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MONITORING OF SEASONAL BIRD ACTIVITY AND MORTALITY ON UNIT 2 AT THE BUFFALO RIDGE WINDPLANT, MINNESOTA

Preliminary Progress Report for the Research
Period May 1- December 31, 1994

Submitted

by

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Executive Summary

From May-October, 1994, we saw a total of 66 bird species in Unit 2 on the Buffalo Ridge Study Site during roadside, site specific, and raptor surveys. During spring and fall migration periods, bird numbers were higher than during summer. In general, blackbirds, western meadowlarks, barn swallows, American crows, American robins, mallards, vesper and savannah sparrows, northern harriers, and red-tailed hawks were the most common species seen on the study site. No threatened or endangered birds were seen. During 13 raptor road surveys, 0.2 raptors were seen/mile of survey route. Northern harriers, American kestrels, and red-tailed and Swainson's hawks were the most common raptors seen during raptor surveys. Most birds (84%) seen during site specific surveys flew at heights above or below the height range of wind turbine blades (70-170 feet, 22-55 m). During mortality searches in wind turbine plots, we found 3 dead birds and 5 dead bats. We did not attribute any of the bird deaths to collisions with wind turbines, indicating that little bird mortality occurred. We concluded the bats found during mortality searches probably died as a result of collision with wind turbines.

Acknowledgments

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Monitoring of Seasonal Bird Activity and Mortality on Unit 2 of the Buffalo Ridge Windplant, Minnesota.

A Report of Findings and Results for the Research Period of May 1-December 31, 1994[1]

INTRODUCTION

Recent improvements in wind turbine technologies have reduced the costs associated with wind power production, and generated increased interest in the use of wind energy as an alternative energy source in the United States (Hansen et al. 1992). Most wind power development has occurred in California, however, over 90% of the wind power potential in the U.S. exists within 12 contiguous midwestern and western states (Iowa, Minnesota, North Dakota and South Dakota, Nebraska, Kansas, Oklahoma, Texas, New Mexico, Colorado, Wyoming, and Montana) (Weinberg and Williams 1990). Due to improved wind turbine efficiency, a dependable source of wind energy, and a demand for supplemental power, wind power companies have recently expanded their initial programs geographically. During the fall of 1993, KENETECH Windpower began development of the first 25 megawatt phase of a 100 megawatt wind plant scheduled for construction on Buffalo Ridge in southwestern Minnesota. The

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facility is currently the largest operating wind plant in the United States outside of California.

A problem from wind power development has been the incidence of bird mortality from collisions with wind turbines, particularly with raptors (Howell and Noone 1992, Howell et at. 1991, McCrary et al. 1986, Orloff and Flannery 1992). Howell and DiDonato (1991) sampled 359 wind turbines in Alameda and Contra Costa counties, California over a 12 month period and found 42 dead birds, of which 25 were thought to be tower strikes and 17 of these 25 were raptors. During 2 years of avian monitoring at the Altamont Pass Wind Resource Area in California, Orloff and Flannery (1992) found 182 dead birds, of which 65% were raptors. They attributed 55% of all raptor deaths within their sample areas to collision with turbines, 8% to electrocution, and 11% to collision with wires. Other potential effects of windpower plants on birds besides collision with wind turbines include electrocution on transmission lines or towers, collision with transmission wires, changes in raptor foraging or migration patterns, habitat reduction, and prey base changes (Orloff and Flannery 1992).

A biological reconnaissance (Nelson 1993) was conducted for Buffalo Ridge prior to construction of the wind power facility due to the concern of the potential effects of wind turbines on birds and other wildlife using Buffalo Ridge. Emphasis was given to migratory bird populations, endangered and threatened species, and other resident wildlife and related habitat. Major conclusions of the report were: 1) migrating waterfowl would likely not be impacted because Buffalo Ridge is not located in a major staging area or along a significant fall or spring migration route, 2) the impact of a wind power

facility on passerines would likely be related to the abundance of migrants and their migration height and would likely vary considerably among sites, and 3) certain species of raptors could be susceptible to collision with wind turbines at the Buffalo Ridge site, including one common and 6 other less common species that migrate through the area.

In April 1994, near the completion of the first phase (25 megawatt capacity) of the 100 megawatt facility, KENETECH Windpower (KENETECH) contracted with South Dakota State University and the South Dakota Cooperative Fish and Wildlife Research Unit of the National Biological Service to conduct avian research on the Buffalo Ridge Windplant near Lake Benton, Minnesota. The purpose of the research is to develop and conduct a systematic avian monitoring program that measures seasonal movements, relative abundance, temporal flight patterns, and incidence of nesting and bird mortality associated with the Buffalo Ridge Windplant.

STUDY AREA

Buffalo Ridge is located in southwest Minnesota and is a 62 mile (100-km) segment of the Bemis Moraine that runs diagonally northwest to southeast, separating the Missouri River and Mississippi River watersheds. It is located in the Coteau des Prairies physiographic region and consists of terminal moraines and stream-dissected lands historically classified as upland prairie and prairie wetlands (Coffin and Pfannmuller 1988). Buffalo Ridge ranges from 1,790 to 2,000 feet (546-610 m) above sea level. The primary habitats on Buffalo Ridge are agricultural (corn, soy beans, small grains, pasture, and hay), or Conservation Reserve Program (CRP) fields. The majority of CRP fields on Buffalo Ridge have been planted to stands of either a smooth brome (Bromus inermis)/alfalfa (Medicago sativa) mixture or switch grass (Panicum virgatum). Small patches of woodlands exist near farmsteads and in ravines. The area supports a variety of grassland, wetland, and mixed grassland/woodland bird species during the summer months, and sparse numbers of breeding and migrating waterfowl and shorebird species.

The Buffalo Ridge Study Site is approximately 34 miles (54 km) from the northwest to the southeast corner. We divided the study area into 3 separate units (Figure 1). Unit 2 encompassed the Buffalo Ridge Windplant. Unit 1 (to the northwest of Unit 2) and Unit 3 (to the southeast of Unit 2) included lands under easement for future wind turbine sites. This report only addresses Unit 2.

The Buffalo Ridge Windplant had 73 wind turbines that were located in 10 turbine strings (Fig. 2) The turbine strings were located in 6 sections (T109, R45W,

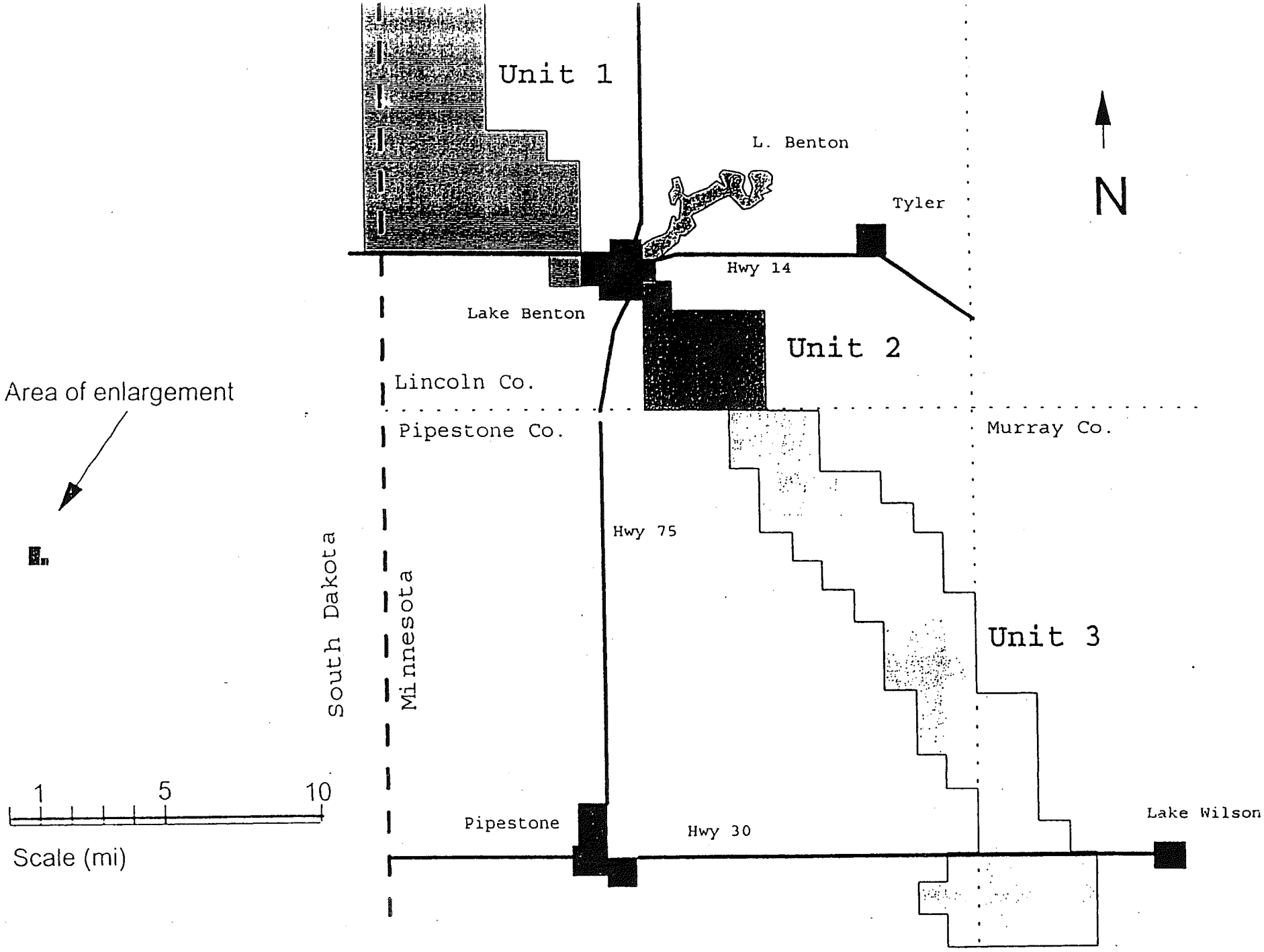

Figure 1. Buffalo Ridge Study Site in southwestern Minnesota, 1994. Wind turbines were located in Unit 2. Units 1 and 3 contained lands under easements for potential future turbine sites.

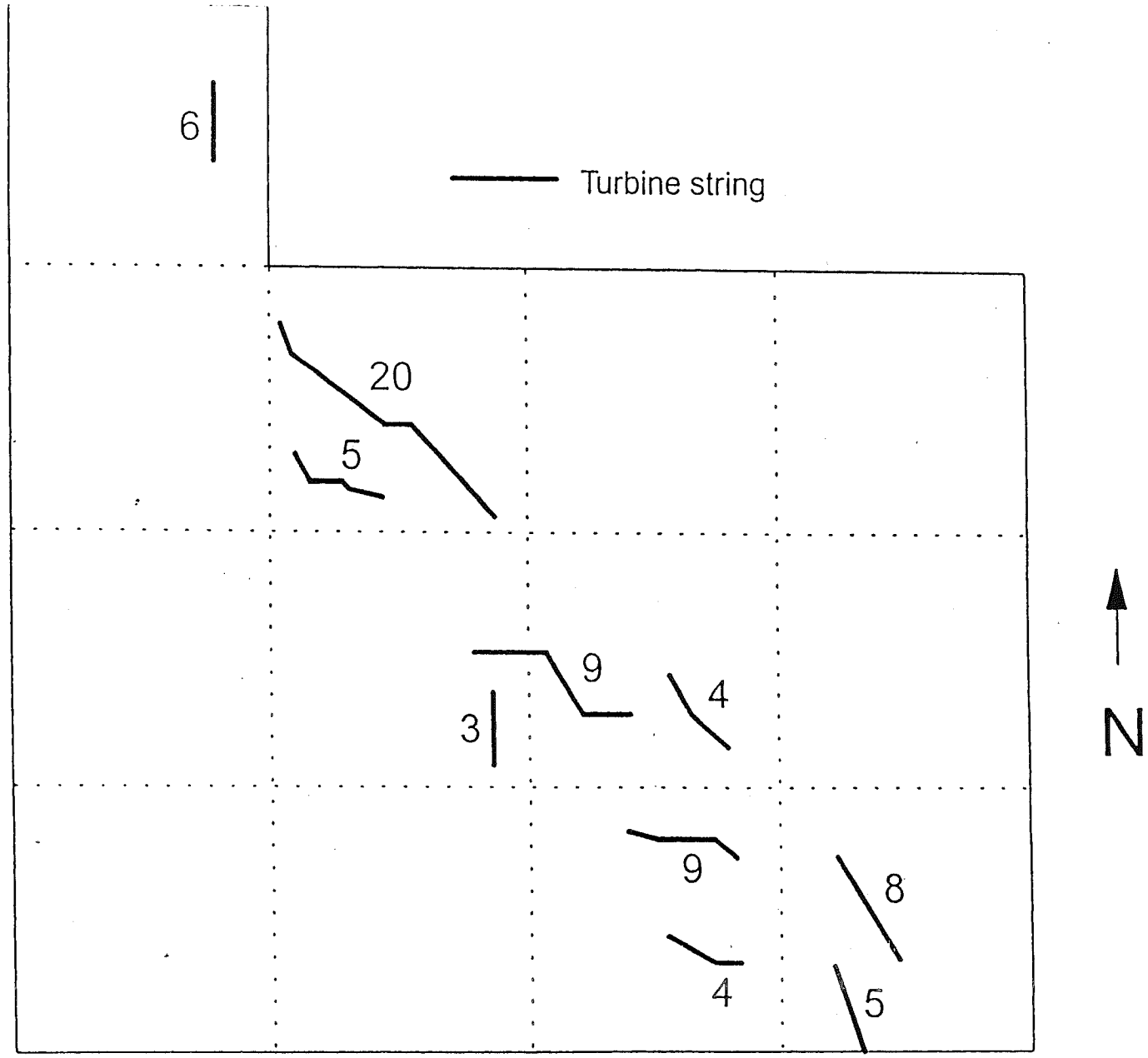

Figure 2. Wind turbine string (N=10) locations (T109N, R45W, sections 16, 22, 26, 27, 35, and 36) in Unit 2 on the Buffalo Ridge Study Site near Lake Benton, Minnesota, 1994. Numbers represent the total turbines in each string. Dotted lines represent legal section lines.

Sec. 16, 22, 26, 27, 35, and 36). The number of wind turbines per string varied from 3 to 20, and within strings, wind turbines were separated by 300-600 feet (91-183 m). Each wind turbine was stationed on top of a 120 foot (37 m) tubular tower and had a blade diameter of 108 feet (33 m). All tower strings were located in corn, soy bean, or CRP fields.

METHODS

We considered the 1994 field season a pilot year. Our primary goal for 1994 was to collect baseline data and examine the effectiveness of our methods in providing basic descriptive data about bird use on the Buffalo Ridge Windplant and proposed future expansion sites. Primary objectives were to: 1) examine species composition and relative abundance of birds throughout the study area, 2) provide a focused description of bird use patterns related to the wind turbines, and 3) determine if avian mortality was occurring as a result of collisions with wind turbines. To meet these objectives, we conducted roadside surveys, activity surveys, and mortality searches. We also searched for occupied raptor nests and conducted raptor road surveys.

Roadside Surveys

We assessed bird species composition and relative abundance on the study area using roadside surveys. We selected a permanent roadside transect that followed paved and improved county roads to enable year-round travel. We selected the transect so that as much of the transect as possible ran adjacent to lands with turbine strings. Unit 2 had 10 stops that were 0.7 miles (1.1 km) apart.

Methods used during roadside surveys were similar to those used during Breeding Bird Surveys conducted each year under the direction of the U.S. Fish and Wildlife Service. At each stop, we recorded the number of birds/species that were seen or heard within a 1/4 mile (0.4 km) radius of the stop location during a 3-minute period. Birds that could not be identified to species were identified to the lowest taxonomic category possible (e.g., unknown sparrow). We started roadside surveys at or near sunrise on days with no precipitation, good visibility, and low to moderate winds. If inclement weather precluded a survey, we postponed the survey until the next suitable day. During May, June, September, and October we conducted one survey/week. In July and August, we conducted two surveys/month. We analyzed roadside survey data using Kruskal-Wallis tests and linear regression (PROC NPAR1WAY, PROC REG, SAS Inst. 1985) to compare numbers of birds and species seen/stop among units and weeks and to test for trends in species seen/stop over time.

Raptor Surveys

In April and May, 1994, we searched 12.5 mi^2 (32 km^2) in Unit 2 for the presence of active raptor nests. We extended our search boundaries to include lands at least 0.5-1.0 miles (0.8-1.6 km) from turbine strings. We drove all available roads before leaf-out. We visually assessed potential raptor nests with spotting scopes and binoculars. We checked potential raptor nests weekly for activity until the nest became occupied or until leaf-out obstructed our vision of the nest. At occupied nests, we recorded the nest location and species of raptor using it.

From 10 June to 26 October 1994, we conducted a raptor road survey to determine temporal and spatial species composition and relative abundance of raptors on the study area. We ran the survey once every 2 weeks from 10 June to 14 September 1994 and once every week for the remainder of the survey period. The survey route traversed Unit 2 and for the most part followed the bird roadside survey route. We started the raptor survey 2-3 hours after sunrise and alternated the starting point (north or south end) each time the survey was run. We drove the survey route at 25 miles per hour (40 km/h) and for each raptor seen we recorded species type, whether the bird was perched or in flight, and the type of perch or estimated flight height above ground. We used linear regression analysis (PROC REG, SAS Inst. 1985) to test for a trend in the number of raptors seen/mile over time.

Activity Surveys

We conducted activity surveys at 2 observation stations in Unit 2 to determine migration patterns and flight characteristics of birds at turbine sites. We selected survey stations that provided an unobstructed view in all directions. Surveys at each site consisted of 3 observation periods: morning, mid-day, and evening. Each observation period consisted of eight 10-minute counts over a 2-hour period. Morning observations were started at sunrise, mid-day observations between 11:00 a.m. and 1:00 PM, and evening observations were started 2 hours before sundown. Morning and evening observation periods were considered important for evaluating passerine and waterfowl and mid-day observation periods for evaluating raptor flights. During each 10 minute count, we identified all birds seen in flight to species or the lowest

taxonomic category possible. For each bird or group of birds seen we recorded the following information: 1) number of birds, 2) bearing direction from the observer (N, NE, E, SE, S, SW, W, or N), 3) angle from observer if greater than 0, 4) estimated flight height (in feet) above ground , 5) estimated distance (in feet) from the observer to determine if there was a flight corridor, 6) flight direction (N, NE, SE, S, SW, W, or NW), and 7) distance (in feet) from the nearest tower. Birds were identified with the assistance of binoculars and spotting scopes. Angles were measured with a clinometer. Observers also recorded wind direction and speed, precipitation, and temperature at the start of each survey. During May through October we conducted surveys at each station once/2 weeks. We analyzed activity survey data with non-parametric methods (PROC NPAR1WAY, SAS Inst. 1985), comparing the number of birds seen and number of species seen among times of day. We used the Kruskal-Wallis test for independent samples (PROC NPAR1WAY, SAS Inst. Inc., 1985). If tests were significant ($P < 0.05$), we used multiple comparison tests to compare treatments.

Bird Mortality Searches

We randomly selected 10 rectangular plots beneath wind turbines on which to conduct bird mortality searches (Fig. 3). Each plot included 3 towers and 41% of all turbines were sampled. Eight of the 10 turbine strings were represented by at least one search plot. Each plot was 400 feet (122 m) wide and extended 200 feet (61 m) beyond the 2 outside turbines enabling searching within a 200-foot (61 m) radius of each turbine. Plot lengths varied between 1,000 and 1,400 feet (305-427 m) because of variable distances between wind turbines. All search plots included a gravel access

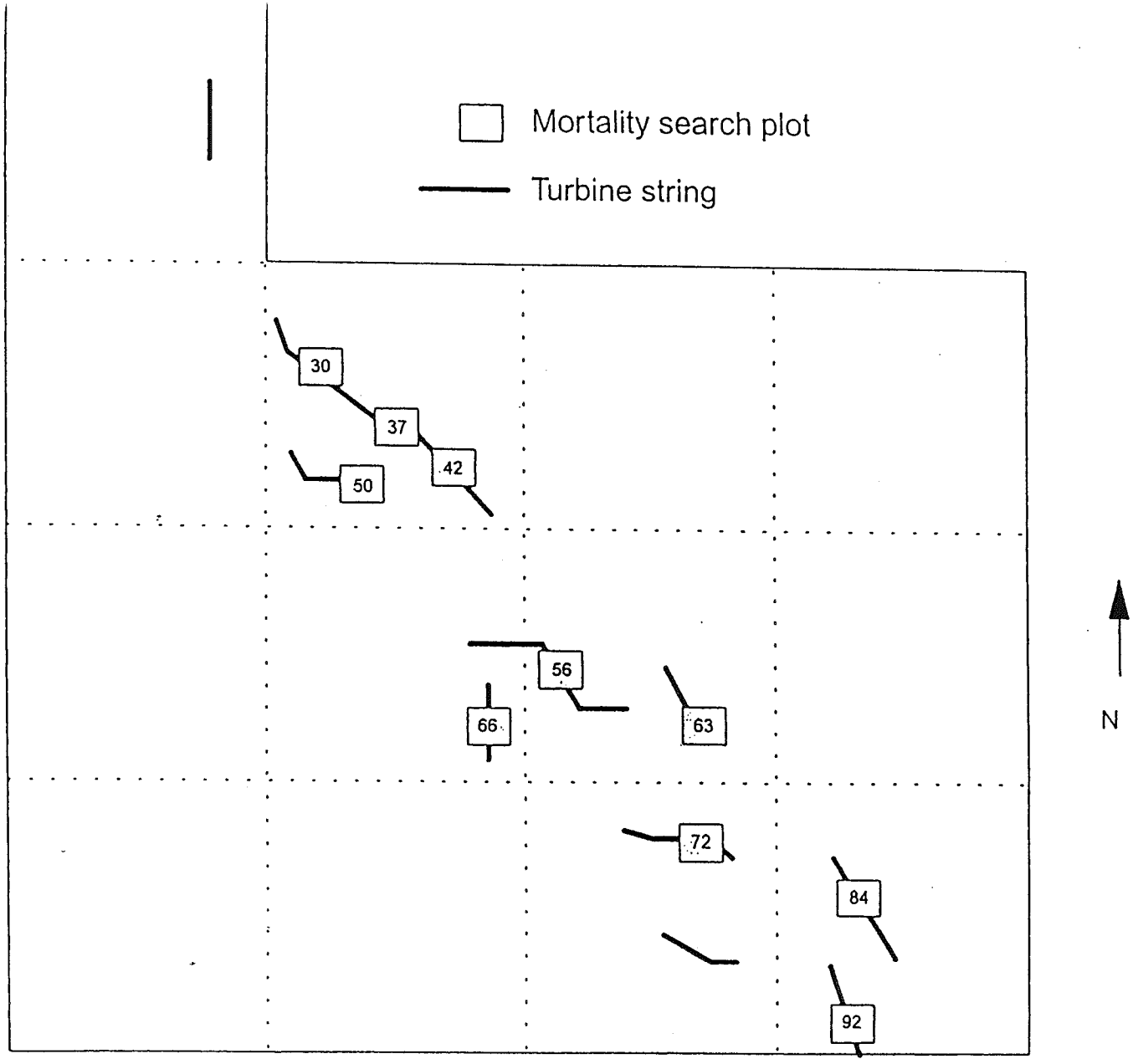

Figure 3. Approximate locations of mortality search plots (N=10) along tower strings in Unit 2 on the Buffalo Ridge Study Site in southwestern Minnesota, 1994. Each search plot contained 3 wind turbines. Numbers represent the middle turbine identification number in each plot. Dotted lines represent legal section lines.

road. Six of the search plots were on land enrolled in CRP and 4 plots were in cropland, mainly corn. The total area under wind turbines searched each week was 38 acres (15.4 ha) in crop fields, and 57.5 acres (23.3 ha) in CRP fields.

We attempted complete searches of plots by walking parallel transects, with each observer separated by an appropriate distance (18-36 feet [5-11 m]) that enabled them to scan the ground for dead birds. During late summer and fall each observer was separated by approximately 18 feet (5 m) in CRP and cropfields. In early summer, observers were separated by approximately 40 feet (12 m) in cropfields. From May 1 to June 30, we searched all turbine plots once/week. In July, we reduced the plot widths from 400 to 200 feet (122 to 61 m) and continued searching with this method through October. The plot width was reduced because heavy cover limited visibility and because our data indicated that most birds fell within a 200 foot (61 m) radius of turbines.

We included 20 additional randomly selected single turbine search plots (170x170 feet [52x52 m]) (Fig. 4) during September and October because we anticipated more bird use of the area during fall migration. Each of the 20 additional search plots included turbines that were not included in our original 3-turbine sample plots. These plots were searched using the same methods that were used to search the 3-turbine plots.

Biases Influencing Bird Mortality Searches

During June we checked for observer detection biases that could influence mortality survey results. On June 2nd and 27th, 1994, we checked for observer bias by

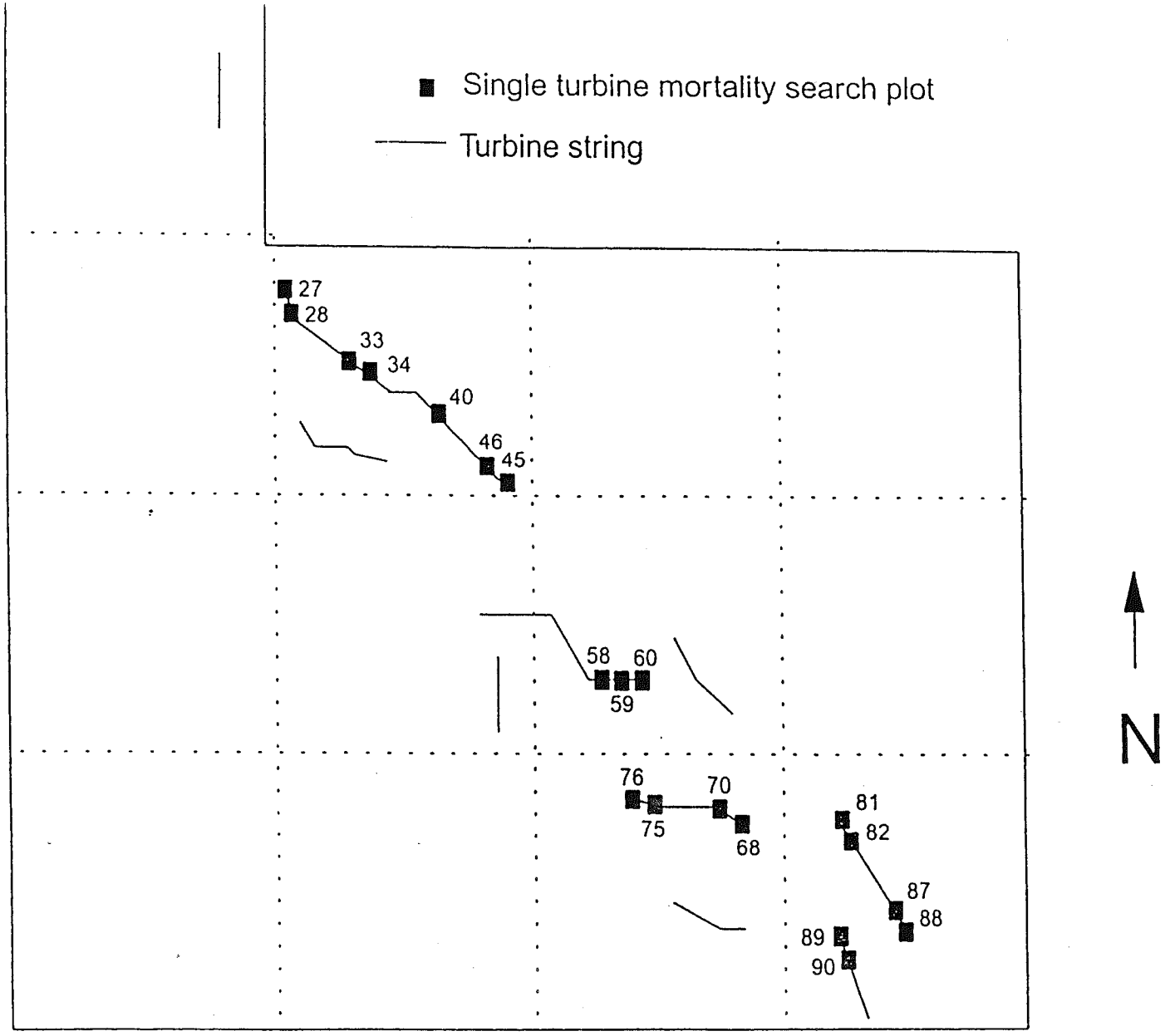

Figure 4. Approximate locations of single turbine mortality search plots (N=20) in Unit 2 on the Buffalo Ridge Study Site in southwestern Minnesota, 1994. Turbine identification numbers are given for turbines in each search plot. Dotted lines represent legal section lines.

placing individually marked salvage birds (black tape around one leg) in search plots. On 2 June 1994, we placed from 4 to 6 birds (20 total) in 4 control plots (2 CRP plots and 2 cropfield plots). On 27 June 1994, we placed 5 to 10 birds (32 total) in 5 tower plots. Birds used during observer bias surveys ranged in size from blackbirds to geese.

We evaluated the rate at which scavengers removed birds from the turbine plots by placing individually marked salvage birds (black tape on one leg) in tower plots and monitoring them daily for 8 days. On 14 June 1994, we randomly placed 15 birds in 5 turbine plots, and on 27 June 1994, we repeated the procedure with 15 more birds. Birds ranged in size from blackbirds to owls. We marked the location of each carcass by placing a small white flag from 5 to 10 paces from the bird.

We also investigated bird decomposition rates to determine how long a dead bird on the tower plots would be visible to observers. We placed 30 robin-sized salvage birds in 10 live traps (3 birds/trap). The live traps prevented scavenging. Five containers were placed on bare ground and 5 containers in tall grass. We monitored, photographed, and recorded the general conditions of the birds daily for 8 days.

Finally, we evaluated how far from a tower a bird might land after striking a wind turbine blade. In these experiments, we dropped salvage birds from the top of a tower on a windy day while the wind turbine was non-operational and subsequently recorded the distance from the final resting place of the bird to the base of the tower.

RESULTS

Roadside Surveys

From 5 May to 25 October 1994, we conducted 19 roadside surveys in Unit 2. We recorded 3,817 birds representing 60 species in 1,052 observations (Table 1). Red-winged blackbirds (scientific names appear in Appendix A) were the most commonly observed species (10.2% of total observations), followed by western meadowlarks (9.2%), barn swallows (4.2%), American crows (4.1%), ring-necked pheasants (4.7%) and vesper sparrows (4.7%). Ten species (western meadowlark, red-winged blackbird, barn swallow, American crow, ring-necked pheasant, vesper sparrow, American robin, common grackle, mourning dove, and common yellowthroat) constituted 50% of all observations. Red-winged blackbirds were the most abundant species during roadside surveys (32% of all birds seen) followed by European starlings (9.2%), barn swallows (6.1%), and western meadowlarks (4.6%). All other species constituted <5.0% each of the total birds seen. Six species (red-winged blackbird, barn swallow, European starling, western meadowlark, common grackle, and American crow) comprised 50% of total birds seen during roadside surveys. Four species of raptors were recorded during surveys (Table 1). A Kruskal-Wallis test revealed no difference for the average number of birds seen/count among weeks (Table 2). In general, there was a downward trend in the average number of species seen/count from May-October (Table 3).

Table 1. Total number of observations and birds per species counted during road surveys conducted in Unit 2 at the Buffalo Ridge Study Site, Minnesota during May-September, 1994. Bird species are listed in phylogenic order. Scientific names for listed species are given in Appendix A.

Species	Total Number of Observations	Total Number of Birds
Franklin's Gull	1	15
Double-Crested Cormorant	1	8
Mallard	16	31
Blue-winged Teal	2	2
Northern Pintail	1	1
Wood Duck	1	3
Canada Goose	2	3
Great Blue Heron	4	4
Sora	1	1
Upland Sandpiper	1	1
Lesser Golden Plover	1	2
Killdeer	34	39
Gray Partridge	2	2
Ring-necked Pheasant	49	66
Rock Dove	26	112
Mourning Dove	36	95
Northern Harrier	9	11
Sharp-shinned Hawk	1	2
Red-tailed Hawk	13	13
Swainson's Hawk	3	4
Downy Woodpecker	1	1
Red-headed Woodpecker	8	8
Northern Flicker	8	9
Eastern Kingbird	15	28
Horned Lark	26	78
Blue Jay	14	17
American Crow	44	144
European Starling	31	346
Bobolink	15	22
Brown-headed Cowbird	34	84
Yellow-headed Blackbird	1	3
Red-winged Blackbird	108	1,241
Western Meadowlark	97	161

Table 1. Continued

Species	Total Number of Observations	Total Number of Birds
Common Grackle	30	115
American Goldfinch	11	19
Vesper Sparrow	34	67
Savannah Sparrow	28	48
Grasshopper Sparrow	14	22
LeConte's Sparrow	1	1
White-crowned Sparrow	1	1
White-throated Sparrow	3	14
American Tree Sparrow	2	3
Chipping Sparrow	1	1
Clay-colored Sparrow	6	9
Field Sparrow	5	5
Song Sparrow	36	63
Lincoln's Sparrow	1	2
Dickcissel	24	56
Cliff Swallow	1	1
Barn Swallow	45	223
Common Yellowthroat	47	77
House Sparrow	14	116
Brown Thrasher	5	5
House Wren	3	3
Sedge Wren	8	16
Marsh Wren	1	2
Black-capped Chickadee	2	2
American Robin	38	68
Unknown	5	7
Unknown Blackbird	17	158
Unknown Duck	4	24
Unknown Hawk	1	1
Unknown Passerine	13	26
Unknown Sparrow	43	102
Unknown Woodpecker	1	1
Unknown Warbler	1	2
Total: 60 Species	1,052	3,817

Table 2. Average number of birds seen per stop per week during road surveys in Unit 2 on the Buffalo Ridge Study Site near Lake Benton, Minnesota, May-October, 1994.

	Average number of birds seen/stop
Week	Unit 2
1	33.1
2	17.5
3	10.8
4	29.4
5	13.3
6	21.4
7	10.7
9	12.3
11	15.3
13	17.0
16	19.3
18	12.6
19	9.5
20	14.9
22	13.1
23	19.1
24	29.0
25	70.8
26	12.6
Weeks combined	20.1

Table 3. Average number of species seen per stop per week during road surveys in Unit 2 on the Buffalo Ridge Study Site near Lake Benton, Minnesota, May-October, 1994.

	Average number of species seen/stop
Week	Unit 2
1	7.6
2	8.6
3	7.5
4	10.9
5	5.6
6	7.7
7	5.8
9	5.5
11	7.0
13	6.0
16	4.5
18	3.5
19	2.5
20	5.0
22	2.2
23	3.5
24	4.7
25	4.9
26	2.2
Weeks combined	5.5

Raptor Surveys

Nest Searches.--During raptor nest searches in April and May, 1994, we recorded 1 occupied nest in Unit 2.

Raptor Road Surveys.--Thirteen road surveys were conducted in Unit 2 in search of raptors from 10 June to 26 October 1994. During raptor surveys, we recorded 4 species and a total of 25 raptors (Table 4). Red-tailed hawks, northern harriers, and American kestrels constituted 96% of the total number of raptors seen during surveys. The number of raptors seen/mile of survey route ranged from 0.1 to 0.6. The number of raptors seen/mile of survey route was highest during late summer and fall , most likely due to influxes of young birds coming off the nest and migrants. An average of 0.2 raptors/mile were seen.

Activity Surveys

Number of birds seen.--We completed 60 activity assessments for a total of 480 activity periods. From May to October, we saw 3,602 birds representing 37 species during site observations (Table 5). Red-winged black birds (33.8%) comprised most of birds seen followed by common grackles (8.3%). About 2% of all birds seen were raptors. All other species made up less than 5% each of the total. The number of birds seen per 10-minute count varied among survey times (Table 6). We saw more birds ($P < 0.01$) during morning observation periods (11.3/count) than at mid-day (5.7/count) or evenings (6.4/count). The number of birds observed did not differ between the North and South Stations. Bird numbers were generally higher during spring and fall (Fig. 5).

Table 4. Number and species of raptors seen during road surveys (N=13) in search of raptors on the Buffalo Ridge Study Site near Lake Benton, Minnesota.

	Total number seen
Species	Unit 2
American Kestrel	2
Northern Harrier	7
Red-tailed Hawk	15
Swainson's Hawk	1

Table 5. Bird species, total number seen of each species, and the number of times each species was seen during activity surveys in Unit 2 on the Buffalo Ridge Study Site near Lake Benton, Minnesota, 1994. Birds are listed in phylogenic order. Scientific names for listed species are given in Appendix A.

Species	Total birds seen	Total times seen
Ring-billed gull	1	1
Franklin's gull	79	15
Double-crested cormorant	1	1
American white pelican	245	2
Mallard	71	36
Blue-winged teal	10	8
Northern pintail	2	1
Canada goose	25	2
Great blue heron	9	5
Killdeer	2	2
Ring-necked pheasant	7	7
Rock dove	146	38
Mourning dove	26	17
Northern harrier	25	22
Red-tailed hawk	31	29
Swainson's hawk	16	16
American kestrel	2	2
Yellow-shafted flicker	2	2
Common nighthawk	1	1
Chimney swift	1	1
Eastern kingbird	4	4
Horned lark	15	3
Bluejay	51	9
American crow	69	38
European starling	100	10
Bobolink	49	45
Lapland longspur	10	2
Brown-headed cowbird	39	24
Red-winged blackbird	1,219	252
Western meadowlark	32	24
Common grackle	299	68
American goldfinch	12	2
Vesper sparrow	5	5
Savannah sparrow	5	4
Dickcissel	13	12

Table 5. (continued).

Species	Total birds seen	Total times seen
Barn swallow	79	38
American robin	8	3
Unknown sparrow	16	11
Unknown swallow	16	8
Unknown duck	27	9
Unknown	13	8
Unknown gull	3	1
Unknown sandpiper	2	1
Unknown hawk	21	17
Unknown blackbird	483	62
Unknown passerine	309	22
Total: 59 species	3,602	890

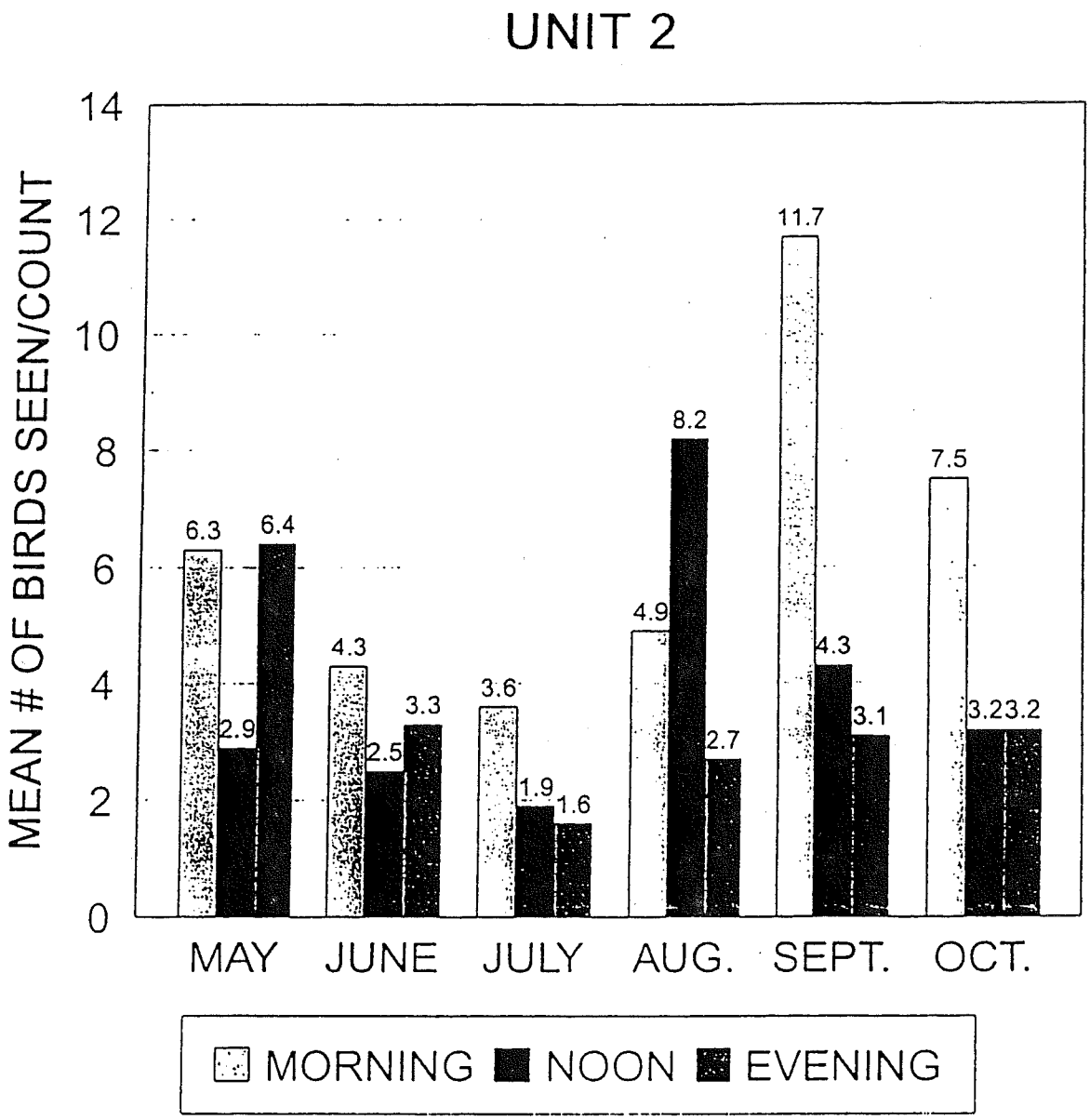

Figure 5. Mean number of birds seen per 10 min. count period during activity surveys on Unit 2 at the Buffalo Ridge Study Site, May-Oct. 1994.

Table 6. Numbers of birds seen per 10-minute activity period during activity surveys in Unit 2 on the Buffalo Ridge Study Site near Lake Benton, Minnesota, 1994.

	Average number of birds seen/10-minute count
Time Period	Unit 2
Morning	8.3
Mid-day	7.1
Evening	5.1
Times combined	7.1

Number of species seen--. In Unit 2 we saw 1.5 species/count. The number of species seen/count was highest in the morning except in May and August (Fig. 6). We saw more species during spring (Fig. 7).

Bird flight characteristics.--Most (75%) of the birds seen flew less than 70 feet (21 m) above the ground (Fig. 8). About 16% flew at a height of 70-170 feet (21-51 m) above the ground, a height range that would allow for collisions with wind turbines. There was no general trend in the distance that birds flew from observers (Fig. 9). Most birds seen were more than 500 feet (155 m) from an observer. About 80% of the birds seen were 100 feet (31 m) or farther away from the nearest turbine at the time of sighting (Fig. 10); about 5% of the birds were seen within 50 feet (16 m) of the towers.

Bird Mortality Searches

Multiple Turbine Plots.--We conducted 226 bird mortality searches (66 searches at 400 foot [122 m] width and 160 at 200 feet [61 m] width) on randomly selected multiple turbine plots from May-October, 1994. Approximately 333.8 hours were spent conducting mortality searches on multiple turbine plots. We also conducted 81 searches of control sites (39 at 400 feet (122 m) width and 42 at 200 feet (61 m) width from May-October that totaled 135.3 hours of search time.

During bird mortality searches in Unit 2, we found 3 dead birds and 5 dead bats (Table 7). Three bats and a sedge wren were found on service roads. The rock doves (commonly called pigeons) were found near the base of a tower. We did not attribute the death of any of the birds to collision with a wind turbine. Remains of the rock doves suggested they had been shot and partially eviscerated before being

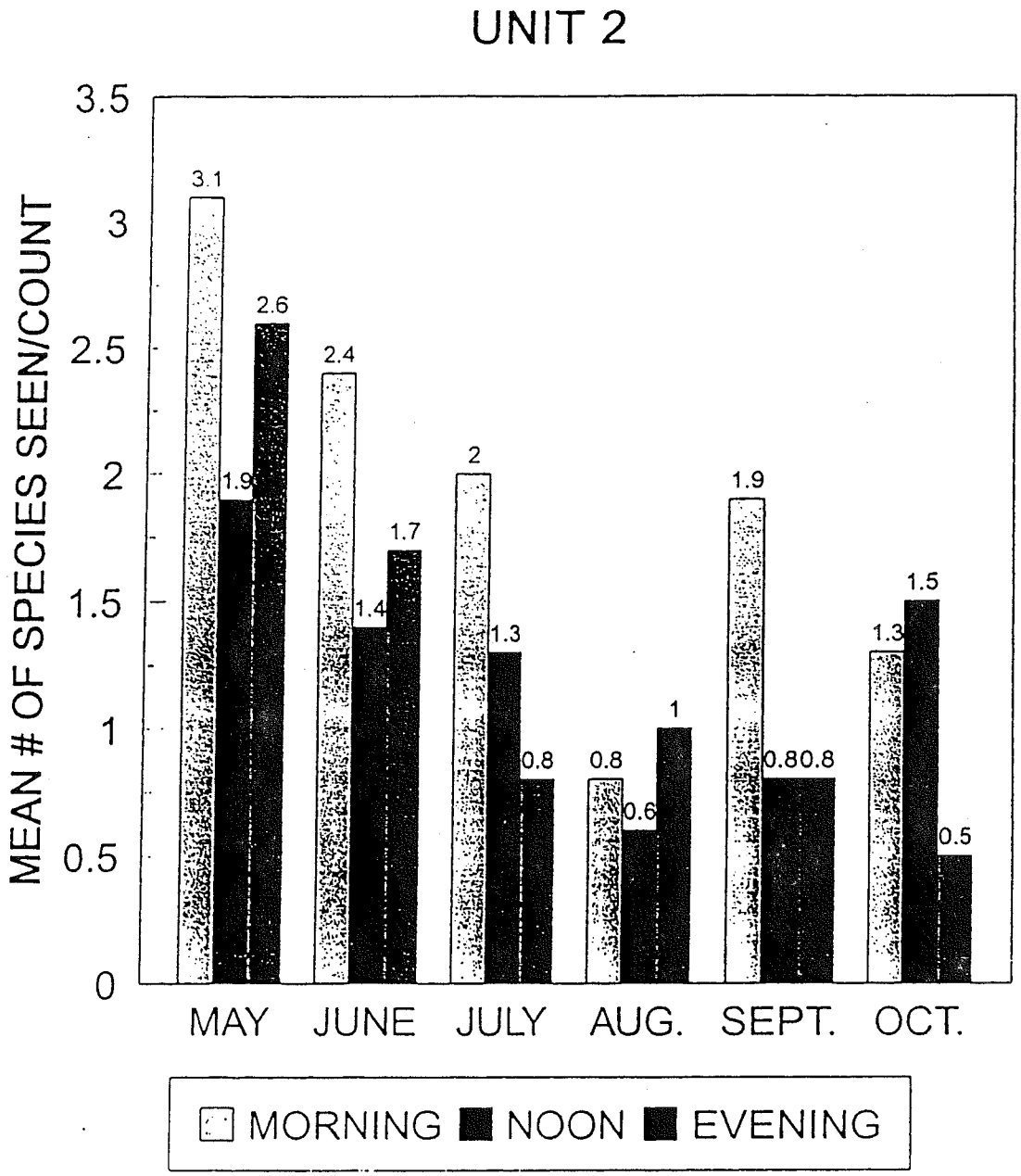

Figure 6. Mean number of bird species seen per 10 minute count period during activity surveys on Unit 2 at the Buffalo Ridge Study Site, May-Oct. 1994.

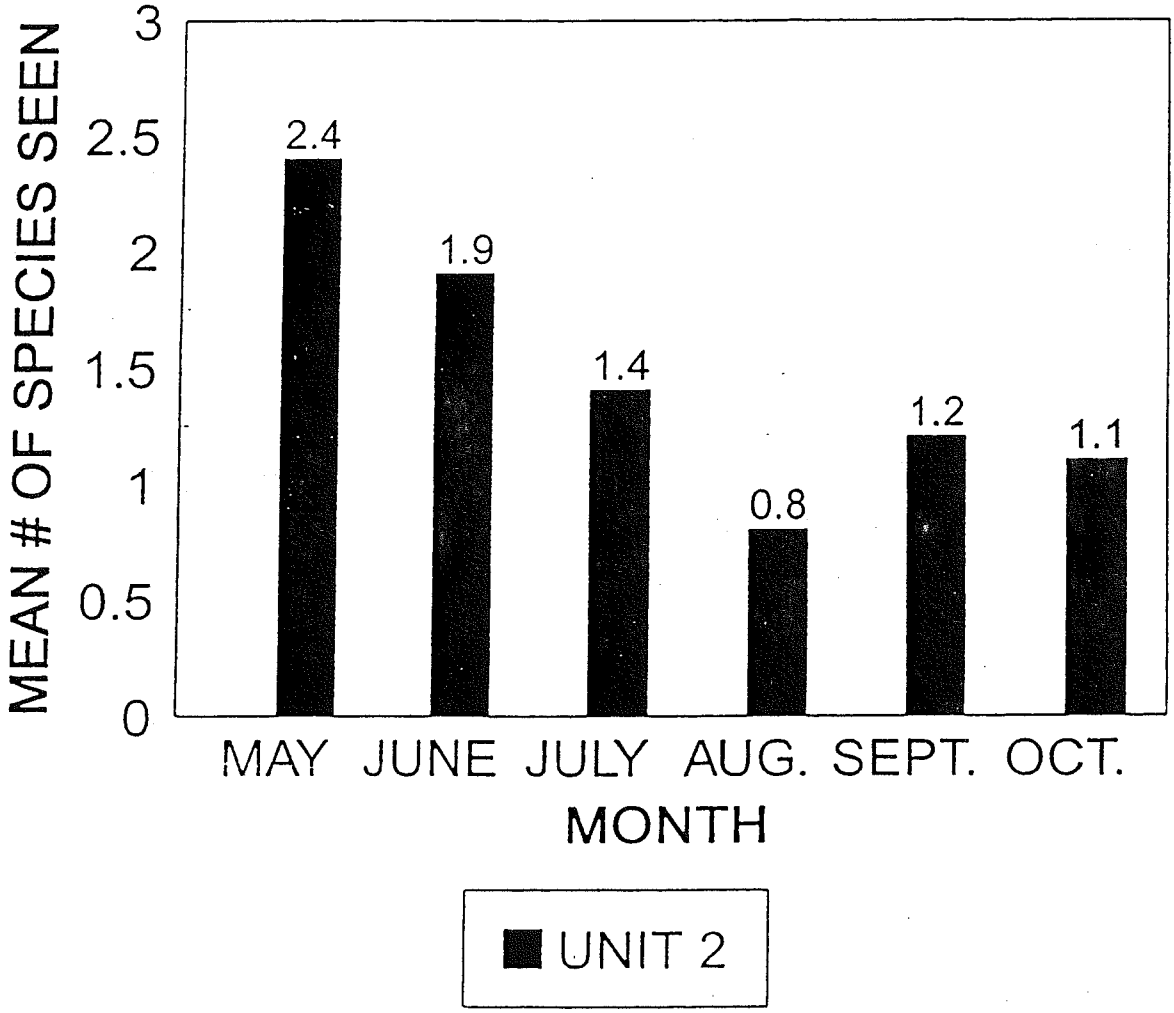

Figure 7. Mean number of bird species seen per 10 minute count on Unit 2 during activity surveys on the Buffalo Ridge Study Site, May-Oct. 1994.

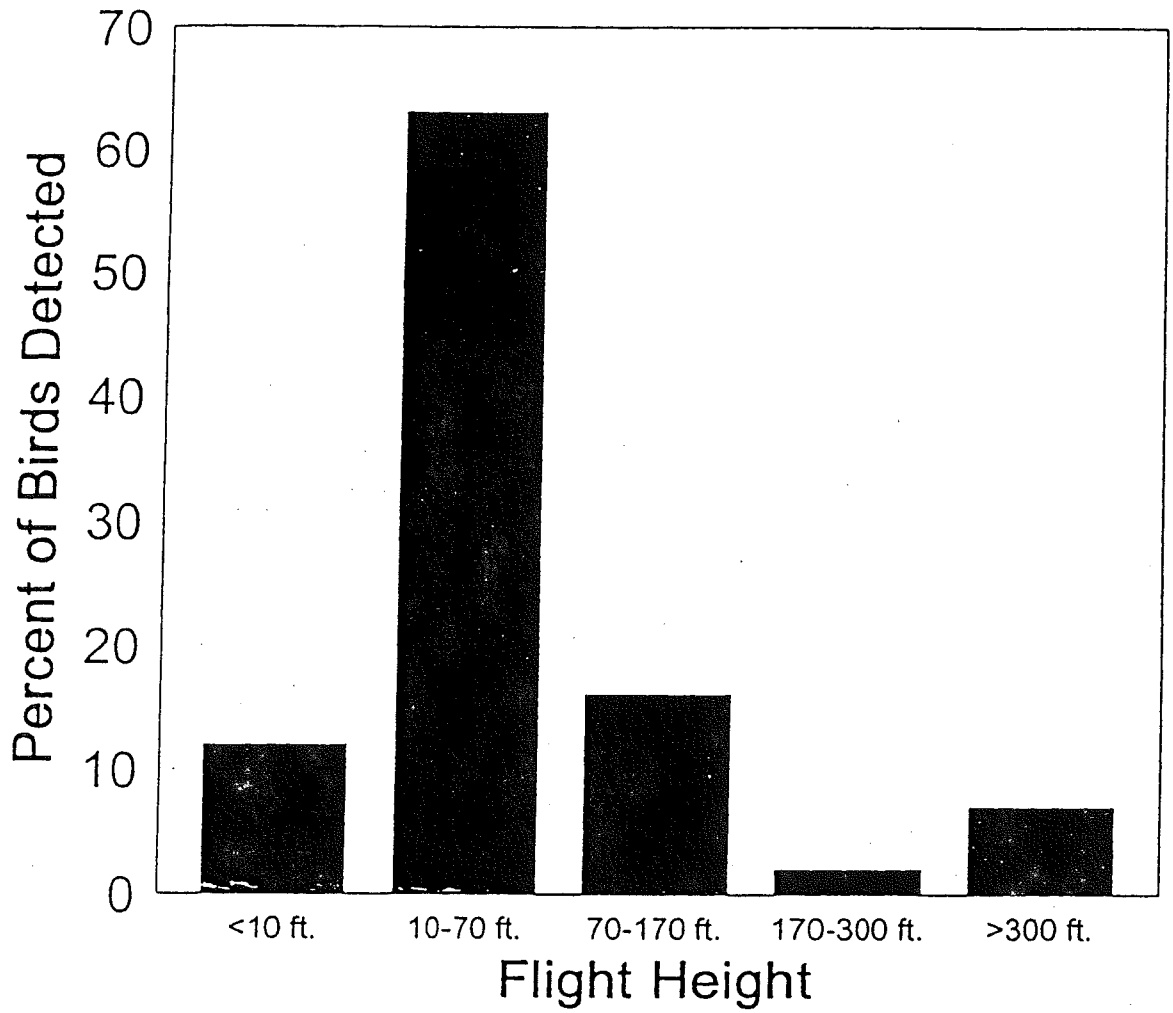

Figure 8. Flight heights of birds (N=11,072) detected during activity surveys on Unit 2 at the Buffalo Ridge Study Site, May-Oct. 1994, expressed as a percentage of total observations.

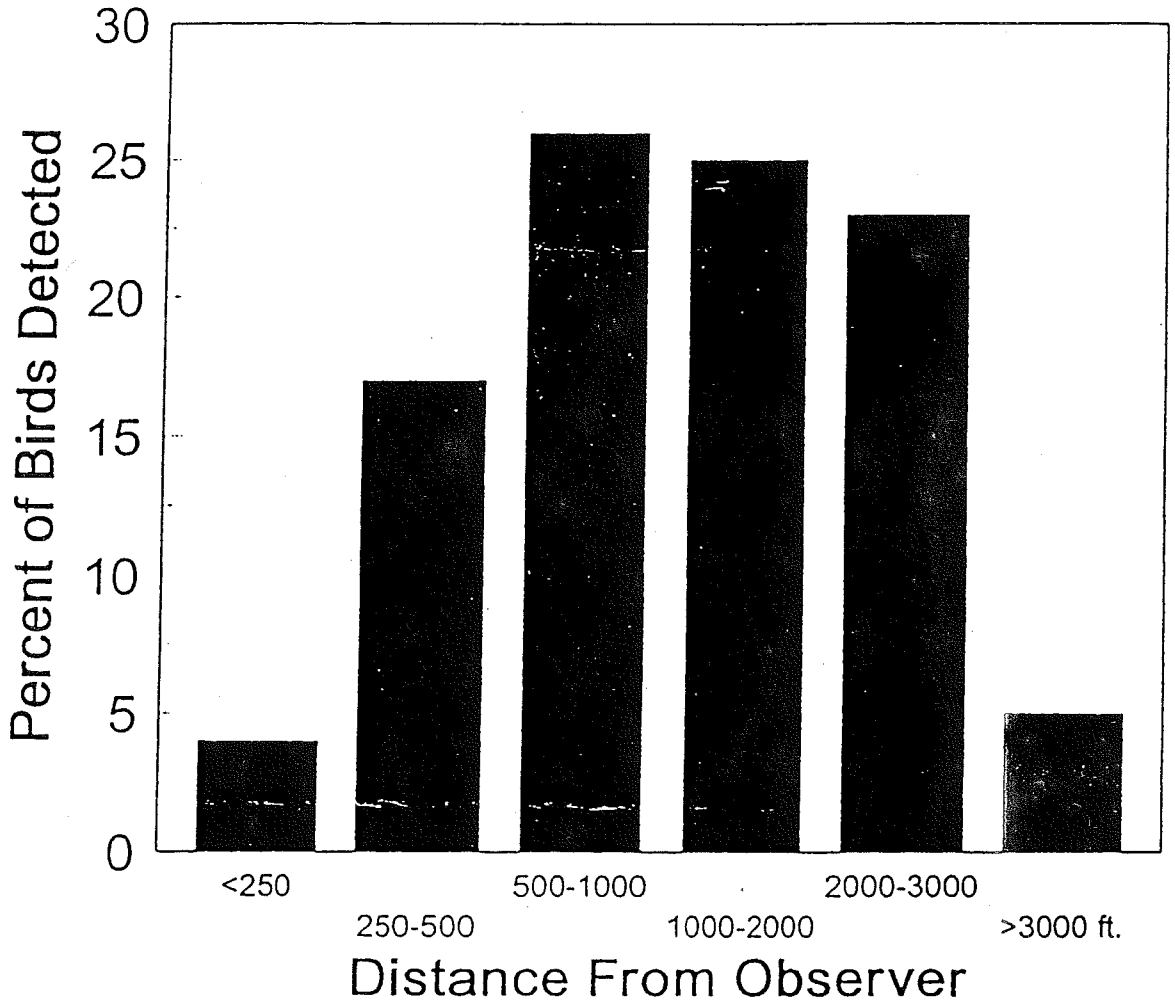

Figure 9. Distances (feet) birds were detected from observers during activity surveys on Unit 2 at the Buffalo Ridge Study Site, May-Oct. 1994, expressed as a percentage of total observations.

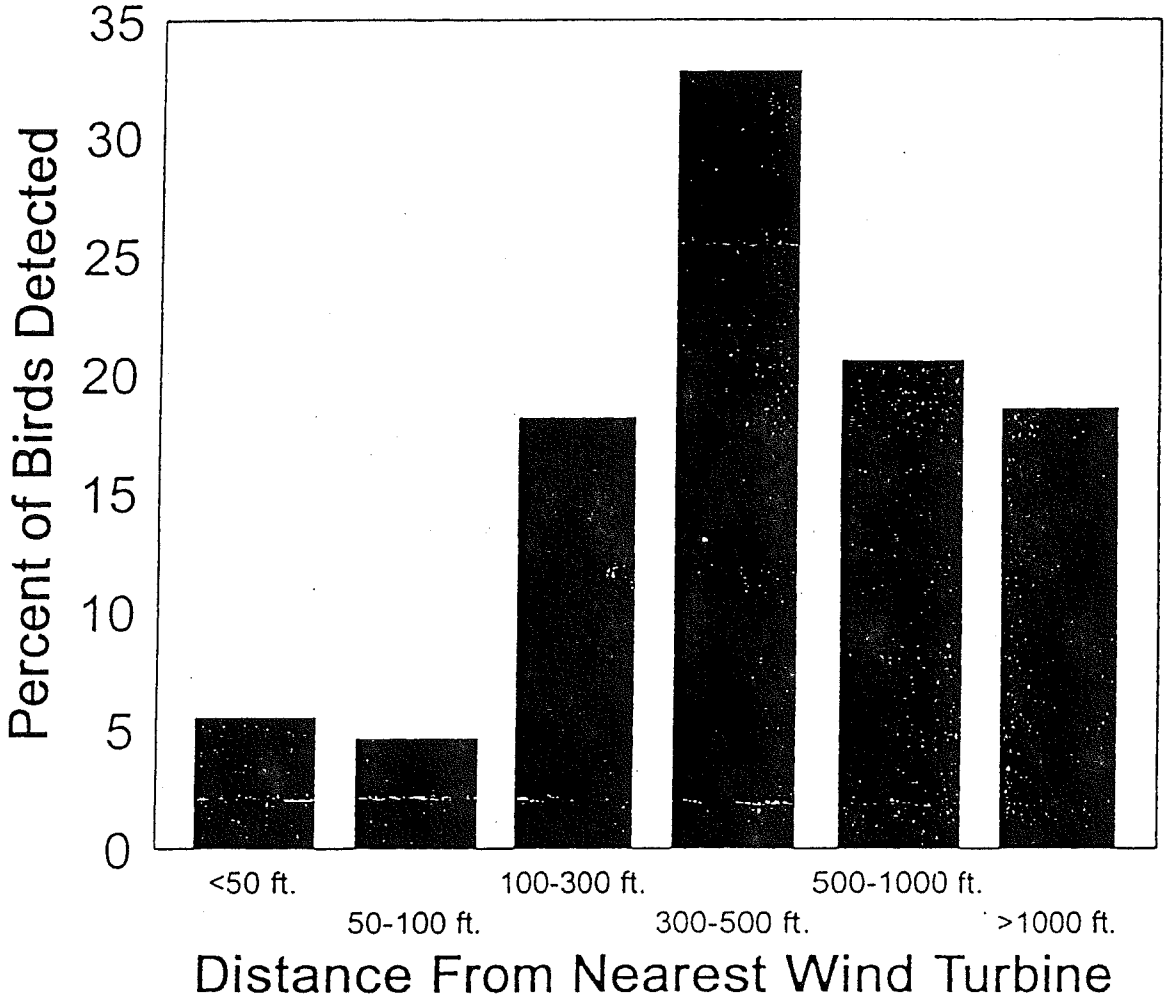

Figure 10. Distance to nearest wind turbine of birds (3,602) detected during activity surveys on Unit 2 at the Buffalo Ridge Study Site, May-Oct. 1994, expressed as a percentage of total observations.

left next to a tower. We attributed the death of the sedge wren to being struck by a vehicle prior to the vehicle coming onto the site. Due to its distorted shape, it is likely the wren fell off the grill or bumper as the vehicle passed through the search plot area. Two of the dead bats were found outside our mortality or control plots (Table 7), and 2 other dead bats were reportedly seen on site, but not collected by maintenance personnel during late summer. We found no dead birds during searches on control plots. All bats found were native to the area.

Single Turbine Plots.--During September-October we conducted 140 bird mortality searches on single turbine plots totaling approximately 13 hours of search time. We found no dead birds during mortality searches in single turbine plots.

Biases Influencing Bird Mortality Searches

Distance from towers that birds fell.--We conducted 6 trials, using a mourning dove and a gray partridge. Each bird was dropped from a tower 3 times while the turbine was not operating. During trials, wind direction was southeast and wind speed was 15-25 mph (24-40 km/h). The mourning dove landed from 50 to 85 feet (16 to 26 m) from the tower, whereas the gray partridge landed from 15 to 50 feet (4-15 m) from the tower (Table 8).

Detection bias.--Detection bias tests varied between cropland and CRP. In cropland, 18 of 22 (81.8%) placed birds were found (Table 9), whereas in CRP, 19 of 30 (63.3%) were found. During the early test period (late May), 80% (N=20) of the birds were found. During the second test period (late June), 66% of the placed birds (N=32) were found even though the height of standing cover was approximately 2-3 feet.

Table 7. Composition and location of species found during bird mortality searches on multiple and single wind turbine plots in Unit 2 at the Buffalo Ridge Windplant near Lake Benton, Minnesota, May-October, 1994.

Species	Turbine # found by	Distance from turbine	Bearing from turbine	Date found
Big Brown Bat[a] (Eptesicus fuscus)	5466	45 ft	105°	7/18
Hoary Bat[b] (Lasiurus cinereus)	5469	63 ft	45°	9/22
Hoary Bat[c]	5486	122 ft	128°	9/14
Silver-haired Bat[a] Lasionycteris noctivagans)	5466	52 ft	55°	8/24
Silver-haired Bat[a]	5466	42 ft	110°	9/6
Rock Dove[a]	5472	24 ft	240°	10/17
Rock Dove (remains)[a]	5472	12 ft	238°	10/17
Sedge Wren[a]	5430	84 ft	75°	9/19

[a] Species found during multiple turbine plot search.
[b] Species found during single turbine plot search.
[c] Species found incidentally.

Table 8. Distances from the base of wind turbines that birds fell when dropped from the top of turbines at the Buffalo Ridge Study Site near Lake Benton, Minnesota 1994.

Bird	Trial number	Distance ft)
Mourning dove	1	85
	2	55
	3	78
Gray partridge	1	45
	2	50
	3	27

Table 9. Number of birds found during detection bias trials on the Buffalo Ridge Study Site near Lake Benton, Minnesota, 1994.

	Bird size placed			
Land use	Small (blackbird)	Medium (duck/pigeon)	Large (goose/owl)	Total
CRP	3/9 (33.3%)	11/15 (73.3%)	5/6 (83.3%)	19/30 (63.3%)
Crop	12/14 (85.7%)	4/6 (66.7%)	2/2 (100%)	18/22 (81.8%)
Total	15/23 (65.2%)	15/21 (71.4%)	7/8 (87.5%)	37/52 (71.1%)

Scavenger rates.--The scavenger rate of birds at the tower plots was low. In the first trial, 12 of 15 (80%) dead birds were still in place after 1 week (Table 10). In the second trial, 12 of 15 (80%) birds were still in place after 5 days.

Decomposition rates.--Most of the birds we examined for decomposition rate were still wholly intact after 1 week of exposure to the elements on tower plots. Birds placed on bare ground stayed intact and, in general were in better condition than birds placed in CRP fields. Insects were feeding on carcasses, but feathers, wings, legs, and heads of birds remained attached to the body for at least 1 week post-placement.

SUMMARY

1. The average number of species seen/count during roadside and activity surveys on the study site was highest in the spring and generally decreased throughout the remainder of the study period.

2. Blackbirds (brown-headed cowbirds, common grackles, European starlings, and red-winged black birds) western meadowlarks, barn swallows, American crows, American robins, mallards, vesper and savannah sparrows, northern harriers, and red-tailed hawks were the most common species seen during roadside and activity surveys from May-October, 1994.

3. Raptors were seen in Unit 2 during all types of surveys we conducted. The number of raptors seen/mile of survey route was low in Unit 2, and only 1 raptor nest was found during nest searches. No eagles were observed. Although the low number of raptors in Unit 2 may be a result of the low amount of foraging and/or nesting habitat

Table 10. Scavenger rate of birds placed on mortality search plots on the Buffalo Ridge Study Site near Lake Benton, Minnesota, 1994.

Trial number	Number of birds placed	Number of birds remaining					
1 (June 14)		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
	15	15	15	13	12	12	12	12
2 (June 27)		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
	15	14	14	14	12	12	8	8

available, it is possible that the presence of wind turbines may be affecting the distribution of raptors and other birds in Unit 2.

4. Waterfowl and shorebird use of the study site from May-October was low. Mallard was the most common waterfowl species seen and killdeer was the most common shorebird species seen on the study site.

5. No threatened or endangered birds covered by current state or federal regulations were seen during roadside, activity, or raptor surveys on Unit 2 of the Buffalo Ridge Study Site from May-October, 1994.

6. Only 16% of the total birds seen during activity surveys were seen at a height (70-170 feet, 22-55 m) which would make collision with a wind turbine possible. Only 10% of the birds seen during activity surveys were observed within 100 feet of a wind turbine. Birds seen flying through tower strings often adjusted their flight patterns when turbine blades were rotating and often made no adjustments when turbine blades were not rotating, suggesting that birds could detect blade movement.

7. During mortality searches (N=366) in multiple (May-October, 1994) and single turbine plots (September-October, 1994) we found 3 dead birds and 5 dead bats. Three of the dead bats were found within 60 feet (19 m) of turbine 5466. None of the bird deaths were attributed to collision with a wind turbine. The bats found during mortality searches were probably killed by collision with a wind turbine. Bats are most active at night . No dead birds were found during mortality searches (N=81) in control plots.

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Appendix A. Scientific names and AOU numbers of birds seen on Buffalo Ridge Study Site, Minnesota during May-October, 1994. Bird species are listed in phylogenic order. Common and scientific names follow those used by DeGraaf et al. (1991).

Species	Scientific Name	AOU #
Ring-billed Gull	Larus delawarensis	54
Franklin's Gull	Larus pipixcan	59
Double-Crested Cormorant	Phalacrocorax auritus	120
American White Pelican	Pelecanus erythrorhynchos	125
Mallard	Anas platyrhynchus	132
Blue-winged Teal	Anas discors	140
Northern Pintail	Anas acuta	143
Wood Duck	Aix sponsa	144
Canada Goose	Branta canadensis	172
Great Blue Heron	Ardea herofias	194
Sora	Porzana carolina	214
Upland Sandpiper	Bartramia longicauda	261
Lesser Golden Plover	Pluvialis dominica	272
Killdeer	Charadrius vociferus	273
Gray Partridge	Perdix perdix	288
Ring-necked Pheasant	Phasianus colchicus	309
Rock Dove	Columbia livia	313
Morning Dove	Zenaida macroura	316
Northern Harrier	Circus cyaneus	331
Sharp-shinned Hawk	Accipiter striatus	332
Red-tailed Hawk	Buteo jamaicensis	337
Swainson's Hawk	Buteo swainsoni	342
American Kestrel	Falco sparvarius	360
Downy Woodpecker	Picoides pubescens	394
Red-headed Woodpecker	Melanerpes eurythrocephalus	406
Northern Flicker	Colaptes auratus	412
Common Nighthawk	Chordeiles minor	420
Chimney Swift	Chaetura pelagica	423
Eastern Kingbird	Tyrannus tyrannus	444
Horned Lark	Eremophila alpestris	474
Blue Jay	Corvus corax	477
American Crow	Corvus brachyrhynchos	488
European Starling	Sturnus vulgaris	493
Bobolink	Dolichonys oryzivorus	494
Brown-headed Cowbird	Molothrus ater	495
Yellow-headed Blackbird	Xanthocephalus xanthocephalus	497
Red-winged Blackbird	Agelaius phoeniceus	498
Western Meadowlark	Sturnella neglecta	501.1
Common Grackle	Quiscalus quiscala	510
American Goldfinch	Carduelis tristis	529

Lapland Longspur	Calcarius lapponicus	536

Appendix A. Continued.

Species	Scientific Name	AOU #
Vesper Sparrow	Pooecetes gramineus	540
Savannah Sparrow	Passerculus sandwichensis	542
Grasshopper Sparrow	Ammodramus savannarum	546
LeConte's Sparrow	Ammodramus leconteii	548
White-crowned Sparrow	Zonotrichia leucophrys	554
White-throated Sparrow	Zonotrichia albicollis	558
American Tree Sparrow	Spizella arborea	559
Chipping Sparrow	Spizella passerina	560
Clay-colored Sparrow	Spizella pallida	561
Field Sparrow	Spizella pusilla	563
Song Sparrow	Melospiza melodia	581
Lincoln's Sparrow	Melospiza lincolnii	583
Dickcissel	Spiza americana	604
Cliff Swallow	Hirundo pyrrhonota	612
Barn Swallow	Hirundo rustica	613
Tree Swallow	Tachycineta bicolor	614
Bank Swallow	Riparia riparia	616
Common Yellowthroat	Geothlypis trichas	681
House Sparrow	Passer domesticus	688.2
Brown Thrasher	Toxostoma rufum	705
House Wren	Troglodytes aedon	721
Sedge Wren	Cistothorus platensis	724
Marsh Wren	Cistothorus palustris	725
Black-capped Chickadee	Parus atricapillus	735
American Robin	Turdus migratorius	761

Appendix B. Legal descriptions of activity survey points on the Buffalo Ridge Study Site near Lake Benton, Minnesota, 1994.

Station	Description
Unit 2 North	T109N, R45W, Sec. 22. The point is approximately 50 feet north of turbine 5437.
Unit 2 South	T109N, R45W, Sec. 36. The point is between turbines 5486 and 5487 on the service road.