Summary of Post-Construction Monitoring at Wind Projects Relevant to Minnesota, Identification of Data Gaps, and Recommendations for Further Research Regarding Wind-Energy Development in Minnesota

Prepared for:

State of Minnesota

Department of Commerce

Prepared by:

Victoria Poulton

Western **E**co**S**ystems **T**echnology, Inc.

2003 Central Avenue

Cheyenne, Wyoming

WEST, Inc.

December 10, 2010

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

INTRODUCTION

Utility-scale wind-energy facilities are installed in 36 states. At the end of 2009, Minnesota had the sixth highest wind energy production after Texas, Iowa, California, Washington, and Oregon (AWEA 2009). Currently, wind energy installed capacity in Minnesota is about 1,797 megawatts (MW) produced by over 1,400 turbines, with another 673 MW in construction (AWEA 2010). Most existing and planned wind power projects are located in the southern part of the state, south of Interstate 94 (Figure 1).

Post-construction monitoring studies at several dozen wind-energy facilities across the U.S. have provided a general picture of direct impacts to bird and bats: passerines are the bird group most commonly found as collision-related fatalities; tree-dwelling bats (genus *Lasiurus* and *Lasionycteris*) are the most common bat fatalities. However, as post-construction data from additional wind-energy facilities become available, some initial hypotheses about the potential for wind-energy impacts to birds and bats have been contradicted. For example, projects in West Virginia, Pennsylvania, and Tennessee had bat fatalities that were exceptionally high compared to projects in other parts of North America (Arnett et al. 2008). It was believed that the location of the projects on forested ridgetops was a main reason that bat fatalities were highest at these wind projects (e.g., Kunz et al. 2007), but recent results from Alberta, Canada, and Wisconsin indicate that bat fatality rates can also be high at projects located in flatter areas used for cultivated agriculture and lacking the continuous tree cover notable on eastern forested ridges.

Publicly-available post-construction wind-energy impacts data are summarized from 19 studies at 16 wind-energy projects in the U.S. that use wind turbines of modern design. Publicly available data come from sources such as journal articles, documents released as part of permitting processes, or information posted on non-password-protected websites. Other wind projects may have had data collected, but if those data are not available in a public forum, they will not be discussed here. Most publicly-available studies are from grasslands and agricultural lands in the arid west. Post-construction monitoring results from other parts of the U.S. such as the wooded ridges along the eastern seaboard may be less relevant to Minnesota since they generally are located where topography, climate, vegetation, and wildlife use are different, but some projects from the eastern states will be reviewed in this document because they are the only wind-energy impact studies in landscapes dominated by forests, or where lakes or wetlands are abundant.

The Minnesota Department of Natural Resources (MDNR) and the U.S. Forest Service have developed an Ecological Classification System (ECS) for ecological mapping and landscape classification in Minnesota (http://www.dnr.state.mn.us/ecs/index.html). Ecological land classifications are used to identify, describe, and map progressively smaller areas of land with increasingly uniform ecological features. The system uses associations of biotic and environmental factors, including climate, geology, topography, soils, hydrology, and vegetation. ECS mapping enables resource managers to consider ecological patterns for areas of varying scale and identify areas with similar management opportunities or constraints relative to that scale. Map units for six of these levels occur in Minnesota (Provinces, Sections, Subsections, Land Type Associations, Land Types, and Land Type Phases). Four Provinces occur in Minnesota (Prairie parkland, Tallgrass aspen parklands, Eastern broadleaf forest, and Laurentian mixed forest; Figure 2) and are considered in this report.

The Province for which there are the most post-construction impact studies in comparable habitat is Prairie Parkland, with a relatively arid climate and landcover dominated by grassland and cultivated agriculture. Most wind-energy development in Minnesota has taken place in the Prairie Parkland Province, though this is changing as more projects are considered in other Provinces. Many wind-energy impact studies may also be applicable, in terms of landcover, to the Tallgrass aspen parklands Province since the climate is arid, and cold, dry winters coupled with spring wildfires prevent woody vegetation from becoming dense. However, the Tallgrass aspen parklands have more open woodlands and wetlands than most of the landscapes where wind-energy projects are currently operating.

The Eastern broadleaf forest Province extends from the southeast corner of Minnesota up to the center of the state and is a transition zone between the prairies to the west and the wetter mixed forests of the northeast. Presettlement vegetation was a mixture of forests, woodlands, and patches of fire-maintained prairie, but much of the Province has been converted to cultivated agriculture or human development. The Laurentian mixed forest Province covers a large portion of Minnesota in the north and east. It is characterized by coniferous forests, mixed forests, lakes, and coniferous bogs and swamps. There are few studies of wind-energy development impacts in landtypes similar to the Eastern broadleaf and Laurentian mixed forest Provinces; some published studies in forested areas are available from New York and Pennsylvania.

Studies of direct and indirect bird and bat impacts due to wind energy facilities are described in this document, and then related to Minnesota by ecological Province. The commercial-scale facilities summarized in this report (Table 1, Table 2) use turbines with capacities ranging from 0.3 to 2.0 MW, have turbines mounted on tubular towers that do not provide perching spots for birds, and have electrical collection lines buried to reduce electrocution risk for birds. The 0.3-MW turbines that were constructed in 1994 at Buffalo Ridge, MN, are much smaller in terms of height and capacity than turbines typically built in 2010, which have taller towers and capacity of 1.5-2.5 MW. Results from the Buffalo Ridge studies are outdated and may not be relevant due to changes in turbine size; however, the Buffalo Ridge studies remain the most rigorous evaluations of wind-energy impacts in the region.

POST-CONSTRUCTION WIND-ENERGY FACILITY FATALITY STUDY SUMMARIES

The number of turbines per project ranges from 20 to 281. Turbine tower heights range from 36 to 80 m, and blade diameters are 33 to 80 m. Post-construction monitoring for these studies included trials to estimate bias introduced by searcher detection rates and carcass scavenging rates. Bias estimates were used to adjust the observed fatality rates (Table 2). During most studies, fatalities were found outside of regularly scheduled turbine searches (incidental finds) by searchers moving about the project area or by wind facility personnel.

Buffalo Ridge, Minnesota

The Buffalo Ridge Wind Power Project is located in Lincoln and Pipestone Counties, in southwest Minnesota. This is the only Minnesota wind-power project with publicly available post-construction monitoring data. It consists of 73 0.34-MW turbines (Phase I) and 281 0.75-MW turbines (Phase II with 143 turbines and Phase III with 138 turbines). Turbine towers in Phase I are 36 m, rotor diameters are 33 m, and maximum turbine height is 69 m. For Phase II and III, towers are 36 m tall, rotor diameters are 48 m, and maximum height is 84 m. Habitats in the study areas included cultivated agriculture (soy, corn, and small grains), pasture, and Conservation Reserve Program (CRP) grasslands. The Buffalo Ridge Wind Resource Area was the first large wind-energy development in the state and extensive research was conducted at this WRA to assess potential for bird and bat impacts and to measure actual impacts (Hawrot and Hanowski 1997; Higgins et al. 1996; Johnson et al. 2000a, 2002b,c, 2003a, 2003b, 2004; Krenz and McMillan 2000; Leddy 1996; Leddy et al. 1997, 1999; Nelson 1993, Osborn et al. 1996, 1998, 2000; Strickland et al. 1997, 2000, 2001; Usgaard et al. 1997).

The primary large-scale studies conducted at Buffalo Ridge to estimate impacts were a 4-year study to measure avian and bat mortality from 1996-1999 (Johnson et al. 2000a, 2002b,c, 2003a) and a 2-year study conducted in 2001-2002 designed specifically to evaluate bat mortality (Johnson et al. 2003b, 2004).

Turbines in three phases of the project, as well as reference areas with no turbines, were searched for fatalities every two weeks over four years (1996-1999; Johnson et al. 2000, 2002, 2003a). Over the four-year study, 55 bird fatalities representing at least 31 species were found at Buffalo Ridge Phases I, II, and II. Bird fatalities included 17 incidental finds. Passerines made up the majority of observed bird fatalities (76%), and warblers were the most common passerine group found (19 individuals, 35% of all bird fatalities). Waterfowl (five individuals, 9% of fatalities), waterbirds (three individuals, 5%), and upland gamebirds (three individuals, 5%) were the other bird groups with more than one fatality. Only one raptor, red-tailed hawk, was found. Most searched turbines had no fatalities that were found; the most fatalities were found at two turbines in Phase III, where 14 passerine fatalities were found on one day in mid-May. Bird fatalities were higher at turbines closer to wetlands, and at turbines with less cropland (i.e., more of other, possibly less disturbed habitat). About 71% of bird fatalities appeared to be migrants, with the remainder being breeders or year-round residents. For the three project phases at Buffalo Ridge, adjusted fatality estimate for all birds ranged from 1.43 – 5.93/MW/year or 0.50 – 4.45 birds/turbine/year.

A total of 184 bats were found, including 69 found incidentally. Six bat species were identified, with hoary bat (*Lasiurus cinereus*) the most numerous (108 individuals, 59% of all bat fatalities), followed by red bat (*L. borealis*; 37 individuals, 20%), silver-haired bat (*Lasionycteris noctivagans*; six individuals, 3%), tri-colored bat (*Perimyotis subflavus*; six individuals, 3%), little brown bat (*Myotis lucifugus*; five individuals, 3%), and one big brown bat (*Eptesicus fuscus*; <1%). Twenty-one bat fatalities were too decomposed for identification. The number of bat fatalities per turbine ranged from zero to eight, with one turbine having eight fatalities. Most (97%) of bat fatalities were found between mid-July and mid-September, and all bat fatalities were found between 20 May and 19 October. The adjusted bat fatality estimate at Buffalo Ridge for the three project phases ranged from 0.76 – 2.72 bats/MW/year or 0.26 – 2.04 bats/turbine/year (Johnson et al. 2003a,c).

Another fatality study focusing on bats was conducted over two years at Buffalo Ridge Phase II and III in 2001 and 2002 (Johnson et al. 2003b, Johnson et al. 2004). Bat fatalities were monitored and bat activity was measured using bat detectors and mist netting. Over the two-year study, the adjusted bat fatality estimate was 2.88/MW/year or 2.16/turbine/year with the majority of fatalities being hoary bats and eastern red bats. Most fatalities were found between mid-July and the end of August. Bat detectors and mist-netting data indicated a relatively large breeding population of bats near the wind project, but these bats were rarely, if ever, among the turbine-related fatalities. There was no statistical relationship between bat activity and fatalities, and there was no correlation between habitat variables and fatalities.

Blue Sky Green Field, Wisconsin

The Blue Sky Green Field Wind Energy Center, located in Fond du Lac County, Wisconsin, became operational in May 2008. The project consists of 88 Vestas V82 wind turbines, with an overall nameplate capacity of 145 MW. The turbine towers are 80 m, rotor diameter is 82 m, and maximum height is 121 m. Turbines are located in cultivated agriculture, mostly corn, soybean, and alfalfa, with scattered woodlots interspersed amongst the fields. Fatality monitoring was conducted July 21 – October 31, 2008, and March 17 – June 6, 2009. Thirty turbines were searched; 10 of these turbines were searched daily (Monday – Friday), and the other 20 turbines were searched once every four to six days (Gruver et al. 2009). Since the turbines were located in crop fields, strips were mowed to facilitate good visibility of fatalities on the ground.

Forty-three bird fatalities representing 12 species were found during approximately six months of fatality surveys at Blue Sky Green Field. Three of the fatalities were found incidentally, and 44% of bird fatalities were unidentified due to decomposition or because they consisted of a pile of feathers. Of identified birds, golden-crowned kinglet (9%), horned lark (7%), and tree swallow (7%) were most common. One raptor, a red-tailed hawk, was found incidentally. Bird fatalities were found at 22 of the 30 searched turbines, and the highest number of bird fatalities found at any one turbine was eight. Bird fatalities were found throughout the fall 2008 and spring 2009 survey periods. Most bird fatalities were found within 30 m of the turbine or more than 60 m from the turbine. Bird fatality numbers were not statistically related to distance from wooded areas. The adjusted fatality estimate for birds at Blue Sky Green Field Wind Energy Center was 11.83 birds/turbine/year or 7.17 birds/MW/year. When estimates for daily and weekly searches were separated, daily searches resulted in a slightly higher estimate, but 90% confidence limits for daily and weekly searches overlapped substantially, indicating that daily searches did not result in significantly more fatalities found.

Surveys at Blue Sky Green Field resulted in 247 bat carcasses representing five species. Twenty-six fatalities were found in areas not regularly searched. Little brown bats were the most common species (29%), followed by silver-haired bats (24%), big brown bats (19%), hoary bats (17%), and red bats (7%). Most bat fatalities were adults (72%), and males and females were found in approximately equal numbers. The number of bat fatalities per turbine ranged from one to 19. All but five bat fatalities were found during the fall surveys. Over half of bat fatalities were found within 20 m of the turbine. Bat fatality numbers were not statistically related to distance from wooded areas. Adjusted bat fatality estimates were 40.5 bats/turbine/year or 24.6 bats/MW/year. Slightly more bats were found at turbines searched weekly compared to turbines searched daily, but this was not a statistically significant difference. More non-migratory species (i.e., little brown bat, big brown bat) were found than migratory species (hoary bat, silver-haired bat, red bat), which is a departure from the pattern seen at most other fatality monitoring studies at wind energy facilities (Gruver et al. 2009, Arnett et al. 2008, Johnson 2005).

Detailed analysis of fatalities found in relation to weather conditions and concomitant bat acoustic monitoring revealed that bat fatalities increased with increasing average nightly temperatures and higher proportion of the night with low visibility. Bat fatalities decreased with increasing wind speed and higher proportion of the night with low ceiling. Number of bat fatalities was positively correlated with the number of bat passes per night detected by acoustic bat detectors on the ground (Gruver et al. 2009).

Kewaunee County, Wisconsin

The Kewaunee County, Wisconsin, fatality study was conducted at 31 0.66-MW Vestas wind turbines arranged in three groups in northern Kewaunee County. Turbine towers are 65 m, rotor diameter is 47 m, and maximum height is 89 m. Land use in the area is cultivated alfalfa/clover or corn (crops and high or dense vegetation were not cleared in this study). The study was conducted from late July 1999 through July 2001, and diurnal and nocturnal bird use was also studied. Fatality searches were conducted at all turbines twice per week from July 1999 to September 2000, and weekly from October 2000 through March 2001, except during spring migration (April and May) and fall migration (late August and September), when searched were conducted daily. Searches were conducted three times per week in June and July 2001 when searcher efficiency trials were also taking place (Howe et al. 2002).

Twenty-five intact bird carcasses representing 19 species were found during the two-year study, and other unidentified feather spots were also found, but not included in fatality lists or estimates. Most of the carcasses were passerines or woodpeckers, and the remainder was waterbirds or waterfowl. Most carcasses were found during May, April, and August, but search effort was also higher during these times. The most bird fatalities found at one turbine was three. The adjusted fatality estimate for birds was 1.29 birds/turbine/year or 1.95 birds/MW/year.

Seventy-two bat casualties (dead or injured animals) representing five species were found during the surveys in Kewaunee County. Most bat fatalities were red bats and hoary bats, and most were found between July and September, with numbers peaking in August. Bats were found at all distances out to 30 m from the turbine, which was the limit of the area searched, and it was assumed that more bat fatalities likely occurred beyond 30 m from the turbines and were not found. Adjusted fatality estimates for bats were 4.26 bats/turbine/year or 6.45 bats/MW/year. Adjusted estimates for this study were based on the assumption that actual mortality was 4 times higher than what was observed.

Cedar Ridge, Wisconsin

The Cedar Ridge Wind Farm is in Fond du Lac County, Wisconsin. It consists of 41 turbines with 1.6 MW capacity each, for a total wind farm capacity of 68 MW. Maximum turbine height is 80 m and rotor diameter is 82 m. The facility is located on land used primarily for cultivated agriculture, with small patches of forested areas, old fields, wetlands, and other landcover types. Twenty of the 41 turbines were searched every one to four days in the spring (mid-March through May) and fall (mid-March to mid-November) of 2009. Searches in late fall (mid-October to mid-November) were focused on large birds. Two of the turbines had the entire 160 x 160-m plot searched, while the other turbines had strip transects that were mowed for searching (BHE 2010).

Thirty-one bird fatalities representing 17 species were found during searches in spring and fall 2009. An additional 11 fatalities were found incidentally and four fatalities were found in the late fall season when the focus was on large birds. Incidental and late fall finds were not included in analyses. The most common species were tree swallow (*Tachycineta bicolor*) and rock pigeon (*Columba livia*), and almost all were small- or medium-bodied in size. One raptor, a red-tailed hawk, was found during regular searches, and another red-tailed hawk was found during late fall searches. Approximately equal numbers of bird fatalities were found in spring and fall. The most bird fatalities found during regular searches was five at turbine six with an additional two found incidentally at this turbine. The adjusted fatality rate for small- to medium-sized birds was 6.53 birds/MW/169-day study period or 10.82 bats/turbine/169-day study period.

Bat fatalities at Cedar Ridge totaled 84 during regular searches with an additional five found incidentally. Five bat species were identified, with hoary bat most common (34.5%), followed by silver-haired bat (19.0%), big brown bat (17.9%), eastern red bats (14.3%), and little brown bats (14.3%). Most bats (92%) were found during fall searches with the bulk of these found in August and September. The most bats found at one turbine was 13 at turbine 40. The adjusted fatality rate was 30.4/MW/169-day study period or 50.5/turbine/169-day study period.

Crescent Ridge, Illinois

The Crescent Ridge Wind Power Project is in Bureau County, Illinois, and is a 49.5-MW facility with 33 1.5-MW turbines and two met towers. Maximum turbine height is 120 m. The project is located on land mostly used for cultivated agriculture, mostly corn and soybeans, and with some fallow fields. All turbines and met towers were searched every five days during September – November 2005 (after an initial clearing search in late August – early September 2005), March – May 2006, and August 2006 (Kerlinger et al. 2007). Crops were not removed to facilitate searching during this study; searchers just walked along the rows of crops to look for fatalities.

During approximately seven months of surveys, 10 bird fatalities were found, representing 10 species. Passerines were the most common (60% of fatalities), and one raptor, a red-tailed hawk was found. No more than one bird fatality was found at any turbine, and FAA lighting on some of the turbine did not appear to influence fatality numbers. Most (80%) of the bird fatalities were found in the fall between September and November. Adjusted bird fatality rates were 0.49 birds/turbine or 0.33 birds/MW in fall 2005 and 0.47 birds/turbine or 0.31 birds/MW in spring 2006.

Twenty-one bat fatalities were found during the study, representing three species. Silver-haired bats were most common (38% of fatalities), followed by hoary bats and eastern red bats (29% each). One bat carcass was unidentified. Bat fatalities per turbine ranged from zero to 10 at one turbine. FAA lighting did not appear to influence fatality numbers; the turbine with 10 fatalities was not lit. All but one bat fatality were found between August and September. Adjusted bat fatality rates were 2.67 bats/turbine or 1.75 bats/MW in fall 2005 and 0.18 bats/turbine or 0.12 bats/MW in August 2006.

Top of Iowa, Iowa

The Top of Iowa Wind Farm in Worth County, Iowa, consists of 89 NEG Micon 0.9-MW turbines, for a total project capacity of 80.1 MW. Turbine towers are 71.6 m, rotor diameters are approximately 52 m, and maximum height is approximately 97.5 m. The wind farm is located in land used to grow corn and soybeans, but is in close proximity to three large state Waterfowl Management Areas (WMAs) with very high use by geese and ducks. Fatality monitoring was conducted at 26 of the 89 turbines from mid-April to mid-December 2003 and from mid-March to mid-December 2004. Searches were conducted every two to three days along six three-meterwide transects that were maintained free of crops and vegetation, and bird use was also monitored during the fatality study (Jain 2005).

During approximately 16 months of surveys, seven bird fatalities were found at Top of Iowa. Bird fatalities included three passerine species and a raptor (red-tailed hawk). Three of the fatalities were unidentified small birds. For the 2003 study period, the adjusted bird fatality rate was 0.49 birds/MW or 0.44 birds /turbine. For the 2004 study period, the adjusted bird fatality rate was 1.07 birds /MW or 0.96 birds /turbine.

Seventy-five bat fatalities were found during surveys at Top of Iowa. Bat species included hoary bat (28%), little brown bat (24%), and eastern red bat (25%). Two additional red bats were found incidentally. All but one bat fatality were found between June and October. For the 2003 study period, the adjusted bat fatality rate was 7.34 bats/MW or 6.60 bats/turbine. For the 2004 study periods, the adjusted bat fatality rate was 9.81 bats/MW or 8.83 bats/turbine.

Bat calls were also recorded at turbine and non-turbine sites while fatality monitoring was conducted. Bat activity (number of calls/detector night) was similar at turbine and non-turbine sites, and most calls were little brown bats.

NPPD (Nebraska Public Power District) Ainsworth Wind Energy Facility, Nebraska

The Ainsworth Wind Energy Facility, operated by NPPD in Brown County, Nebraska, has 36 turbines with 1.65 MW capacity each. Turbine towers are 70 m, rotor diameter is 80 m, and maximum turbine height is about 115 m. Most of the Facility is located in native grassland used for grazing. All 36 turbines were searched every 14 days between March 13 and November 4, 2006, and a clearing search was conducted in early March to remove fatalities that occurred before the study period (Derby et al. 2007).

Over approximately eight months of fatality searches, 27 birds of 14 species were found, including one incidental find. Passerines were the most common bird type found (78% of bird fatalities). Three raptors (two American kestrels, one short-eared owl) were found. The most birds found at any one turbine was three, and no spatial patterns were evident in bird fatality locations within the Wind Energy Facility. The adjusted fatality estimate for birds at the Ainsworth Facility was 1.63 birds/MW/period of study or 2.69 birds/turbine/period of study.

Sixteen bat fatalities were found during the Ainsworth study, the majority of which were hoary bats (75% of bat fatalities). The most bats found at any one turbine was three, and no spatial patterns were evident in bat fatality locations within the Wind Energy Facility. The adjusted fatality estimate for bats at the Ainsworth Facility was 1.16 bats/MW/period of study or 1.91 bats/turbine/period of study.

Foote Creek Rim, Wyoming

The Foote Creek Rim Windpower Project is in Carbon County, Wyoming. Phase I of the Project consists of 69 0.6-MW Mitsubishi turbines with 40-m towers, 42-m rotor diameter, and 61-m maximum height. The Project is located on a flat-topped ridge or mesa. Vegetation in the Project is cushion plant grassland, and surrounding habitat includes sagebrush steppe and an aspen stand. All 69 turbines and five met towers were searched every 28 days between November 1998 and December 2000, and half of these were searched every two weeks during this period. From June

2001 to June 2002, half of the turbines and all of the met towers were searched once every 28 days. The study was conducted for 38 months out of a 44-month period (Young et al. 2003).

Over the course of the study, 122 bird fatalities representing at least 37 species were found. Thirty-six of the bird fatalities were associated with met towers, and three were not close to turbines or met towers. Passerines were the most common bird type found (92% of bird fatalities) and horned lark was the most common species (26%). Five raptors of three species were found. Birds were found at 46 of the 69 turbines, and the most birds found at any one turbine was five. Mid-row turbines had a slightly higher risk for collision than end-row turbines, and there was a higher probability of collision risk for met towers compared to turbines, but no other spatial patterns were evident in the locations of fatalities. The adjusted fatality rate for birds at Foote Creek Rim was 2.50 birds/MW/year or 1.5 birds/turbine/year.

Seventy-nine bats of four species were found during monitoring at Foote Creek Rim, including eight found incidentally. Hoary bat was the most common species (80% of bat fatalities). No bats were found at met towers. Bats were found at 48 of the 69 searched turbines and the maximum number of bats found at any one turbine was four. The adjusted fatality rate for bats at Foote Creek Rim was 2.23 bats/MW/year or 1.34 bats/turbine/year.

Judith Gap, Montana

The Judith Gap Wind Project is in Wheatland County, Montana, and consists of 90 GE 1.5-MW turbines. Towers are 80 m, rotor diameter is 77 m, and maximum turbine height is approximately 118 m. Landcover in the project area is cultivated wheat fields, native grassland used for grazing, and CRP grassland. Twenty of the 90 turbines were searched every month from August to October of 2006 and February to May of 2007 (TRC 2008).

During the seven months of searches, 15 bird fatalities representing seven species were found during regularly scheduled searches. An additional 11 birds were found incidentally. For birds found during regular searches, passerines made up the majority of fatalities (67%) and horned lark was the most common species (27%). A short-eared owl was the only raptor found. Birds were found at 11 of the 20 searched turbines, and the maximum number of birds found at one turbine was two. More birds were found in August and September than other months. The adjusted fatality rate for birds at Judith Gap was 3.01/MW/study period or 4.5 birds/turbine/study period.

Thirty-six bats were found during the seven months of searches at Judith Gap, including one incidental find. Hoary bats made up 49% of bat fatalities found during regular searches, unidentified bats made up 40%, and silver-haired bats made up 11% of fatalities. Bats were found at 17 of the 20 searched turbines, and the maximum of four bats was found at two different turbines. Seventy-one percent of bat fatalities were found in August. The adjusted fatality rate for bats at Judith Gap was 8.93 bats MW/study period or 13.40 bats/turbine/study period.

Summerview, Alberta, Canada

The Summerview Wind Farm is in southern Alberta, Canada, and consists of 39 Vestas V80 1.8-MW turbines. Towers are 67 m, rotor diameter is 80 m, and maximum height is 107 m. Land cover in the area is cultivated wheat and seeded pasture. All turbines were searched weekly over the period of a year in 2006, and searches were increased to twice per week during migration periods (May – July and September; Brown and Hamilton 2006a).

Over the one-year study period, 50 bird fatalities representing 15 species were found. Passerines were the most common bird type found (58% of fatalities) and horned lark was the most common species (20%). Waterbirds (gulls and grebes) were the next most common bird type found (20%). Five raptors of three species were found. Birds were found throughout the year, though more were found in late August-September, and fewer were found during winter. There was no relation between bird fatalities and location along a turbine row or location in pasture or crop. The adjusted fatality rate for birds at Summerview was 1.06 birds/MW/year or 1.91 birds/turbine/year.

During the year of searches at Summerview, 532 bat fatalities of five species were found. The majority of bats were silver-haired bats (51% of bat fatalities) and hoary bats (46%). More bats were found in the northern half of the wind farm, and bat mortalities were lower at end-row turbines compared to turbines in the middle of the row. Lit turbines tended to have somewhat lower bat mortalities, but this was confounded with turbine location since all lit turbines were also end-row turbines. All bats were found between March and October, with the majority found in August and September. The adjusted fatality rate for bats at Summerview was 10.27 bats/MW/year or 18.49 bats/turbine/year.

Bat fatalities were monitored at Summerview again in the summer and fall of 2006 and 2007. Searches were conducted daily at 10 of the turbines and weekly at the other 29 turbines. The adjusted fatality rate for bats during 2006-2007 was 14.62 bats/MW/period of study or 26.32 bats/turbine/year (Baerwald 2008).

McBride Lake, Alberta, Canada

The McBride Lake Wind Farm, in southern Alberta, Canada, comprises 114 Vestas V47-660 turbines with a capacity of 0.66 MW each. Towers are 50 m, rotor diameter is 47 m, and maximum height is about 74 m. The Wind Farm is located in cultivated wheat and barley fields and grazed native pasture. All turbines were searched over one year on a weekly basis except during migration periods (May – June, September – October) when they were searched twice per week. Bias trials were not conducted during this study, so fatality rates are unadjusted for searcher efficiency and scavenger removal (Brown and Hamilton 2004).

During a year of monitoring at McBride Lake, 41 bird fatalities representing 15 species were found. Passerines were the most common bird type found (51% of fatalities), but Swainson's hawk was the most common species found (17%). Raptors as a group made up 22% of fatalities. Most birds were found in fall and spring, but most hawks were found in summer. There was no pattern to fatality location within the Wind Farm. The unadjusted fatality rate for birds at McBride Lake was 0.54/MW/year or 0.36 birds/turbine/year.

Fifty-four bat fatalities representing four species were found during searches at McBride Lake. The most common species was hoary bat (87% of bat fatalities). All but one bat were found between early August and mid-October. Bats were found at 42 of the 114 turbines, and the most bats per turbine was three. No spatial pattern of carcass distribution in the Wind Farm was apparent. The unadjusted fatality rate for bats at McBride Lake was 0.71 bats/MW/year or 0.47 bats/turbine.

Castle River, Alberta, Canada

The Castle River Wind Farm is also in southern Alberta, Canada. It comprises 60 Vestas V47-660 turbines with 0.66-MW capacity each. Towers are 50 m, rotor diameter is 47, and maximum height is approximately 74 m. As for the other Alberta wind farms, Castle River is located among cultivated fields or grazed native grassland. All turbines were searched over a 21-month period on a weekly basis except during migration periods (May – June, September) when they were searched twice per week. Bias trials were not conducted during this study, so fatality rates are unadjusted for searcher efficiency and scavenger removal (Brown and Hamilton 2006b).

During surveys at Castle River, 19 bird fatalities of 13 species were found. Passerines were the most common bird type found (74% of bird fatalities). Only one or two of each species were found. 47% of birds were found during spring, and none were found in winter. There was no apparent spatial pattern to bird fatality distribution throughout the wind farm. The unadjusted bird fatality rate in 2001 was 0.23 birds/MW/year or 0.15 birds/turbine/year. In 2002, the unadjusted bird fatality rate was 0.35 birds/MW/year or 0.23 birds/turbine/year.

Fifty-two bat carcasses were found during surveys at Castle River, representing three species. Hoary bat was the most common species found (55% of fatalities). Bat fatalities were found between June and November. There was no apparent spatial pattern to bat fatality locations. The unadjusted bat fatality rate in 2001 was 1.35 bats/MW/year or 0.89 bats/turbine/year. In 2002, the unadjusted bat fatality rate was 0.33 bats/MW/year or 0.22 bats/turbine/year.

Mars Hill, Maine

The Mars Hill Wind Farm is in northeastern Maine, in Aroostook County. The Wind Farm consists of 28 turbines with 1.5-MW capacity each. Towers are 80 m, rotor diameter is 77 m, and maximum turbine height is 119 m. The Wind Farm is located along a forested ridge top, dominated by northern hardwood forest species. Four of the turbines are located in old field grassland or partially forested/grassland habitats. Laydown areas were cleared and leveled for the turbines, and turbines were located in the center or to the side of cleared areas that had been reseeded with grass. All turbines were searched within the cleared areas during Apr 23-Jun 3, Jul 15-Aug12, and Aug 13-Sep 23, 2007, and Apr 19-Jun 6, Jul 15-Aug 12, and Aug 13-Oct 8, 2008. Cleared areas typically had a 76-m radius, but when the turbine was not centered, the cleared area could be as little as 10 m from the turbine base. In 2007, turbines were searched every seven days, with two randomly selected turbines searched every day during the search periods. Two turbines per search period were also subjected to an extended search plot (238 m diameter). A dog was also used to search a subset of turbines at the end of each search session. In 2008, all turbines were searched weekly during Apr 19-Jun 6, Jul 15-Aug 12, and Aug 13-Oct 8. One extended search was conducted per search period, and dogs were used to search some turbines once or twice per search period (Stantec 2008, 2009).

A total of 22 bird fatalities were found in 2007 at Mars Hill, with six found during regular searches, three incidental finds, and 13 found during dog searches. All fatalities were songbird species. There were no apparent seasonal or spatial patterns. In 2008, 21 bird fatalities were found; 14 during standard searches, four incidentally, one during an extended plot search, and two during dog searches. Most fatalities were songbirds with the exceptions of a barred owl and a ruffed grouse, and there were no strong spatial or seasonal patterns in fatality numbers. Adjusted fatality rates for birds in 2007 were 0.29 birds/MW/year or 0.43 birds/turbine/year for weekly searches, 0.69 birds/MW/year or 1.04 birds/turbine/year for daily searches, and 1.65 birds/MW/year or 2.47 birds/turbine/year for dog searches. In 2008, adjusted fatality rates for birds were 1.36 birds/MW/year or 2.04 birds/turbine/year for weekly searches and 1.76 birds/MW/year or 2.65 birds/turbine/year for dog searches.

During 2007, 24 bat fatalities were found, with two found during standard searches, two found incidentally, one found in an extended search plot, and 19 found during dog searches. Most fatalities (38%) were silver-haired bat, and hoary bat (21%), little brown bat (17%), and eastern red bat (13%) were also found. Most bats were found between late July and August. During 2008, five bats were found, with four found during standard searches and one found during dog searches. Fatalities were hoary bats, eastern red bats, and a silver-haired bat found between late July and early September. Adjusted fatality rates for bats in 2007 were 0.29 bats/MW/year or 0.43 bats/turbine/year for weekly searches, 1.36 bats/MW/year or 2.04 bats/turbine/year for daily searches, and 2.91 bats/MW/year or 4.37 bats/turbine/year for dog searches. In 2008, adjusted bat fatalities were 0.45 bats/MW/year or 0.68 bats/turbine/year for weekly searches and 0.12 bats/MW/year or 0.17 bats bats/turbine/ year for dog searches.

There were no bird or bat fatalities at Mars Hill communication or met towers. Statistical analyses accounted for reduced searcher efficiency in the second year of study due to growth of vegetation on the turbine pads, so lower fatality rates were speculated to be due to variation in bat populations, variation in bat behavior possibly due to a relatively cool, wet late summer, and/or behavior adaptations to wind turbines.

Maple Ridge, NY

The Maple Ridge Wind Power Project is in Lewis County, New York. It consists of 195 turbines and three met towers. Turbines have 1.65-MW capacity, 80-m towers, 82-m rotor diameter, and maximum height of 122 meters. Turbines were erected in two phases: Phase I consisted of 120 turbines constructed in 2005, and Phase IA and II were 75 turbines constructed between May and December 2006. Landcover in the project area is a mix of cultivated agriculture and pastures with some forested areas. In 2006, 50 of the Phase I turbines were searched between June and November 2006, with 10 searched every day, 10 searched every three days, and 10 searched every 7 days. In 2007, 64 of the 195 available turbines were searched once per week between late April and mid-November. Met towers were also searched both years (Jain et al. 2007, 2008).

During 2006, 125 bird casualties were found during regular searches, and three were found incidentally. In 2007, 64 bird casualties were found during regular searches, and 32 were found incidentally. Most casualties were passerines, with one American kestrel found in 2006, and six red-tailed hawks found in 2007 (three of these were incidental finds). Bird fatalities did not show consistent seasonal patterns; in 2007 they were lowest in June and July, while in 2007 bird fatalities declined strongly in late fall. Habitat did not seem to affect bird fatalities. Adjusted fatality rates for birds were 5.81 birds/MW/ study period or 9.59 birds/turbine/ study period for daily searches, 2.71 birds/MW/ study period or 4.47 birds/turbine/study period for 3-day searches, and 1.90-3.82 birds/MW/study period or 3.13-6.31 birds/turbine/study period for weekly searches.

For bat fatalities in 2006, 326 were found during regular searches, representing hoary bat, silver-haired bat, eastern red bat, little brown bat, and big brown bat. In 2007, 202 bats were found during regular searches and 81 were found incidentally. Species composition was the same as 2006, and most bat fatalities were found in July and August. There were no strong spatial patterns in bat fatality location, but in both years there was some indication that bat fatalities were slightly more abundant at turbines closer to wetlands, and in 2007, there was moderate evidence that bat fatalities were greater near wooded areas, though this was not detected in 2006. Adjusted fatality rates for bats were 14.87 bats/MW/ study period or 25.53 bats/turbine/ study period for daily searches, 13.54 bats/MW/ study period or 22.34 bats/turbine/ study period for 3-day searches, and 9.21-11.23 bats/MW/study period or 15.20-18.53 bats/turbine/study period for weekly searches.

Mountaineer, West Virginia

The Mountaineer Wind Energy Center, in Tucker County, West Virginia, has 44 turbines and two met towers with a total capacity of 66 MW. Turbine towers are 70 m, rotor diameter is 72 m, and maximum height is 105 m. Turbines are located along a forested ridge top where clearings were created for turbine construction and roads. Two post-construction studies are available: the first was conducted April-November 2003 and focused on birds and bats, the second study from July to September 2004 was paired with a study at Meyersdale, Pennsylvania (discussed below) and focused only on bats. The 2003 study had all turbines searched about every three days in spring, once in summer, and every 2.5 days in the fall. The 2004 bat study searched half of the turbines daily and the other half weekly during the study period (Arnett 2005).

During the 2003 study, 69 bird fatalities representing 24 species were found. Passerines were the most common finds. Thirty-three of the fatalities were found on one day near three turbines and the substation. Weather conditions prior to the fatality event included heavy fog and very low visibility. The substation had bright sodium-vapor lights, and the locations of the fatalities indicated that they were attracted to the bright lights and collided with turbines or the substation in the low-visibility conditions. This is the only recorded event of anomalously high fatalities at a wind farm. Excluding birds from the fatality event, bird fatalities showed no spatial pattern in distribution, and were not higher at lit turbines. Adjusted fatality estimates, excluding fatalities from the weather-related event, were 2.69 birds/MW/study period or 4.04 birds/turbine/study period.

For bats during the 2003 study, 475 fatalities representing seven species were found. Red bats were the most common fatality, and most (92.5%) of bat fatalities were found between mid-August and the end of September. During the 2004 study, 398 bat fatalities were found during regular searches, and 68 were found incidentally, with hoary bat being the most common fatality (33.7%). Bat fatalities were found at all turbines except one that was not operational during the study, and FAA lighting on turbines did not have an effect on bat fatality numbers. Adjusted bat fatality rates were 31.69 bats/MW/study period or 47.53 bats/turbine/study period in 2003. In 2004, adjusted fatality rates were 25.3 bats/MW/6 weeks or 38.0 bats/turbine/6 weeks for daily searches. Adjusted estimates were not made for weekly searches since scavenger rates were very high and many of the searches took place before nights with higher fatalities, so these fatalities were likely missed by the weekly searches, leading to an inaccurately low estimate.

Meyersdale, Pennsylvania

The Meyersdale Wind Energy Center is in Somerset County, Pennsylvania, about 90 km northeast of the Mountaineer Wind Energy Center discussed above. The Meyersdale project consists of 20 1.5-MW turbines with 70-m towers, 72-m rotor diameters, and 105-m maximum height. As at Mountaineer, turbines at Meyersdale are arrayed along a forested ridge top, with clearings at the turbine locations. Fatality monitoring was paired with the study at Mountaineer in 2004 and focused on bats. Fatality searches were conducted at all turbines between August and September 2004, and half the turbines were searched daily while the other half were searched weekly (Arnett 2005).

During six weeks of study at Meyersdale, 262 bat fatalities were found during regular searches and 37 were found incidentally. Seven species were represented in the bat fatalities, with hoary bats the most common (46.2%), followed by eastern red bat (27.2%), eastern pipistrelle (7.7%), big brown and silver-haired bats (6.0% each), little brown bats (3.0%), and northern long-eared bat (0.7%). Bat fatalities were found at all turbines during the study and FAA lighting did not affect bat fatalities. Adjusted bat fatality rates at Meyersdale were 20 bats/MW/6 weeks or 30 bats/turbine/6 weeks for weekly searches (scavenging rates were much lower at Meyersdale than Mountaineer) and 16.7 bats/MW/turbine or 25 bats/turbine/6 weeks for daily searches.

Pairing the studies revealed that timing of bat fatalities at both sites was correlated, more adult bat fatalities and more male bats were found, and bat fatalities were higher on low wind nights and before and after storm fronts passed through the area.

GRASSLAND BIRD DISPLACEMENT STUDIES

Studies of indirect impacts to wildlife from wind-energy facilities are not as commonly undertaken as fatality studies. The permanent impact to habitat and vegetative communities due to construction of wind-energy facilities is generally about one acre per turbine, but wildlife may respond to the presence of tall, spinning structures outside of the relatively small footprint of the turbine pad, access roads, and maintenance building, or disturbance may stem from habitat fragmentation or increased human activity. It is generally believed that wildlife species of open habitats (grassland, shrub-steppe) are more likely to respond negatively to wind-energy facilities due to the novelty of tall structures in open areas. Displacement of grassland birds has been studied in Minnesota, Wisconsin, the Dakotas, Iowa, Oklahoma, Washington, and Oregon. Displacement or disturbance studies of wind power and forest birds are not available, though the effects of other types of disturbance that causes fragmentation of forests has been shown to affect bird use (Keller and Yahner 2007, Keller et al. 2009).

Buffalo Ridge, Minnesota

Several efforts have been made to study grassland bird displacement at the Buffalo Ridge Wind Power Project. Johnson et al. (2000) collected data following a Before/After-Control/Impact (BACI) design. Point counts were conducted at 157 point in turbine development areas and a reference area with no development, and in areas before turbines were constructed and in the same area after turbines were constructed. Point counts were conducted between mid-March and mid-November over four years, during morning hours, within a 100-m viewshed, and for five minutes at each point. Each point was visited every two weeks (Johnson et al. 2000).

Results from the bird use studies at Buffalo Ridge indicated that in general, bird use in the study area was highest in woodlands and wetlands, and lowest in croplands. Several bird groups showed decreasing use with increasing distance from wetlands (sparrows, finches, upland gamebirds, waterfowl). Other groups showed decreasing use with increasing distance from woodlands (doves, woodpeckers, swallows, blackbirds, corvids, warblers/vireos, thrushes, chickadees/nuthatches, finches, wrens).

For 22 breeding grassland bird species at small-scales (within 100 m), BACI analysis was used in the Phase 2 part of the wind project in 1998 and 1999. In 1998, the first year after turbine construction, use was lower than expected by common yellowthroat and northern harrier, and higher than expected by horned lark and vesper sparrow. In 1999, two years after construction, use was lower than expected for seven species as well as all grassland breeders combined, and no species had higher than expected use. Comparisons of counts when turbines were running and when they were not also revealed that turbine noise may have prevented detection of some birds that were frequently detected by sound.

At a larger scale (105 – 5,364 m), the only breeding grassland bird to show lower than expected use was northern harrier in 1998. No other species showed significant effects of turbines. The conclusions of this study were that some grassland bird use was reduced in close proximity to turbines, possibly due to vegetation clearing around the turbine pad and access road, but these effects did not appear to extend beyond 100 m.

Leddy (1996) and Leddy et al. (1999) studied bird use along transects in CRP fields with and without turbines at Buffalo Ridge Phase I. Grasslands without turbines and areas more than 180 m from turbines had higher densities of grassland birds compared to areas within 80 m of turbines.

The only published report of avoidance of wind turbines by nesting raptors occurred at Buffalo Ridge, where raptor nest density on 101 mi^2 (261.6 km^2) of land surrounding a wind-energy facility was 5.94 nests/39 mi^2 (5.94 nests/101.0 km^2) yet no nests were present in the 12 mi^2 (31.1 km^2) facility itself, even though habitat was similar (Usgaard et al. 1997).

Kewaunee, Wisconsin

At the Kewaunee County wind project, bird use was surveyed using three-minute point counts and 30-minute counts located in designated turbine areas or reference area. Counts were conducted before and after turbines were constructed. Analysis of Variance (ANOVA) was used to compare counts in the reference and turbine areas, and among the seasons and three years of surveys (Howe et al. 2002). Results did not reveal any clear or consistent pattern of reduced bird numbers or species richness due to construction of turbines, though the turbine area did include large patches of land with no turbines, and use of a different analysis method such as regression analysis may have revealed distance-based responses.

North and South Dakota

Shaffer and Johnson (2009) examined displacement of grassland birds in the northern Great Plains. Intensive transect surveys were conducted within grid cells that contained turbines as well as reference areas. The study focused on five species at two study sites, one in South Dakota and one in North Dakota. Based on this analysis, killdeer (*Charadrius vociferous*), western meadowlark (*Sturnella neglecta*), and chestnut-collared longspur (*Calcarius ornatus*) did not show any avoidance of wind turbines; killdeer actually showed attraction to the turbine areas, probably because they prefer to nest in bare habitats such as turbine pads. However, grasshopper sparrow (*Ammodramus savannarum*) and, to a lesser degree, clay-colored sparrow (*Spizella pallida*) showed avoidance of areas with turbines.

Breeding puddle ducks (mallard, blue-winged-teal, gadwall, northern pintail, and northern shoveler) were counted on wetland complexes within two wind energy developments as well as similar reference areas in North and South Dakota during the 2008 breeding season (Walker et al. 2008). Based on results of the surveys, breeding puddle duck abundance was not lower than expected in areas of wind energy development, and wind turbines did not appear to displace breeding ducks. The project is continuing through 2010 to further assess response of breeding ducks to wind energy development.

Top of Iowa, Iowa

The Top of Iowa wind farm was located in land used for cultivated agriculture, but was near three Wildlife Management Areas that had wetland, grassland, and wooded habitat and were important to grassland species as well as waterfowl. Point counts were conducted within the wind farm and in similar agricultural habitat outside of the wind farm. Geographic blocks were defined and points placed within these blocks to systematically ensure that points were evenly distributed at wind turbine sites, sites away from wind turbines but within the wind farm, and in similar agricultural habitats away from the wind farm. Point counts had 100-m radius, were conducted for 10 minutes at different times of day, and were revisited approximately every six days for each of four time periods throughout the day, but only morning counts were used to compare differences in abundance at the different sites. ANOVA was used to compare abundance at different sites and seasons (Jain 2005).

Results from the point count surveys at Top of Iowa did not reveal any clear patterns of reduced bird abundance at turbine sites compared to non-turbine sites within the wind farm or away from the wind farm. In summer of 2003, red-winged blackbird was more abundant at off-wind farm sites, and in summer of 2004, common grackle and song sparrow were more abundant at sites under wind turbines, but these patterns were not repeated in other seasons. Points were selected for homogeneity of landcover (mostly corn and soybean fields), and bird use was considered low overall.

Oklahoma Wind Energy Center, Oklahoma

The Oklahoma Wind Energy Center (OWEC) is a 102-MW facility with 68 turbines in northwestern Oklahoma. It is located on land used for cultivated agriculture (wheat) and cattle grazing. Indirect impacts of turbines were investigated by conducting four 200-m radius point counts along transects that ran along turbines strings (five transects), were within 1-5 km of turbines (nine transects), and were 5-10 km distant from turbines (12 transects). Transects occurred in one of three habitat types: cultivated crop, native prairie, and mixed pasture and eastern redcedar scrub. Counts were conducted during early morning hours in the breeding season, twice in 2004 and three times in 2005. Vegetation variables were also measured for the different transects by habitat type, and density of singing male birds was analyzed using regression analysis and a General Linear Model (GLM) with factors of year, distance from turbines, and year/distance interaction (Piorkowski 2006).

Twenty-three bird species were recorded frequently enough at all distance categories to allow calculation of detection probability and an adjusted estimate of the number of singing males per 100 hectares. Four species (greater roadrunner, mourning dove, northern mockingbird, and western meadowlark) had higher densities at distances further from turbines for both years. Other species such as field sparrow, northern cardinal, brown-headed cowbird, grasshopper sparrow, northern bobwhite, and scissor-tailed flycatcher showed decreasing densities with increasing distances from turbines. Unmeasured habitat variables such as patch size and edge effects may have been more influential to many of the bird species recorded than the presence of turbines.

Oregon and Washington

The Stateline Wind Project spans the state line between Walla Walla County, Washington, and Umatilla County, Oregon. It consists of 454 Vestas turbines with a capacity of 0.66 MW each. Land cover in the Project area is dryland wheat, native grassland, non-native CRP grassland, and bands of sagebrush along riparian corridors. Twenty transects were monitored in grassland habitat before project construction in 2001 and after construction in 2002. Transects were surveyed three times during the breeding season and observations within 50 m of the transects were recorded. Transects were broken into 50-m segments to evaluate distance from turbines (Erickson et al. 2004). As a group, overall grassland passerine use estimates were similar for the pre- and post-construction surveys. For use estimates by transect subsections, grassland passerines had a significant decline in use in the first 50-m transect segment, but use was similar for all other transect segments before and after construction. Grasshopper sparrows were the only species to show an overall significant decrease in use after construction. For transect subsections, grasshopper sparrows and western meadowlarks had significant decreases in use in the first 50-m segment, and grasshopper sparrows also had significantly decreased use in the second segment. Reduced bird use within 50-100m of the turbines in the year following turbine construction was attributed to vegetation disturbance around the turbine pad and construction area.

Bird use was evaluated before and after construction of the Combine Hills Wind Project in Oregon between 2004 and 2005 (Young et al. 2006). Point counts were conducted at points near turbines and offset from turbines. Birds as a group did not show declines at points located near turbines after the turbines were constructed, though western meadowlarks did decline at turbine points after construction.

Foote Creek Rim, Wyoming

Results of a long-term mountain plover monitoring study at the Foote Creek Rim wind project in Wyoming suggest that construction of the wind-energy facility may have resulted in some displacement of mountain plovers, though declines at the wind project occurred when mountain plover declines were recorded throughout the region. The mountain plover population has slowly increased since, although not to the same level as it was prior to construction. It is not known if this was due to presence of the wind-energy facility or to regional declines in mountain plover populations. Some mountain plovers have apparently become habituated to the turbines, as several mountain plover nests have been located within 75 m (246 ft) of turbines, and many of the nests were successful (Young et al. 2005a).

RELATING POST-CONSTRUCTION WIND-ENERGY FACILITY FATALITY STUDY DATA TO MINNESOTA

The body of literature documenting wind energy impacts on biological resources is still being developed. The recently published National Wind Coordinating Committee (NWCC) Factsheet (NWCC 2010) describes what wind energy/wildlife issues are well-studied, issues that are less-well-understood but have data collected, and issues that remain poorly studied with large data gaps. These issues apply broadly to Minnesota as well: it is understood that birds and bats are killed by colliding with turbines, fatality rates vary from project to project (Figures 3a-c), most birds killed are passerines, bird fatalities at a project are influenced by how many birds use the area and what their behavior is, and bird fatality rates due to wind energy are very small compared to other man-made causes of fatalities.

Bat fatalities at wind energy facilities peak in late summer and early fall, and migratory tree-roosting species seem particularly vulnerable (NWCC 2010). FAA required lighting does not appear to affect the number of bird or bat fatalities (Kerlinger et al. 2010 in press). Indirect impacts such as displacement have been much more difficult to quantify, but evidence from some studies indicates that some grassland species such as breeding songbirds, prairie grouse, and ground-nesting raptors with specific habitat requirements may be displaced when turbines and associated roads are constructed; however, these studies are not conclusive.

Bird fatality estimates for wind-energy facilities in the west and upper Midwest range from 0.31 to 7.17 birds/MW/study period or 0.44 to 11.83 birds/turbine/study period (Table 3, Figure 3a). Raptor fatalities are low; usually one or two per study (Figure 3b). For bats, west and Midwest fatality estimates range widely from 0.18 to 30.4 bats/MW/study period or 0.12 to 40.5 bats/turbine/study period (Table 3, Figure 3c). It is interesting to note that newer turbines with taller towers don't seem to affect bird fatality rates, but do appear to increase per turbine (but not per MW) bat fatality rates (Barclay et al. 2007).

The results from most of these projects are at the low end of the range of fatalities reported from around the United States (Arnett et al. 2008, NRC 2007), but several facilities had higher than expected bat fatality estimates despite being located in similar open grassland or agricultural settings. Currently, it is unclear why some wind facilities in the upper Midwest experience high fatality rates relative to the rest of the region. The answer may lie in larger landscape characteristics that are unlikely to be detected at the scale of project-based baseline or post-construction studies. Baerwald and Barclay (2009) compared bat activity and wind-energy-related mortality in Alberta, Canada, and found some evidence that bat migration activity was higher near the foothills of the Rocky Mountains compared to the prairies to the east, and this effect may have contributed to high bat fatality rates at the Summerview project in Alberta (Brown and Hamilton 2006a, Baerwald 2008). Elevated bat fatalities and inclusion of substantial numbers of resident cave-dwelling bats (big brown bats, little brown bats) some of the upper mid-west projects also deviate from the pattern that seemed to indicate that bat fatalities were higher on forested ridges along the eastern seaboard compared to open, flat landscapes in the West and Midwest, and are mostly made up of migrant tree-dwelling species (hoary bats, silver-haired bats, eastern red bats). Few studies have conducted acoustic bat monitoring at the same time as fatality monitoring. These comparisons were available for Buffalo Ridge and at Blue Sky Green Field, as was pre-construction acoustic bat monitoring data, but results from pre-construction surveys conducted at two met towers on site were not a good indicator of fatalities in this case, even though acoustic surveys during fatality studies showed a correlation between bat fatalities and acoustic bat activity (Gruver et al. 2009).

Currently, available post-construction studies are available mostly from agricultural and grassland and shrub-steppe environments of the arid west, with a few located on forested ridgetops in the eastern US or near wetlands in the Midwest. Little information applies to areas of extensive bogs or flat, forested areas as occur in northern and eastern Minnesota. The Prairie Parkland Province and Tallgrass Aspen Parklands Province have landcover and animal habitat characteristics most similar to the locations of other wind-energy impact studies in the U.S., with open landscapes dominated by grasslands and a relatively arid climate.

The most common avian fatalities in these open, arid environments tend to be common passerine species, and patterns in raptor mortality do not follow overall bird mortality very closely, with raptor fatalities highest in California and New York (Figures 2a, b). Available data show a relationship between raptor use of a site (number of birds observed in 20 minutes at one plot) and post-construction mortality (Figure 3); however, this relationship is strongly influenced by projects in California where raptor use and mortality were high. More data are needed to determine if the relationship holds at intermediate levels of raptor use. Currently, accurate fatality estimates from nearby existing wind projects provide the best tools to predict fatalities at proposed facilities.

Studies of wind facility indirect impacts on passerines, waterbirds, and waterfowl have revealed some small-scale displacement for some species, in the range of 50-200 meters from the turbine (Erickson et al. 2004, Young et al. 2006, Shaffer and Johnson 2009, Johnson et al. 2000). But other studies have not detected any effect of turbines on bird use (Howe et al. 2002, Jain 2005, Piorkowski 2006), indicating that other factors such as habitat patch size (Piorkowski 2006) or large-scale population trends (Young et al. 2005b) may affect how these birds use wind-energy facilities.

Prairie grouse (*Centrocercus* and *Tympanuchus* spp.) are the focus of debate about the indirect effects of wind projects. It is speculated that grouse species respond negatively to the construction of tall structures in their otherwise open habitats with low vegetation (Manes et al. 2002, USFWS 2003, NWCC 2004) since several studies have shown that prairie grouse avoid structures such as roads, power lines, oil and gas wells, and buildings (Robel et al. 2004, Holloran 2005, Pruett et al. 2009a,b). However, levels of activity and traffic at wind facilities would likely be different than other forms of energy development, and few studies have been completed that look specifically at the effects of wind development on grouse. Some telemetry studies are in progress now. Lek surveys at existing wind projects in Nebraska (NGPC 2009) and Minnesota (USFWS 2004) showed that prairie grouse did use lek sites near turbines and, in Minnesota, nesting hens did not avoid turbines, leading to the conclusion that distribution of nesting hens was affected by the presence of adequate residual grass cover, not the presence of tall structures (Toepfer and Vodehnal 2009). In Butler County, Kansas, greater prairie chicken leks declined drastically in the four years following construction of a 100-turbine wind project, but this mirrored region-wide declines in lek counts attributed to increased spring burning and cattle stocking rates that removed vegetative cover important for nesting and brood-rearing (Johnson et al. 2009b, Robbins et al. 2002).

The Eastern Broadleaf Forest Province and the Laurentian Mixed Forest Province do not share many characteristics with environments where post-construction wind project effects have been studied. These areas have more forested and woodland habitat on flat to varied terrain, and bogs, forested lakes, and wet forests are common. Studies of wind project impacts in forested habitats have been conducted in the eastern and northeastern US, in many cases where topography is mountainous or consists of well-defined north/south ridges and valleys (the Appalachians of Virginia, West Virginia, and Pennsylvania). Fatality monitoring results from these eastern and northeastern projects have shown that passerines are the most common bird fatalities and raptor fatality rates vary widely from project to project. The Mountaineer project in West Virginia has the only documented large mortality event for a wind project, and was attributed to bright lights at the substation that attracted and disoriented migrating passerines on a foggy night (Arnett 2005).

The eastern Appalachians are known to be along an important bird migration route in the Atlantic Flyway, while Minnesota is in the path of the Mississippi Flyway. Migrating birds avoid crossing large bodies of water such as Lake Superior, travelling over Minnesota along the Lake Superior shoreline. Points like Hawk Ridge Nature Reserve near Duluth are popular places to watch large numbers of migrating birds, especially raptors. Migratory behavior across the rest of Minnesota is probably not very comparable to the Appalachians due to flatter topography – radar monitoring in southwestern Minnesota indicated that nocturnal migration followed a broad-front pattern (Hawrot and Hanowski 1997), but some factors such as attraction to bright facility lights in poor visibility conditions likely apply to Minnesota as well at the eastern states. We are not aware of any studies of indirect effects of wind facilities on forest birds. The effects of forest fragmentation due to other types of development such as roadbuilding or logging are well studied and indicate that bird communities do change with changes in forest edge and patch size (see Keller and Yahner 2007 and Keller et al. 2009).

DATA GAPS AND SUGGESTED STUDIES

The ability to predict wind facility impacts is heavily dependent upon collection of data at the site before construction, and since these predictions are based on what we know from existing studies, mostly conducted in open grassland, shrubland, and agricultural habitats, they are likely to be most accurate for projects in these habitats. For projects in less-studied habitats in Minnesota such as forests, forested lake lands, and bogs, more data are needed to learn about region-specific effects of wind facility development. For proposed projects in these less-studied habitats, it may be reasonable to request that more extensive pre- and post-construction data be collected, and be made publicly available, to contribute to the pool of knowledge about wind facility impacts.

The hierarchical data collection and decision-making process recently proposed in the guidelines suggested by the FAC to the USFWS (WTGAC 2010) provides a good structure to follow in planning wind energy/wildlife studies in Minnesota. The guidelines describe a tiered approach to choosing sites and planning development, starting at the broad landscape level and narrowing in focus and study objectives with each subsequent Tier. In Minnesota, site characterization studies (USFWS Tier 1 and 2) should be conducted for all proposed wind projects prior to construction, as recommended in the USFWS Wind Turbine Guidelines (WTGAC 2010). Results from site characterization studies (USFWS Tier 2) may indicate the need for pre-construction surveys to collect baseline data (USFWS Tier 3), which should be designed to address specific wildlife issues, predict impacts, and determine appropriate mitigation measures. Post-construction monitoring (USFWS Tiers 4 and 5) should be conducted as appropriate based on data gathered in site characterization studies and pre-construction baseline surveys. As illustrated by studies done on existing wind facilities in the U.S. and Canada and summarized in this report, avian and bat fatality rates vary considerably, and survey work should be designed specifically for each project to address potential adverse impacts and risks associated with each proposed project.

At the Tier 1 level of evaluation, developers determine if wind-energy development is appropriate given land-use constraints and presence of protected species and habitats. Tier 2 proceeds to characterization of potential sites using available data, site visits, and dialogue with agencies and organizations about sensitive resources. Tier 3 includes scientifically rigorous baseline studies designed to collect quantitative, standardized new data in the proposed project area to aid in identifying potential risks and impacts, planning layout to minimize impacts, and designing potential mitigation. The scope and duration of baseline monitoring would depend on the results of the site characterization and the availability of fatality data from nearby projects. Fatality data from nearby projects would be considered useful to evaluate risk at the proposed project if the two projects will use turbines of similar size and number, and they are located in the same ecological province with similar topography and geographic features, climate and precipitation, and vegetation and landuse patterns. If the site characterization and data from nearby fatality studies indicate low risk, baseline studies may only include some fixed point observations to confirm similar species composition and level of bird use. If higher risk is indicated, or no data are available from nearby wind projects, baseline studies may require more fixed-point observations, as well as other studies such as breeding bird surveys, raptor migration surveys, nocturnal bird surveys, or other surveys types depending on risk indicated by data or habitat types.

In cases where baseline studies confirmed low risk to birds and bats, and fatality data are available from similar projects nearby that also indicate low risk, post-construction monitoring (Tier 4) may not be required. If collision risks are predicted to be low, but no fatality data are available from a similar project, at least one year of post-construction fatality monitoring should be conducted, but search effort may not be intense (relatively few turbines searched, long intervals between searches). For projects where bird or bat use is high, ESA-listed species are present, other risk factors are identified, such as potential migratory corridors, nearby wetlands or lakes, or the project is in forested habitat, bog habitat, or other such poorly-studied environment, at least one year of standardized post-construction fatality monitoring (Tier 4 and Tier 5 studies, see WTGAC 2010) is more important, and may include more effort (e.g., more turbines searched, shorter search intervals). More intense standardized monitoring may also be necessary at projects where low intensity fatality monitoring had unexpected results such as high fatality rates or sensitive species fatalities.

Post-construction monitoring also would be appropriate for wind facilities proposed near the existing Buffalo Ridge project in southwestern Minnesota. New projects have relied on the post-construction data from the Buffalo Ridge project for over 10 years, but these data may be no longer comparable to new development due to the substantial increase in turbine size (0.3 MW compared to 2.0 MW or larger turbines currently in use). New wind development in southwestern Minnesota should conduct follow-up pre- and post-construction studies to provide comparison to the Buffalo Ridge data. If impacts from new wind developments are similar to other regional studies (or Buffalo Ridge in particular), then no further study would be warranted as risk would appear consistently low in this part of the state for a wide range of turbine sizes. If impacts to birds and/or bats are higher than predicted, higher than regional averages, or ESA-listed species are among the fatalities, subsequent years of post-construction fatality monitoring should be conducted to see if the pattern is consistent on an annual basis and attempt to determine and mitigate causal factors of fatalities at the project.

Where projects are constructed in high-quality grassland (large, contiguous tracts of native prairie or CRP lands), post-construction bird use monitoring for multiple years after construction (an example of Tier 5 studies) will help answer the question of whether small-scale impacts near turbines are persistent over time or are short-term and likely due to habitat disturbance from construction. Where sharp-tailed grouse or greater prairie chickens may occur near a proposed wind-energy facility, pre- and post-construction surveys should be conducted to document grouse response, and these surveys should be repeated for several years after the project is built to provide more information about time lags in prairie grouse response to wind facility installation. In forested habitats, post-construction songbird displacement studies may fill a void in the literature about wind power impacts; however, it may be difficult to separate the effects of turbines from forest edge effects since forest must be cleared to build turbines.

For bats, curtailment of turbine operation (increase in the cut-in speed) appeared to be an effective and relatively inexpensive way to reduce bat mortality at the Casselman Wind Project in Pennsylvania. Previous studies showed that bat mortality was highest during nights with lower wind speed (Arnett et al. 2008). Experiments at Casselman in 2008 and 2009 showed that increasing the cut-in speed for turbines significantly decreased bat mortality with minimal loss to power output (Arnett et al. 2010). However, no published studies are available in the Midwest on curtailment. Curtailment at low wind speeds might be an option if mortality is at unacceptable levels. Experiments should be considered for Midwest sites, and curtailment at lower treatment levels should be tested. Current research has shown reductions at 5 m/sec cut-in speeds (see Arnett et al. 2010), however lower cut in speeds have not been tested.

Bat migration patterns are poorly understood and difficult to study, but more insight into bat activity at wind-energy facilities may be gained by conducting pre-construction acoustic monitoring *and* post-construction acoustic monitoring concurrently with fatality monitoring. Bat fatality estimate accuracy may be improved by clearing vegetation such as tall, thick grass and crops from within search plots, since such vegetation greatly reduces searcher efficiency.

REFERENCES

American Wind Energy Association (AWEA). 2009. AWEA website. Home page: **http://www.awea.org/**; September 2009 capacity data available at: **http://www.awea.org/publications/reports/3Q09.pdf**; Average household use from: **http://www.awea.org/newsroom/releases/Call_for_Immediate_Extension_of_Key_RE_Incentive_042108.html**; Current US wind energy capacity by state (updated April 8, 2010): **http://www.awea.org/projects/**

American Wind Energy Association (AWEA). 2010. U.S. Wind Energy Projects - Minnesota. As of July 20, 2010. Minnesota projects available online at: **http://www.awea.org/projects/Projects.aspx?s=Minnesota**

Arnett, E. B., technical editor. 2005. Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Bat Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas. **http://www.batsandwind.org/pdf/ar2004.pdf**

Arnett, E.B., K. Brown, W.P. Erickson, J. Fiedler, B.L. Hamilton, T.H. Henry, A. Jain, G.D. Johnson, J. Kerns, R.R. Kolford, C.P. Nicholson, T. O'Connell, M. Piorkowski, and R. Tankersley, Jr. 2008. Patterns of Bat Fatalities at Wind Energy Facilities in North America. Journal of Wildlife Management 72(1): 61-78.

Arnett, E.B., W.P. Erickson, J. Kerns, and J. Horn. 2005. Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines. Prepared for the Bats and Wind Energy Cooperative. March 2005.

Arnett, E.B., M. Schirmacher, M.M.P. Huso, and J.P. Hayes. 2009. Effectiveness of Changing Wind Turbine Cut-in Speed to Reduce Bat Fatalities at Wind Facilities: 2008 Annual Report. Prepared for the Bats and Wind Energy Cooperative (BWEC) and the Pennsylvania Game Commission. April 2009. **http://www.batsandwind.org/pdf/Curtailment_2008_Final_Report.pdf**

Arnett, E.B., M. Schirmacher, M.M.P. Huso, and J.P. Hayes. 2010. Effectiveness of Changing Wind Turbine Cut-in Speed to Reduce Bat Fatalities at Wind Facilities: Final Report. Annual report prepared for the Bats and Wind Energy Cooperative (BWEC) and the Pennsylvania Game Commission. May 2010. Available online at: **http://www.batsandwind.org/pdf/Curtailment%20Final%20Report%205-15-10%20v2.pdf**

Baerwald, E.F. 2008. Variation in the Activity and Fatality of Migratory Bats at Wind Energy Facilities in Southern Alberta: Causes and Consequences. Thesis. University of Calgary, Calgary, Alberta, Canada.

Baerwald, E.F. and R.M.R. Barclay. 2009. Geographic Variation in Activity and Fatality of Migratory Bats at Wind Energy Facilities. Journal of Mammalogy 90(6): 1341–1349.

Barclay, R.M.R., E.F. Baerwald, and J.C. Gruver. 2007. Variation in Bat and Bird Fatalities at Wind Energy Facilities: Assessing the Effects of Rotor Size and Tower Height. Canadian Journal of Zoology 85: 381-387. **http://www.bio.ucalgary.ca/contact/faculty/pdf/Barclay07Tur.pdf**

BHE Environmental, Inc. (BHE). 2010. Post-Construction Bird and Bat Mortality Study: Cedar Ridge Wind Farm, Fond Du Lac County, Wisconsin. Interim Report prepared for Wisconsin Power and Light, Madison, Wisconsin. Prepared by BHE Environmental, Inc. Cincinnati, Ohio. February 2010.

Brown, W.K. and B.L. Hamilton. 2004. Bird and Bat Monitoring at the McBride Lake Wind Farm, Alberta, 2003-2004. Report for Vision Quest Windelectric, Inc., Calgary, Alberta, Canada. September 2004.

Brown, W.K. and B.L. Hamilton. 2006a. Bird and Bat Interactions with Wind Turbines Castle River Wind Facility, Alberta, 2001-2002. Report for Vision Quest Windelectric, Inc., Calgary, Alberta, Canada.

Brown, W.K. and B.L. Hamilton. 2006b. Monitoring of Bird and Bat Collisions with Wind Turbines at the Summerview Wind Power Project, Alberta: 2005-2006. Prepared for Vision Quest Windelectric, Calgary, Alberta by TAEM Ltd., Calgary, Alberta, and BLH Environmental Services, Pincher Creek, Alberta. September 2006. **http://www.batsandwind.org/pdf/Brown2006.pdf**

Chatfield, A., W. Erickson, and K. Bay. 2009. Avian and Bat Fatality Study, Dillon Wind-Energy Facility, Riverside County, California. Final Report: March 26, 2008 - March 26, 2009. Prepared for Iberdrola Renewables, Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. June 3, 2009.

Derby, C., A. Dahl, W. Erickson, K. Bay, and J. Hoban. 2007. Post-Construction Monitoring Report for Avian and Bat Mortality at the NPPD Ainsworth Wind Farm. Unpublished report prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, for the Nebraska Public Power District.

Endangered Species Act (ESA). 1973. 16 United States Code § 1531-1544. December 28, 1973.

Enk, T., K. Bay, M. Sonnenberg, J. Baker, M. Kesterke, J. Boehrs, and A. Palochak. 2010. Biglow Canyon Wind Farm Phase I Post-Construction Avian and Bat Monitoring Second Annual Report, Sherman County, Oregon. January 26, 2009 - December 11, 2009. Prepared for Portland General Electric Company, Portland, Oregon. Prepared by Western EcoSystems Technology, Inc.(WEST) Cheyenne, Wyoming, and Walla Walla, Washington. April 2010.

Erickson, W.P., J. Jeffrey, K. Kronner, and K. Bay. 2004. Stateline Wind Project Wildlife Monitoring Final Report: July 2001 - December 2003. Technical report for and peer-reviewed by FPL Energy, Stateline Technical Advisory Committee, and the Oregon Energy Facility Siting Council, by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, and Walla Walla, Washington, and Northwest Wildlife Consultants (NWC), Pendleton, Oregon. December 2004. **http://www.west-inc.com**

Erickson, W.P., J. Jeffrey, and V.K. Poulton. 2008. Avian and Bat Monitoring: Year 1 Report. Puget Sound Energy Wild Horse Wind Project, Kittitas County, Washington. Prepared for Puget Sound Energy, Ellensburg, Washington, by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. January 2008.

Erickson, W.P., G.D. Johnson, K. Bay, and K. Kronner. 2002a. Ecological Baseline Study for the Zintel Canyon Wind Project. Final Report April 2001 – June 2002. Technical report prepared for Energy Northwest. Prepared for Energy Northwest by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, and Northwest Wildlife Consultants, Inc. (NWC), Pendleton, Oregon. June 2002.

Erickson, W.P., G.D. Johnson, D.P. Young, Jr., D. Strickland, R. Good, M. Bourassa, K. Bay, and K. Sernka. 2002b. Synthesis and Comparison of Baseline Avian and Bat Use, Raptor Nesting and Mortality Information from Proposed and Existing Wind Developments. Technical report prepared for Bonneville Power Administration, Portland, Oregon by WEST, Inc., Cheyenne, Wyoming. December 2002. http://www.bpa.gov/Power/pgc/wind/Avian_and_Bat_Study_12-2002.pdf

Erickson, W.P., G.D. Johnson, M.D. Strickland, and K. Kronner. 2000. Avian and Bat Mortality Associated with the Vansycle Wind Project, Umatilla County, Oregon: 1999 Study Year. Technical report prepared by WEST, Inc. for Umatilla County Department of Resource Services and Development, Pendleton, Oregon. 21pp. **http://www.west-inc.com/reports/vansyclereportnet.pdf**

Erickson, W.P., K. Kronner, and B. Gritski. 2003a. Nine Canyon Wind Power Project Avian and Bat Monitoring Report. September 2002 – August 2003. Prepared for the Nine Canyon Technical Advisory Committee and Energy Northwest by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, and Northwest Wildlife Consultants (NWC), Pendleton, Oregon. October 2003. **http://www.west-inc.com/reports/nine_canyon_monitoring_final.pdf**

Erickson, W.P., D.P. Young, G. Johnson, J. Jeffrey, K. Bay, R. Good, and H. Sawyer. 2003b. Wildlife Baseline Study for the Wild Horse Wind Project. Summary of Results from 2002-2003 Wildlife Surveys May 10, 2002- May 22, 2003. Draft report prepared for Zilkha Renewable Energy, Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. November 2003.

Fiedler, J.K., T.H. Henry, R.D. Tankersley, and C.P. Nicholson. 2007. Results of Bat and Bird Mortality Monitoring at the Expanded Buffalo Mountain Windfarm, 2005. Tennessee Valley Authority, Knoxville, Tennessee. **https://www.tva.gov/environment/bmw_report/results.pdf**

Gritski, B., S. Downes, and K. Kronner. 2009. Klondike III (Phase 1) Wind Power Project Wildlife Monitoring Year One Summary, October 2007-October 2008. Prepared for Iberdrola Renewables, Portland, Oregon. Prepared by Northwest Wildlife Consultants, Inc. (NWC), Pendleton, Oregon. April 3, 2009.

Gritski, B., K. Kronner, and S. Downes. 2008. Leaning Juniper Wind Power Project, 2006 – 2008. Wildlife Monitoring Final Report. Prepared for PacifiCorp Energy, Portland, Oregon. Prepared by Northwest Wildlife Consultants, Inc. (NWC), Pendleton, Oregon. December 30, 2008.

Gruver, J., M. Sonnenburg, K. Bay, and W. Erickson. 2009. Post-Construction Bat and Bird Fatality Study at the Blue Sky Green Field Wind Energy Center, Fond Du Lac County, Wisconsin July 21 - October 31, 2008 and March 15 - June 4, 2009. Unpublished report prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. December 17, 2009.

Hawrot, R.Y. and J.M. Hanowski. 1997. Avian Assessment Document: Avian Population Analysis for Wind Power Generation Regions. NRRI Technical Report No. NRRI/TR-97-23. Center for Water and the Environment, Natural Resources Research Institute. Duluth, Minnesota. 14 pp.

Higgins, K.F., R.G. Osborn, C.D. Dieter, and R.E. Usgaard. 1996. Monitoring of Seasonal Bird Activity and Mortality at the Buffalo Ridge Wind Resource Area, Minnesota, 1994-1995. Completion Report for the Research Period May 1, 1994 - December 31, 1995. Unpublished report prepared for Kenetech Windpower, Inc. by the South Dakota Cooperative Fish and Wildlife Research Unit, Brookings, South Dakota. 84 pp.

Holloran, M.J. 2005. Greater Sage-Grouse (*Centrocercus urophasianus*) Population Response to Natural Gas Field Development in Western Wyoming. Ph.D. Dissertation. University of Wyoming, Laramie, Wyoming. 211 pp.

Howe, R.W., W. Evans, and A.T. Wolf. 2002. Effects of Wind Turbines on Birds and Bats in Northeastern Wisconsin. Prepared by University of Wisconsin-Green Bay, for Wisconsin Public Service Corporation and Madison Gas and Electric Company, Madison, Wisconsin. November 21, 2002. 104 pp.

Jacques Whitford Stantec Limited (Jacques Whitford). 2009. Ripley Wind Power Project Postconstruction Monitoring Report. Project No. 1037529.01. Report to Suncor Energy Products Inc., Calgary, Alberta, and Acciona Energy Products Inc., Calgary, Alberta. Prepared for the Ripley Wind Power Project Post-Construction Monitoring Program. Prepared by Jacques Whitford, Markham, Ontario. April 30, 2009. **www.jacqueswhitford.com**

Jain, A. 2005. Bird and Bat Behavior and Mortality at a Northern Iowa Windfarm. M.S. Thesis. Iowa State University, Ames, Iowa.

Jain, A., P. Kerlinger, R. Curry, and L. Slobodnik. 2007. Annual Report for the Maple Ridge Wind Power Project: Post-Construction Bird and Bat Fatality Study – 2006. Final Report. Prepared for PPM Energy and Horizon Energy and Technical Advisory Committee (TAC) for the Maple Ridge Project Study.

Jain, A., P. Kerlinger, R. Curry, and L. Slobodnik. 2008. Annual Report for the Maple Ridge Wind Power Project: Post-Construction Bird and Bat Fatality Study - 2007. Final report prepared for PPM Energy and Horizon Energy and Technical Advisory Committee (TAC) for the Maple Ridge Project Study.

Jain, A., P. Kerlinger, R. Curry, L. Slobodnik, A. Fuerst, and C. Hansen. 2009a. Annual Report for the Noble Ellenburg Windpark, LLC, Postconstruction Bird and Bat Fatality Study - 2008. Prepared for Noble Environmental Power, LLC by Curry and Kerlinger, LLC. April 13, 2009.

Jain, A., P. Kerlinger, R. Curry, L. Slobodnik, J. Histed, and J. Meacham. 2009b. Annual Report for the Noble Clinton Windpark, LLC, Postconstruction Bird and Bat Fatality Study - 2008. Prepared for Noble Environmental Power, LLC by Curry and Kerlinger, LLC. April 13, 2009.

Jain, A., P. Kerlinger, R. Curry, L. Slobodnik, J. Quant, and D. Pursell. 2009c. Annual Report for the Noble Bliss Windpark, LLC, Postconstruction Bird and Bat Fatality Study - 2008. Prepared for Noble Environmental Power, LLC by Curry and Kerlinger, LLC. April 13, 2009.

Jain, A., P. Kerlinger, L. Slobodnik, R. Curry, A. Fuerst, and A. Harte. 2010a. Annual Report for the Noble Bliss Windpark, LLC: Postconstruction Bird and Bat Fatality Study - 2009. Prepared for Noble Environmental Power, LLC. Prepared by Curry and Kerlinger, LLC, Cape May, New Jersey. March 9, 2010.

Jain, A., P. Kerlinger, L. Slobodnik, R. Curry, and K. Russell. 2010b. Annual Report for the Noble Clinton Windpark, LLC: Postconstruction Bird and Bat Fatality Study - 2009. Prepared for Noble Environmental Power, LLC. Prepared by Curry and Kerlinger, LLC, Cape May, New Jersey. March 9, 2010.

Jain, A., P. Kerlinger, L. Slobodnik, R. Curry, and K. Russell. 2010c. Annual Report for the Noble Ellenburg Windpark, LLC: Postconstruction Bird and Bat Fatality Study - 2009. Prepared for Noble Environmental Power, LLC. Prepared by Curry and Kerlinger, LLC, Cape May, New Jersey. March 14, 2010.

Jeffrey, J.D., K. Bay, W.P. Erickson, M. Sonneberg, J. Baker, M. Kesterke, J. Boehrs, and A. Palochak. 2009. Portland General Electric Biglow Canyon Wind Farm Phase I Post-Construction Avian and Bat Monitoring First Annual Report, Sherman County, Oregon. January 2008 - December 2008. Technical report prepared for Portland General Electric Company, Portland, Oregon. Prepared by Western EcoSystems Technology (WEST) Inc., Cheyenne, Wyoming, and Walla Walla, Washington. April 29, 2009.

Johnson, G.D. 2004. Analysis of Potential Wildlife and Habitat Impacts from the Klondike II Project, Sherman County, Oregon. Technical report prepared by WEST, Inc., for CH2MHILL and PPM Energy.

Johnson, G.D. 2005. A Review of Bat Mortality at Wind-Energy Developments in the United States. Bat Research News 46(2): 45-49.

Johnson, G.D. and W.P. Erickson. 2004. Analysis of Potential Wildlife/Wind Plant Interactions, Bighorn Site, Klickitat County, Washington. Prepared for CH2MHILL, Portland, Oregon by WEST, Inc., Cheyenne, Wyoming. August 2004.

Johnson, G.D., W.P. Erickson, K. Bay, and K. Kronner. 2002a. Baseline Ecological Studies for the Klondike Wind Project, Sherman County, Oregon. Final report prepared for Northwestern Wind Power, Goldendale, Washington, by Western EcoSystems Technology, Inc. (WEST) Cheyenne, Wyoming, and Northwest Wildlife Consultants, Inc. (NWC), Pendleton, Oregon. May 29, 2002.

Johnson, G.D., W.P. Erickson, M.D. Strickland, M. Perlik, and C. Nations. 2002b. Bat Interactions with Wind Turbines at the Buffalo Ridge, Minnesota Wind Resource Area: 2001 Field Season. Technical report prepared for Electric Power Research Institute, Palo Alto, California.

Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd, and D.A. Shepherd. 2000a. Avian Monitoring Studies at the Buffalo Ridge Wind Resource Area, Minnesota: Results of a 4-Year Study. Final report prepared for Northern States Power Company, Minneapolis, Minnesota, by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. September 22, 2000. 212 pp. **http://www.west-inc.com**

Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd, D.A. Shepherd, and S.A. Sarappo. 2002c. Collision Mortality of Local and Migrant Birds at a Large-Scale Wind-Power Development on Buffalo Ridge, Minnesota. Wildlife Society Bulletin 30(3): 879-887.

Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd, D.A. Shepherd, and S.A. Sarappo. 2003a. Mortality of Bats at a Large-Scale Wind Power Development at Buffalo Ridge, Minnesota. The American Midland Naturalist 150: 332-342.

Johnson, G.D., W.P. Erickson, and J. White. 2003b. Avian and Bat Mortality During the First Year of Operation at the Klondike Phase I Wind Project, Sherman County, Oregon. March 2003. Technical report prepared for Northwestern Wind Power, Goldendale, Washington, by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. http://www.west-inc.com

Johnson, G.D., W.P. Erickson, and D. Young. 2009. Greater Prairie-Chicken Lek Surveys, Elk River Wind Farm, Butler County, Kansas. Unpublished report prepared for Iberdrola Renewables by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming.

Johnson, G.D., M.K. Perlik, W.P. Erickson, and M.D. Strickland. 2004. Bat Activity, Composition and Collision Mortality at a Large Wind Plant in Minnesota. Wildlife Society Bulletin 32(4): 1278-1288.

Johnson, G.D., M.K. Perlik, W.P. Erickson, M.D. Strickland, D.A. Shepherd, and P. Sutherland, Jr. 2003c. Bat Interactions with Wind Turbines at the Buffalo Ridge, Minnesota Wind Resource Area: An Assessment of Bat Activity, Species Composition, and Collision Mortality. Electric Power Research Institute, Palo Alto, California and Xcel Energy, Minneapolis, Minnesota. In press. EPRI report # 1009178.

Johnson, G.D., D.P. Young, W.P. Erickson, C.E. Derby, M.D. Strickland, and R.E. Good. 2000b. Wildlife Monitoring Studies, SeaWest Windpower Plant, Carbon County, Wyoming, 1995-1999. Final report prepared for SeaWest Energy Corporation, San Diego, California, and the Bureau of Land Management, Rawlins, Wyoming, by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. August 9, 2000. **http://www.west-inc.com** and **http://www.west-inc.com/reports/fcr_final_baseline.pdf**

Keller, G.S., B.D. Ross, D.S. Klute, and R.H. Yahner. 2009. Temporal Changes in Migratory Bird Use of Edge During Spring and Fall Seasons in Pennsylvania. Northeastern Naturalist 16(4):535-552.

Keller, G.S. and R.H. Yahner. 2007. Seasonal Forest-Patch Use by Birds in Fragmented Landscapes of South-Central Pennsylvania. Wilson Journal of Ornithology 119: 410-148.

Kerlinger et al. 2010. In press.

Kerlinger, P., L. Culp, and R. Curry. 2005. Post-Construction Avian Monitoring Study for the High Winds Wind Power Project, Solano County, California. Year One Report. Prepared for High Winds, LLC and FPL Energy.

Kerlinger, P., R. Curry, L. Culp, A. Jain, C. Wilkerson, B. Fischer, and A. Hasch. 2006. Post-Construction Avian and Bat Fatality Monitoring for the High Winds Wind Power Project, Solano County, California: Two Year Report. Prepared for High Winds LLC, FPL Energy by Curry and Kerlinger, LLC. April 2006.

Kerlinger, P., R. Curry, A. Hasch, and J. Guarnaccia. 2007. Migratory Bird and Bat Monitoring Study at the Crescent Ridge Wind Power Project, Bureau County, Illinois: September 2005 - August 2006. Final draft prepared for Orrick Herrington and Sutcliffe, LLP. May 2007.

Kerns, J. and P. Kerlinger. 2004. A Study of Bird and Bat Collisions at the Mountaineer Wind Energy Facility, Tucker County, West Virginia: Annual Report for 2003. Prepared for FPL Energy and the Mountaineer Wind Energy Center Technical Review Committee. February 14, 2004. Technical report prepared by Curry and Kerlinger, LLC., for FPL Energy and Mountaineer Wind Energy Center Technical Review Committee. Curry and Kerlinger, LLC. 39 pp. **http://www.wvhighlands.org/Birds/MountaineerFinalAvianRpt-%203-15-04PKJK.pdf**

Krenz, J.D. and B.R. McMillan. 2000. Final Report: Wind-Turbine Related Bat Mortality in Southwestern Minnesota. Minnesota Department of Natural Resources, St. Paul, Minnesota.

Kronner, K., B. Gritski, and S. Downes. 2008. Big Horn Wind Power Project Wildlife Fatality Monitoring Study: 2006–2007. Final report prepared for PPM Energy and the Big Horn Wind Project Technical Advisory Committee by Northwest Wildlife Consultants, Inc. (NWC), Mid-Columbia Field Office, Goldendale, Washington. June 1, 2008.

Kunz, T.H., E.B. Arnett, W.P. Erickson, A.R. Hoar, G.D. Johnson, R.P. Larkin, M.D. Strickland, R.W. Thresher, and M.D. Tuttle. 2007. Ecological Impacts of Wind Energy Development on Bats: Questions, Research Needs, and Hypotheses. Frontiers in Ecology and the Environment 5(6): 315-324.

Leddy, K.L. 1996. Effects of Wind Turbines on Nongame Birds in Conservation Reserve Program Grasslands in Southwestern Minnesota. M.S. Thesis. South Dakota State University, Brookings. 61 pp.

Leddy, K.L., K.F. Higgins, and D.E. Naugle. 1997. The Importance of Conservation Reserve Program Fields to Breeding Grassland Birds at Buffalo Ridge, Minnesota. South Dakota Academy of Science 76: 105-111.

Leddy, K.L., K.F. Higgins, and D.E. Naugle. 1999. Effects of Wind Turbines on Upland Nesting Birds in Conservation Reserve Program Grasslands. Wilson Bulletin 111(1): 100-104.

Manes, R., S. Harmon, B. Obermeyer, and R. Applegate. 2002. Wind Energy and Wildlife: An Attempt at Pragmatism. Special Report of the Wildlife Management Institute. October, 2002. 11 pp.

Minnesota Department of Administration. 2008. Wind Turbines in Minnesota. Prepared for the Minnesota Department of Commerce Energy Facility Permitting. Prepared by the Land Management Information Center, Minnesota Department of Administration.

National Research Council (NRC). 2007. Environmental Impacts of Wind-Energy Projects. National Academies Press. Washington, D.C. **www.nap.edu**

National Wind Coordinating Collaborative (NWCC). 2004. Wind Turbine Interactions with Birds and Bats: A Summary of Research Results and Remaining Questions. Fact Sheet. 2nd Edition. November 2004.

National Wind Coordinating Collaborative (NWCC). 2010. Wind Turbine Interactions with Birds, Bats, and Their Habitats: A Summary of Research Results and Priority Questions. NWCC c/o RESOLVE, Washington, D.C. Available online at: **http://www.nationalwind.org//publications/bbfactsheet.aspx**

Nebraska Game and Parks Commission (NGPC). 2009. Location of Sharp-Tailed Grouse and Greater Prairie-Chicken Display Grounds in Relation to NPPD Ainsworth Wind Energy Facility: 2006-2009. NGPC, Lincoln, Nebraska.

Nelson, H.K. 1993. A Biological Reconnaissance of Buffalo Ridge, Lincoln and Pipestone Counties, Minnesota. Prepared for WindRiver Power Company, Davenport, Iowa.

Nicholson, C.P. 2003. Buffalo Mountain Windfarm Bird and Bat Mortality Monitoring Report: October 2001 - September 2002. Tennessee Valley Authority, Knoxville, Tennessee. February 2003.

Nicholson, C.P., J. R.D. Tankersley, J.K. Fiedler, and N.S. Nicholas. 2005. Assessment and Prediction of Bird and Bat Mortality at Wind Energy Facilities in the Southeastern United States. Final Report. Tennessee Valley Authority, Knoxville, Tennessee.

Northwest Wildlife Consultants, Inc. (NWC) and Western EcoSystems Technology, Inc. (WEST). 2007. Avian and Bat Monitoring Report for the Klondike II Wind Power Project. Sherman County, Oregon. Prepared for PPM Energy, Portland, Oregon. Managed and conducted by NWC, Pendleton, Oregon. Analysis conducted by WEST, Cheyenne, Wyoming. July 17, 2007.

Osborn, R.G., C.D. Dieter, K.F. Higgins, and R.E. Usgaard. 1998. Bird Flight Characteristics near Wind Turbines in Minnesota. American Midland Naturalist 139: 29-38.

Osborn, R.G., K.F. Higgins, C.D. Dieter, and R.E. Usgaard. 1996. Bat Collisions with Wind Turbines in Southwestern Minnesota. Bat Research News 37: 105-108.

Osborn, R.G., K.F. Higgins, R.E. Usgaard, C.D. Dieter, and R.G. Neiger. 2000. Bird Mortality Associated with Wind Turbines at the Buffalo Ridge Wind Resource Area, Minnesota. American Midland Naturalist 143: 41-52.

Piorkowski, M.D. 2006. Breeding Bird Habitat Use and Turbine Collisions of Birds and Bats Located at a Wind Farm in Oklahoma Mixed-Grass Prairie. M.S. Thesis. Oklahoma State University, Stillwater, Oklahoma. 112 pp. July 2006. **http://www.batsandwind.org/pdf/Piorkowski_2006.pdf**

Pruett, C.L., M.A. Patten, and D.H. Wolfe. 2009a. Avoidance Behavior by Prairie Grouse: Implications for Wind Energy Development. Conservation Biology 23(5): 1253-1259.

Pruett, C.L., M.A. Patten, and D.H. Wolfe. 2009b. It's Not Easy Being Green: Wind Energy and a Declining Grassland Bird. BioScience 59: 257-262.

Robbins, M.B., A.T. Peterson, and M.A. Ortega-Huerta. 2002. Major Negative Impacts of Early Intensive Cattle Stocking on Tallgrass Prairies: The Case of the Greater Prairie-Chicken (*Tympanuchus cupido*). North American Birds 56: 239-244.

Robel, R.J., J. A. Harrington, Jr., C.A. Hagen, J.C. Pitman, and R.R. Reker. 2004. Effect of Energy Development and Human Activity on the Use of Sand Sagebrush Habitat by Lesser Prairie-Chickens in Southwestern Kansas. Transactions of the North American Wildlife and Natural Resources Conference 69: 251-266.

Shaffer, J.A. and D.H. Johnson. 2009. Displacement Effects of Wind Developments on Grassland Birds in the Northern Great Plains. Presented at the National Wind Coordinating Collaborative (NWCC) Wildlife and Wind Research Meeting VII, October 28-29, 2008, Milwaukee, Wisconsin. Pre-Conference Session, October 27, 2008. Prepared for the NWCC by S.S. Schwartz. Published June 2009.

Stantec Consulting, Inc. (Stantec). 2008. 2007 Spring, Summer, and Fall Post-Construction Bird and Bat Mortality Study at the Mars Hill Wind Farm, Maine. Prepared for UPC Wind Management, LLC, Cumberland, Maine, by Stantec Consulting, formerly Woodlot Alternatives, Inc., Topsham, Maine. January, 2008.

Stantec Consulting, Inc. (Stantec). 2009a. Post-Construction Monitoring at the Mars Hill Wind Farm, Maine - Year 2, 2008. Prepared for First Wind Management, LLC, Portland, Maine. Prepared by Stantec Consulting, Topsham, Maine. January 2009.

Stantec Consulting, Inc. (Stantec). 2009b. Stetson I Mountain Wind Project. Year 1 Post-Construction Monitoring Report, 2009 for the Stetson Mountain Wind Project in Penobscot and Washington Counties, Maine. Prepared for First Wind Management, LLC. Portland, Maine. Prepared by Stantec, Topsham, Maine. January 2009.

Stantec Consulting Inc. (Stantec). 2008a. 2007 Spring, Summer, and Fall Post-Construction Bird and Bat Mortality Study at the Mars Hill Wind Farm, Maine. Prepared for UPC Wind Management, LLC, Cumberland, Maine, by Stantec Consulting, formerly Woodlot Alternatives, Inc., Topsham, Maine. January, 2008.

Stantec Consulting Inc. (Stantec). 2008b. Post-Construction Monitoring at the Munnsville Wind Farm, New York: 2008. Prepared for E.ON Climate and Renewables, Austin, Texas. Prepared by Stantec Consulting, Topsham, Maine. January 2009.

Stantec Consulting Ltd. (Stantec Ltd.). 2010. Wolfe Island Ecopower Centre Post-Construction Followup Plan. Bird and Bat Resources Monitoring Report No. 2: July - December 2009. File No. 160960494. Prepared for TransAlta Corporation's wholly owned subsidiary, Canadian Renewable Energy Corporation. Prepared by Stantec Ltd., Guelph, Ontario. May 2010.

Stantec Consulting Services Inc. (Stantec). 2010. Cohocton and Dutch Hill Wind Farms Year 1 Post-Construction Monitoring Report, 2009, for the Cohocton and Dutch Hill Wind Farms in Cohocton, New York. Prepared for Canandaigua Power Partners, LLC and Canandaigua Power Partners II, LLC, Portland, Maine. Prepared by Stantec, Topsham, Maine. January 2010.

Strickland, M.D., G.D. Johnson, W.P. Erickson, and K. Kronner. 2001. Avian Studies at Wind Plants Located at Buffalo Ridge, Minnesota and Vansycle Ridge, Oregon. *In:* Proceedings of the National Avian-Wind Power Planning Meeting IV, National Wind Coordinating Collaborative (NWCC)/RESOLVE. Washington, D.C. Pp 38-52.

Strickland, M.D., G.D. Johnson, W.P. Erickson, S. Sarappo, and R. Halet. 1997. Assessing Impacts to Birds from the Buffalo Ridge, Minnesota Windplant Development. *In:* Proceedings of the 1997 American Wind Energy Association Annual Meeting, American Wind Energy Association, Washington, D.C. Pp 281-290.

Strickland, M.D., G.D. Johnson, W.P. Erickson, S.A. Sarappo, and R.M. Halet. 2000. Avian Use, Flight Behavior and Mortality on the Buffalo Ridge, Minnesota Wind Resource Area. *In:* Proceedings of the National Avian-Wind Power Planning Meeting III, National Wind Coordinating Collaborative (NWCC)/RESOLVE. Washington, D.C. Pp 70-79.

Tierney, R. 2007. Buffalo Gap I Wind Farm Avian Mortality Study: February 2006-January 2007. Final Survey Report. Prepared for AES SeaWest, Inc. TRC, Albuquerque, New Mexico.TRC Report No. 110766-C-01. May 2007.

Toepfer, J.E. and W.L. Vodehnal. 2009. Greater Prairie Chickens: Grasslands and Vertical Structures. Presentation at the 28th Meeting of the Prairie Grouse Technical Council, Portales, New Mexico, October 5-8, 2009.

TRC Environmental Corporation. 2008. Post-Construction Avian and Bat Fatality Monitoring and Grassland Bird Displacement Surveys at the Judith Gap Wind Energy Project, Wheatland County, Montana. Prepared for Judith Gap Energy, LLC, Chicago, Illinois. TRC Environmental Corporation, Laramie, Wyoming. TRC Project 51883-01 (112416). January 2008. **http://www.newwest.net/pdfs/AvianBatFatalityMonitoring.pdf**

URS, W.P. Erickson, and L. Sharp. 2005. Phase 1 and Phase 1A Avian Mortality Monitoring Report for 2004-2005 for the SMUD Solano Wind Project. Prepared for Sacramento Municipal Utility District (SMUD), Sacramento, California. Co-Authors: Wally Erickson, Western EcoSystems Technology, Inc. (WEST) and Lynn Sharp, Environmental Consultant. August 2005.

URS Corporation. 2010a. Final Marengo I Wind Project Year One Avian Mortality Monitoring Report. Prepared for PacifiCorp, Salt Lake City, Utah. Prepared by URS Corporation, Seattle, Washington. March 22, 2010.

URS Corporation. 2010b. Final Marengo II Wind Project Year One Avian Mortality Monitoring Report. Prepared for PacifiCorp, Salt Lake City, Utah. Prepared by URS Corporation, Seattle, Washington. March 22, 2010.

US Fish and Wildlife Service (USFWS). 2003. Interim Guidelines to Avoid and Minimize Wildlife Impacts from Wind Turbines. May 13, 2003. USFWS. Washington, D.C. **http://www.fws.gov/habitatconservation/wind.pdf**

US Fish and Wildlife Service (USFWS). 2004. Prairie Grouse Leks and Wind Turbines: US Fish and Wildlife Service Justification for a 5-Mile Buffer from Leks; Additional Grassland Songbird Recommendations. An unpublished briefing paper.

Usgaard, R.E., D.E. Naugle, R.G. Osborn, and K.F. Higgins. 1997. Effects of Wind Turbines on Nesting Raptors at Buffalo Ridge in Southwestern Minnesota. Proceedings of the South Dakota Academy of Science 76: 113-117.

Walker, J., S.E. Stephens, N.D. Niemuth, C.R. Loesch, R.E. Reynolds, J.S. Gleason, and M.A. Erickson. 2008. Assessing Potential Impacts of Wind Energy Development on Abundance of Breeding Duck Pairs in the Prairie Pothole Region of North and South Dakota. Unpublished report, Ducks Unlimited, Bismarck, North Dakota.

Western EcoSystems Technology, Inc. (WEST). 2006. Diablo Winds Wildlife Monitoring Progress Report, March 2005 - February 2006. Technical report submitted to FPL Energy and Alameda County California. WEST. Cheyenne, Wyoming.

Western EcoSystems Technology, Inc. (WEST). 2008. Diablo Winds Wildlife Monitoring Progress Report: March 2005 – February 2007. Prepared by WEST, Cheyenne, Wyoming. August 2008.

Wind Turbine Guidelines Advisory Committee (WTGAC). 2010. Consensus Recommendations on Developing Effective Measures to Mitigate Impacts to Wildlife and Their Habitats Related to Land-Based Wind Energy Facilities. Prepared by Kearns and West for the US Department of the Interior (USDOI), Washington, D.C. WTGAC homepage available online at: **http://www.fws.gov/habitatconservation/windpower/wind_turbine_advisory_committee.html**; Recommendations to the Secretary of the Interior available online at: **http://www.fws.gov/habitatconservation/windpower/Wind_Turbine_Guidelines_Advisory_Committee_Recommendations_Secretary.pdf**

Woodward-Clyde International-Americas, (WCIA) and Western EcoSystems Technology, Inc. (WEST). 1997. Avian Baseline Study for the Vansycle Ridge Project - Vansycle Ridge, Oregon and Wildlife Mortality Studies, Vansycle Wind Project, Washington. Prepared for Esi Vansycle Partners, L.P., North Palm Beach, Florida.

Young, D.P. Jr., W.P. Erickson, K. Bay, J. Jeffrey, E.G. Lack, R.E. Good, and H.H. Sawyer. 2003a. Baseline Avian Studies for the Proposed Hopkins Ridge Wind Project, Columbia County, Washington. Final Report, March 2002 - March 2003. Prepared for RES North America, LLC., Portland, Oregon, by Western EcoSystems Technology, Inc.(WEST), Cheyenne, Wyoming. April 30, 2003.

Young, D.P. Jr., W.P. Erickson, K. Bay, S. Nomani, and W. Tidhar. 2009. Mount Storm Wind Energy Facility, Phase 1 Post-Construction Avian and Bat Monitoring, July - October 2008. Prepared for NedPower Mount Storm, LLC, Houston, Texas, by Western EcoSystems Technology (WEST), Inc., Cheyenne, Wyoming.

Young, D.P. Jr., W.P. Erickson, and J.P. Eddy. 2005a. Mountain Plover (*Charadrius montanus*) Surveys, Foote Creek Rim Wind Plant, Carbon County, Wyoming, 1995-2005. Unpublished report prepared for PacifiCorp and SeaWest Windpower, Inc. by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming.

Young, D.P. Jr., W.P. Erickson, J. Jeffrey, K. Bay, and M. Bourassa. 2005b. Eurus Combine Hills Turbine Ranch. Phase 1 Post Construction Wildlife Monitoring Final Report February 2004 February 2005. Technical report for Eurus Energy America Corporation and the Combine Hills Technical Advisory Committee, Umatilla County, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, and Northwest Wildlife Consultants, Inc. (NWC), Pendleton, Oregon.

Young, D.P. Jr., W.P. Erickson, R.E. Good, M.D. Strickland, and G.D. Johnson. 2003b. Avian and Bat Mortality Associated with the Initial Phase of the Foote Creek Rim Windpower Project, Carbon County, Wyoming, Final Report, November 1998 - June 2002. Prepared for Pacificorp, Inc. Portland, Oregon, SeaWest Windpower Inc. San Diego, California, and Bureau of Land Management, Rawlins District Office, Rawlins, Wyoming.

Young, D.P. Jr., W.P. Erickson, J. Jeffrey, K. Bay, R.E. Good, and E.G. Lack. 2003c. Avian and Sensitive Species Baseline Study Plan and Final Report. Eurus Combine Hills Turbine Ranch, Umatilla County, Oregon. Technical report prepared for Eurus Energy America Corporation, San Diego, California and Aeropower Services, Inc., Portland, Oregon, by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. March 10, 2003.

Young, D.P. Jr., W.P. Erickson, J. Jeffrey, and V.K. Poulton. 2007. Puget Sound Energy Hopkins Ridge Wind Project Phase 1 Post-Construction Avian and Bat Monitoring First Annual Report, January - December 2006. Technical report for Puget Sound Energy, Dayton, Washington and Hopkins Ridge Wind Project Technical Advisory Committee, Columbia County, Washington. Western EcoSystems Technology, Inc. (WEST) Cheyenne, Wyoming, and Walla Walla, Washington. 25 pp.

Young, D.P. Jr., J. Jeffrey, W.P. Erickson, K. Bay, and V.K. Poulton. 2006. Eurus Combine Hills Turbine Ranch. Phase 1 Post Construction Wildlife Monitoring First Annual Report. Technical report prepared for Eurus Energy America Corporation, San Diego, California, and the Combine Hills Technical Advisory Committee, Umatilla County, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, and Northwest Wildlife Consultants, Inc. (NWC), Pendleton, Oregon.

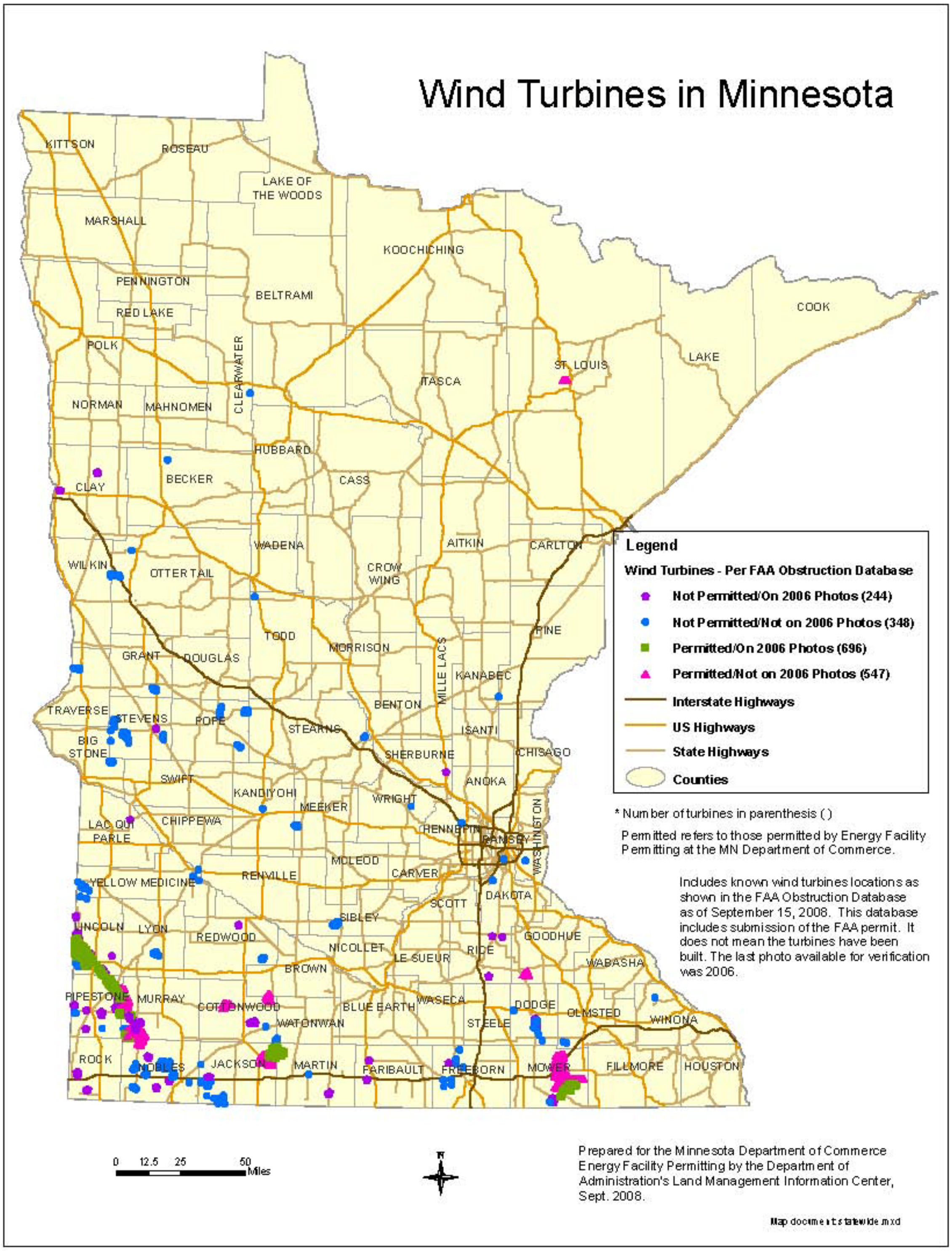

Figure 1. Map of constructed and planned wind-energy facilities in Minnesota (from Minnesota Department of Commerce).

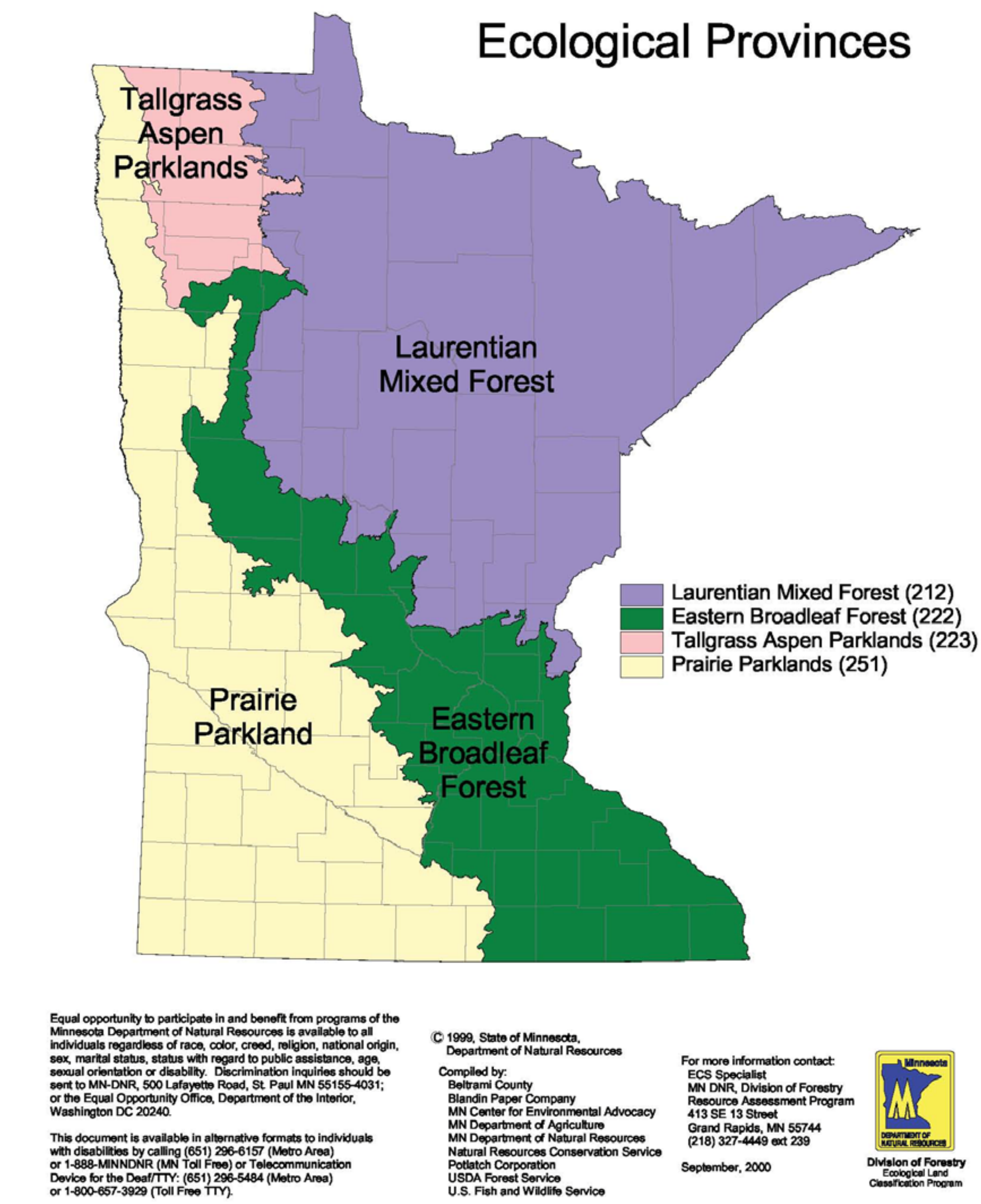

Figure 2. Ecological Provinces of Minnesota as defined by the Ecological Classification System (ECS) of the Minnesota Department of Natural Resources (MN DNR).

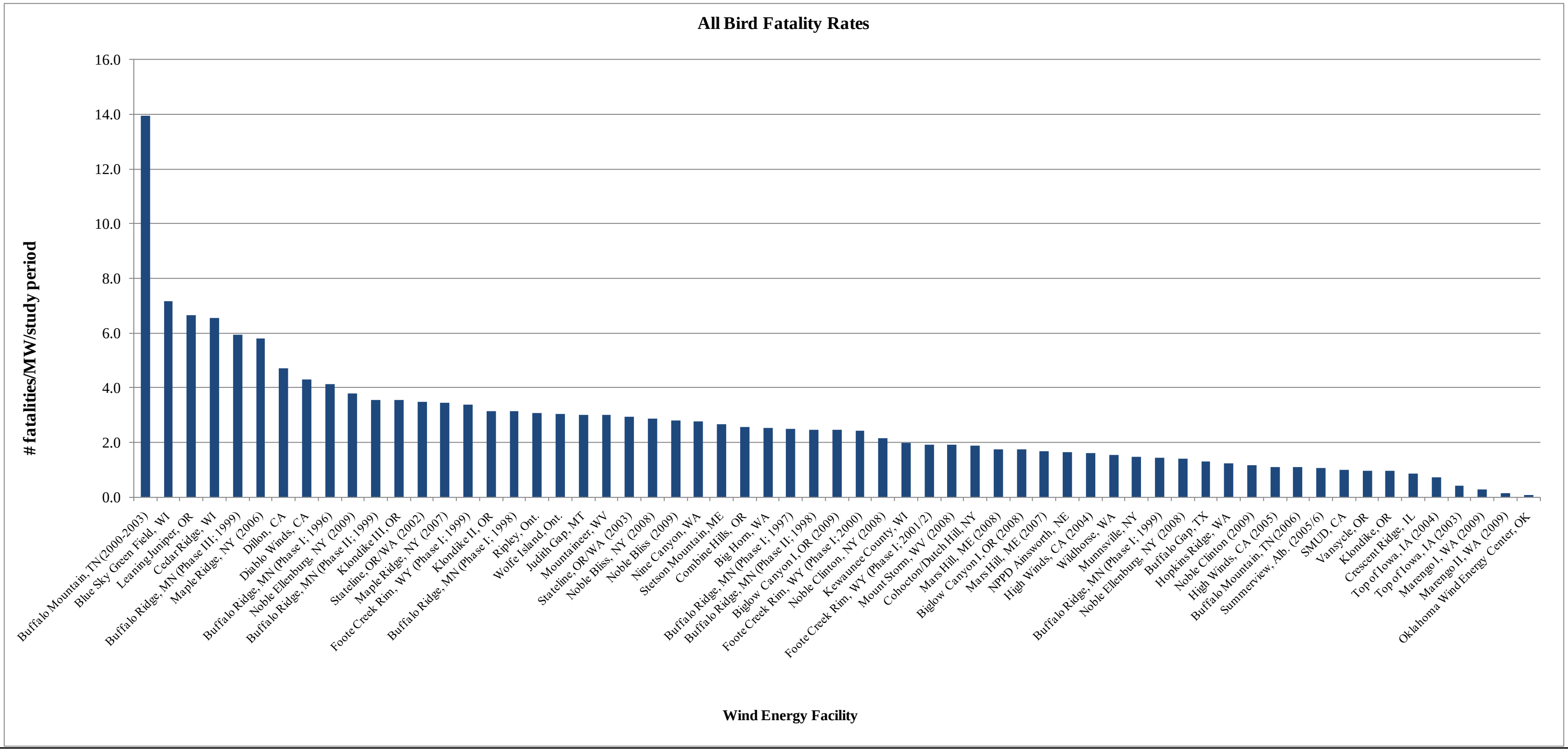

Figure 3a. Total adjusted bird fatality rates (per megawatt per year) from post-construction wind project monitoring across North America.

Figure 3a (*continued*). Total adjusted bird fatality rates (per megawatt per year) from post-construction wind project monitoring across North America.

Data from the following sources:

Facility, Location	Fatality Reference	Facility, Location	Fatality Reference	Facility, Location	Fatality Reference
Buffalo Mountain, TN (00-03)	Nicholson et al. 2005	Stateline, OR/WA (03)	Erickson et al. 2004	Wild Horse, WA	Erickson et al. 2008
Blue Sky Green Field, WI	Gruver et al. 2009	Noble Bliss, NY (08)	Jain et al. 2009c	Munnsville, NY	Stantec 2008b
Leaning Juniper, OR	Gritski et al. 2008	Noble Bliss, NY (09)	Jain et al. 2010a	Buffalo Ridge, MN (Phase I; 99)	Johnson et al. 2000a
Cedar Ridge, WI	BHE 2010	Nine Canyon, WA	Erickson et al. 2003a	Noble Ellenburg, NY (08)	Jain et al. 2009a
Buffalo Ridge, MN (Phase III; 99)	Johnson et al. 2000a	Stetson Mountain, ME	Stantec 2009b	Buffalo Gap, TX	Tierney 2007
Maple Ridge, NY (06)	Jain et al. 2007	Combine Hills, OR	Young et al. 2006	Hopkins Ridge, WA	Young et al. 2007
Dillon, CA	Chatfield et al. 2009	Big Horn, WA	Kronner et al. 2008	Noble Clinton, NY (09)	Jain et al. 2010b
Diablo Winds, CA	WEST 2008	Buffalo Ridge, MN (Phase I; 97)	Johnson et al. 2000a	High Winds, CA (05)	Kerlinger et al. 2006
Buffalo Ridge, MN (Phase I; 96)	Johnson et al. 2000a	Buffalo Ridge, MN (Phase II; 98)	Johnson et al. 2000a	Buffalo Mountain, TN (06)	Fiedler et al. 2007
Noble Ellenburg, NY (09)	Jain et al. 2010c	Biglow Canyon I, WA (2009)	Enk et al. 2010	Summerview, Alb. (2005/2006)	Brown and Hamilton 2006b
Buffalo Ridge, MN (Phase II; 99)	Johnson et al. 2000a	Foote Creek Rim, WY (Phase I; 00)	Young et al. 2003b	SMUD, CA	URS et al. 2005
Klondike III, OR	Gritski et al. 2009	Noble Clinton, NY (08)	Jain et al. 2009b	Vansycle, OR	Erickson et al. 2000
Stateline, OR/WA (02)	Erickson et al. 2004	Kewaunee County, WI	Howe et al. 2002	Klondike, OR	Johnson et al. 2003b
Maple Ridge, NY (07)	Jain et al. 2008	Foote Creek Rim, WY (Phase I; 01/02)	Young et al. 2003b	Crescent Ridge, IL	Kerlinger et al. 2007
Foote Creek Rim, WY (Phase I; 99)	Young et al. 2003b	Mount Storm, WV (08)	Young et al. 2009	Top of Iowa, IA (04)	Jain 2005
Klondike II, OR	NWC and WEST 2007	Cohocton/Dutch Hill, NY	Stantec 2010	Top of Iowa, IA (03)	Jain 2005
Buffalo Ridge, MN (Phase I; 98)	Johnson et al. 2000a	Mars Hill, ME (08)	Stantec 2009a	Marengo I, WA	URS Corporation 2010a
Ripley, Ont.	Jacques Whitford 2009	Biglow Canyon I, WA (2008)	Jeffrey et al. 2009	Marengo II, WA	URS Corporation 2010b
Wolfe Island, Ont.	Stantec Ltd. 2010	Mars Hill, ME (07)	Stantec 2008	Oklahoma Wind Energy Center, OK	Piorkowski 2006
Judith Gap, MT	TRC 2008	NPPD Ainsworth, NE	Derby et al. 2007		
Mountaineer, WV	Kerns and Kerlinger 2004	High Winds, CA (04)	Kerlinger et al. 2006		

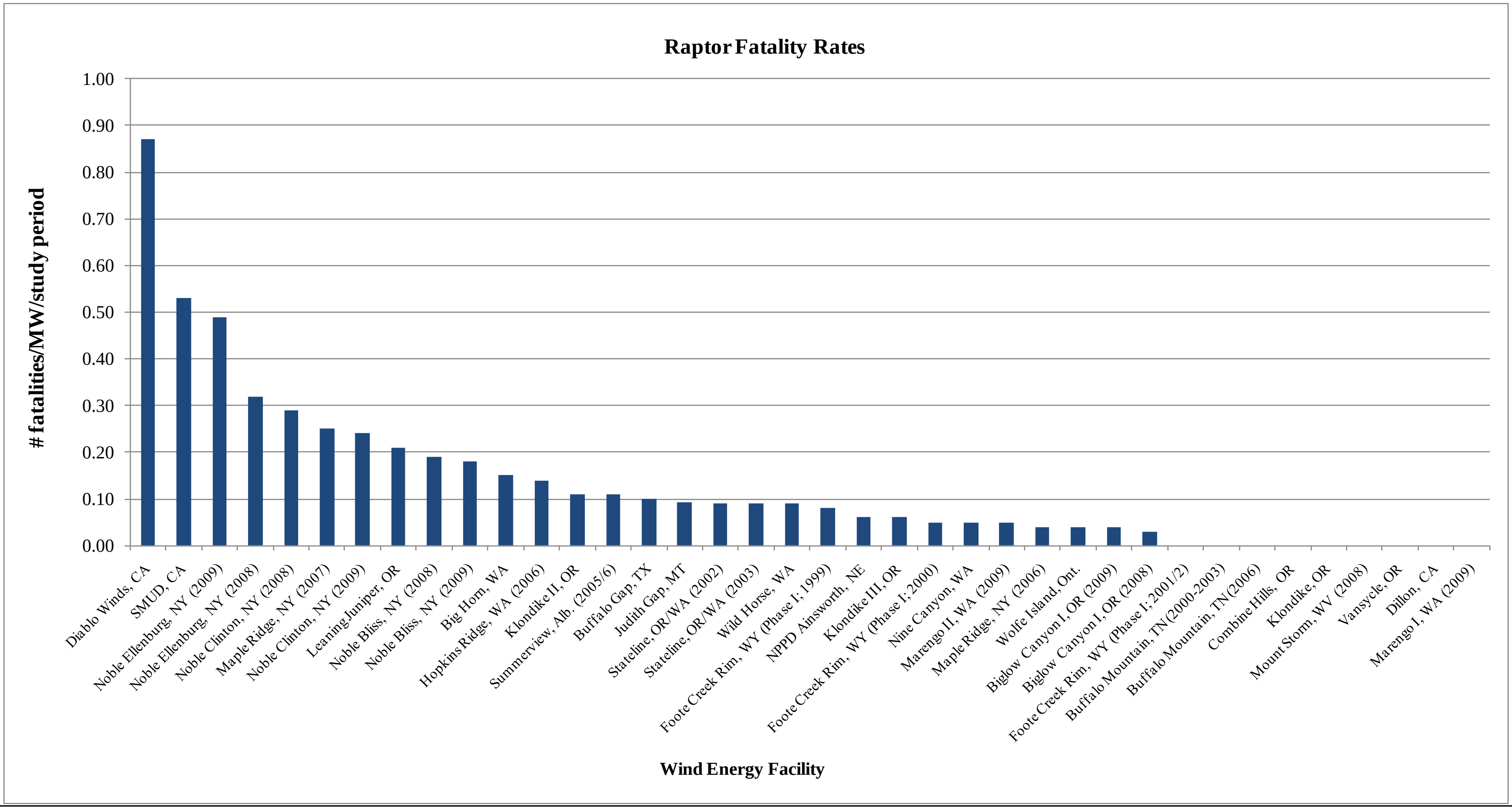

Figure 3b. Total adjusted raptor fatality rates (per megawatt per year) from post-construction wind project monitoring across North America.

Figure 3b (*continued*). Total adjusted raptor fatality rates (per megawatt per year) from post-construction wind project monitoring across North America.

Data from the following sources:

Facility, Location	Fatality Reference	Facility, Location	Fatality Reference	Facility, Location	Fatality Reference
Diablo Winds, CA	WEST 2008	Summerview, Alb. (05/06)	Brown and Hamilton 2006b	Wolfe Island, Ont.	Stantec Ltd. 2010
SMUD, CA	URS et al. 2005	Buffalo Gap, TX	Tierney 2007	Biglow Canyon I, WA (2009)	Enk et al. 2010
Noble Ellensburg, NY (09)	Jain et al. 2010c	Judith Gap, MT	TRC 2008	Biglow Canyon I, WA (2008)	Jeffrey et al. 2009
Noble Ellensburg, NY (08)	Jain et al. 2009a	Stateline, OR/WA (02)	Erickson et al. 2004	Foote Creek Rim, WY (Phase I; 01/02)	Young et al. 2003b
Noble Clinton, NY (08)	Jain et al. 2009b	Stateline, OR/WA (03)	Erickson et al. 2004	Buffalo Mountain, TN (00-03)	Nicholson 2003, 2005
Maple Ridge, NY (07)	Jain et al. 2008	Wild Horse, WA	Erickson et al. 2008	Buffalo Mountain, TN (06)	Fiedler et al. 2007
Noble Clinton, NY (09)	Jain et al. 2010b	Foote Creek Rim, WY (Phase I; 99)	Young et al. 2003b	Combine Hills, OR	Young et al. 2006
Leaning Juniper, OR	Gritski et al. 2008	NPPD Ainsworth, NE	Derby et al. 2007	Klondike, OR	Johnson et al. 2003b
Noble Bliss, NY (08)	Jain et al. 2009c	Klondike III, OR	Gritski et al. 2009	Mount Storm, WV (08)	Young et al. 2009
Noble Bliss, NY (09)	Jain et al. 2010a	Foote Creek Rim, WY (Phase I; 00)	Young et al. 2003b	Vansycle, OR	Erickson et al. 2000
Big Horn, WA	Kronner et al. 2008	Nine Canyon, WA	Erickson et al. 2003a	Dillon, CA	Chatfield et al. 2009
Hopkins Ridge, WA	Young et al. 2007	Marengo II, WA	URS Corporation 2010b	Marengo I, WA	URS Corporation 2010a
Klondike II, OR	NWC and WEST 2007	Maple Ridge, NY (06)	Jain et al. 2007		

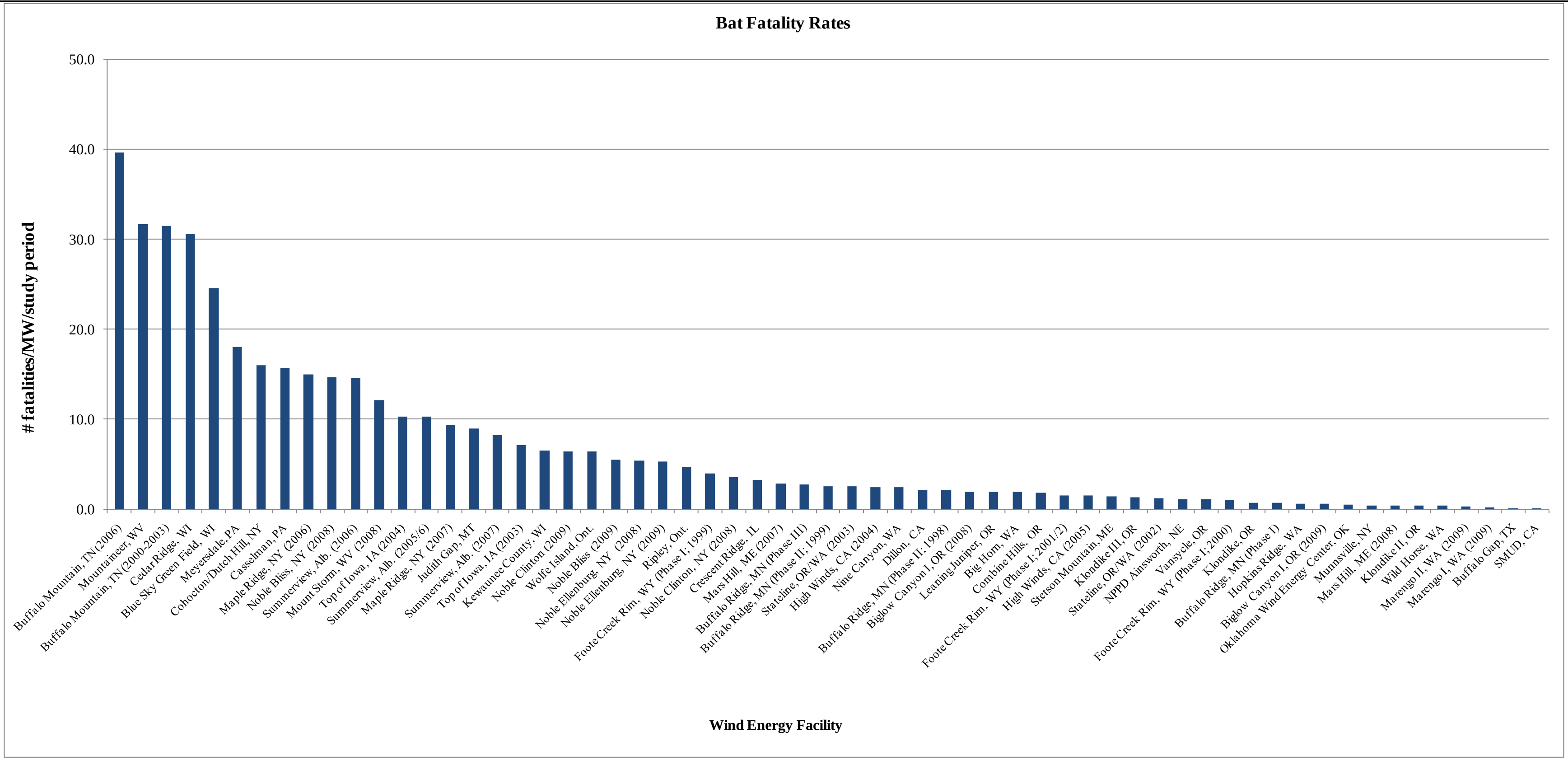

Figure 3c. Total adjusted bat fatality rates (per megawatt per year) from post-construction wind project monitoring across North America.

Figure 3c (c*ontinued*). Total adjusted bat fatality rates (per megawatt per year) from post-construction wind project monitoring across North America.

Data from the following sources:

Facility, Location	Fatality Reference	Facility, Location	Fatality Reference	Facility, Location	Fatality Reference
Buffalo Mountain, TN (06)	Fiedler et al. 2007	Noble Bliss, NY (09)	Jain et al. 2010a	Stetson Mountain, ME	Stantec 2009b
Mountaineer, WV	Kerns and Kerlinger 2004	Noble Ellensburg, NY (08)	Jain et al. 2009a	Klondike III, OR	Gritski et al. 2009
Buffalo Mountain, TN (00-03)	Nicholson et al. 2005	Noble Ellenburg, NY (09)	Jain et al. 2010c	Stateline, OR/WA (02)	Erickson et al. 2004
Cedar Ridge, WI	BHE 2010	Ripley, Ont.	Jacques Whitford 2009	NPPD Ainsworth, NE	Derby et al. 2007
Blue Sky Green Field, WI	Gruver et al. 2009	Foote Creek Rim, WY (Phase I; 99)	Young et al. 2003b	Vansycle, OR	Erickson et al. 2000
Meyersdale, PA	Arnett et al. 2005	Noble Clinton, NY (08)	Jain et al. 2009b	Foote Creek Rim, WY (Phase I; 00)	Young et al. 2003b
Cohocton/Dutch Hill, NY	Stantec 2010	Crescent Ridge, IL	Kerlinger et al. 2007	Klondike, OR	Johnson et al. 2003b
Casselman, PA	Arnett et al. 2009	Mars Hill, ME (07)	Stantec 2008a	Buffalo Ridge, MN (Phase I; 99)	Johnson et al. 2000a
Maple Ridge, NY (06)	Jain et al. 2007	Buffalo Ridge, MN (Phase III; 99)	Johnson et al. 2004	Hopkins Ridge, WA	Young et al. 2007
Noble Bliss, NY (08)	Jain et al. 2009c	Buffalo Ridge, MN (Phase II; 99)	Johnson et al. 2004	Biglow Canyon I, WA (2009)	Enk et al. 2010
Summerview, Alb. (06)	Baerwald 2008	Stateline, OR/WA (03)	Erickson et al. 2004	Oklahoma Wind Energy Center, OK	Piorkowski 2006
Mount Storm, WV (08)	Young et al. 2009	High Winds, CA (04)	Kerlinger et al. 2006	Munnsville, NY	Stantec 2008b
Top of Iowa, IA (2004)	Jain 2005	Nine Canyon, WA	Erickson et al. 2003a	Mars Hill, ME (08)	Stantec 2009a
Summerview, Alb. (05/06)	Brown and Hamilton 2006b	Dillon, CA	Chatfield et al. 2009	Klondike II, OR	NWC and WEST 2007
Maple Ridge, NY (07)	Jain et al. 2008	Buffalo Ridge, MN (Phase II; 98)	Johnson et al. 2004	Wild Horse, WA	Erickson et al. 2008
Judith Gap, MT	TRC 2008	Biglow Canyon I, WA (2008)	Jeffrey et al. 2009	Marengo II, WA	URS Corporation 2010b
Summerview, Alb. (07)	Baerwald 2008	Leaning Juniper, OR	Gritski et al. 2008	Marengo I, WA	URS Corporation 2010a
Top of Iowa, IA (03)	Jain 2005	Big Horn, WA	Kronner et al. 2008	Buffalo Gap, TX	Tierney 2007
Kewaunee County, WI	Howe et al. 2002	Combine Hills, OR	Young et al. 2006	SMUD, CA	URS et al. 2005
Noble Clinton, NY (09)	Jain et al. 2010b	Foote Creek Rim, WY (Phase I; 01/02)	Young et al. 2003b		
Wolfe Island, Ont.	Stantec, Ltd. 2010	High Winds, CA (05)	Kerlinger et al. 2006		

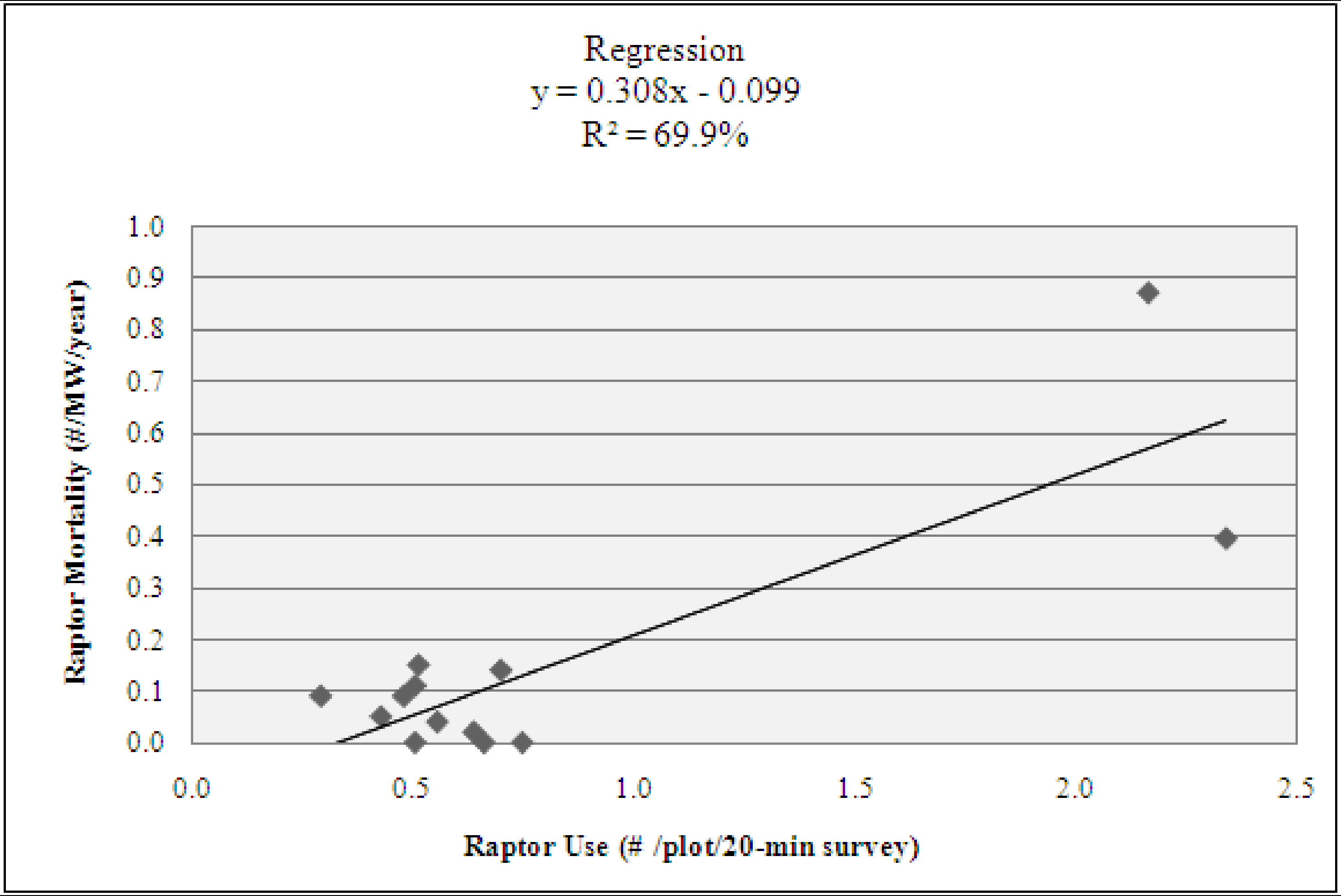

Figure 4. Regression analysis showing relationship between raptor use (number of birds/20-minute survey) and fatality rates (number/megawatt/year).

Figure 4 (*continued*). Regression analysis showing relationship between raptor use (number of birds/20-minute survey) and fatality rates (number/megawatt/year). Data from the following sources:

Study and Location	Raptor Use (birds/plot /20-min survey)	Source	Raptor Mortality (fatalities/MW/yr)	Source
Buffalo Ridge, MN	0.64	Erickson et al. 2002b	0.02	Erickson et al. 2002b
Combine Hills, OR	0.75	Young et al. 2003c	0.00	Young et al. 2006
Diablo Winds, CA	2.161	WEST 2006	0.87	WEST 2008
Foote Creek Rim, WY	0.55	Johnson et al. 2000b	0.04	Young et al. 2003b
High Winds, CA	2.34	Kerlinger et al. 2005	0.39	Kerlinger et al. 2006
Hopkins Ridge, WA	0.70	Young et al. 2003a	0.14	Young et al. 2007
Klondike II, OR	0.50	Johnson 2004	0.11	NWC and WEST 2007
Klondike, OR	0.50	Johnson et al. 2002a	0.00	Johnson et al. 2003b
Stateline, WA/OR	0.48	Erickson et al. 2004	0.09	Erickson et al. 2002b
Vansycle, OR	0.66	WCIA and WEST 1997	0.00	Erickson et al. 2000
Wild Horse, WA	0.29	Erickson et al. 2003b	0.09	Erickson et al. 2008
Zintel, WA	0.43	Erickson et al. 2002a	0.05	Erickson et al. 2002b
Bighorn, WA	0.51	Johnson and Erickson 2004	0.15	Kronner et al. 2008

Table 1. Summary of wind-energy facility characteristics and reference information for 16 studies at 19 wind projects in the western United States and Canada.

Wind Energy Facility	County	State	Number of Turbines	Turbine Capacity (MW)	Blade Diameter (m)	Tower height (m)	Total Site MW	Habitat	Reference
Buffalo Ridge Phase I	Lincoln, Pipestone	MN	73	0.34	33	36	24.8	grassland/agriculture	Johnson et al. 2000a
Buffalo Ridge Phase II, III	Lincoln, Pipestone	MN	281	0.75	48	36	210.8	grassland/agriculture	Johnson et al. 2000a
Blue Sky Green Field	Fond du Lac	WI	88	1.6	82	80	145	agriculture	Gruver et al. 2009
Kewaunee County	Kewaunee	WI	31	0.66	47	65	20.5	agriculture	Howe et al. 2002
Cedar Ridge	Fond du Lac	WI	41	1.6	82	80	68	mostly agriculture	BHE 2010
Crescent Ridge	Bureau	IL	33	1.5			49.5	agriculture	Kerlinger et al. 2007
Top of Iowa	Worth	IA	89	0.9	52	71.6	80.1	agriculture	Jain 2005
NPPD Ainsworth	Brown	NE	36	1.65	80	70	59.4	grassland/agriculture	Derby et al. 2007
Foote Creek Rim	Carbon	WY	69	0.6	42	40	41.4	grassland	Young et al. 2003b
Judith Gap	Wheatland	MT	90	1.5	77	80	135	grassland/agriculture	TRC 2008
Summerview 2006	Canada	Alberta	39	1.8	80	67	70.2	grassland/agriculture	Brown and Hamilton 2006b
Summerview 2008	Canada	Alberta	39	1.8	80	67	70.2	grassland/agriculture	Baerwald 2008
McBride Lake	Canada	Alberta	114	0.66	47	50	75.2	grassland/agriculture	Brown and Hamilton 2004

Table 1. Summary of wind-energy facility characteristics and reference information for 16 studies at 19 wind projects in the western United States and Canada.

Wind Energy Facility	County	State	Number of Turbines	Turbine Capacity (MW)	Blade Diameter (m)	Tower height (m)	Total Site MW	Habitat	Reference
Mars Hill	Aroostook	ME	28	1.5	77	80	42	hardwood forest, some grassland	Stantec 2009
Maple Ridge	Lewis	NY	Ph. 1-120, Ph.1A&2-75	1.65	82	80	322	cultivated ag, pastures, some forest	Jain et al. 2008
Mountaineer	Tucker	WV	44	1.5	72	69.5	66	forested	Kern and Kerlinger 2004
Mountaineer	Tucker	WV	44	1.5	72	69.5	66	forested	Arnett 2005
Meyersdale	Somerset	PA	20	1.5	72	80	30	forested	Arnett 2005
Castle River	Canada	Alberta	60	0.66	47	50	39.6	grassland/agriculture	Brown and Hamilton 2006a

Table 2. Summary of wind-energy facility fatality monitoring methods for 16 studies at 19 wind projects in the western United States and Canada.

Wind Energy Facility	State	Search Plot Size	Study Duration	Search Intensity
Buffalo Ridge Phase I-III	MN	100m x 100m	1996-1999	bi-monthly
Blue Sky Green Field	WI	160m x160 m, cleared transects	Jul-Oct 2008, Mar-Jun 2009	daily, weekly
Kewaunee County	WI	60m x 60m	Jul 1999-Jul 2001	daily, bi-weekly, weekly
Cedar Ridge	WI	160m x160 m, cleared transects	Mar-May; July-Nov 2009	daily to every 4 days
Crescent Ridge	IL	140m x 140m, or 70m radius	Sep-Nov 2005; Mar-May 2006; Aug 2006	every 5 days
Top of Iowa	IA	76m x 76m, cleared transects	Apr-Dec 2003; Mar-Dec 2004	every 2-3 days
NPPD Ainsworth	NE	220m x 220m	Mar-Nov, 2006	bi-monthly
Foote Creek Rim	WY	126m x 126m	Nov 1998-Jun 2002	monthly or every 2 weeks
Judith Gap	MT	190m x 190m	Aug-Oct 2006, Feb-May, 2007	monthly
Summerview 2006	Canada	140m x 140m, or 40m radius	Jan 2005-Jan 2006	weekly, bi-weekly in May-Jul, Sep
Summerview 2008	Canada	52m radius	Jul-Sep, 2006 & 2007	daily (10 turbines), weekly (29 turbines)
McBride Lake	Canada	120m	Jul 2003-Jun 2004	weekly, bi-weekly (May-Jul, Sep-Oct)
Castle River	Canada	120m	April 2001-Jan 2002	weekly, twice weekly (May-Jul, Sep)
Mars Hill	ME	typically 76 m, extended up to 238 m	Apr-Sep 2007; Apr-Oct 2008	Year 1: 2 turbines daily, all others weekly; Year 2: all turbines weekly, dogs also used
Maple Ridge	NY	130x120 m	Jun-Nov 2006 (Ph.1); Apr-Nov 2007 (all)	daily, 3 days, weekly

Table 2. Summary of wind-energy facility fatality monitoring methods for 16 studies at 19 wind projects in the western United States and Canada.

Wind Energy Facility	State	Search Plot Size	Study Duration	Search Intensity
Mountaineer	WV	60m radius	Apr-Nov 2003	one search in summer, 2.5-3 days in spring, fall
Mountaineer	WV	130x120 m	31 Jul-11 Sep 2004	daily, weekly
Meyersdale	PA	130x120 m	2 Aug - 13 Sep 2004	daily, weekly

Table 3. Summary of wind-energy facility fatality monitoring results for 21 studies at 20 wind projects in the western United States and Canada.

Wind Energy Facility	State	Adjusted bird fats. /MW/year	Adjusted bird fats. /turbine/year	Obs. bird fats/turbine/yr (*max./turbine*)	Adjusted raptor fats. /MW/year	Adjusted raptor fats. /turbine/year	Obs. raptor fats/turbine/yr (*max./turbine*)	Adjusted bat fats. /MW/year	Adjusted bat fats. /turbine/year	Obs. bat fats/turbine/yr (*max./turbine*)
Buffalo Ridge	MN	1.43-5.93	0.50-4.45	0.03 (*14*)				0.76 – 2.72	0.26 – 2.04	0.08 (*8*)
Blue Sky Green Field	WI	7.17	11.83	0.45/study period (*8*)	0	0	0	24.6	40.5	2.51/study period (*19*)
Kewaunee County	WI	1.95	1.29	0.40 (*3*)	0	0	0	6.45	4.26	1.16 (*n/a*)
Cedar Ridge	WI	6.52/MW/169 days	10.82/turbine/169 days	0.76/study period (*7*)			0.02/study period (*1*)	30.4/MW/169 days	50.5/turbine/169 days	2.05/study period (*13*)
Crescent Ridge	IL	0.31-0.33	0.47-0.49	0.30/ study period (*1*)				0.18-2.67	0.12-1.75	0.64/study period (*10*)
Top of Iowa	IA	0.49-1.07	0.44-0.96	0.08/study period (*n/a*)				7.34-9.81	6.60-8.83	0.84/study period
NPPD Ainsworth	NE	1.63/8-month study	2.69/8-month study	0.75 (*3*)	0.06	0.1	0.08 (*1*)	1.16/8-month study	1.91/8-month study	0.44 (*3*)
Foote Creek Rim	WY	2.5	1.5	0.41 (*5*)	0.04	0.02	0.02 (*1*)	2.23	1.34	0.38 (*4*)
Judith Gap	MT	3.01/7-month study	4.5/7-month study	0.17/7-month study(*2*)	0.09	0.14	0.01/7-month study (*1*)	8.93/7-month study	13.40/7-month study	0.39/7-month study (*4*)
Summerview 2006	Canada	1.06	1.91	1.28 (*n/a*)	0.11	0.19	0.13 (*n/a*)	10.27	18.49	13.64 (*n/a*)
Summerview 2008	Canada	n/a	n/a	n/a	n/a	n/a	n/a	14.62	26.32	12.73 (*n/a*)
McBride Lake	Canada	unadj 0.54	unadj 0.36	0.36 (*n/a*)	not reported	not reported	0.08 (*n/a*)	unadj 0.71	unadj 0.47	0.47 (*n/a*)
Castle River	Canada	unadj 0.23(2001) 0.35(2002)	unadj 0.15(2001) 0.23(2002)	0.15 in 2001, 0.23 in 2002 (*n/a*)	not reported	not reported	not reported	unadj 1.35(2001) 0.33(2002)	unadj 0.89(2001) 0.22(2002)	0.89 in 2001, 0.22 in 2002 (*n/a*)

Table 3. Summary of wind-energy facility fatality monitoring results for 21 studies at 20 wind projects in the western United States and Canada.

Wind Energy Facility	State	Adjusted bird fats. /MW/year	Adjusted bird fats. /turbine/year	Obs. bird fats/turbine/yr (*max./turbine*)	Adjusted raptor fats. /MW/year	Adjusted raptor fats. /turbine/year	Obs. raptor fats/turbine/yr (*max./turbine*)	Adjusted bat fats. /MW/year	Adjusted bat fats. /turbine/year	Obs. bat fats/turbine/yr (*max./turbine*)
Mars Hill	ME	0.29-1.76	0.44-2.65	3	3	not reported	not reported	1	1	0.12-2.91
Maple Ridge	NY	3.82-5.81	6.31-9.59		6	not reported	not reported		not reported	11.23-14.87
Mountaineer	WV	3.00	4.04		3	not reported	not reported		1	31.69
Mountaineer	WV	not reported	not reported	not reported	not reported	not reported	not reported	not reported	not reported	25/6 weeks
Meyersdale	PA	not reported	not reported	not reported	not reported	not reported	not reported	not reported	not reported	20/6 weeks