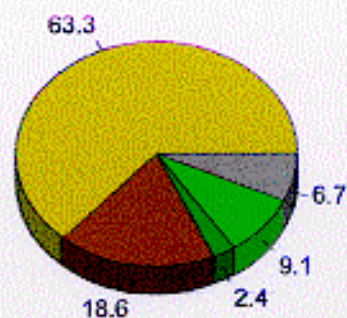


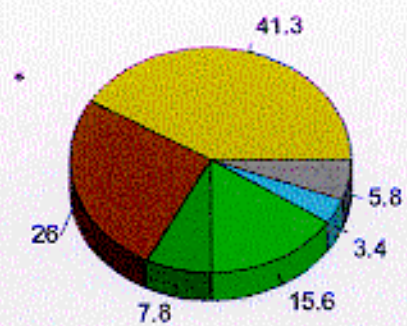
Figure 6 (Continued). Habitat composition on Buffalo Ridge and the P1, P2, P3 and Reference study areas.

1996 HABITAT COMPARISONS

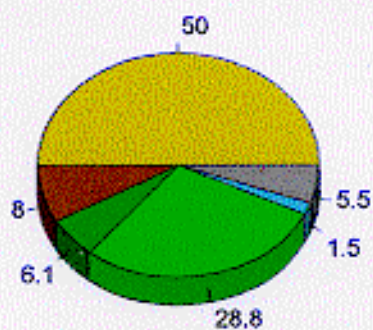
PHASE I



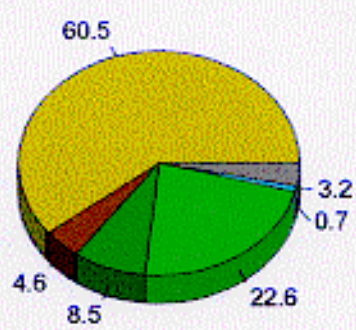
PHASE II



PHASE III



REF



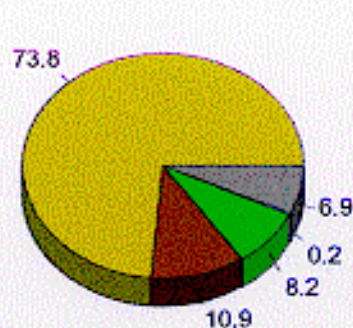
* Significantly different than reference



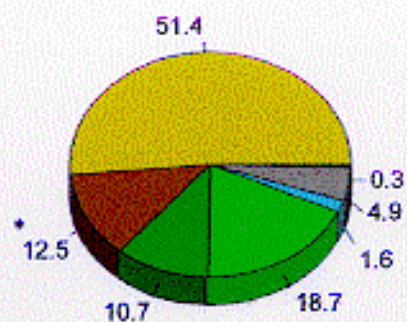
Figure 6 (Continued). Habitat composition on Buffalo Ridge and the P1, P2, P3 and Reference study areas.

1997 HABITAT COMPARISONS

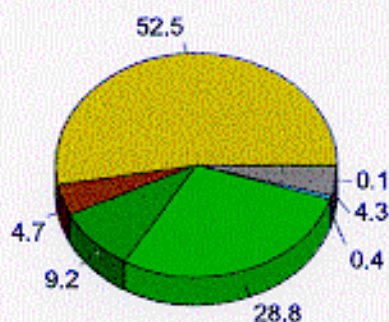
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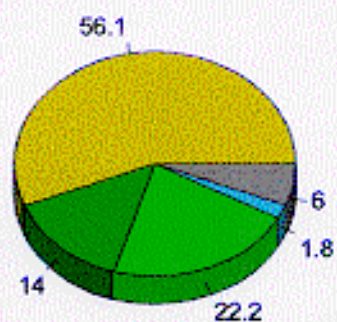
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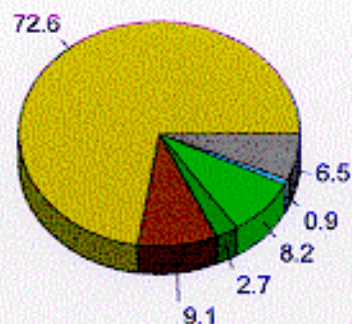
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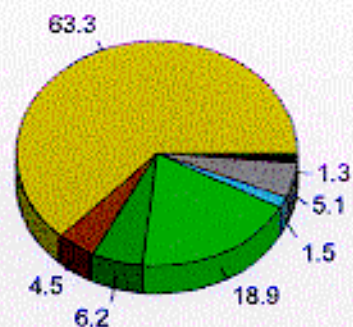
Figure 6 (Continued). Habitat composition on Buffalo Ridge and the P1, P2, P3 and Reference study areas.

1998 HABITAT COMPARISONS

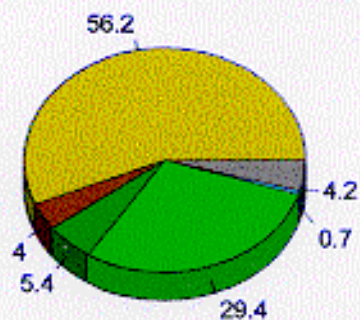
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PHASE II



PHASE III



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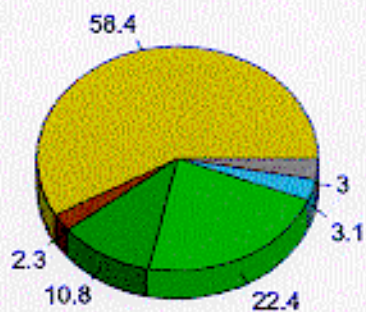
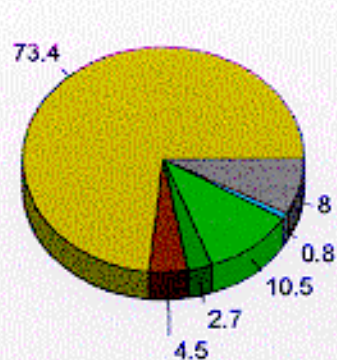


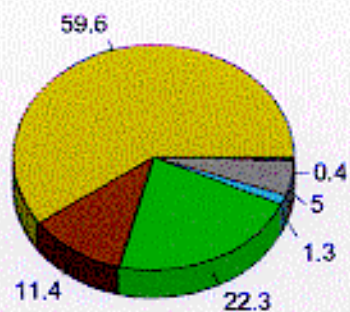
Figure 6 (Continued). Habitat composition on Buffalo Ridge and the P1, P2, P3 and Reference study areas.

1999 HABITAT COMPARISONS

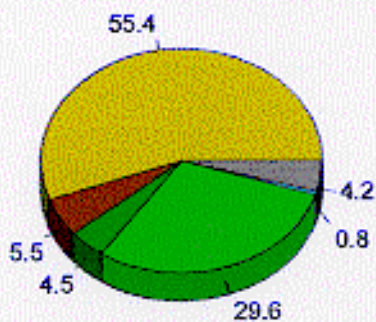
PHASE I



PHASE II



PHASE III



REF

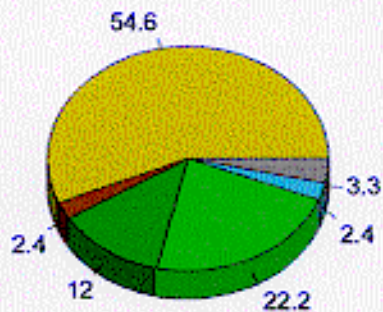


Figure 7. Avian richness (expressed as number of species/survey) by study area and season based on point count survey data.

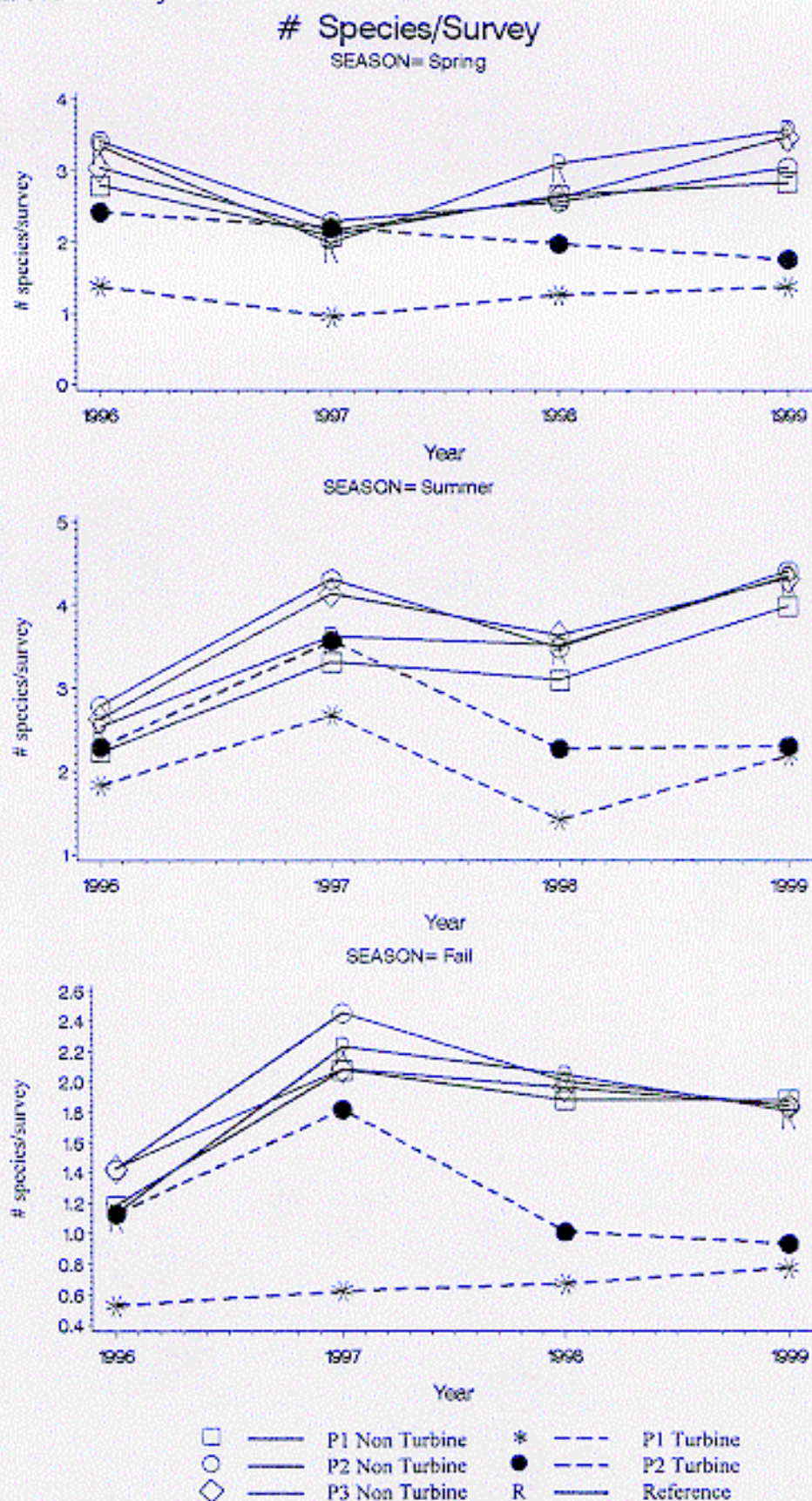


Figure 8. Avian abundance (expressed as number observed per survey) by study area and season based on point count survey data.

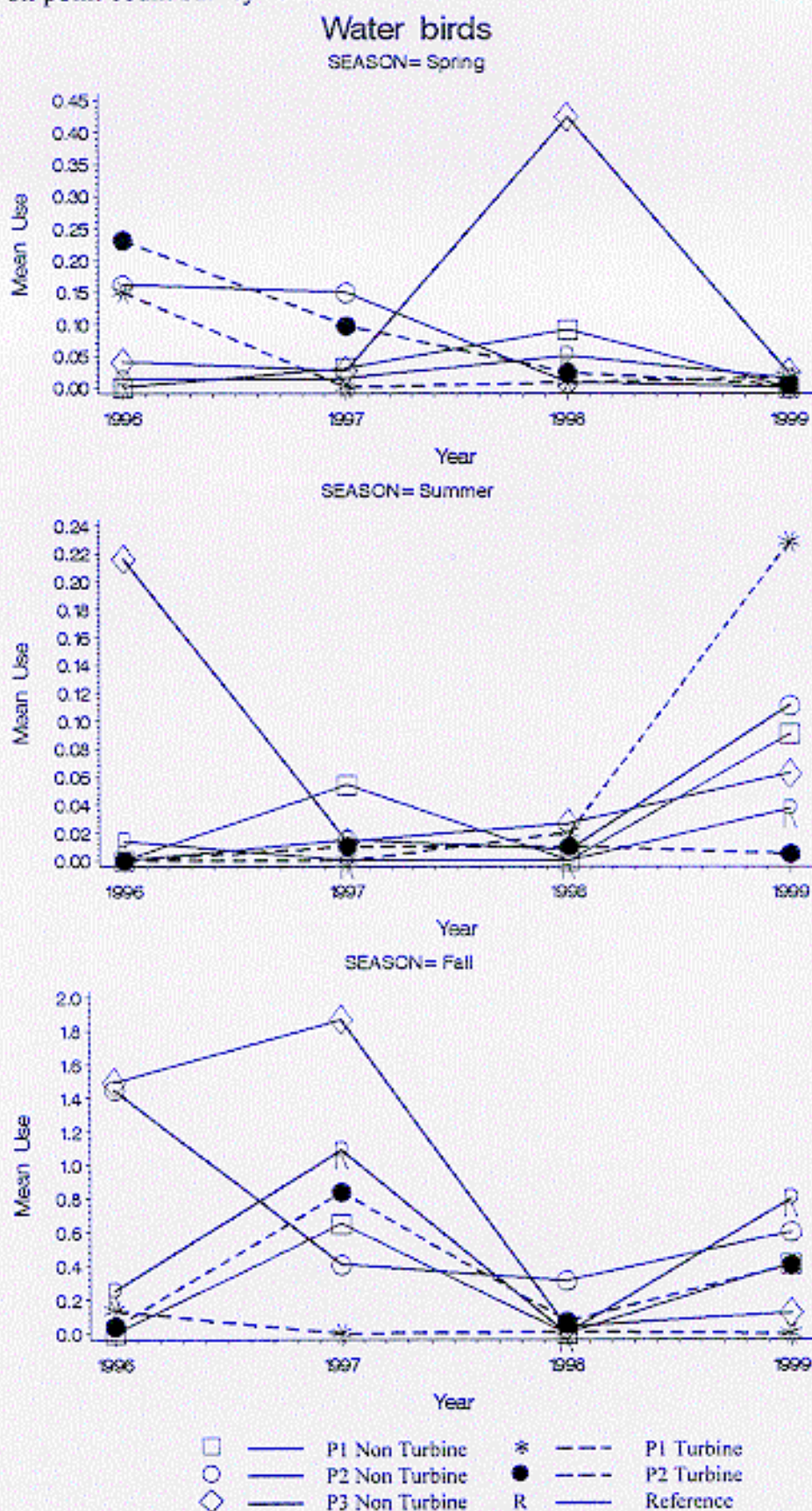


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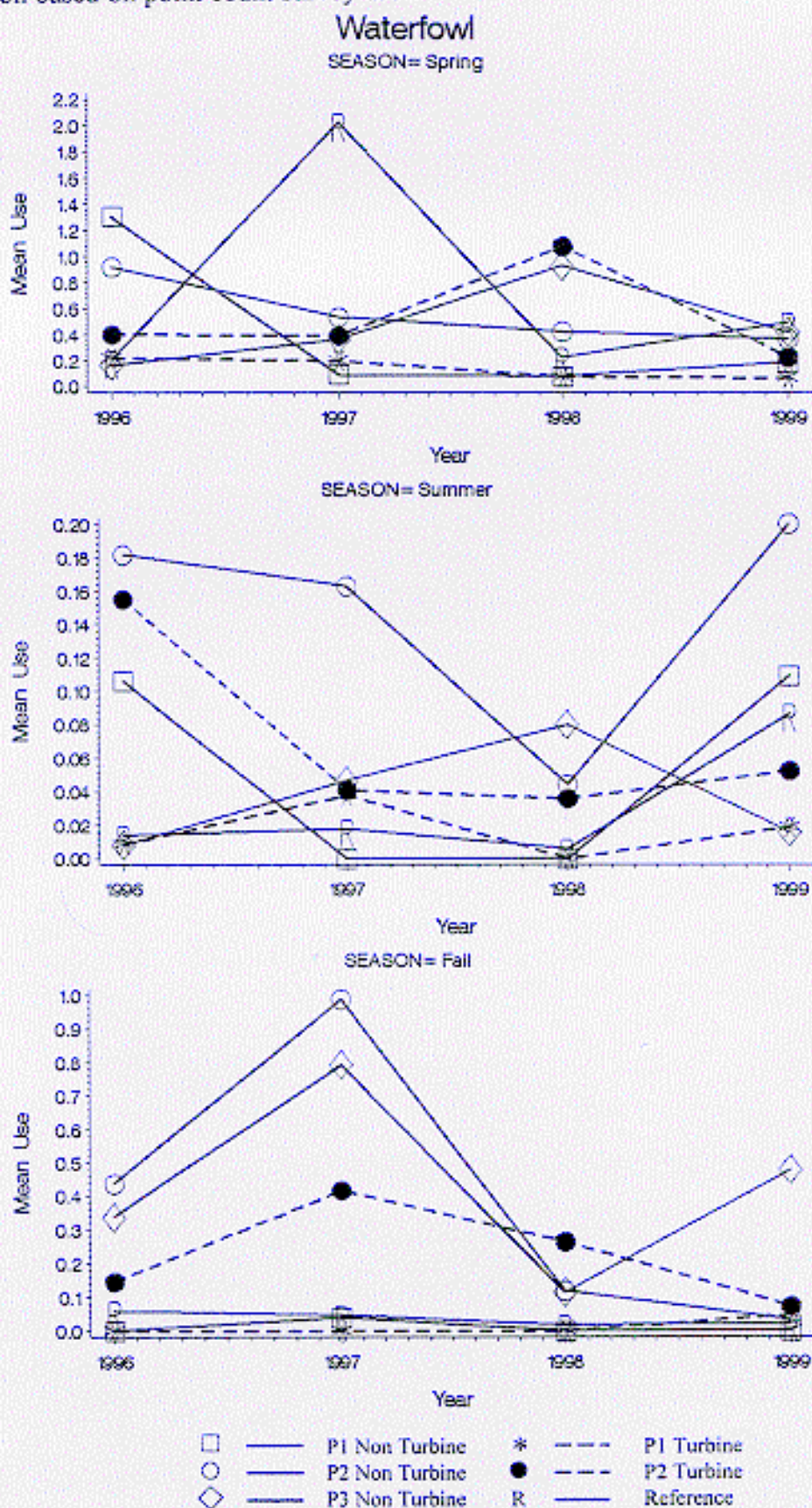


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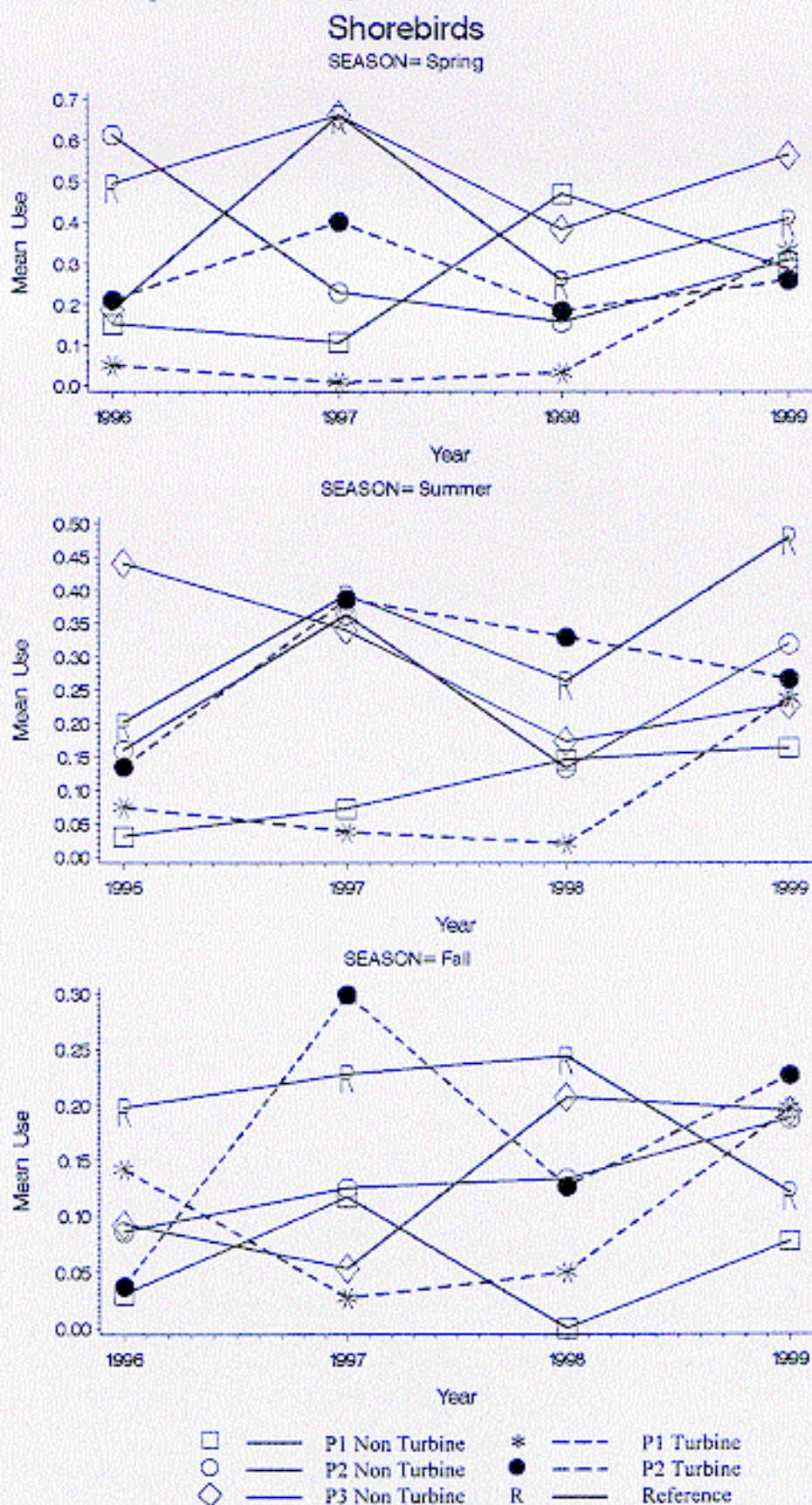


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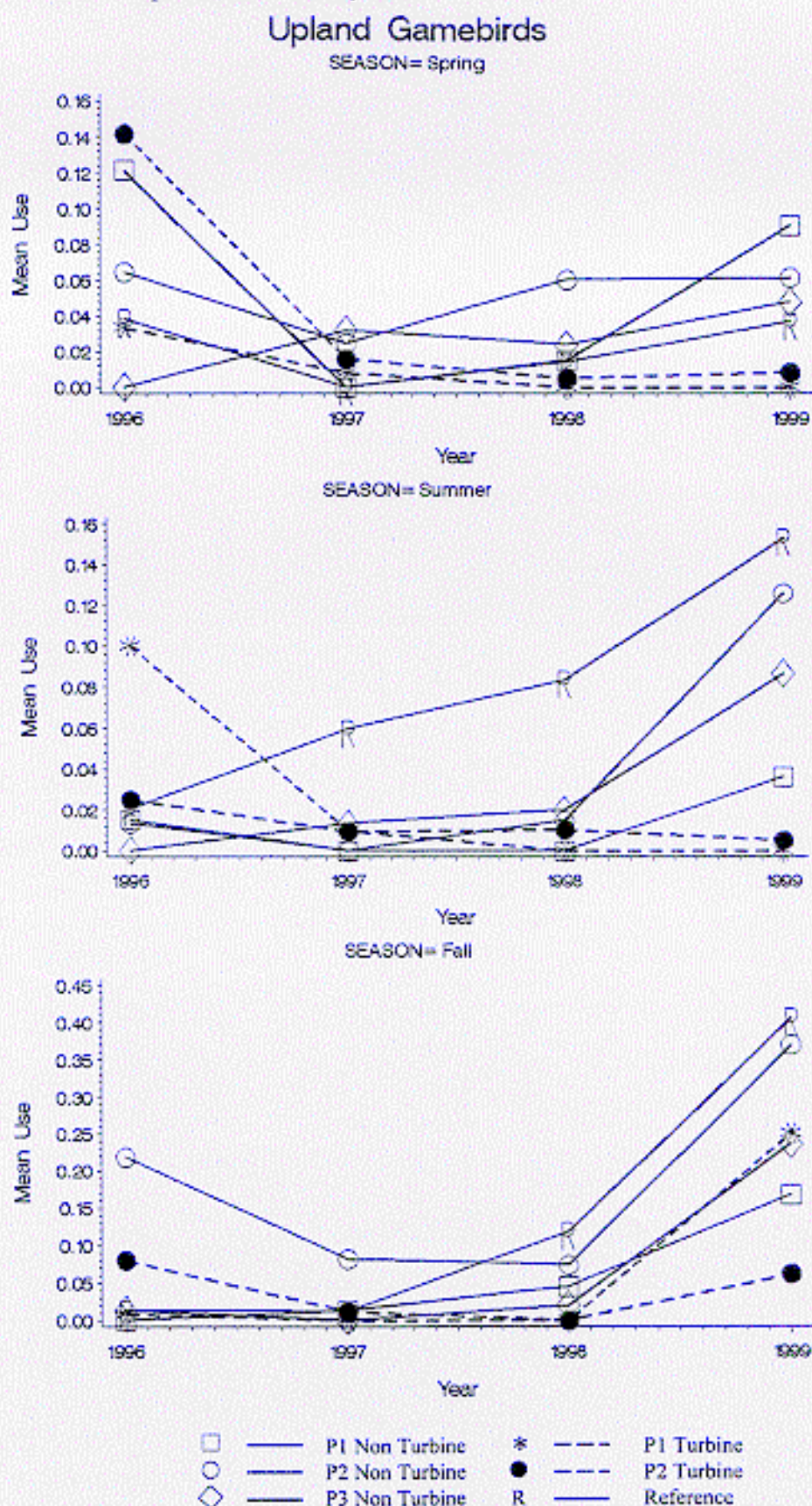


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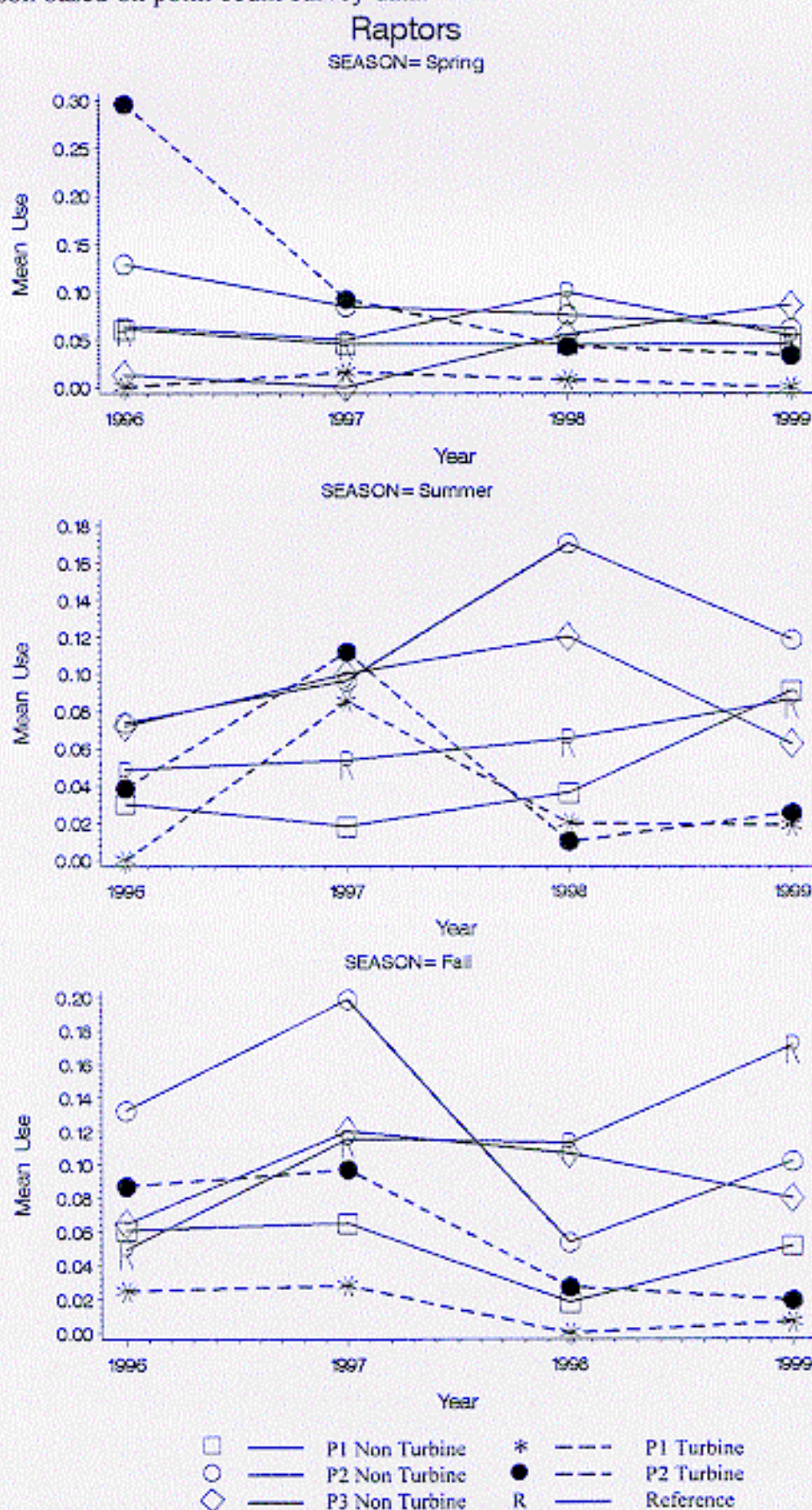


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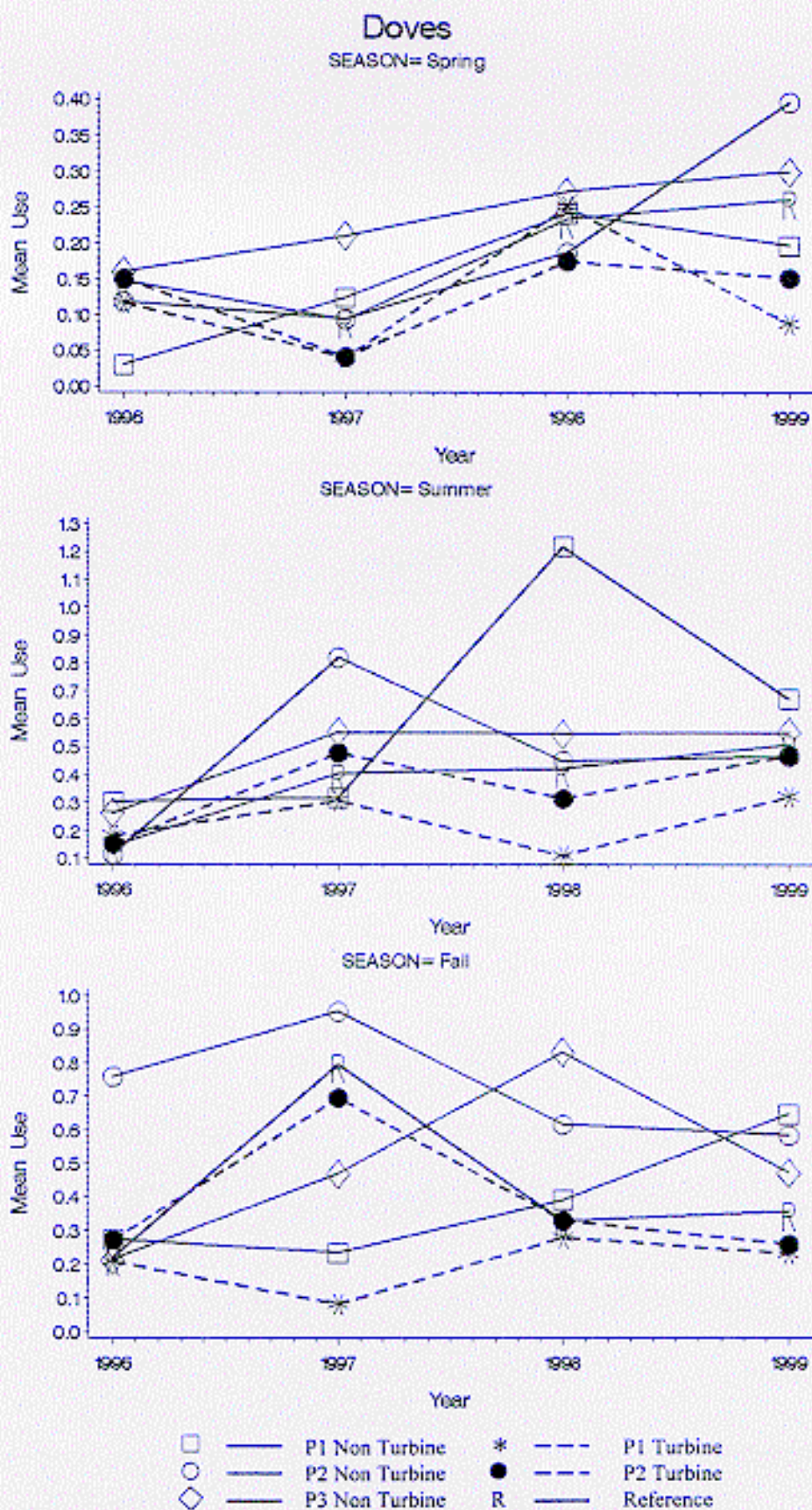


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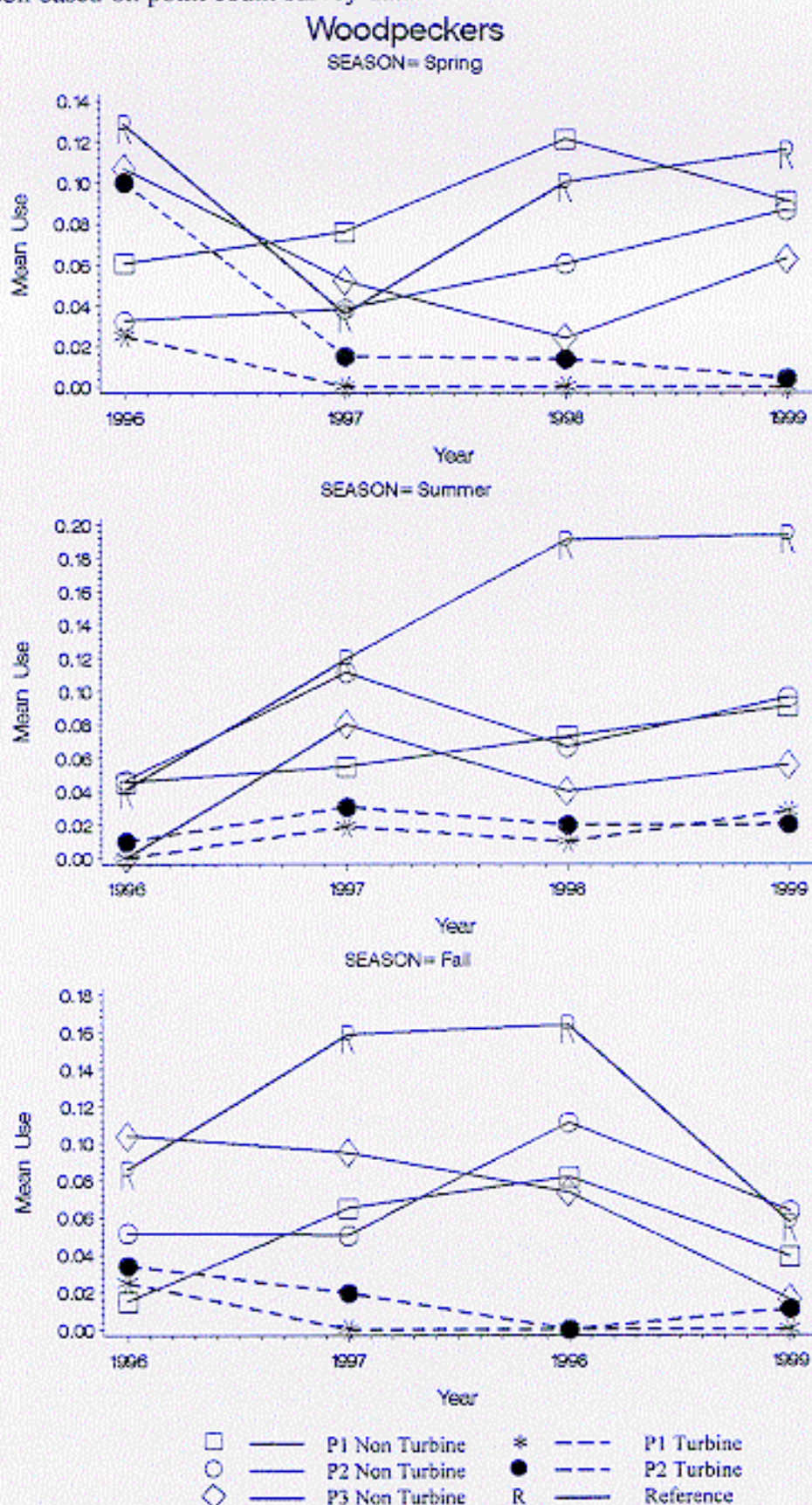


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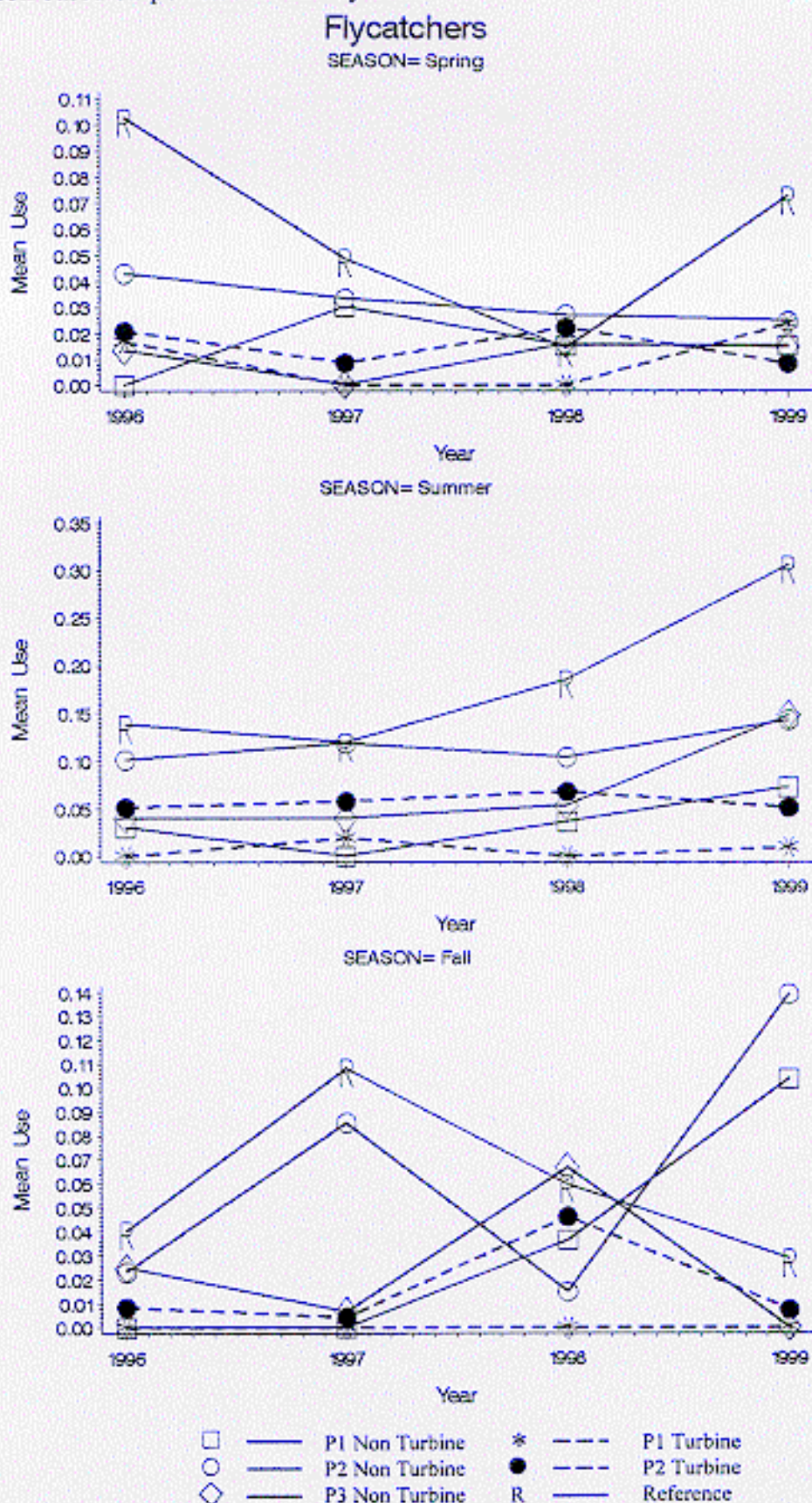


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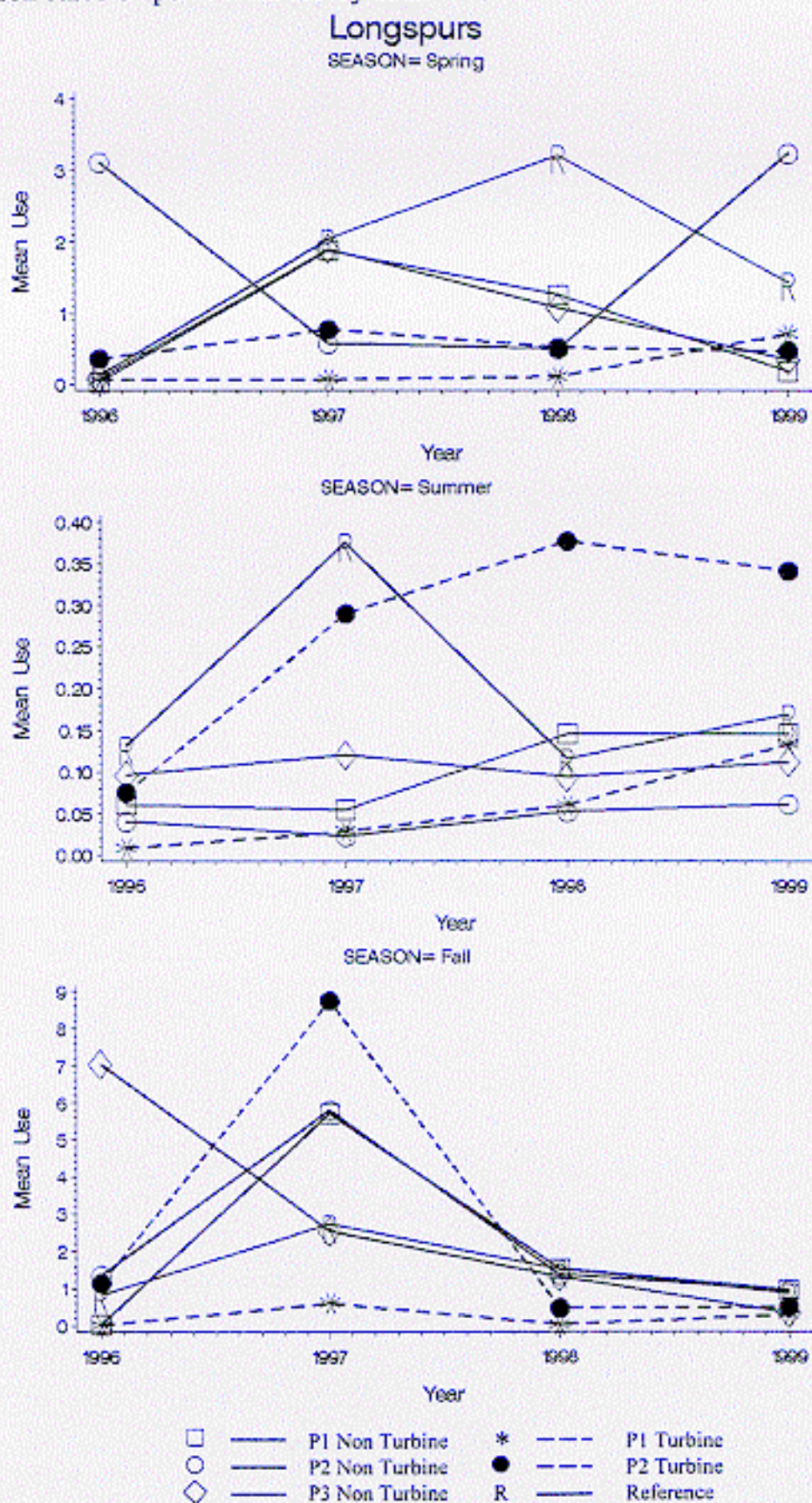


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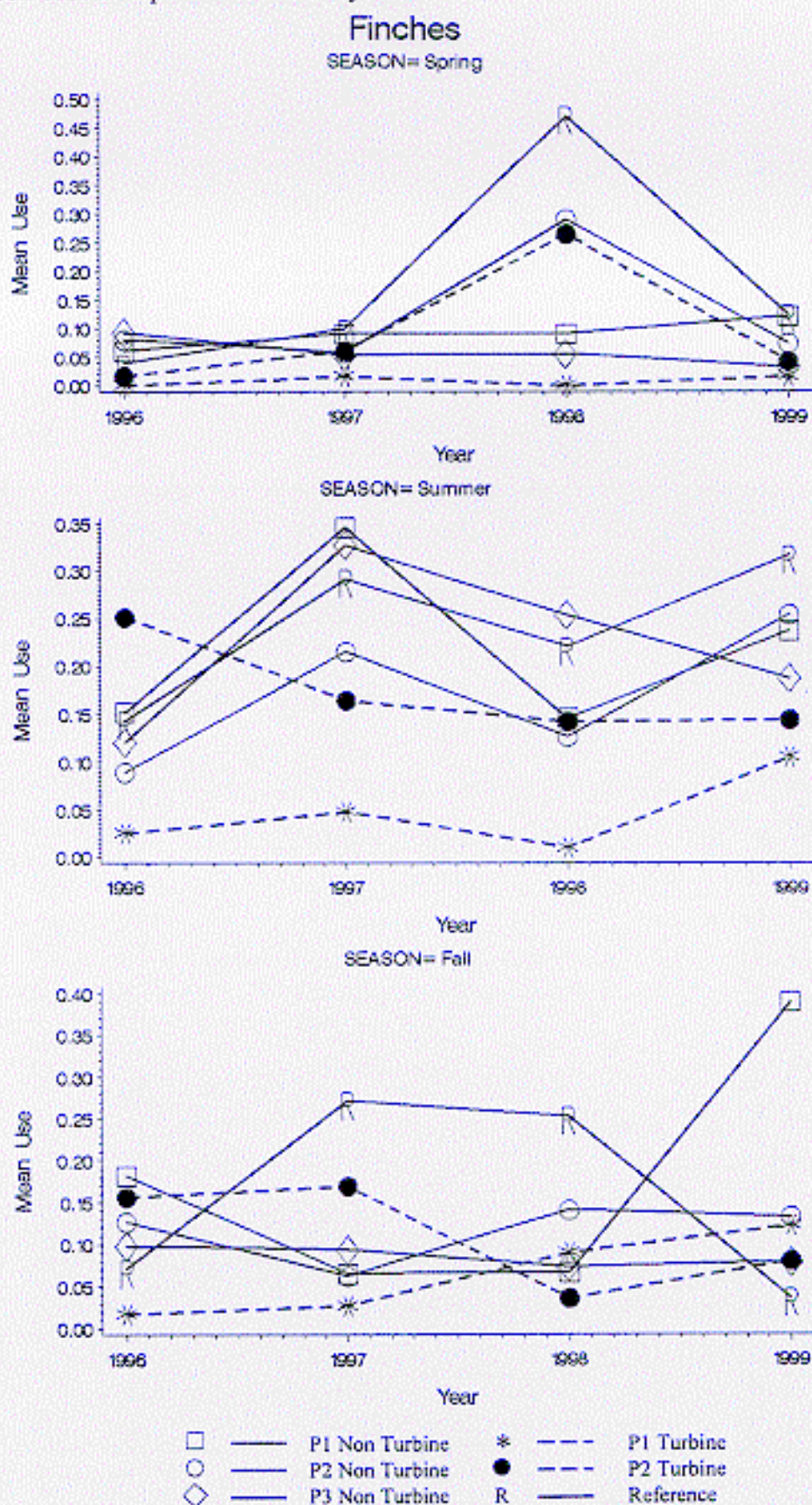


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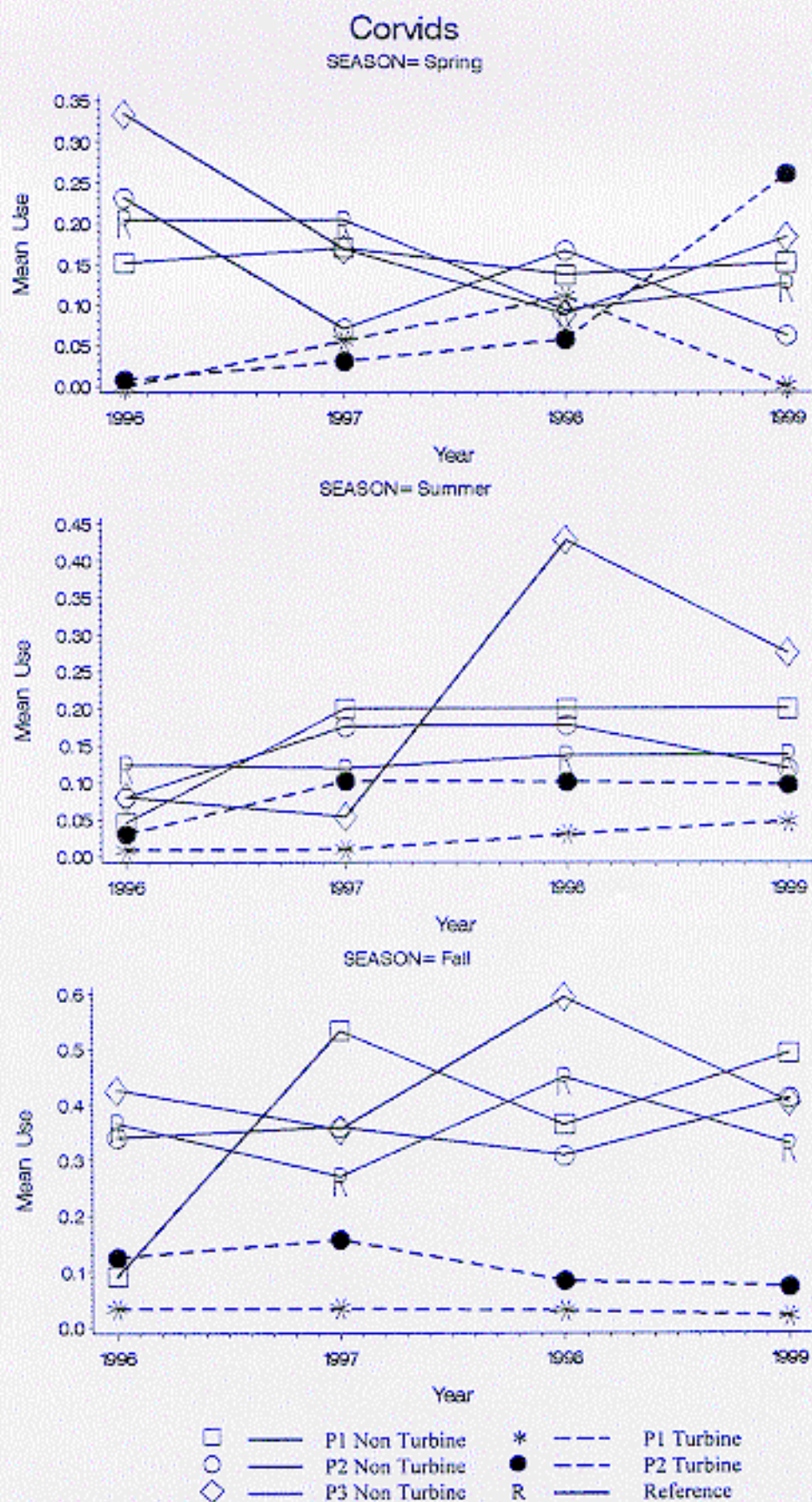


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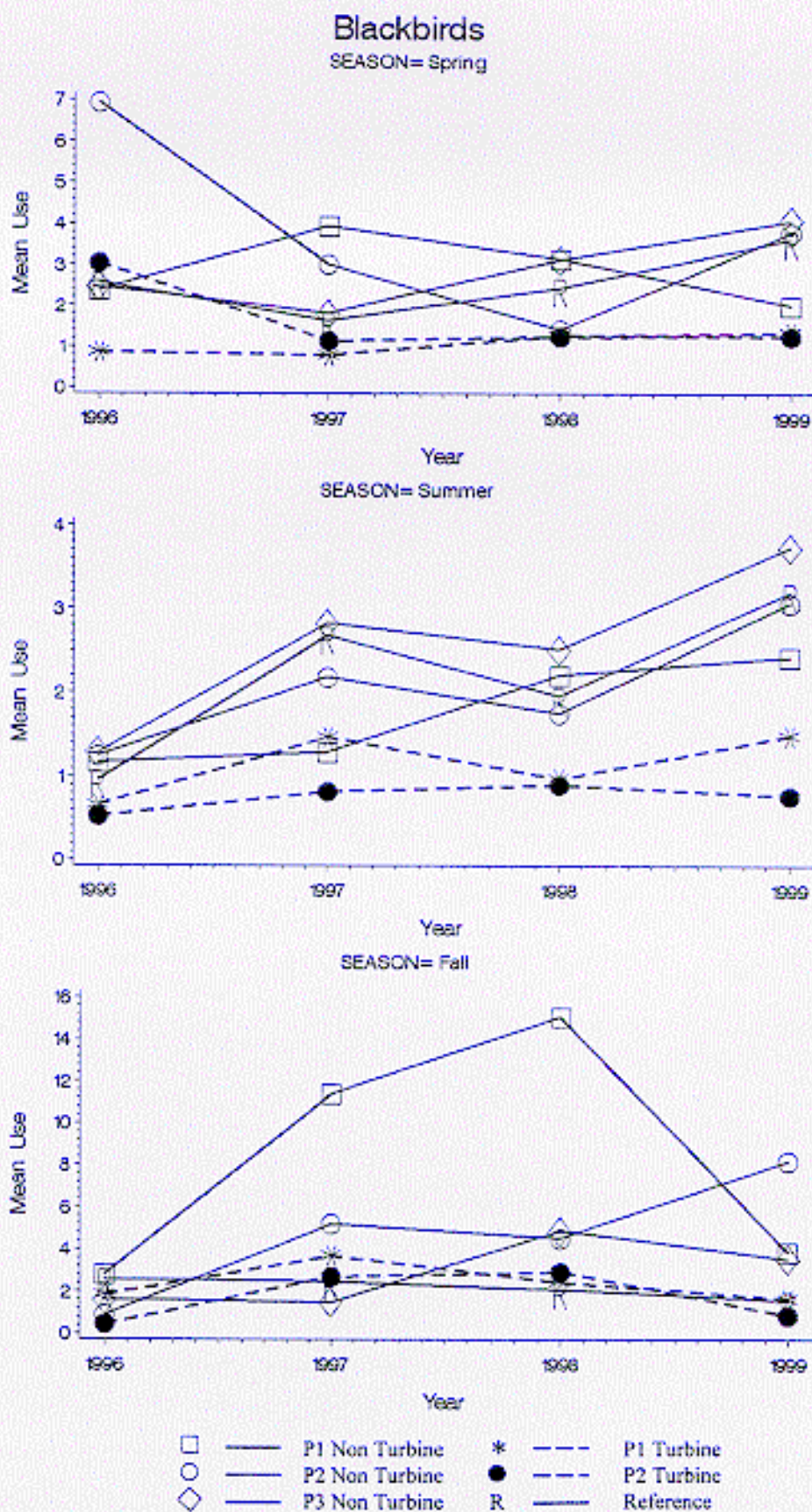


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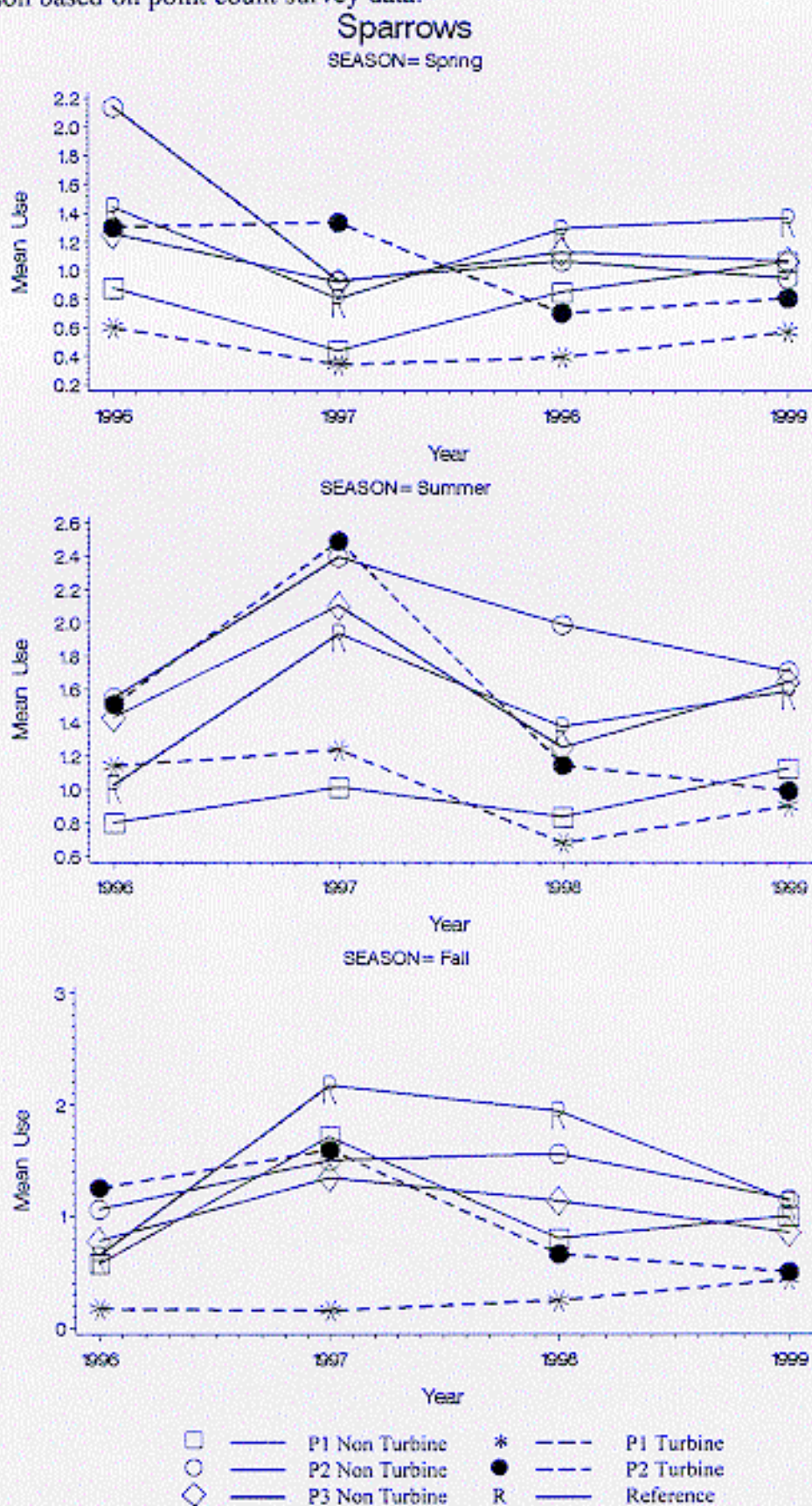


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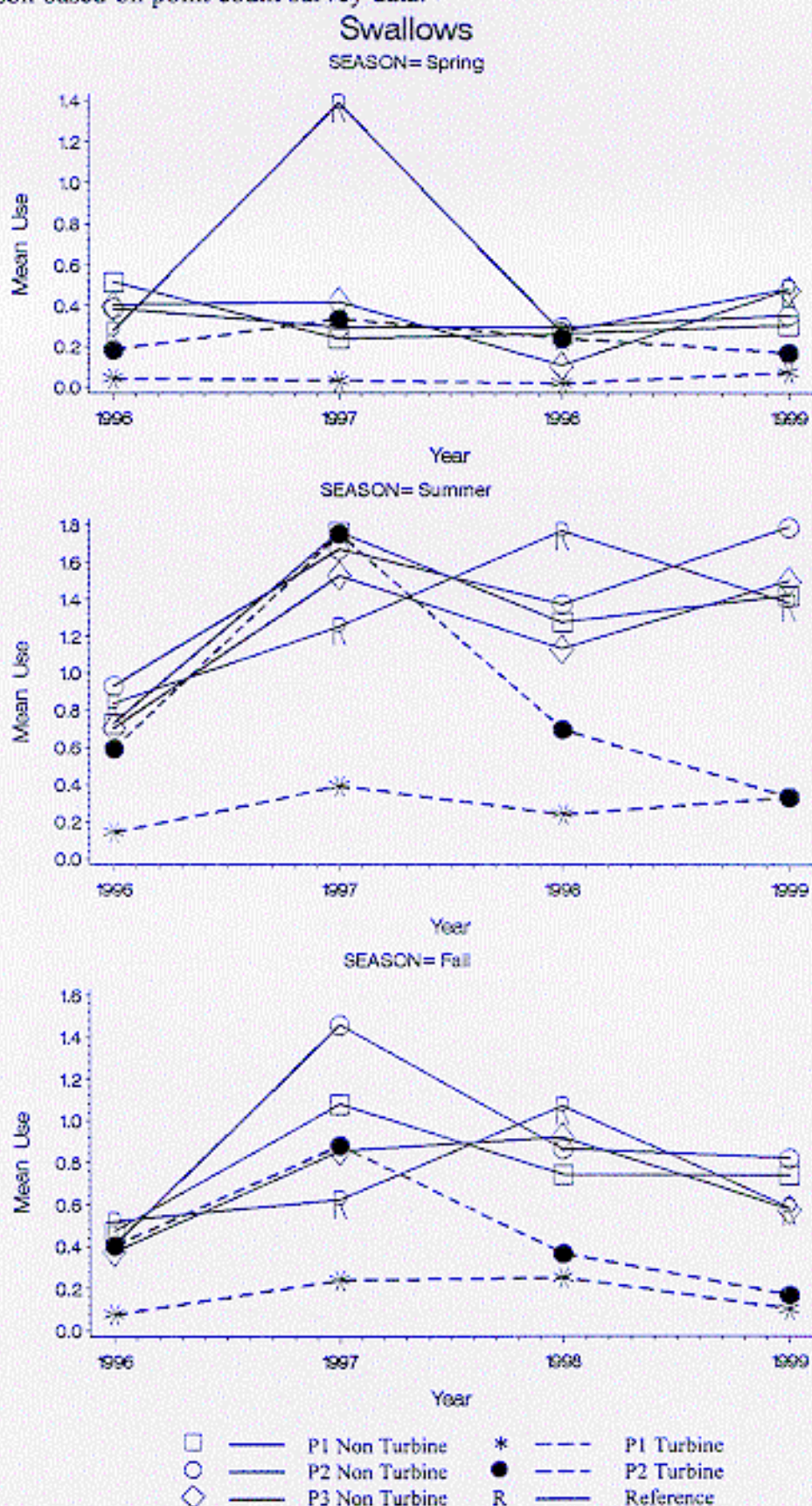
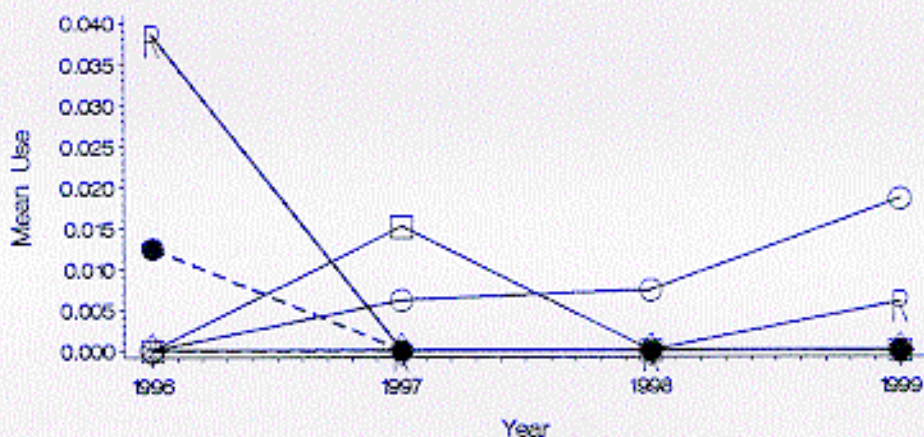


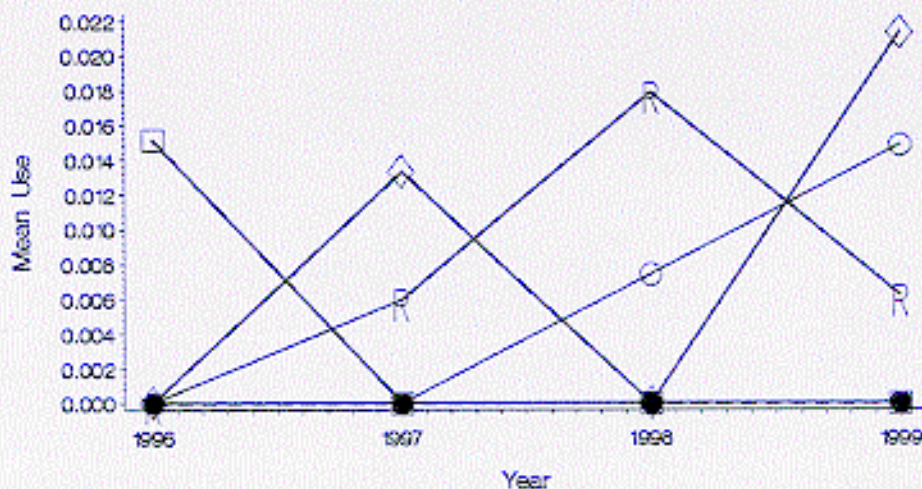
Figure 8 (Continued). Avian abundance (expressed as number observed per survey) by study area and season based on point count survey data.

Tanagers & Orioles

SEASON= Spring



SEASON= Summer



SEASON= Fall

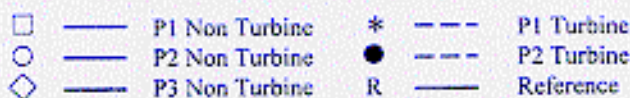
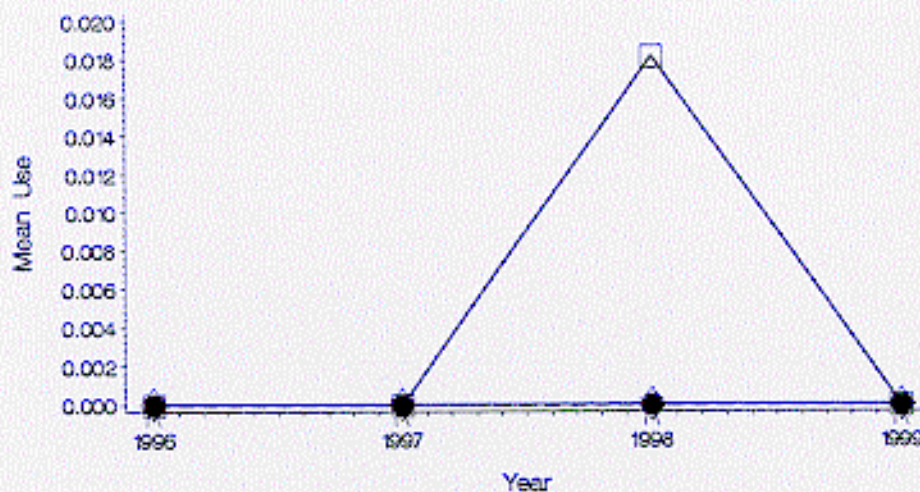


Figure 8 (Continued). Avian abundance (expressed as number observed per survey) by study area and season based on point count survey data.

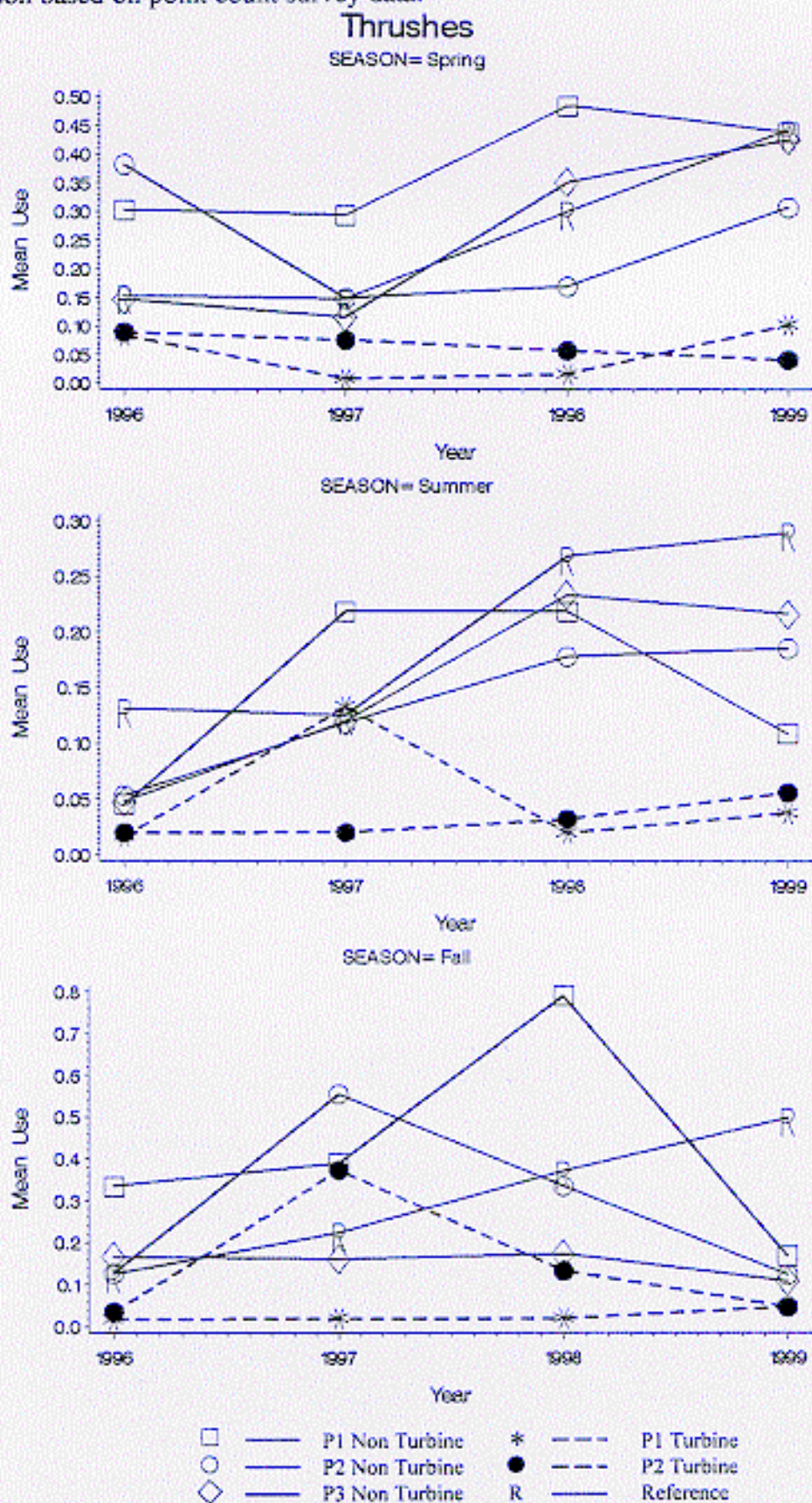


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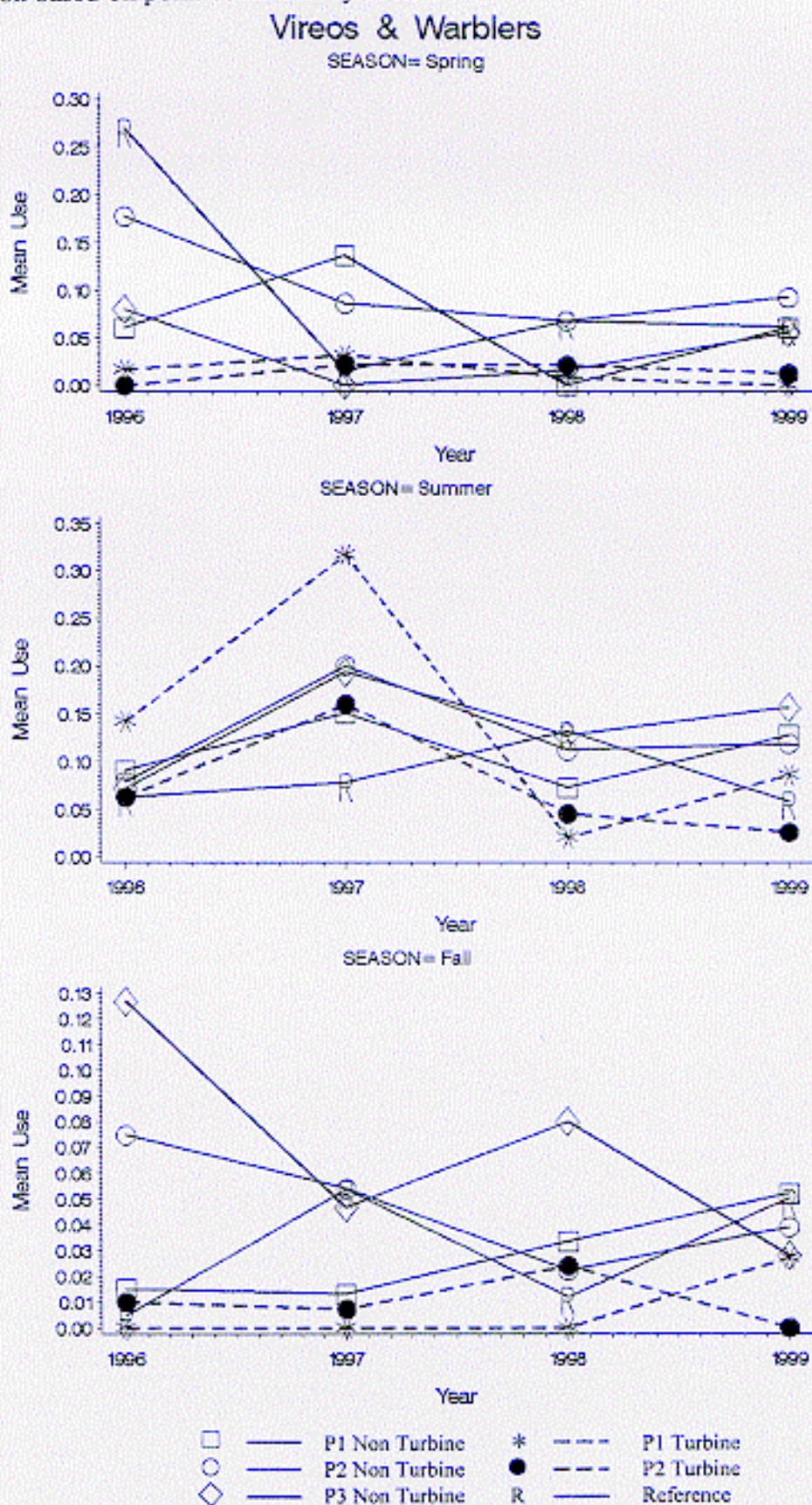


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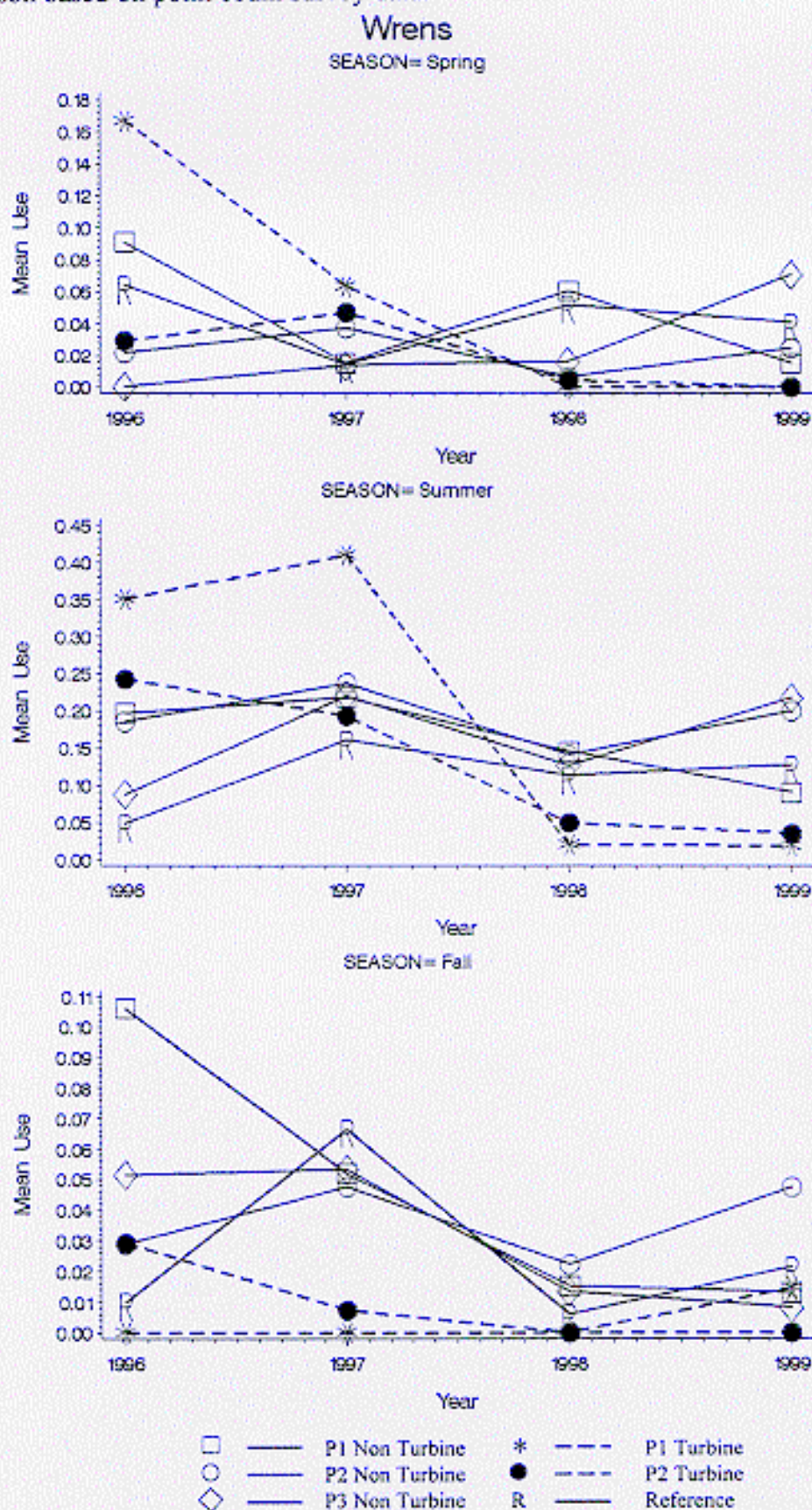


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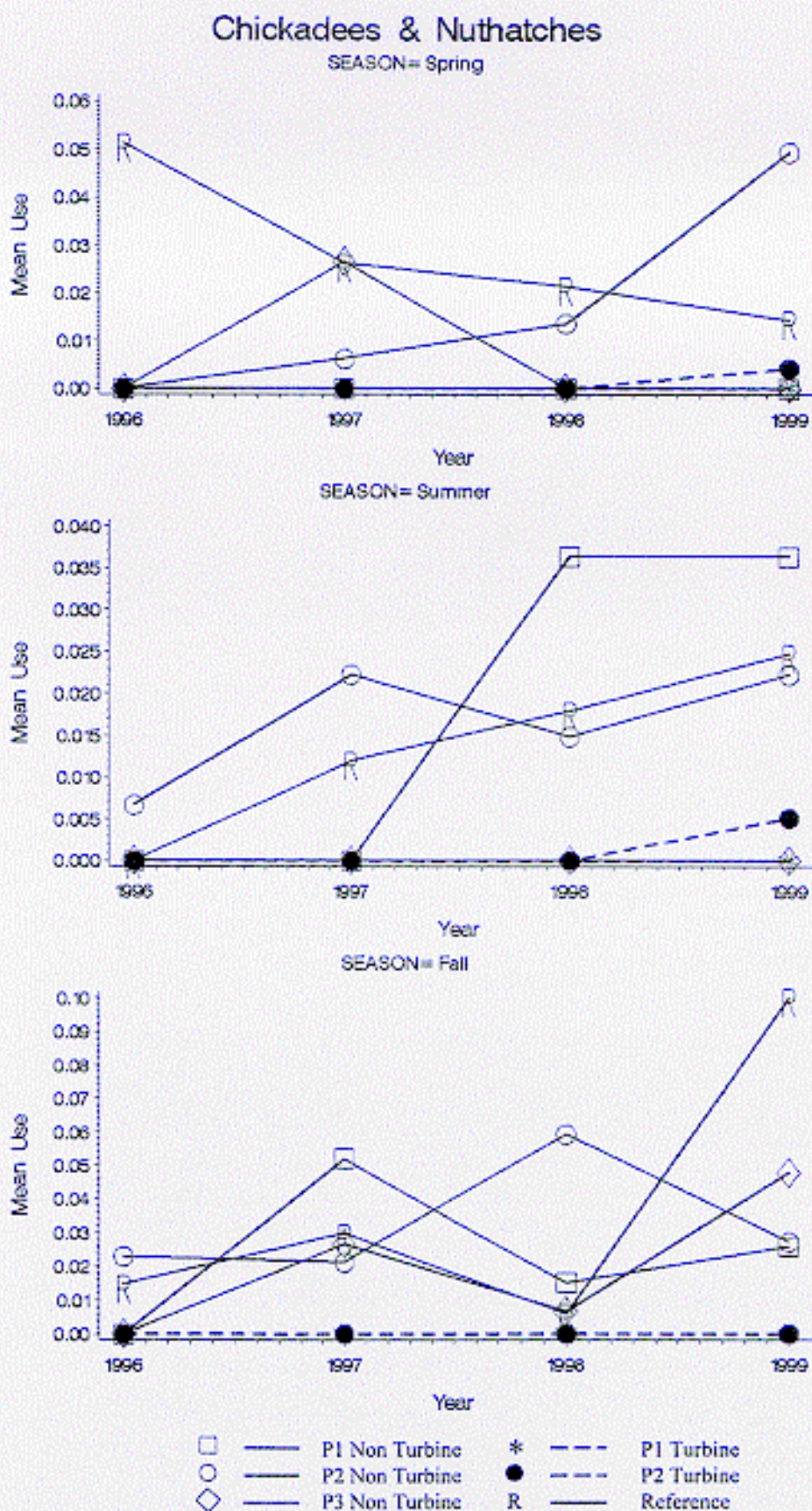


Figure 8 (Continued). Avian abundance (expressed as number observed per survey) by study area and season based on point count survey data.

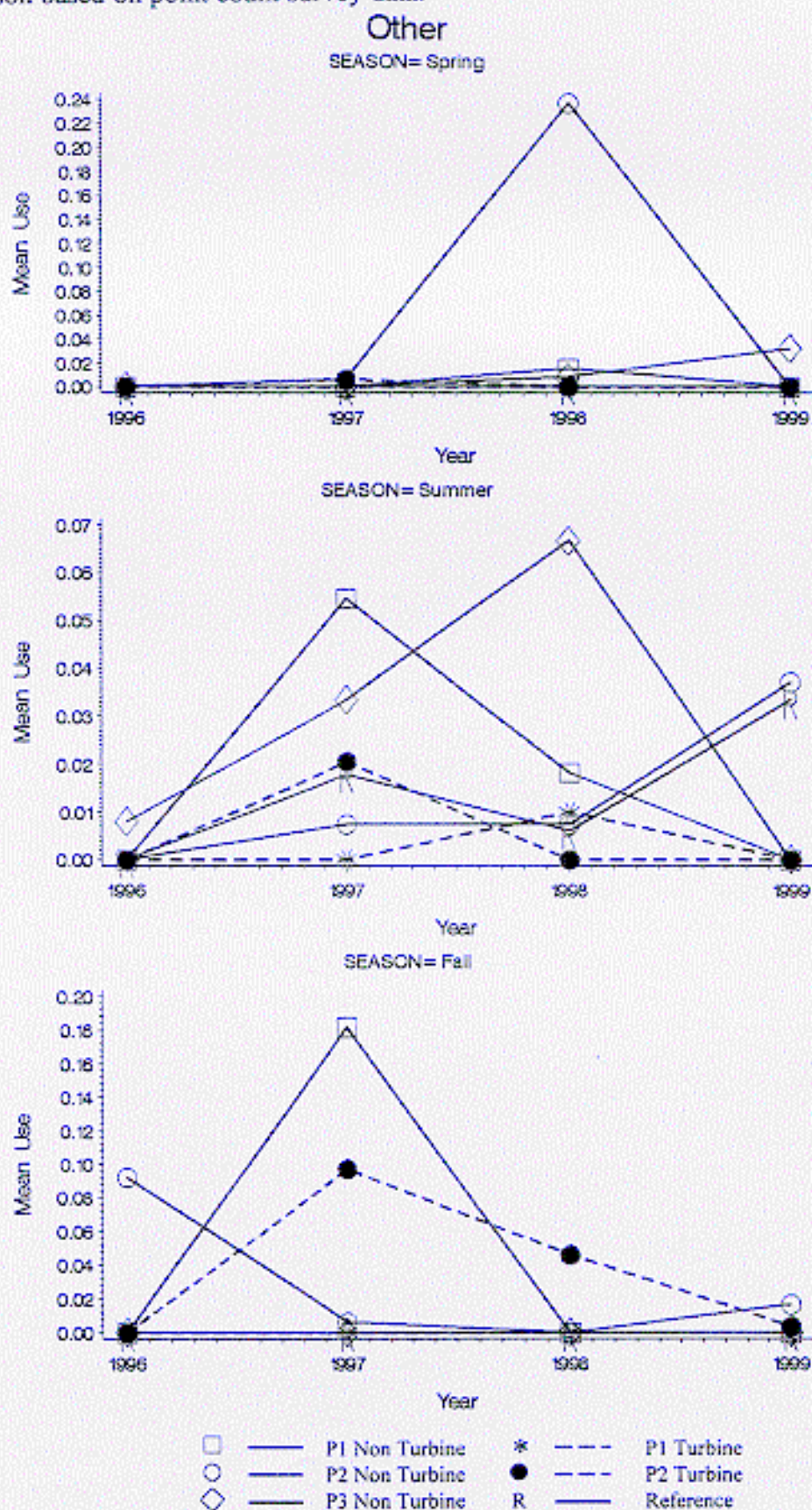


Figure 8 (Continued). Avian abundance (expressed as number observed per survey) by study area and season based on point count survey data.

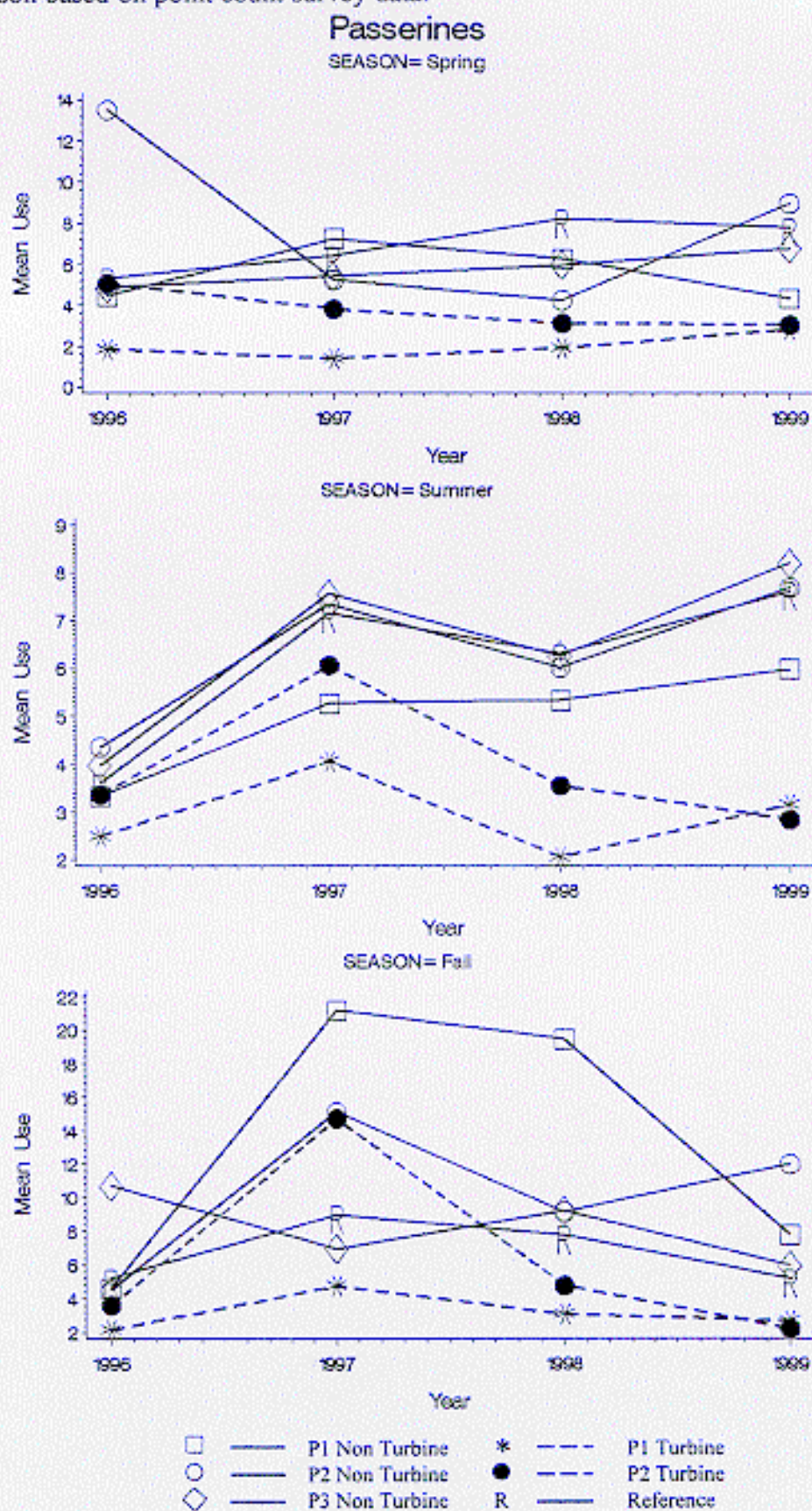


Figure 9. Avian richness (expressed as number of species/survey) by study area and season based on RLB survey data.

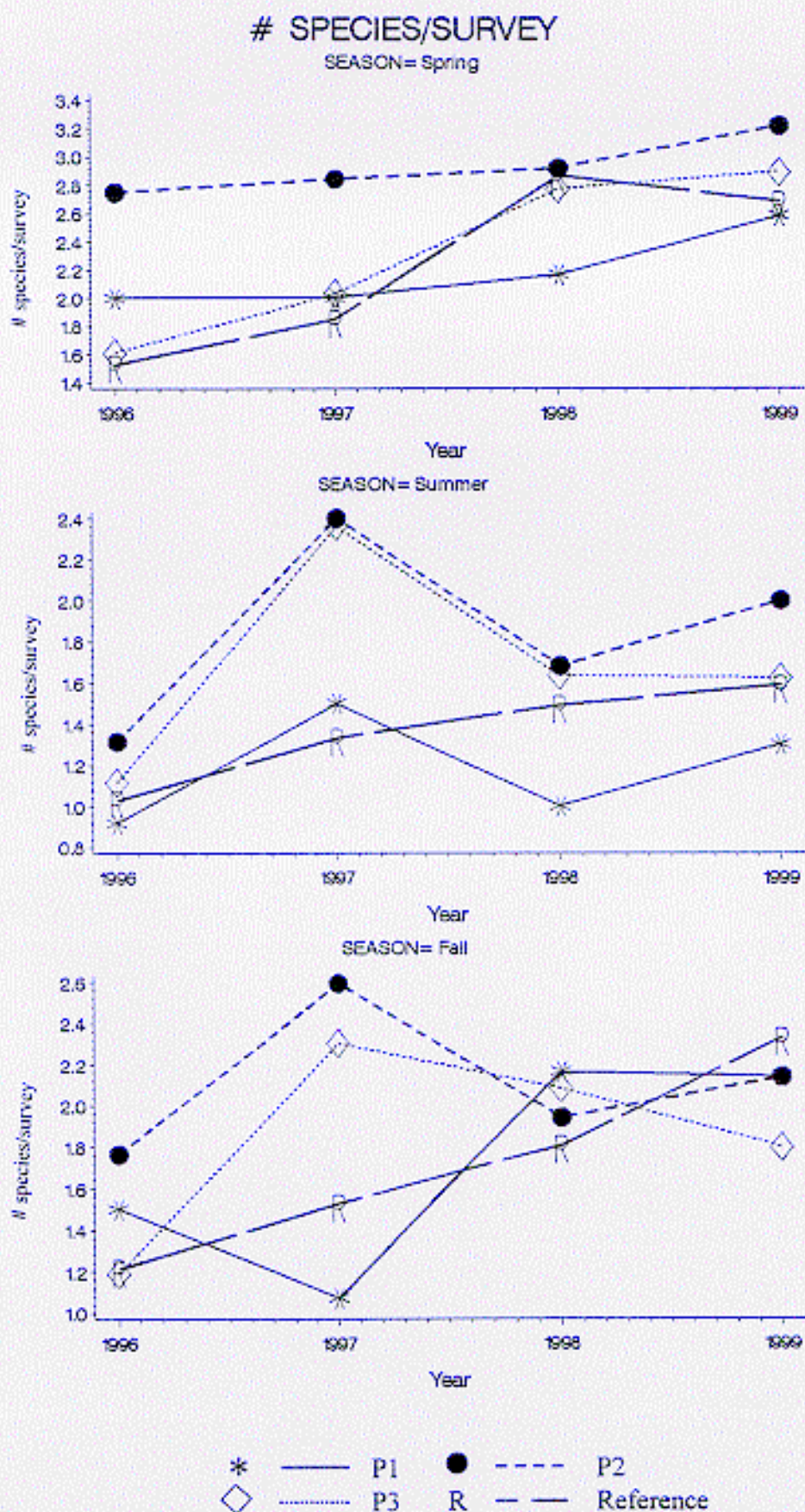


Figure 10. Avian abundance (expressed as number observed per survey) by study area and season based on RLB survey data.

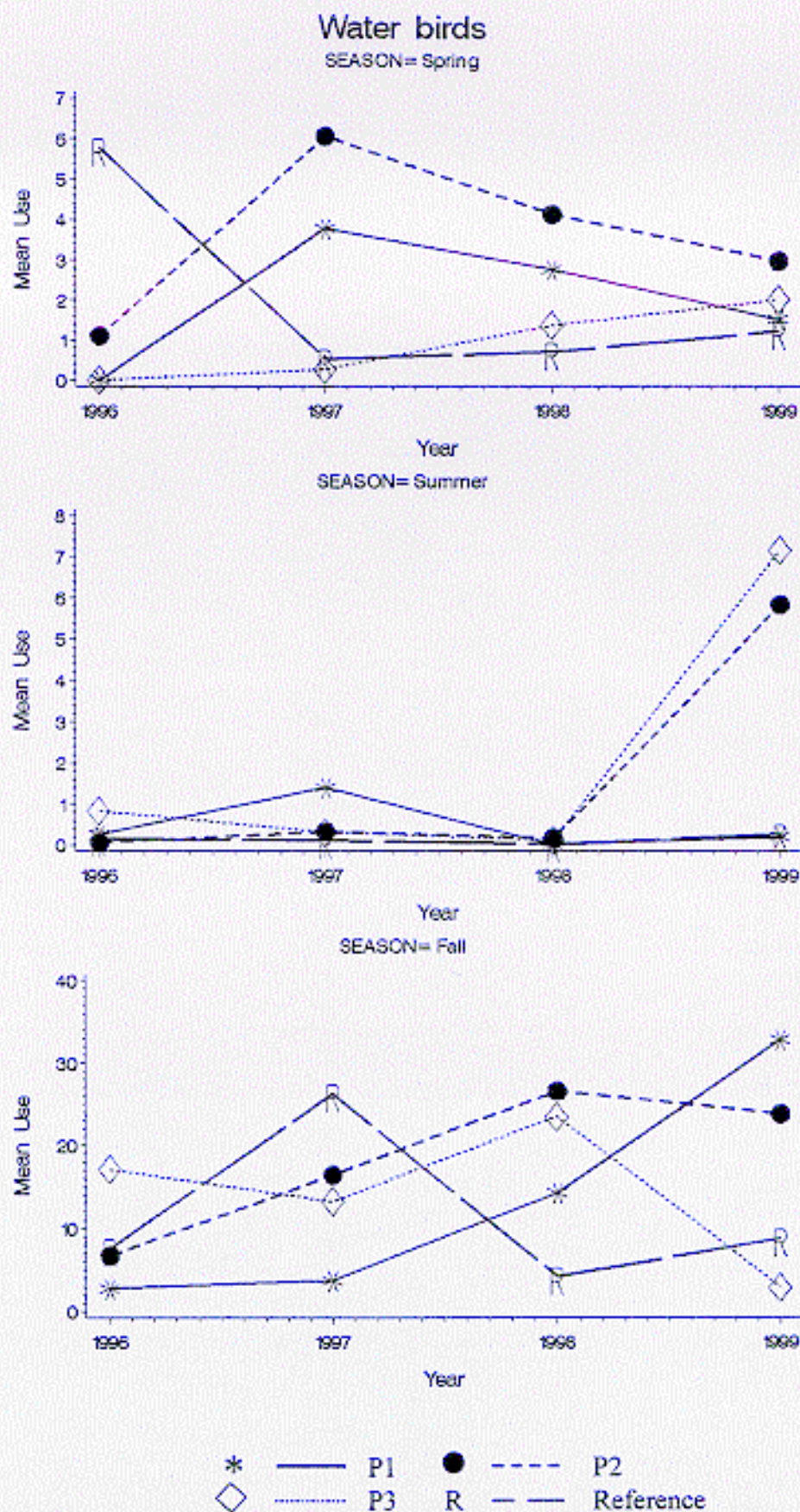


Figure 10 (Continued). Avian abundance (expressed as number observed per survey) by study area and season based on RLB survey data.

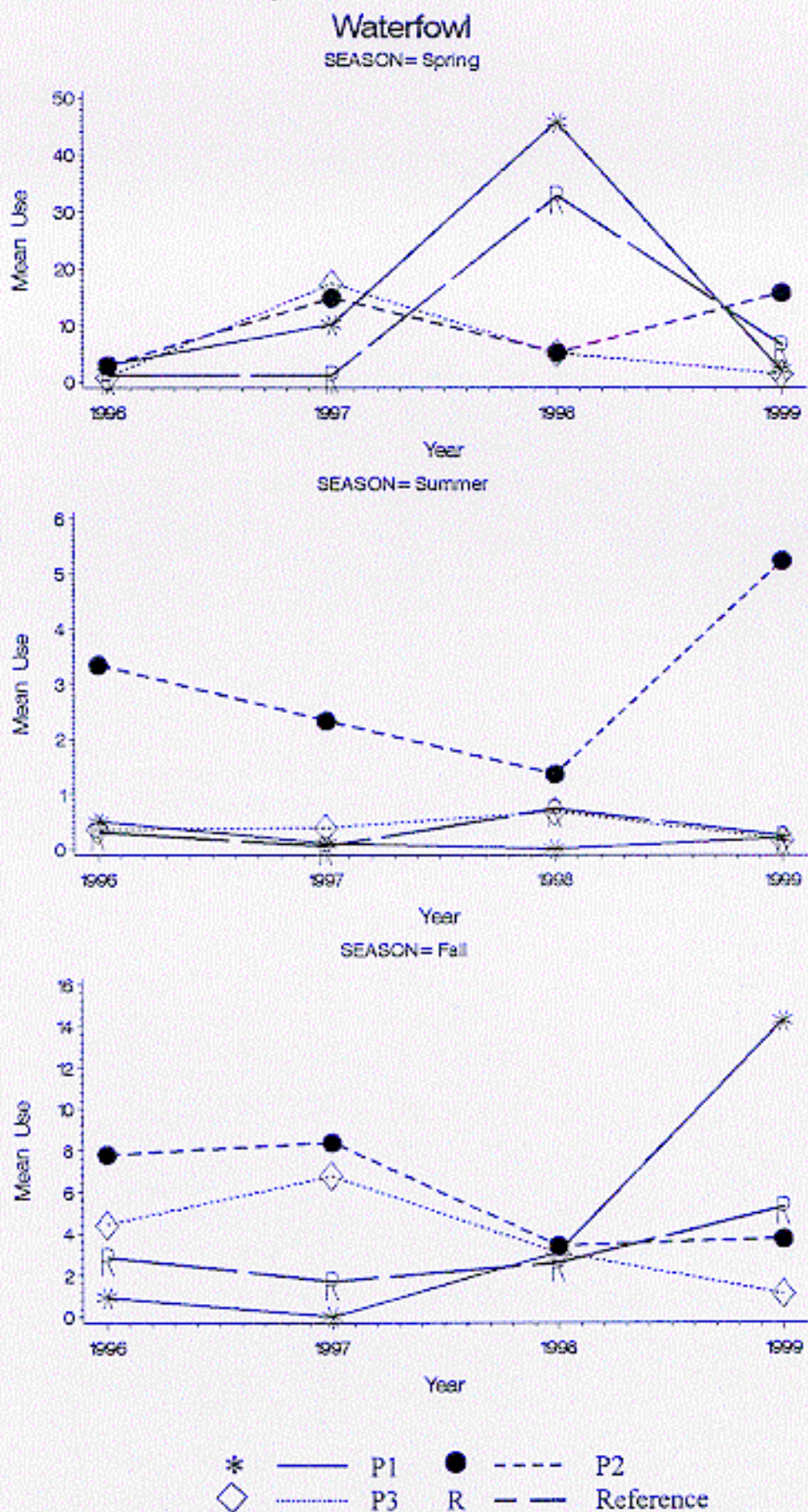


Figure 10 (Continued). Avian abundance (expressed as number observed per survey) by study area and season based on RLB survey data.

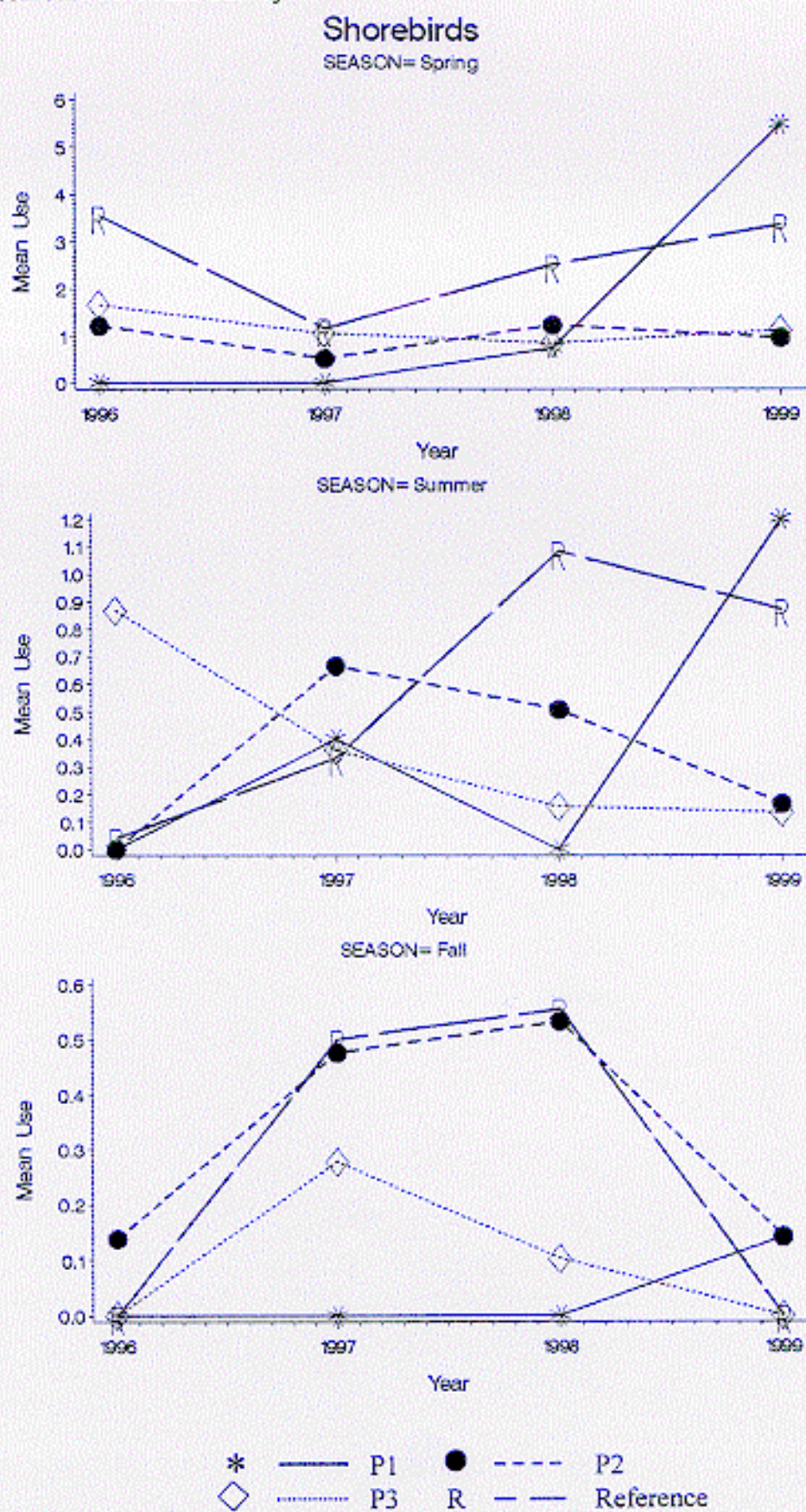


Figure 10 (Continued). Avian abundance (expressed as number observed per survey) by study area and season based on RLB survey data.

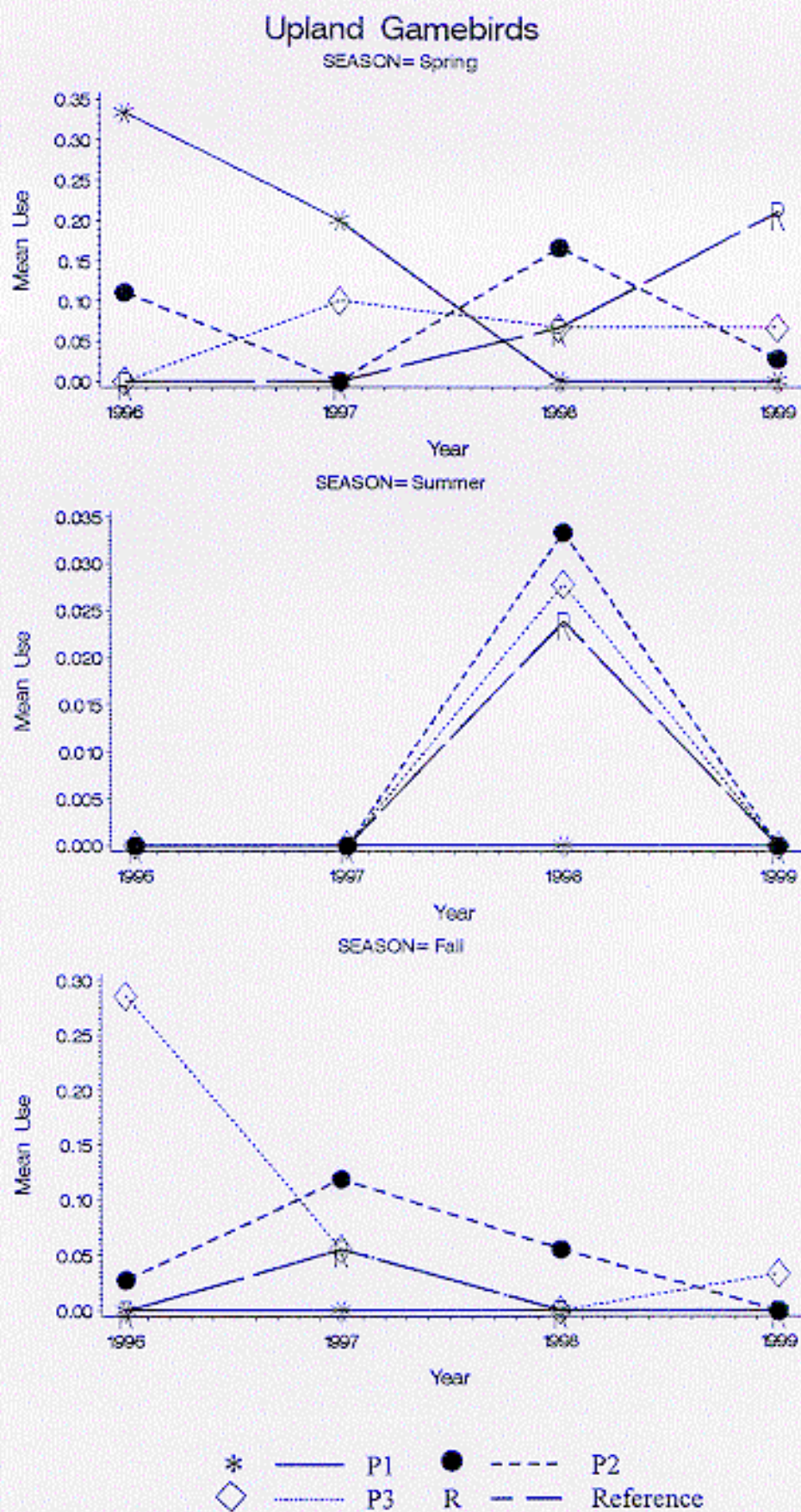


Figure 10 (Continued). Avian abundance (expressed as number observed per survey) by study area and season based on RLB survey data.

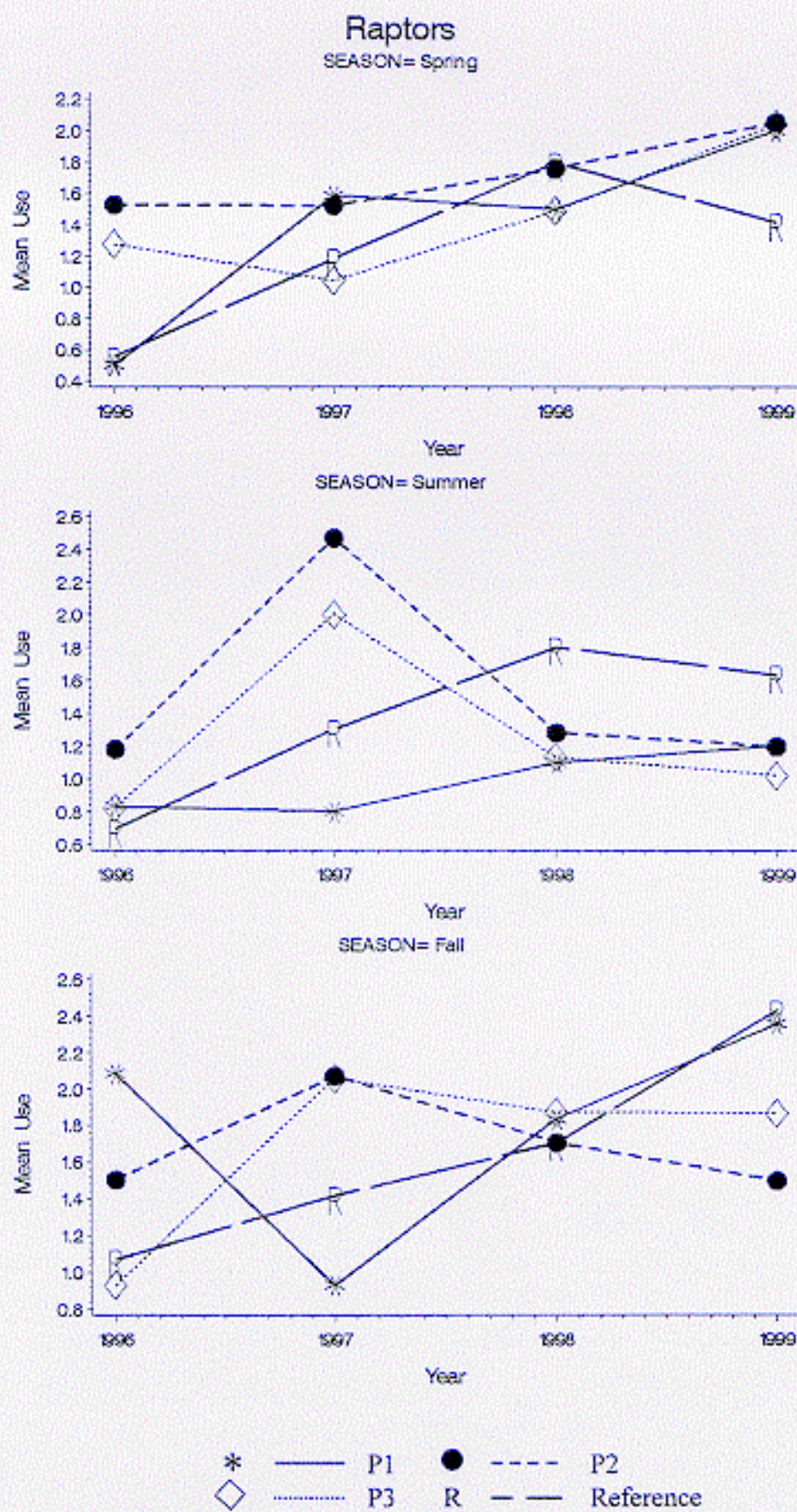


Figure 10 (Continued). Avian abundance (expressed as number observed per survey) by study area and season based on RLB survey data.

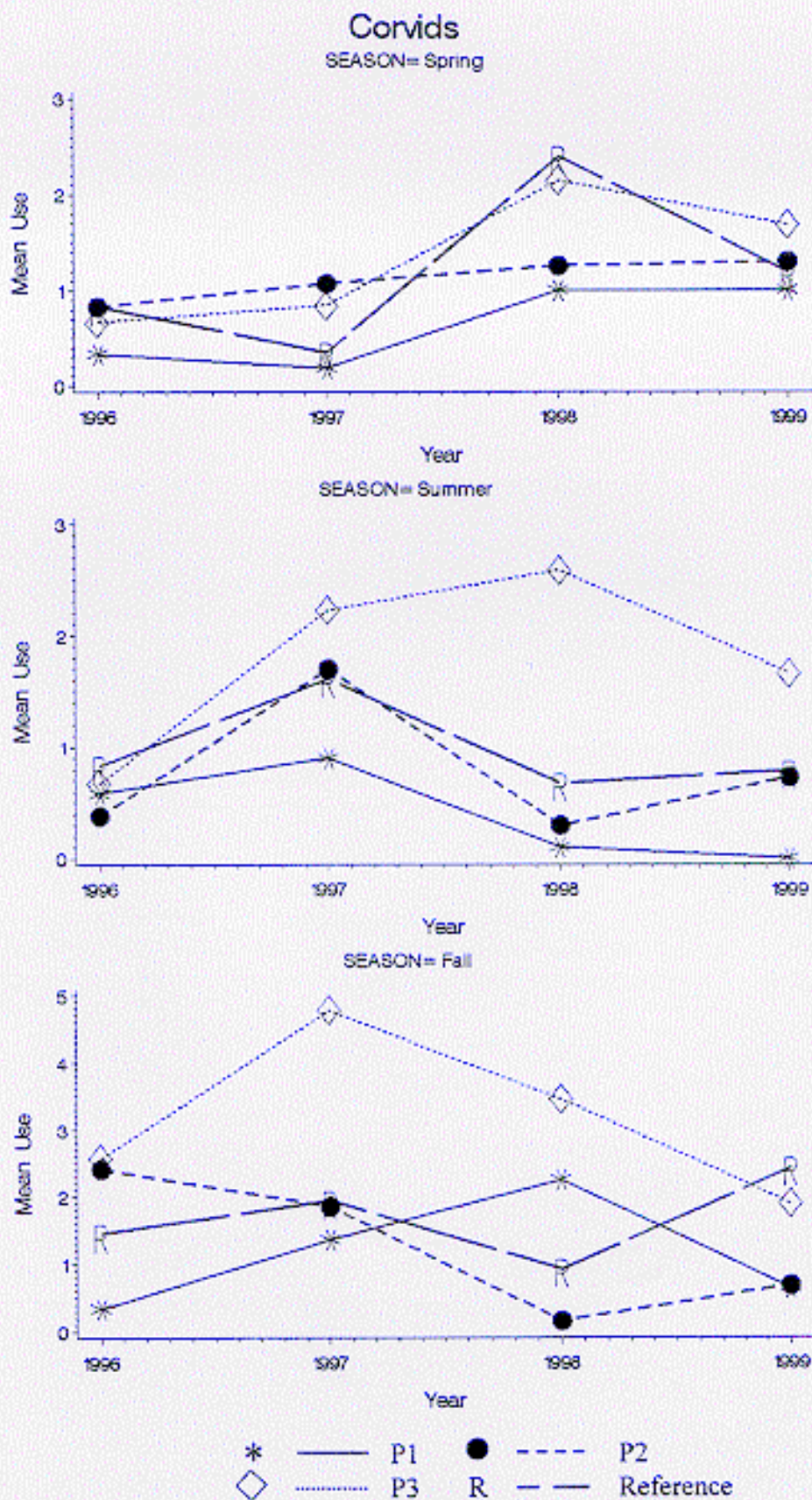


Figure 10 (Continued). Avian abundance (expressed as number observed per survey) by study area and season based on RLB survey data.

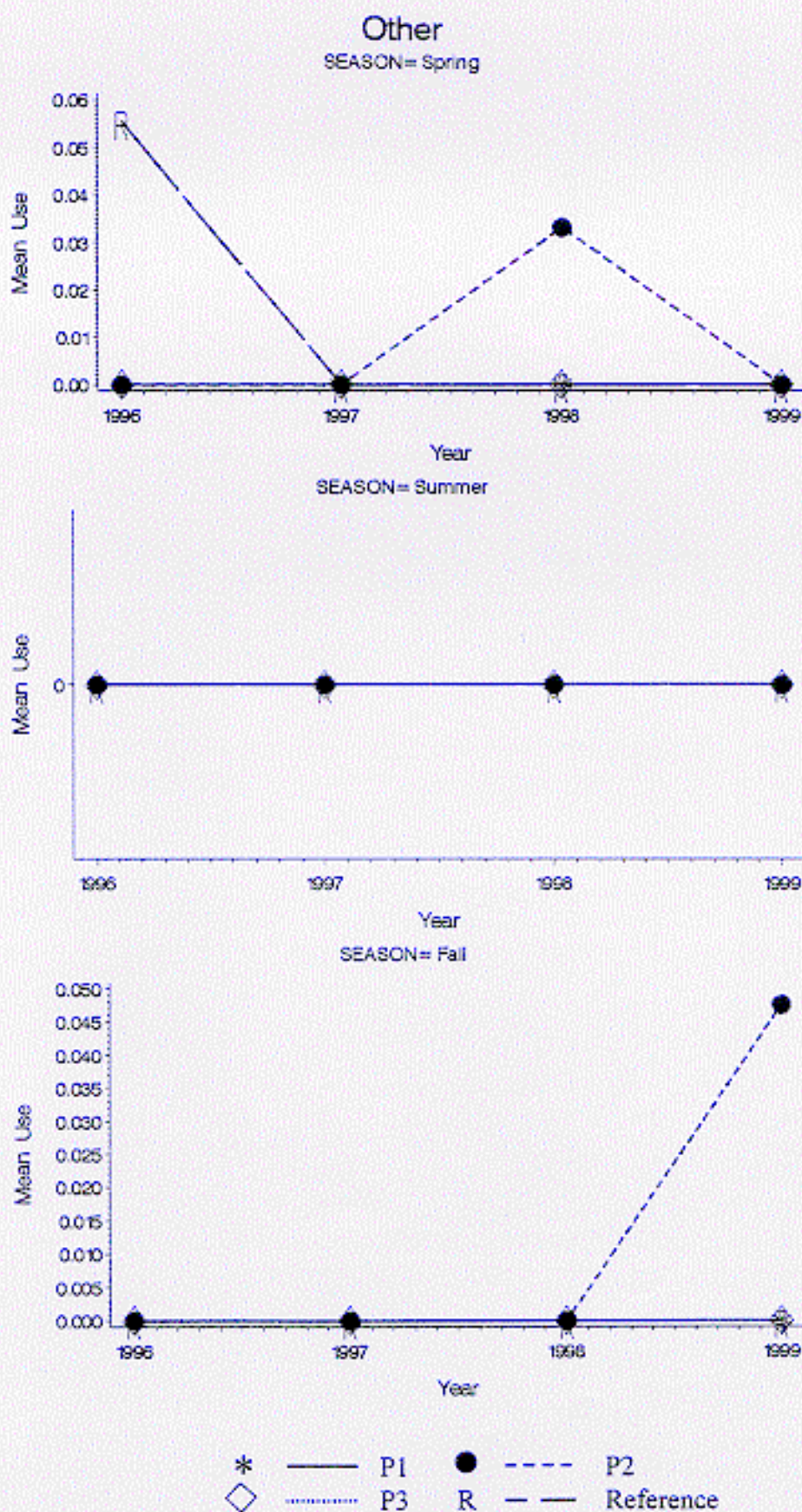


Figure 11. Proportion of flight heights by avian group within the rotor-swept height of Turbines A and B \pm 95% CI based on point count survey data.

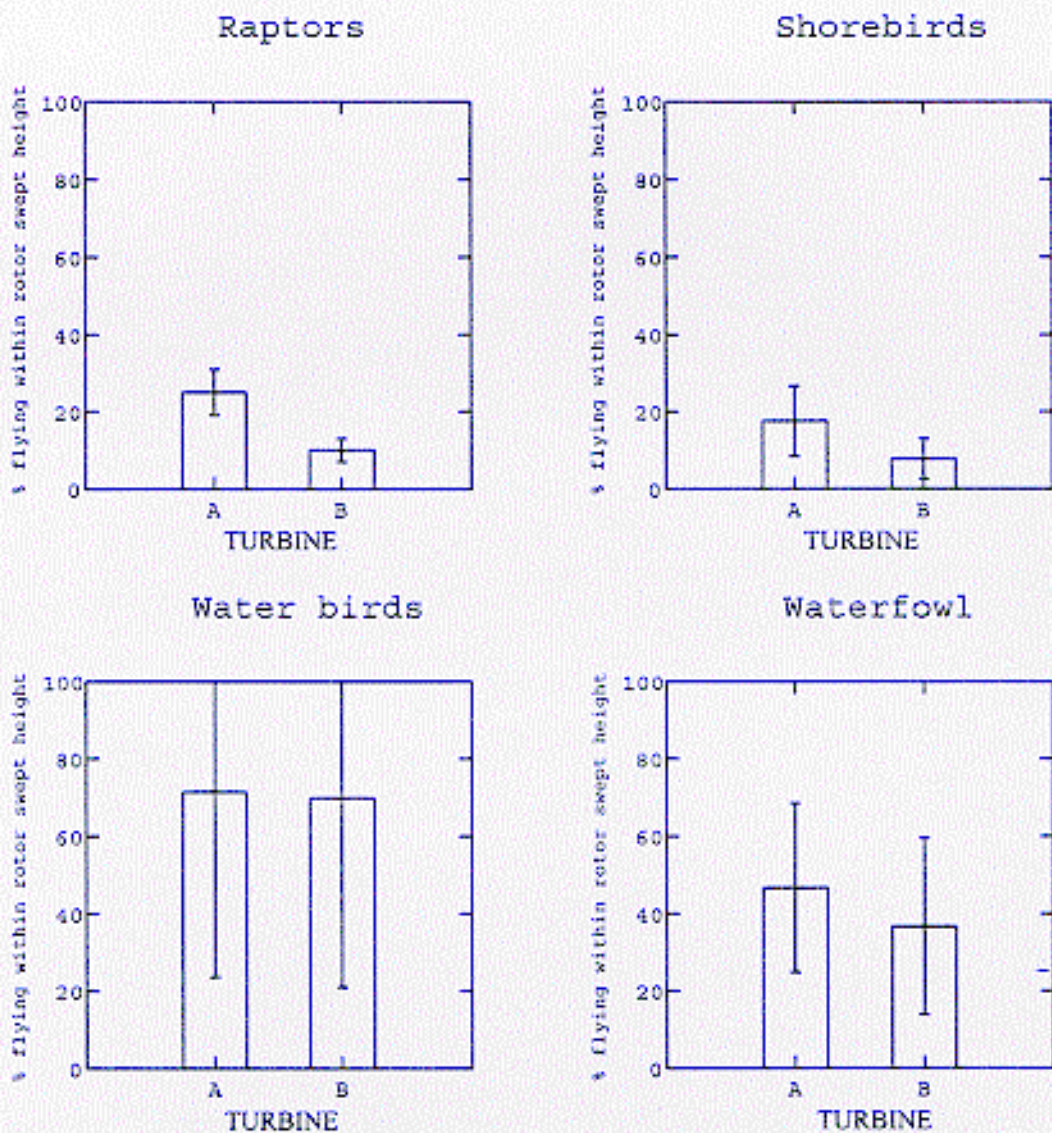


Figure 11 (Continued). Proportion of flight heights by avian group within the rotor-swept height of Turbines A and B \pm 95% CI based on point count survey data.

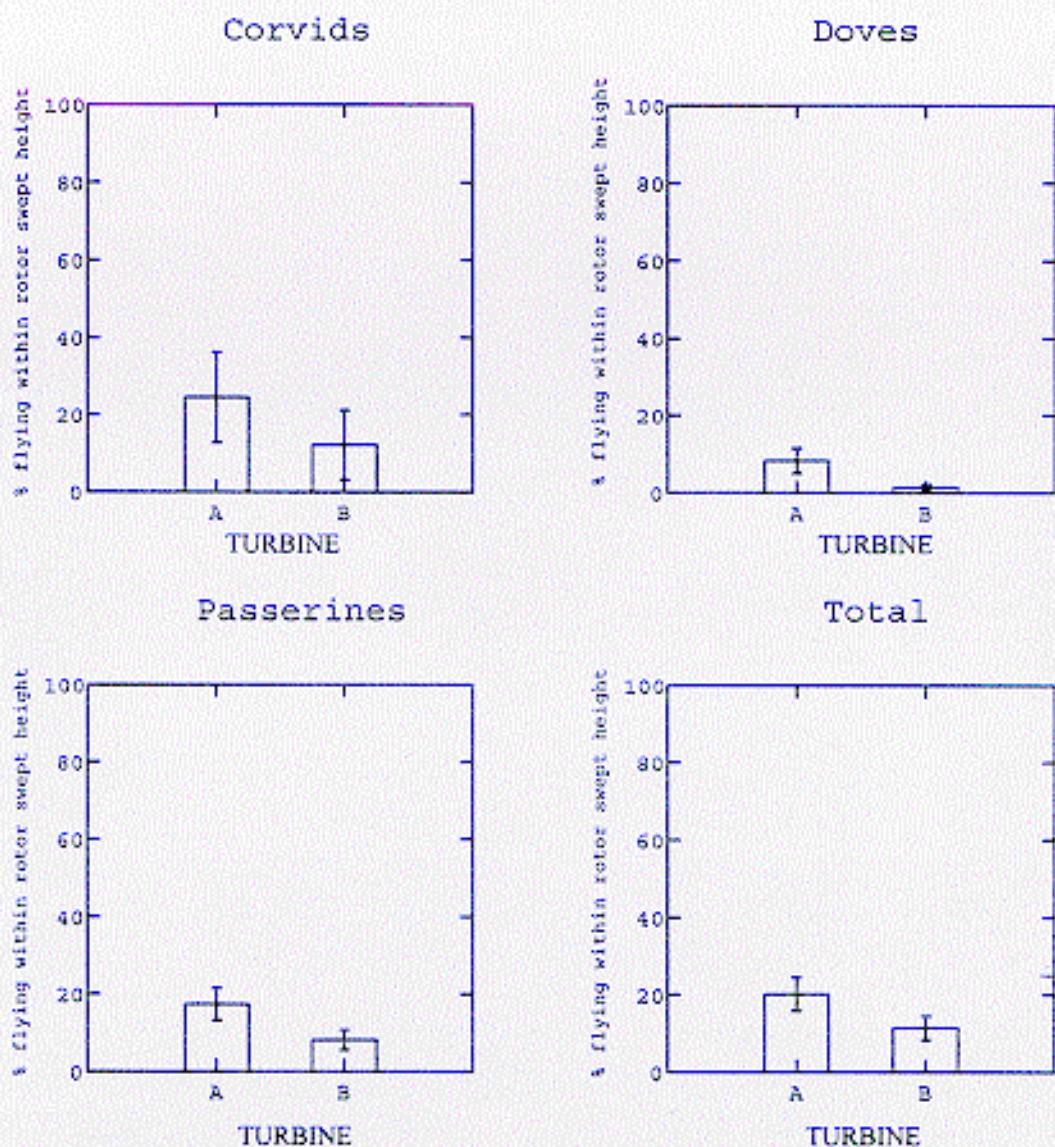


Figure 12. Flight height \pm 95% CI as a function of habitat for avian groups observed during point count surveys.

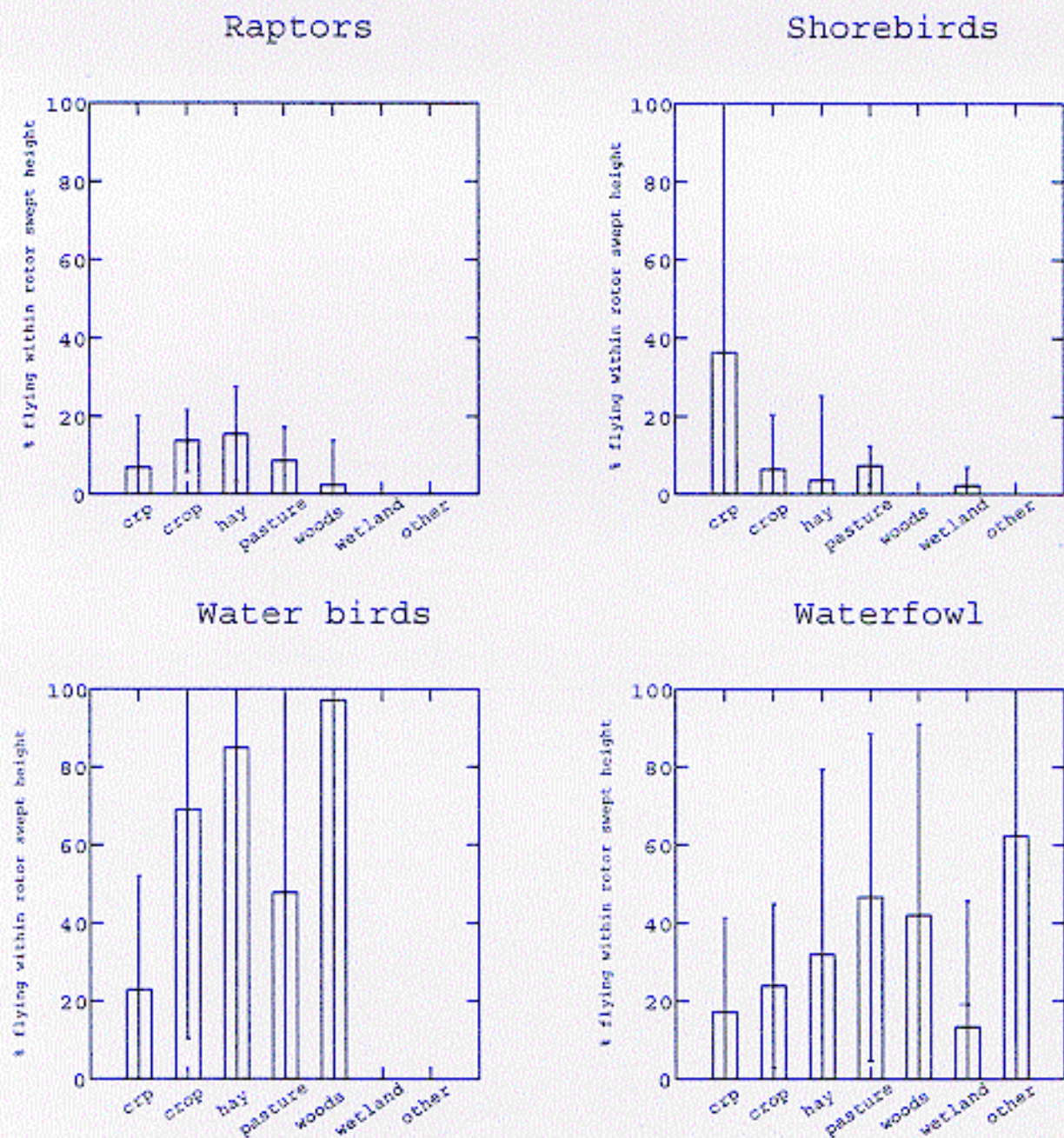
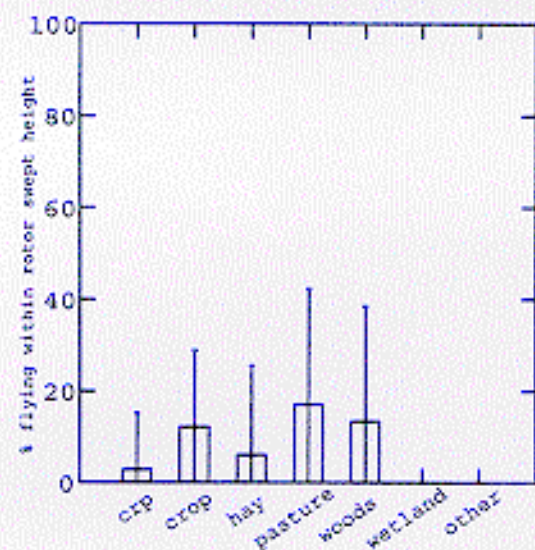
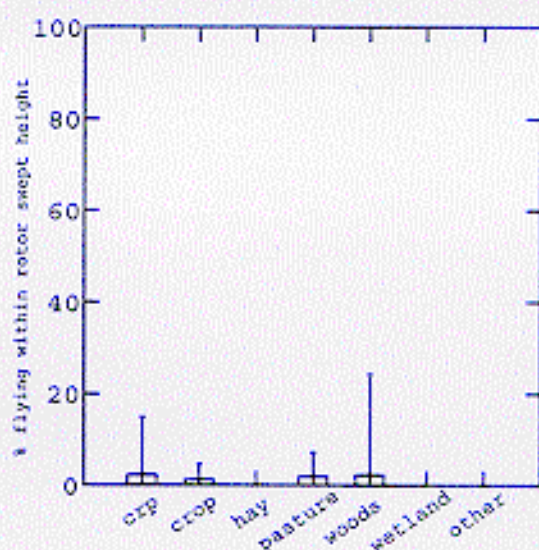


Figure 12 (Continued). Flight height \pm 95% CI as a function of habitat for avian groups observed during point count surveys.

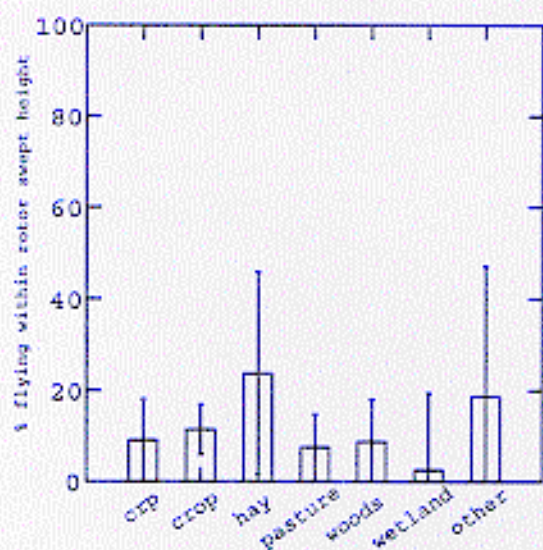
Corvids



Doves



Passerines



Total

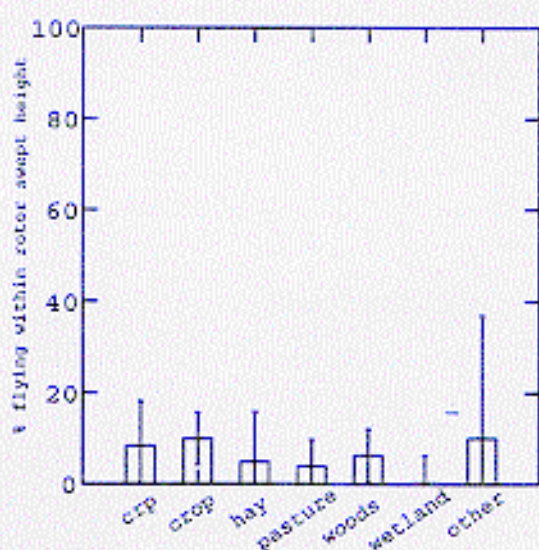


Figure 13. Flight height \pm 95% CI as a function of turbine presence or absence for avian groups observed during point count surveys.

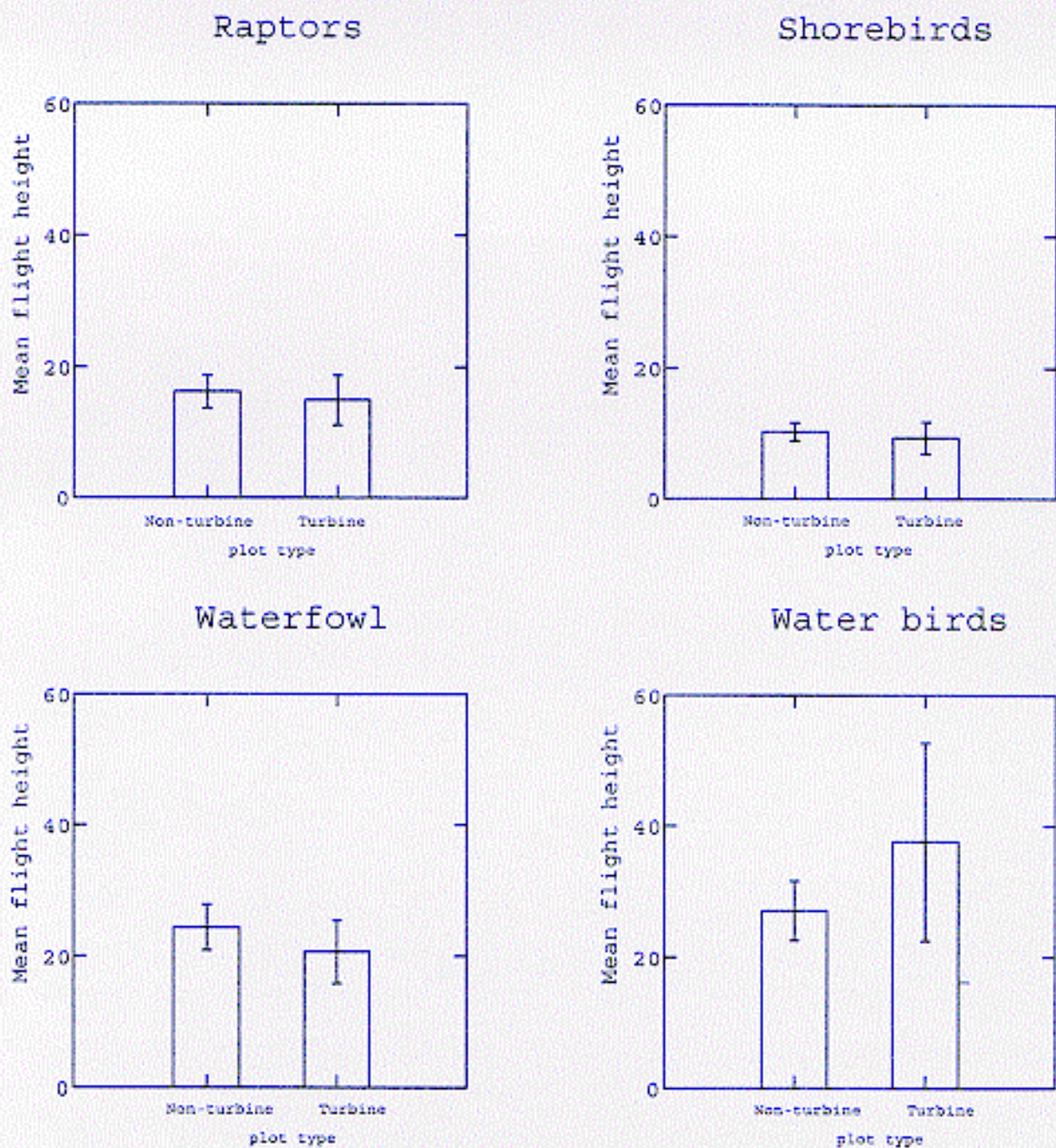


Figure 13 (Continued). Flight height \pm 95% CI as a function of turbine presence or absence for avian groups observed during point count surveys.

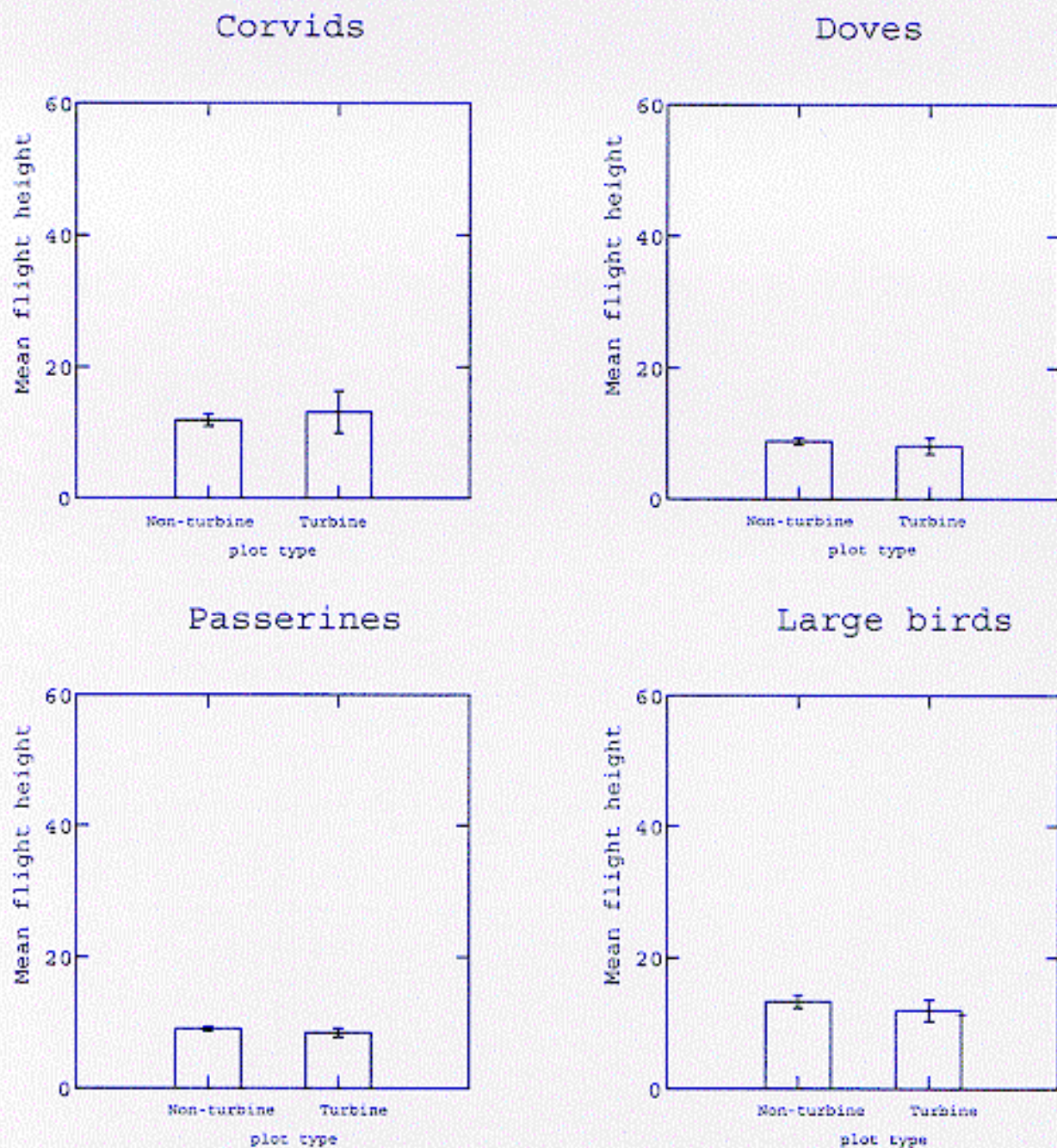


Figure 14. Proportion of flight heights by avian group within the rotor-swept area of Turbines A and B \pm 95% CI based on RLB survey data.

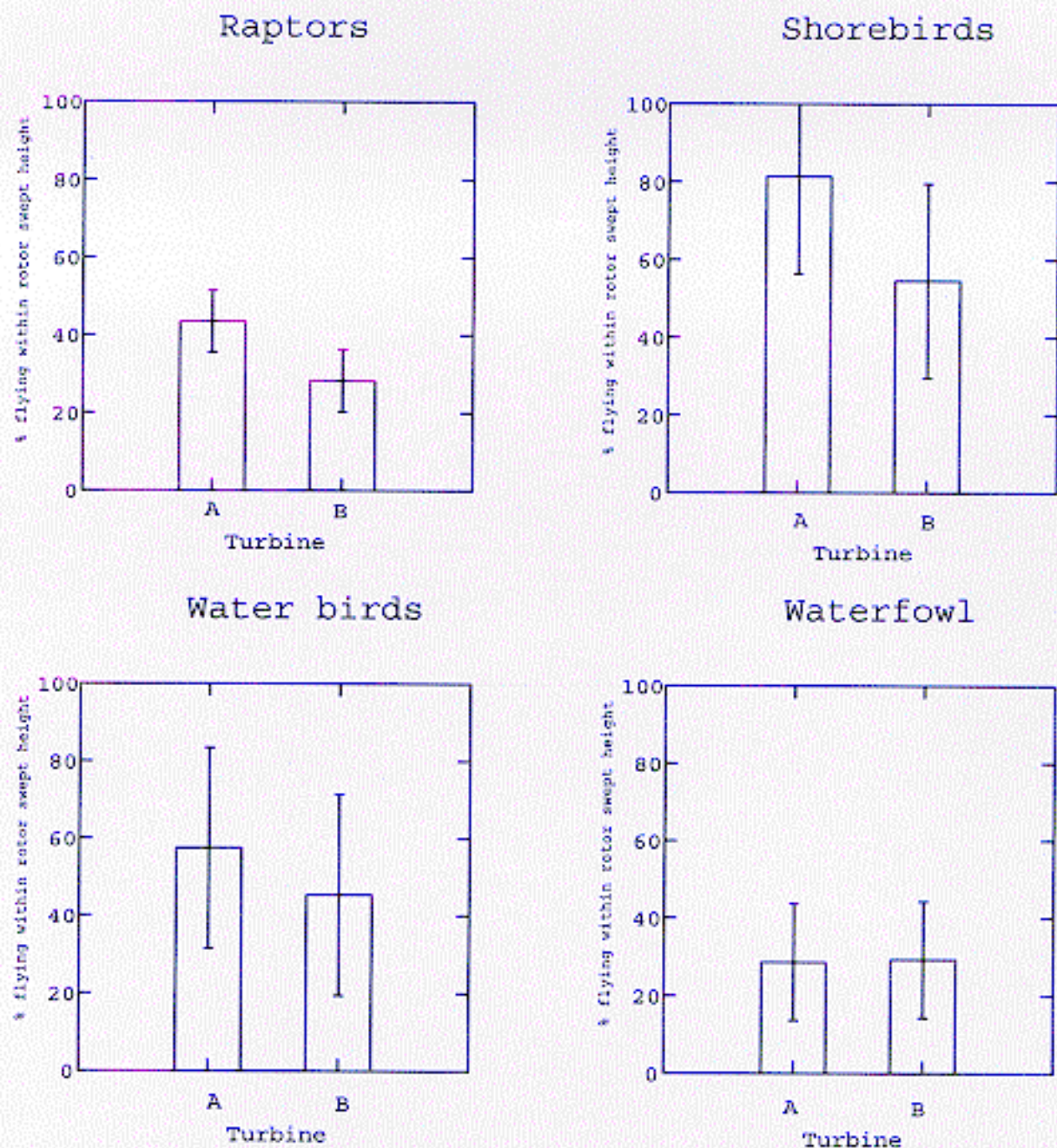


Figure 14 (Continued). Proportion of flight heights by avian group within the rotor-swept area of Turbines A and B \pm 95% CI based on RLB survey data.

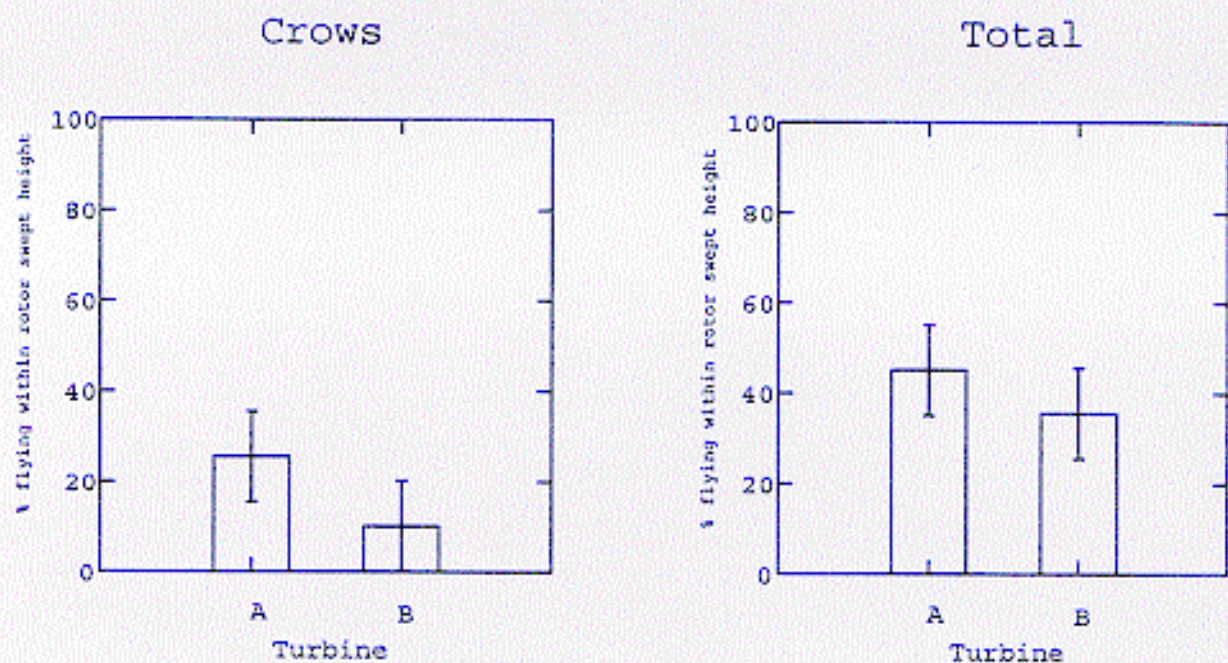


Figure 15. Avian use (# observed/km²) \pm 95% CI by habitat type on the Buffalo Ridge study area based on point count survey data.

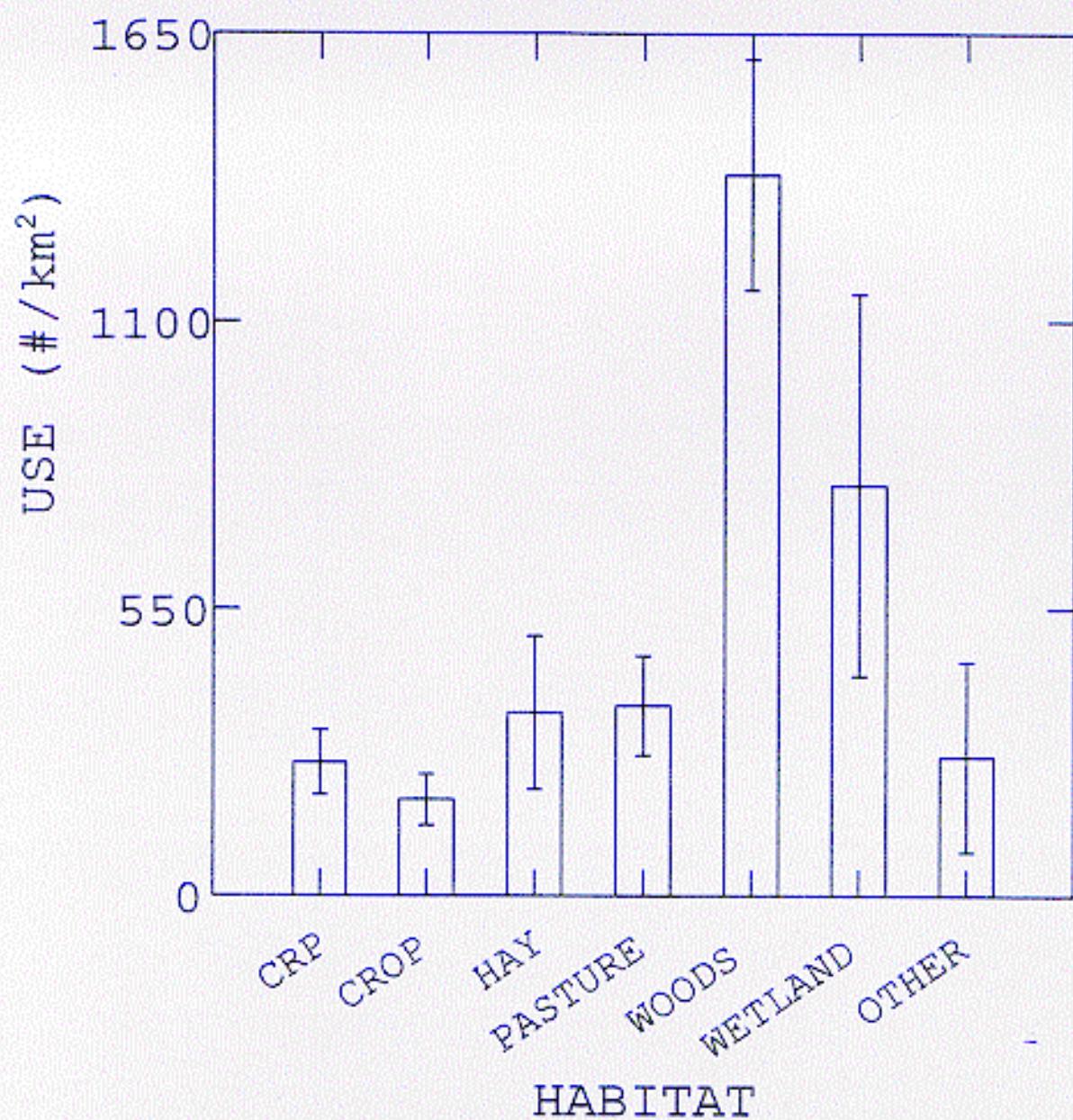


Figure 16. Average distance to observations of birds \pm 95% CI during point count surveys based on presence or absence of turbines within the plot.

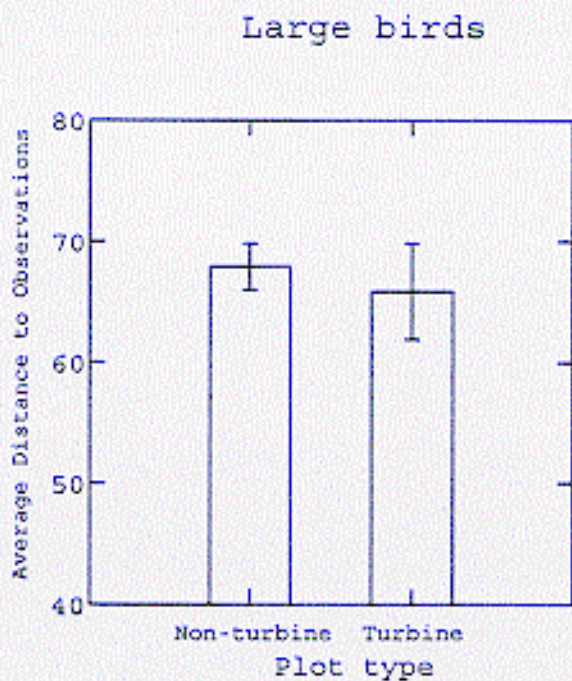
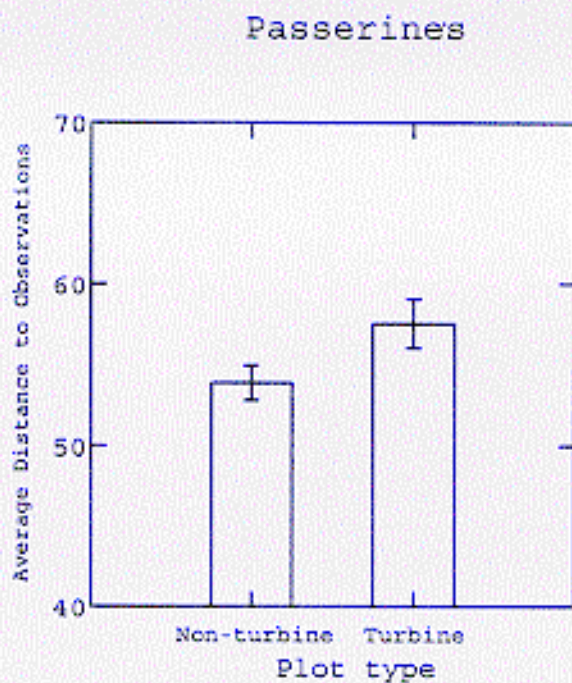


Figure 17. Abundance (expressed as number observed per survey) of breeding grassland bird species by study area and year based on point count survey data.

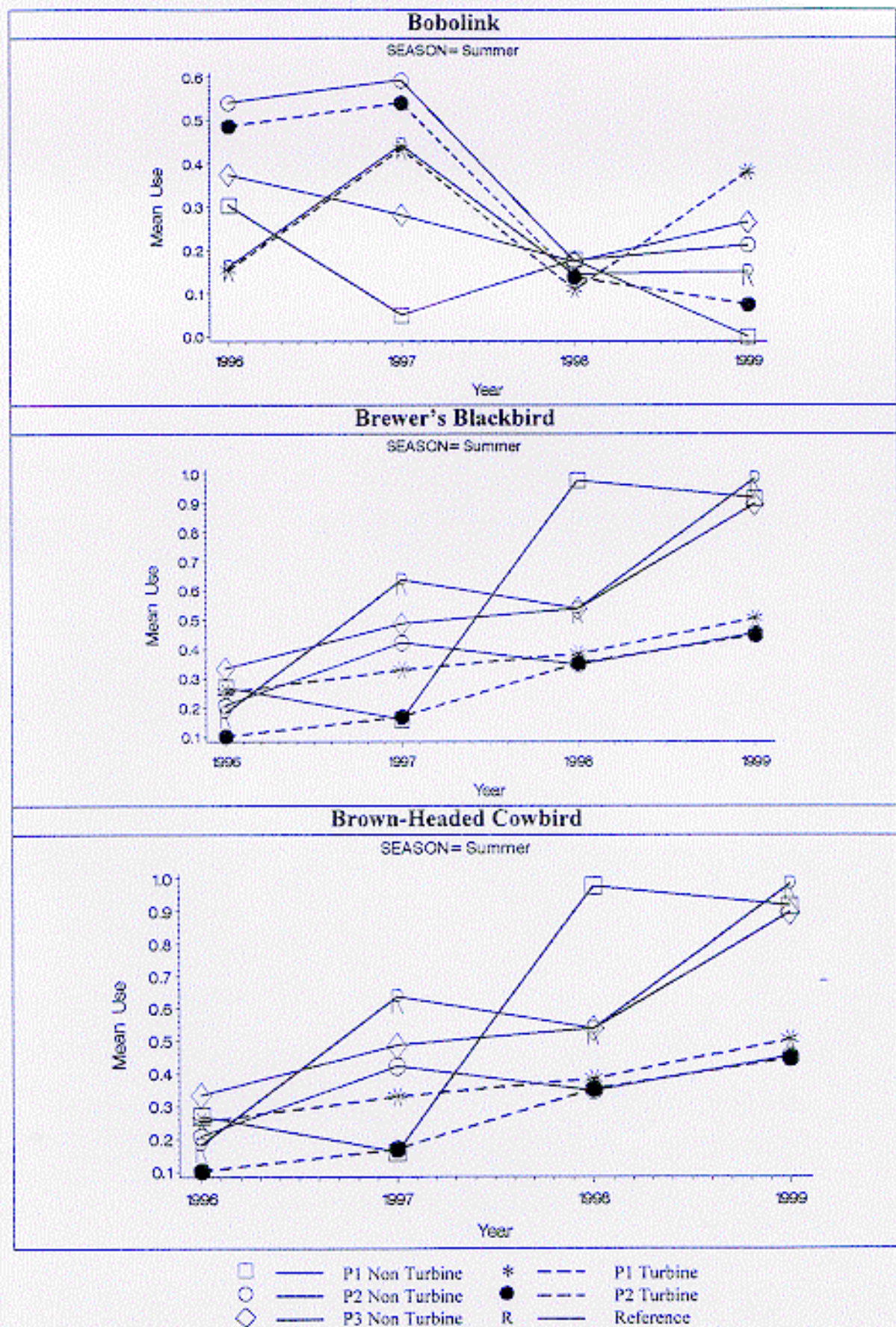


Figure 17 (Continued). Abundance (expressed as number observed per survey) of breeding grassland bird species by study area and year based on point count survey data.

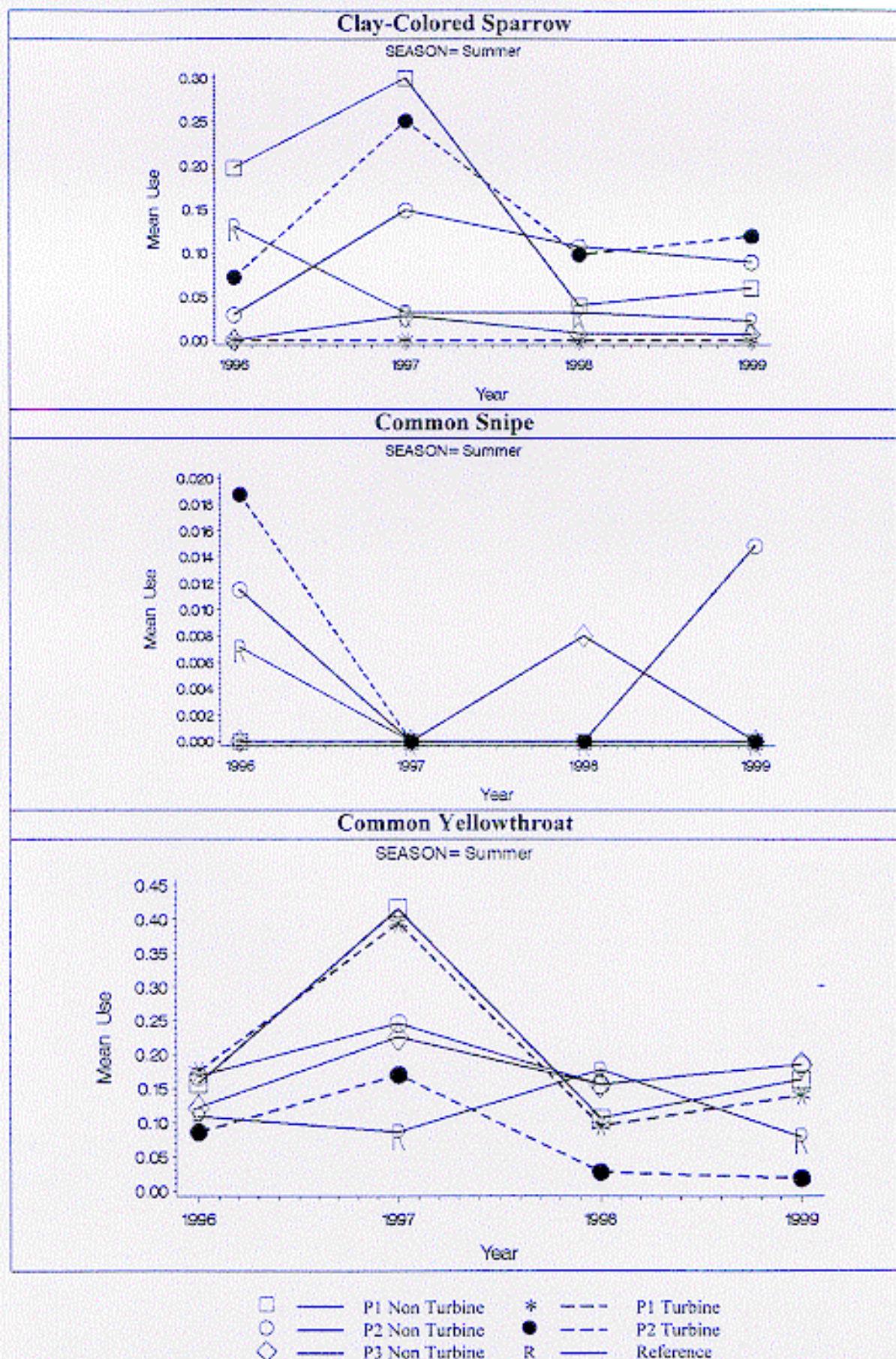


Figure 17 (Continued). Abundance (expressed as number observed per survey) of breeding grassland bird species by study area and year based on point count survey data.

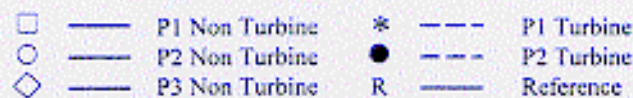
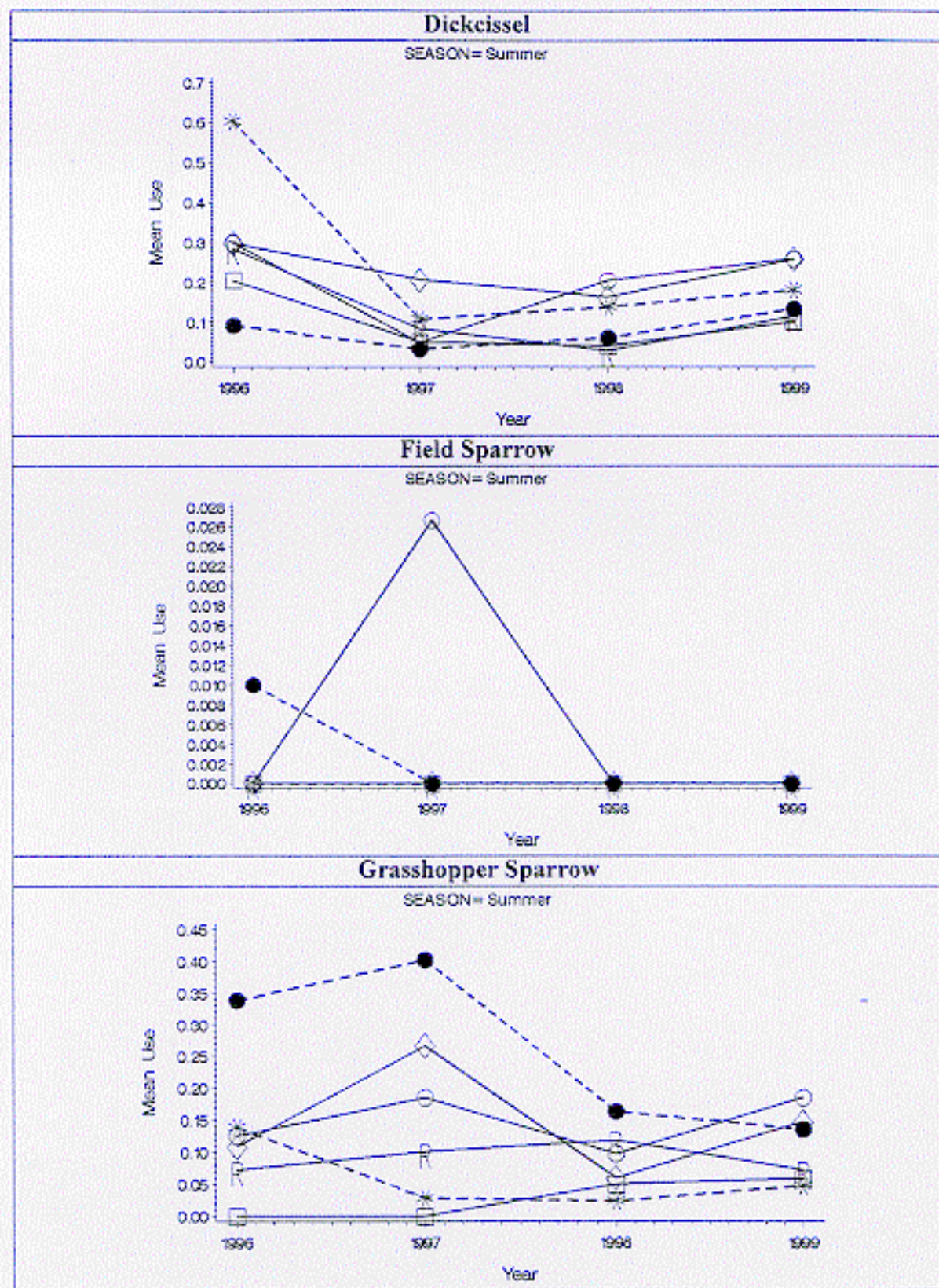


Figure 17 (Continued). Abundance (expressed as number observed per survey) of breeding grassland bird species by study area and year based on point count survey data.

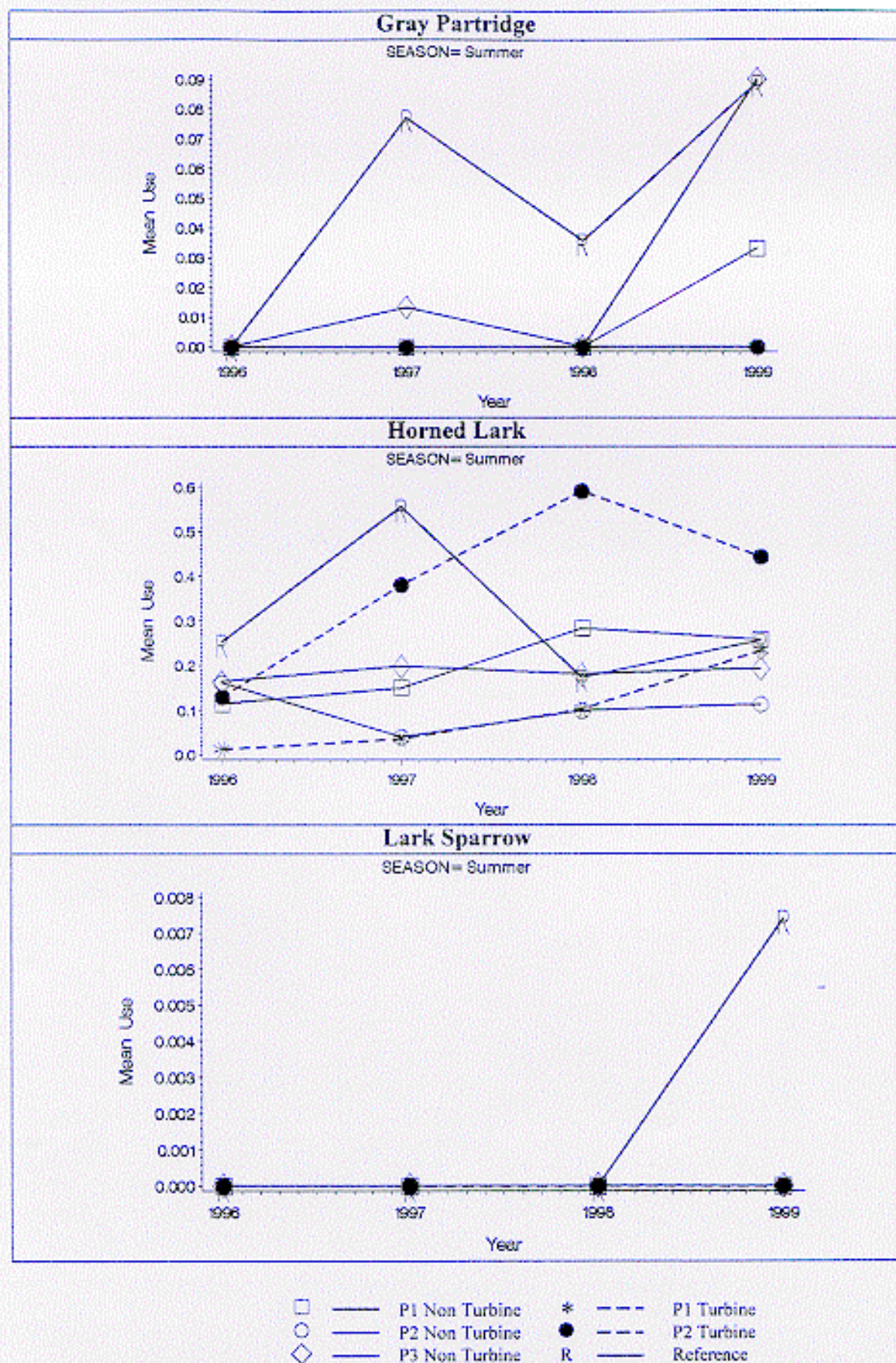


Figure 17 (Continued). Abundance (expressed as number observed per survey) of breeding grassland bird species by study area and year based on point count survey data.

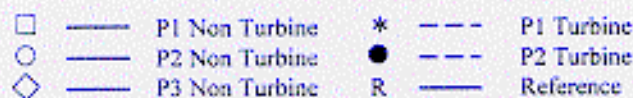
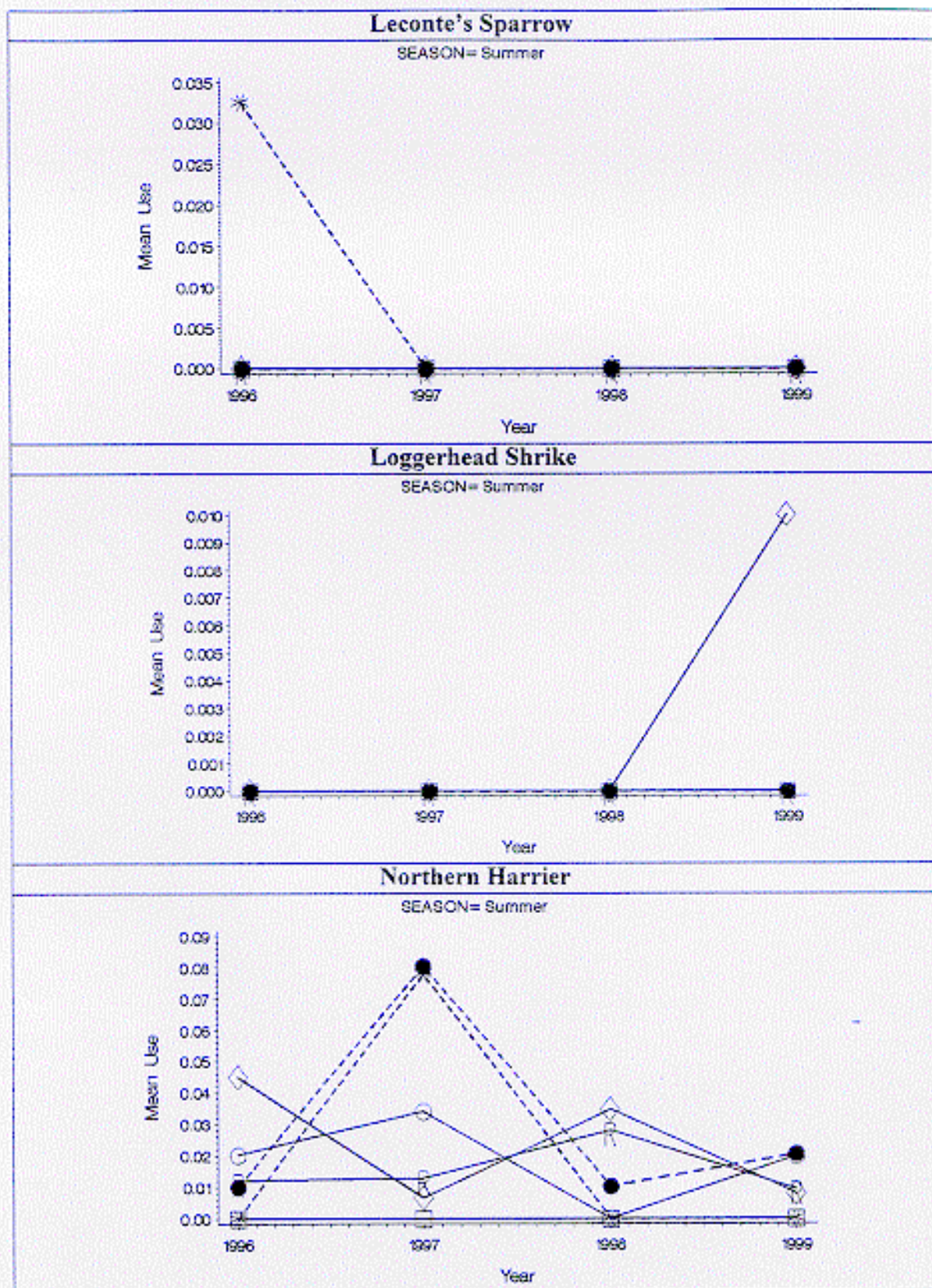
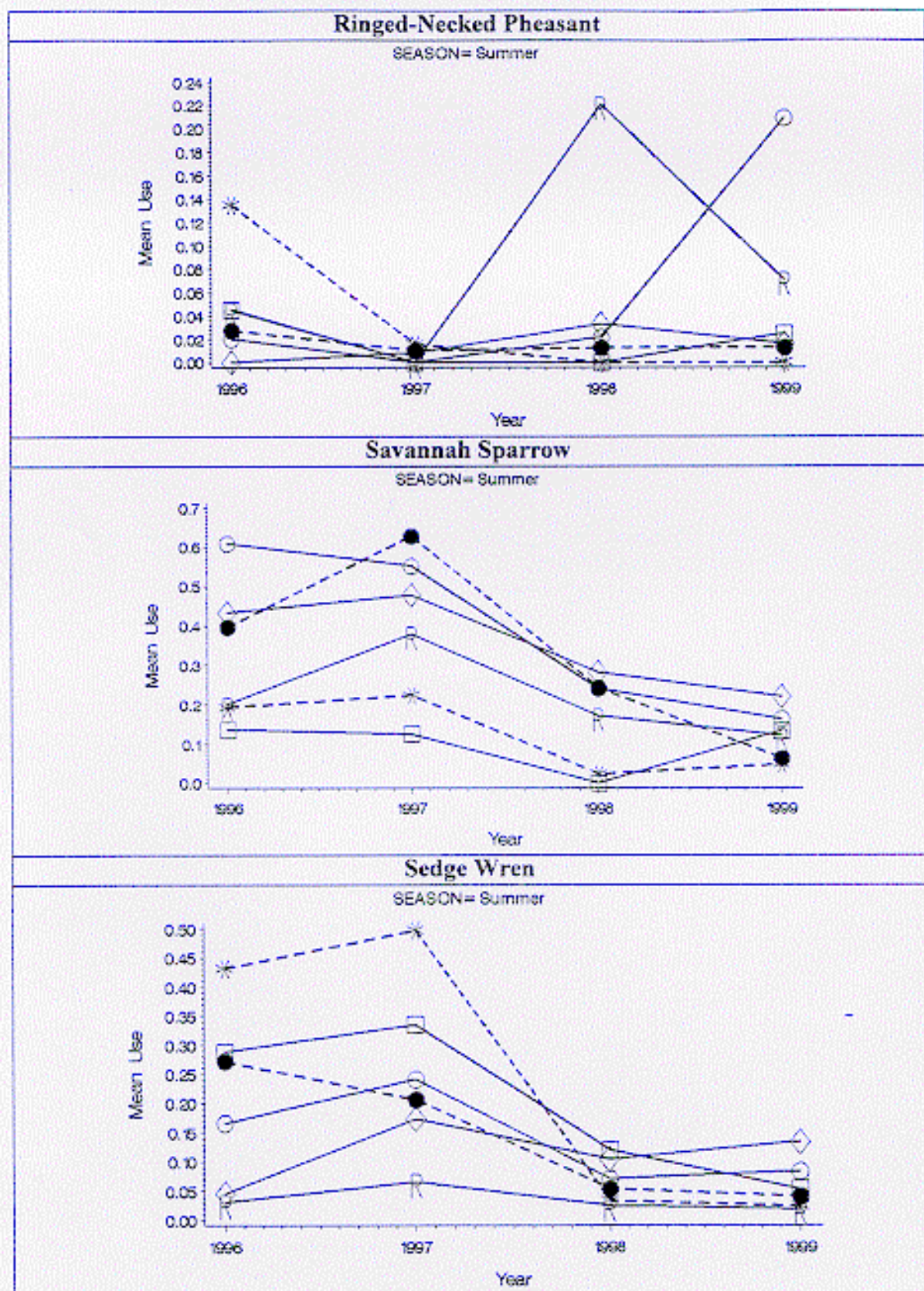


Figure 17 (Continued). Abundance (expressed as number observed per survey) of breeding grassland bird species by study area and year based on point count survey data.



P1 Non Turbine * --- P1 Turbine
 P2 Non Turbine ● --- P2 Turbine
 P3 Non Turbine R --- Reference

Figure 17 (Continued). Abundance (expressed as number observed per survey) of breeding grassland bird species by study area and year based on point count survey data.

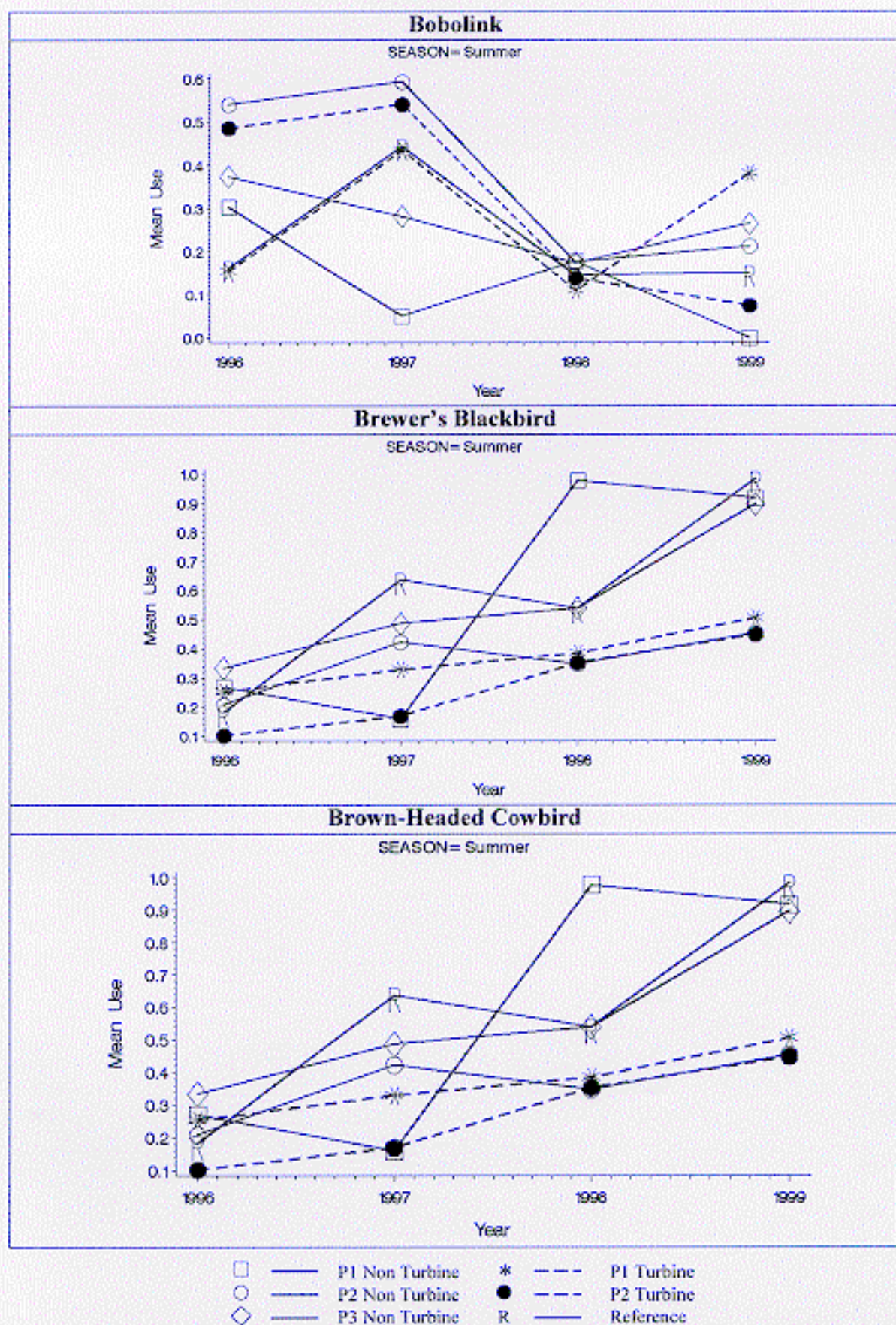


Figure 17 (Continued). Abundance (expressed as number observed per survey) of breeding grassland bird species by study area and year based on point count survey data.

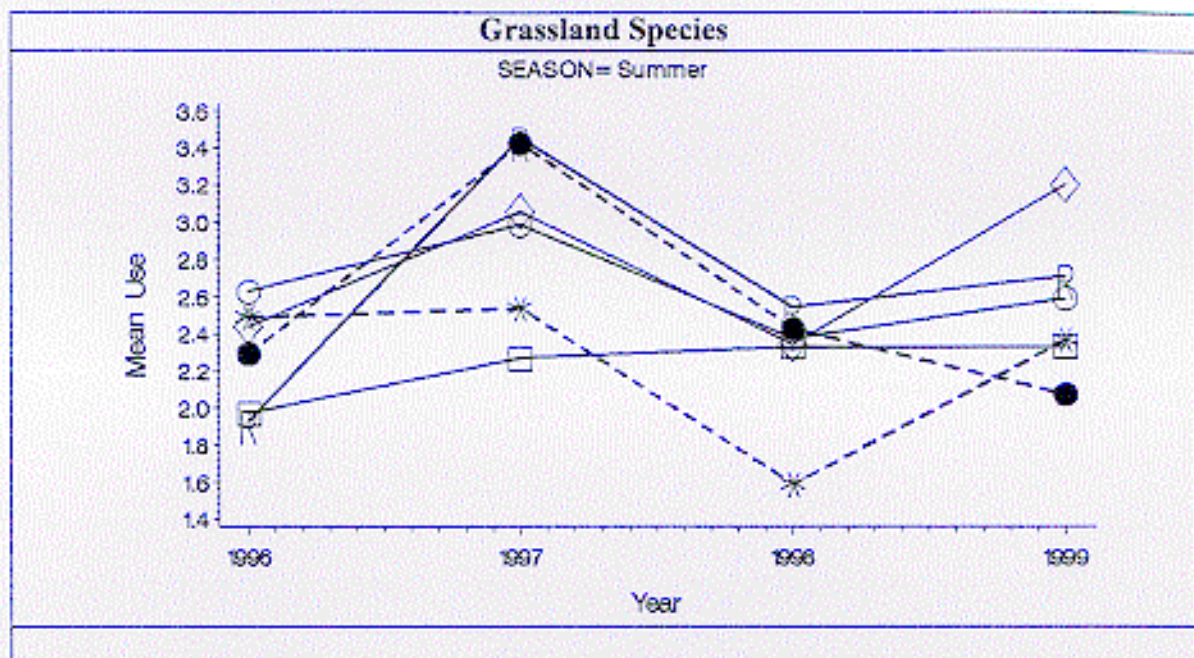


Figure 18. Distribution of avian and bat fatalities as a function of distance from the base of turbines at the Buffalo Ridge Wind Resource Area.

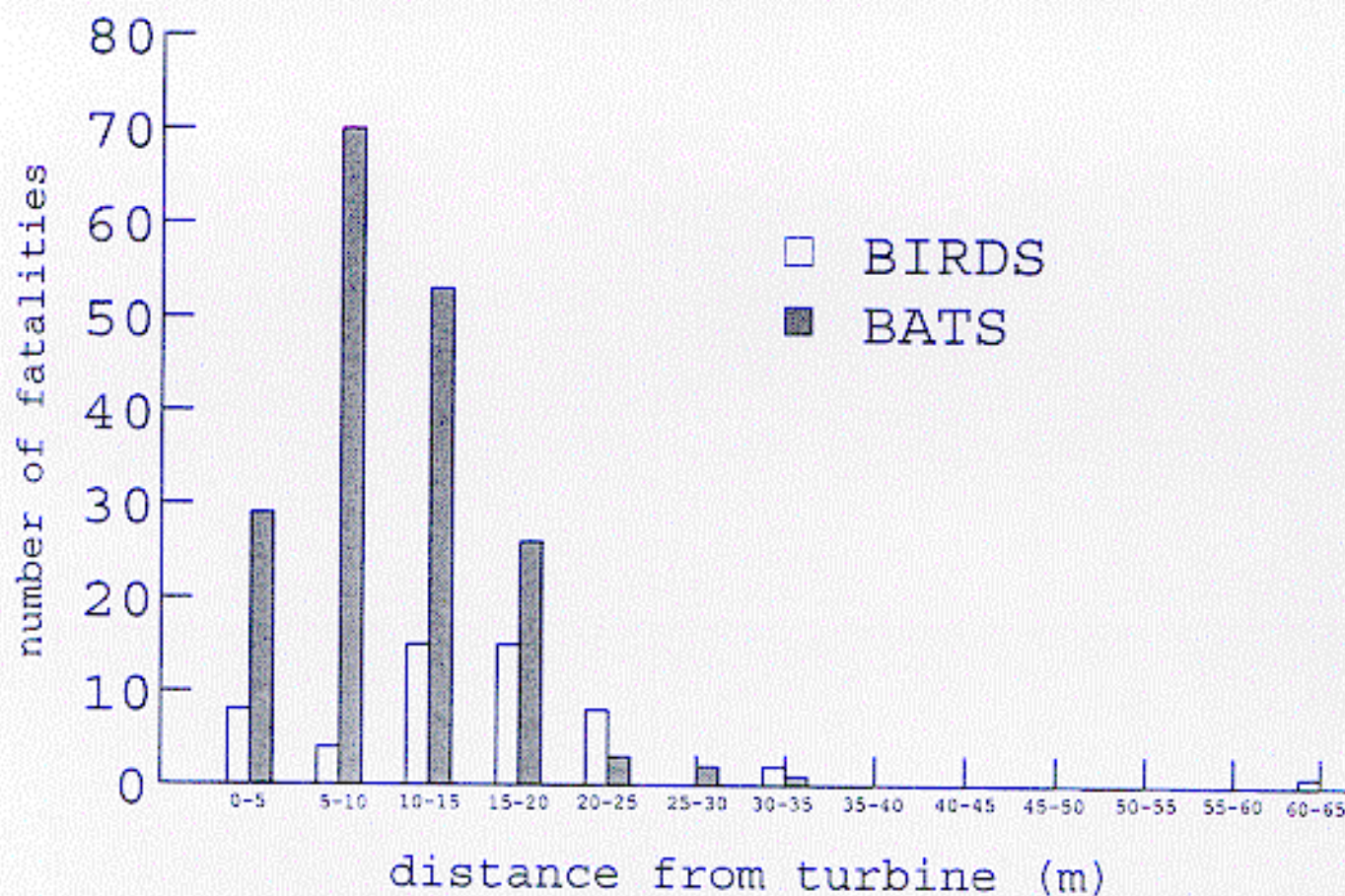
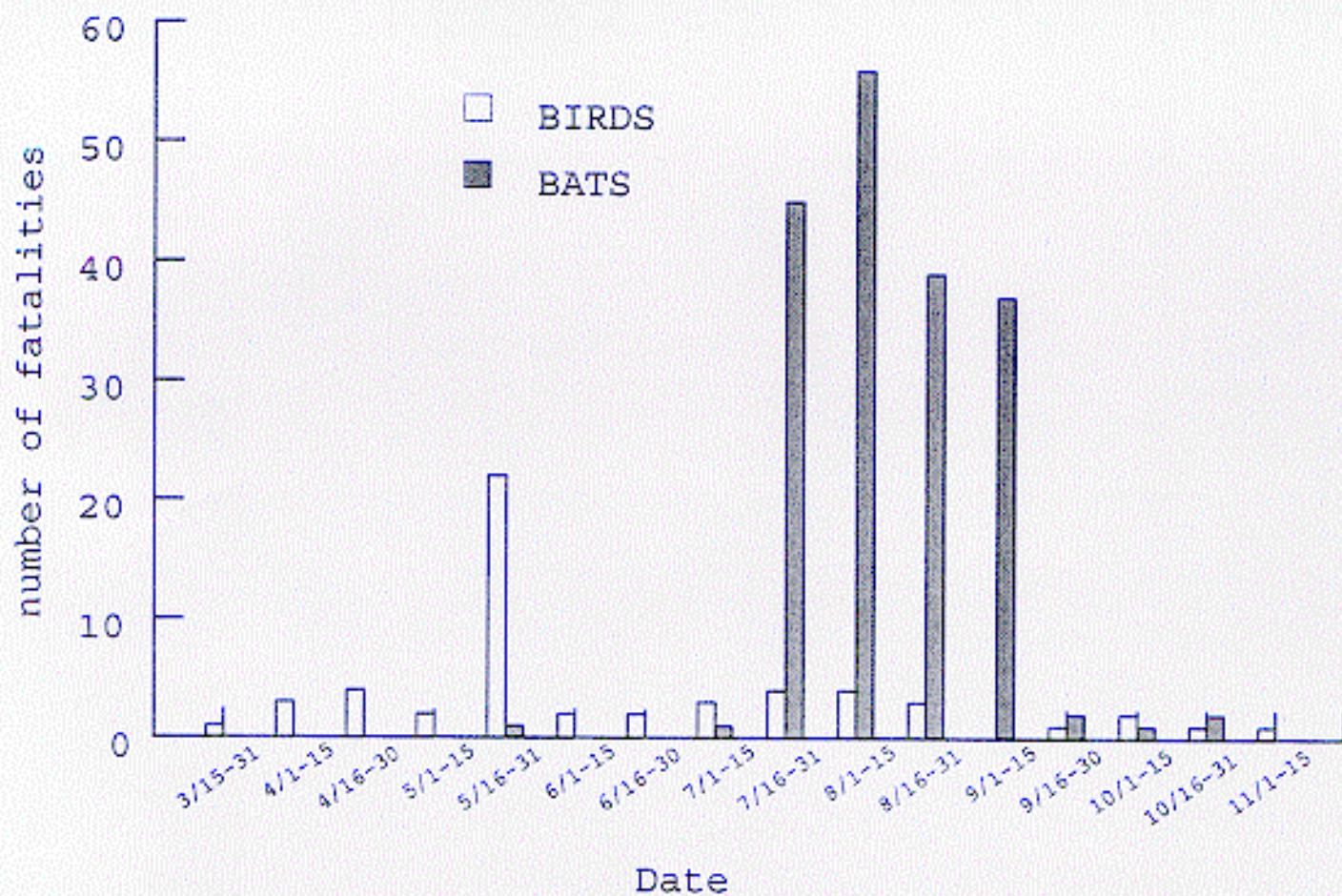


Figure 19. Seasonal distribution of avian and bat fatalities at the Buffalo Ridge Wind Resource Area.



Appendix A. List of birds seen in vicinity of Buffalo Ridge study area, 1996-1999.

Common Name	Scientific Name
Common Loon ^b	<i>Gavia immer</i>
Pied-billed Grebe ^{ab}	<i>Podilymbus podiceps</i>
Western Grebe ^c	<i>Aechmophorus occidentalis</i>
Horned Grebe ^c	<i>Podiceps auritus</i>
Eared Grebe ^c	<i>Podiceps nigricollis</i>
Red-necked Grebe ^c	<i>Podiceps grisegena</i>
American White Pelican ^{ab}	<i>Pelicanus erythrorhynchos</i>
Double-crested Cormorant ^{ab}	<i>Phalacrocorax auritus</i>
American Bittern ^a	<i>Botaurus lentiginosus</i>
Least Bittern ^c	<i>Ixobrychus exilis</i>
Green Heron ^{ab}	<i>Butorides striatus</i>
Cattle Egret ^a	<i>Bubulcus ibis</i>
Great Egret ^{ab}	<i>Casmerodius albus</i>
Great Blue Heron ^{ab}	<i>Ardea herodias</i>
Turkey Vulture ^b	<i>Cathartes aura</i>
Tundra Swan ^c	<i>Cygnus columbianus</i>
Canada Goose ^{ab}	<i>Branta canadensis</i>
Greater White-fronted Goose ^{ab}	<i>Anser albifrons</i>
Snow Goose ^{ab}	<i>Chen caerulescens</i>
Mallard ^{ab}	<i>Anas platyrhynchos</i>
Black Duck ^c	<i>Anas rubripes</i>
Gadwall ^{ab}	<i>Anas strepera</i>
American Wigeon ^{ab}	<i>Anas americana</i>
Northern Pintail ^{ab}	<i>Anas acuta</i>
Green-winged Teal ^a	<i>Anas crecca</i>
Blue-winged Teal ^{ab}	<i>Anas discors</i>
Northern Shoveler ^{ab}	<i>Anas clypeata</i>
Wood Duck ^{ab}	<i>Aix sponsa</i>
Canvasback ^b	<i>Aythya vallisineria</i>
Redhead ^c	<i>Aythya americana</i>
Ring-necked Duck ^b	<i>Aythya collaris</i>
Greater Scaup ^a	<i>Aythya marila</i>
Lesser Scaup ^{ab}	<i>Aythya affinis</i>
Common Goldeneye ^a	<i>Bucephala clangula</i>
Bufflehead ^a	<i>Bucephala albeola</i>
Ruddy Duck ^c	<i>Oxyura jamaicensis</i>
Hooded Merganser ^c	<i>Lophodytes cucullatus</i>
Common Merganser ^{ab}	<i>Mergus merganser</i>
Red-breasted Merganser ^{ab}	<i>Mergus serrator</i>
Northern Goshawk ^{ab}	<i>Accipiter gentilis</i>
Sharp-shinned Hawk ^{ab}	<i>Accipiter striatus</i>
Cooper's Hawk ^{ab}	<i>Accipiter cooperi</i>
Red-tailed Hawk ^{ab}	<i>Buteo jamaicensis</i>
Broad-winged Hawk ^{ab}	<i>Buteo platypterus</i>
Swainson's Hawk ^{ab}	<i>Buteo swainsoni</i>
Rough-legged Hawk ^{ab}	<i>Buteo lagopus</i>

^a Observed during point count surveys; ^b Observed during RLB surveys;

^c Observed only during incidental wildlife observations

Appendix A (Continued). List of birds seen in vicinity of Buffalo Ridge study area, 1996-1999.

Common Name	Scientific Name
Ferruginous Hawk ^{ab}	<i>Buteo regalis</i>
Northern Harrier ^{ab}	<i>Circus cyaneus</i>
Golden Eagle ^{ab}	<i>Aquila chrysaetos</i>
Bald Eagle ^{ab}	<i>Haliaeetus leucocephalus</i>
Osprey ^{ab}	<i>Pandion haliaetus</i>
Peregrine Falcon ^{ab}	<i>Falco peregrinus</i>
Merlin ^a	<i>Falco columbarius</i>
American Kestrel ^{ab}	<i>Falco sparverius</i>
Wild Turkey ^b	<i>Meleagris gallopavo</i>
Ring-necked Pheasant ^{ab}	<i>Phasianus colchicus</i>
Gray Partridge ^{ab}	<i>Perdix perdix</i>
Sandhill Crane ^{ab}	<i>Grus canadensis</i>
Sora ^c	<i>Porzana carolina</i>
Virginia Rail ^c	<i>Rallus limicola</i>
American Coot ^{ab}	<i>Fulica americana</i>
Semipalmated Plover ^c	<i>Charadrius semipalmatus</i>
Buff-breasted Sandpiper ^a	<i>Tryngites subruficollis</i>
American Golden-plover ^{ab}	<i>Pluvialis dominica</i>
Killdeer ^a	<i>Charadrius vociferus</i>
Black-bellied Plover ^b	<i>Pluvialis squatarola</i>
Common Snipe ^{ab}	<i>Gallinago gallinago</i>
Upland Sandpiper ^{ab}	<i>Bartramia longicauda</i>
Spotted Sandpiper ^a	<i>Actitis macularia</i>
Solitary Sandpiper ^{ab}	<i>Tringa solitaria</i>
Greater Yellowlegs ^{ab}	<i>Tringa melanoleuca</i>
Lesser Yellowlegs ^{ab}	<i>Tringa flavipes</i>
Marbled Godwit ^c	<i>Limosa fedoa</i>
Pectoral Sandpiper ^{ab}	<i>Calidris melanotos</i>
White-rumped Sandpiper ^a	<i>Caladris fuscicollis</i>
Least Sandpiper ^a	<i>Calidris minutilla</i>
Dowitcher ^b	<i>Limnodromus sp.</i>
Semipalmated Sandpiper ^c	<i>Calidris pusilla</i>
Wilson's Phalarope ^c	<i>Phalaropus tricolor</i>
Herring Gull ^b	<i>Larus argentatus</i>
California Gull ^c	<i>Larus californicus</i>
Ring-billed Gull ^{ab}	<i>Larus delawarensis</i>
Franklin's Gull ^{ab}	<i>Larus pipixcan</i>
Bonaparte's Gull ^{ab}	<i>Larus philadelphia</i>
Forster's Tern ^{ab}	<i>Sterna forsteri</i>
Common Tern ^b	<i>Sterna hirundo</i>
Black Tern ^{ab}	<i>Chlidonias niger</i>
Mourning Dove ^a	<i>Zenaida macroura</i>
Rock Dove ^a	<i>Columba livia</i>
Black-billed Cuckoo ^a	<i>Coccyzus erythrophthalmus</i>
Yellow-billed Cuckoo ^a	<i>Coccyzus americanus</i>
Eastern Screech-owl ^c	<i>Otus asio</i>

^a Observed during point count surveys; ^b Observed during RLB surveys;

^c Observed only during incidental wildlife observations

Appendix A (Continued). List of birds seen in vicinity of Buffalo Ridge study area, 1996-1999.

Common Name	Scientific Name
Great Horned Owl ^{ab}	<i>Bubo virginianus</i>
Snowy Owl ^c	<i>Nyctea scandiaca</i>
Long-eared Owl ^c	<i>Asio otus</i>
Short-eared Owl ^a	<i>Asio flammeus</i>
Common Nighthawk ^{ab}	<i>Chordeiles minor</i>
Whip-poor-will ^c	<i>Caprimulgus carolinensis</i>
Chimney Swift ^a	<i>Chaetura pelagica</i>
Ruby-throated Hummingbird ^a	<i>Archilochus colubris</i>
Belted Kingfisher ^{ab}	<i>Ceryle alcyon</i>
Northern Flicker ^a	<i>Colaptes auratus</i>
Red-headed Woodpecker ^a	<i>Melanerpes erythrocephalus</i>
Red-bellied Woodpecker ^a	<i>Melanerpes carolinus</i>
Hairy Woodpecker ^a	<i>Picoides villosus</i>
Downy Woodpecker ^a	<i>Picoides pubescens</i>
Yellow-bellied Sapsucker ^c	<i>Sphyrapicus varius</i>
Eastern Kingbird ^a	<i>Tyrannus tyrannus</i>
Western Kingbird ^a	<i>Tyrannus verticalis</i>
Eastern Phoebe ^a	<i>Sayornis phoebe</i>
Say's Phoebe ^a	<i>Sayornis saya</i>
Eastern Wood Pewee ^a	<i>Contopus virens</i>
Least Flycatcher ^a	<i>Empidonax minimus</i>
Yellow-bellied Flycatcher ^c	<i>Empidonax flaviventris</i>
Olive-sided Flycatcher ^c	<i>Contopus borealis</i>
Great Crested Flycatcher ^c	<i>Myiarchus crinitus</i>
Horned Lark ^a	<i>Eremophila alpestris</i>
Purple Martin ^a	<i>Progne subis</i>
Tree Swallow ^a	<i>Tachycineta bicolor</i>
Bank Swallow ^a	<i>Riparia riparia</i>
Northern Rough-winged Swallow ^a	<i>Stelgidopteryx serripennis</i>
Barn Swallow ^a	<i>Hirundo rustica</i>
Cliff Swallow ^a	<i>Hirundo pyrrhonota</i>
Blue Jay ^a	<i>Cyanocitta cristata</i>
American Crow ^{ab}	<i>Corvus brachyrhynchos</i>
Black-capped Chickadee ^a	<i>Parus atricapillus</i>
White-breasted Nuthatch ^a	<i>Sitta carolinensis</i>
Red-breasted Nuthatch ^c	<i>Sitta canadensis</i>
Brown Creeper ^a	<i>Certhia americana</i>
House Wren ^a	<i>Troglodytes aedon</i>
Sedge Wren ^a	<i>Cistothorus platensis</i>
Marsh Wren ^c	<i>Cistothorus palustris</i>
Gray Catbird ^a	<i>Dumetella carolinensis</i>
Brown Thrasher ^a	<i>Toxostoma rufum</i>
American Robin ^a	<i>Turdus migratorius</i>
Hermit Thrush ^a	<i>Catharus guttatus</i>
Swainson's Thrush ^a	<i>Catharus ustulatus</i>
Gray-cheeked Thrush ^a	<i>Catharus minimus</i>

^a Observed during point count surveys; ^b Observed during RLB surveys;

^c Observed only during incidental wildlife observations

Appendix A (Continued). List of birds seen in vicinity of Buffalo Ridge study area, 1996-1999.

Common Name	Scientific Name
Eastern Bluebird ^a	<i>Sialia sialis</i>
Mountain Bluebird ^c	<i>Sialia currucoides</i>
Golden-crowned Kinglet ^c	<i>Regulus satrapa</i>
Ruby-crowned Kinglet ^a	<i>Regulus calendula</i>
Blue-gray Gnatcatcher ^c	<i>Piliptila caerulea</i>
American Pipit ^a	<i>Anthus spinoletta</i>
Cedar Waxwing ^a	<i>Bombycilla cedrorum</i>
Northern Shrike ^a	<i>Lanius excubitor</i>
Loggerhead Shrike ^a	<i>Lanius ludovicianus</i>
European Starling ^a	<i>Sturnus vulgaris</i>
Blue-headed Vireo ^a	<i>Vireo solitarius</i>
Red-eyed Vireo ^a	<i>Vireo olivaceus</i>
Warbling Vireo ^a	<i>Vireo gilvus</i>
Philadelphia Vireo ^c	<i>Vireo philadelphicus</i>
Yellow-throated Vireo ^c	<i>Vireo flavifrons</i>
Black-and-white Warbler ^a	<i>Mniotilta varia</i>
Tennessee Warbler ^a	<i>Vermivora peregrina</i>
Orange-crowned Warbler ^a	<i>Vermivora celata</i>
Nashville Warbler ^a	<i>Vermivora ruficapilla</i>
Brewster's Warbler ^c	<i>Vermivora chrysopterna</i> X <i>pinus</i>
Blue-winged Warbler ^c	<i>Vermivora pinus</i>
Yellow Warbler ^a	<i>Dendroica petechia</i>
Yellow-rumped Warbler ^a	<i>Dendroica coronata</i>
Black-throated Green Warbler ^a	<i>Dendroica virens</i>
Pine Warbler ^c	<i>Dendroica pinus</i>
Cape May Warbler ^c	<i>Dendroica tigrina</i>
Chestnut-sided Warbler ^c	<i>Dendroica pensylvanica</i>
Blackburnian Warbler ^c	<i>Dendroica fusca</i>
Magnolia Warbler ^a	<i>Dendroica magnolia</i>
Blackpoll Warbler ^a	<i>Dendroica striata</i>
Palm Warbler ^a	<i>Dendroica palmarum</i>
Northern Parula ^c	<i>Parula americana</i>
Connecticut Warbler ^a	<i>Oporornis agilis</i>
Mourning Warbler ^a	<i>Oporornis philadelphia</i>
Common Yellowthroat ^a	<i>Geothlypis trichas</i>
Wilson's Warbler ^c	<i>Wilsonia pusilla</i>
Canada Warbler ^a	<i>Wilsonia canadensis</i>
American Redstart ^a	<i>Setophaga ruticilla</i>
Ovenbird ^c	<i>Seiurus aurocapillus</i>
Northern Waterthrush ^c	<i>Seiurus noveboracensis</i>
House Sparrow ^a	<i>Passer domesticus</i>
Bobolink ^a	<i>Dolichonyx oryzivorus</i>
Western Meadowlark ^a	<i>Sturnella neglecta</i>
Yellow-headed Blackbird ^a	<i>Xanthocephalus xanthocephalus</i>
Red-winged Blackbird ^a	<i>Agelaius phoeniceus</i>

^a Observed during point count surveys; ^b Observed during RLB surveys;

^c Observed only during incidental wildlife observations

Appendix A (Continued). List of birds seen in vicinity of Buffalo Ridge study area, 1996-1999.

Common Name	Scientific Name
Orchard Oriole ^a	<i>Icterus spurius</i>
Baltimore Oriole ^a	<i>Icterus galbula</i>
Brewer's Blackbird ^a	<i>Euphagus cyanocephalus</i>
Rusty Blackbird ^a	<i>Euphagus carolinus</i>
Common Grackle ^a	<i>Quiscalus quiscula</i>
Brown-headed Cowbird ^a	<i>Molothrus ater</i>
Scarlet Tanager ^a	<i>Piranga olivacea</i>
Rose-breasted Grosbeak ^a	<i>Pheucticus ludovicianus</i>
Blue Grosbeak ^a	<i>Guiraca caerulea</i>
Indigo Bunting ^a	<i>Passerina cyanea</i>
Dickcissel ^a	<i>Spiza americana</i>
House Finch ^a	<i>Carpodacus mexicanus</i>
American Goldfinch ^a	<i>Carduelis tristis</i>
Pine Siskin ^a	<i>Carduelis pinus</i>
Common Redpoll ^a	<i>Carduelis flammea</i>
Savannah Sparrow ^a	<i>Passerculus sandwichensis</i>
Grasshopper Sparrow ^a	<i>Ammodramus savannarum</i>
Le Conte's Sparrow ^a	<i>Ammodramus leconteii</i>
Vesper Sparrow ^a	<i>Pooecetes gramineus</i>
Lark Sparrow ^a	<i>Chondestes grammacus</i>
Dark-eyed Junco ^a	<i>Junco hyemalis</i>
American Tree Sparrow ^a	<i>Spizella arborea</i>
Chipping Sparrow ^a	<i>Spizella passerina</i>
Clay-colored Sparrow ^a	<i>Spizella pallida</i>
Field Sparrow ^a	<i>Spizella pusilla</i>
Harris' Sparrow ^a	<i>Zonotrichia querula</i>
White-crowned Sparrow ^a	<i>Zonotrichia leucophrys</i>
White-throated Sparrow ^a	<i>Zonotrichia albicollis</i>
Lincoln's Sparrow ^a	<i>Melospiza lincolnii</i>
Swamp Sparrow ^a	<i>Melospiza georgiana</i>
Song Sparrow ^a	<i>Melospiza melodia</i>
Fox Sparrow ^c	<i>Passerella iliaca</i>
Lapland Longspur ^a	<i>Calcarius lapponicus</i>
Smith's Longspur ^a	<i>Calcarius pictus</i>
Snow Bunting ^a	<i>Plectrophenax nivalis</i>

^a Observed during point count surveys; ^b Observed during RLB surveys;

^c Observed only during incidental wildlife observations

Appendix B. Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Buffalo Ridge			Buffalo Ridge			Buffalo Ridge		
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Pied-billed Grebe	<0.01	0	<0.01	<0.01	0	<0.01	0.03	0	0.03
Ring-billed Gull	0.01	<0.01	<0.01	0.22	<0.01	0.03	0.49	0.03	0.08
Franklin's Gull	0.01	0.02	0.25	0.19	0.29	2.74	0.47	0.33	0.73
Unidentified Gull	<0.01	<0.01	0.05	0.02	0.01	0.60	0.06	0.03	0.05
Bonaparte's Gull	<0.01	0	0	0.01	0	0	0.03	0	0
Black Tern	<0.01	0.01	0	0.05	0.11	0	0.15	0.03	0
Forster's Tern	<0.01	0	0	0.07	0	0	0.05	0	0
Unidentified Tern	<0.01	0	0	0.01	0	0	0.05	0	0
Double-crested Cormorant	0.03	<0.01	0.15	0.41	0.02	1.62	0.34	0.12	0.35
American White Pelican	<0.01	0	<0.01	0.04	0	0.04	0.04	0	0.02
Common Merganser	<0.01	0	0	0.06	0	0	0.20	0	0
Red-breasted Merganser	<0.01	0	0	0.02	0	0	0.03	0	0
Mallard	0.20	0.05	0.04	3.01	0.78	0.45	8.81	2.14	0.64
Gadwall	<0.01	<0.01	<0.01	0.02	0.02	0.01	0.09	0.06	0.07
Northern Shoveler	<0.01	0	0	0.05	0	0	0.05	0	0
American Wigeon	<0.01	0	0	0.07	0	0	0.10	0	0
Blue-winged Teal	0.01	<0.01	0.01	0.22	0.04	0.11	0.60	0.16	0.21
Green-winged Teal	<0.01	<0.01	<0.01	0.03	<0.01	0.02	0.08	0.03	0.03
Northern Pintail	0.01	0	0	0.17	0	0	0.51	0	0
Bufflehead	<0.01	0	0	0.05	0	0	0.03	0	0
Wood Duck	0.01	<0.01	<0.01	0.22	0.03	<0.01	0.52	0.03	0.03
Lesser Scaup	0.01	0	0	0.22	0	0	0.18	0	0
Common Goldeneye	<0.01	0	0	0.02	0	0	0.06	0	0
Unidentified Scaup	<0.01	0	0	0.05	0	0	0.03	0	0
Unidentified Duck	0	0	<0.01	0	0	0.01	0	0	0.03
Canada Goose	0.12	0.01	0.14	1.87	0.17	1.59	2.15	0.10	0.86
Snow Goose	0.07	0	0.01	1.03	0	0.13	0.09	0	0.02
Greater White-fronted Goose	0.03	0	0	0.46	0	0	0.07	0	0
Great Blue Heron	<0.01	0.01	0.01	0.03	0.12	0.07	0.18	0.54	0.60
Green Heron	<0.01	<0.01	0	0.01	<0.01	0	0.05	0.03	0
Cattle Egret	<0.01	0	0	0.01	0	0	0.05	0	0
American Bittern	<0.01	0	0	0.01	0	0	0.04	0	0
Great Egret	<0.01	0	0	<0.01	0	0	0.03	0	0
American Coot	<0.01	<0.01	<0.01	0.04	<0.01	0.01	0.09	0.03	0.03
Sandhill Crane	0	0	0.03	0	0	0.32	0	0	0.02
Upland Sandpiper	0.01	0.03	<0.01	0.18	0.50	0.01	1.00	1.97	0.06
American Golden-Plover	0.07	0	0	0.99	0	0	0.36	0	0
Spotted Sandpiper	0	<0.01	0	0	<0.01	0	0	0.03	0

^aMean Abundance = Mean number observed /5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Buffalo Ridge								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Killdeer	0.15	0.19	0.14	2.27	3.10	1.53	9.28	10.93	4.67
Buff-breasted Sandpiper	0	<0.01	0	0	0.02	0	0	0.03	0
Least Sandpiper	<0.01	0	0	0.05	0	0	0.08	0	0
Pectoral Sandpiper	0.03	0.02	<0.01	0.46	0.31	0.01	0.42	0.09	0.03
White-rumped Sandpiper	<0.01	0	0	0.02	0	0	0.03	0	0
Solitary Sandpiper	0	<0.01	<0.01	0	0.01	0.01	0	0.03	0.02
Unidentified Sandpiper	0.03	<0.01	<0.01	0.47	0.07	0.01	0.34	0.12	0.05
Greater Yellowlegs	0.01	0	<0.01	0.13	0	0.01	0.36	0	0.03
Lesser Yellowlegs	<0.01	0	<0.01	0.03	0	0.01	0.09	0	0.03
Common Snipe	0.01	<0.01	<0.01	0.22	0.04	0.03	0.88	0.26	0.25
Unidentified Shorebird	<0.01	<0.01	<0.01	0.04	0.03	0.01	0.09	0.07	0.08
Gray Partridge	0.01	0.01	0.05	0.17	0.18	0.57	0.57	0.22	0.44
Ring-necked Pheasant	0.02	0.02	0.04	0.36	0.38	0.47	2.04	1.21	1.51
Rock Dove	0.09	0.13	0.19	1.34	2.10	2.07	3.59	4.02	3.82
Mourning Dove	0.08	0.27	0.26	1.23	4.50	2.93	4.90	13.93	9.53
Northern Harrier	0.02	0.02	0.02	0.27	0.28	0.22	1.62	1.55	1.66
Sharp-shinned Hawk	<0.01	0	<0.01	0.01	0	0.03	0.09	0	0.22
Cooper's Hawk	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.03	0.03	0.11
Broad-winged Hawk	<0.01	0	0	0.02	0	0	0.11	0	0
Red-tailed Hawk	0.01	0.02	0.04	0.22	0.35	0.42	1.40	1.85	3.49
Northern Goshawk	0	0	<0.01	0	0	<0.01	0	0	0.02
Swainson's Hawk	<0.01	0.01	<0.01	0.04	0.10	0.04	0.28	0.55	0.26
Rough-legged Hawk	0	0	<0.01	0	0	0.01	0	0	0.05
Unidentified Buteo	0	0	<0.01	0	0	0.01	0	0	0.06
Ferruginous Hawk	<0.01	0	0	<0.01	0	0	0.03	0	0
Golden Eagle	0	0	<0.01	0	0	<0.01	0	0	0.02
Bald Eagle	0	0	<0.01	0	0	0.01	0	0	0.03
Osprey	0	0	<0.01	0	0	<0.01	0	0	0.03
Merlin	<0.01	0	<0.01	<0.01	0	<0.01	0.03	0	0.02
American Kestrel	0.03	0.02	0.01	0.39	0.27	0.09	1.18	1.20	0.71
Peregrine Falcon	0	0	<0.01	0	0	<0.01	0	0	0.03
Great Horned Owl	0.01	0.01	<0.01	0.09	0.10	0.03	0.51	0.40	0.23
Short-eared Owl	0	0	<0.01	0	0	<0.01	0	0	0.02
Ruby-throated Hummingbird	0	0	<0.01	0	0	0.01	0	0	0.05
Belted Kingfisher	<0.01	<0.01	0	0.02	0.07	0	0.13	0.40	0
Yellow-billed Cuckoo	0	<0.01	0	0	0.01	0	0	0.07	0
Black-billed Cuckoo	0	<0.01	0	0	0.01	0	0	0.06	0

^aMean Abundance = Mean number observed / 5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Hairy Woodpecker	<0.01	<0.01	<0.01	0.01	0.01	0.03	0.07	0.09	0.30
Downy Woodpecker	0.01	<0.01	0.01	0.11	0.08	0.06	0.63	0.42	0.49
Red-headed Woodpecker	0.01	0.02	0.01	0.12	0.32	0.13	0.70	1.48	0.91
Red-Bellied Woodpecker	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	0.03	0.02
Northern Flicker	0.04	0.03	0.03	0.53	0.55	0.37	2.81	2.75	2.34
Unidentified Woodpecker	<0.01	0	<0.01	0.02	0	0.02	0.16	0	0.16
Common Nighthawk	0	0	<0.01	0	0	<0.01	0	0	0.02
Chimney Swift	<0.01	<0.01	<0.01	0.03	0.03	0.03	0.17	0.11	0.15
Eastern Kingbird	0.01	0.07	0.03	0.18	1.14	0.34	1.01	4.61	1.39
Western Kingbird	<0.01	0.01	<0.01	0.05	0.24	0.01	0.26	0.91	0.03
Eastern Phoebe	<0.01	<0.01	<0.01	0.03	0.01	0.02	0.15	0.04	0.12
Say's Phoebe	<0.01	0	0	0.01	0	0	0.08	0	0
Eastern Wood-pewee	<0.01	0	<0.01	<0.01	0	0.01	0.03	0	0.03
Least Flycatcher	<0.01	<0.01	0	0.05	0.01	0	0.30	0.03	0
Unidentified Flycatcher	<0.01	<0.01	<0.01	0.05	0.01	0.01	0.31	0.06	0.08
Horned Lark	0.27	0.15	0.86	4.12	2.43	9.53	9.45	7.95	9.42
American Pipit	<0.01	0	0.02	<0.01	0	0.23	0.03	0	0.31
Blue Jay	0.07	0.03	0.11	1.02	0.55	1.27	2.55	2.32	3.89
American Crow	0.06	0.09	0.15	0.87	1.43	1.65	3.43	3.17	4.66
White-breasted Nuthatch	<0.01	<0.01	<0.01	0.02	0.01	0.01	0.10	0.06	0.05
European Starling	0.20	0.32	0.97	3.01	5.34	10.80	7.18	8.21	9.93
Scarlet Tanager	<0.01	0	0	0.01	0	0	0.05	0	0
Bobolink	0.13	0.24	0.06	1.91	3.93	0.71	5.73	10.37	0.84
Brown-headed Cowbird	0.39	0.29	0.03	5.87	4.82	0.36	17.08	14.49	0.93
Yellow-headed Blackbird	0.04	<0.01	0.01	0.61	0.03	0.10	0.59	0.17	0.12
Red-winged Blackbird	1.18	0.62	0.72	17.91	10.23	7.97	28.98	26.21	4.57
Rusty Blackbird	<0.01	0	0.01	0.02	0	0.08	0.06	0	0.08
Brewer's Blackbird	0.01	0.01	0.01	0.21	0.09	0.15	0.48	0.14	0.24
Unidentified Blackbird	0.27	0.11	1.13	4.16	1.89	12.52	1.33	2.32	3.96
Western Meadowlark	0.27	0.23	0.17	4.08	3.74	1.92	21.30	17.75	8.64
Orchard Oriole	<0.01	<0.01	<0.01	0.01	0.02	<0.01	0.08	0.09	0.03
Baltimore Oriole	<0.01	<0.01	0	0.05	0.04	0	0.28	0.21	0
Common Grackle	0.34	0.33	0.20	5.14	5.40	2.26	11.31	11.70	2.62
House Finch	<0.01	0.01	0.01	0.02	0.11	0.07	0.14	0.31	0.30
American Goldfinch	0.06	0.17	0.09	0.87	2.85	1.04	3.25	10.16	4.51
Pine Siskin	0	0	0.01	0	0	0.10	0	0	0.10
Common Redpoll	0.04	0	0.01	0.58	0	0.06	0.15	0	0.03

^aMean Abundance = Mean number observed / 5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Snow Bunting	<0.01	0	<0.01	0.06	0	0.02	0.10	0	0.07
Lapland Longspur	0.76	0	1.16	11.53	0	12.95	2.37	0	2.99
Smith's Longspur	<0.01	0	<0.01	<0.01	0	<0.01	0.03	0	0.03
Unidentified Longspur	<0.01	0	0	0.02	0	0	0.05	0	0
Vesper Sparrow	0.11	0.14	0.12	1.71	2.33	1.30	9.26	11.79	4.91
Savannah Sparrow	0.16	0.23	0.12	2.49	3.77	1.33	12.69	16.33	3.41
Grasshopper Sparrow	0.02	0.13	0.01	0.37	2.08	0.12	1.85	9.11	0.51
LeConte's Sparrow	<0.01	<0.01	<0.01	0.03	0.01	0.02	0.19	0.05	0.12
Harris' Sparrow	0.02	0	0.03	0.23	0	0.34	0.42	0	0.61
White-throated Sparrow	0.01	0	0.01	0.19	0	0.10	0.58	0	0.30
American Tree Sparrow	0.06	<0.01	0.07	0.93	0.03	0.77	1.17	0.06	1.10
Chipping Sparrow	0.01	0.01	0.01	0.14	0.22	0.06	0.48	0.88	0.25
Clay-colored Sparrow	0.03	0.06	0.01	0.42	1.04	0.06	1.79	4.39	0.30
Field Sparrow	<0.01	<0.01	<0.01	0.03	0.02	0.01	0.16	0.10	0.06
Swamp Sparrow	0	<0.01	<0.01	0	0.02	0.02	0	0.06	0.08
Lark Sparrow	<0.01	<0.01	0	<0.01	<0.01	0	0.03	0.03	0
Dark-eyed Junco	0.01	0	0.04	0.12	0	0.43	0.31	0	0.88
Song Sparrow	0.11	0.13	0.06	1.69	2.15	0.65	8.44	11.07	3.76
Lincoln's Sparrow	0.01	0	0.01	0.08	0	0.15	0.34	0	0.63
White-crowned Sparrow	<0.01	0	<0.01	0.03	0	0.02	0.09	0	0.08
Unidentified Sparrow	0.03	0.12	0.23	0.52	2.02	2.55	2.58	6.86	10.19
Dickcissel	<0.01	0.12	<0.01	0.03	1.94	0.05	0.11	9.32	0.19
Indigo Bunting	0	<0.01	<0.01	0	<0.01	0.01	0	0.03	0.06
Rose-breasted Grosbeak	<0.01	0	0	0.03	0	0	0.14	0	0
Blue Grosbeak	0	<0.01	0	0	0.02	0	0	0.10	0
Purple Martin	<0.01	<0.01	<0.01	0.02	0.01	0.01	0.05	0.04	0.07
Cliff Swallow	0.03	0.19	0.05	0.40	3.08	0.54	1.20	5.66	0.90
Northern Rough-winged Swallow	<0.01	<0.01	<0.01	0.03	0.08	0.05	0.06	0.26	0.08
Barn Swallow	0.21	0.76	0.52	3.25	12.49	5.79	8.59	29.12	14.07
Tree Swallow	0.06	0.02	<0.01	0.88	0.36	0.04	2.74	1.27	0.16
Bank Swallow	0.02	0.06	0.01	0.23	1.07	0.15	0.37	1.47	0.27
Unidentified Swallow	0	0.02	<0.01	0	0.27	0.04	0	0.89	0.18
Blue-headed Vireo	<0.01	0	0	<0.01	0	0	0.03	0	0
Warbling Vireo	<0.01	0	0	0.02	0	0	0.14	0	0
Red-eyed Vireo	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.06	0.03	0.03
American Redstart	<0.01	0	0	0.04	0	0	0.14	0	0
Blackpoll Warbler	<0.01	0	0	0.01	0	0	0.05	0	0

^aMean Abundance = Mean number observed / 5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Black-throated Green Warbler	<0.01	0	0	0.01	0	0	0.05	0	0
Canada Warbler	<0.01	0	0	0.01	0	0	0.05	0	0
Connecticut Warbler	<0.01	0	0	0.01	0	0	0.05	0	0
Common Yellowthroat	0.02	0.10	0.01	0.32	1.70	0.07	1.70	9.26	0.43
Orange-crowned Warbler	<0.01	0	<0.01	0.04	0	<0.01	0.25	0	0.03
Tennessee Warbler	<0.01	<0.01	<0.01	0.03	0.01	0.01	0.18	0.04	0.06
Palm Warbler	<0.01	0	<0.01	0.04	0	0.01	0.17	0	0.08
Yellow Warbler	0.01	<0.01	<0.01	0.12	0.06	0.01	0.70	0.35	0.11
Yellow-rumped Warbler	0.01	0	0.02	0.14	0	0.21	0.58	0	0.65
Nashville Warbler	0	0	<0.01	0	0	<0.01	0	0	0.02
Mourning Warbler	0	0	<0.01	0	0	<0.01	0	0	0.03
Magnolia Warbler	<0.01	0	0	<0.01	0	0	0.03	0	0
Unidentified Warbler	<0.01	0	<0.01	<0.01	0	0.02	0.03	0	0.16
House Sparrow	0.04	0.07	0.09	0.66	1.22	1.04	1.48	2.63	2.19
Gray Catbird	<0.01	<0.01	<0.01	0.03	0.04	0.02	0.19	0.25	0.15
Brown Thrasher	0.01	0.01	<0.01	0.20	0.20	0.01	1.04	1.01	0.10
House Wren	0.01	0.04	0.01	0.21	0.70	0.13	1.18	3.68	0.75
Sedge Wren	0.02	0.11	0.01	0.27	1.86	0.13	1.25	8.68	0.99
Ruby-crowned Kinglet	<0.01	0	<0.01	0.06	0	0.04	0.34	0	0.11
Black-capped Chickadee	<0.01	0.01	0.01	0.07	0.11	0.15	0.34	0.50	0.77
Hermit Thrush	<0.01	0	0	0.01	0	0	0.09	0	0
Gray-cheeked Thrush	<0.01	0	0	0.01	0	0	0.04	0	0
Swainson's Thrush	<0.01	0	0	0.01	0	0	0.06	0	0
Unidentified Thrush	<0.01	0	0	0.01	0	0	0.05	0	0
American Robin	0.17	0.09	0.18	2.56	1.53	1.99	9.21	6.52	5.09
Eastern Bluebird	<0.01	0.01	0.02	0.03	0.09	0.25	0.20	0.37	0.69
Northern Shrike	<0.01	<0.01	<0.01	0.02	<0.01	0.01	0.03	0.03	0.06
Brown Creeper	0	0	<0.01	0	0	<0.01	0	0	0.03
Loggerhead Shrike	<0.01	<0.01	0	<0.01	<0.01	0	0.03	0.03	0
Cedar Waxwing	<0.01	<0.01	0.02	0.01	0.06	0.18	0.03	0.09	0.14
Unidentified Bird	0.01	<0.01	<0.01	0.17	0.04	0.01	0.10	0.19	0.05
TOTAL	6.59	6.06	8.99	100.00	100.00	100.00	--	--	--

^aMean Abundance = Mean number observed / 5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Ring-billed Gull	0.01	0	0	0.20	0	0	0.52	0	0
Franklin's Gull	0	0.04	0.04	0	1.02	0.51	0	0.63	0.36
Unidentified Gull	0.01	0	0	0.13	0	0	0.13	0	0
Forster's Tern	0.02	0	0	0.61	0	0	0.26	0	0
Double-crested Cormorant	0	<0.01	0.09	0	0.07	1.20	0	0.16	0.65
American White Pelican	0	0	0.02	0	0	0.26	0	0	0.11
Great Blue Heron	<0.01	0.01	<0.01	0.03	0.15	0.02	0.13	0.47	0.11
Mallard	0.10	0.03	<0.01	2.53	0.66	0.05	4.93	1.61	0.22
Blue-winged Teal	0.01	<0.01	0	0.34	0.03	0	0.52	0.13	0
Northern Pintail	0.01	0	0	0.30	0	0	0.39	0	0
Wood Duck	<0.01	0	0	0.07	0	0	0.13	0	0
Canada Goose	0.11	0	0.01	2.74	0	0.11	1.04	0	0.11
Upland Sandpiper	0	<0.01	0	0	0.04	0	0	0.16	0
American Golden-Plover	0.02	0	0	0.44	0	0	0.13	0	0
Killdeer	0.12	0.09	0.08	3.24	2.13	1.15	6.10	6.57	2.64
Pectoral Sandpiper	0.01	0	0	0.17	0	0	0.26	0	0
Solitary Sandpiper	0	0	<0.01	0	0	0.05	0	0	0.11
Unidentified Sandpiper	0.01	0	0	0.13	0	0	0.13	0	0
Common Snipe	<0.01	0	0	0.07	0	0	0.13	0	0
Unidentified Shorebird	0	<0.01	0	0	0.07	0	0	0.16	0
Gray Partridge	0.01	<0.01	0.02	0.17	0.04	0.26	0.39	0.16	0.11
Ring-necked Pheasant	0.02	0.02	0.04	0.51	0.48	0.60	1.95	0.72	1.05
Rock Dove	0.06	0.11	0.07	1.67	2.53	1.03	2.92	4.02	2.41
Mourning Dove	0.07	0.26	0.19	1.69	6.05	2.68	4.04	14.48	8.93
Northern Harrier	<0.01	0.01	<0.01	0.03	0.25	0.02	0.13	0.63	0.11
Sharp-shinned Hawk	<0.01	0	0	0.07	0	0	0.26	0	0
Cooper's Hawk	<0.01	0	0	0.03	0	0	0.13	0	0
Broad-winged Hawk	<0.01	0	0	0.03	0	0	0.13	0	0
Red-tailed Hawk	0.01	0.01	0.02	0.17	0.25	0.22	0.65	0.92	1.43
Swainson's Hawk	0	<0.01	<0.01	0	0.07	0.05	0	0.31	0.36
Merlin	0	0	<0.01	0	0	0.02	0	0	0.11
American Kestrel	0.01	0.01	0.01	0.20	0.25	0.07	0.78	0.94	0.54
Downy Woodpecker	<0.01	<0.01	0.01	0.10	0.07	0.08	0.39	0.31	0.60
Red-headed Woodpecker	0.01	0.01	<0.01	0.24	0.22	0.04	0.78	0.94	0.29
Northern Flicker	0.02	0.02	0.01	0.47	0.46	0.17	1.82	1.68	0.86
Unidentified Woodpecker	<0.01	0	0	0.07	0	0	0.26	0	0
Chimney Swift	<0.01	<0.01	<0.01	0.07	0.09	0.02	0.26	0.27	0.16

^aMean Abundance = Mean number observed / 5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Phase I Study Area								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Cliff Swallow	<0.01	0.01	0.01	0.12	0.33	0.18	0.16	0.45	0.60
Barn Swallow	0.09	0.59	0.34	2.43	13.78	4.76	4.56	21.18	10.14
Tree Swallow	0.04	0.01	0.01	0.91	0.18	0.11	1.43	0.39	0.33
Bank Swallow	<0.01	0	0	0.07	0	0	0.13	0	0
Unidentified Swallow	0	0.01	<0.01	0	0.25	0.02	0	0.47	0.11
Eastern Kingbird	<0.01	0.01	0.01	0.10	0.28	0.15	0.39	0.92	0.49
Western Kingbird	<0.01	<0.01	0	0.10	0.11	0	0.13	0.47	0
Eastern Phoebe	<0.01	0	0	0.03	0	0	0.13	0	0
Least Flycatcher	<0.01	0	0	0.03	0	0	0.13	0	0
Unidentified Flycatcher	<0.01	0	<0.01	0.03	0	0.02	0.13	0	0.11
European Starling	0.10	0.19	1.55	2.62	4.55	21.42	4.17	6.71	8.70
Brown-headed Cowbird	0.31	0.28	0.05	8.05	6.54	0.69	15.00	14.43	0.89
Yellow-headed Blackbird	0.03	<0.01	0	0.71	0.04	0	0.78	0.16	0
Red-winged Blackbird	0.72	0.57	1.09	18.56	13.31	15.00	23.21	26.94	4.20
Rusty Blackbird	<0.01	0	0	0.04	0	0	0.16	0	0
Brewer's Blackbird	<0.01	0.01	0.01	0.07	0.15	0.17	0.13	0.31	0.11
Unidentified Blackbird	0.12	0.02	1.44	3.06	0.40	19.85	1.98	1.70	4.80
Common Grackle	0.40	0.29	0.25	10.35	6.80	3.51	11.88	12.49	3.13
Blue Jay	0.02	0.01	0.04	0.57	0.33	0.58	1.43	1.09	2.55
American Crow	0.06	0.06	0.10	1.46	1.33	1.44	3.83	3.06	3.16
Warbling Vireo	<0.01	0	0	0.03	0	0	0.13	0	0
American Redstart	<0.01	0	0	0.10	0	0	0.26	0	0
Common Yellowthroat	0.02	0.13	<0.01	0.51	3.08	0.06	1.56	10.94	0.22
Orange-crowned Warbler	<0.01	0	0	0.03	0	0	0.13	0	0
Tennessee Warbler	<0.01	0	0	0.07	0	0	0.13	0	0
Yellow Warbler	<0.01	0	0	0.07	0	0	0.26	0	0
Yellow-rumped Warbler	0	0	0.01	0	0	0.08	0	0	0.49
Unidentified Warbler	0	0	<0.01	0	0	0.05	0	0	0.38
Bobolink	0.11	0.17	0.03	2.83	4.08	0.42	6.10	8.17	0.69
Western Meadowlark	0.13	0.14	0.09	3.31	3.24	1.24	11.72	11.30	4.63
Vesper Sparrow	0.11	0.14	0.06	2.79	3.25	0.85	9.49	12.54	2.36
Savannah Sparrow	0.06	0.08	0.05	1.57	1.79	0.65	5.36	6.15	1.30
Grasshopper Sparrow	0.01	0.03	0	0.24	0.73	0	0.65	2.44	0
LeConte's Sparrow	<0.01	<0.01	0	0.10	0.09	0	0.39	0.27	0
Harris' Sparrow	0	0	0.01	0	0	0.12	0	0	0.24
White-throated Sparrow	0.01	0	0.01	0.27	0	0.09	0.65	0	0.13
American Tree Sparrow	0.02	0	0.03	0.40	0	0.42	0.39	0	0.33

^aMean Abundance = Mean number observed / 5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Chipping Sparrow	0.01	0.01	0	0.27	0.15	0	0.52	0.31	0
Clay-colored Sparrow	0.02	0.03	<0.01	0.40	0.77	0.03	0.65	2.55	0.22
Dark-eyed Junco	<0.01	0	0.02	0.10	0	0.22	0.13	0	0.47
Song Sparrow	0.05	0.08	0.03	1.28	1.82	0.40	3.91	6.38	2.12
Lincoln's Sparrow	0	0	0.01	0	0	0.10	0	0	0.38
Unidentified Sparrow	0.03	0.08	0.13	0.68	1.97	1.85	2.11	6.14	6.77
Dickcissel	<0.01	0.14	0.01	0.07	3.22	0.18	0.26	10.71	0.45
House Sparrow	0.03	0.07	0.04	0.88	1.60	0.57	1.17	3.39	1.88
Gray Catbird	0	<0.01	<0.01	0	0.04	0.04	0	0.16	0.29
Brown Thrasher	0.01	0.01	0	0.17	0.22	0	0.39	0.78	0
Hermit Thrush	<0.01	0	0	0.07	0	0	0.26	0	0
Swainson's Thrush	<0.01	0	0	0.03	0	0	0.13	0	0
American Robin	0.15	0.07	0.15	3.86	1.73	2.03	7.08	4.76	3.76
Eastern Bluebird	0	0	0.01	0	0	0.15	0	0	0.36
Northern Shrike	0.01	0	<0.01	0.13	0	0.02	0.13	0	0.13
Horned Lark	0.29	0.07	0.19	7.42	1.69	2.65	8.41	5.38	4.81
American Pipit	0	0	0.02	0	0	0.22	0	0	0.13
Snow Bunting	0.01	0	<0.01	0.27	0	0.05	0.26	0	0.22
Lapland Longspur	0.15	0	0.65	3.85	0	9.00	0.91	0	1.67
House Finch	<0.01	<0.01	0.01	0.03	0.11	0.16	0.13	0.29	0.40
American Goldfinch	0.04	0.10	0.09	0.91	2.39	1.25	2.21	7.35	4.65
Orchard Oriole	0	0	<0.01	0	0	0.02	0	0	0.16
Baltimore Oriole	<0.01	<0.01	0	0.03	0.03	0	0.13	0.13	0
House Wren	<0.01	0.01	0.01	0.10	0.29	0.12	0.39	1.07	0.49
Sedge Wren	0.05	0.17	0.01	1.25	4.07	0.14	2.86	12.56	0.87
Black-capped Chickadee	0	0.01	0.01	0	0.15	0.11	0	0.47	0.47
Belted Kingfisher	<0.01	<0.01	0	0.03	0.07	0	0.13	0.31	0
Cedar Waxwing	0	<0.01	0.02	0	0.04	0.22	0	0.16	0.11
Unidentified Bird	0	<0.01	0	0	0.07	0	0	0.31	0
TOTAL	3.86	4.28	7.25	100.00	100.00	100.00	--	--	--

^aMean Abundance = Mean number observed /5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Phase II Study Area								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Pied-billed Grebe	<0.01	0	<0.01	0.01	0	0.01	0.08	0	0.06
Ring-billed Gull	0.03	0	0.01	0.41	0	0.06	0.78	0	0.11
Franklin's Gull	0.02	0.01	0.16	0.33	0.15	1.62	0.88	0.23	1.06
Unidentified Gull	<0.01	0	0.12	0.01	0	1.29	0.08	0	0.12
Black Tern	<0.01	0	0	0.01	0	0	0.06	0	0
Unidentified Tern	<0.01	0	0	0.02	0	0	0.12	0	0
Double-crested Cormorant	0.02	0	0.20	0.29	0	2.05	0.47	0	0.25
American White Pelican	0.01	0	0	0.09	0	0	0.09	0	0
Common Merganser	0.01	0	0	0.09	0	0	0.31	0	0
Red-breasted Merganser	<0.01	0	0	0.04	0	0	0.08	0	0
Mallard	0.28	0.07	0.08	4.08	1.24	0.85	11.59	2.92	1.16
Gadwall	<0.01	0	<0.01	0.05	0	0.03	0.19	0	0.15
Northern Shoveler	0.01	0	0	0.10	0	0	0.12	0	0
Blue-winged Teal	0.01	0.01	0.01	0.15	0.09	0.15	0.57	0.29	0.29
Green-winged Teal	<0.01	<0.01	0	0.02	0.01	0	0.06	0.08	0
Northern Pintail	0.02	0	0	0.28	0	0	0.89	0	0
Wood Duck	0.02	0	<0.01	0.36	0	0.01	0.72	0	0.06
Lesser Scaup	0.03	0	0	0.39	0	0	0.25	0	0
Common Goldeneye	<0.01	0	0	0.05	0	0	0.13	0	0
Unidentified Scaup	0.01	0	0	0.11	0	0	0.08	0	0
Unidentified Duck	0	0	<0.01	0	0	0.02	0	0	0.06
Canada Goose	0.06	0.02	0.19	0.87	0.39	2.01	2.27	0.22	1.14
Snow Goose	0.09	0	0	1.28	0	0	0.13	0	0
Great Blue Heron	<0.01	0.01	0.01	0.03	0.13	0.06	0.18	0.68	0.60
Green Heron	<0.01	<0.01	0	0.02	0.01	0	0.12	0.08	0
Cattle Egret	<0.01	0	0	0.02	0	0	0.12	0	0
Great Egret	<0.01	0	0	0.01	0	0	0.06	0	0
American Coot	0.01	<0.01	0	0.08	0.01	0	0.19	0.08	0
Upland Sandpiper	0.01	0.02	<0.01	0.17	0.38	0.01	1.00	1.73	0.05
American Golden-Plover	0.03	0	0	0.41	0	0	0.13	0	0
Killdeer	0.15	0.23	0.15	2.27	3.95	1.51	9.75	12.36	5.40
Buff-breasted Sandpiper	0	<0.01	0	0	0.04	0	0	0.07	0
Least Sandpiper	0.01	0	0	0.10	0	0	0.18	0	0
Pectoral Sandpiper	0.04	0	0	0.52	0	0	0.48	0	0
White-rumped Sandpiper	<0.01	0	0	0.04	0	0	0.08	0	0
Unidentified Sandpiper	0.02	<0.01	<0.01	0.31	0.03	0.02	0.35	0.08	0.06
Greater Yellowlegs	0.02	0	<0.01	0.24	0	0.03	0.61	0	0.06

^aMean Abundance = Mean number observed / 5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Phase II Study Area								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Lesser Yellowlegs	<0.01	0	0	0.03	0	0	0.12	0	0
Common Snipe	0.01	<0.01	<0.01	0.15	0.08	0.05	0.55	0.46	0.39
Unidentified Shorebird	<0.01	<0.01	<0.01	0.05	0.04	0.01	0.14	0.07	0.11
Gray Partridge	0.02	0	0.04	0.24	0	0.46	0.82	0	0.40
Ring-necked Pheasant	0.03	0.02	0.06	0.44	0.39	0.58	2.64	1.47	1.78
Rock Dove	0.09	0.16	0.30	1.36	2.73	3.07	3.68	4.07	4.81
Mourning Dove	0.06	0.24	0.23	0.95	4.06	2.44	4.06	11.77	8.28
Northern Harrier	0.03	0.02	0.02	0.38	0.38	0.25	2.30	2.11	2.01
Sharp-shinned Hawk	0	0	<0.01	0	0	0.03	0	0	0.19
Cooper's Hawk	0	0	<0.01	0	0	0.02	0	0	0.18
Broad-winged Hawk	<0.01	0	0	0.01	0	0	0.06	0	0
Red-tailed Hawk	0.02	0.02	0.04	0.24	0.41	0.42	1.47	2.18	3.68
Northern Goshawk	0	0	<0.01	0	0	0.01	0	0	0.05
Swainson's Hawk	<0.01	0.01	<0.01	0.07	0.09	0.01	0.48	0.51	0.06
Rough-legged Hawk	0	0	<0.01	0	0	0.01	0	0	0.06
Unidentified Buteo	0	0	<0.01	0	0	0.01	0	0	0.13
American Kestrel	0.05	0.01	0.01	0.68	0.24	0.07	1.56	1.16	0.65
Peregrine Falcon	0	0	<0.01	0	0	0.01	0	0	0.06
Great Horned Owl	0.01	0.01	<0.01	0.15	0.15	0.05	0.91	0.53	0.39
Short-eared Owl	0	0	<0.01	0	0	0.01	0	0	0.05
Ruby-throated Hummingbird	0	0	<0.01	0	0	0.01	0	0	0.11
Belted Kingfisher	<0.01	<0.01	0	0.02	0.06	0	0.16	0.38	0
Yellow-billed Cuckoo	0	<0.01	0	0	0.01	0	0	0.08	0
Hairy Woodpecker	0	0	<0.01	0	0	0.03	0	0	0.25
Downy Woodpecker	0.01	<0.01	0.01	0.09	0.05	0.05	0.51	0.30	0.44
Red-headed Woodpecker	<0.01	0.01	0.01	0.05	0.24	0.10	0.31	0.97	0.73
Red-Bellied Woodpecker	0	0	<0.01	0	0	0.01	0	0	0.05
Northern Flicker	0.03	0.03	0.02	0.47	0.48	0.20	2.36	2.03	1.48
Unidentified Woodpecker	0	0	<0.01	0	0	0.01	0	0	0.12
Chimney Swift	<0.01	0	<0.01	0.03	0	0.01	0.19	0	0.05
Eastern Kingbird	0.01	0.06	0.04	0.16	0.98	0.37	0.88	3.73	1.65
Western Kingbird	<0.01	0.02	0	0.03	0.37	0	0.19	1.36	0
Eastern Phoebe	<0.01	<0.01	0	0.02	0.03	0	0.14	0.09	0
Say's Phoebe	<0.01	0	0	0.03	0	0	0.18	0	0
Eastern Wood-pewee	<0.01	0	<0.01	0.01	0	0.01	0.08	0	0.06
Least Flycatcher	<0.01	0	0	0.04	0	0	0.30	0	0
Unidentified Flycatcher	<0.01	0	0	0.04	0	0	0.24	0	0

^aMean Abundance = Mean number observed / 5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Phase II Study Area			Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Horned Lark	0.31	0.18	1.34	4.59	3.03	13.97	10.20	8.79	11.38			
American Pipit	0	0	0.02	0	0	0.19	0	0	0.21			
Blue Jay	0.08	0.03	0.05	1.10	0.56	0.57	2.33	2.19	2.72			
American Crow	0.03	0.07	0.16	0.49	1.24	1.62	2.33	2.70	4.61			
White-breasted Nuthatch	0	0	<0.01	0	0	0.01	0	0	0.05			
European Starling	0.15	0.22	0.67	2.24	3.77	6.92	6.34	5.46	8.52			
Bobolink	0.17	0.29	0.11	2.47	4.88	1.19	7.25	11.83	1.10			
Brown-headed Cowbird	0.32	0.22	0.02	4.67	3.71	0.22	14.16	12.25	0.66			
Yellow-headed Blackbird	0.06	<0.01	0.02	0.94	0.03	0.18	0.26	0.16	0.19			
Red-winged Blackbird	1.31	0.53	0.81	19.17	9.03	8.44	25.06	22.14	4.56			
Rusty Blackbird	<0.01	0	<0.01	0.04	0	0.04	0.06	0	0.05			
Brewer's Blackbird	0.01	0.01	<0.01	0.17	0.13	0.04	0.36	0.09	0.06			
Unidentified Blackbird	0.47	0.09	1.19	6.88	1.46	12.39	1.23	2.25	3.93			
Western Meadowlark	0.29	0.20	0.16	4.27	3.42	1.66	22.81	16.64	8.06			
Orchard Oriole	<0.01	0	0	0.03	0	0	0.18	0	0			
Baltimore Oriole	<0.01	<0.01	0	0.05	0.04	0	0.26	0.23	0			
Common Grackle	0.23	0.22	0.22	3.37	3.81	2.28	8.23	8.43	2.23			
House Finch	0	0.01	0.01	0	0.13	0.06	0	0.37	0.34			
American Goldfinch	0.06	0.16	0.10	0.87	2.79	1.01	3.14	9.29	4.39			
Pine Siskin	0	0	0.01	0	0	0.10	0	0	0.14			
Common Redpoll	0.05	0	0	0.68	0	0	0.20	0	0			
Snow Bunting	<0.01	0	<0.01	0.06	0	0.02	0.09	0	0.05			
Lapland Longspur	0.77	0	1.21	11.31	0	12.59	2.63	0	3.28			
Smith's Longspur	<0.01	0	0	0.01	0	0	0.06	0	0			
Vesper Sparrow	0.10	0.15	0.11	1.47	2.48	1.14	8.45	12.21	5.08			
Savannah Sparrow	0.18	0.29	0.15	2.62	5.00	1.60	13.86	20.03	3.68			
Grasshopper Sparrow	0.04	0.19	0.02	0.59	3.23	0.16	3.12	13.56	0.80			
LeConte's Sparrow	<0.01	0	<0.01	0.04	0	0.02	0.25	0	0.22			
Harris' Sparrow	0.01	0	0.02	0.10	0	0.24	0.28	0	0.46			
White-throated Sparrow	<0.01	0	0.01	0.04	0	0.08	0.28	0	0.28			
American Tree Sparrow	0.10	0	0.07	1.43	0	0.70	1.67	0	0.91			
Chipping Sparrow	0.01	0.01	0.01	0.16	0.25	0.07	0.46	1.00	0.30			
Clay-colored Sparrow	0.04	0.10	0.01	0.55	1.78	0.09	2.66	7.48	0.29			
Field Sparrow	<0.01	<0.01	<0.01	0.07	0.05	0.01	0.37	0.22	0.06			
Swamp Sparrow	0	<0.01	<0.01	0	0.01	0.01	0	0.08	0.05			
Dark-eyed Junco	0.01	0	0.03	0.12	0	0.32	0.48	0	0.63			
Song Sparrow	0.11	0.11	0.05	1.54	1.93	0.52	8.00	9.95	3.48			

^aMean Abundance = Mean number observed / 5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Phase II Study Area								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Lincoln's Sparrow	<0.01	0	0.01	0.01	0	0.06	0.06	0	0.42
White-crowned Sparrow	0	0	<0.01	0	0	0.01	0	0	0.05
Unidentified Sparrow	0.03	0.16	0.26	0.45	2.67	2.75	2.21	7.70	10.73
Dickcissel	0	0.10	<0.01	0	1.68	0.03	0	7.96	0.17
Indigo Bunting	0	0	<0.01	0	0	0.01	0	0	0.13
Rose-breasted Grosbeak	<0.01	0	0	0.04	0	0	0.24	0	0
Blue Grosbeak	0	<0.01	0	0	0.03	0	0	0.17	0
Purple Martin	0	<0.01	<0.01	0	0.02	0.02	0	0.09	0.17
Cliff Swallow	0.02	0.14	0.07	0.34	2.32	0.71	1.22	6.01	1.10
Northern Rough-winged Swallow	<0.01	0.01	0.01	0.01	0.13	0.05	0.06	0.30	0.06
Barn Swallow	0.16	0.78	0.52	2.41	13.27	5.44	8.71	30.66	14.29
Tree Swallow	0.06	0.02	<0.01	0.91	0.38	0.03	2.68	1.30	0.14
Bank Swallow	0.02	0.13	0.02	0.31	2.23	0.22	0.48	2.65	0.41
Unidentified Swallow	0	0.01	0.01	0	0.20	0.08	0	0.92	0.36
Blue-headed Vireo	<0.01	0	0	0.01	0	0	0.06	0	0
Warbling Vireo	<0.01	0	0	0.02	0	0	0.12	0	0
Red-eyed Vireo	<0.01	0	0	0.02	0	0	0.06	0	0
American Redstart	<0.01	0	0	0.01	0	0	0.06	0	0
Blackpoll Warbler	<0.01	0	0	0.02	0	0	0.12	0	0
Common Yellowthroat	0.02	0.09	0.01	0.34	1.55	0.11	1.85	8.19	0.71
Orange-crowned Warbler	<0.01	0	0	0.07	0	0	0.48	0	0
Tennessee Warbler	<0.01	<0.01	0	0.03	0.02	0	0.19	0.09	0
Palm Warbler	0	0	<0.01	0	0	0.02	0	0	0.12
Yellow Warbler	0.01	<0.01	<0.01	0.12	0.06	0.01	0.67	0.34	0.12
Yellow-rumped Warbler	0.01	0	0.01	0.12	0	0.11	0.57	0	0.64
Nashville Warbler	0	0	<0.01	0	0	0.01	0	0	0.05
Magnolia Warbler	<0.01	0	0	0.01	0	0	0.06	0	0
Unidentified Warbler	0	0	<0.01	0	0	0.01	0	0	0.06
House Sparrow	0.05	0.08	0.10	0.80	1.37	1.08	1.54	2.51	2.04
Gray Catbird	<0.01	<0.01	<0.01	0.05	0.04	0.01	0.30	0.22	0.06
Brown Thrasher	0.01	<0.01	<0.01	0.16	0.08	0.03	0.91	0.37	0.22
House Wren	0.01	0.03	0.01	0.13	0.59	0.10	0.62	3.00	0.81
Sedge Wren	0.01	0.12	0.01	0.18	2.05	0.11	0.96	9.58	0.93
Ruby-crowned Kinglet	<0.01	0	<0.01	0.02	0	0.02	0.12	0	0.06
Black-capped Chickadee	0.01	0.01	0.01	0.09	0.13	0.10	0.45	0.53	0.52
American Robin	0.13	0.06	0.18	1.87	1.04	1.86	7.85	4.92	4.24
Eastern Bluebird	<0.01	0.01	0.02	0.03	0.09	0.23	0.19	0.37	0.46

^aMean Abundance = Mean number observed / 5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Phase II Study Area			Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Northern Shrike	0	<0.01	0	0	0.01	0	0	0.08	0			
Brown Creeper	0	0	<0.01	0	0	0.01	0	0	0.06			
Cedar Waxwing	0	<0.01	0.03	0	0.04	0.31	0	0.08	0.25			
Unidentified Bird	0.02	<0.01	<0.01	0.35	0.03	0.02	0.15	0.15	0.12			
TOTAL	6.82	5.87	9.62	100.00	100.00	100.00	--	--	--			

^aMean Abundance = Mean number observed /5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Ring-billed Gull	0	<0.01	<0.01	0	0.03	0.03	0	0.20	0.17
Franklin's Gull	0	0.03	0.58	0	0.34	5.67	0	0.57	0.84
Unidentified Gull	0	<0.01	0	0	0.04	0	0	0.17	0
Black Tern	0.02	0.04	0	0.28	0.56	0	0.73	0.20	0
Double-crested Cormorant	0.11	0	0.10	1.48	0	1.00	0.40	0	0.30
Mallard	0.19	0.03	<0.01	2.59	0.41	0.02	7.72	1.73	0.16
Gadwall	0	0.01	0	0	0.09	0	0	0.33	0
American Wigeon	0.03	0	0	0.36	0	0	0.60	0	0
Blue-winged Teal	0.03	0	0.02	0.48	0	0.20	0.93	0	0.47
Green-winged Teal	0	0	0.01	0	0	0.10	0	0	0.17
Northern Pintail	<0.01	0	0	0.03	0	0	0.20	0	0
Bufflehead	0.02	0	0	0.25	0	0	0.20	0	0
Wood Duck	0.01	0	0	0.09	0	0	0.33	0	0
Lesser Scaup	0.01	0	0	0.20	0	0	0.40	0	0
Canada Goose	0.18	0	0.32	2.51	0	3.13	3.27	0	1.34
Snow Goose	0	0	0.07	0	0	0.69	0	0	0.14
Great Blue Heron	0	0.01	0.01	0	0.09	0.10	0	0.33	0.83
American Bittern	<0.01	0	0	0.03	0	0	0.25	0	0
Sandhill Crane	0	0	0.18	0	0	1.73	0	0	0.14
Upland Sandpiper	0.01	0.05	0	0.18	0.64	0	1.27	3.00	0
American Golden-Plover	0.14	0	0	1.90	0	0	0.40	0	0
Spotted Sandpiper	0	<0.01	0	0	0.03	0	0	0.20	0
Killdeer	0.16	0.12	0.13	2.22	1.61	1.23	10.47	8.50	5.05
Pectoral Sandpiper	0.05	0.10	0	0.73	1.28	0	0.50	0.37	0
Solitary Sandpiper	0	<0.01	0	0	0.04	0	0	0.17	0
Unidentified Sandpiper	0.06	0.02	<0.01	0.80	0.29	0.02	0.73	0.50	0.17
Greater Yellowlegs	<0.01	0	0	0.03	0	0	0.20	0	0
Lesser Yellowlegs	<0.01	0	<0.01	0.06	0	0.03	0.20	0	0.17
Common Snipe	0.03	<0.01	<0.01	0.36	0.02	0.03	1.93	0.17	0.33
Gray Partridge	0.01	0.02	0.03	0.11	0.26	0.31	0.40	0.57	0.32
Ring-necked Pheasant	0.02	0.01	0.03	0.25	0.14	0.32	1.20	1.03	1.53
Rock Dove	0.16	0.19	0.14	2.24	2.50	1.36	6.73	7.50	5.40
Mourning Dove	0.08	0.29	0.35	1.05	3.84	3.41	4.92	15.67	11.48
Northern Harrier	0.02	0.02	0.03	0.27	0.21	0.24	1.90	1.60	1.85
Sharp-shinned Hawk	<0.01	0	0.01	0.03	0	0.08	0.20	0	0.67
Red-tailed Hawk	0.01	0.03	0.04	0.11	0.37	0.42	0.80	2.43	4.01
Swainson's Hawk	<0.01	0.02	0.01	0.03	0.20	0.07	0.20	1.37	0.45

^aMean Abundance = Mean number observed / 5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Phase III Study Area			Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Ferruginous Hawk	<0.01	0	0	0.03	0	0	0.20	0	0			
Golden Eagle	0	0	<0.01	0	0	0.01	0	0	0.14			
Osprey	0	0	<0.01	0	0	0.02	0	0	0.17			
American Kestrel	0.01	0.02	0.01	0.08	0.23	0.05	0.60	1.03	0.50			
Great Horned Owl	0	0.01	0	0	0.16	0	0	0.87	0			
Belted Kingfisher	<0.01	<0.01	0	0.03	0.04	0	0.20	0.33	0			
Hairy Woodpecker	0	<0.01	0.01	0	0.02	0.08	0	0.17	0.83			
Downy Woodpecker	0.01	<0.01	<0.01	0.07	0.04	0.03	0.53	0.33	0.33			
Red-headed Woodpecker	<0.01	0.02	0.01	0.03	0.22	0.06	0.20	1.17	0.50			
Red-Bellied Woodpecker	0	<0.01	0	0	0.02	0	0	0.17	0			
Northern Flicker	0.05	0.02	0.05	0.66	0.27	0.49	3.68	1.70	3.32			
Unidentified Woodpecker	0.01	0	<0.01	0.09	0	0.03	0.67	0	0.31			
Chimney Swift	0	0.01	<0.01	0	0.07	0.02	0	0.33	0.16			
Eastern Kingbird	<0.01	0.07	0.02	0.02	0.89	0.22	0.17	4.60	1.12			
Western Kingbird	<0.01	0	0	0.05	0	0	0.33	0	0			
Eastern Phoebe	<0.01	0	0	0.06	0	0	0.20	0	0			
Unidentified Flycatcher	<0.01	<0.01	<0.01	0.03	0.04	0.02	0.20	0.33	0.17			
Horned Lark	0.12	0.11	0.46	1.66	1.39	4.45	7.18	6.93	9.76			
American Pipit	0	0	0.05	0	0	0.46	0	0	0.96			
Blue Jay	0.10	0.03	0.21	1.36	0.43	2.07	2.80	2.07	4.22			
American Crow	0.10	0.18	0.23	1.34	2.33	2.19	5.50	5.27	7.15			
European Starling	0.29	0.69	1.15	4.02	9.09	11.11	8.87	13.03	13.99			
Bobolink	0.08	0.23	0.01	1.13	3.05	0.06	3.92	11.67	0.33			
Brown-headed Cowbird	0.33	0.35	0.07	4.59	4.67	0.67	19.88	15.50	2.39			
Yellow-headed Blackbird	0.01	<0.01	0	0.20	0.05	0	0.70	0.40	0			
Red-winged Blackbird	1.44	0.80	0.32	20.12	10.64	3.10	41.52	33.13	6.20			
Brewer's Blackbird	0.05	<0.01	0.01	0.64	0.04	0.11	1.40	0.17	0.41			
Unidentified Blackbird	0.20	0.21	1.13	2.78	2.77	10.90	1.53	3.23	4.50			
Western Meadowlark	0.29	0.31	0.24	4.11	4.08	2.29	24.57	23.27	12.72			
Orchard Oriole	0	<0.01	0	0	0.03	0	0	0.20	0			
Baltimore Oriole	0	0.01	0	0	0.09	0	0	0.33	0			
Common Grackle	0.54	0.53	0.17	7.60	6.96	1.60	19.92	17.90	3.74			
House Finch	<0.01	0.01	0.01	0.03	0.18	0.06	0.20	0.50	0.19			
American Goldfinch	0.06	0.21	0.08	0.79	2.76	0.77	4.00	12.20	4.64			
Lapland Longspur	0.73	0	2.29	10.13	0	22.18	2.45	0	4.24			
Smith's Longspur	0	0	<0.01	0	0	0.02	0	0	0.17			
Unidentified Longspur	0.01	0	0	0.09	0	0	0.33	0	0			

^aMean Abundance = Mean number observed /5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Phase III Study Area			Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Vesper Sparrow	0.08	0.11	0.07	1.15	1.51	0.70	6.63	10.33	4.15			
Savannah Sparrow	0.24	0.30	0.10	3.42	3.92	0.98	18.28	23.67	3.75			
Grasshopper Sparrow	0.01	0.14	0.01	0.17	1.80	0.06	0.53	9.53	0.33			
LeConte's Sparrow	0	0	<0.01	0	0	0.03	0	0	0.17			
Harris' Sparrow	0.05	0	0.01	0.70	0	0.14	1.23	0	0.48			
White-throated Sparrow	0.04	0	<0.01	0.59	0	0.04	0.80	0	0.31			
American Tree Sparrow	0.02	0	0.06	0.34	0	0.54	0.20	0	0.95			
Chipping Sparrow	0.01	0.02	0.01	0.07	0.28	0.08	0.53	1.37	0.50			
Clay-colored Sparrow	0.02	0.01	0	0.24	0.13	0	0.87	1.00	0			
Field Sparrow	0	0	<0.01	0	0	0.03	0	0	0.17			
Swamp Sparrow	0	0.01	0.01	0	0.07	0.05	0	0.17	0.17			
Dark-eyed Junco	0.02	0	0.04	0.28	0	0.34	0.40	0	0.67			
Song Sparrow	0.13	0.15	0.06	1.76	1.95	0.58	10.28	11.70	4.22			
Lincoln's Sparrow	0.01	0	0.03	0.19	0	0.27	0.73	0	0.83			
White-crowned Sparrow	<0.01	0	0	0.06	0	0	0.20	0	0			
Unidentified Sparrow	0.06	0.11	0.27	0.89	1.47	2.59	4.32	6.70	12.51			
Dickcissel	0	0.18	0	0	2.34	0	0	13.47	0			
Indigo Bunting	0	<0.01	0	0	0.03	0	0	0.20	0			
Purple Martin	0.01	0	0	0.09	0	0	0.33	0	0			
Cliff Swallow	0.05	0.26	0.03	0.64	3.42	0.27	2.00	8.67	0.66			
Northern Rough-winged Swallow	0.01	<0.01	0.01	0.17	0.05	0.11	0.20	0.37	0.32			
Barn Swallow	0.21	0.87	0.64	2.92	11.48	6.21	10.63	35.87	18.45			
Tree Swallow	0.04	<0.01	0	0.61	0.05	0	2.62	0.37	0			
Bank Swallow	0.03	0.03	0	0.45	0.44	0	0.80	1.00	0			
Unidentified Swallow	0	0.04	0	0	0.55	0	0	1.50	0			
Red-eyed Vireo	0	<0.01	<0.01	0	0.02	0.02	0	0.17	0.17			
Common Yellowthroat	0.02	0.13	0	0.27	1.72	0	1.93	12.20	0			
Orange-crowned Warbler	0	0	<0.01	0	0	0.02	0	0	0.17			
Tennessee Warbler	0	0	<0.01	0	0	0.02	0	0	0.17			
Palm Warbler	0.01	0	0	0.07	0	0	0.53	0	0			
Yellow Warbler	0	0.01	<0.01	0	0.07	0.03	0	0.50	0.33			
Yellow-rumped Warbler	0.01	0	0.06	0.13	0	0.55	0.93	0	1.07			
Mourning Warbler	0	0	<0.01	0	0	0.02	0	0	0.19			
Unidentified Warbler	<0.01	0	<0.01	0.03	0	0.03	0.20	0	0.17			
House Sparrow	0.01	0.05	0.11	0.15	0.65	1.06	0.58	1.73	3.03			
Gray Catbird	<0.01	<0.01	0	0.05	0.02	0	0.33	0.17	0			

^aMean Abundance = Mean number observed / 5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Brown Thrasher	0.02	0.02	0	0.29	0.30	0	2.07	1.90	0
House Wren	0.02	0.06	0.01	0.21	0.79	0.08	1.33	5.00	0.48
Sedge Wren	0.01	0.10	0.02	0.14	1.37	0.23	0.77	7.80	1.84
Ruby-crowned Kinglet	0.01	0	0.01	0.09	0	0.11	0.33	0	0.36
Black-capped Chickadee	0	0	0.01	0	0	0.08	0	0	0.69
Swainson's Thrush	<0.01	0	0	0.03	0	0	0.20	0	0
American Robin	0.23	0.13	0.15	3.24	1.70	1.47	11.50	8.40	6.27
Loggerhead Shrike	<0.01	<0.01	0	0.03	0.02	0	0.20	0.17	0
Cedar Waxwing	<0.01	0.02	0	0.06	0.20	0	0.20	0.17	0
Unidentified Bird	<0.01	0.01	0	0.06	0.09	0	0.20	0.17	0
TOTAL	7.16	7.56	10.32	100.00	100.00	100.00	--	--	--

^aMean Abundance = Mean number observed / 5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Reference Area								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Ring-billed Gull	<0.01	0	0	0.02	0	0	0.18	0	0
Franklin's Gull	0.01	0	0.40	0.13	0	4.82	0.36	0	0.33
Bonaparte's Gull	<0.01	0	0	0.04	0	0	0.18	0	0
Double-crested Cormorant	<0.01	<0.01	0.12	0.04	0.07	1.49	0.32	0.48	0.30
Common Merganser	0.01	0	0	0.08	0	0	0.33	0	0
Mallard	0.13	0.02	0.02	1.51	0.30	0.22	7.40	1.24	0.30
Blue-winged Teal	0.01	0	0	0.10	0	0	0.50	0	0
Green-winged Teal	0.01	0	0	0.11	0	0	0.32	0	0
Wood Duck	0.01	0.01	0	0.13	0.13	0	0.65	0.15	0
Canada Goose	0.25	0	0.01	2.90	0	0.16	2.11	0	0.63
Snow Goose	0.16	0	0	1.89	0	0	0.18	0	0
Greater White-fronted Goose	0.16	0	0	1.93	0	0	0.36	0	0
Great Blue Heron	<0.01	0.01	0.01	0.04	0.11	0.11	0.36	0.48	0.93
American Coot	0	0	<0.01	0	0	0.05	0	0	0.15
Upland Sandpiper	0.03	0.06	<0.01	0.31	0.88	0.02	2.00	3.66	0.18
American Golden-Plover	0.15	0	0	1.76	0	0	1.15	0	0
Killdeer	0.16	0.25	0.19	1.86	3.50	2.28	10.92	14.69	4.93
Pectoral Sandpiper	0.02	0.02	<0.01	0.27	0.23	0.04	0.33	0.19	0.15
Unidentified Sandpiper	0.06	0	0	0.69	0	0	0.18	0	0
Greater Yellowlegs	<0.01	0	0	0.04	0	0	0.32	0	0
Common Snipe	0.03	<0.01	<0.01	0.35	0.02	0.01	1.68	0.17	0.12
Unidentified Shorebird	0.01	0	<0.01	0.06	0	0.02	0.18	0	0.15
Gray Partridge	0.01	0.04	0.12	0.07	0.56	1.48	0.30	0.48	1.04
Ring-necked Pheasant	0.02	0.04	0.01	0.19	0.54	0.17	1.33	1.32	1.32
Rock Dove	0.04	0.02	0.09	0.46	0.22	1.09	1.29	0.81	1.67
Mourning Dove	0.14	0.35	0.33	1.70	4.92	4.01	7.98	16.98	11.44
Northern Harrier	0.02	0.01	0.02	0.18	0.17	0.29	1.41	1.22	2.40
Sharp-shinned Hawk	0	0	<0.01	0	0	0.02	0	0	0.15
Cooper's Hawk	0	<0.01	<0.01	0	0.02	0.02	0	0.15	0.18
Broad-winged Hawk	<0.01	0	0	0.04	0	0	0.30	0	0
Red-tailed Hawk	0.03	0.02	0.05	0.31	0.29	0.60	2.61	1.60	4.87
Swainson's Hawk	<0.01	<0.01	0.01	0.02	0.02	0.10	0.18	0.17	0.48
Rough-legged Hawk	0	0	<0.01	0	0	0.02	0	0	0.15
Bald Eagle	0	0	<0.01	0	0	0.04	0	0	0.15
Merlin	<0.01	0	0	0.02	0	0	0.18	0	0
American Kestrel	0.01	0.03	0.02	0.14	0.36	0.24	1.21	1.74	1.28
Great Horned Owl	0.01	<0.01	<0.01	0.08	0.02	0.04	0.64	0.15	0.30

^aMean Abundance = Mean number observed / 5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Reference Area								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Belted Kingfisher	0	0.01	0	0	0.11	0	0	0.61	0
Yellow-billed Cuckoo	0	<0.01	0	0	0.03	0	0	0.19	0
Black-billed Cuckoo	0	<0.01	0	0	0.05	0	0	0.33	0
Hairy Woodpecker	<0.01	<0.01	<0.01	0.04	0.05	0.04	0.36	0.33	0.30
Downy Woodpecker	0.01	0.01	0.01	0.17	0.17	0.08	1.25	0.91	0.63
Red-headed Woodpecker	0.02	0.05	0.03	0.29	0.64	0.35	2.14	3.57	2.39
Red-Bellied Woodpecker	<0.01	0	0	0.02	0	0	0.15	0	0
Northern Flicker	0.05	0.07	0.07	0.60	1.03	0.90	4.23	6.66	5.19
Unidentified Woodpecker	0	0	<0.01	0	0	0.03	0	0	0.27
Common Nighthawk	0	0	<0.01	0	0	0.01	0	0	0.12
Chimney Swift	<0.01	0	0.01	0.02	0	0.09	0.18	0	0.36
Eastern Kingbird	0.04	0.16	0.05	0.42	2.28	0.56	2.93	10.94	2.04
Western Kingbird	0.01	0.02	<0.01	0.06	0.27	0.04	0.50	1.14	0.18
Eastern Phoebe	<0.01	0	0.01	0.04	0	0.09	0.18	0	0.63
Least Flycatcher	0.01	<0.01	0	0.09	0.05	0	0.76	0.17	0
Unidentified Flycatcher	0.01	0	<0.01	0.09	0	0.02	0.80	0	0.15
Horned Lark	0.29	0.20	0.82	3.39	2.75	9.89	10.84	9.81	9.71
American Pipit	<0.01	0	0.01	0.02	0	0.09	0.18	0	0.15
Blue Jay	0.07	0.06	0.25	0.85	0.78	2.95	4.21	4.23	7.87
American Crow	0.08	0.07	0.11	0.99	1.02	1.28	3.85	2.52	4.14
White-breasted Nuthatch	0.01	<0.01	<0.01	0.06	0.04	0.02	0.54	0.31	0.15
European Starling	0.34	0.39	0.88	3.95	5.42	10.50	11.06	12.17	10.99
Scarlet Tanager	<0.01	0	0	0.04	0	0	0.32	0	0
Bobolink	0.08	0.20	0.03	0.97	2.78	0.38	3.34	8.08	0.87
Brown-headed Cowbird	0.69	0.43	0.01	8.13	5.98	0.11	24.10	19.10	0.29
Yellow-headed Blackbird	0.02	0	0.01	0.18	0	0.09	1.14	0	0.18
Red-winged Blackbird	1.16	0.72	0.43	13.57	10.07	5.17	34.17	28.82	3.51
Rusty Blackbird	0	0	0.03	0	0	0.35	0	0	0.33
Brewer's Blackbird	<0.01	0	0.04	0.04	0	0.48	0.36	0	0.62
Unidentified Blackbird	0.01	0.21	0.62	0.09	2.92	7.38	0.63	2.40	2.57
Western Meadowlark	0.35	0.32	0.24	4.13	4.39	2.91	25.40	22.88	10.89
Orchard Oriole	0	0.01	0	0	0.08	0	0	0.30	0
Baltimore Oriole	0.01	<0.01	0	0.09	0.02	0	0.79	0.15	0
Common Grackle	0.34	0.44	0.14	4.05	6.08	1.72	10.40	13.02	1.97
House Finch	<0.01	0	<0.01	0.05	0	0.04	0.45	0	0.15
American Goldfinch	0.08	0.24	0.10	0.93	3.35	1.24	4.10	13.58	4.56
Pine Siskin	0	0	0.02	0	0	0.29	0	0	0.22
Common Redpoll	0.10	0	0.03	1.13	0	0.32	0.36	0	0.18

^aMean Abundance = Mean number observed /5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Lapland Longspur	1.42	0	0.65	16.61	0	7.82	3.20	0	2.70
Vesper Sparrow	0.18	0.16	0.24	2.05	2.17	2.82	13.29	11.19	8.06
Savannah Sparrow	0.18	0.18	0.14	2.08	2.55	1.64	13.29	12.45	4.82
Grasshopper Sparrow	0.01	0.07	0.01	0.15	1.01	0.16	1.27	5.71	0.52
Harris' Sparrow	0.02	0	0.09	0.26	0	1.06	0.51	0	1.52
White-throated Sparrow	0.01	0	0.02	0.12	0	0.23	1.05	0	0.52
American Tree Sparrow	0.05	0.01	0.13	0.62	0.15	1.54	1.65	0.30	2.56
Chipping Sparrow	0.01	0.01	0.01	0.09	0.17	0.06	0.40	0.79	0.18
Clay-colored Sparrow	0.03	0.05	0.01	0.34	0.63	0.11	1.81	2.20	0.65
Swamp Sparrow	0	0	<0.01	0	0	0.02	0	0	0.18
Lark Sparrow	<0.01	<0.01	0	0.02	0.02	0	0.18	0.15	0
Dark-eyed Junco	0	0	0.09	0	0	1.04	0	0	2.14
Song Sparrow	0.19	0.21	0.11	2.19	2.96	1.33	13.17	18.41	5.83
Lincoln's Sparrow	0.01	0	0.03	0.17	0	0.31	1.12	0	1.25
White-crowned Sparrow	0.01	0	<0.01	0.07	0	0.06	0.33	0	0.33
Unidentified Sparrow	0.03	0.09	0.21	0.31	1.31	2.57	2.48	5.92	10.70
Dickcissel	0.01	0.09	<0.01	0.11	1.23	0.03	0.32	7.46	0.12
Rose-breasted Grosbeak	<0.01	0	0	0.04	0	0	0.15	0	0
Blue Grosbeak	0	<0.01	0	0	0.02	0	0	0.15	0
Cliff Swallow	0.04	0.44	0.06	0.49	6.06	0.71	1.66	8.05	0.97
Northern Rough-winged Swallow	0	<0.01	0	0	0.05	0	0	0.34	0
Barn Swallow	0.47	0.79	0.61	5.57	11.01	7.28	11.26	28.44	14.03
Tree Swallow	0.09	0.05	<0.01	1.01	0.73	0.04	4.46	3.01	0.18
Bank Swallow	0	0.01	0.02	0	0.14	0.25	0	0.74	0.51
Unidentified Swallow	0	0.01	0	0	0.17	0	0	0.74	0
Warbling Vireo	<0.01	0	0	0.04	0	0	0.32	0	0
Red-eyed Vireo	<0.01	0	0	0.04	0	0	0.18	0	0
American Redstart	0.01	0	0	0.11	0	0	0.32	0	0
Black-throated Green Warbler	<0.01	0	0	0.04	0	0	0.32	0	0
Canada Warbler	<0.01	0	0	0.04	0	0	0.32	0	0
Connecticut Warbler	<0.01	0	0	0.04	0	0	0.32	0	0
Common Yellowthroat	0.02	0.08	<0.01	0.23	1.05	0.04	1.33	7.29	0.36
Tennessee Warbler	<0.01	0	<0.01	0.04	0	0.02	0.36	0	0.18
Palm Warbler	0.01	0	<0.01	0.13	0	0.02	0.50	0	0.15
Yellow Warbler	0.02	0.01	0	0.24	0.09	0	1.91	0.62	0
Yellow-rumped Warbler	0.02	0	0.02	0.25	0	0.26	1.00	0	0.48
Unidentified Warbler	0	0	<0.01	0	0	0.01	0	0	0.12
House Sparrow	0.06	0.09	0.12	0.69	1.21	1.39	2.57	2.84	2.15

^aMean Abundance = Mean number observed /5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix B (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during point counts on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a

Species	Reference Area			Reference Area			Reference Area		
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Gray Catbird	0	<0.01	<0.01	0	0.07	0.04	0	0.49	0.35
Brown Thrasher	0.02	0.02	0	0.21	0.33	0	1.13	1.94	0
House Wren	0.04	0.08	0.02	0.44	1.11	0.25	3.40	7.09	1.16
Sedge Wren	0.01	0.03	0.01	0.06	0.45	0.06	0.51	2.94	0.54
Ruby-crowned Kinglet	0.01	0	<0.01	0.15	0	0.01	1.30	0	0.12
Black-capped Chickadee	0.01	0.01	0.03	0.12	0.15	0.42	0.82	0.90	1.76
Hermit Thrush	<0.01	0	0	0.02	0	0	0.18	0	0
Gray-cheeked Thrush	<0.01	0	0	0.03	0	0	0.22	0	0
Unidentified Thrush	<0.01	0	0	0.04	0	0	0.32	0	0
American Robin	0.23	0.16	0.24	2.69	2.20	2.89	12.75	10.69	7.59
Eastern Bluebird	0.01	0.02	0.06	0.08	0.22	0.71	0.68	1.13	2.26
Northern Shrike	0	0	<0.01	0	0	0.02	0	0	0.18
Unidentified Bird	0	<0.01	0	0	0.02	0	0	0.15	0
TOTAL	8.52	7.20	8.34	100.00	100.00	100.00	--	--	--

^aMean Abundance = Mean number observed /5-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded

Appendix C. Total number of bird observations during surveys on Buffalo Ridge, March through November, 1996-1999.

Point Count Surveys - Avian Groups

Avian Group	# Flocks	# Individuals
Blackbirds	5361	23,450
Chickadees and Nuthatches	73	111
Corvids	693	1699
Doves	1396	3386
Finches	662	1297
Flycatchers	306	463
Longspurs	1264	10,958
Other	1272	151
Raptors	585	662
Shorebirds	1044	2206
Sparrow/sparrowlikes	7070	11,236
Swallows	2475	6337
Tanagers and Orioles	21	26
Thrushes	838	1635
Upland Gamebirds	177	520
Vireos and Warblers	505	599
Waterbirds	169	2286
Waterfowl	546	2513
Woodpeckers	439	531
Wrens	575	661
TOTAL	25,471	70,727

RLB Surveys - Avian Groups

Avian Group	# Flocks	# Individuals
Waterbirds	346	8715
Waterfowl	681	6519
Shorebirds	142	875
Upland Gamebirds	27	57
Raptors	1723	1970
Corvids	624	1895
Other	3	4
TOTAL	3546	20,035

Appendix C (Continued). Total number of bird observations during surveys on Buffalo Ridge, March through November, 1996-1999.

Point Count Surveys - Species

Species	No. Observed				TOTAL
	1996	1997	1998	1999	
Pied-billed Grebe	1	0	1	0	2
Ring-billed Gull	8	35	8	4	55
Franklin's Gull	95	542	21	341	999
Unidentified Gull	0	200	4	0	204
Bonaparte's Gull	0	0	2	0	2
Black Tern	24	3	0	3	30
Forster's Tern	9	0	0	0	9
Unidentified Tern	1	0	0	0	1
Double-crested Cormorant	537	63	114	65	779
American White Pelican	7	0	0	17	24
Common Merganser	4	2	0	4	10
Red-breasted Merganser	0	4	0	0	4
Mallard	187	341	187	187	902
Gadwall	2	5	4	0	11
Northern Shoveler	6	0	0	0	6
American Wigeon	0	0	13	0	13
Blue-winged Teal	37	9	13	22	81
Green-winged Teal	3	1	6	2	12
Northern Pintail	3	7	35	9	54
Bufflehead	0	0	0	9	9
Wood Duck	7	6	26	10	49
Greater Scaup	0	0	24	0	24
Lesser Scaup	21	0	1	9	31
Common Goldeneye	0	2	3	0	5
Unidentified Scaup	0	10	0	0	10
Unidentified Duck	3	0	0	0	3
Canada Goose	127	443	178	161	909
Snow Goose	50	90	138	0	278
Greater White-fronted Goose	0	92	0	0	92
Great Blue Heron	6	11	16	18	51
Green Heron	1	1	0	0	2
Cattle Egret	1	0	0	0	1
American Bittern	0	1	0	0	1
Great Egret	0	0	0	1	1
American Coot	2	3	5	0	10
Sandhill Crane	125	0	0	0	125
Upland Sandpiper	24	65	34	15	138
American Golden-Plover	11	88	36	60	195
Spotted Sandpiper	0	0	0	1	1
Killdeer	217	399	354	555	1525
Buff-breasted Sandpiper	3	0	0	0	3

Appendix C (Continued). Total number of bird observations during surveys on Buffalo Ridge, March through November, 1996-1999.

Species	No. Observed				TOTAL
	1996	1997	1998	1999	
Least Sandpiper	4	0	0	3	7
Pectoral Sandpiper	60	25	4	46	135
White-rumped Sandpiper	0	4	0	0	4
Solitary Sandpiper	0	0	2	3	5
Unidentified Sandpiper	16	80	0	0	96
Greater Yellowlegs	14	4	1	2	21
Lesser Yellowlegs	2	0	4	0	6
Common Snipe	19	17	10	8	54
Unidentified Shorebird	4	0	6	6	16
Gray Partridge	4	13	30	209	256
Ring-necked Pheasant	83	35	43	103	264
Rock Dove	259	518	296	278	1351
Mourning Dove	242	508	619	666	2035
Northern Harrier	31	73	32	33	169
Sharp-shinned Hawk	1	6	5	0	12
Cooper's Hawk	2	2	1	1	6
Broad-winged Hawk	0	1	2	0	3
Red-tailed Hawk	56	87	43	59	245
Northern Goshawk	0	0	0	1	1
Swainson's Hawk	12	10	9	10	41
Rough-legged Hawk	1	0	1	0	2
Unidentified Buteo	0	2	0	0	2
Ferruginous Hawk	0	0	1	0	1
Golden Eagle	1	0	0	0	1
Bald Eagle	0	2	0	0	2
Osprey	1	1	0	0	2
Merlin	0	0	1	1	2
American Kestrel	33	21	38	36	128
Peregrine Falcon	0	1	0	0	1
Great Horned Owl	12	4	20	7	43
Short-eared Owl	0	1	0	0	1
Ruby-throated Hummingbird	1	0	0	1	2
Belted Kingfisher	0	9	4	5	18
Yellow-billed Cuckoo	0	0	0	2	2
Black-billed Cuckoo	0	0	1	1	2
Hairy Woodpecker	3	8	2	3	16
Downy Woodpecker	2	13	18	25	58
Red-headed Woodpecker	21	33	48	22	124
Red-Bellied Woodpecker	0	2	0	1	3
Northern Flicker	69	84	82	85	320
Unidentified Woodpecker	9	1	0	0	10

Appendix C (Continued). Total number of bird observations during surveys on Buffalo Ridge, March through November, 1996-1999.

Species	No. Observed				TOTAL
	1996	1997	1998	1999	
Common Nighthawk	1	0	0	0	1
Chimney Swift	3	6	5	5	19
Eastern Kingbird	63	85	84	138	370
Western Kingbird	14	8	15	15	52
Eastern Phoebe	0	1	10	3	14
Say's Phoebe	1	0	0	0	1
Eastern Wood-pewee	0	2	1	0	3
Least Flycatcher	4	2	1	3	10
Unidentified Flycatcher	3	5	1	4	13
Horned Lark	253	3127	547	550	4477
American Pipit	3	37	26	9	75
Blue Jay	193	124	208	184	709
American Crow	158	286	267	279	990
White-breasted Nuthatch	0	1	1	5	7
European Starling	675	1850	1223	1645	5393
Scarlet Tanager	1	0	0	0	1
Bobolink	355	480	195	292	1322
Brown-headed Cowbird	269	475	604	833	2181
Yellow-headed Blackbird	57	18	0	47	122
Red-winged Blackbird	1466	2580	1867	1899	7812
Rusty Blackbird	0	8	5	16	29
Brewer's Blackbird	11	3	34	57	105
Unidentified Blackbird	906	771	1929	1426	5032
Western Meadowlark	363	469	597	656	2085
Orchard Oriole	1	0	4	2	7
Baltimore Oriole	3	5	2	8	18
Common Grackle	220	806	688	1062	2776
House Finch	6	9	18	15	48
American Goldfinch	223	321	229	302	1075
Pine Siskin	2	0	22	0	24
Common Redpoll	0	15	127	0	142
Snow Bunting	0	15	0	3	18
Lapland Longspur	1793	2191	1237	1163	6384
Smith's Longspur	0	2	0	0	2
Unidentified Longspur	2	0	0	0	2
Vesper Sparrow	113	280	373	421	1187
Savannah Sparrow	447	658	289	174	1568
Grasshopper Sparrow	134	169	99	87	489
LeConte's Sparrow	4	8	0	0	12
Harris' Sparrow	4	51	66	20	141
White-throated Sparrow	12	8	40	5	65

Appendix C (Continued). Total number of bird observations during surveys on Buffalo Ridge, March through November, 1996-1999.

Species	No. Observed				TOTAL
	1996	1997	1998	1999	
American Tree Sparrow	159	118	79	42	398
Chipping Sparrow	6	23	27	32	88
Clay-colored Sparrow	52	124	64	52	292
Field Sparrow	3	2	4	6	15
Swamp Sparrow	0	8	1	0	9
Lark Sparrow	0	0	1	1	2
Dark-eyed Junco	14	53	74	18	159
Song Sparrow	187	252	231	242	912
Lincoln's Sparrow	8	45	7	1	61
White-crowned Sparrow	0	3	2	6	11
Unidentified Sparrow	259	506	325	238	1328
Dickcissel	171	62	53	112	398
Indigo Bunting	1	2	0	0	3
Rose-breasted Grosbeak	1	0	0	4	5
Blue Grosbeak	0	0	1	2	3
Purple Martin	3	3	0	0	6
Cliff Swallow	147	210	298	190	845
Northern Rough-winged Swallow	0	9	0	27	36
Barn Swallow	795	1744	1216	1090	4845
Tree Swallow	48	54	36	91	229
Bank Swallow	12	125	50	99	286
Unidentified Swallow	2	62	2	4	70
Blue-headed Vireo	0	0	0	1	1
Warbling Vireo	2	1	0	0	3
Black-and-white Warbler	0	0	0	1	1
Red-eyed Vireo	0	4	2	0	6
American Redstart	3	2	0	2	7
Blackpoll Warbler	1	0	0	0	1
Black-throated Green Warbler	1	0	0	0	1
Canada Warbler	1	0	0	0	1
Connecticut Warbler	1	0	0	0	1
Common Yellowthroat	95	155	74	84	408
Orange-crowned Warbler	2	2	0	3	7
Tennessee Warbler	1	2	5	1	9
Palm Warbler	4	0	2	4	10
Yellow Warbler	7	7	11	13	38
Yellow-rumped Warbler	24	27	26	17	94
Nashville Warbler	0	1	0	0	1
Mourning Warbler	0	0	0	1	1
Magnolia Warbler	0	0	0	1	1
Unidentified Warbler	5	0	1	2	8

Appendix C (Continued). Total number of bird observations during surveys on Buffalo Ridge, March through November, 1996-1999.

Species	No. Observed				TOTAL
	1996	1997	1998	1999	
House Sparrow	99	273	130	192	694
Gray Catbird	7	4	2	5	18
Brown Thrasher	18	7	24	32	81
House Wren	34	66	41	75	216
Sedge Wren	162	176	57	50	445
Ruby-crowned Kinglet	7	6	0	7	20
Black-capped Chickadee	5	21	22	35	83
Hermit Thrush	1	0	0	1	2
Gray-cheeked Thrush	0	1	0	0	1
Swainson's Thrush	0	1	0	1	2
Unidentified Thrush	1	0	0	0	1
American Robin	182	418	421	398	1419
Eastern Bluebird	14	9	42	37	102
Northern Shrike	1	1	0	5	7
Brown Creeper	0	0	0	1	1
Loggerhead Shrike	0	0	0	2	2
Cedar Waxwing	15	43	18	2	78
Unidentified Bird	0	5	34	7	46
TOTAL	12,808	23,501	16,743	17,675	70,727

Appendix C (Continued). Total number of bird observations during surveys on Buffalo Ridge, March through November, 1996-1999.

Species	RLB Surveys - Species				Total
	1996	1997	Number Observed		
			1998	1999	
Pied-billed Grebe	0	0	3	1	4
Ring-billed Gull	214	25	99	26	364
Franklin's Gull	769	2111	1668	2058	6606
Herring Gull	0	2	0	0	2
Unidentified Gull	0	15	29	0	44
Bonaparte's Gull	0	0	0	18	18
Black Tern	10	4	0	27	41
Common Loon	0	0	0	1	1
Forster's Tern	1	4	0	0	5
Common Tern	0	0	1	0	1
Unidentified Tern	1	0	0	0	1
Double-crested Cormorant	298	230	382	136	1046
American White Pelican	152	16	90	170	428
Common Merganser	0	4	2	0	6
Red-breasted Merganser	0	4	0	0	4
Canvasback	0	0	0	14	14
Mallard	397	412	484	518	1811
Gadwall	0	2	7	22	31
Northern Shoveler	4	0	1	20	25
American Wigeon	0	0	1	0	1
Ring-necked Duck	0	4	13	0	17
Blue-winged Teal	32	20	37	48	137
Northern Pintail	7	27	120	28	182
Wood Duck	9	6	50	16	81
Lesser Scaup	0	0	0	3	3
Unidentified Scaup	0	0	0	55	55
Unidentified Duck	58	107	35	45	245
Canada Goose	159	699	775	562	2195
Snow Goose	149	526	566	230	1471
Greater White-fronted Goose	0	28	196	0	224
Great Blue Heron	13	34	26	43	116
Great Egret	0	8	0	7	15
Green Heron	0	0	0	2	2
American Coot	0	11	3	3	17
Sandhill Crane	20	0	1	0	21
Upland Sandpiper	5	22	17	15	59
American Golden-Plover	0	15	79	3	97
Black-bellied Plover	40	0	0	0	40
Pectoral Sandpiper	20	28	37	145	230
Solitary Sandpiper	1	0	0	0	1
Unidentified Sandpiper	63	51	12	26	152

Appendix C (Continued). Total number of bird observations during surveys on Buffalo Ridge, March through November, 1996-1999.

Species	RLB Surveys - Species				Total
	1996	1997	1998	1999	
Greater Yellowlegs	10	7	18	9	44
Lesser Yellowlegs	4	2	0	7	13
Yellowlegs	0	0	11	0	11
Common Snipe	0	7	3	11	21
Unidentified Dowitcher	2	0	5	5	12
Unidentified Shorebird	0	44	76	87	207
Gray Partridge	14	5	4	4	27
Ring-necked Pheasant	3	9	11	3	26
Wild Turkey	0	0	0	4	4
Northern Harrier	68	152	117	115	452
Sharp-shinned Hawk	6	6	10	8	30
Cooper's Hawk	4	2	4	7	17
Broad-winged Hawk	4	1	2	0	7
Unidentified Accipiter	1	0	0	0	1
Turkey Vulture	3	1	1	2	7
Red-tailed Hawk	150	203	249	299	901
Northern Goshawk	0	0	0	1	1
Swainson's Hawk	45	92	57	59	253
Rough-legged Hawk	0	3	3	1	7
Unidentified Buteo	0	0	1	0	1
Ferruginous Hawk	0	1	1	1	3
Unidentified Hawk	0	4	0	0	4
Golden Eagle	0	0	0	1	1
Bald Eagle	0	6	3	5	14
Osprey	0	0	1	1	2
American Kestrel	27	54	72	58	211
Peregrine Falcon	0	2	0	0	2
Great Horned Owl	1	3	5	11	20
Unidentified Raptor	0	23	1	0	24
Belted Kingfisher	1	0	1	0	2
Common Nighthawk	0	0	0	2	2
American Crow	362	605	507	421	1895
TOTAL	3127	5647	5897	5364	20,035

Appendix D. List of bird species grouped for analysis on the Buffalo Ridge study area

Point Count Survey Data

Waterbirds

American Bittern
Great Blue Heron
Green Heron
Great Egret
Cattle Egret
Sandhill Crane
Pied-billed Grebe
Ring-billed Gull
Franklin's Gull
Bonaparte's Gull
Unidentified Gull
Black Tern
Forster's Tern
Unidentified Tern
Double-crested Cormorant
American White Pelican

Shorebirds

Upland Sandpiper
American Golden-Plover
Killdeer
Buff-breasted Sandpiper
Least Sandpiper
Spotted Sandpiper
Solitary Sandpiper
Pectoral Sandpiper
White-rumped Sandpiper
Unidentified Sandpiper
Greater Yellowlegs
Lesser Yellowlegs
Common Snipe
Unidentified Shorebird

Upland game birds

Gray Partridge
Ring-necked Pheasant

Doves

Rock Dove
Mourning Dove

Waterfowl

American Coot
Red-breasted Merganser
Common Merganser
Bufflehead
Mallard
Gadwall
Blue-winged Teal
Green-winged Teal
Northern Shoveler
American Wigeon
Northern Pintail
Wood Duck
Lesser Scaup
Greater Scaup
Unidentified Scaup
Common Goldeneye
Unidentified Duck
Canada Goose
Snow Goose
Greater White-fronted Goose

Raptors

Northern Harrier
Sharp-shinned Hawk
Cooper's Hawk
Northern Goshawk
Red-tailed Hawk
Swainson's Hawk
Ferruginous Hawk
Rough-legged Hawk
Broad-winged Hawk
Unidentified Buteo
Golden Eagle
Bald Eagle
Osprey
Merlin
American Kestrel
Peregrine Falcon
Great Horned Owl
Short-eared Owl

Appendix D (Continued). List of bird species grouped for analysis on the Buffalo Ridge study area

Point Count Survey Data

Woodpeckers

Hairy Woodpecker
Downy Woodpecker
Red-headed Woodpecker
Red-bellied Woodpecker
Northern Flicker
Unidentified Woodpecker

Flycatchers

Eastern Kingbird
Western Kingbird
Say's Phoebe
Eastern Phoebe
Eastern Wood Pewee
Least Flycatcher
Unidentified Flycatcher

Finches

House Finch
American Goldfinch
Common Redpoll
Pine Siskin
Rose-breasted Grosbeak
Blue Grosbeak

Blackbirds

Common Grackle
European Starling
Brown-headed Cowbird
Rusty Blackbird
Yellow-headed Blackbird
Red-winged Blackbird
Brewer's Blackbird
Unid./Mixed Blackbirds

Corvids

Blue Jay
American Crow

Swallows

Common Nighthawk
Chimney Swift
Purple Martin
Cliff Swallow
Barn Swallow
Tree Swallow
Northern Rough-winged Swallow
Bank Swallow
Unidentified Swallow

Sparrows and sparrowlikes

Bobolink
Western Meadowlark
Vesper Sparrow
Lark Sparrow
Savannah Sparrow
Grasshopper Sparrow
LeConte's Sparrow
Harris' Sparrow
White-throated Sparrow
White-crowned Sparrow
American Tree Sparrow
Chipping Sparrow
Clay-colored Sparrow
Field Sparrow
Swamp Sparrow
Dark-eyed Junco
Song Sparrow
Lincoln's Sparrow
Dickcissel
House Sparrow
Unidentified Sparrow

Chickadees and Nuthatches

White-breasted Nuthatch
Black-capped Chickadee
Brown Creeper
Ruby-crowned Kinglet

Appendix D (Continued). List of bird species grouped for analysis on the Buffalo Ridge study area

Point Count Survey Data

Tanagers and Orioles

Scarlet Tanager

Orchard Oriole

Baltimore Oriole

Thrushes and thrushlike

Gray Catbird

Brown Thrasher

Hermit Thrush

Gray-cheeked Thrush

Swainson's Thrush

Unidentified Thrush

American Robin

Eastern Bluebird

Northern Shrike

Loggerhead Shrike

Longspurs & Larks

Horned Lark

American Pipit

Lapland Longspur

Smith's Longspur

Unidentified Longspur

Snow Bunting

Other

Belted Kingfisher

Ruby-throated Hummingbird

Cedar Waxwing

Indigo Bunting

Black-billed Cuckoo

Yellow-billed Cuckoo

Wrens

House Wren

Sedge Wren

Vireos and Warblers

Warbling Vireo

Blue-headed Vireo

Red-eyed Vireo

American Redstart

Blackpoll Warbler

Black-throated Green Warbler

Black-and-white Warbler

Canada Warbler

Connecticut Warbler

Mourning Warbler

Common Yellowthroat

Orange-crowned Warbler

Magnolia Warbler

Tennessee Warbler

Palm Warbler

Yellow Warbler

Yellow-rumped Warbler

Nashville Warbler

Unidentified Warbler

Appendix D (Continued). List of bird species grouped for analysis on the Buffalo Ridge study area

Point Count Survey Data

Grassland Breeders

Upland Sandpiper

Common Snipe

Gray Partridge

Ring-necked Pheasant

Northern Harrier

Short-eared Owl

Horned Lark

Bobolink

Brown-headed Cowbird

Brewer's Blackbird

Western Meadowlark

Vesper Sparrow

Savannah Sparrow

Grasshopper Sparrow

LeConte's Sparrow

Clay-colored Sparrow

Field Sparrow

Lark Sparrow

Dickcissel

Common Yellowthroat

Sedge Wren

Loggerhead Shrike

Appendix D (Continued). List of bird species grouped for analysis on the Buffalo Ridge study area

RLB Survey Data^a

Waterbirds

Common Loon
Pied-billed Grebe
Double-crested Cormorant
American White Pelican
Great Blue Heron
Green Heron
Great Egret
Sandhill Crane
Ring-billed Gull
Herring Gull
Franklin's Gull
Bonaparte's Gull
Unidentified Gull
Black Tern
Forster's Tern
Common Tern
Unidentified Tern

Shorebirds

American Golden Plover
Black-bellied Plover
Upland Sandpiper
Pectoral Sandpiper
Solitary Sandpiper
Unidentified Sandpiper
Greater Yellowlegs
Lesser Yellowlegs
Unidentified Yellowlegs
Unidentified Dowitcher
Common Snipe
Unidentified Shorebird

Upland game birds

Wild Turkey
Ring-necked Pheasant
Gray Partridge

Corvids

American Crow

Waterfowl

American Coot
Canada Goose
Snow Goose
Greater White-fronted Goose
Mallard
Northern Pintail
Gadwall
American Wigeon
Northern Shoveler
Blue-winged Teal
Wood Duck
Canvasback
Lesser Scaup
Unidentified Scaup
Ring-necked Duck
Common Merganser
Red-breasted Merganser
Unidentified Duck

Raptors

Northern Harrier
Sharp-shinned Hawk
Cooper's Hawk
Northern Goshawk
Unidentified Accipiter
Red-tailed Hawk
Swainson's Hawk
Broad-winged Hawk
Rough-legged Hawk
Ferruginous Hawk
Unidentified Buteo
American Kestrel
Peregrine Falcon
Osprey
Bald Eagle
Golden Eagle
Turkey Vulture
Great Horned Owl
Unidentified Hawk
Unidentified Raptor

^a Two species (belted kingfisher, common nighthawk) not included in RLB groups due to very low sample sizes (4 individuals combined).

Appendix E. Mean abundance, percent composition, and percent frequency of occurrence of birds observed during RLB surveys on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a.

Species	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Pied-billed Grebe	0.01	<0.01	0	0.05	0.05	0	0.50	0.25	0
Ring-billed Gull	0.13	<0.01	0.66	0.82	0.05	2.90	4.15	0.25	1.24
Franklin's Gull	1.06	0.84	11.59	6.67	15.94	50.75	3.27	0.96	9.32
Herring Gull	0	<0.01	<0.01	0	0.04	0.01	0	0.21	0.18
Unidentified Gull	0.02	<0.01	0.07	0.14	0.05	0.30	0.75	0.25	0.77
Bonaparte's Gull	0.04	0	0	0.24	0	0	0.21	0	0
Black Tern	0.11	0	0	0.70	0	0	1.40	0	0
Common Loon	0	0	<0.01	0	0	0.01	0	0	0.18
Forster's Tern	0.02	0	0	0.10	0	0	0.98	0	0
Common Tern	<0.01	0	0	0.02	0	0	0.25	0	0
Unidentified Tern	<0.01	0	0	0.03	0	0	0.42	0	0
Double-crested Cormorant	0.55	0.02	1.64	3.45	0.45	7.17	2.94	1.29	3.63
American White Pelican	0.16	0.21	0.53	1.02	4.06	2.33	1.75	1.06	2.40
Common Merganser	0.02	0	0	0.11	0	0	0.81	0	0
Red-breasted Merganser	0.01	0	0	0.08	0	0	0.31	0	0
Canvasback	0.04	0	0	0.22	0	0	0.25	0	0
Mallard	2.04	0.80	1.40	12.88	15.20	6.12	38.54	15.14	5.98
Gadwall	0.04	0.02	0.01	0.25	0.29	0.06	1.44	0.75	0.36
Northern Shoveler	0.06	0	0.01	0.35	0	0.04	1.79	0	0.25
American Wigeon	<0.01	0	0	0.02	0	0	0.25	0	0
Ring-necked Duck	0.05	0	0	0.28	0	0	0.81	0	0
Blue-winged Teal	0.11	0.02	0.18	0.70	0.39	0.78	3.29	0.99	2.30
Northern Pintail	0.39	0.02	0.05	2.46	0.42	0.23	4.29	0.81	0.43
Wood Duck	0.12	0.03	0.03	0.78	0.61	0.15	2.94	0.56	0.60
Lesser Scaup	0.01	0	0	0.04	0	0	0.21	0	0
Unidentified Scaup	0.14	0	0	0.87	0	0	0.25	0	0
Unidentified Duck	0.16	0	0.36	1.01	0	1.56	1.38	0	0.98
Canada Goose	2.73	0.28	1.87	17.21	5.28	8.18	12.73	2.33	7.10
Snow Goose	2.96	0	0.32	18.66	0	1.40	2.04	0	0.71
Greater White-fronted Goose	0.49	0	0.06	3.09	0	0.26	0.25	0	0.21
Great Blue Heron	0.05	0.12	0.09	0.32	2.23	0.38	3.38	8.48	6.00
Great Egret	0.01	0	0.02	0.04	0	0.10	0.71	0	1.04
Green Heron	<0.01	<0.01	0	0.02	0.05	0	0.25	0.25	0
American Coot	0.04	0	0	0.26	0	0	1.17	0	0
Sandhill Crane	<0.01	0	0.04	0.02	0	0.16	0.25	0	0.36
Upland Sandpiper	0.04	0.10	0.01	0.23	1.83	0.03	2.42	5.05	0.36
Black-bellied Plover	0.17	0	0	1.05	0	0	0.83	0	0

^a Mean abundance = Mean number observed /60-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded.

Appendix E (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during RLB surveys on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a.

Species	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Pectoral Sandpiper	0.37	0.14	0.03	2.33	2.72	0.14	2.29	1.31	0.39
American Golden-Plover	0.23	0	0	1.44	0	0	1.27	0	0
Solitary Sandpiper	0	0	<0.01	0	0	0.01	0	0	0.21
Unidentified Sandpiper	0.41	0.06	0.01	2.56	1.11	0.05	1.65	0.96	0.25
Greater Yellowlegs	0.08	0.01	0.03	0.52	0.19	0.12	2.04	0.50	1.04
Lesser Yellowlegs	0.02	0	0.01	0.14	0	0.04	1.23	0	0.21
Unidentified Yellowlegs	0.01	0	0.02	0.03	0	0.10	0.25	0	0.50
Common Snipe	0.02	0	0.02	0.13	0	0.10	0.77	0	1.13
Unidentified Dowitcher	0.01	0	0.02	0.08	0	0.07	0.25	0	0.46
Unidentified Shorebird	0.27	0.12	0.07	1.67	2.33	0.32	1.48	1.73	0.77
Gray Partridge	0.03	0	0.03	0.21	0	0.12	1.67	0	0.36
Ring-necked Pheasant	0.03	0.01	0.02	0.21	0.12	0.09	1.54	0.64	1.68
Wild Turkey	0.01	0	0	0.05	0	0	0.21	0	0
Northern Harrier	0.45	0.35	0.26	2.86	6.71	1.12	30.04	19.93	20.57
Sharp-shinned Hawk	0.02	0	0.05	0.09	0	0.23	1.50	0	4.88
Cooper's Hawk	0.02	0	0.02	0.11	0	0.10	1.71	0	2.31
Broad-winged Hawk	<0.01	0	0.01	0.01	0	0.05	0.21	0	0.63
Northern Goshawk	0	0	<0.01	0	0	0.01	0	0	0.25
Unidentified Accipiter	0	0	<0.01	0	0	0.01	0	0	0.21
Turkey Vulture	0.02	<0.01	0.01	0.09	0.05	0.02	1.50	0.25	0.25
Red-tailed Hawk	0.60	0.54	0.89	3.75	10.22	3.91	32.29	33.43	44.96
Swainson's Hawk	0.15	0.25	0.19	0.93	4.68	0.83	10.94	16.35	10.45
Rough-legged Hawk	0.01	0	0.01	0.04	0	0.04	0.71	0	0.83
Unidentified Buteo	0	0	<0.01	0	0	0.01	0	0	0.21
Ferruginous Hawk	<0.01	<0.01	<0.01	0.02	0.05	0.01	0.25	0.25	0.25
Unidentified Hawk	0	0.01	0	0	0.17	0	0	0.88	0
Bald Eagle	0.02	0	0.01	0.13	0	0.04	1.63	0	1.02
Golden Eagle	<0.01	0	0	0.01	0	0	0.25	0	0
Osprey	<0.01	0	<0.01	0.02	0	0.01	0.25	0	0.25
American Kestrel	0.14	0.16	0.17	0.91	3.04	0.77	12.13	11.57	13.02
Peregrine Falcon	0	0	<0.01	0	0	0.02	0	0	0.42
Great Horned Owl	0.02	0.01	0.01	0.15	0.23	0.03	2.00	0.96	0.79
Unidentified Raptor	<0.01	0.02	0.03	0.01	0.42	0.11	0.21	1.58	1.79
Belted Kingfisher	0.01	0	0	0.04	0	0	0.67	0	0
Common Nighthawk	0	0	<0.01	0	0	0.02	0	0	0.18
American Crow	1.16	1.10	1.96	7.29	21.02	8.58	38.71	29.66	32.96
TOTAL	15.87	5.24	22.84	100.00	100.00	100.00	--	--	--

^a Mean abundance = Mean number observed /60-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded.

Appendix E (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during RLB surveys on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a.

Species	Phase I			% Composition			% Freq. Of Occurrence		
	Mean Abundance			Spr	Sum	Fall	Spr	Sum	Fall
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Ring-billed Gull	0	0	0.16	0	0	0.77	0	0	1.79
Franklin's Gull	0	0	7.52	0	0	35.89	0	0	10.71
Unidentified Gull	0.15	0	0.54	0.72	0	2.59	2.50	0	2.08
Double-crested Cormorant	0.92	0.05	3.51	4.38	2.05	16.77	4.17	2.50	10.12
American White Pelican	0.88	0.33	1.58	4.18	13.31	7.56	8.33	2.50	9.82
Mallard	0.72	0.20	3.80	3.45	8.19	18.14	25.83	11.25	3.87
Northern Pintail	0.04	0	0	0.20	0	0	4.17	0	0
Canada Goose	5.19	0	0.77	24.83	0	3.68	23.33	0	6.25
Snow Goose	9.23	0	0	44.14	0	0	6.25	0	0
Great Blue Heron	0.04	0.09	0.08	0.20	3.58	0.37	4.17	6.67	5.65
Great Egret	0.02	0	0	0.10	0	0	2.08	0	0
Upland Sandpiper	0	0	0.04	0	0	0.17	0	0	1.79
Pectoral Sandpiper	0.90	0	0	4.28	0	0	4.17	0	0
Unidentified Sandpiper	0	0.10	0	0	4.10	0	0	2.50	0
Unidentified Shorebird	0.67	0.30	0	3.19	12.29	0	2.08	2.50	0
Gray Partridge	0.13	0	0	0.64	0	0	6.67	0	0
Northern Harrier	0.32	0.10	0.06	1.53	3.92	0.28	27.92	9.58	5.95
Sharp-shinned Hawk	0.02	0	0.06	0.10	0	0.28	2.08	0	5.95
Cooper's Hawk	0.02	0	0.02	0.10	0	0.10	2.08	0	2.08
Broad-winged Hawk	0	0	0.10	0	0	0.50	0	0	4.17
Red-tailed Hawk	0.65	0.26	1.06	3.09	10.58	5.06	27.08	21.67	44.05
Swainson's Hawk	0.17	0.43	0.26	0.80	17.41	1.25	14.58	30.00	12.80
Rough-legged Hawk	0	0	0.02	0	0	0.10	0	0	2.08
Bald Eagle	0.02	0	0.02	0.10	0	0.09	2.08	0	1.79
American Kestrel	0.20	0.20	0.20	0.96	8.36	0.94	15.42	12.08	17.86
American Crow	0.63	0.40	1.15	3.01	16.21	5.47	33.75	16.67	23.21
TOTAL	20.91	2.44	20.95	100.00	100.00	100.00	--	--	--

^a Mean abundance = Mean number observed /60-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded.

Appendix E (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during RLB surveys on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a.

Species	Phase II								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Pied-billed Grebe	0.02	0.01	0	0.10	0.11	0	0.83	0.83	0
Ring-billed Gull	0.24	0	2.15	1.42	0	7.80	5.35	0	3.55
Franklin's Gull	2.49	1.04	14.51	14.48	14.22	52.51	5.14	2.50	11.65
Herring Gull	0	0	0.01	0	0	0.02	0	0	0.60
Unidentified Gull	0.02	0.01	0.04	0.10	0.11	0.13	0.83	0.83	1.19
Black Tern	0.10	0	0	0.61	0	0	1.74	0	0
Common Loon	0	0	0.01	0	0	0.02	0	0	0.60
Forster's Tern	0.04	0	0	0.23	0	0	1.88	0	0
Unidentified Tern	0.01	0	0	0.08	0	0	1.39	0	0
Double-crested Cormorant	0.44	0	1.04	2.54	0	3.75	2.92	0	2.98
American White Pelican	0.10	0.39	0.44	0.61	5.35	1.61	1.39	1.67	2.72
Common Merganser	0.03	0	0	0.18	0	0	1.04	0	0
Red-breasted Merganser	0.04	0	0	0.24	0	0	1.04	0	0
Mallard	3.08	2.22	2.11	17.89	30.25	7.65	56.25	26.46	12.28
Gadwall	0.11	0.04	0.05	0.62	0.57	0.17	3.96	1.67	1.19
Northern Shoveler	0.11	0	0	0.65	0	0	3.47	0	0
American Wigeon	0.01	0	0	0.05	0	0	0.83	0	0
Ring-necked Duck	0.05	0	0	0.29	0	0	1.88	0	0
Blue-winged Teal	0.17	0.06	0.53	0.99	0.85	1.91	6.04	2.71	7.06
Northern Pintail	0.26	0.07	0	1.53	0.99	0	8.89	2.71	0
Wood Duck	0.31	0.08	0.04	1.82	1.02	0.14	6.25	0.83	1.29
Lesser Scaup	0.02	0	0	0.12	0	0	0.69	0	0
Unidentified Duck	0.13	0	0.04	0.77	0	0.15	2.08	0	0.60
Canada Goose	3.97	0.60	2.89	23.10	8.19	10.45	12.71	4.17	8.61
Snow Goose	1.40	0	0.18	8.16	0	0.65	1.39	0	0.60
Great Blue Heron	0.09	0.15	0.18	0.55	2.08	0.66	5.14	10.21	11.51
Great Egret	0.01	0	0.05	0.05	0	0.19	0.83	0	1.79
American Coot	0.02	0	0	0.12	0	0	1.39	0	0
Upland Sandpiper	0.06	0.07	0	0.33	0.94	0	3.26	4.38	0
American Golden-Plover	0.24	0	0	1.37	0	0	0.69	0	0
Black-bellied Plover	0.14	0	0	0.81	0	0	1.39	0	0
Pectoral Sandpiper	0.20	0.09	0.01	1.18	1.25	0.04	1.53	1.67	0.60
Solitary Sandpiper	0	0	0.01	0	0	0.02	0	0	0.69
Unidentified Sandpiper	0	0.13	0.04	0	1.82	0.15	0	1.67	0.83
Greater Yellowlegs	0.14	0.03	0.09	0.81	0.45	0.34	2.78	1.67	3.45
Lesser Yellowlegs	0	0	0.03	0	0	0.10	0	0	0.69
Unidentified Yellowlegs	0	0	0.03	0	0	0.12	0	0	0.83

^a Mean abundance = Mean number observed /60-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded.

Appendix E (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during RLB surveys on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a.

Species	Phase II								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Common Snipe	0.01	0	0.05	0.06	0	0.19	1.04	0	2.38
Unidentified Dowitcher	0	0	0.06	0	0	0.20	0	0	1.53
Unidentified Shorebird	0.21	0.01	0.05	1.20	0.11	0.19	1.53	0.83	1.19
Gray Partridge	0	0	0.02	0	0	0.06	0	0	0.60
Ring-necked Pheasant	0.08	0.01	0.03	0.44	0.11	0.12	3.47	0.83	1.98
Northern Harrier	0.56	0.65	0.28	3.26	8.93	1.01	31.53	32.29	24.11
Sharp-shinned Hawk	0.03	0	0.03	0.20	0	0.12	3.47	0	3.21
Cooper's Hawk	0.04	0	0.03	0.24	0	0.09	4.17	0	2.62
Broad-winged Hawk	0.01	0	0	0.04	0	0	0.69	0	0
Unidentified Accipiter	0	0	0.01	0	0	0.02	0	0	0.69
Turkey Vulture	0	0.01	0	0	0.11	0	0	0.83	0
Red-tailed Hawk	0.66	0.52	1.01	3.84	7.05	3.66	32.92	36.25	50.10
Swainson's Hawk	0.18	0.22	0.10	1.07	2.99	0.36	14.03	14.38	5.83
Rough-legged Hawk	0.01	0	0	0.05	0	0	0.83	0	0
Ferruginous Hawk	0	0.01	0	0	0.11	0	0	0.83	0
Unidentified Hawk	0	0.01	0	0	0.11	0	0	0.83	0
Bald Eagle	0.02	0	0.01	0.09	0	0.05	1.53	0	1.43
Golden Eagle	0	0	0.01	0	0	0.02	0.69	0	0
Osprey	0	0	0.01	0	0	0.03	0	0	0.83
American Kestrel	0.11	0.06	0.11	0.65	0.82	0.42	11.11	6.04	9.70
Great Horned Owl	0.08	0.03	0.02	0.47	0.45	0.06	6.67	2.50	1.79
Unidentified Raptor	0.01	0.03	0.03	0.04	0.34	0.11	0.69	2.50	1.79
Belted Kingfisher	0.01	0	0	0.05	0	0	0.83	0	0
Common Nighthawk	0	0	0.01	0	0	0.04	0	0	0.60
American Crow	1.12	0.78	1.28	6.51	10.63	4.63	33.26	22.92	25.54
TOTAL	17.19	7.33	27.63	100.00	100.00	100.00	--	--	--

^a Mean abundance = Mean number observed /60-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded.

Appendix E (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during RLB surveys on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a.

Species	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Pied-billed Grebe	0.01	0	0	0.07	0	0	0.83	0	0
Ring-billed Gull	0.07	0.01	0	0.61	0.14	0	3.40	0.83	0
Franklin's Gull	0.09	1.74	12.24	0.85	29.45	53.12	1.04	0.69	9.01
Unidentified Gull	0.01	0	0.01	0.07	0	0.06	0.83	0	0.69
Black Tern	0.01	0	0	0.07	0	0	0.83	0	0
Common Tern	0.01	0	0	0.07	0	0	0.83	0	0
Double-crested Cormorant	0.54	0.01	1.52	4.88	0.12	6.58	1.67	0.69	3.61
American White Pelican	0.12	0.21	0.22	1.05	3.52	0.96	0.83	1.04	0.60
Common Merganser	0.01	0	0	0.07	0	0	0.83	0	0
Mallard	1.46	0.20	0.85	13.15	3.40	3.68	30.90	10.69	3.27
Gadwall	0	0.01	0	0	0.14	0	0	0.83	0
Northern Shoveler	0.08	0	0.03	0.68	0	0.14	2.50	0	0.83
Blue-winged Teal	0.02	0	0	0.15	0	0	0.83	0	0
Northern Pintail	0.01	0	0.01	0.07	0	0.05	0.83	0	0.60
Wood Duck	0.04	0.03	0	0.36	0.53	0	1.88	1.04	0
Unidentified Duck	0.07	0	0.97	0.60	0	4.22	0.83	0	1.98
Canada Goose	0.65	0.16	1.23	5.87	2.70	5.36	13.54	2.08	6.23
Snow Goose	3.71	0	0.54	33.41	0	2.32	0.83	0	0.60
Greater White-fronted Goose	0	0	0.19	0	0	0.84	0	0	0.69
Great Blue Heron	0.04	0.13	0.04	0.36	2.16	0.15	3.19	9.31	2.82
Great Egret	0.01	0	0.03	0.07	0	0.11	0.83	0	1.67
Green Heron	0.01	0.01	0	0.07	0.14	0	0.83	0.83	0
American Coot	0.12	0	0	1.05	0	0	2.50	0	0
Sandhill Crane	0	0	0.12	0	0	0.52	0	0	1.19
Upland Sandpiper	0	0.06	0.01	0	0.94	0.05	0	3.89	0.60
American Golden-Plover	0.14	0	0	1.28	0	0	1.67	0	0
Black-bellied Plover	0.42	0	0	3.75	0	0	1.39	0	0
Pectoral Sandpiper	0.34	0.23	0	3.10	3.94	0	2.36	1.88	0
Unidentified Sandpiper	0	0.03	0	0	0.47	0	0	0.69	0
Greater Yellowlegs	0.09	0	0	0.83	0	0	1.67	0	0
Lesser Yellowlegs	0.04	0	0	0.35	0	0	1.53	0	0
Common Snipe	0	0	0.02	0	0	0.09	0	0	1.39
Unidentified Dowitcher	0.04	0	0	0.38	0	0	0.83	0	0
Unidentified Shorebird	0.15	0.06	0.06	1.31	1.06	0.27	1.04	1.39	0.69
Gray Partridge	0.03	0	0.07	0.30	0	0.31	1.67	0	0.60
Ring-necked Pheasant	0.03	0.01	0.02	0.23	0.12	0.10	0.83	0.69	2.22
Northern Harrier	0.47	0.32	0.31	4.25	5.36	1.33	31.81	17.78	21.55
Sharp-shinned Hawk	0	0	0.07	0	0	0.30	0	0	5.97

^a Mean abundance = Mean number observed /60-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded.

Appendix E (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during RLB surveys on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a.

Species	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Cooper's Hawk	0	0	0.02	0	0	0.07	0	0	1.53
Broad-winged Hawk	0	0	0.01	0	0	0.03	0	0	0.69
Turkey Vulture	0.02	0	0	0.20	0	0	2.22	0	0
Red-tailed Hawk	0.59	0.39	0.74	5.34	6.58	3.23	37.43	28.54	38.77
Swainson's Hawk	0.14	0.19	0.31	1.23	3.22	1.36	7.50	15.28	15.44
Rough-legged Hawk	0.01	0	0.01	0.06	0	0.03	0.69	0	0.69
Unidentified Buteo	0	0	0.01	0	0	0.03	0	0	0.69
Unidentified Hawk	0	0.01	0	0	0.12	0	0	0.69	0
Bald Eagle	0.03	0	0.01	0.29	0	0.03	1.53	0	0.69
American Kestrel	0.16	0.31	0.17	1.44	5.18	0.74	13.89	20.90	10.77
Peregrine Falcon	0	0	0.01	0	0	0.03	0	0	0.69
Unidentified Raptor	0	0.03	0.03	0	0.59	0.12	0	2.08	1.39
American Crow	1.34	1.78	3.18	12.04	30.14	13.78	54.17	46.46	46.41
TOTAL	11.10	5.92	23.05	100.00	100.00	100.00	--	--	--

^a Mean abundance = Mean number observed /60-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded.

Appendix E (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during RLB surveys on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a.

Species	Reference Area								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Ring-billed Gull	0.12	0	0	0.68	0	0	5.07	0	0
Franklin's Gull	0.95	0	9.37	5.37	0	50.74	4.72	0	6.85
Herring Gull	0	0.01	0	0	0.20	0	0	0.69	0
Bonaparte's Gull	0.13	0	0	0.71	0	0	0.69	0	0
Black Tern	0.26	0	0	1.46	0	0	2.08	0	0
Forster's Tern	0.01	0	0	0.08	0	0	1.39	0	0
Double-crested Cormorant	0.54	0.06	1.74	3.05	1.63	9.40	3.82	2.78	2.12
American White Pelican	0.03	0	0.58	0.14	0	3.13	0.83	0	1.43
Common Merganser	0.02	0	0	0.09	0	0	0.83	0	0
Canvasback	0.12	0	0	0.66	0	0	0.83	0	0
Mallard	2.04	0.17	0.43	11.56	5.00	2.34	32.71	9.55	3.08
Gadwall	0.03	0	0	0.14	0	0	0.83	0	0
Ring-necked Duck	0.10	0	0	0.57	0	0	0.83	0	0
Blue-winged Teal	0.18	0.01	0.07	1.04	0.18	0.35	4.10	0.60	0.60
Northern Pintail	1.01	0	0.17	5.75	0	0.90	3.19	0	0.83
Wood Duck	0.06	0	0.08	0.33	0	0.41	1.67	0	0.69
Unidentified Scaup	0.46	0	0	2.60	0	0	0.83	0	0
Unidentified Duck	0.33	0	0.17	1.89	0	0.94	1.67	0	0.69
Canada Goose	2.75	0.16	1.85	15.59	4.77	10.00	8.40	1.53	6.75
Snow Goose	1.68	0	0.35	9.54	0	1.90	2.50	0	1.19
Greater White-fronted Goose	1.63	0	0	9.26	0	0	0.83	0	0
Great Blue Heron	0.02	0.08	0.05	0.13	2.37	0.25	1.53	6.53	3.79
Sandhill Crane	0.01	0	0	0.05	0	0	0.83	0	0
Upland Sandpiper	0.07	0.20	0	0.37	5.75	0	4.79	8.58	0
American Golden-Plover	0.39	0	0	2.18	0	0	1.88	0	0
Pectoral Sandpiper	0.39	0.15	0.10	2.20	4.40	0.53	2.36	0.83	0.69
Unidentified Sandpiper	1.35	0	0	7.67	0	0	5.49	0	0
Greater Yellowlegs	0.05	0	0	0.27	0	0	2.36	0	0
Lesser Yellowlegs	0.04	0	0	0.20	0	0	2.57	0	0
Yellowlegs	0.02	0	0.04	0.09	0	0.23	0.83	0	0.83
Common Snipe	0.06	0	0	0.32	0	0	1.53	0	0
Unidentified Shorebird	0.31	0.24	0.13	1.75	6.95	0.68	1.67	2.72	0.69
Gray Partridge	0.03	0	0	0.19	0	0	1.67	0	0
Ring-necked Pheasant	0.01	0.01	0.01	0.05	0.18	0.08	0.83	0.60	1.39
Wild Turkey	0.03	0	0	0.16	0	0	0.69	0	0
Northern Harrier	0.37	0.17	0.25	2.12	4.97	1.33	27.50	13.17	20.93
Sharp-shinned Hawk	0.01	0	0.06	0.05	0	0.31	0.83	0	5.08
Cooper's Hawk	0.01	0	0.03	0.05	0	0.15	0.83	0	2.86

^a Mean abundance = Mean number observed /60-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded.

Appendix E (Continued). Mean abundance, percent composition, and percent frequency of occurrence of birds observed during RLB surveys on the Buffalo Ridge study area, 15 March to 15 November, 1996-1999^a.

Species	Reference Area								
	Mean Abundance			% Composition			% Freq. Of Occurrence		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Northern Goshawk	0	0	0.01	0	0	0.04	0	0	0.69
Turkey Vulture	0.03	0	0.02	0.16	0	0.09	2.78	0	0.83
Red-tailed Hawk	0.52	0.79	0.86	2.93	23.26	4.68	28.26	39.40	46.33
Swainson's Hawk	0.12	0.27	0.13	0.68	7.82	0.71	10.07	14.83	9.29
Rough-legged Hawk	0.01	0	0.01	0.05	0	0.08	0.83	0	1.39
Ferruginous Hawk	0.01	0	0.01	0.05	0	0.04	0.83	0	0.83
Unidentified Hawk	0	0.01	0	0	0.41	0	0	1.39	0
Bald Eagle	0.02	0	0.01	0.09	0	0.04	1.67	0	0.69
Osprey	0.01	0	0	0.05	0	0	0.83	0	0
American Kestrel	0.14	0.10	0.23	0.81	2.84	1.26	10.28	7.58	16.96
Peregrine Falcon	0	0	0.01	0	0	0.04	0	0	0.69
Great Horned Owl	0	0.01	0.01	0	0.20	0.04	0	0.69	0.83
Unidentified Raptor	0	0.01	0.03	0	0.41	0.15	0	0.69	2.78
Belted Kingfisher	0.01	0	0	0.08	0	0	1.39	0	0
American Crow	1.19	0.98	1.69	6.76	28.68	9.15	30.35	23.95	30.20
TOTAL	17.64	3.41	18.47	100.00	100.00	100.00	--	--	--

^a Mean abundance = Mean number observed /60-minute count; Percent Composition = percent of all observations comprised of species *i*; Frequency of Occurrence = percent of all surveys where species *i* was recorded.

Appendix F. Flock size characteristics of birds observed on Buffalo Ridge^a.

Point Count Surveys				
Species	# flocks	mean	min	max
Pied-billed Grebe	2	1.0	1	1
Ring-billed Gull	19	2.9	1	11
Franklin's Gull	56	17.8	1	180
Unidentified Gull	6	34.0	1	125
Bonaparte's Gull	1	2.0	2	2
Black Tern	5	6.0	1	21
Forster's Tern	1	9.0	9	9
Unidentified Tern	1	1.0	1	1
Double-crested Cormorant	25	31.2	1	250
American White Pelican	2	12.0	7	17
Common Merganser	5	2.0	2	2
Red-breasted Merganser	1	4.0	4	4
Mallard	348	2.6	1	70
Gadwall	6	1.8	1	2
Northern Shoveler	1	6.0	6	6
American Wigeon	3	4.3	2	9
Blue-winged Teal	28	2.9	1	9
Green-winged Teal	4	3.0	1	6
Northern Pintail	14	3.9	1	23
Bufflehead	1	9.0	9	9
Wood Duck	15	3.3	1	20
Greater Scaup	1	24.0	24	24
Lesser Scaup	5	6.2	1	21
Common Goldeneye	2	2.5	2	3
Unidentified Scaup	1	10.0	10	10
Unidentified Duck	1	3.0	3	3
Canada Goose	100	9.1	1	75
Snow Goose	4	69.5	50	90
Greater White-fronted Goose	2	46.0	22	70
Great Blue Heron	44	1.2	1	3
Green Heron	2	1.0	1	1
Cattle Egret	1	1.0	1	1
American Bittern	1	1.0	1	1
Great Egret	1	1.0	1	1
American Coot	4	2.5	1	4
Sandhill Crane	2	62.5	50	75
Upland Sandpiper	109	1.3	1	5
American Golden-Plover	11	17.7	4	45
Spotted Sandpiper	1	1.0	1	1
Killdeer	828	1.8	1	30
Buff-breasted Sandpiper	1	3.0	3	3

^a mean flock size = number of birds per observed flock; min = number of birds in smallest flock observed; max = number of birds in largest flock observed.

Appendix F (Continued). Flock size characteristics of birds observed on Buffalo Ridge^a.

Point Count Surveys				
Species	# flocks	mean	min	max
Least Sandpiper	2	3.5	3	4
Pectoral Sandpiper	15	9.0	2	45
White-rumped Sandpiper	1	4.0	4	4
Solitary Sandpiper	2	2.5	2	3
Unidentified Sandpiper	13	7.4	1	33
Greater Yellowlegs	9	2.3	1	8
Lesser Yellowlegs	3	2.0	2	2
Common Snipe	41	1.3	1	4
Unidentified Shorebird	8	2.0	1	4
Gray Partridge	40	6.4	1	17
Ring-necked Pheasant	137	1.9	1	11
Rock Dove	394	3.4	1	67
Mourning Dove	1002	2.0	1	29
Northern Harrier	157	1.1	1	3
Sharp-shinned Hawk	10	1.2	1	2
Cooper's Hawk	6	1.0	1	1
Broad-winged Hawk	3	1.0	1	1
Red-tailed Hawk	231	1.1	1	3
Northern Goshawk	1	1.0	1	1
Swainson's Hawk	36	1.1	1	2
Rough-legged Hawk	2	1.0	1	1
Unidentified Buteo	2	1.0	1	1
Ferruginous Hawk	1	1.0	1	1
Golden Eagle	1	1.0	1	1
Bald Eagle	1	2.0	2	2
Osprey	2	1.0	1	1
Merlin	2	1.0	1	1
American Kestrel	94	1.4	1	18
Peregrine Falcon	1	1.0	1	1
Great Horned Owl	34	1.3	1	3
Short-eared Owl	1	1.0	1	1
Ruby-throated Hummingbird	2	1.0	1	1
Belted Kingfisher	17	1.1	1	2
Yellow-billed Cuckoo	2	1.0	1	1
Black-billed Cuckoo	2	1.0	1	1
Hairy Woodpecker	16	1.0	1	1
Downy Woodpecker	52	1.1	1	2
Red-headed Woodpecker	102	1.2	1	3
Red-Bellied Woodpecker	3	1.0	1	1
Northern Flicker	256	1.3	1	5
Unidentified Woodpecker	10	1.0	1	1

^a mean flock size = number of birds per observed flock; min = number of birds in smallest flock observed; max = number of birds in largest flock observed.

Appendix F (Continued). Flock size characteristics of birds observed on Buffalo Ridge^a.

Point Count Surveys				
Species	# flocks	mean	min	max
Common Nighthawk	1	1.0	1	1
Chimney Swift	14	1.4	1	2
Eastern Kingbird	237	1.6	1	7
Western Kingbird	34	1.5	1	4
Eastern Phoebe	10	1.4	1	2
Say's Phoebe	1	1.0	1	1
Eastern Wood-pewee	2	1.5	1	2
Least Flycatcher	9	1.1	1	2
Unidentified Flycatcher	13	1.0	1	1
Horned Lark	1049	4.3	1	173
American Pipit	15	5.0	1	12
Blue Jay	305	2.3	1	45
American Crow	388	2.6	1	27
White-breasted Nuthatch	7	1.0	1	1
European Starling	937	5.8	1	250
Scarlet Tanager	1	1.0	1	1
Bobolink	593	2.2	1	40
Brown-headed Cowbird	1073	2.0	1	30
Yellow-headed Blackbird	22	5.5	1	50
Red-winged Blackbird	2120	3.7	1	300
Rusty Blackbird	6	4.8	1	12
Brewer's Blackbird	29	3.6	1	11
Unidentified Blackbird	284	17.7	1	400
Western Meadowlark	1551	1.3	1	12
Orchard Oriole	5	1.4	1	3
Baltimore Oriole	15	1.2	1	2
Common Grackle	890	3.1	1	90
House Finch	24	2.0	1	4
American Goldfinch	622	1.7	1	9
Pine Siskin	3	8.0	2	11
Common Redpoll	6	23.7	2	50
Snow Bunting	6	3.0	1	5
Lapland Longspur	191	33.4	1	750
Smith's Longspur	2	1.0	1	1
Unidentified Longspur	1	2.0	2	2
Vesper Sparrow	875	1.4	1	15
Savannah Sparrow	1134	1.4	1	21
Grasshopper Sparrow	394	1.2	1	4
LeConte's Sparrow	10	1.2	1	2
Harris' Sparrow	35	4.0	1	12
White-throated Sparrow	26	2.5	1	9

^a mean flock size = number of birds per observed flock; min = number of birds in smallest flock observed; max = number of birds in largest flock observed.

Appendix F (Continued). Flock size characteristics of birds observed on Buffalo Ridge^a.

Point Count Surveys				
Species	# flocks	mean	min	max
American Tree Sparrow	74	5.4	1	34
Chipping Sparrow	49	1.8	1	7
Clay-colored Sparrow	222	1.3	1	12
Field Sparrow	10	1.5	1	3
Swamp Sparrow	5	1.8	1	3
Lark Sparrow	2	1.0	1	1
Dark-eyed Junco	42	3.8	1	12
Song Sparrow	743	1.2	1	6
Lincoln's Sparrow	40	1.5	1	4
White-crowned Sparrow	6	1.8	1	3
Unidentified Sparrow	709	1.9	1	85
Dickcissel	333	1.2	1	9
Indigo Bunting	3	1.0	1	1
Rose-breasted Grosbeak	4	1.3	1	2
Blue Grosbeak	3	1.0	1	1
Purple Martin	5	1.2	1	2
Cliff Swallow	273	3.1	1	37
Northern Rough-winged Swallow	14	2.6	1	6
Barn Swallow	1939	2.5	1	90
Tree Swallow	119	1.9	1	8
Bank Swallow	72	4.0	1	21
Unidentified Swallow	37	1.9	1	10
Blue-headed Vireo	1	1.0	1	1
Warbling Vireo	3	1.0	1	1
Black-and-white Warbler	1	1.0	1	1
Red-eyed Vireo	4	1.5	1	2
American Redstart	4	1.8	1	3
Blackpoll Warbler	1	1.0	1	1
Black-throated Green Warbler	1	1.0	1	1
Canada Warbler	1	1.0	1	1
Connecticut Warbler	1	1.0	1	1
Common Yellowthroat	380	1.1	1	3
Orange-crowned Warbler	7	1.0	1	1
Tennessee Warbler	8	1.1	1	2
Palm Warbler	7	1.4	1	3
Yellow Warbler	36	1.1	1	2
Yellow-rumped Warbler	40	2.4	1	11
Nashville Warbler	1	1.0	1	1
Mourning Warbler	1	1.0	1	1
Magnolia Warbler	1	1.0	1	1

^a mean flock size = number of birds per observed flock; min = number of birds in smallest flock observed; max = number of birds in largest flock observed.

Appendix F (Continued). Flock size characteristics of birds observed on Buffalo Ridge^a.

Point Count Surveys				
Species	# flocks	mean	min	max
Unidentified Warbler	7	1.1	1	2
House Sparrow	217	3.2	1	30
Gray Catbird	17	1.1	1	2
Brown Thrasher	65	1.2	1	3
House Wren	191	1.1	1	4
Sedge Wren	384	1.2	1	3
Ruby-crowned Kinglet	12	1.7	1	5
Black-capped Chickadee	53	1.6	1	3
Hermit Thrush	2	1.0	1	1
Gray-cheeked Thrush	1	1.0	1	1
Swainson's Thrush	2	1.0	1	1
Unidentified Thrush	1	1.0	1	1
American Robin	701	2.0	1	27
Eastern Bluebird	43	2.4	1	8
Northern Shrike	4	1.8	1	4
Brown Creeper	1	1.0	1	1
Loggerhead Shrike	2	1.0	1	1
Cedar Waxwing	10	7.8	1	17
Unidentified Bird	11	4.2	1	30

^a mean flock size = number of birds per observed flock; min = number of birds in smallest flock observed; max = number of birds in largest flock observed.

Appendix F (Continued). Flock size characteristics of birds observed on Buffalo Ridge^a.

RLB Surveys				
Species	# flocks	mean	min	max
Pied-billed Grebe	3	1.3	1	2
Ring-billed Gull	26	14.0	1	150
Franklin's Gull	114	57.9	1	550
Herring Gull	2	1.0	1	1
Unidentified Gull	8	5.5	1	26
Bonaparte's Gull	1	18.0	18	18
Black Tern	6	6.8	1	17
Common Loon	1	1.0	1	1
Forster's Tern	3	1.7	1	3
Common Tern	1	1.0	1	1
Unidentified Tern	1	1.0	1	1
Double-crested Cormorant	43	24.3	1	200
American White Pelican	25	17.1	1	72
Common Merganser	3	2.0	1	3
Red-breasted Merganser	1	4.0	4	4
Canvasback	1	14.0	14	14
Mallard	359	5.0	1	200
Gadwall	17	1.8	1	3
Northern Shoveler	9	2.8	1	5
American Wigeon	1	1.0	1	1
Ring-necked Duck	3	5.7	1	12
Blue-winged Teal	41	3.3	1	11
Northern Pintail	31	5.9	1	28
Wood Duck	24	3.4	1	13
Lesser Scaup	1	3.0	3	3
Unidentified Scaup	1	55.0	55	55
Unidentified Duck	12	20.4	2	56
Canada Goose	146	15.0	1	150
Snow Goose	20	73.6	1	200
Greater White-fronted Goose	4	56.0	6	100
Great Blue Heron	94	1.2	1	5
Great Egret	13	1.2	1	2
Green Heron	2	1.0	1	1
American Coot	7	2.4	1	7
Sandhill Crane	3	7.0	1	13
Upland Sandpiper	43	1.4	1	5
American Golden-Plover	5	19.4	1	45
Black-bellied Plover	2	20.0	10	30
Pectoral Sandpiper	20	11.5	1	34
Solitary Sandpiper	1	1.0	1	1
Unidentified Sandpiper	16	9.5	1	20

^a mean flock size = number of birds per observed flock; min = number of birds in smallest flock observed; max = number of birds in largest flock observed.

Appendix F (Continued). Flock size characteristics of birds observed on Buffalo Ridge^a.

RLB Surveys				
Species	no. flocks	mean	min	max
Greater Yellowlegs	15	2.9	1	8
Lesser Yellowlegs	7	1.9	1	3
Yellowlegs	3	3.7	2	5
Common Snipe	10	2.1	1	7
Unidentified Dowitcher	4	3.0	1	5
Unidentified Shorebird	20	10.4	1	32
Gray Partridge	8	3.4	2	12
Ring-necked Pheasant	18	1.4	1	5
Wild Turkey	1	4.0	4	4
Northern Harrier	428	1.1	1	3
Sharp-shinned Hawk	29	1.0	1	2
Cooper's Hawk	17	1.0	1	1
Broad-winged Hawk	5	1.4	1	2
Unidentified Accipiter	1	1.0	1	1
Turkey Vulture	6	1.2	1	2
Red-tailed Hawk	754	1.2	1	6
Northern Goshawk	1	1.0	1	1
Swainson's Hawk	215	1.2	1	10
Rough-legged Hawk	7	1.0	1	1
Unidentified Buteo	1	1.0	1	1
Ferruginous Hawk	3	1.0	1	1
Unidentified Hawk	4	1.0	1	1
Golden Eagle	1	1.0	1	1
Bald Eagle	14	1.0	1	1
Osprey	2	1.0	1	1
American Kestrel	188	1.1	1	2
Peregrine Falcon	2	1.0	1	1
Great Horned Owl	19	1.1	1	2
Unidentified Raptor	22	1.1	1	2
Belted Kingfisher	2	1.0	1	1
Common Nighthawk	1	2.0	2	2
American Crow	624	3.0	1	62

^a mean flock size = number of birds per observed flock; min = number of birds in smallest flock observed; max = number of birds in largest flock observed.

Appendix G. Percent of birds observed flying below, within, and above the rotor-swept height of turbines^a.

Species	Point Count Surveys							
	# Flocks	# Individ.	Turbine A			Turbine B		
			Below	Within	Above	Below	Within	Above
Ring-billed Gull	19	55	71	29	0	84	16	0
Franklin's Gull	56	999	14	86	10	39	53	1
Unidentified Gull	6	204	63	38	1175	4	48	0
Bonaparte's Gull	1	2	100	0	0	100	0	0
Black Tern	4	29	90	10	0	100	0	0
Forster's Tern	1	9	0	100	0	0	100	0
Unidentified Tern	1	1	0	0	0	0	50	0
Double-crested Cormorant	25	779	0	98	18	1	84	12
American White Pelican	2	24	0	9	22	0	29	71
Common Merganser	4	8	0	100	0	100	0	0
Mallard	312	779	57	41	20	66	17	14
Gadwall	6	9	56	44	0	56	44	0
Northern Shoveler	1	6	100	0	0	100	0	0
American Wigeon	3	13	69	31	0	100	0	0
Blue-winged Teal	21	62	53	47	0	89	11	0
Green-winged Teal	4	11	27	73	0	82	18	0
Northern Pintail	13	50	10	27	32	54	0	46
Bufflehead	1	9	0	100	0	100	0	0
Wood Duck	11	19	79	21	0	89	11	0
Greater Scaup	1	24	0	100	0	0	100	0
Lesser Scaup	4	10	70	30	0	80	20	0
Common Goldeneye	2	5	40	60	0	40	60	0
Canada Goose	92	787	36	61	31	41	36	18
Snow Goose	4	278	0	93	20	0	82	18
Greater White-fronted Goose	2	92	0	100	318	0	57	0
Great Blue Heron	42	49	62	38	4	88	8	0
Green Heron	1	1	0	100	0	100	0	0
American Bittern	1	1	100	0	0	100	0	0
Great Egret	1	1	0	100	0	0	100	0
American Coot	2	5	60	40	0	100	0	0
Sandhill Crane	2	125	0	100	0	0	100	0
Upland Sandpiper	83	110	67	33	6	77	18	0
American Golden-Plover	10	180	82	18	0	82	18	0
Spotted Sandpiper	1	1	100	0	0	100	0	0
Killdeer	572	1027	88	12	0	94	6	0
Pectoral Sandpiper	10	111	56	44	0	100	0	0
White-rumped Sandpiper	1	4	100	0	0	100	0	0
Solitary Sandpiper	1	2	0	100	0	100	0	0

^aTurbine A: 0 - 19.5m = below; 19.5 - 52.5m = within; >52.5m = above rotor-swept height

Turbine B: 0 - 26m = below; 26 - 74m = within; >74m = above rotor-swept height

Appendix G (Continued). Percent of birds observed flying below, within, and above the rotor-swept height of turbines^a.

Species	Point Count Surveys							
	# Flocks	# Individ.	Turbine A			Turbine B		
			Below	Within	Above	Below	Within	Above
Unidentified Sandpiper	12	93	99	1	0	99	1	0
Greater Yellowlegs	7	16	69	31	0	94	6	0
Lesser Yellowlegs	3	6	33	67	0	100	0	0
Common Snipe	34	41	47	47	2	78	20	2
Unidentified Shorebird	8	16	44	56	0	94	6	0
Gray Partridge	23	184	100	0	0	100	0	0
Ring-necked Pheasant	37	87	100	0	0	100	0	0
Rock Dove	384	1321	86	14	0	98	2	0
Mourning Dove	867	1708	96	4	0	99	1	0
Northern Harrier	156	168	92	8	1	94	5	1
Sharp-shinned Hawk	10	12	33	67	0	83	17	0
Cooper's Hawk	6	6	67	33	0	83	17	0
Broad-winged Hawk	3	3	3	3	3	67	0	33
Red-tailed Hawk	212	225	59	41	3	83	14	1
Northern Goshawk	1	1	100	0	0	100	0	0
Swainson's Hawk	34	39	27	50	20	53	28	9
Rough-legged Hawk	2	2	50	50	0	100	0	0
Unidentified Buteo	2	2	100	0	0	100	0	0
Ferruginous Hawk	1	1	100	0	0	100	0	0
Golden Eagle	1	1	0	100	0	0	100	0
Bald Eagle	1	2	0	100	0	100	0	0
Osprey	2	2	0	100	0	50	50	0
Merlin	2	2	100	0	0	100	0	0
American Kestrel	78	91	93	7	0	99	1	0
Peregrine Falcon	1	1	100	0	0	100	0	0
Great Horned Owl	18	21	100	0	0	100	0	0
Short-eared Owl	1	1	100	0	0	100	0	0
Ruby-throated Hummingbird	2	2	100	0	0	100	0	0
Belted Kingfisher	16	17	94	6	0	94	6	0
Black-billed Cuckoo	1	1	100	0	0	100	0	0
Hairy Woodpecker	5	5	100	0	0	100	0	0
Downy Woodpecker	13	14	100	0	0	100	0	0
Red-headed Woodpecker	66	73	93	7	0	99	1	0
Red-Bellied Woodpecker	1	1	100	0	0	100	0	0
Northern Flicker	167	213	97	3	0	99	1	0
Unidentified Woodpecker	1	1	0	0	0	0	50	0
Common Nighthawk	1	1	100	0	0	100	0	0
Chimney Swift	14	19	89	11	6	90	5	0

^aTurbine A: 0 - 19.5m = below; 19.5 - 52.5m = within; >52.5m = above rotor-swept height
Turbine B: 0 - 26m = below; 26 - 74m = within; >74m = above rotor-swept height

Appendix G (Continued). Percent of birds observed flying below, within, and above the rotor-swept height of turbines^a.

Species	Point Count Surveys							
	# Flocks	# Individ.	Turbine A			Turbine B		
			Below	Within	Above	Below	Within	Above
Eastern Kingbird	155	239	94	6	0	95	5	0
Western Kingbird	25	36	100	0	0	100	0	0
Eastern Phoebe	6	7	86	14	0	86	14	0
Say's Phoebe	1	1	0	100	0	0	100	0
Least Flycatcher	1	2	100	0	0	100	0	0
Unidentified Flycatcher	1	1	100	0	0	100	0	0
Horned Lark	771	3980	70	30	2	81	18	0
American Pipit	11	54	93	7	0	100	0	0
Blue Jay	191	562	73	27	0	87	13	0
American Crow	353	905	77	23	0	88	12	0
European Starling	771	4706	82	18	0	89	10	0
Bobolink	389	859	90	10	3	89	9	1
Brown-headed Cowbird	892	1747	95	5	0	99	1	0
Yellow-headed Blackbird	21	121	41	59	0	98	2	0
Red-winged Blackbird	1589	6596	81	19	9	85	7	8
Rusty Blackbird	5	25	100	0	0	100	0	0
Brewer's Blackbird	22	76	95	5	0	100	0	0
Unidentified Blackbird	279	4806	75	25	14	80	8	11
Western Meadowlark	542	902	99	1	0	100	0	0
Orchard Oriole	4	6	100	0	0	100	0	0
Baltimore Oriole	5	7	100	0	0	100	0	0
Common Grackle	796	2414	87	13	6	87	7	4
House Finch	20	42	93	7	0	93	7	0
American Goldfinch	522	885	92	8	0	98	2	0
Pine Siskin	3	24	54	46	0	100	0	0
Common Redpoll	4	101	53	47	0	55	45	0
Snow Bunting	6	18	94	6	0	94	6	0
Lapland Longspur	182	6342	68	32	0	87	13	0
Unidentified Longspur	1	2	0	100	0	100	0	0
Vesper Sparrow	174	316	100	0	0	100	0	0
Savannah Sparrow	122	209	100	0	0	100	0	0
Grasshopper Sparrow	10	12	100	0	0	100	0	0
Harris' Sparrow	3	13	100	0	0	100	0	0
American Tree Sparrow	7	58	100	0	0	100	0	0
Chipping Sparrow	6	12	100	0	0	100	0	0
Clay-colored Sparrow	11	15	100	0	0	100	0	0
Swamp Sparrow	1	3	100	0	0	100	0	0
Dark-eyed Junco	17	54	100	0	0	100	0	0

^aTurbine A: 0 - 19.5m = below; 19.5 - 52.5m = within; >52.5m = above rotor-swept height
Turbine B: 0 - 26m = below; 26 - 74m = within; >74m = above rotor-swept height

Appendix G (Continued). Percent of birds observed flying below, within, and above the rotor-swept height of turbines^a.

Species	Point Count Surveys							
	# Flocks	# Individ.	Turbine A			Turbine B		
			Below	Within	Above	Below	Within	Above
Song Sparrow	29	39	100	0	0	100	0	0
Lincoln's Sparrow	2	3	100	0	0	100	0	0
Unidentified Sparrow	622	1189	95	5	0	98	1	0
Dickcissel	39	60	88	12	0	100	0	0
Rose-breasted Grosbeak	1	1	100	0	0	100	0	0
Purple Martin	5	6	83	17	0	83	17	0
Cliff Swallow	272	842	91	9	0	95	5	0
Northern Rough-winged	13	30	100	0	0	100	0	0
Barn Swallow	1929	4741	98	2	0	98	2	0
Tree Swallow	116	223	87	13	0	92	8	0
Bank Swallow	71	284	91	9	0	96	4	0
Unidentified Swallow	37	70	69	31	0	87	13	0
American Redstart	1	2	100	0	0	100	0	0
Common Yellowthroat	12	14	100	0	0	100	0	0
Orange-crowned Warbler	1	1	100	0	0	100	0	0
Palm Warbler	1	1	100	0	0	100	0	0
Yellow Warbler	5	6	100	0	0	100	0	0
Yellow-rumped Warbler	20	37	95	5	0	100	0	0
Unidentified Warbler	4	5	60	40	0	100	0	0
House Sparrow	133	429	92	8	0	98	2	0
Brown Thrasher	19	25	100	0	0	100	0	0
House Wren	9	12	100	0	0	100	0	0
Sedge Wren	14	16	100	0	0	100	0	0
Ruby-crowned Kinglet	3	4	100	0	0	100	0	0
Black-capped Chickadee	6	10	100	0	0	100	0	0
American Robin	399	932	86	13	2	91	7	2
Eastern Bluebird	24	56	88	13	0	100	0	0
Northern Shrike	3	6	33	67	0	33	67	0
Loggerhead Shrike	2	2	100	0	0	100	0	0
Cedar Waxwing	10	78	85	15	0	97	3	0
Unidentified Bird	10	45	20	80	0	87	13	0
All Passerines	11,745	45,346	79.5	17.3	3.1	89.3	8.1	2.6
All Birds	15,247	55,607	75.7	20.1	4.2	85.7	11.3	3.0

^aTurbine A: 0 - 19.5m = below; 19.5 - 52.5m = within; >52.5m = above rotor-swept height

Turbine B: 0 - 26m = below; 26 - 74m = within; >74m = above rotor-swept height

Appendix G (Continued). Percent of birds observed flying below, within, and above the rotor-swept height of turbines^a.

Species	RLB Surveys							
	# Flocks	# Individ.	Turbine A			Turbine B		
			Below	Within	Above	Below	Within	Above
Ring-billed Gull	26	364	8	51	42	11	48	42
Franklin's Gull	111	6095	16	57	26	39	43	18
Herring Gull	2	2	50	50	0	100	0	0
Unidentified Gull	8	44	5	20	75	18	7	75
Bonaparte's Gull	1	18	100	0	0	100	0	0
Black Tern	6	41	59	41	0	100	0	0
Common Loon	1	1	0	0	100	0	0	100
Forster's Tern	3	5	93	7	0	100	0	0
Common Tern	1	1	100	0	0	100	0	0
Unidentified Tern	1	1	0	100	0	0	100	0
Double-crested Cormorant	39	1032	1	66	33	7	61	32
American White Pelican	25	428	0	51	49	1	52	46
Common Merganser	2	3	0	33	67	33	67	0
Canvasback	1	14	0	100	0	0	100	0
Mallard	250	1259	16	44	40	31	35	34
Gadwall	6	12	20	80	0	50	50	0
Northern Shoveler	5	13	0	100	0	69	31	0
Ring-necked Duck	2	16	0	25	75	0	25	75
Blue-winged Teal	8	26	62	38	0	81	19	0
Northern Pintail	20	163	1	27	72	8	20	72
Wood Duck	16	63	57	43	0	79	21	0
Unidentified Scaup	1	55	0	100	0	0	100	0
Unidentified Duck	12	245	0	15	85	0	15	85
Canada Goose	101	1886	5	37	57	12	38	50
Snow Goose	20	1471	0	6	94	0	19	81
Greater White-fronted Goose	4	224	0	0	100	0	0	100
Great Blue Heron	75	93	27	70	3	62	36	2
Great Egret	8	9	37	63	0	63	37	0
Green Heron	2	2	0	100	0	50	50	0
Sandhill Crane	3	21	0	95	5	33	67	0
Upland Sandpiper	40	52	49	47	4	85	11	4
American Golden-Plover	5	97	4	96	0	4	96	0
Black-bellied Plover	2	40	0	100	0	100	0	0
Pectoral Sandpiper	17	216	18	82	0	45	55	0
Unidentified Sandpiper	14	147	7	93	0	39	61	0
Greater Yellowlegs	9	28	25	75	0	64	36	0
Lesser Yellowlegs	5	9	33	67	0	89	11	0
Yellowlegs	2	7	0	100	0	0	100	0
Common Snipe	7	16	88	13	0	88	13	0

^a Turbine A: 0 - 19.5m = below; 19.5 - 52.5m = within; >52.5m = above rotor-swept height
Turbine B: 0 - 26m = below; 26 - 74m = within; >74m = above rotor-swept height

Appendix G (Continued). Percent of birds observed flying below, within, and above the rotor-swept height of turbines^a.

Species	RLB Surveys							
	# Flocks	# Individ.	Turbine A			Turbine B		
			Below	Within	Above	Below	Within	Above
Unidentified Dowitcher	1	5	0	100	0	100	0	0
Unidentified Shorebird	17	200	24	76	0	42	58	0
Gray Partridge	7	25	100	0	0	100	0	0
Ring-necked Pheasant	11	19	100	0	0	100	0	0
Northern Harrier	427	451	84	14	2	90	9	1
Sharp-shinned Hawk	29	30	35	62	3	58	38	3
Cooper's Hawk	17	17	21	63	17	44	41	15
Broad-winged Hawk	5	7	0	71	29	14	71	14
Unidentified Accipiter	1	1	0	0	100	0	0	100
Turkey Vulture	6	7	14	50	36	43	36	21
Red-tailed Hawk	711	845	24	58	19	47	38	15
Northern Goshawk	1	1	100	0	0	100	0	0
Swainson's Hawk	208	243	17	59	24	38	45	17
Rough-legged Hawk	6	6	29	50	21	43	43	14
Unidentified Buteo	1	1	0	100	0	0	100	0
Ferruginous Hawk	3	3	0	100	0	0	100	0
Unidentified Hawk	4	4	0	100	0	25	75	0
Golden Eagle	1	1	0	100	0	50	50	0
Bald Eagle	14	14	18	68	14	43	43	14
Osprey	2	2	0	100	0	0	100	0
American Kestrel	187	210	75	25	0	92	8	0
Peregrine Falcon	2	2	0	50	50	50	0	50
Great Horned Owl	12	12	100	0	0	100	0	0
Unidentified Raptor	18	19	34	32	34	50	16	34
Belted Kingfisher	2	2	100	0	0	100	0	0
Common Nighthawk	1	2	0	100	0	100	0	0
American Crow	601	1796	73	26	2	88	10	1
TOTAL	3,156	18,144	20.9	45.1	34.0	35.7	35.6	28.7

^aTurbine A: 0 - 19.5m = below; 19.5 - 52.5m = within; >52.5m = above rotor-swept height

Turbine B: 0 -26m = below; 26 - 74m = within; >74m = above rotor-swept height

Appendix H. Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

Point Count Survey Data

Spring

Species	Exposure Index ^a		Mean Abund.	Detect. Adjust.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B				Turb A	Turb B
Lapland Longspur	0.713	0.295	0.760	0.34	99	32	13
Red-winged Blackbird	0.394	0.156	1.181	0.45	84	18	7
Horned Lark	0.306	0.190	0.272	0.23	89	29	18
Unidentified Blackbird	0.122	0.044	0.274	0.47	96	22	8
Common Grackle	0.089	0.051	0.339	0.40	87	12	7
Mallard	0.060	0.030	0.198	1.00	87	35	17
Brown-headed Cowbird	0.058	0.013	0.387	0.27	80	5	1
Snow Goose	0.056	0.056	0.068	1.00	100	82	82
Canada Goose	0.051	0.040	0.124	1.00	87	47	37
Yellow-headed Blackbird	0.050	0.001	0.040	0.47	99	59	2
European Starling	0.046	0.027	0.198	0.65	86	17	10
Common Redpoll	0.041	0.039	0.038	0.31	71	47	45
American Robin	0.039	0.022	0.169	0.37	66	13	7
Unidentified Bird	0.027	0.004	0.011	0.33	98	80	13
Killdeer	0.025	0.012	0.150	0.50	68	12	6
Double-crested Cormorant	0.023	0.024	0.027	1.00	100	84	87
Pectoral Sandpiper	0.022	0	0.030	0.50	82	44	0
American Golden-Plover	0.021	0.021	0.065	0.50	92	18	18
Barn Swallow	0.021	0.016	0.214	0.23	98	2	2
Blue Jay	0.018	0.009	0.067	0.80	80	27	13
Tree Swallow	0.017	0.011	0.058	0.42	97	13	8
Rock Dove	0.016	0.003	0.088	0.72	98	14	2
Bobolink	0.016	0.015	0.126	0.49	65	10	9
Cliff Swallow	0.016	0.009	0.026	0.15	100	9	5
American Crow	0.012	0.006	0.058	1.00	92	23	12
American Goldfinch	0.012	0.003	0.058	0.32	83	8	2
Bank Swallow	0.010	0.005	0.015	0.14	99	9	4
Franklin's Gull	0.010	0.007	0.012	1.00	100	79	57
Upland Sandpiper	0.009	0.005	0.012	0.33	80	31	19
Mourning Dove	0.008	0.001	0.081	0.37	84	4	1
House Sparrow	0.007	0.002	0.044	0.31	62	8	2
Greater White-fronted Goose	0.007	0.031	0.031	1.00	100	24	100
Common Snipe	0.005	0.002	0.014	1.00	78	49	20
Red-tailed Hawk	0.005	0.002	0.015	1.00	92	40	14
Blue-winged Teal	0.005	0.001	0.015	1.00	77	47	11
Forster's Tern	0.005	0.005	0.005	1.00	100	100	100
Unidentified Sparrow	0.004	0.001	0.034	0.31	90	5	1

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix H (Continued). Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

Point Count Survey Data

Spring

Species	Exposure Index ^a		Mean Abund.	Detect. Adjust.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B				Turb A	Turb B
Ring-billed Gull	0.004	0.002	0.014	1.00	100	29	16
Greater Yellowlegs	0.004	0.001	0.009	0.50	76	31	6
Northern Pintail	0.004	0	0.011	1.00	93	40	0
Common Merganser	0.003	0	0.004	1.00	80	100	0
Unidentified Longspur	0.003	0	0.001	0.34	100	100	0
Bufflehead	0.003	0	0.003	1.00	100	100	0
Unidentified Shorebird	0.003	<0.0010	0.002	0.50	100	56	6
Lesser Yellowlegs	0.002	0	0.002	0.50	100	67	0
Northern Flicker	0.002	0.001	0.035	0.37	67	3	1
Say's Phoebe	0.002	0.002	0.001	0.47	100	100	100
Northern Shrike	0.002	0.002	0.001	0.37	86	67	67
Green-winged Teal	0.002	<0.001	0.002	1.00	100	73	18
Lesser Scaup	0.001	0.001	0.015	1.00	32	30	20
Swainson's Hawk	0.001	0.001	0.003	1.00	95	51	31
Northern Harrier	0.001	0.001	0.018	1.00	99	8	5
American Wigeon	0.001	0	0.004	1.00	100	31	0
American Kestrel	0.001	<0.001	0.026	1.00	71	7	1
Wood Duck	0.001	0.001	0.015	1.00	39	21	11
Brewer's Blackbird	0.001	0	0.014	0.47	75	5	0
Eastern Kingbird	0.001	0.001	0.012	0.42	65	6	5
Common Goldeneye	0.001	0.001	0.001	1.00	100	60	60
Purple Martin	0.001	0.001	0.001	0.22	100	17	17
Chimney Swift	0.001	<0.001	0.002	0.22	100	11	5
American White Pelican	0.001	0.001	0.003	1.00	100	29	29
Western Meadowlark	0.001	0	0.269	0.85	43	1	0
Snow Bunting	0.001	0.001	0.004	0.31	100	6	6
Yellow-rumped Warbler	0.001	0	0.009	0.31	44	5	0
Vesper Sparrow	0.001	0	0.113	0.14	27	0	0
Unidentified Sandpiper	0.001	0.001	0.031	0.50	97	1	1
Great Blue Heron	0.001	<0.001	0.002	1.00	96	37	8
Gadwall	0.001	0.001	0.001	1.00	100	44	44
Red-headed Woodpecker	0.001	<0.001	0.008	0.52	59	7	1
Sharp-shinned Hawk	0.001	<0.001	0.001	1.00	100	67	17
American Coot	<0.001	0	0.002	1.00	50	40	0
Eastern Bluebird	<0.001	0	0.002	0.33	55	13	0
Eastern Phoebe	<0.001	<0.001	0.002	0.47	57	14	14
Broad-winged Hawk	<0.001	0	0.001	1.00	100	33	0

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix H (Continued). Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

Point Count Survey Data

Spring

Species	Exposure Index ^a		Mean Abund.	Detect. Adjust.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B				Turb A	Turb B
Black Tern	<0.001	0	0.004	1.00	97	10	0
Great Egret	<0.001	<0.001	<0.001	1.00	100	100	100
Cedar Waxwing	<0.001	<0.001	0.001	0.37	100	15	3
House Finch	<0.001	<0.001	0.001	0.31	88	7	7
Green Heron	<0.001	0	0.001	1.00	50	100	0
Unidentified Warbler	<0.001	0	<0.001	0.31	63	40	0
Cooper's Hawk	<0.001	<0.001	<0.001	1.00	100	33	17
Belted Kingfisher	<0.001	<0.001	0.001	0.80	94	6	6
American Pipit	<0.001	0	<0.001	0.23	72	7	0
Dickcissel	<0.001	0	0.002	0.82	15	12	0
Unidentified Gull	<0.001	0.001	0.001	1.00	100	3	93
Unidentified Tern	0	0.001	0.001	1.00	100	0	100
Unidentified Woodpecker	0	<0.001	0.002	0.48	10	0	100
Savannah Sparrow	0	0	0.164	0.29	13	0	0
Song Sparrow	0	0	0.111	0.22	4	0	0
American Tree Sparrow	0	0	0.061	0.14	14	0	0
Clay-colored Sparrow	0	0	0.028	0.24	5	0	0
Grasshopper Sparrow	0	0	0.024	0.23	2	0	0
Ring-necked Pheasant	0	0	0.024	1.00	33	0	0
Common Yellowthroat	0	0	0.021	0.31	3	0	0
Sedge Wren	0	0	0.018	0.15	4	0	0
Harris' Sparrow	0	0	0.015	0.31	9	0	0
House Wren	0	0	0.014	0.37	6	0	0
Brown Thrasher	0	0	0.013	0.37	33	0	0
White-throated Sparrow	0	0	0.012	0.31	0	0	0
Gray Partridge	0	0	0.011	1.00	72	0	0
Chipping Sparrow	0	0	0.009	0.31	14	0	0
Yellow Warbler	0	0	0.008	0.31	16	0	0
Dark-eyed Junco	0	0	0.008	0.31	34	0	0
Downy Woodpecker	0	0	0.007	0.48	24	0	0
Great Horned Owl	0	0	0.006	1.00	49	0	0
Lincoln's Sparrow	0	0	0.005	0.06	5	0	0
Black-capped Chickadee	0	0	0.005	0.31	12	0	0
Ruby-crowned Kinglet	0	0	0.004	0.45	20	0	0
Unidentified Scaup	0	0	0.003	1.00	0	0	0
Northern Shoveler	0	0	0.003	1.00	100	0	0
Western Kingbird	0	0	0.003	0.47	69	0	0

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix H (Continued). Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

Point Count Survey Data

Spring

Species	Exposure Index ^a		Mean Abund.	Detect. Adjust.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B				Turb A	Turb B
Unidentified Flycatcher	0	0	0.003	0.47	8	0	0
Baltimore Oriole	0	0	0.003	0.33	39	0	0
Least Sandpiper	0	0	0.003	0.50	0	0	0
Least Flycatcher	0	0	0.003	0.47	20	0	0
Palm Warbler	0	0	0.003	0.31	10	0	0
American Redstart	0	0	0.003	0.31	29	0	0
Orange-crowned Warbler	0	0	0.003	0.47	14	0	0
Field Sparrow	0	0	0.002	0.31	0	0	0
Northern Rough-winged Swallow	0	0	0.002	0.22	83	0	0
Gray Catbird	0	0	0.002	0.32	0	0	0
Tennessee Warbler	0	0	0.002	0.31	0	0	0
LeConte's Sparrow	0	0	0.002	0.31	0	0	0
Rose-breasted Grosbeak	0	0	0.002	1.00	20	0	0
White-crowned Sparrow	0	0	0.002	0.22	0	0	0
Rusty Blackbird	0	0	0.001	0.47	86	0	0
Warbling Vireo	0	0	0.001	0.31	0	0	0
Red-breasted Merganser	0	0	0.001	1.00	0	0	0
White-rumped Sandpiper	0	0	0.001	0.50	100	0	0
Red-eyed Vireo	0	0	0.001	0.31	0	0	0
White-breasted Nuthatch	0	0	0.001	0.48	0	0	0
Hermit Thrush	0	0	0.001	0.31	0	0	0
Orchard Oriole	0	0	0.001	0.33	86	0	0
Bonaparte's Gull	0	0	0.001	1.00	100	0	0
Hairy Woodpecker	0	0	0.001	0.48	31	0	0
Swainson's Thrush	0	0	0.001	0.37	0	0	0
Cattle Egret	0	0	0.001	1.00	0	0	0
Scarlet Tanager	0	0	0.001	0.31	0	0	0
Blackpoll Warbler	0	0	0.001	0.31	0	0	0
Black-throated Green Warbler	0	0	0.001	0.31	0	0	0
Canada Warbler	0	0	0.001	0.31	0	0	0
Connecticut Warbler	0	0	0.001	0.31	0	0	0
Unidentified Thrush	0	0	0.001	0.37	0	0	0
American Bittern	0	0	<0.001	1.00	100	0	0
Gray-cheeked Thrush	0	0	<0.001	0.37	0	0	0
Pied-billed Grebe	0	0	<0.0010	1.00	0	0	0
Ferruginous Hawk	0	0	<0.0010	1.00	100	0	0
Merlin	0	0	<0.001	1.00	100	0	0

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix H (Continued). Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

Point Count Survey Data

Spring

Species	Exposure Index ^a		Mean Abund.	Detect. Adjust.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B				Turb A	Turb B
Red-Bellied Woodpecker	0	0	<0.001	0.48	33	0	0
Eastern Wood-pewee	0	0	<0.001	0.47	0	0	0
Smith's Longspur	0	0	<0.001	0.34	0	0	0
Lark Sparrow	0	0	<0.001	0.31	0	0	0
Blue-headed Vireo	0	0	<0.001	0.31	0	0	0
Magnolia Warbler	0	0	<0.001	0.31	0	0	0
Loggerhead Shrike	0	0	<0.001	0.37	100	0	0
Black-and-white Warbler	0	0	<0.001	0.31	0	0	0

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix H (Continued). Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

Point Count Survey Data
Summer

Species	Exposure Index ^a		Mean Abund.	Detect. Adjust.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B				Turb A	Turb B
Red-winged Blackbird	0.207	0.082	0.620	0.45	84	18	7
Horned Lark	0.166	0.103	0.147	0.23	89	29	18
Cliff Swallow	0.109	0.061	0.186	0.15	100	9	5
Common Grackle	0.086	0.049	0.327	0.40	87	12	7
Barn Swallow	0.076	0.057	0.757	0.23	98	2	2
European Starling	0.075	0.044	0.324	0.65	86	17	10
Unidentified Blackbird	0.051	0.018	0.115	0.47	96	22	8
Brown-headed Cowbird	0.044	0.009	0.292	0.27	80	5	1
Bank Swallow	0.043	0.020	0.065	0.14	99	9	4
American Goldfinch	0.036	0.008	0.173	0.32	83	8	2
Killdeer	0.031	0.015	0.188	0.50	68	12	6
Bobolink	0.030	0.028	0.238	0.49	65	10	9
Mourning Dove	0.026	0.004	0.273	0.37	84	4	1
Unidentified Swallow	0.024	0.010	0.017	0.22	100	31	13
Rock Dove	0.024	0.004	0.127	0.72	98	14	2
Upland Sandpiper	0.022	0.014	0.030	0.33	80	31	19
American Robin	0.022	0.012	0.093	0.37	66	13	7
American Crow	0.018	0.009	0.087	1.00	92	23	12
Unidentified Sparrow	0.016	0.005	0.122	0.31	90	5	1
Mallard	0.014	0.007	0.047	1.00	87	35	17
Franklin's Gull	0.014	0.010	0.018	1.00	100	79	57
Pectoral Sandpiper	0.014	0	0.019	0.50	82	44	0
House Sparrow	0.012	0.003	0.074	0.31	62	8	2
Blue Jay	0.009	0.004	0.033	0.80	80	27	13
Red-tailed Hawk	0.008	0.003	0.021	1.00	92	40	14
Eastern Kingbird	0.007	0.005	0.069	0.42	65	6	5
Unidentified Bird	0.006	0.001	0.003	0.33	98	80	13
Tree Swallow	0.006	0.004	0.022	0.42	97	13	8
Canada Goose	0.004	0.003	0.010	1.00	87	47	37
Swainson's Hawk	0.003	0.002	0.006	1.00	95	51	31
Great Blue Heron	0.003	0.001	0.007	1.00	96	37	8
Dickcissel	0.003	0	0.117	0.82	15	12	0
Yellow-headed Blackbird	0.002	<0.0010	0.002	0.47	99	59	2
Northern Flicker	0.002	0.001	0.034	0.37	67	3	1
Unidentified Shorebird	0.002	<0.001	0.002	0.50	100	56	6
Cedar Waxwing	0.002	<0.001	0.004	0.37	100	15	3
Red-headed Woodpecker	0.002	<0.001	0.020	0.52	59	7	1

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix H (Continued). Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

Point Count Survey Data
Summer

Species	Exposure Index ^a		Mean Abund.	Detect. Adjust.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B				Turb A	Turb B
Northern Harrier	0.001	0.001	0.017	1.00	99	8	5
House Finch	0.001	0.001	0.006	0.31	88	7	7
Double-crested Cormorant	0.001	0.001	0.002	1.00	100	84	87
Eastern Bluebird	0.001	0	0.005	0.33	55	13	0
Common Snipe	0.001	<0.001	0.003	1.00	78	49	20
Blue-winged Teal	0.001	<0.001	0.003	1.00	77	47	11
Vesper Sparrow	0.001	0	0.141	0.14	27	0	0
Chimney Swift	0.001	<0.001	0.002	0.22	100	11	5
American Kestrel	0.001	<0.001	0.016	1.00	71	7	1
Black Tern	0.001	0	0.007	1.00	97	10	0
Western Meadowlark	0.001	0	0.227	0.85	43	1	0
Savannah Sparrow	0.001	0	0.228	0.29	13	0	0
Gadwall	<0.001	<0.0010	0.001	1.00	100	44	44
Solitary Sandpiper	<0.0010	0	0.001	0.50	40	100	0
Northern Shrike	<0.001	<0.001	<0.001	0.37	86	67	67
Brewer's Blackbird	<0.001	0	0.005	0.47	75	5	0
Purple Martin	<0.001	<0.001	<0.001	0.22	100	17	17
Belted Kingfisher	<0.001	<0.001	0.004	0.80	94	6	6
Green-winged Teal	<0.001	<0.001	<0.001	1.00	100	73	18
Green Heron	<0.001	0	<0.001	1.00	50	100	0
Eastern Phoebe	<0.001	<0.001	0.001	0.47	57	14	14
Wood Duck	<0.001	<0.001	0.002	1.00	39	21	11
Cooper's Hawk	<0.001	<0.001	<0.001	1.00	100	33	17
Unidentified Sandpiper	<0.001	<0.001	0.004	0.50	97	1	1
Ring-billed Gull	<0.001	<0.001	<0.001	1.00	100	29	16
American Coot	<0.001	0	<0.001	1.00	50	40	0
Unidentified Gull	<0.001	0.001	0.001	1.00	100	3	93
Song Sparrow	0	0	0.130	0.22	4	0	0
Grasshopper Sparrow	0	0	0.126	0.23	2	0	0
Sedge Wren	0	0	0.113	0.15	4	0	0
Common Yellowthroat	0	0	0.103	0.31	3	0	0
Clay-colored Sparrow	0	0	0.063	0.24	5	0	0
House Wren	0	0	0.042	0.37	6	0	0
Ring-necked Pheasant	0	0	0.023	1.00	33	0	0
Western Kingbird	0	0	0.014	0.47	69	0	0
Chipping Sparrow	0	0	0.014	0.31	14	0	0
Brown Thrasher	0	0	0.012	0.37	33	0	0

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix H (Continued). Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

Point Count Survey Data
Summer

Species	Exposure Index ^a		Mean Abund.	Detect. Adjust.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B				Turb A	Turb B
Gray Partridge	0	0	0.011	1.00	72	0	0
Black-capped Chickadee	0	0	0.007	0.31	12	0	0
Great Horned Owl	0	0	0.006	1.00	49	0	0
Downy Woodpecker	0	0	0.005	0.48	24	0	0
Northern Rough-winged Swallow	0	0	0.005	0.22	83	0	0
Yellow Warbler	0	0	0.004	0.31	16	0	0
Baltimore Oriole	0	0	0.003	0.33	39	0	0
Gray Catbird	0	0	0.003	0.32	0	0	0
American Tree Sparrow	0	0	0.002	0.14	14	0	0
Orchard Oriole	0	0	0.001	0.33	86	0	0
Field Sparrow	0	0	0.001	0.31	0	0	0
Swamp Sparrow	0	0	0.001	0.31	33	0	0
Buff-breasted Sandpiper	0	0	0.001	0.50	0	0	0
Blue Grosbeak	0	0	0.001	1.00	0	0	0
Hairy Woodpecker	0	0	0.001	0.48	31	0	0
LeConte's Sparrow	0	0	0.001	0.31	0	0	0
Yellow-billed Cuckoo	0	0	0.001	0.48	0	0	0
Black-billed Cuckoo	0	0	0.001	0.48	50	0	0
Least Flycatcher	0	0	0.001	0.47	20	0	0
Unidentified Flycatcher	0	0	0.001	0.47	8	0	0
White-breasted Nuthatch	0	0	0.001	0.48	0	0	0
Tennessee Warbler	0	0	<0.001	0.31	0	0	0
Spotted Sandpiper	0	0	<0.001	0.50	100	0	0
Red-Bellied Woodpecker	0	0	<0.001	0.48	33	0	0
Lark Sparrow	0	0	<0.001	0.31	0	0	0
Indigo Bunting	0	0	<0.001	1.00	0	0	0
Red-eyed Vireo	0	0	<0.001	0.31	0	0	0
Loggerhead Shrike	0	0	<0.001	0.37	100	0	0

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix H (Continued). Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

Point Count Survey Data

Fall

Species	Exposure Index ^a		Mean Abund.	Detect. Adjust.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B				Turb A	Turb B
Horned Lark	0.965	0.599	0.857	0.23	89	29	18
Lapland Longspur	1.093	0.452	1.165	0.34	99	32	13
Unidentified Blackbird	0.503	0.180	1.126	0.47	96	22	8
Franklin's Gull	0.194	0.140	0.247	1.00	100	79	57
European Starling	0.226	0.132	0.972	0.65	86	17	10
Double-crested Cormorant	0.123	0.127	0.146	1.00	100	84	87
Red-winged Blackbird	0.239	0.094	0.717	0.45	84	18	7
Unidentified Gull	0.002	0.050	0.054	1.00	100	3	93
Canada Goose	0.059	0.046	0.143	1.00	87	47	37
Barn Swallow	0.052	0.040	0.521	0.23	98	2	2
Common Grackle	0.054	0.031	0.204	0.40	87	12	7
Sandhill Crane	0.029	0.029	0.029	1.00	100	100	100
American Robin	0.042	0.023	0.179	0.37	66	13	7
Cliff Swallow	0.028	0.016	0.048	0.15	100	9	5
American Crow	0.031	0.016	0.148	1.00	92	23	12
Blue Jay	0.031	0.015	0.114	0.80	80	27	13
Killdeer	0.023	0.011	0.137	0.50	68	12	6
Snow Goose	0.010	0.010	0.012	1.00	100	82	82
Unidentified Sparrow	0.030	0.009	0.229	0.31	90	5	1
Bobolink	0.008	0.008	0.064	0.49	65	10	9
Mallard	0.012	0.006	0.040	1.00	87	35	17
Rock Dove	0.034	0.006	0.186	0.72	98	14	2
Common Redpoll	0.005	0.005	0.005	0.31	71	47	45
Red-tailed Hawk	0.014	0.005	0.038	1.00	92	40	14
American Goldfinch	0.019	0.004	0.094	0.32	83	8	2
Bank Swallow	0.009	0.004	0.013	0.14	99	9	4
House Sparrow	0.016	0.004	0.094	0.31	62	8	2
Mourning Dove	0.025	0.004	0.264	0.37	84	4	1
Unidentified Swallow	0.005	0.002	0.004	0.22	100	31	13
Eastern Kingbird	0.003	0.002	0.030	0.42	65	6	5
House Finch	0.001	0.001	0.007	0.31	88	7	7
American White Pelican	0.001	0.001	0.004	1.00	100	29	29
Cedar Waxwing	0.007	0.001	0.016	0.37	100	15	3
Swainson's Hawk	0.002	0.001	0.004	1.00	95	51	31
Brown-headed Cowbird	0.005	0.001	0.033	0.27	80	5	1
Northern Harrier	0.001	0.001	0.019	1.00	99	8	5
Northern Shrike	0.001	0.001	0.001	0.37	86	67	67

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix H (Continued). Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

Point Count Survey Data

Fall

Species	Exposure Index ^a		Mean Abund.	Detect. Adjust.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B				Turb A	Turb B
Northern Flicker	0.002	0.001	0.033	0.37	67	3	1
Blue-winged Teal	0.004	0.001	0.010	1.00	77	47	11
Tree Swallow	0.001	0.001	0.003	0.42	97	13	8
Chimney Swift	0.001	0.001	0.002	0.22	100	11	5
Gadwall	0.001	0.001	0.001	1.00	100	44	44
Purple Martin	0.001	0.001	0.001	0.22	100	17	17
Great Blue Heron	0.002	<0.001	0.006	1.00	96	37	8
Ring-billed Gull	0.001	<0.001	0.003	1.00	100	29	16
Sharp-shinned Hawk	0.002	<0.001	0.003	1.00	100	67	17
Common Snipe	0.001	<0.001	0.003	1.00	78	49	20
Upland Sandpiper	0.001	<0.001	0.001	0.33	80	31	19
Unidentified Woodpecker	0	<0.001	0.002	0.48	10	0	100
Green-winged Teal	0.001	<0.001	0.002	1.00	100	73	18
Yellow-headed Blackbird	0.011	<0.001	0.009	0.47	99	59	2
Unidentified Bird	0.002	<0.001	0.001	0.33	98	80	13
Snow Bunting	<0.001	<0.001	0.001	0.31	100	6	6
Eastern Phoebe	<0.001	<0.001	0.001	0.47	57	14	14
Golden Eagle	<0.001	<0.001	<0.001	1.00	100	100	100
Cooper's Hawk	<0.001	<0.001	0.001	1.00	100	33	17
Red-headed Woodpecker	0.001	<0.001	0.011	0.52	59	7	1
Osprey	<0.001	<0.001	<0.001	1.00	100	100	50
Greater Yellowlegs	0.001	<0.001	0.001	0.50	76	31	6
Unidentified Shorebird	0.001	<0.001	0.001	0.50	100	56	6
American Kestrel	<0.001	<0.001	0.008	1.00	71	7	1
Unidentified Sandpiper	<0.001	<0.001	0.001	0.50	97	1	1
Wood Duck	<0.001	<0.001	<0.001	1.00	39	21	11
Pine Siskin	0.013	0	0.009	0.31	100	46	0
Eastern Bluebird	0.005	0	0.023	0.33	55	13	0
American Pipit	0.005	0	0.021	0.23	72	7	0
Yellow-rumped Warbler	0.001	0	0.019	0.31	44	5	0
Unidentified Warbler	0.001	0	0.002	0.31	63	40	0
Brewer's Blackbird	0.001	0	0.014	0.47	75	5	0
Lesser Yellowlegs	0.001	0	0.001	0.50	100	67	0
Vesper Sparrow	0.001	0	0.117	0.14	27	0	0
Bald Eagle	0.001	0	0.001	1.00	100	100	0
Solitary Sandpiper	0.001	0	0.001	0.50	40	100	0
Western Meadowlark	<0.001	0	0.173	0.85	43	1	0

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix H (Continued). Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

Point Count Survey Data

Fall

Species	Exposure Index ^a		Mean Abund.	Detect. Adjust.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B				Turb A	Turb B
Pectoral Sandpiper	<0.001	0	0.001	0.50	82	44	0
Savannah Sparrow	0	0	0.120	0.29	13	0	0
Rough-legged Hawk	<0.001	0	0.001	1.00	100	50	0
American Coot	<0.001	0	0.001	1.00	50	40	0
Dickcissel	<0.001	0	0.004	0.82	15	12	0
American Tree Sparrow	0	0	0.069	0.14	14	0	0
Song Sparrow	0	0	0.059	0.22	4	0	0
Gray Partridge	0	0	0.051	1.00	72	0	0
Ring-necked Pheasant	0	0	0.042	1.00	33	0	0
Dark-eyed Junco	0	0	0.039	0.31	34	0	0
Harris' Sparrow	0	0	0.031	0.31	9	0	0
Black-capped Chickadee	0	0	0.014	0.31	12	0	0
Lincoln's Sparrow	0	0	0.014	0.06	5	0	0
Sedge Wren	0	0	0.012	0.15	4	0	0
House Wren	0	0	0.011	0.37	6	0	0
Grasshopper Sparrow	0	0	0.010	0.23	2	0	0
White-throated Sparrow	0	0	0.009	0.31	0	0	0
Rusty Blackbird	0	0	0.007	0.47	86	0	0
Common Yellowthroat	0	0	0.006	0.31	3	0	0
Clay-colored Sparrow	0	0	0.006	0.24	5	0	0
Chipping Sparrow	0	0	0.005	0.31	14	0	0
Downy Woodpecker	0	0	0.005	0.48	24	0	0
Northern Rough-winged Swallow	0	0	0.004	0.22	83	0	0
Ruby-crowned Kinglet	0	0	0.003	0.45	20	0	0
Hairy Woodpecker	0	0	0.003	0.48	31	0	0
Great Horned Owl	0	0	0.003	1.00	49	0	0
LeConte's Sparrow	0	0	0.002	0.31	0	0	0
Gray Catbird	0	0	0.002	0.32	0	0	0
Swamp Sparrow	0	0	0.001	0.31	33	0	0
White-crowned Sparrow	0	0	0.001	0.22	0	0	0
Brown Thrasher	0	0	0.001	0.37	33	0	0
Field Sparrow	0	0	0.001	0.31	0	0	0
Yellow Warbler	0	0	0.001	0.31	16	0	0
Palm Warbler	0	0	0.001	0.31	10	0	0
Unidentified Duck	0	0	0.001	1.00	0	0	0
Unidentified Flycatcher	0	0	0.001	0.47	8	0	0
Western Kingbird	0	0	0.001	0.47	69	0	0

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix H (Continued). Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

Point Count Survey Data

Fall

Species	Exposure Index ^a		Mean Abund.	Detect. Adjust.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B				Turb A	Turb B
Unidentified Buteo	0	0	0.001	1.00	100	0	0
Eastern Wood-pewee	0	0	0.001	0.47	0	0	0
Indigo Bunting	0	0	0.001	1.00	0	0	0
Tennessee Warbler	0	0	0.001	0.31	0	0	0
Ruby-throated Hummingbird	0	0	0.001	0.06	100	0	0
White-breasted Nuthatch	0	0	0.001	0.48	0	0	0
Pied-billed Grebe	0	0	<0.001	1.00	0	0	0
Peregrine Falcon	0	0	<0.0010	1.00	100	0	0
Orchard Oriole	0	0	<0.0010	0.33	86	0	0
Smith's Longspur	0	0	<0.001	0.34	0	0	0
Red-eyed Vireo	0	0	<0.0010	0.31	0	0	0
Orange-crowned Warbler	0	0	<0.001	0.47	14	0	0
Mourning Warbler	0	0	<0.001	0.31	0	0	0
Brown Creeper	0	0	<0.001	0.37	0	0	0
Northern Goshawk	0	0	<0.001	1.00	100	0	0
Merlin	0	0	<0.001	1.00	100	0	0
Short-eared Owl	0	0	<0.001	1.00	100	0	0
Red-Bellied Woodpecker	0	0	<0.001	0.48	33	0	0
Common Nighthawk	0	0	<0.001	1.00	100	0	0
Nashville Warbler	0	0	<0.001	0.31	0	0	0

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix H (Continued). Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

RLB Survey Data						
Spring						
Species	Exposure Index		Mean Abund.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B			Turbine A	Turbine B
Canada Goose	0.831	0.847	2.7315	82	37	38
Mallard	0.602	0.474	2.0442	66	44	35
Franklin's Gull	0.506	0.381	1.0594	84	57	43
Unidentified Sandpiper	0.366	0.238	0.4060	97	93	61
Double-crested Cormorant	0.355	0.326	0.5469	98	66	61
Pectoral Sandpiper	0.264	0.176	0.3700	87	82	55
American Crow	0.238	0.095	1.1575	81	26	10
American Golden-Plover	0.215	0.215	0.2290	98	96	96
Snow Goose	0.189	0.552	2.9613	100	6	19
Unidentified Shorebird	0.188	0.144	0.2650	93	76	58
Black-bellied Plover	0.167	0.000	0.1667	100	100	0
Unidentified Scaup	0.138	0.138	0.1375	100	100	100
Northern Pintail	0.091	0.068	0.3900	86	27	20
American White Pelican	0.082	0.084	0.1613	100	51	52
Swainson's Hawk	0.080	0.061	0.1483	92	59	45
Ring-billed Gull	0.066	0.062	0.1296	100	51	48
Northern Harrier	0.063	0.039	0.4544	95	14	9
Black Tern	0.046	0.000	0.1108	100	41	0
Wood Duck	0.038	0.018	0.1231	72	43	21
Greater Yellowlegs	0.036	0.017	0.0833	58	75	36
Canvasback	0.035	0.035	0.0350	100	100	100
American Kestrel	0.031	0.010	0.1442	88	25	8
Northern Shoveler	0.029	0.009	0.0558	52	100	31
Great Blue Heron	0.027	0.014	0.0513	75	70	36
Unidentified Duck	0.024	0.024	0.1596	100	15	15
Bald Eagle	0.021	0.011	0.0213	100	100	50
Upland Sandpiper	0.013	0.003	0.0367	73	47	11
Gadwall	0.011	0.007	0.0396	35	80	50
Cooper's Hawk	0.011	0.007	0.0171	100	63	41
Ring-necked Duck	0.011	0.011	0.0450	94	25	25
Lesser Yellowlegs	0.009	0.002	0.0225	63	67	11
Sharp-shinned Hawk	0.009	0.006	0.0150	96	62	38
Blue-winged Teal	0.008	0.004	0.1108	19	38	19
Turkey Vulture	0.007	0.005	0.0150	86	58	38
Unidentified Dowitcher	0.005	0.000	0.0125	42	100	0
Unidentified Gull	0.005	0.002	0.0225	100	20	7

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix H (Continued). Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

RLB Survey Data						
Spring						
Species	Exposure Index		Mean Abund.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B			Turbine A	Turbine B
Unidentified Tern	0.004	0.004	0.0042	100	100	100
Rough-legged Hawk	0.004	0.003	0.0071	100	50	43
Yellowlegs	0.003	0.003	0.0050	64	100	100
Common Merganser	0.003	0.006	0.0169	50	33	67
Green Heron	0.003	0.001	0.0025	100	100	50
Ferruginous Hawk	0.003	0.003	0.0025	100	100	100
Osprey	0.003	0.003	0.0025	100	100	100
Sandhill Crane	0.002	0.002	0.0025	100	95	67
Great Egret	0.002	0.001	0.0071	47	63	37
Common Snipe	0.002	0.002	0.0202	64	13	13
Broad-winged Hawk	0.002	0.002	0.0021	100	71	71
Golden Eagle	0.001	0.001	0.0018	100	68	43
Forster's Tern	0.001	0.000	0.0160	100	7	0
Unidentified Raptor	0.000	0.000	0.0021	71	32	16
Red-tailed Hawk	0.000	0.000	0.5952	40	0	0
Greater White-fronted Goose	0.000	0.000	0.4900	100	0	0
American Coot	0.000	0.000	0.0413	0	0	0
Bonaparte's Gull	0.000	0.000	0.0375	100	0	0
Gray Partridge	0.000	0.000	0.0333	31	0	0
Ring-necked Pheasant	0.000	0.000	0.0329	45	0	0
Great Horned Owl	0.000	0.000	0.0242	32	0	0
Red-breasted Merganser	0.000	0.000	0.0125	0	0	0
Wild Turkey	0.000	0.000	0.0083	0	0	0
Pied-billed Grebe	0.000	0.000	0.0075	0	0	0
Belted Kingfisher	0.000	0.000	0.0067	100	0	0
Lesser Scaup	0.000	0.000	0.0063	0	0	0
Common Tern	0.000	0.000	0.0025	100	0	0
American Wigeon	0.000	0.000	0.0025	0	0	0

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix H (Continued). Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

RLB Survey Data						
Summer						
Species	Exposure Index		Mean Abund.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B			Turbine A	Turbine B
Franklin's Gull	0.399	0.301	0.835	84	57	43
Mallard	0.235	0.185	0.797	66	44	35
American Crow	0.227	0.091	1.102	81	26	10
Swainson's Hawk	0.133	0.102	0.245	92	59	45
American White Pelican	0.107	0.111	0.213	100	51	52
Pectoral Sandpiper	0.102	0.068	0.143	87	82	55
Unidentified Shorebird	0.087	0.066	0.122	93	76	58
Canada Goose	0.084	0.086	0.277	82	37	38
Great Blue Heron	0.062	0.032	0.117	75	70	36
Unidentified Sandpiper	0.053	0.034	0.058	97	93	61
Northern Harrier	0.048	0.030	0.352	95	14	9
American Kestrel	0.034	0.011	0.159	88	25	8
Upland Sandpiper	0.033	0.008	0.096	73	47	11
Double-crested Cormorant	0.015	0.014	0.024	98	66	61
Wood Duck	0.010	0.005	0.032	72	43	21
Unidentified Hawk	0.009	0.007	0.009	100	100	75
Northern Pintail	0.005	0.004	0.022	86	27	20
Unidentified Raptor	0.005	0.002	0.022	71	32	16
Greater Yellowlegs	0.004	0.002	0.010	58	75	36
Gadwall	0.004	0.003	0.015	35	80	50
Green Heron	0.003	0.001	0.003	100	100	50
Ferruginous Hawk	0.003	0.003	0.003	100	100	100
Blue-winged Teal	0.001	0.001	0.021	19	38	19
Ring-billed Gull	0.001	0.001	0.003	100	51	48
Turkey Vulture	0.001	0.001	0.003	86	58	38
Herring Gull	0.001	0.000	0.002	100	50	0
Unidentified Gull	0.001	0.000	0.003	100	20	7
Red-tailed Hawk	0.000	0.000	0.535	40	0	0
Great Horned Owl	0.000	0.000	0.012	32	0	0
Ring-necked Pheasant	0.000	0.000	0.006	45	0	0
Pied-billed Grebe	0.000	0.000	0.003	0	0	0

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix H (Continued). Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

RLB Survey Data						
Fall						
Species	Exposure Index		Mean Abund.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B			Turbine A	Turbine B
Franklin's Gull	5.540	4.173	11.589	84	57	43
Double-crested Cormorant	1.063	0.975	1.638	98	66	61
Canada Goose	0.568	0.579	1.868	82	37	38
Mallard	0.412	0.324	1.399	66	44	35
American Crow	0.404	0.161	1.959	81	26	10
Ring-billed Gull	0.335	0.315	0.662	100	51	48
American White Pelican	0.269	0.277	0.531	100	51	52
Swainson's Hawk	0.103	0.078	0.189	92	59	45
Unidentified Duck	0.054	0.054	0.356	100	15	15
Unidentified Shorebird	0.051	0.039	0.072	93	76	58
Great Blue Heron	0.046	0.024	0.087	75	70	36
American Kestrel	0.038	0.012	0.175	88	25	8
Northern Harrier	0.035	0.022	0.256	95	14	9
Sandhill Crane	0.034	0.024	0.036	100	95	67
Sharp-shinned Hawk	0.031	0.020	0.053	96	62	38
Pectoral Sandpiper	0.023	0.016	0.033	87	82	55
Snow Goose	0.020	0.060	0.320	100	6	19
Cooper's Hawk	0.014	0.010	0.023	100	63	41
Yellowlegs	0.014	0.014	0.023	64	100	100
Unidentified Gull	0.014	0.005	0.069	100	20	7
Blue-winged Teal	0.013	0.007	0.178	19	38	19
Northern Pintail	0.013	0.009	0.054	86	27	20
Greater Yellowlegs	0.012	0.006	0.028	58	75	36
Unidentified Sandpiper	0.011	0.007	0.013	97	93	61
Wood Duck	0.011	0.005	0.034	72	43	21
Bald Eagle	0.010	0.005	0.010	100	100	50
Broad-winged Hawk	0.009	0.009	0.013	100	71	71
Unidentified Dowitcher	0.007	0.000	0.017	42	100	0
Great Egret	0.007	0.004	0.024	47	63	37
Unidentified Raptor	0.006	0.003	0.026	71	32	16
Northern Shoveler	0.005	0.002	0.010	52	100	31
Rough-legged Hawk	0.004	0.004	0.008	100	50	43
Gadwall	0.004	0.003	0.014	35	80	50
Common Nighthawk	0.004	0.000	0.004	100	100	0
Lesser Yellowlegs	0.003	0.001	0.008	63	67	11
Ferruginous Hawk	0.003	0.003	0.003	100	100	100

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix H (Continued). Relative turbine exposure indices for birds observed during point count and RLB surveys on Buffalo Ridge study areas.

RLB Survey Data						
Fall						
Species	Exposure Index		Mean Abund.	% Flying	% Flying in Rotor-swept height	
	Turb A	Turb B			Turbine A	Turbine B
Osprey	0.003	0.003	0.003	100	100	100
Turkey Vulture	0.002	0.002	0.005	86	58	38
Upland Sandpiper	0.002	0.001	0.007	73	47	11
Peregrine Falcon	0.002	0.000	0.004	100	50	0
Unidentified Buteo	0.002	0.002	0.002	100	100	100
Common Snipe	0.002	0.002	0.022	64	13	13
Unidentified Accipiter	0.001	0.001	0.002	90	50	36
Herring Gull	0.001	0.000	0.002	100	50	0
Red-tailed Hawk	0.000	0.000	0.892	40	0	0
Greater White-fronted Goose	0.000	0.000	0.058	100	0	0
Gray Partridge	0.000	0.000	0.027	31	0	0
Ring-necked Pheasant	0.000	0.000	0.021	45	0	0
Great Horned Owl	0.000	0.000	0.008	32	0	0
Solitary Sandpiper	0.000	0.000	0.002	0	0	0
Northern Goshawk	0.000	0.000	0.002	100	0	0
Common Loon	0.000	0.000	0.002	100	0	0

^a Exposure index calculated by multiplying mean abundance (#/survey) adjusted for visibility bias times proportion of all observations where species *i* was observed flying times proportion of all flying observations where species *i* was observed within the rotor-swept height of each of the turbines.

Appendix I. Avian group use (#/km²) by individual habitat types on Buffalo Ridge study area.

Point Count Survey Data							
Habitat	Waterbirds	Waterfowl	Shorebirds	Upland			
				gamebirds	Doves	Raptors	Woodpeckers
AF	0.00	0.40	4.86	1.01	3.12	1.71	0.99
AS	0.00	0.00	7.33	0.00	6.90	2.30	0.00
BG	0.00	0.00	38.36	0.39	56.52	1.50	0.50
BS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BU	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CC	0.00	0.00	0.74	0.00	2.17	2.25	0.00
CH	0.00	0.00	3.50	3.66	0.00	4.94	1.50
CO	0.00	0.05	2.23	1.49	4.50	0.98	0.63
CRP	0.02	0.71	0.84	2.92	1.68	1.56	0.41
CS	0.00	0.00	2.32	3.01	1.90	0.56	0.93
FA	0.00	0.90	6.84	2.30	5.27	1.08	0.18
GO	0.00	0.00	4.50	0.00	9.01	0.00	9.18
GP	0.10	0.00	8.34	4.84	6.08	4.53	0.84
GR	0.00	0.00	16.03	0.79	19.72	0.00	0.00
HF	0.00	0.00	3.94	0.22	4.88	3.94	0.55
OT	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PA	0.03	0.94	6.95	2.93	4.73	2.66	0.83
PL	0.00	0.32	5.17	1.14	3.31	0.76	0.25
RW	0.00	0.00	0.28	2.79	21.18	11.64	19.46
SB	0.03	0.15	3.60	1.12	4.95	1.08	0.41
SG	0.00	0.12	2.80	0.52	7.00	1.91	0.38
SN	0.00	0.00	0.00	0.00	0.51	0.27	0.00
SS	0.00	0.21	8.45	2.23	1.20	1.59	0.49
TR	0.00	0.00	0.00	1.57	13.82	15.43	23.57
WET	3.63	73.92	25.30	0.47	0.00	1.63	0.83
WS	0.00	34.16	3.58	2.28	27.28	3.41	0.00
WW	0.00	0.00	0.00	0.00	0.00	6.80	0.00

Key to Habitats

AF = alfalfa	HF = hayfield
AS = alfalfa stubble	OT = other
BG = bare ground	PA = pasture
BS = buckwheat stubble	PL = plowed field
BU = buckwheat	RW = residential woodlot
CC = cut CRP field	SB = soybean field
CH = cut hayfield	SG = small grain
CO = corn	SN = snow
CRP = uncut CRP	SS = soybean stubble
CS = corn stubble	TR = trees
FA = fallow land	WET = wetland
GO = gravel operation	WS = wheat stubble
GP = grazed pasture	WW = winter wheat
GR = gravel road	

Appendix I (Continued). Avian group use (#/km²) by individual habitat types on Buffalo Ridge study area.

Point Count Survey Data

Habitat	Swallows	Flycatchers	Finches	Blackbirds	Corvids	Tanagers & Orioles	Warblers & Vireos
AF	39.03	1.00	0.62	32.27	3.36	0.00	0.65
AS	29.91	0.00	0.00	0.00	4.89	0.00	0.00
BG	53.26	0.00	1.00	7.80	1.16	0.00	0.00
BS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BU	20.29	0.00	0.00	0.00	0.00	0.00	0.00
CC	9.97	0.00	0.83	5.60	0.00	0.00	0.00
CH	14.97	4.49	0.87	50.17	4.68	0.00	0.00
CO	18.97	0.69	1.08	19.51	0.89	0.05	0.36
CRP	17.44	0.58	1.75	19.42	0.50	0.05	2.91
CS	1.74	0.18	0.15	59.07	0.26	0.00	0.18
FA	23.52	0.45	15.10	42.72	0.36	0.00	5.91
GO	802.98	14.02	26.53	163.17	0.00	0.00	22.69
GP	89.37	8.54	1.49	31.21	0.92	0.00	0.60
GR	9.51	0.70	0.84	0.76	0.00	0.00	0.00
HF	15.29	0.33	2.03	22.03	0.71	0.00	2.05
OT	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PA	32.29	1.50	1.92	30.82	1.14	0.05	0.92
PL	5.96	0.38	0.42	21.74	1.58	0.00	0.07
RW	46.45	7.55	9.86	99.66	22.17	1.77	28.02
SB	24.30	0.93	0.98	18.67	1.54	0.00	0.19
SG	31.89	1.32	1.85	28.71	0.33	0.00	1.50
SN	0.00	0.00	0.00	1.19	1.07	0.00	0.00
SS	3.15	0.15	0.00	36.64	1.31	0.06	0.23
TR	12.30	18.52	20.38	164.17	23.40	0.00	25.24
WET	51.63	0.92	4.11	171.83	0.00	0.46	15.44
WS	29.36	0.00	1.12	4.40	0.74	0.00	0.00
WW	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Key to Habitats

AF = alfalfa	HF = hayfield
AS = alfalfa stubble	OT = other
BG = bare ground	PA = pasture
BS = buckwheat stubble	PL = plowed field
BU = buckwheat	RW = residential woodlot
CC = cut CRP field	SB = soybean field
CH = cut hayfield	SG = small grain
CO = corn	SN = snow
CRP = uncut CRP	SS = soybean stubble
CS = corn stubble	TR = trees
FA = fallow land	WET = wetland
GO = gravel operation	WS = wheat stubble
GP = grazed pasture	WW = winter wheat
GR = gravel road	

Appendix I (Continued). Avian group use (#/km²) by individual habitat types on Buffalo Ridge study area.

Point Count Survey Data							
Habitat	Chickadees &						Total
	Sparrows	Longspurs	Nuthatches	Wrens	Thrushes	Other	
AF	36.07	0.87	0.75	0.54	6.87	0.33	134.45
AS	55.79	0.00	0.00	4.60	4.89	0.00	116.62
BG	48.81	46.27	0.00	0.00	0.00	0.00	255.56
BS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BU	5.07	0.00	0.00	0.00	0.00	0.00	25.36
CC	30.39	2.34	0.00	1.47	1.67	0.00	57.43
CH	43.31	76.31	0.00	1.64	0.00	0.00	210.04
CO	12.94	1.98	0.00	0.12	0.83	0.02	67.31
CRP	48.47	0.89	0.00	6.79	1.30	0.00	108.25
CS	20.21	23.49	0.00	0.00	1.55	0.00	115.54
FA	59.04	1.45	0.00	5.26	1.41	0.00	171.78
GO	267.50	0.00	4.50	4.50	13.51	0.00	1342.09
GP	71.35	2.53	0.00	1.05	4.07	0.04	235.89
GR	21.37	21.47	0.00	0.00	0.45	0.00	91.64
HF	55.04	0.85	0.00	2.12	1.90	0.00	115.87
OT	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PA	56.21	0.52	0.00	1.34	2.17	0.11	148.06
PL	13.23	31.13	0.04	0.00	2.16	0.02	87.68
RW	126.03	0.00	9.69	21.63	42.11	0.90	471.21
SB	19.71	4.20	0.00	0.24	1.81	0.05	83.97
SG	27.71	2.56	0.00	2.06	5.57	0.00	116.22
SN	0.16	62.93	0.00	0.00	0.00	0.00	66.12
SS	13.98	17.74	0.00	0.00	4.40	0.00	91.84
TR	185.70	0.00	10.64	17.73	50.16	0.22	582.83
WET	80.55	0.00	0.44	9.81	2.20	0.63	443.81
WS	10.65	13.49	0.00	0.00	7.48	0.00	137.93
WW	6.80	6.40	0.00	0.00	0.00	0.00	19.99

Key to Habitats

AF = alfalfa	HF = hayfield
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CS = corn stubble	TR = trees
FA = fallow land	WET = wetland
GO = gravel operation	WS = wheat stubble
GP = grazed pasture	WW = winter wheat
GR = gravel road	

Appendix I (Continued). Avian group use (#/km²) by individual habitat types on Buffalo Ridge study area.

RLB Survey Data							
Habitat	Upland						Total
	Waterbirds	Waterfowl	Shorebirds	Gamebirds	Raptors	Corvids	
AF	2.68	0.00	0.08	0.01	0.05	0.07	2.89
AS	0.60	0.00	0.00	0.00	0.14	0.09	0.84
BG	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH	1.10	0.01	0.06	0.01	0.19	0.20	1.56
CO	14.75	1.94	0.36	0.01	1.78	3.58	22.42
CRP	2.06	1.44	0.48	0.05	1.27	0.78	6.08
CS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FA	0.00	0.00	0.00	0.00	0.02	0.00	0.02
GP	11.53	3.08	0.51	0.00	2.36	1.68	19.16
GR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HF	8.84	0.29	0.42	0.00	0.56	0.26	10.38
OT	0.02	0.00	0.00	0.00	0.19	0.22	0.43
PA	4.05	4.05	1.02	0.03	1.15	0.95	11.25
PL	15.43	16.35	1.82	0.04	2.05	2.35	38.04
RW	0.16	0.22	0.00	0.01	1.09	2.19	3.67
SB	1.58	0.57	0.21	0.01	0.54	0.36	3.26
SG	4.19	0.64	0.39	0.00	0.90	1.20	7.33
SN	0.13	5.96	0.00	0.00	0.25	0.16	6.50
SS	7.23	2.13	0.25	0.07	0.75	0.74	11.18
TR	0.00	0.05	0.00	0.00	2.09	1.45	3.59
WET	12.89	57.92	4.24	0.00	0.98	0.23	76.26
WS	0.00	0.03	0.01	0.00	0.08	0.17	0.29
WW	0.00	0.00	1.38	0.00	1.38	0.00	2.77

Key to Habitats

AF = alfalfa	PA = pasture
AS = alfalfa stubble	PL = plowed field
BG = bare ground	RW = residential woodlot
CH = cut hayfield	SB = soybean field
CO = corn	SG = small grain
CRP = uncut CRP	SN = snow
CS = corn stubble	SS = soybean stubble
FA = fallow land	TR = trees
GP = grazed pasture	WET= wetland
GR = gravel road	WS = wheat stubble
HF = hayfield	WW = winter wheat
OT = other	

Appendix J. Avian use (#/km²) by species and habitat types on Buffalo Ridge study area.

Species	Habitat						
	CRP	Crop	Hay	Pasture	Woods	Wetlands	Other
Mallard	0.64	0.10	0.21	0.23	0.00	36.93	0.00
Upland Sandpiper	0.04	0.08	0.38	0.52	0.00	0.00	0.00
Killdeer	0.81	5.13	3.98	13.94	0.00	21.33	20.54
Gray Partridge	0.84	0.73	0.20	5.10	0.24	0.00	0.00
Ring-necked Pheasant	2.01	0.61	1.10	2.67	3.08	0.46	0.22
Rock Dove	0.00	1.47	0.11	0.33	3.19	0.00	8.03
Mourning Dove	2.58	5.73	9.56	9.99	27.80	0.00	17.19
Northern Harrier	1.09	0.30	0.90	0.81	0.11	0.67	0.00
Red-tailed Hawk	0.24	0.33	0.78	0.96	4.77	0.67	0.07
American Kestrel	0.19	0.24	0.57	0.72	2.74	0.37	0.12
Great Horned Owl	0.00	0.01	0.00	0.00	5.03	0.00	0.00
Downy Woodpecker	0.05	0.01	0.10	0.00	7.74	0.58	0.18
Red-headed Woodpecker	0.00	0.18	0.17	0.16	10.17	0.00	0.00
Northern Flicker	0.80	0.80	0.67	1.94	16.23	1.17	0.22
Eastern Kingbird	0.72	0.55	1.39	3.42	14.15	1.20	0.19
Western Kingbird	0.15	0.10	0.12	0.65	1.87	0.00	0.42
Horned Lark	0.61	13.13	1.56	3.27	0.00	0.00	37.37
Blue Jay	0.21	0.22	1.19	0.33	34.93	0.00	0.44
American Crow	0.74	1.83	5.04	1.82	10.74	0.00	0.68
European Starling	3.53	12.02	53.14	30.32	226.46	8.79	8.91
Bobolink	27.90	1.86	14.91	7.49	0.56	3.16	0.00
Brown-headed Cowbird	11.60	10.79	16.15	15.16	79.25	20.54	5.05
Red-winged Blackbird	23.76	22.99	23.65	40.02	57.17	550.61	9.29
Unidentified Blackbird	4.86	7.40	3.43	8.28	82.91	1.26	6.73
Western Meadowlark	13.38	4.39	19.08	37.98	7.42	3.43	3.08
Common Grackle	7.43	10.50	6.12	8.91	85.86	10.79	0.36
American Goldfinch	7.79	1.83	2.96	4.25	29.31	9.69	2.36
Lapland Longspur	1.77	12.22	16.82	0.00	0.00	0.00	46.74
Vesper Sparrow	5.29	7.38	7.88	7.68	12.74	5.45	6.64
Savannah Sparrow	19.08	3.37	25.51	19.24	5.93	11.56	5.20
Grasshopper Sparrow	6.34	0.27	5.05	10.25	2.09	1.09	0.00
Harris' Sparrow	0.00	0.36	1.40	0.23	14.83	6.00	1.16
White-throated Sparrow	0.00	0.23	0.00	0.18	6.33	3.27	0.33
American Tree Sparrow	1.23	0.95	0.21	2.61	32.56	14.42	0.54
Chipping Sparrow	0.41	0.18	0.00	0.68	7.18	0.00	1.05
Clay-colored Sparrow	5.03	0.19	1.08	2.20	19.00	2.20	0.72
Dark-eyed Junco	0.18	0.17	0.28	0.11	17.45	0.00	3.15
Song Sparrow	3.15	1.18	1.65	3.58	103.16	69.85	3.53
Lincoln's Sparrow	0.08	0.06	0.36	0.69	3.41	3.39	0.17
Unidentified Sparrow	6.15	4.73	7.43	7.17	13.47	4.33	2.50
Dickcissel	7.54	0.70	4.53	2.44	4.05	2.90	0.41
Cliff Swallow	4.24	5.87	9.40	25.97	16.73	37.20	1.18
Barn Swallow	47.23	42.31	100.09	95.77	140.38	53.42	29.93
Tree Swallow	5.27	1.94	5.00	4.13	4.04	1.98	1.10
Bank Swallow	8.27	1.06	0.00	5.09	0.41	7.78	19.17

Appendix J (Continued). Avian use (#/km²) by species and habitat types on Buffalo Ridge study area.

Species	Habitat						
	CRP	Crop	Hay	Pasture	Woods	Wetlands	Other
Unidentified Swallow	0.37	0.60	0.91	0.82	2.20	0.00	0.67
Common Yellowthroat	2.74	0.16	0.91	1.02	14.75	13.79	0.51
Yellow Warbler	0.00	0.01	0.00	0.02	3.19	0.78	0.00
Yellow-rumped Warbler	0.04	0.02	0.00	0.05	5.58	1.02	0.00
House Sparrow	0.83	1.09	3.13	2.86	47.52	0.00	1.32
Brown Thrasher	0.00	0.17	0.22	0.21	19.58	0.00	0.00
House Wren	0.15	0.02	0.23	0.23	42.10	3.23	0.14
Sedge Wren	16.39	0.13	1.73	2.80	1.33	33.31	0.19
Black-capped Chickadee	0.00	0.03	0.90	0.00	13.11	0.00	0.20
American Robin	0.75	4.61	7.30	2.32	116.08	3.05	2.20
Eastern Bluebird	1.12	0.02	0.00	0.41	12.94	0.64	0.00

Appendix K. Avian mortalities found on Buffalo Ridge study area, March - November, 1996-1999.

Reference Mortality							
Species	Study Area	Location	Found during fatality search	Habitat	Date	Condition	Comments
Dickcissel	REF	Roadside Point #24	Yes	Crop	7/24/96	Intact	Blood around head, found 50 m from highway, appears to have been hit by vehicle
Rock Dove	REF	Roadside Point #20	Yes	Wetland	10/01/96	Scavenged	Portions of wing, neck, vertebrae and feathers found at base of fence post, suggesting predation
Red-tailed Hawk	REF	Roadside Point #14	Yes	Pasture	5/06/97	Scavenged	Body found without wings or tail, cause of death undetermined
Mourning Dove	REF	Roadside Point #6	Yes	Wheat Stubble	9/09/97	Feather Spot	Numerous feathers found at one location, cause of death likely predation
Mourning Dove	REF	Roadside Point #4	Yes	Bare Ground	9/24/97	Feather Spot	Numerous feathers found at one location, cause of death likely predation
Franklin's Gull	REF	Roadside Point #20	Yes	Grazed Pasture	9/25/97	Feather Spot	Over 60 feathers found at one location, cause of death undetermined
Red-tailed Hawk	REF	Roadside Point #6	Yes	Plowed Field	3/23/98	Scavenged	Immature hawk with breast and stomach eaten, cause of death unknown
Red-tailed Hawk	REF	Roadside Point #19	No	Grazed Pasture	9/22/98	Scavenged	Pieces of wing, several feathers, bone fragments found at one location, cause of death unknown.
American Tree Sparrow	REF	Roadside Point #30	Yes	Corn Stubble	11/3/98	Intact	Fresh carcass with missing tail feathers. Possibly hit by vehicle or farm implement.
Brewer's Blackbird	REF	Roadside Point #8	Yes	Pasture	4/19/99	Intact	Fresh carcass found close to gravel road; likely killed by vehicle

Appendix K (Continued). Avian mortalities found on Buffalo Ridge study area, March - November, 1996-1999.

Reference Mortality							
Species	Study Area	Location	Found during fatality search	Habitat	Date	Condition	Comments
Unidentified Passerine	P1	Roadside Point #9	Yes	CRP	4/18/96	Feather spot	12 feathers, no flesh, no indications as to cause of death
Mallard	P1	Roadside Point #9	Yes	CRP	7/01/96	Scavenged	Part of one wing found, no indication as to cause of death
Gray Partridge	P1	Roadside Point #1	No	Tree Row	4/13/98	Feather Spot	~75 feathers at one location under tree, cause of death likely predation
Ring-necked Pheasant	P2	Roadside Point #25	Yes	Woodlot	5/09/96	Scavenged	Found under great horned owl nest, appeared related to predation
Ring-necked Pheasant	P2	Roadside Point #8	No	CRP	4/15/97	Scavenged	Portions of body and feathers, cause of death likely predation
Ring-necked Pheasant	P2	Proposed Turbine 28	No	Hayfield	4/28/97	Feather Spot	Numerous feathers found at one location, cause of death likely predation
Gray Partridge	P2	Proposed Turbine 102	No	Grazed Pasture	8/06/97	Feather Spot	Numerous feathers at one location, cause of death likely predation
Mourning Dove	P2	Proposed Turbine 69	Yes	Soybean Field	5/20/97	Feather Spot	Numerous feathers at one location, cause of death likely predation
Mallard	P2	Proposed Turbine 133	Yes	Grazed Pasture	9/04/97	Feather Spot	Several feathers at one location, cause of death likely predation
Mourning Dove	P2	Proposed Turbine 109	Yes	Grazed Pasture	9/15/97	Scavenged	Portions of wings and feathers, cause of death likely predation
Rock Dove	P2	Proposed Turbine 69	Yes	Soybean Stubble	11/13/97	Feather Spot	Several feathers at one location, cause of death likely predation

Appendix K (Continued). Avian mortalities found on Buffalo Ridge study area, March - November, 1996-1999.

Reference Mortality							
Species	Study Area	Location	Found during fatality search	Habitat	Date	Condition	Comments
Rock Dove	P2	Turbine 76	Yes	Plowed Field	5/7/98	Scavenged	One wing found 34.7 m from turbine. Cause of death likely predation - not turbine related as turbine was under construction and not in operation.
Unidentified Sparrow	P2	Turbine 137	No	Access Road	9/4/98	Scavenged	Nestling too young to fly. Cause of death likely predation or heavy equipment during turbine construction.
Canada Goose	P2	Roadside Point #23	Yes	Grazed Pasture	3/29/99	Feather Spot	Portions of wing and feathers. Cause of death likely predation.
Ring-necked Pheasant	P2	Roadside Point #3	No	Corn Field	5/27/99	Scavenged	Carcass plucked and dismembered. Cause of death likely predation.
Chipping Sparrow	P3	Roadside Point #9	Yes	Plowed Field	4/29/96	Intact	Fractured skull and back, found in tire track in plowed field, appeared hit by implement
Killdeer	P3	Roadside Point #7	Yes	Alfalfa	7/30/97	Feather Spot	Numerous feathers in one location, cause of death likely predation
Ring-necked Pheasant	P3	Roadside Point #5	Yes	Corn Field	8/28/97	Scavenged	Feathers and portions of body, cause of death likely predation
Gray Partridge	P3	Roadside Point #15	Yes	Soybean Field	9/27/97	Feather Spot	Numerous feathers in one location, cause of death likely predation
Dark-eyed Junco	P3	Roadside Point #27	Yes	CRP	10/24/97	Feather Spot	Numerous feathers in one location, cause of death likely predation
Common Grackle	P3	Roadside Point #3	Yes	Soybean Field	6/29/98	Scavenged	Juvenile bird with legs missing and stomach ripped open. Cause of death likely predation.

Appendix K (Continued). Avian mortalities found on Buffalo Ridge study area, March - November, 1996-1999.

Windpower-related Mortality								
Species	Study Area	Location	Found during fatality search	Habitat	Date	Condition	Dist. from Turbine	Comments
Pied-billed Grebe	P2	T 102	Yes	Pasture	4/13/99	Intact	17.4 m	Fresh carcass with fractured neck and wing.
American Coot	P2	T 36	No	Plowed Field	4/29/99	Intact	6.4 m	Found on road next to turbine; body had been flattened by vehicle.
Mallard	P2	T 95	Yes	Pasture	5/12/99	Intact	14.9 m	Fresh carcass with fractured wings and gash in stomach.
Common Yellowthroat	P2	T 3	Yes	Plowed Field	5/20/99	Scavenged	14.0 m	Decapitated with abrasions on body.
Magnolia Warbler	P2	T 3	Yes	Plowed Field	5/20/99	Intact	15.5 m	Fresh carcass with fractured neck and wing.
Barn Swallow	P2	T 3	Yes	Plowed Field	5/20/99	Intact	11.3 m	Fresh carcass with fractured neck.
Black and White Warbler	P2	T 3	Yes	Plowed Field	5/20/99	Scavenged	18.0 m	Abrasions on body, fractured wing and neck.
Gray Catbird	P2	T 65	Yes	Corn Field	6/8/99	Intact	5.8 m	Fresh carcass with abrasions on body.
Common Grackle	P2	T 138	Yes	CRP	6/21/99	Intact	13.1 m	Fresh carcass with fractured neck and wing.
Mallard	P2	T 117	Yes	Soybean Field	7/6/99	Scavenged	14.3 m	Fractured wing.
Chipping Sparrow	P2	T 10	No	Corn Field	7/22/99	Intact	0.9 m	Fresh carcass with fractured neck.
Ring-necked Pheasant	P2	T 51	No	Soybean Field	7/23/99	Scavenged	11.3 m	Decomposed carcass with crushed skull and fractured neck and wing.

Appendix K (Continued). Avian mortalities found on Buffalo Ridge study area, March - November, 1996-1999.

Windpower-related Mortality								
Species	Study Area	Location	Found during fatality search	Habitat	Date	Condition	Dist. from Turbine	Comments
Vesper Sparrow	P2	T 23	Yes	Soybean Field	8/13/99	Intact	11.3 m	Fresh carcass with fractured neck.
Common Yellowthroat	P3	T 9	No	Plowed Field	5/17/99	Intact	22.9 m	Fresh carcass with abrasions on head.
Yellow-rumped Warbler	P3	T 9	No	Plowed Field	5/17/99	Dismember	24.1 m	Fresh decapitated carcass with left wing missing and gash in body.
Yellow Warbler	P3	T 9	No	Plowed Field	5/17/99	Intact	2.1 m	Fresh carcass with fractured wing.
Unid. Empidonax Flycatcher	P3	T 9	No	Plowed Field	5/17/99	Intact	14.3 m	Fresh carcass with fractured neck.
Orange-crowned Warbler	P3	T 9	No	Plowed Field	5/17/99	Intact	14.3 m	Fresh carcass with fractured wing and abrasions on back.
Orange-crowned Warbler	P3	T 9	No	Plowed Field	5/17/99	Intact	30.8 m	Fresh carcass with abrasions on back.
Black and White Warbler	P3	T 8	Yes	Plowed Field	5/17/99	Intact	16.8 m	Fresh carcass with no visible trauma.
Yellow Warbler	P3	T 8	Yes	Plowed Field	5/17/99	Intact	15.9 m	Fresh carcass with fractured skull and wings.
Common Yellowthroat	P3	T 8	Yes	Plowed Field	5/17/99	Intact	22.3 m	Fresh carcass with fractured wing.
Blackpoll Warbler	P3	T 8	Yes	Plowed Field	5/17/99	Intact	20.1 m	Fresh carcass with fractured wing.

Appendix K (Continued). Avian mortalities found on Buffalo Ridge study area, March - November, 1996-1999.

Windpower-related Mortality								
Species	Study Area	Location	Found during fatality search	Habitat	Date	Condition	Dist. from Turbine	Comments
Pied-billed Grebe	P2	T 102	Yes	Pasture	4/13/99	Intact	17.4 m	Fresh carcass with fractured neck and wing.
American Coot	P2	T 36	No	Plowed Field	4/29/99	Intact	6.4 m	Found on road next to turbine; body had been flattened by vehicle.
Mallard	P2	T 95	Yes	Pasture	5/12/99	Intact	14.9 m	Fresh carcass with fractured wings and gash in stomach.
Common Yellowthroat	P2	T 3	Yes	Plowed Field	5/20/99	Scavenged	14.0 m	Decapitated with abrasions on body.
Magnolia Warbler	P2	T 3	Yes	Plowed Field	5/20/99	Intact	15.5 m	Fresh carcass with fractured neck and wing.
Barn Swallow	P2	T 3	Yes	Plowed Field	5/20/99	Intact	11.3 m	Fresh carcass with fractured neck.
Black and White Warbler	P2	T 3	Yes	Plowed Field	5/20/99	Scavenged	18.0 m	Abrasions on body, fractured wing and neck.
Gray Catbird	P2	T 65	Yes	Corn Field	6/8/99	Intact	5.8 m	Fresh carcass with abrasions on body.
Common Grackle	P2	T 138	Yes	CRP	6/21/99	Intact	13.1 m	Fresh carcass with fractured neck and wing.
Mallard	P2	T 117	Yes	Soybean Field	7/6/99	Scavenged	14.3 m	Fractured wing.
Chipping Sparrow	P2	T 10	No	Corn Field	7/22/99	Intact	0.9 m	Fresh carcass with fractured neck.
Ring-necked Pheasant	P2	T 51	No	Soybean Field	7/23/99	Scavenged	11.3 m	Decomposed carcass with crushed skull and fractured neck and wing.

Appendix K (Continued). Avian mortalities found on Buffalo Ridge study area, March - November, 1996-1999.

Windpower-related Mortality								
Species	Study Area	Location	Found during fatality search	Habitat	Date	Condition	Dist. from Turbine	Comments
Vesper Sparrow	P2	T 23	Yes	Soybean Field	8/13/99	Intact	11.3 m	Fresh carcass with fractured neck.
Common Yellowthroat	P3	T 9	No	Plowed Field	5/17/99	Intact	22.9 m	Fresh carcass with abrasions on head.
Yellow-rumped Warbler	P3	T 9	No	Plowed Field	5/17/99	Dismember	24.1 m	Fresh decapitated carcass with left wing missing and gash in body.
Yellow Warbler	P3	T 9	No	Plowed Field	5/17/99	Intact	2.1 m	Fresh carcass with fractured wing.
Unid. Empidonax Flycatcher	P3	T 9	No	Plowed Field	5/17/99	Intact	14.3 m	Fresh carcass with fractured neck.
Orange-crowned Warbler	P3	T 9	No	Plowed Field	5/17/99	Intact	14.3 m	Fresh carcass with fractured wing and abrasions on back.
Orange-crowned Warbler	P3	T 9	No	Plowed Field	5/17/99	Intact	30.8 m	Fresh carcass with abrasions on back.
Black and White Warbler	P3	T 8	Yes	Plowed Field	5/17/99	Intact	16.8 m	Fresh carcass with no visible trauma.
Yellow Warbler	P3	T 8	Yes	Plowed Field	5/17/99	Intact	15.9 m	Fresh carcass with fractured skull and wings.
Common Yellowthroat	P3	T 8	Yes	Plowed Field	5/17/99	Intact	22.3 m	Fresh carcass with fractured wing.
Blackpoll Warbler	P3	T 8	Yes	Plowed Field	5/17/99	Intact	20.1 m	Fresh carcass with fractured wing.

Appendix K (Continued). Avian mortalities found on Buffalo Ridge study area, March - November, 1996-1999.

Windpower-related Mortality								
Species	Study Area	Location	Found during fatality search	Habitat	Date	Condition	Dist. from Turbine	Comments
Orange-crowned Warbler	P3	T 8	Yes	Plowed Field	5/17/99	Intact	24.1 m	Fresh carcass with fractured skull and back.
Orange-crowned Warbler	P3	T 8	Yes	Plowed Field	5/17/99	Intact	23.2 m	Fresh carcass with fractured wing.
Warbling Vireo	P3	T 8	Yes	Plowed Field	5/17/99	Intact	60.1 m	Fresh carcass with fractured skull and wing.
Least Flycatcher	P3	T 8	Yes	Plowed Field	5/17/99	Intact	13.7 m	Fresh carcass with no visible trauma.
Unid. Empidonax Flycatcher	P3	T 39	Yes	Soybean Field	5/28/99	Dismember	15.2 m	Body split into two pieces.
Common Yellowthroat	P3	T 39	Yes	Soybean Field	5/28/99	Scavenged	14.3 m	Carcass with abrasions and fractured wing.
Sedge Wren	P3	T 48	Yes	Soybean Field	5/29/99	Scavenged	15.2 m	Fractured wing and neck.
Black and White Warbler	P3	T 17	Yes	Corn Field	6/2/99	Intact	10.4 m	Fractured wing and neck.
Gray Partridge	P3	T 119	No	Grazed Pasture	7/15/99	Scavenged	11.3 m	Heavily infested with maggots; no discernable injuries.
Unidentified Passerine	P3	T 124	No	Alfalfa	8/11/99	Scavenged	0.6 m	Only skeleton left.

Appendix L. Bat mortalities found on Buffalo Ridge study area, 1996 - 1999.

Phase I Study area							
Species	Turbine No.	Found during fatality search	Habitat	Date	Condition	Distance from turbine	Comments
Red Bat	5487	No	Corn Field	8/31/98	Intact	13.7 m	Fractured wing, leg
Hoary Bat	5434	No	CRP	9/3/98	Intact	19.2 m	Head wound
Red Bat	5460	No	Soybean Field	7/23/99	Scavenged	34.8 m	Fractured wing
Hoary Bat	5464	No	Corn Field	8/4/99	Scavenged	3.7 m	Decomposed
Hoary Bat	5489	Yes	Soybean Field	8/5/99	Scavenged	2.4 m	Fractured wing and legs
Hoary Bat	5464	Yes	Corn Field	8/18/99	Scavenged	8.8 m	Fractured neck and wing
Hoary Bat	5465	Yes	Corn Field	9/15/99	Scavenged	5.2 m	Decomposed
Phase II Study area							
Hoary Bat	132	No	Grazed Pasture	7/20/98	Intact	1.8 m	Fractured wing
Red Bat	115	No	Wheat Field	7/21/98	Intact	9.4 m	Fractured wing
Red Bat	23	Yes	Soybean Field	7/22/98	Scavenged	4.9 m	Wound under right wing, possible fractured neck
Red Bat	83	Yes	Soybean Field	7/22/98	Scavenged	11.9 m	Fractured wing, fractured leg
Silver-haired Bat	140	Yes	CRP	7/23/98	Scavenged	14.9 m	Fractured wing
Red Bat	115	Yes	Wheat Field	7/29/98	Scavenged	11.0 m	Fractured neck, fractured wings
Hoary Bat	12	Yes	Soybeans/CRP	7/31/98	Scavenged	7.0 m	Fractured wings, legs
Hoary Bat	123	Yes	Grazed pasture	7/31/98	Intact	6.7 m	Blood on head and nares

Appendix L (Continued). Bat mortalities found on Buffalo Ridge study area, 1996 - 1999.

Phase II Study area							
Species	Turbine No.	Found during fatality search	Habitat	Date	Condition	Distance from turbine	Comments
Hoary Bat	62	No	Soybean field	7/31/98	Intact	25.3 m	Abrasion on chest, bloody head
Silver-haired Bat	138	Yes	CRP	7/31/98	Intact	11.9 m	Injury to abdomen
Hoary Bat	79	No	Corn Field	7/31/98	Intact	15.2 m	Fractured leg
Hoary Bat	136	No	CRP	7/31/98	Scavenged	9.8 m	Bloody fluid in urogenital tract
Hoary Bat	136	No	CRP	7/31/98	Intact	9.1 m	Lower abdomen injured
Unidentified Bat	62	No	Soybean Field	7/31/98	Scavenged	14.9 m	Fractured wing, leg
Hoary Bat	137	Yes	CRP	7/31/98	Intact	7.3 m	Fractured neck, wings
Hoary Bat	122	No	Grazed Pasture	7/31/98	Scavenged	11.3 m	Fractured wings, feet
Hoary Bat	70	No	Corn Field	7/31/98	Intact	15.8 m	Fractured wing, leg
Unidentified Bat	32	Yes	Soybean Field	8/1/98	Scavenged	7.9 m	Fractured wing, leg
Red Bat	34	Yes	Corn & Soybeans	8/1/98	Scavenged	15.8 m	Fractured wing, legs
Hoary Bat	82	No	Soybean Field	8/1/98	Intact	7.0 m	Injured head, fractured neck, leg
Hoary Bat	82	No	Soybean Field	8/1/98	Scavenged	12.8 m	Fractured neck
Unidentified Bat	81	Yes	Corn Field	8/4/98	Scavenged	5.2 m	Fractured wing
Hoary Bat	16	No	Corn Field	8/5/98	Intact	7.9 m	Bloody head, fractured wing
Hoary Bat	18	Yes	Grazed Pasture	8/6/98	Scavenged	26.5 m	Decomposed
Red Bat	12	Yes	Soybeans/CRP	8/6/98	Intact	5.2 m	Fractured wing, leg

Appendix L (Continued). Bat mortalities found on Buffalo Ridge study area, 1996 - 1999.

Phase II Study area							
Species	Turbine No.	Found during fatality search	Habitat	Date	Condition	Distance from turbine	Comments
Hoary Bat	16	No	Corn Field	8/6/98	Intact	18.9 m	Fractured wing, bloody head
Hoary Bat	87	No	Corn Field	8/7/98	Intact	17.1 m	Fractured wing
Hoary Bat	138	Yes	CRP	8/7/98	Scavenged	9.4 m	Decomposed
Little Brown Bat	138	Yes	CRP	8/7/98	Scavenged	9.1 m	Decomposed
Hoary Bat	138	Yes	CRP	8/7/98	Scavenged	12.2 m	Fractured neck, bloody head
Hoary Bat	121	Yes	Grazed Pasture	8/13/98	Scavenged	0.3 m	Fractured neck, wings
Eastern Pipistrelle	138	No	CRP	8/14/98	Scavenged	8.8 m	Fractured wing
Unidentified Bat	138	No	CRP	8/14/98	Scavenged	10.1 m	Decomposed
Red Bat	138	No	CRP	8/14/98	Scavenged	2.4 m	Left wing and both feet missing
Silver-haired Bat	137	No	CRP	8/14/98	Intact	5.5 m	Crushed skull, fractured back and legs
Unidentified Bat	18	Yes	Grazed Pasture	8/14/98	Scavenged	8.8 m	Decomposed
Unidentified Bat	3	Yes	Plowed Field/Tree Row	8/17/98	Scavenged,	4.0 m	Fractured wing
Eastern Pipistrelle	28	Yes	Corn Field	8/18/98	Scavenged	11.9 m	Fractured legs
Red Bat	27	No	Soybean Field	8/18/98	Intact	5.5 m	Fractured wing, wound on ventral side
Unidentified Bat	27	No	Soybean Field	8/18/98	Scavenged	5.8 m	Decomposed

Appendix L (Continued). Bat mortalities found on Buffalo Ridge study area, 1996 - 1999.

Phase II Study area							
Species	Turbine No.	Found during fatality search	Habitat	Date	Condition	Distance from turbine	Comments
Hoary Bat	37	No	Corn Field	8/19/98	Scavenged	3.7 m	Fractured neck, wing and legs
Hoary Bat	37	No	Corn Field	8/19/98	Scavenged	15.5 m	Fractured wing
Hoary Bat	139	Yes	CRP	8/20/98	Intact	8.5 m	Fractured neck
Red Bat	137	No	Corn Field	8/20/98	Intact	11.0 m	Possible fractured neck
Hoary Bat	29	No	Corn Field	8/20/98	Intact	4.6 m	Fractured wing
Hoary Bat	132	Yes	Grazed Pasture	8/20/98	Intact	17.4 m	Wound on abdomen
Hoary Bat	26	No	Soybean Field	8/20/98	Intact	6.7 m	Fractured wing, open wound on side
Hoary Bat	36	No	Soybean Field	8/20/98	Intact	3.0 m	Large abrasion on shoulder and back
Unidentified Bat	121	Yes	Grazed Pasture	8/20/98	Scavenged	5.8 m	Decomposed
Hoary Bat	83	No	Soybean Field	8/20/98	Intact	11.6 m	Fractured wing
Hoary Bat	109	Yes	Grazed Pasture	8/20/98	Intact	7.3 m	Fractured wing
Hoary Bat	88	No	Corn Field	8/20/98	Intact	7.9 m	Fractured wing, bloody head
Hoary Bat	88	No	Corn Field	8/20/98	Intact	3.0 m	Bloody head, wound at base of wing
Unidentified Bat	95	Yes	Grazed Pasture/Soybeans	8/21/98	Scavenged	6.7 m	Decomposed
Hoary Bat	114	No	Small Grain	8/21/98	Intact	8.2 m	Fractured wings, abrasions on shoulder
Hoary Bat	115	Yes	Small Grain	8/21/98	Intact	7.9 m	Wound on head

Appendix L (Continued). Bat mortalities found on Buffalo Ridge study area, 1996 - 1999.

Phase II Study area							
Species	Turbine No.	Found during fatality search	Habitat	Date	Condition	Distance from turbine	Comments
Unidentified Bat	139	No	CRP	8/27/98	Scavenged	0.9 m	Numerous fractured bones
Hoary Bat	132	Yes	Grazed Pasture	8/27/98	Scavenged	8.2 m	Numerous fractured bones
Unidentified Bat	121	Yes	Grazed Pasture	8/27/98	Scavenged	9.4 m	Decomposed, numerous fractured bones
Unidentified Bat	117	Yes	Corn Field	8/27/98	Scavenged	6.7 m	Decomposed, fractured wings
Hoary Bat	70	No	Corn Field	8/29/98	Intact	9.1 m	No external injuries visible
Unidentified Bat	89	Yes	Corn Field	8/29/98	Scavenged	5.2 m	Fractured skull, ribs
Eastern Pipistrelle	138	Yes	CRP	8/31/98	Scavenged	12.5 m	Open wound in lower abdomen
Hoary Bat	140	Yes	CRP	8/31/98	Scavenged	5.8 m	Fractured wing
Unidentified Bat	110	Yes	Grazed Pasture	9/1/98	Scavenged	11.9 m	Decomposed, fractured wings
Red Bat	113	No	Grazed Pasture	9/1/98	Scavenged	18.0 m	Fractured wing
Silver-haired Bat	87	Yes	Corn Field	9/1/98	Intact	8.2 m	Wound on abdomen
Silver-haired Bat	85	No	CRP	9/1/98	Intact	12.2 m	Fractured wing, head wound
Red Bat	33	No	Soybean Field	9/1/98	Intact	5.2 m	Fractured wing, head wound
Hoary Bat	46	No	CRP	9/2/98	Scavenged	10.7 m	Fractured wing
Hoary Bat	120	No	Grazed Pasture	9/2/98	Scavenged	7.3 m	Decomposed
Hoary Bat	120	Yes	Grazed Pasture	9/2/98	Scavenged	9.8 m	Decomposed

Appendix L (Continued). Bat mortalities found on Buffalo Ridge study area, 1996 - 1999.

Phase II Study area							
Species	Turbine No.	Found during fatality search	Habitat	Date	Condition	Distance from turbine	Comments
Hoary Bat	120	No	Grazed Pasture	9/2/98	Scavenged	6.4 m	Decomposed
Red Bat	139	No	CRP	9/4/98	Scavenged	11.0 m	Decomposed
Hoary Bat	142	No	CRP	9/4/98	Scavenged	11.6 m	Decomposed
Red Bat	32	Yes	Soybean Field	9/11/98	Scavenged	2.7 m	Fractured back, wings, legs
Hoary Bat	3	Yes	Plowed Field	5/20/99	Scavenged	19.5 m	Fractured wings
Hoary Bat	69	Yes	Soybean Field	7/8/99	Scavenged	2.1 m	Trauma to head
Red Bat	32	Yes	Soybean Field	7/16/99	Intact	8.5 m	Fractured wings, head trauma
Hoary Bat	72	No	Soybean Field	7/21/99	Intact	12.2 m	Trauma to shoulder
Hoary Bat	81	Yes	Soybean Field	7/21/99	Intact	18.3 m	Fractured wing
Hoary Bat	89	Yes	Soybean Field	7/21/99	Intact	8.5 m	Fractured wing, trauma to head
Hoary Bat	10	No	Corn Field	7/22/99	Scavenged	3.4 m	Fractured wing
Red Bat	25	No	Soybean Field	7/22/99	Intact	16.8 m	Fractured wing, trauma to head
Hoary Bat	21	Yes	Soybean Field	7/22/99	Intact	6.7 m	Trauma to head
Red Bat	26	Yes	Corn Field	7/22/99	Scavenged	8.5 m	Trauma to head
Hoary Bat	26	Yes	Corn Field	7/22/99	Scavenged	13.7 m	Fractured wing, neck
Hoary Bat	27	No	Soybean Field	7/22/99	Scavenged	11.9 m	Fractured wings
Red Bat	28	Yes	Soybean Field	7/22/99	Scavenged	6.4 m	Trauma to head

Appendix L (Continued). Bat mortalities found on Buffalo Ridge study area, 1996 - 1999.

Phase II Study area							
Species	Turbine No.	Found during fatality search	Habitat	Date	Condition	Distance from turbine	Comments
Hoary Bat	4	No	Soybean Field	7/22/99	Scavenged	2.1 m	Decomposed
Red Bat	56	Yes	Corn Field	7/23/99	Scavenged	7.3 m	Fractured wing, trauma to head
Red Bat	56	Yes	Corn Field	7/23/99	Intact	8.8 m	Trauma to head
Red Bat	39	Yes	Corn Field	7/23/99	Scavenged	9.8 m	No obvious external wounds
Red Bat	44	Yes	Corn Field	7/23/99	Intact	12.8 m	Trauma to torso and leg
Red Bat	44	Yes	Corn Field	7/23/99	Scavenged	11.3 m	Fractured neck and wings
Big Brown Bat	69	Yes	Soybean Field	7/25/99	Scavenged	14.6 m	Trauma to head
Hoary Bat	72	No	Soybean Field	7/25/99	Scavenged	14.0 m	Trauma to head
Hoary Bat	53	Yes	Soybean Field	8/3/99	Intact	5.8 m	Fractured neck
Little Brown Bat	71	Yes	Soybean Field	8/3/99	Scavenged	14.0 m	Fractured wing, head trauma
Hoary Bat	109	Yes	Pasture	8/4/99	Intact	10.4 m	Fractured neck and wing
Hoary Bat	137	No	CRP	8/4/99	Scavenged	8.8 m	Fractured wing and legs
Hoary Bat	3	Yes	Soybean Field	8/5/99	Scavenged	5.2 m	Abrasions to torso
Red Bat	34	Yes	Soybean Field	8/5/99	Intact	7.3 m	Trauma to abdomen, fractured wing
Hoary Bat	34	Yes	Soybean Field	8/5/99	Scavenged	9.8 m	Decomposed
Hoary Bat	35	No	Soybean Field	8/5/99	Scavenged	12.8 m	Decomposed
Hoary Bat	132	Yes	Grazed Pasture	8/12/99	Scavenged	10.7 m	Fractured wings

Appendix L (Continued). Bat mortalities found on Buffalo Ridge study area, 1996 - 1999.

Phase II Study area							
Species	Turbine No.	Found during fatality search	Habitat	Date	Condition	Distance from turbine	Comments
Red Bat	76	Yes	Soybean Field	8/12/99	Scavenged	12.2 m	Decomposed
Hoary Bat	21	Yes	Soybean Field	8/13/99	Intact	4.3 m	Fractured wing
Hoary Bat	23	Yes	Soybean Field	8/13/99	Intact	13.1 m	Fractured neck
Hoary Bat	42	No	CRP	8/13/99	Intact	10.7 m	Fractured neck, wing
Hoary Bat	63	No	Corn Field	8/17/99	Intact	12.8 m	Fractured neck and wings
Hoary Bat	49	No	Soybean Field	8/17/99	Intact	19.2 m	Fractured neck, trauma to head
Hoary Bat	76	Yes	Soybean Field	8/17/99	Intact	6.4 m	Fractured neck
Red Bat	39	Yes	Corn Field	8/18/99	Scavenged	1.8 m	Abrasions on abdomen
Hoary Bat	41	Yes	Soybean Field	8/18/99	Injured	5.5 m	Injured, not captured
Hoary Bat	123	Yes	Grazed Pasture	8/19/99	Scavenged	10.1 m	Fractured wing
Hoary Bat	95	Yes	Pasture	8/19/99	Scavenged	14.6 m	Fractured wing and legs
Hoary Bat	69	Yes	Soybean Field	8/31/99	Scavenged	10.4 m	Fractured neck, wing
Eastern Pipistrelle	89	Yes	Soybean Field	8/31/99	Intact	8.8 m	Fractured neck, wing
Eastern Pipistrelle	132	Yes	Grazed Pasture	9/1/99	Scavenged	22.3 m	Fractured wing
Hoary Bat	5	Yes	Soybean Field	9/2/99	Intact	15.5 m	Trauma to head
Hoary Bat	32	Yes	Soybean Field	9/2/99	Intact	18.9 m	Trauma to head

Appendix L (Continued). Bat mortalities found on Buffalo Ridge study area, 1996 - 1999.

Phase II Study area							
Species	Turbine No.	Found during fatality search	Habitat	Date	Condition	Distance from turbine	Comments
Hoary Bat	32	Yes	Soybean Field	9/2/99	Intact	10.4 m	Fractured neck
Hoary Bat	2	No	Soybean Field	9/3/99	Scavenged	12.5 m	Fractured neck, wing
Hoary Bat	6	No	Soybean Field	9/3/99	Intact	6.7 m	Fractured wing
Hoary Bat	6	No	Soybean Field	9/3/99	Scavenged	0.9 m	Fractured neck
Eastern Pipistrelle	3	Yes	Soybean Field	9/3/99	Intact	2.7 m	Fractured wing, gash in abdomen
Hoary Bat	7	No	Soybean Field	9/3/99	Intact	2.1 m	Trauma to head
Hoary Bat	76	Yes	Soybean Field	9/3/99	Intact	4.3 m	Fractured neck
Red Bat	12	Yes	Corn Field and Plowed	9/13/99	Scavenged	10.7 m	Decomposed
Little Brown Bat	12	Yes	Corn Field and Plowed	9/13/99	Scavenged	10.1 m	Decomposed
Hoary Bat	12	Yes	Corn Field and Plowed	9/13/99	Scavenged	11.0 m	Decomposed
Red Bat	123	Yes	Grazed Pasture	9/30/99	Intact	7.3 m	Fractured neck and wing
Phase III Study area							
Hoary Bat	39	Yes	Soybean Field	7/25/99	Intact	17.4 m	No visible injuries
Hoary Bat	21	Yes	Alfalfa	7/25/99	Dismembered	3.4 m	Missing head and left wing
Hoary Bat	62	Yes	Soybean Field	7/25/99	Intact	11.0 m	Fractured wing, trauma to shoulder

Appendix L (Continued). Bat mortalities found on Buffalo Ridge study area, 1996 - 1999.

Phase III Study area							
Species	Turbine No.	Found during fatality search	Habitat	Date	Condition	Distance from turbine	Comments
Hoary Bat	93	Yes	Corn/Soybean Field	7/27/99	Intact	8.8 m	Trauma to head
Hoary Bat	115	Yes	Corn Field	7/28/99	Intact	7.6 m	Trauma to head
Hoary Bat	115	Yes	Corn Field	7/28/99	Intact	8.2 m	Trauma to head
Hoary Bat	115	Yes	Corn Field	7/28/99	Scavenged	17.4 m	Fractured neck
Hoary Bat	27	No	CRP	7/28/99	Scavenged	19.5 m	Fractured wing, abrasions on torso
Hoary Bat	27	No	CRP	8/9/99	Scavenged	17.7 m	Fractured legs
Hoary Bat	28	No	Woodlot	8/9/99	Scavenged	10.4 m	Fractured wing, trauma to head
Little Brown Bat	53	Yes	Corn Field/Alfalfa	8/10/99	Scavenged	3.4 m	Fractured wing
Hoary Bat	52	No	Soybean Field	8/10/99	Scavenged	7.6 m	Decomposed
Red Bat	129	Yes	Corn Field	8/11/99	Scavenged	2.1 m	Fractured wing
Hoary Bat	124	No	Alfalfa	8/11/99	Intact	19.2 m	Fractured wing, trauma to head
Hoary Bat	124	No	Alfalfa	8/11/99	Intact	12.8 m	Fractured wing
Hoary Bat	125	Yes	Corn Field	8/11/99	Scavenged	14.0 m	Fractured wings
Hoary Bat	115	Yes	Corn Field	8/11/99	Scavenged	18.9 m	Decomposed
Hoary Bat	8	Yes	Corn Field	8/12/99	Intact	25.0 m	Trauma to head
Red Bat	7	No	Corn Field	8/12/99	Scavenged	11.9 m	Fractured neck

Appendix L (Continued). Bat mortalities found on Buffalo Ridge study area, 1996 - 1999.

Phase III Study area							
Species	Turbine No.	Found during fatality search	Habitat	Date	Condition	Distance from turbine	Comments
Hoary Bat	9	No	Corn Field	8/12/99	Scavenged	9.5 m	Fractured wing
Hoary Bat	13	Yes	Corn/Soybean Field	8/12/99	Scavenged	7.3 m	Fractured neck and wing
Hoary Bat	13	Yes	Corn/Soybean Field	8/12/99	Scavenged	13.1 m	Fractured wings
Hoary Bat	42	No	Soybean Field	8/12/99	Scavenged	7.3 m	Fractured neck and wings
Hoary Bat	62	Yes	Soybean Field	8/12/99	Intact	18.9 m	Fractured neck
Hoary Bat	96	Yes	Soybean Field/Alfalfa	8/13/99	Scavenged	11.3 m	Decomposed
Hoary Bat	96	Yes	Soybean Field/Alfalfa	8/13/99	Scavenged	13.7 m	Decomposed
Red Bat	96	Yes	Soybean Field/Alfalfa	8/13/99	Scavenged	19.2 m	Decomposed
Red Bat	96	Yes	Soybean Field/Alfalfa	8/13/99	Scavenged	5.8 m	Fractured neck
Red Bat	96	Yes	Soybean Field/Alfalfa	8/13/99	Scavenged	7.0 m	Decomposed
Unidentified Bat	111	Yes	Fallow	8/13/99	Scavenged	20.7 m	Decomposed
Unidentified Bat	3	Yes	Corn Field	9/6/99	Scavenged	19.2 m	Decomposed
Red Bat	129	Yes	Corn Field	9/7/99	Scavenged	15.5 m	Decomposed

Appendix L (Continued). Bat mortalities found on Buffalo Ridge study area, 1996 - 1999.

Phase III Study area							
Species	Turbine No.	Found during fatality search	Habitat	Date	Condition	Distance from turbine	Comments
Little Brown Bat	120	Yes	Grazed Pasture	9/7/99	Injured	1.5 m	Injured, not captured
Unidentified Bat	120	Yes	Grazed Pasture	9/7/99	Scavenged	5.8 m	Decomposed
Unidentified Bat	111	Yes	Woodlot/fallow	9/7/99	Scavenged	9.1 m	Fractured wing
Unidentified Bat	80	Yes	Corn/Soybean Field	9/8/99	Scavenged	0.6 m	Decomposed
Unidentified Bat	84	Yes	Corn Field	9/8/99	Scavenged	11.0 m	Decomposed
Hoary Bat	62	Yes	Soybean Field	9/9/99	Scavenged	3.0 m	Fractured wing
Unidentified Bat	53	Yes	Corn Field/Alfalfa	9/9/99	Scavenged	2.1 m	Decomposed
Hoary Bat	30	Yes	Soybean Field	9/10/99	Scavenged	8.8 m	Fractured wing and legs
Silver-haired Bat	102	Yes	CRP	9/21/99	Scavenged	15.9 m	Fractured neck
Red Bat	48	Yes	Soybean Field	10/5/99	Scavenged	9.1 m	Decomposed
Red Bat	75	Yes	Soybean Field	10/19/99	Scavenged	11.9 m	Decomposed
Hoary Bat	72	No	CRP	10/19/99	Scavenged	14.0 m	Fractured neck, wings

Appendix M. Mean length of stay (days) by location, season, habitat, and size class for avian carcasses placed to monitor scavenger removal rate in the Buffalo Ridge study area, 15 March to 15 November 1996-1999.

Phase I Study area

Season	Habitat	Size	N	Mean Length of Stay (Days)	90% CI	
					LL	UL
SPRING	CRP	L	9	2.9	1.6	4.3
		M	9	4.5	1.9	7.1
		S	8	6.8	3.9	9.7
	Snow	L	4	0.5	0.5	0.5
		M	4	0.5	0.5	0.5
		S	5	1.1	0.0	2.2
	Wetland	L	2	1.0	0.0	3.2
		M	2	3.0	0.8	5.2
		S	2	2.0	0.0	8.7
SUMMER	Crop	L	7	2.9	0.5	5.4
		M	15	5.6	3.6	7.6
		S	10	3.6	1.5	5.7
	CRP	L	10	6.1	3.6	8.7
		M	13	13.9	9.6	18.1
		S	12	3.5	2.6	4.4
	Hay	L	2	3.0	0.8	5.2
		M	3	4.2	0.0	8.6
		S	3	3.5	1.1	5.9
	Woods	L	5	0.9	0.4	1.4
		M	5	0.7	0.3	1.1
		S	5	0.9	0.4	1.4
FALL	Bare ground	L	2	13.4	0.0	27.7
		M	1	10.5	10.5	10.5
		S	2	2.0	0.0	4.2
	Crop	L	8	9.8	4.3	15.3
		M	9	12.0	6.5	17.4
		S	8	5.6	0.9	10.3
	CRP	L	15	4.8	3.3	6.3
		M	15	12.8	9.8	15.9
		S	15	10.9	8.1	13.8

Appendix M (Continued). Mean length of stay (days) by location, season, habitat, and size class for avian carcasses placed to monitor scavenger removal rate in the Buffalo Ridge study area, 15 March to 15 November 1996-1999.

Phase II Study area

Season	Habitat	Size	N	Mean Length of Stay (Days)	90% CI		
					LL	UL	
SPRING	CRP	L	5	6.3	1.3	11.3	
		M	3	2.8	0.7	4.9	
		S	7	4.8	2.6	7.0	
	Pasture	L	5	8.9	5.9	11.9	
		M	5	6.9	5.0	8.8	
		S	5	2.5	1.3	3.7	
SUMMER	Bare ground	S	2	0.5	0.5	0.5	
		Crop	L	11	14.4	9.7	19.1
			M	16	8.2	5.7	10.8
	S		11	4.3	1.6	7.0	
	CRP	L	4	9.0	2.0	16.0	
		M	4	7.0	4.6	9.4	
		S	4	8.3	5.6	10.9	
	Pasture	L	7	9.6	4.9	14.2	
		M	8	12.2	5.2	19.3	
		S	7	4.2	3.4	5.1	
	FALL	Bare ground	S	3	4.2	0.0	8.6
			Crop	L	6	4.8	3.4
M				9	4.3	1.7	6.9
S		11		3.9	1.6	6.1	
CRP		L	11	13.7	8.9	18.5	
		M	6	12.3	3.7	20.9	
		S	11	13.7	7.1	20.2	
Woods		L	5	15.8	3.0	28.7	
		M	5	15.8	3.5	28.0	
		S	5	10.2	2.5	18.0	

Appendix M (Continued). Mean length of stay (days) by location, season, habitat, and size class for avian carcasses placed to monitor scavenger removal rate in the Buffalo Ridge study area, 15 March to 15 November 1996-1999.

Phase III Study area

Season	Habitat	Size	N	Mean Length of Stay (Days)	90% CI	
					LL	UL
SPRING	Crop	L	7	5.5	2.8	8.2
		M	1	4.5	4.5	4.5
		S	11	6.0	3.6	8.4
	CRP	L	5	6.3	4.0	8.6
		M	3	5.8	1.9	9.8
		S	7	4.5	2.8	6.2
	Pasture	L	2	4.0	1.8	6.2
		M	5	4.1	3.3	4.9
		S	2	0.5	0.5	0.5
	Snow	L	3	6.5	1.5	11.5
		M	4	1.5	0.7	2.3
		S	4	0.5	0.5	0.5
	Woods	L	3	4.2	0.7	7.6
		S	3	3.8	0.0	8.0
SUMMER	Bare ground	L	2	1.5	1.5	1.5
		M	2	12.1	0.0	59.1
		S	1	2.5	na	na
	Crop	L	5	8.8	0.0	18.3
		M	7	6.7	2.5	10.8
		S	8	4.4	1.7	7.0
	CRP	L	2	12.6	0.0	47.3
		S	1	10.5	10.5	10.5
	Hay	L	2	4.5	0.0	9.0
		M	1	15.1	15.1	15.1
		S	1	1.5	1.5	1.5
	Pasture	L	5	21.6	12.5	30.8
		M	4	7.0	0.0	14.6
		S	4	3.5	1.6	5.4
FALL	Crop	L	13	7.3	4.6	9.9
		M	11	7.0	3.4	10.7
		S	13	3.8	2.3	5.3
	CRP	L	4	15.1	14.8	15.5
		M	5	15.1	14.8	15.4
		S	6	12.5	4.6	20.5
	Pasture	L	1	15.1	na	na
		M	3	10.4	0.0	21.8
		S	2	3.5	0.0	8.0
	Wetland	L	1	15.1	na	na
		S	1	2.5	na	na

Appendix M (Continued). Mean length of stay (days) by location, season, habitat, and size class for avian carcasses placed to monitor scavenger removal rate in the Buffalo Ridge study area, 15 March to 15 November 1996-1999.

Reference Area

Season	Habitat	Size	N	Mean Length of Stay (Days)	90% CI	
					LL	UL
SPRING	Crop	L	7	11.3	5.9	16.6
		M	8	7.4	2.9	11.8
		S	5	9.2	4.0	14.5
	Pasture	L	9	4.6	2.8	6.4
		M	9	4.9	1.9	8.0
		S	10	5.4	1.8	8.9
	Snow	L	4	3.3	2.3	4.2
		M	3	2.8	2.0	3.6
		S	5	2.1	1.6	2.6
	SUMMER	Crop	L	6	4.7	3.3
M			8	4.1	3.1	5.2
S			9	5.1	2.7	7.5
CRP		L	2	6.5	0.0	24.4
		M	2	10.5	10.5	10.5
		S	1	4.5	4.5	4.5
Hay		L	1	15.1	15.1	15.1
		M	1	15.1	15.1	15.1
		S	1	4.5	4.5	4.5
Pasture		L	10	7.9	4.5	11.3
		M	8	6.8	3.7	9.9
		S	7	2.9	0.5	5.3
Wetland		L	1	15.1	15.1	15.1
		M	1	3.5	3.5	3.5
		S	1	2.5	2.5	2.5
FALL	Bare ground	L	5	4.3	1.3	7.3
		M	6	10.7	5.9	15.6
		S	8	2.6	1.9	3.3
	Crop	L	4	13.5	2.2	24.9
		M	3	7.6	0.0	21.3
		S	3	3.8	0.0	11.8
	Pasture	L	2	12.0	0.0	63.0
		M	12	5.9	4.1	7.7
		S	8	4.1	1.1	7.2
	Woods	L	4	21.1	7.5	34.6
		M	4	21.9	6.8	37.1
		S	2	12.6	0.0	47.3