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Bird and Bat Interactions With Wind Turbines Castle River Wind Farm, Alberta

2001-2002

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SUMMARY

INTRODUCTION

Vision Quest Windelectric Inc. began a program in 1999 to examine bird and bat interactions with wind turbines in southern Alberta. To assess factors that may contribute to collisions of birds and bats with wind turbines, and to determine collision rates of each group of species, we observed bird reactions to turbines and systematically surveyed the ground around turbines for bird and bat carcasses at Vision Quest's Castle River Wind Farm between April 2001 and December 2002 and at other Vision Quest turbines in southern Alberta prior to construction of the wind farm. These are the first systematically collected data on bird and bat collisions from a Canadian wind farm.

STUDY AREA

Castle River Wind Farm

The Castle River Wind Farm is located in southern Alberta, 5 km west of the town of Pincher Creek. It comprises 60 Vestas model V47-660 turbines in 7 arrays. Turbines are set on 50-m-high, tubular-steel towers, with a diameter-at- base of about 3 m. Each turbine has 3 blades, with a rotor diameter of 47 m. Blades turn at speeds of 20-35 revolutions per minute. Turbines within arrays are separated by 100-150 m. All turbines are located in cultivated fields or in heavily grazed native pasture.

Outlying Turbines

We also monitored bird and bat mortality at 5 individual Vestas V44-600 turbines at separate locations in southern Alberta, including Castle River, Belly River, Belly River Bend, Waterton, and Blue Ridge turbines. All turbines were located in cultivated fields during our study.

METHODS

The study included 3 components:

- observations of birds in flight within the Castle River Wind Farm to assess behaviour that may have contributed to avoidance or collision with turbines,

- weekly systematic ground surveys of the wind farm and outlying turbines to locate carcasses of birds and bats that may have been killed by collisions with turbines. Survey frequency was increased to twice weekly during spring and fall migration periods; and

- acoustical surveys for bats within the wind farm and in the Castle River valley which transects the wind farm.

RESULTS

Bird Observations

We watched birds on 91 days from March 2001 through December 2002. Only 11.6% of 1728 birds we observed within the wind farm approached turbines at the level of the rotor disk (the area described by the turning blades) where there is the greatest potential for collision. All others flew above or below the rotor disk.

Only a few birds (2.5%) other than waterfowl were near enough to turbines to change their flight path. Ducks were an exception. Of 413 ducks (primarily Mallards and Northern Pintails in flocks of up to 120 birds), 71.4% altered their course. Almost all (98.6%) flew over, and very few (1.4%) flew around turbines.

Of 269 raptors of 9 species we observed within the wind farm, only 3% came near enough to a turbine to change their flight path. A large number of raptors in the area (>200 individuals that we did not include in our observations) were over the Castle River valley, and did not enter the wind farm. The valley allowed raptors to move through the wind farm area without encountering turbines.

Species groups apparently behaved differently when encountering turbines. In general:

Raptors - flew over or around the rotor disk;
Passerines - remained below the rotor disk; and
Waterfowl (primarily dabbling ducks) - flew directly upward or in tight, upward spirals to climb above the rotor disk regardless of their height at first encounter of the turbine array

Great Blue Herons, which nested in the Castle River valley at the southwest corner of the wind farm, entered and left the colony via the valley and therefore encountered turbines rarely. Those that did ($n = 3$) altered their flight paths several hundred metres from the turbines to fly over or around the rotor disk.

Carcass Surveys

Birds

We found no bird carcasses during 101 weekly inspections of the 5 outlying turbines between May and December, 2000. One incidental recovery was made prior to our systematic surveys when an adult male American Coot was found that apparently flew into or was blown into the tower of the Belly River Bend wind turbine.

At the Castle River Wind Farm, we recovered 19 bird carcasses in 96 surveys of the entire wind farm between April 2001 and January 2002. Fourteen (74%) of the birds recovered were passerines (perching birds) or passerine-like (*i.e.*, doves). None of the species is considered to be of conservation concern either provincially or federally.

Our rates of recovery of 0.15 birds/ turbine/year and no raptor deaths in 2001, and 0.23 birds/turbine/year and 0.017 raptors/turbine/year in 2002, with only a single raptor mortality, at the Castle River Wind Farm was low relative to other sites. Across the United States, mean mortality rates were 2.19 birds/turbine/year for all species, and 0.033 raptors/turbine/year.

We could not adjust our carcass recovery rates for searcher efficiency or carcass persistence (which included scavenging rates and loss to other factors such as desiccation or decay). However, we believe our rates closely approximated actual mortality rates given the short, sparse vegetation present through most of the year leaving carcasses highly visible, low numbers of potential scavengers, frequent surveys (weekly or twice weekly during spring and fall migration periods), and a high rate of carcass recovery (>70%) in a limited trial at Castle River and in a more-comprehensive trial at the nearby Summerview Wind Farm.

Since the field surveys were completed in December 2002, 3 birds of conservation concern have been recovered at the Castle River wind farm by facility personnel, including a Red-tailed, a Bald Eagle, and a Western Grebe. The Bald Eagle and Western Grebe are considered Sensitive in Alberta (ASRD 2003). Although the species is not listed as sensitive, mortality of raptors such as the Red-tailed Hawk is a concern at other locations. The deaths of single individuals of these species are not likely to have an effect on local or regional populations; however, subsequent mortality of listed species should be considered in a conservation context to assess potential population effects.

Bats

We recovered 1 bat carcass during weekly inspections (*n* = 101 individual searches) of the 5 outlying turbines between May and December, 2000. The bat was a little brown myotis collected at the Belly River Bend turbine on 21 May 2000.

At the Castle River Wind Farm, we recovered 52 bat carcasses in 96 surveys of the entire wind farm between April 2001 and January 2002. Rates of recovery were 0.89 bats/turbine/year in 2001 and 0.22 bats/turbine/year in 2002. Species included hoary bat, silver-haired bat, and little brown myotis. All are considered Secure in Alberta and none are listed federally. Hoary and silver-haired bats comprised 61% and 14%, respectively, of all bats found that could be identified. A high proportion of those species is consistent with a continent-wide pattern of bat mortality at wind turbines.

Bats we recovered within the wind farm appeared healthy otherwise, with full stomachs and good fat reserves, and did not demonstrate any conditions that may have compromised their health potentially making them more vulnerable to collisions with turbines.

Our finding of male adult hoary bats was unexpected. Most commonly, males of that species remain in the western United States during summer. Few are captured as far north as Alberta.

CONCLUSIONS

Turbines at the Castle River Wind Farm were not a major hazard to birds or bats during our study. Our estimated collision rates were similar to rates documented elsewhere in the western and midwestern United States. Collision rates were not high enough to have an effect on local or regional populations of birds or bats.

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Dr. Judit Smits, University of Saskatchewan, performed all necropsies.

Hans Michel and family, Hill Springs, monitored turbines during the first year of the study.

Dave Willms and Hal Jorgenson, Vision Quest, Brian Schmidt, Vestas, and the Vision Quest/Vestas crews at the Castle Wind Farm alerted us to carcasses and provided logistical support.

Dr. Robert Barclay, University of Calgary, provided advice on bats and provided an ultrasonic detector to confirm the presence of bats around turbines.

Dr. Margo Pybus, Alberta Fish and Wildlife Division (AFWD), discussed bats with us.

Travis Brown, TAEM Ltd., found the first carcass (a little brown myotis), recorded during this study.

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1.0 INTRODUCTION

In 1999, Vision Quest Windelectric Inc. began a program to examine bird and bat interactions with wind turbines in southern Alberta. Bird collisions with man-made structures have been a concern to managers and conservationists since at least the 1950s (Erickson *et al.* 2001). As wind became recognized as a valuable and expanding energy resource in the 1980s, concerns arose when eagles and other raptors were killed at turbines at wind farms in California and Spain (Colson and Associates 1995). In response, a national council, the Avian Subcommittee of the National Wind Coordinating Committee, was formed in the United States to collectively address issues related to bird collisions with turbines (e.g., Savitt Schwartz 2001). Research has been on-going to quantify impacts and develop mitigative measures.

More recently, surveys have documented bat mortalities at some wind energy facilities (*e.g.*, Feidler 2004, Kerns *et al.* 2005, Arnett *et al.* 2005). Levels of bat mortality and contributing factors are not well understood, and information on those aspects is important to design and siting of future wind farms (Arnett *et al.* in prep).

To assess factors that may contribute to collisions of birds and bats with wind turbines, and to determine collision rates, we observed bird reactions to turbines and systematically surveyed the ground around turbines for bird and bat carcasses at Vision Quest's Castle River Wind Farm between April 2001 and December 2002.

2.0 STUDY AREA

2.1 Castle River Wind Farm

The Castle River Wind Farm, operated by Vision Quest Windelectric Inc., is located in southern Alberta, 5 km west of the town of Pincher Creek (Figure 1). When we began the study in April 2001, 23 turbines were located east of the Castle River. Turbines were added through the year. By the end of the study in January 2003, the wind farm comprised 60 turbines, including 41 east of the Castle River in 4 arrays, and 19 west of the Castle River in 3 arrays.

Turbines are Vestas model V47-660 set on 50-m-high, tubular-steel towers, with a diameter-at-base of about 3 m. Each turbine has 3 blades, with a rotor diameter of 47 m. Blades turn at speeds of 20-35 revolutions per minute. One Vestas model V44-600 turbine, with slightly smaller tower and rotor dimensions, is included in the array immediately bordering eastern edge the Castle River valley. Turbines within arrays are separated by 100-150 m.

2.2 Outlying Turbines

During the initial phase of this study in 1999-2000, before the Castle River Wind Farm was constructed, we also checked 5 individual Vision Quest turbines (Vestas V44-600) for carcasses. Included were the first turbine installed at Castle River, plus the Belly River, Belly River Bend Waterton, and Blue Ridge turbines. All were single turbines located in cropland on level-to-gently rolling terrain.

2.3 Biophysical Characteristics

The Castle River Wind Farm and outlying turbines are located within the Foothills Fescue Subregion of the Grassland Natural Region (ANHIC 2005). Land use is entirely agricultural. Turbines at the Castle River Wind Farm are located in cultivated land ($n = 38$) or grazed pasture ($n = 22$). Terrain is flat to gently sloping. The Castle River valley, which is 50-60 m deep and 600-1000 m across, runs southwest to northeast through the center of the wind farm. The Belly River, Waterton, Blue Ridge, and River Bend turbines are located on cultivated lands.

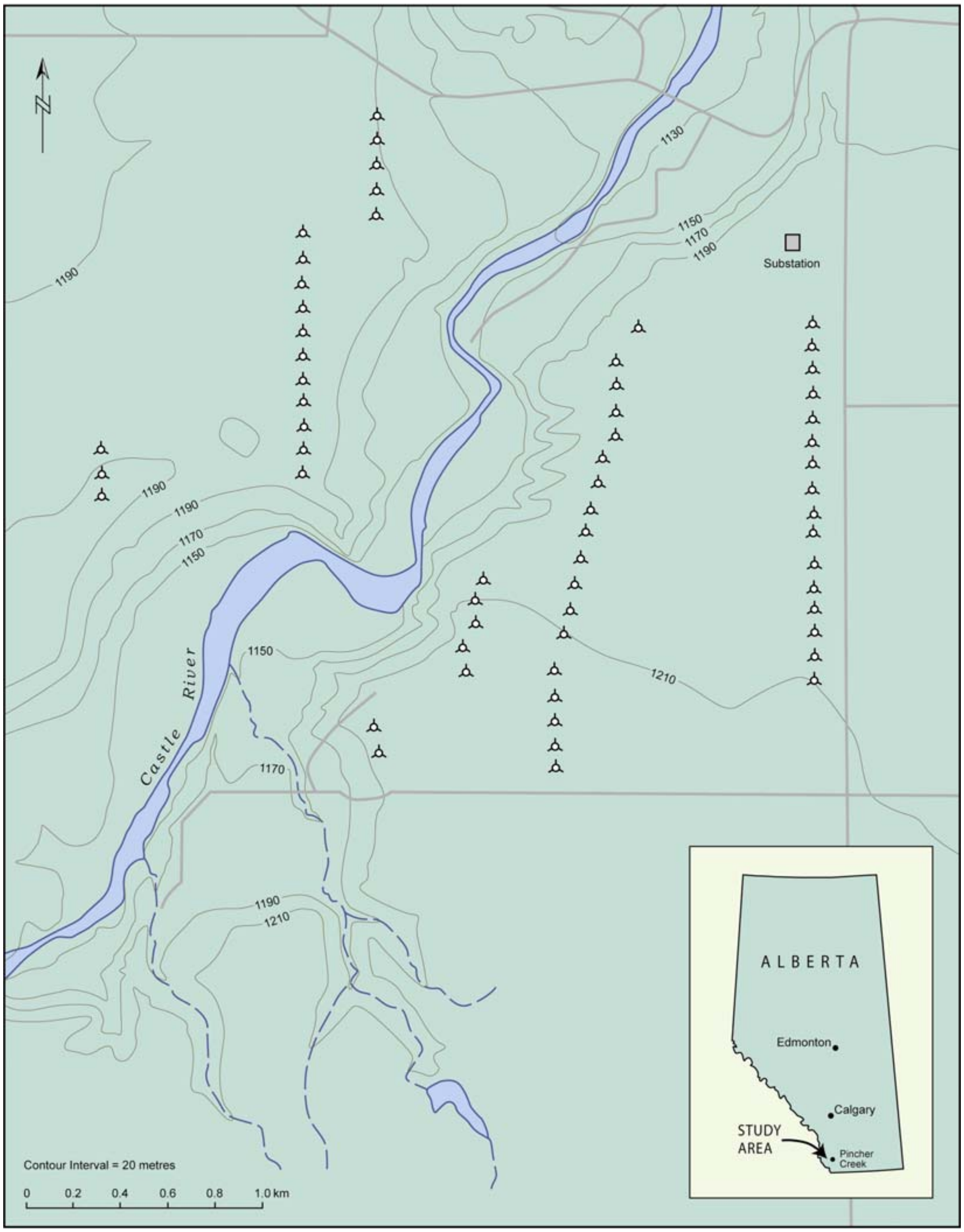

Figure 1. Turbine layout, Castle River Wind Farm, Alberta.

Native vegetation in the region is dominated by grasses and forbs. Fescues (*Festuca* spp.), needle grasses (*Stipa* spp.), wheat grasses (*Agropyron* spp.), and blue grama (*Bouteloua gracilis*) occur in uncultivated areas. Common forbs include yarrow (*Achillea millefolium*), three-flowered avens (*Geum triflorum*), and vetches (*Astragalus* spp.). Shrubs include buckbrush (*Symphoricarpos occidentalis*), wolf willow (*Elaeagnus commutata*), saskatoon (*Amelanchier alnifolia),* willow (*Salix* spp.), rose (*Rosa acicularis*), and pin cherry *(Prunus pensylvanica*). Cottonwoods and aspen (*Populus* spp.), occur in small stands, primarily in the Castle River valley. Pastures are heavily grazed, resulting in patches of bare ground and an increase in weedy species such as pasture sage (*Artemisia frigida*), Canada thistle (*Cirsium arvense*), and sweet clover (*Melilotus* spp.). Crop land was planted to barley in 2001 and 2002.

Wildlife diversity in the area has been affected by long-term agricultural use. Species present are those typically able to co-exist with cultivation and cattle grazing. Large mammals include mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), and coyote (*Canis latrans*). Other mammals include white-tailed jackrabbit (*Lepus townsendii*), northern pocket gopher (*Thomomys talpoides*), Richardson's ground squirrel (*Spermophilus richardsonii*), and meadow vole (*Microtus pennsylvanicus*). Bats that are most common in the area include little brown (*Myotis lucifugus*), small-footed (*M. ciliolabrum*), and big brown (*Eptesicus fuscus*). Hoary (*Lasiurus cinereus*) and silver-haired bats (*Lasionycteris noctivagans*) move through the region during spring (June) and fall (July-September) migration periods.

Characteristic breeding birds include waterfowl such as Mallard (*Anas platyrhynchos*), Northern Pintail (*Anas acuta*), and Northern Shoveler (*Anas clypeata*); raptors, including Prairie Falcon (*Falco* mexicanus), Swainson's Hawk (*Buteo swainsoni*), and Northern Harrier (*Circus cyaneus*); and other typical prairie species such as Killdeer (*Charadrius vociferus*), Horned Lark (*Eremophila alpestris*), Clay-colored Sparrow (*Spizella pallida*), and Western Meadowlark (*Sturnella neglecta*). A Great-blue Heron (*Ardea herodias*) colony was located in the Castle River valley near the southwestern corner of the wind farm. Both years of the study Bald Eagles (*Haliaeetus leucocephalus*) nested in the Castle River valley near the heron colony, and Swainson's Hawks nested in a poplar tree along the eastern edge of the wind farm. Both nests fledged young each year. Nesting opportunities for raptors and waterfowl are limited within the wind farm by level terrain and scarcity of trees and standing water.

More bird species are present during spring and fall migrations, including species such Tundra Swan (*Cygnus columbianus*), Bald Eagle (*Haliaeetus leucocephalus*), Rough-legged Hawk (*Buteo lagopus*), Golden Eagle (*Aquila chrysaetos*), and numerous passerines (perching birds).

Most-common amphibians and reptiles may include and striped chorus frog (*Pseudacris maculata*), wood frog (*Rana silvatica*). western terrestrial garter snake (*Thamnophis elegans*) and plains garter snake (*Thamnophis radix*).

3.0 METHODS

The study comprised 3 components:

- observations of birds in flight within the Castle River Wind Farm to assess behaviour that may have contributed to avoidance or collision with turbines,

- regular, systematic ground surveys of the wind farm and outlying turbines to locate carcasses of birds and bats that may have been killed by collisions with turbines; and

- acoustical surveys for bats within the wind farm and in the Castle River valley which transects the wind farm.

3.1 Bird Observations

To determine birds' reactions to turbines, we recorded location, species, number, flight direction, height relative to rotor disk (above, within, or below the area described by the turning blades), and changes in flight pattern (apparent reaction to turbine) of birds within the Castle River Wind Farm. For analyses, we grouped data based on broad taxonomic groups, including raptors, waterfowl, and passerines. We examined responses of individual species if distinctive patterns were apparent.

We observed Great Blue Herons (*Ardea herodias*) at the colony located in the Castle River valley to determine routes used by the birds to exit and enter the nesting area. We recorded flight direction and height relative to the valley edge to assess potential for interactions with turbines.

3.2 Carcass Surveys

During 1999-2000, the first year of the study, Vision Quest had single turbines at 5 sites in the Pincher Creek region, as described above. To locate carcasses of birds that may have collided with the turbines, we searched within a 50-m radius of the tower base. On the prevailing downwind (eastern) side of each turbine, we extended the search area an additional 25 m (total = 75 m from the tower base) to account for birds that may have been blown away from the tower by strong winds. Observers walked transects spaced 10-m apart to search for carcasses.

In April 2001, we began regular carcass searches at the Castle River Wind Farm. During each survey, we walked 4 parallel transects spaced at 30-m intervals to survey a strip about 120 m wide that extended the length of each array, including an area 15 m beyond the end of the array (Figure 2). As in our searches of individual turbines in 1999-2000, we extended the search area downwind (east) of each array to account for carcasses that may have been carried downwind after the collision by strong, prevailing westerly winds.

We recorded species and distance and direction to the nearest turbine for all carcasses, then sealed them in a labeled plastic bag, and chilled or froze them, depending on their condition. We shipped carcasses as soon as possible (usually within 1-3 days) to the University of Saskatchewan for necropsy. Dr. Judit E. G. Smits, Toxicology Centre, University of Saskatchewan, performed all necropsies and histopathology examinations. She confirmed species identification and sex of the specimens, assessed cause of death, and determined age of some individual bats by examining cartilage development in the phalanges.

Surveys were designed to detect large birds, especially raptors, because of concern over federally and provincially listed species (ASRD 2003; COSEWIC 2006). We expected that detectability of passerines and other, smaller species would be lower than that of raptors. To assess carcass recovery rates, we conducted a preliminary trial with a small number of carcasses to develop an appropriate method for testing searcher efficiency. An independent researcher placed carcasses of birds and bats at randomly selected locations within our regular search area. Within a half-hour (to reduce potential for losses to scavenger), we conducted a regular survey. To determine searcher efficiency we compared carcasses recovered to carcasses present. We based carcass-recovery rates within the Castle River Wind Farm on the mean number of turbines that were operational during our surveys.

Later in summer (August), after crops reached 20-30 cm in height and until harvest, we revised the linear transect pattern to search within a 15-m-radius of the tower base in cropland. This pattern increased search effort around the tower to increase the potential to find carcasses obscured by the tall crops. To increase the likelihood of locating carcasses, we asked facility personnel to notify us of any bird carcasses they observed while commissioning and maintaining turbines.

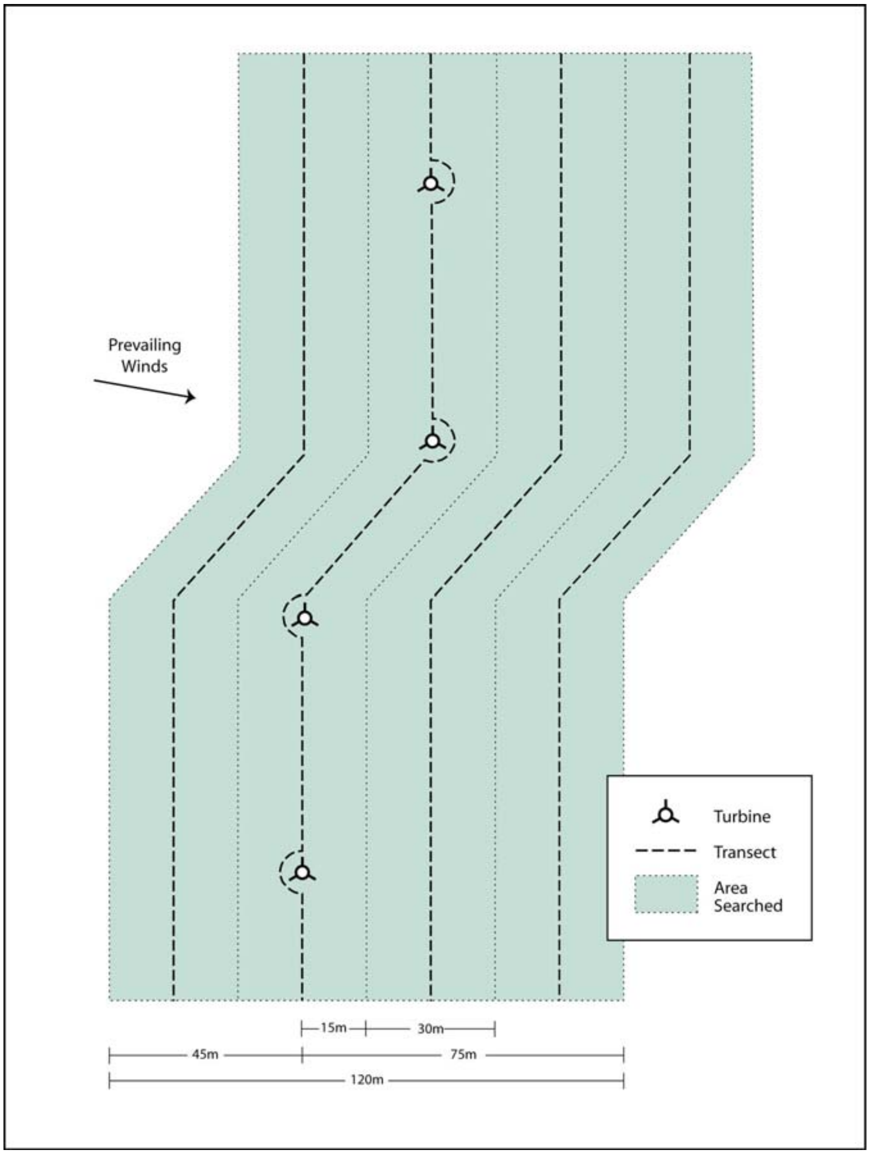

Figure 2. Pattern of carcass searches, Castle River Wind Farm, April 2001 – December 2002.

3.3 Bat Acoustical Surveys

To gather preliminary information on occurrence and distribution of bats, we used a hand-held Pettersson Electronik D100 bat detector to monitor bat calls at locations throughout the wind farm and in the Castle River valley. At each site, we listened for 5 minutes at each of 3 frequencies (20 kHz, 30 kHz, and 40 kHz) to detect hoary bats, silver-haired and big brown bats, and *Myotis* spp., respectively, and noted calls heard (Vonhof 2005). Calls were of 2 types: "passes" which indicated normal echolocation during flight, and "feeding buzzes" which are rapid bursts of sound used by the bat to locate prey at short distances and indicate the animals are foraging (Vonhof 2005).

4.0 RESULTS

4.1 Bird Observations

We watched birds on 91 days from March 2001 through December 2002. Of 1,728 birds of 29 species in 537 groups (mean = 3.22 birds/group) within the wind farm, only 11.6% (n = 200) of individuals approached turbines at the level of the rotor disk (the area described by the turning blades), where there is the greatest potential for collision (Table 1; Appendix 1). All other birds approached turbines above (19.9%; n = 344) or below (68.5%; n = 1184) the rotor disk. Only a few birds (2.5%; n = 43) other than waterfowl were near enough to turbines to change their flight path (Table 2; Appendix 2). Ducks were an exception. Of 413 ducks (primarily Mallards (*Anas platyrhynchos)* and Northern Pintails (*Anas acuta*) in flocks of up to 120 birds), we observed within the wind farm (Appendix 2), 71.4% (n = 295) altered their course. Almost all (98.6%; n = 291) flew over, and very few (1.4%; n = 4) flew around turbines.

Table 1. Bird interactions with wind turbines: altitude of birds (%) relative to turbines as they entered or were first observed within the wind farm, Castle River Wind Farm, March 2001 – December 2002.

Species Group	Altitude Approaching Turbine % (n)			
	Above Rotor Disk	At Rotor Disk	Below Rotor Disk	Total
Passerines/Others	11.3 (95)	9.7 (82)	79.0 (664)	100 (841)
Raptors	36.8 (99)	24.5 (66)	38.7 (104)	100 (269)
Waterfowl	19.8 (102)	7.6 (39)	72.6 (373)	100 (514)
Other Species	46.2 (48)	12.5 (13)	41.3 (43)	100 (104)
Total	19.9 (344)	11.6 (200)	68.5 (1184)	100 (1728)

Of 269 raptors of 9 species we observed within the wind farm, only 3% (*n* = 9) changed their flight path to avoid a turbine (Table 2; Appendix 2). A large number of raptors in the area (>200 individuals that we did not include in our observations) were over the Castle River valley, and did not enter the wind farm. Those birds appeared to gain lift along the east side of the valley from the updrafts created by the prevailing westerly winds, or used the valley as shelter when wind speeds were high. The only raptor nests we located in the study area were those of a Bald Eagle (*Haliaeetus leucocephalus*) along the Castle River, and a Swainson's Hawk (*Buteo swainsoni*) at the eastern edge of the wind farm. Raptors within the wind farm included buteos (*n* = 213), eagles (*n* = 21), harriers (*n* = 8), accipiters (*n* = 1), and falcons (*n* = 26) (Appendix 1).

Table 2. Bird interactions with wind turbines: flight paths taken by birds in apparent avoidance of turbines, Castle River Wind Farm, March 2001 – December 2002.

Species Group	Altered Flight % (n)			
	Fly Over Rotor Disk	Fly Around Rotor Disk	Fly Below Rotor Disk	Total
Passerines/Others	6.7 (2)	43.3 (13)	50 (15)	100 (30)
Raptors	55.6 (5)	22.2 (2)	22.2 (2)	100 (9)
Waterfowl	98.3 (350)	1.7 (6)	0 (0)	100 (356)
Other Species	50 (2)	50 (2)	0 (0)	100 (4)
Total	90.0 (359)	5.8 (23)	4.2 (17)	100 (399)

Although sample sizes were small for groups other than waterfowl, species groups apparently behaved differently when encountering turbines (Table 2). In general:

Raptors - flew over or around the rotor disk;

Passerines - remained below the rotor disk; and
Waterfowl (primarily dabbling ducks) - flew directly upward or in tight, upward spirals to climb above the rotor disk regardless of their height at first encounter of the turbine array.

A Great Blue Heron colony, located in cottonwood (*Populus* spp.) trees along the south bank of the Castle River, southwest of the wind farm, had 15 active nests and 27 young in 2001. Of 36 herons we observed flying to and from the colony on 14 and 17 July 2001, only 1 climbed out of the Castle River valley within our view. The other birds stayed below the top of the valley at least until they were beyond the perimeter of the wind farm. Of 23 herons we observed within the wind farm, only 3 altered their flight paths to avoid turbines: on 17 April, we observed 2 herons fly together out of the valley, and over turbines; on 17 May, 1 heron altered its course to fly around the end of an array. On both occasions, the birds were 300-400 m from turbines when they changed flight direction.

4.2 Carcass Surveys

We surveyed the Belly River, Waterton, Blue Ridge, Castle, and River Bend turbines a total of 101 times from May through December 2000.

We surveyed the entire Castle River Wind Farm 96 times between April 2001 and December 2002. Surveys were done weekly most of the year and twice weekly during bird migration periods in spring and early summer (May-July) and fall (September), 2002.

4.2.1 Birds

No bird carcasses were recovered during weekly inspections (n = 101 individual searches) the 5 outlying turbines between May and December, 2000. One incidental recovery was made prior to our systematic surveys. On 20 October 1999, an adult male American Coot (*Fulica americana*), was found that apparently flew or was blown into the tower of the Belly River Bend wind turbine. Necropsy results indicated that the bird had struck a solid object head on, and was not struck by a moving blade. This was the first bird carcass recovered at a Vision Quest wind turbine.

In 96 surveys of 23 to 60 turbines at the Castle River Wind Farm between April 2001 and January 2002, we recovered 19 bird carcasses (Table 3). Fourteen (74%) of the birds recovered were passerines (perching birds) or passerine-like (*i.e.*, doves) (Figure 3). None of the species is considered to be of conservation concern (ASRD 2003, COSEWIC 2006). Rates of recovery were 0.15 birds/turbine/year in 2001 (5 carcasses recovered from April 2001 - December 2001, average number of turbines per survey = 44) and 0.23 birds/turbine/year in 2002 (14 carcasses recovered from January 2002-December 2002 at 60 turbines).

Table 3. Bird carcasses recovered at turbines, Castle River Wind Farm, Alberta, April 2001 – December 2002.

N	Species	Scientific Name	Alberta Status[1]	COSEWIC Status[2]
1	Blue-winged Teal	*Anas discors*	Secure	Not Listed
1	American Kestrel	*Falco sparverius*	Secure	Not Listed
1	American Coot	*Fulica americana*	Secure	Not Listed
1	Rock Dove	*Columba livia*	Exotic	Not Listed
2	Mourning Dove	*Zenaida macroura*	Secure	Not Listed
1	Northern Flicker	*Colaptes auratus*	Secure	Not Listed
1	Golden-crowned Kinglet	*Regulus satrapa*	Secure	Not Listed
2	American Robin	*Turdus migratorius*	Secure	Not Listed
1	Cedar Waxwing	*Bombycilla cedrorum*	Secure	Not Listed
2	European Starling	*Sturnus vulgaris*	Exotic	Not Listed
2	Yellow-rumped Warbler	*Dendroica coronata*	Secure	Not Listed
1	Red-winged Blackbird	*Agelaius phoeniceus*	Secure	Not Listed
1	Common Redpoll	*Carduelis flammea*	Secure	Not Listed
1	Unidentified shorebird[3]	-	-	-
1	Unidentified sparrow[3]	-	-	-
19	**Total**			

[1] Alberta Status - ASRD 2003
[2] COSEWIC Status - COSEWIC 2006
[3] Carcasses of unidentified birds were in too poor condition to allow precise identification.

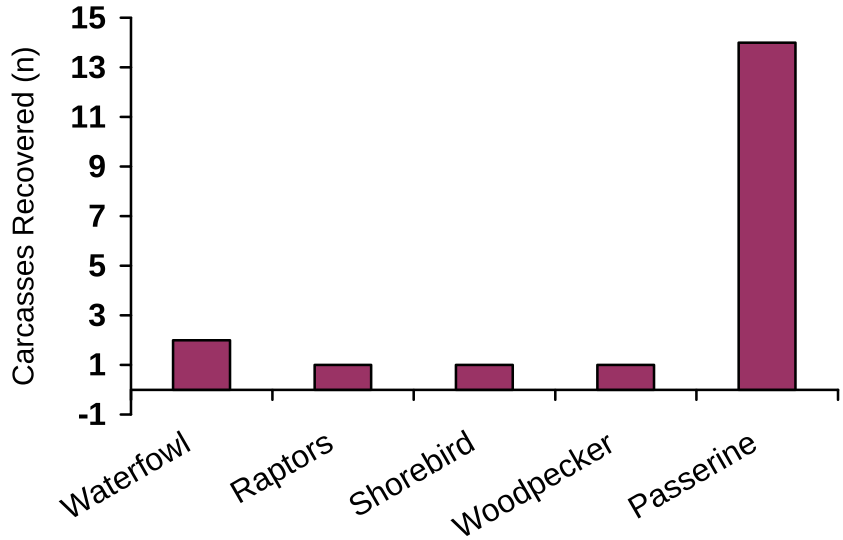

Figure 3. Bird species groups recovered at the Castle River Wind Farm, April 2001 – December 2002.

Bird carcasses were located a mean distance of 26.8 m from the turbines (range = 0-60, SD = 17.7, median = 29 m), and 90% were within 43 m of turbines (Figure 4). Carcasses were distributed primarily downwind of the prevailing westerly and northerly winds, indicating many birds likely were carried by the wind after colliding with the turbine (Figure 5).

During a carcass survey on 12 September 2001, we observed 1 Mourning Dove in flight hit a tower. The bird flushed, possibly in response to our presence about 30 m away. It flew from bare ground, 3–5 m from the tower base, collided with the tower about 3 m above ground level, then fell back to the ground. It flew away < 1-minute later, as we approached.

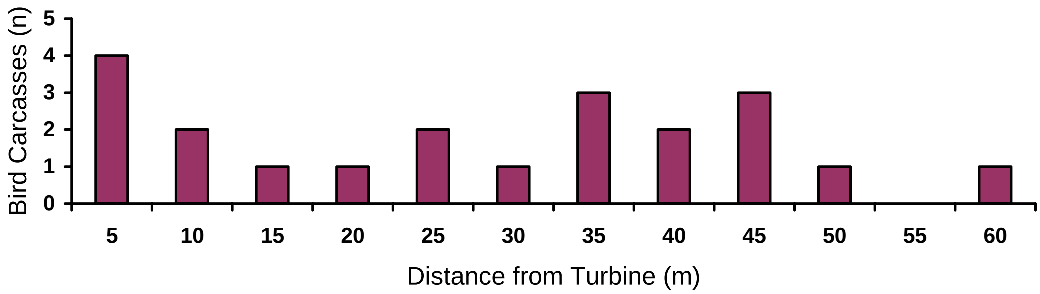

Figure 4. Distance of bird carcasses from turbines, Castle River Wind Farm, April 2001 – December 2002.

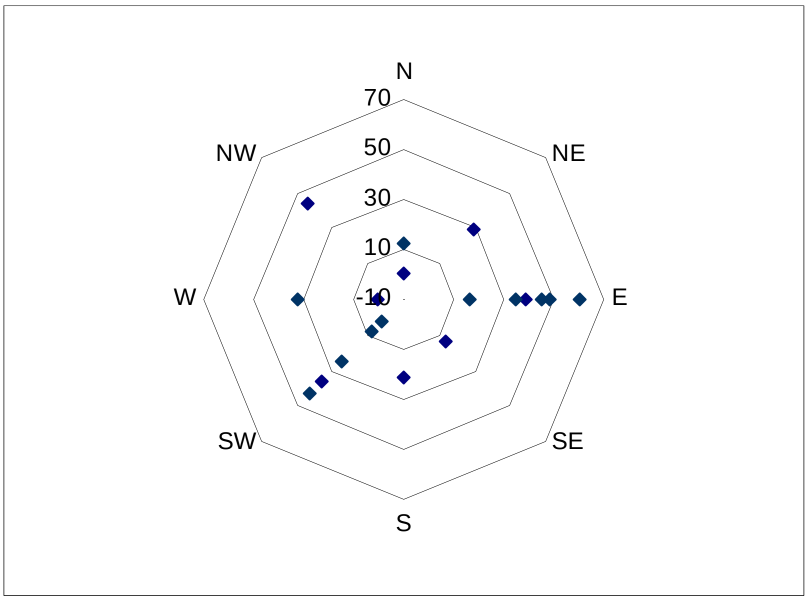

Figure 5. Distribution of bird carcasses around turbines, Castle River Wind Farm, April 2001 – December 2002.

Almost half of birds found collided with turbines during the spring migration period (April-May; n = 9, or 47% of all birds recovered); none were found during winter (Figure 6). Birds were found throughout the wind farm, with no apparent pattern of distribution related to turbine location. There was a nearly significantly greater number of birds (n = 8) at end-row turbines than mid-row turbines (n = 11) (χ^2 = 3.7, df = 1, P = 0.053). However, the sample size of 19 birds is low, and conclusions are not possible from these data about the susceptibility of birds to collisions with end-row *vs.* mid-row turbines.

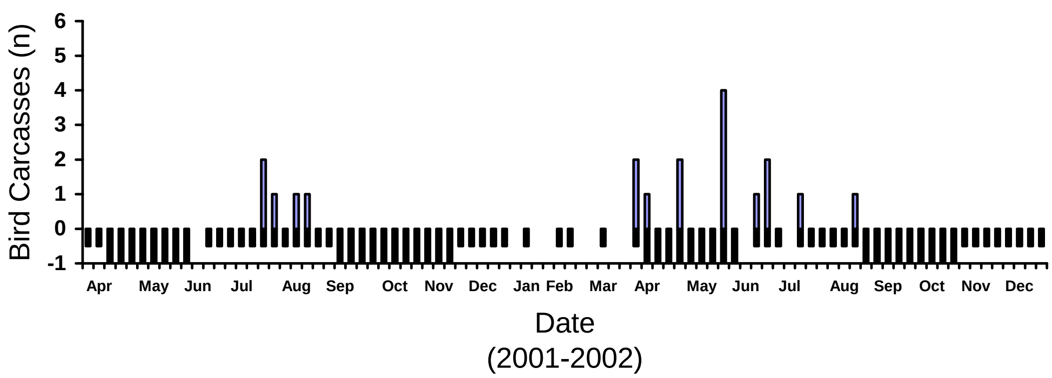

Figure 6. Timing of bird carcass recoveries, Castle River Wind Farm, April 2001 – December 2002. Bars below data indicate number of surveys per week (blank = 0 surveys, short bar =1 survey, long bar = 2 surveys).

Since the field surveys were completed in December 2002, 3 birds of conservation concern have been recovered by facility personnel. On 14 May 2003, a Red-tailed Hawk (*Buteo jamaicensis*) was recovered at the far western edge of the Castle River Wind Farm, 40 m north of turbine 50. The necropsy indicated it had died from trauma consistent with a blade strike. The bird tested negative for West Nile Virus. On 17 November 2004, an adult Bald Eagle (*Haliaeetus leucocephalus*) was found, also at the western edge of the wind farm. Cause of death was not determined, but the bird was found between two adjacent turbines. On 25 September 2004, a Western Grebe (*Aechmophorus occidentalis*) was recovered 20 m northeast of the Waterton Wind Turbine, a single turbine about 40 km southeast of the Castle site.

The Bald Eagle and Western Grebe are considered Sensitive in Alberta (ASRD 2003). Sensitive species are "[a]ny species that is not at risk of extinction or extirpation but may require special attention or protection to prevent it from becoming at risk" (ASRD 2003). Although the species is not listed as sensitive, mortality of raptors such as the Red-tailed Hawk is a concern at other locations.

During the development of a test of searcher efficiency, we recovered 5 of 7 bird carcasses (71%) and 4 of 6 bat carcasses (66%) placed in the field by an independent researcher. Survey conditions were difficult due to exceptionally by high winds (50-60 km/h). Because we were developing appropriate methods to test searcher efficiency, this trial involved only a limited number of carcasses.

4.2.2 Bats

We recovered 1 bat carcass during weekly inspections (*n* = 101 individual searches) of the 5 outlying turbines between May and December, 2000. The bat was a little brown myotis collected at the Belly River Bend turbine on 21 May 2000.

In 96 surveys of 23 to 60 turbines at the Castle River Wind Farm between April 2001 and January 2002, we recovered 52 bat carcasses (Table 4). Rates of recovery were 0.89 bats/turbine/year in 2001 (39 carcasses recovered from April 2001 – December 2001, average number of turbines per survey = 44) and 0.22 bats/turbine/year in 2002 (13 carcasses recovered from January 2002-December 2002 at 60 turbines). Species included hoary bat (*Lasiurus cinereus*), silver-haired bat (*Lasionycteris noctivagans*), and little brown myotis (*Myotis lucifugus*). All are considered Secure in Alberta (ASRD 2003) and none are listed federally (COSEWIC 2006). Hoary and silver-haired bats comprised 61% and 14%, respectively, of all bats found that could be identified. Both adults and juveniles of each species were recovered (Table 5).

Table 4. Bat species recovered at turbines, Castle River Wind Farm, April 2001 – December 2002.

N	Species	Scientific Name	Alberta Status[1]	COSEWIC Status[2]
30	Hoary Bat	*Lasiurus cinereus*	Secure	Not Listed
7	Silver-haired Bat	*Lasionycteris noctivagans*	Secure	Not Listed
12	Little Brown Myotis	*Myotis lucifugus*	Secure	Not Listed
3	Unidentified			
52	**Total**			

Alberta Status[1] - ASRD 2003
COSEWIC Status[2] - COSEWIC 2006

Table 5. Age and sex of 49 bats recovered at turbines, Castle River Wind Farm, April 2001 – December 2002. (3 of 52 bats recovered could not be identified to species. F = Female; M = Male; Juv = juvenile; U = unidentified)

Hoary (*n* = 30)							**Silver-haired** (*n* = 7)						**Little Brown** (*n* = 12)						
Adult (*n* = 18)			Juv (*n* = 10)			U	Adult (*n* = 6)			Juv (*n* = 1)			Adult (*n* = 3)			Juv (*n* = 5)			U
F	M	U	F	M	U		F	M	U	F	M	U	F	M	U	F	M	U	
5	8	5	2	5	3	2	4	-	2	-	1	-	1	-	2	-	-	5	4

Bat carcasses were distributed a mean distance of 15.2 m from the turbines (range = 1-54, SD = 10.0, median = 13 m), and 90% were within 25 m of turbines (Figure 7). Sixty percent (*n* = 31) of bats were collected northeast, east, and southeast of turbines (Figure 8), down wind of prevailing westerly winds. .

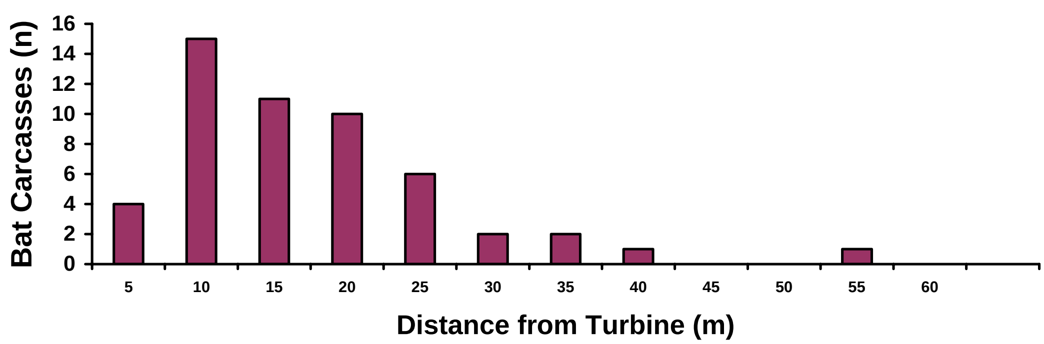

Figure 7. Distances of bat carcasses from turbines, Castle River Wind Farm, April 2001 – December 2002.

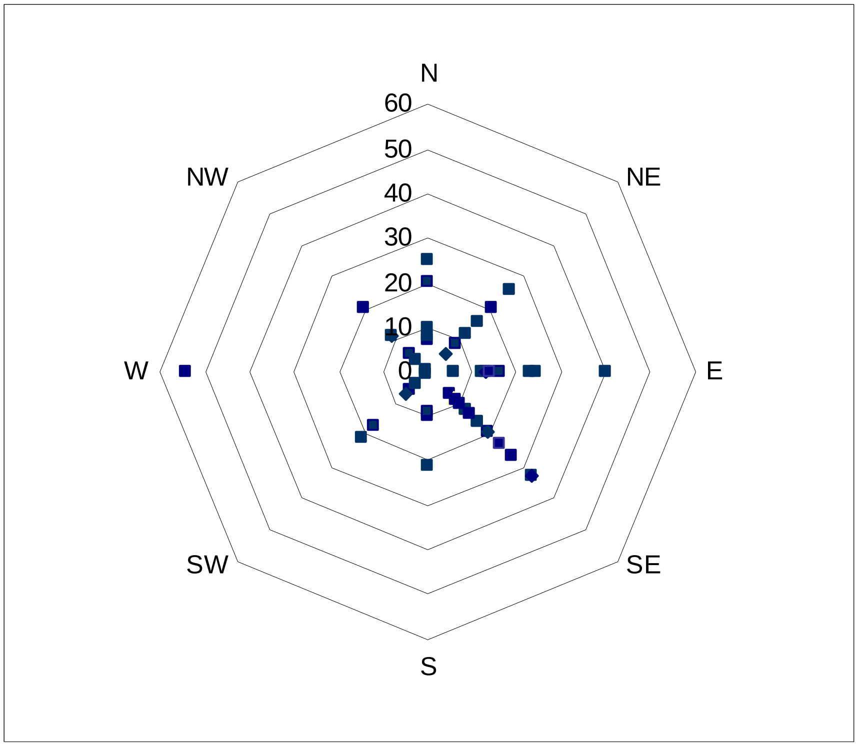

Figure 8. Distribution of bat carcasses around turbines, Castle River Wind Farm, April 2001 – December 2002.

Bat carcasses were distributed throughout the wind farm, with no apparent concentrations at individual turbines. More bats were killed at turbines in pasture than in crop ($\chi^2 = 8.17$, df = 1, $P = 0.004$). There was no significant difference between number of bat collisions at turbines <200 m from the Castle River valley and number at turbines >200 m from the valley ($\chi^2 = 0.08$, df = 1, $P = 0.78$). There were no differences in collision rates by bats at end-row *vs.* mid-row turbines ($\chi^2 = 0.49$, df = 1, $P = 0.49$).

We recovered bats between 26 July and 8 September in 2001, and 5 June and 21 November in 2002 (Figure 9). Few bats collided with turbines in spring. Most were recovered in August. In fall, hoary bats, were the most commonly collected species during August. Silver-haired bats were most abundant from late August through September. The little brown bat collected in November 2002 likely had collided with a turbine earlier in fall and remained undiscovered until November.

Because our sampling in 2001 included all periods in which we could expect bats to be in the study area, we considered our estimated collision rate of 0.89 bats/turbine/year to be the actual annual rate (*i.e.*, no adjustment was necessary because we did not survey during the January-March period).

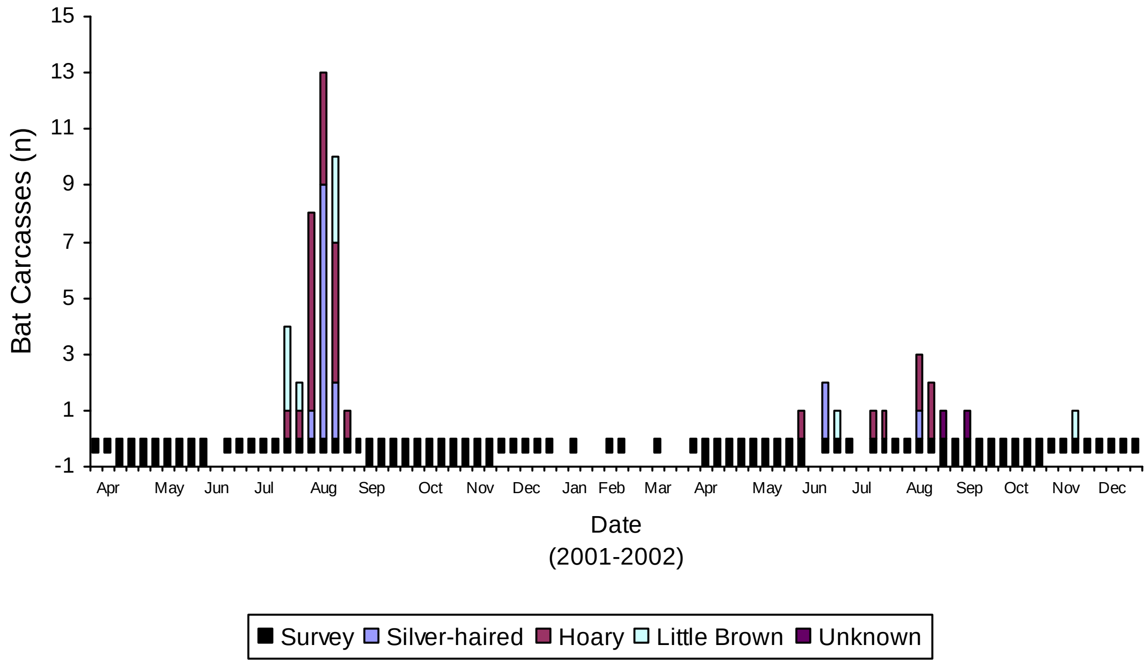

Figure 9. Timing of bat carcass recoveries, Castle River Wind Farm, April 2001 – December 2002. Bars below data indicate number of surveys per week (blank = 0 surveys, short bar =1 survey, long bar = 2 surveys).

Although there was no significant difference between number of bat collisions at turbines <200 m from the Castle River valley and number at turbines >200 m from the valley, as described above, bats were much more active within the Castle River Valley than within the wind farm (Table 6). In 16 monitoring periods at 2 sites within the Castle valley on 8 nights between 22 July and 10 September 2002, we detected a total of 214 passes and an additional 81 feeding buzzes (295 total passes), at all 3 frequencies combined. In contrast, during 31 monitoring periods within the wind farm during the same period, we detected a total of 72 passes and 13 feeding buzzes (85 total passes) at 13 sites.

Table 6. Bat echolocation calls detected during acoustical surveys within the Castle River Wind Farm and Castle River valley, 22 July – 10 September 2002.

Location	Monitoring Periods (n)	Hoary Bat (20 kHz)		Silver-haired Bat (30 kHz)		*Myotis* spp. (40 kHz)		Totals
		Passes	Feeding Buzzes	Passes	Feeding Buzzes	Passes	Feeding Buzzes	
Within Wind Farm (13 sites)	31	35	10	32	3	5	0	85
Castle River Valley (2 sites)	16	77	51	64	22	73	8	295

5.0 DISCUSSION

5.1 Birds

Most birds we observed within the Castle River Wind Farm did not interact with turbines, primarily because they approached turbines either above or below the level of the rotor disk. Of birds that did approach at the height of the blades (about 26–63 m above ground level), most flew between towers without altering their course. Only a few birds within the wind farm (3% of all birds other than waterfowl; see below) appeared to be close enough to change their flight path.

Some ducks, mostly Mallards and Northern Pintails, that approached turbines below blade level, flew vigorously to pass arrays above the level of the rotor disk when it appeared they could more-easily have flown under or around turbines. We do not know the reasons ducks behaved differently than other species groups. By avoiding turbines in that way, ducks probably reduced their potential for collisions with towers or blades- we recovered only 1 duck (a Blue-winged Teal) that had collided with a turbine, in spite of their abundance in the wind farm and surrounding area. However, turbines installed directly adjacent to wetlands could interfere with normal flight patterns of waterfowl.

Raptors (eagles, hawks, and falcons) have been a focal point of bird-turbine collision studies elsewhere (e.g., Savitt Schwartz 2001). At the Castle River Wind Farm, most raptors moved along the Castle valley without entering the wind farm. Turbines were set far enough back from the valley edge that raptors in the valley did not encounter them. Most raptors were present in spring (March-May) and fall (September-October), and appeared to be migrating. The Castle River valley, which the birds used as a flight corridor, may be a significant feature that reduced the encounter rate of raptors with turbines. Within the wind farm, raptors successfully maintained separation from turbines: of 269 raptors we observed, only 9 (3%) flew close enough to turbines to require active avoidance.

The only raptor nests we located in the study area were those of a Bald Eagle (*Haliaeetus leucocephalus*) in the Castle River valley, and a Swainson's Hawk at the eastern edge of the wind farm. Young Swainson's Hawks may be more vulnerable to collisions with turbines than other buteos (Brown and Hamilton 2004). However, Swainson's Hawks using a nest located within 60 m of 2 turbines at the Castle River Wind Farm, successfully fledged young both years of the study, with no adults or young lost to collisions.

Great Blue Herons entered and left the colony by flying along the Castle River valley. Very few climbed out of the valley into the vicinity of turbines. The 3 herons we did observe within the wind farm altering their flight paths to fly over or around turbines.

Bird behaviour was consistent with low collision rates. We did not recover any bird carcasses during our initial surveys of the 5 individual outlying turbines, and only 1 bird, a coot, was found incidentally at those turbines. Our rates of recovery of 0.15 birds/ turbine/year and no raptor deaths in 2001, and 0.23 birds/turbine/year and 0.017 raptors/turbine/year in 2002, with only a single raptor mortality, at the Castle River Wind Farm were low relative to other sites. A review of bird mortality rates across the United States calculated mean mortality rates of 2.19 birds/turbine/year for all species, and 0.033 raptors/turbine/year (Erickson *et al.* 2001). Most birds (74%, n = 19) we found were passerines which is also consistent with other studies.

The low recovery rate of bird carcasses at the Castle River Wind Farm likely is representative of the actual collision rate. Our survey coverage was adequate to locate birds that had collided with turbines. Carcasses were distributed well within the surveyed area that extended a minimum of 60-75 m from each turbine; 90% of all bird carcasses were within 43 m of the tower base. Extending survey coverage downwind of prevailing winds was warranted given the distribution of carcasses around turbines. We believe we located most carcasses given the short, sparse vegetation present through most of the year. In similar surveys elsewhere, searcher efficiency (proportion of carcasses recovered) averaged between 69% and 100% (Orloff and Flannery 1992; Tobin and Dolbeer 1990). In separate trials completed at the nearby Summerview Wind Farm, we documented searcher efficiency rates of >70%. Surveys repeated weekly or twice-weekly further increased the potential for recovering carcasses that could be lost to scavenging, desiccation, or decay.

We believe scavenging rate of bird carcasses (carcass disappearance rate) was low based on our relatively high recovery of bat carcasses (which we would expect to be scavenged at a similar rate to birds), the infrequent presence of coyotes or other scavengers, behaviour of coyotes and other scavengers, and few carcass observations by on-site personnel, who generally visited each turbine at least once each day to perform routine maintenance before and after commissioning. We observed few coyotes during surveys. Common Ravens (*Corvus corax*) were present during most surveys; however, their behaviour did not indicate they were searching specifically around turbines. Bird and bat strikes likely are too infrequent and widely distributed across the wind farm for scavengers to associate carcasses with turbines. Weekly and twice-weekly surveys also reduced the potential for loss of carcasses to scavengers.

Populations of all bird species we recovered at turbines during systematic surveys from April 2001-December 2002 are considered secure in Alberta (ASRD 2003). The Bald Eagle and Western Grebe, found by facility personnel after our surveys were complete, are considered Sensitive in Alberta (ASRD 2003). The deaths of single individuals are unlikely to affect local or regional populations; however, additional mortality of these of other sensitive species may require further monitoring.

Nine of 19 birds we recovered were found during spring (April-May), and may have been migrants. Data from other studies (*e.g.*, Anonymous 2004) have indicated that resident birds may be less susceptible to collisions with turbines than migrants. More mortality may have occurred at end-row turbines than at mid-row turbines, but our sample size is low and definitive conclusions about susceptibility of birds relative to turbine location are not possible.

Birds involved in collisions with turbines may not always be struck by blades. Collisions with stationary structures such as towers and buildings kill millions of birds annually across North America (Erickson *et al.* 2001). Injuries to 1 Mourning Dove and to the American Coot recovered incidentally in October 1999 were consistent with the birds flying into a tower. Those birds may have been blown into a tower by strong winds or may have struck the tower during periods of fog, precipitation, or low light levels that obscured the birds' vision. Our direct observation of a Mourning Dove flying into a tower indicated that this type of collision may occur, even when winds are calm.

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5.2 Bats

Our recovery rates of bats of 0.89 bats/turbine/year in 2001 and 0.22 bats/turbine/year in 2002 are similar to, or lower than, rates at other wind farms in western North America. At 8 sites in the western and midwestern United States, bat mortality ranged from 0.7-6.4 bats/turbine/year (Erickson *et al.* 1999; Johnson *et al.* 1999; NWCC 2004; Strickland 2001). Bat mortality appeared to be substantially lower in 2002 given that we recovered only one-third as many carcasses at fewer turbines as during the previous year (n = 13 at an average of 44 turbines/survey *vs.* 39 at 60 turbines). That difference may indicate inter-annual variation in bat mortality; however, no conclusions are possible based on only 2 years of data.

Seventy-six percent of bats at the Castle River Wind Farm that we could identify were hoary and silver-haired. A high proportion of those species is consistent with a continent-wide pattern of bat mortality at wind turbines (Erickson *et al.* 1999, 2003, 2004; Keeley *et al,* 2001; Strickland 2001). Reasons those species are more vulnerable to collisions with wind turbines are not known, and considerable study is being devoted in Alberta and elsewhere currently to understanding bat interactions with wind turbines (*e.g.*, Arnett *et al.* 2005; R.M.R. Barclay, University of Calgary, personal communication). Both species are migratory, moving northward in spring (May and June) from wintering areas in the southern United States and Mexico, spending summer in boreal and parkland forests of northern Alberta, and returning southward in fall (August and September) (Barclay 1993; Pybus 1994). Possible factors that may influence susceptibility of hoary and silver-haired bats to collisions with turbines may include migrating altitude and reduced echo-location during migratory flight (*e.g.*, Keeley *et al.* 2001).

Bats we recovered within the wind farm appeared healthy otherwise, and did not demonstrate any conditions that may have made them more vulnerable to collisions with turbines by compromising their health. Rabies has been detected in hoary and little brown bats in Alberta (Pybus 1994); however, all bats we tested from our study area (n = 12) tested negative for rabies. Stomachs full of prey, good fat reserves, and good muscle condition also indicated bats were feeding normally, and generally were healthy (J. Smits, personal communication).

Although numbers of hoary and silver-haired bats throughout the province are not known, it is extremely unlikely that the levels of mortality we documented at the Castle River Wind Farm would have biologically significant effects on populations of either species.

We did not locate any hoary bat carcasses and only 1 silver-haired bat carcass in spring when those species should have been moving northward. Migration routes in the province are not well understood, and the animals may use a different route in spring that does not take them through the region of the wind farm.

Our finding of male adult hoary bats was unexpected. Most commonly, males of that species remain in the western United States during summer (Pybus 1994), and few are captured as far north as Alberta (Barclay 1993).

We do not know if hoary bats were summer residents in our study area. Some individuals may stay to rear young rather than continue northward; however, no information exists regarding population densities or occurrence of hoary bats in southern Alberta during summer (Barclay 1993).

Summer-resident bats, including big brown and little brown myotis, typically experience very low collision rates at wind turbines (*e.g.*, NWCC 2004). Our finding of 12 little brown myotis is higher than expected and may be due to the close proximity of the Castle River valley which transects the wind farm. In prairie environments, bats favor riparian areas (Barclay 1993; Holloway and Barclay 2000), and our ultrasonic surveys indicated bats were abundant in the valley. Our surveys also indicated bats may forage in the wind farm >200 m from the valley.

Those bats may have been a combination of resident and migratory individuals. Little brown is the most common species in Alberta (Pybus 1994), and is found throughout the province during summer. In fall, little brown myotis migrate to the mountains to hibernate in caves or other suitable features, such as mines (Barclay 1993; Pybus 1994). We detected little browns during our ultrasonic surveys; however, carcasses we recovered in August may have included animals migrating from other areas toward the mountains.

There is little information on mechanisms of bat collisions with wind turbines. Bats may echolocate in a zone that is too small to detect a turbine blade through the full sweep of the blade’s rotation. As a blade moves into a bat’s path, the animal may not perceive it until it is too late to avoid collision. Although turbines turn relatively slowly (<25 rpm), tip speeds may exceed 200 km/h. This scenario is consistent with mortality of both adult bats and young-of-year at turbines. Flight experience and ability related to age would not be factors if the bats were hit by blades sweeping into their paths from beyond sonar range

6.0 CONCLUSIONS

Turbines at the Castle River Wind Farm were not a major hazard to birds or bats during our study. Our estimated mortality rates of 0.15 and 0.23 birds/turbine/year and 0.89 and 0.22 bats/turbine/year were similar to rates documented elsewhere in the western and midwestern United States. We could not adjust our estimated rates to reflect searcher efficiency or carcass persistence; however, given 1) high rates of searcher efficiency (>70%) in a limited trial at Castle River and in a more-extensive trial at a nearby wind farm, 2) frequency of surveys (weekly or, during migration periods, twice-weekly), and few observations of potential scavengers during our surveys, we believe we found a high proportion of carcasses within the wind farm and that our estimated mortality rates approximate the true rates. None of the rates were high enough to have effects on local or regional populations of birds or bats.

Most birds that collided with turbines were passerines (perching birds), likely because of their abundance in the study area relative to other species groups. None of the birds we recovered during our systematic surveys is of conservation concern provincially or nationally. Since the study was completed, 2 species considered Sensitive in Alberta have been recovered at Vision Quest turbines, including a Bald Eagle and a Western Grebe. Single fatalities of these species are unlikely to have an effect on local population levels.

The high proportion of hoary and silver-haired bats recovered (75% of all bats we could identify) and timing of mortality (primarily in August) at the Castle River Wind Farm are consistent with a continent-wide pattern. Because population sizes, migratory routes, and behaviour of those species in Alberta are not well known, we cannot assess the actual effects of bat collisions with turbines at the Castle River Wind Farm. However, the small numbers involved (7-30 individuals of each species) are not likely a concern at the population level.

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APPENDIX 1.

Bird interactions with wind turbines: altitude of birds relative to turbines as they entered or were first observed within the wind farm, Castle River Wind Farm, March 2001 – December 2002.

Species	Above Rotor (n)	At Rotor (n)	Below Rotor (n)	Total (n)
Passerines/Others				
Rock Dove	1	2	3	6
Northern Shrike	0	0	1	1
Black-billed Magpie	0	0	0	0
Common Raven/Crow	62	31	38	131
Horned Lark	1	2	62	65
Mountain Bluebird	0	0	2	2
American Robin	0	0	25	25
European Starling	0	27	435	462
Dark-eyed Junco	0	0	2	2
Western Meadowlark	0	0	0	0
Unidentified Passerine	31	20	96	147
Total Passerines/Others	95	82	664	841
Raptors				
Bald Eagle	12	3	3	18
Northern Harrier	0	2	6	8
Unidentified Accipiter	0	0	1	1
Swainson's Hawk	6	14	10	30
Red-tailed Hawk	34	13	25	72
Rough-legged Hawk	22	20	29	71
Unidentified Buteo	23	13	4	40
Golden Eagle	2	1	0	3
American Kestrel	0	0	19	19
Prairie Falcon	0	0	7	7
Total Raptors	99	66	104	269
Waterfowl				
Dabbling Ducks	79	20	314	413
Canada Goose	23	19	59	101
Total Waterfowl	102	39	373	514
Other				
Great Blue Heron	4	8	11	23

Sharp-tailed Grouse	0	0	9	9
Killdeer	1	3	5	9
Gulls	43	2	15	60
Great-horned Owl	0	0	3	3
Total Other	48	13	43	104
Total	344	200	1184	1728

APPENDIX 2

Bird interactions with wind turbines: flight paths taken by birds in apparent avoidance of turbines, Castle River Wind Farm, March 2001 – December 2002.

Species	Fly Over (n)	Fly Around (n)	Fly Below (n)	Total (n)
Passerines/Others				
Rock Dove	1	0	0	1
Northern Shrike	0	0	0	0
Black-billed Magpie	0	0	0	0
Common Raven/Crow	1	13	13	27
Horned Lark	0	0	2	2
Mountain Bluebird	0	0	0	0
American Robin	0	0	0	0
European Starling	0	0	0	0
Dark-eyed Junco	0	0	0	0
Western Meadowlark	0	0	0	0
Unidentified Passerine	0	0	0	0
Total Passerines/Others	2	13	15	30
Raptors				
Bald Eagle	1	0	1	2
Northern Harrier	0	0	1	1
Unidentified Accipiter	0	0	0	0
Swainson's Hawk	0	0	0	0
Red-tailed Hawk	4	0	0	4
Rough-legged Hawk	0	1	0	1
Unidentified Buteo	0	0	0	0
Golden Eagle	0	1	0	1
American Kestrel	0	0	0	0
Prairie Falcon	0	0	0	0
Total Raptors	5	2	2	9
Waterfowl				
Dabbling Ducks	291	4	0	295
Canada Goose	59	2	0	61
Total Waterfowl	350	6	0	356
Other				

Great Blue Heron	2	1	0	3
Sharp-tailed Grouse	0	0	0	0
Killdeer	0	0	0	0
Gulls	0	1	0	1
Great-horned Owl	0	0	0	0
Total Other	2	2	0	4
Total	359	23	17	399