Wind Turbines and Birds

A Background Review for Environmental Assessment

DRAFT MAY 12 2005

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May 12, 2005

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This document will be reviewed and updated as required. To ensure that you have the most up-to-date version, please consult our web site at http://www.cws-scf.ec.gc.ca/publications/index.cfm?lang=e . The companion document, Wind Turbines and Birds: A Guidance Document for Environmental Assessment, is also available at this website.

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Executive Summary

This document presents the results of an extensive literature review on wind turbine and bird interactions from around the world. It provided the basis for, and is intended for use as a companion document to, Environment Canada's environmental assessment document, "Wind Turbines and Birds: A Guidance Document for Environmental Assessment".

The literature review identified two main types of potential effects of wind turbines on birds: collision impacts and disturbance effects. Both of these types of effects are addressed in the document. Reaserach has also indicated that high levels of bat mortality can occur at wind turbines, although this impact has not been specifically dealt with in this document.

Wind has been used successfully around the globe to generate electricity, and is generally considered an environmentally healthy and viable means of power generation. However, concerns have been raised about the possible impact of wind turbines on bird populations. These concerns were first raised in the 1980s when it was discovered that large numbers of raptors were colliding with wind turbines and their associated power lines at two specific wind farms in California. Raptor collisions with wind turbines in Tarifa, Spain, raised further concerns. While these collisions have been attributed to the unique combination of site specific factors in these areas, they demonstrate that potential exists for adverse effects from direct collisions and reinfoirce the need to better understand turbine and bird interactions.

Subsequent studies that have been undertaken around the world suggest that, despite a few important exceptions, very low numbers of bird fatalities occur at wind energy facilities. Appropriate site selection appears to be the key factor in preventing negative impacts on birds. The observed mortality cause by wind energy facilities is also very low compared to other existing sources of human-caused avian mortality. However, critics contend that mortality has been underestimated due to the inherent difficulties in locating carcasses, especially those of small birds, in the vicinity of turbines. In addition, even a relatively small number of deaths per turbine can have significant population impacts if the number of turbines at a wind farm is large.

Raptors are often cited as the bird group most threatened by wind facilities, mainly due to fatalities that continue to occur in California and Tarifa, Spain. In almost all areas, however, raptors are able to avoid wind turbines, resulting in very few or no collisions. A number of specific factors have contributed to the raptor deaths observed in California, including unusually high raptor densities, topography, and possibly older turbine technology.

In North America, the birds most commonly observed to collide with wind turbines are songbirds. Often, these collisions are believed to occur at night during nocturnal migration, although collisions also occur during the day. Factors such as topography, turbine lighting, turbine height, the presence of guy wires, weather, and numbers of birds moving through an area on migration can influence the number of migrant collisions observed at a facility.

The greatest adverse effects that wind energy facilities may have on birds is disturbance to breeding and wintering birds, although this has received little attention. Disturbance is an especially important concern in prairie habitat where certain susceptible bird species breed, and in offshore areas that are important feeding areas or movement corridors.

Interest in offshore wind energy facilities has been increasing in recent years. Although no facilities

have been built in North America, several exist in Europe. It has been difficult to assess mortality at offshore locations as victims are lost in the water. However, certain species appear to avoid offshore turbines, and rows of turbines may act as barriers to movement. Offshore wind farms may also displace birds from foraging areas. There is still much that needs to be learned about the effect of offshore wind facilities on bird populations.

Finally, while much research has been undertaken, relatively few comprehensive research programs have been published in peer-reviewed journals, and relatively few studies have been conducted in Canada. Furthermore, there are still many gaps in our knowledge, particularly with respect to bird migration, turbine lighting, and potential impacts of offshore wind development.

The wind industry in Canada is in its relative infancy. The number of wind energy facilities, and the overall number of turbines, is expected to rise sharply in the next few years. While this means that the potential for cumulative effects on birds increases, it also provides an opportunity, through continued research and careful site selection, to ensure that development occurs in a way that minimizes the adverse effects on birds.

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1 Introduction

Climate change presents a serious global threat to the environment, including to biodiversity and human health. The Government of Canada ratified the Kyoto Protocol in 2002, and recently released its 2005 Climate Change Plan, *Moving Forward on Climate Change: A Plan for Honouring our Kyoto Commitment*. One key feature is the promotion of renewable energy, including wind energy.

Wind energy in Canada is still in its relative infancy, but is clearly poised for rapid expansion and growth. This is an opportune time to ensure that the industry grows in a manner that does not adversely affect other areas of the environment. In particular, concerns have been raised regarding potential adverse effects on birds and bats, following cases in California in the late 1980s where high numbers of birds of prey and some bird species at risk were found to be killed by wind turbines and their associated power lines.

While such cases clearly show that the potential exists for adverse effects on birds, successful wind energy projects exist across the globe, including facilities in Africa, Asia, Europe, Australia, South America, the U.S. and Canada. The challenge lies in identifying the particular features of the environment or of the technology that increase the risks to birds, so that adverse effects can be avoided or minimized.

With this goal in mind, a review of available literature and research, including both unpublished reports and peer-reviewed articles, was undertaken by Bird Studies Canada. While many studies have been conducted, relatively few have been comprehensive science-based studies subject to the rigors of peer-review for publication in scientific journals. Some findings have been contradictory and in many cases, there are gaps related to the availability of background information on migratory birds and our understanding of the complex interactions between wind turbines and birds. Most empirical data on the effects of wind energy facilities on birds comes from U.S. and European research. In the U.S., most of the work has concentrated on assessing and documenting bird collisions with wind turbines, whereas research in Europe has placed more focus on examining indirect effects such as disturbance. Comparatively little data are available for Canada.

Two basic types of effects have been observed: 1) direct fatality or injury through collision, and 2) disturbance and habitat loss. In most cases direct fatalities appear to be relatively uncommon, although corrections for observer efficiency and scavenging rate are not always made. As the industry grows, the potential for cumulative effects from direct mortality and disturbance through habitat loss also grows.

The information provided in this document was reviewed by scientists from Environment Canada, and provided the basis for identifying the general requirements for assessing potential environmental effects of proposed wind farm projects on birds in the context of environmental assessments. Best available information was used to identify features of the environment which could present greater risk to birds, and information requirements were identified for sites presenting various levels of sensitivity. This environmental assessment guidance is provided in *Wind Turbines and Birds: a Guidance Document for Environmental Assessment*, available at www.whatever. This research summary serves as a as a companion document to the EA guideline. Both documents will be updated when required to reflect new information that will be generated through ongoing research and environmental assessment follow-up.

1.1 Purpose

The purpose of this document is to provide an overview of available information on interactions between wind turbines and birds. This information was collected through an extensive review of both published and unpublished research and literature from around the world. This document provides the background information for Environment Canada’s guidance document on assessing environmental effects of proposed wind farms on birds.

2. Background

2.1 Green Power

All of the commonly used methods of power generation cause negative environmental effects, although some are worse than others. Nuclear power creates thermal pollution in waterbodies and causes concern over waste disposal issues and the potential for harming the environment with radiation. Large hydroelectric facilities disrupt aquatic ecosystems and may flood large areas of land, leading to various environmental concerns, including significant loss of bird habitat. Adverse effects of fossil fuel-burning plants have caused concern among environmentalists, regulators and the general public. Coal’s contribution to greenhouse gas emissions and poor air quality has fuelled a need for alternative sources of energy. Climate change may have global impacts on biodiversity and natural habitats, and on birds and other organisms that are dependent upon those habitats. Wind turbines are an affordable form of power generation that have relatively little environmental impact when properly sited. As a result, there has been a dramatic increase in the popularity of wind energy in recent years.

The most significant factor contributing to the rise in popularity of wind energy has been a change in environmental awareness and an increased concern over human and environmental health. With such international endeavours as the Kyoto Protocol, alternative energy production has been pushed to the forefront of people’s minds. The Canadian government has recognised the importance of cleaner sources of energy in light of its commitment to the Kyoto Protocol (Government of Canada 2005). Emerging renewable energy technologies are highlighted as an important contribution in the fight against climate change, and the Government of Canada is providing expanded incentives for wind energy through the Wind Power Production Incentive (WPPI) program managed by Natural Resources Canada (NRCan). In addition, the Canadian Government has set a target that at least 10% of Canada’s new electricity generating capacity in 2010 should come from renewable energy sources, including wind.

2.2 Environment Canada’s Mandate

Environment Canada's mandate is to preserve and enhance the quality of the natural environment, including water, air and soil quality; to conserve Canada's renewable resources, including migratory birds and other flora and fauna; to conserve and protect Canada's water resources; to carry out meteorology; to enforce the rules made by the Canada - United States International Joint Commission relating to boundary waters; and to co-ordinate environmental policies and programs for the federal government.

Environment Canada's vision is to see a Canada where people make responsible decisions about the environment, and where the environment is thereby sustained for the benefit of present and future generations, and for the benefit of biotic and abiotic components in and for themselves.

Environment Canada's mission is to make sustainable development a reality in Canada by helping Canadians live and prosper in an environment that needs to be respected, protected and conserved.

Environment Canada has the responsibility to protect migratory birds and species at risk, and therefore must ensure that populations of migratory birds are not adversely affected by projects such as wind energy developments. Environment Canada also has responsibilities under the Government of Canada's commitment to the Kyoto Protocol, and is committed to encouraging the establishment of alternate energy sources such as wind power. As an expert Federal Authority under the *Canadian Environmental Assessment Act*, Environment Canada also provides advice on migratory birds, species at risk and other areas related to its mandate to other federal departments on the potential environmental effects of projects on private and public land.

2.3 Legislation, Policy and Initiatives

Most birds living in Canada do so for only part of the year, and are thus considered migratory. Most of these migratory species have been internationally protected under the *Migratory Birds Convention* of 1916, implemented in Canada in 1917 through the *Migratory Birds Convention Act (MBCA), 1994*. This act is the Canadian domestic legislation implementing the international treaty between Canada and the United States to protect migratory birds. The MBCA (paragraph 5) prohibits any person to possess a migratory bird or nest, or buy, sell, exchange or give a migratory bird or nest or make it the subject of a commercial transaction. Therefore, permits are required for the handling of migratory birds or bird carcasses. The *Migratory Birds Regulation* (MBR), in Section 6, prohibits the killing, disturbance, destruction, taking of a nest, egg, nest shelter, eider duck shelter or duck box of a migratory bird; or the possession of a live migratory bird, or its carcass, skin, nest or egg, except under authority of a permit. It is important to note that under the MBR, no permits can be issued for economic activities or development projects, and therefore permits cannot be provided for the incidental take of birds resulting from economic development activities. Section 35 of the MBR also prohibits in general the deposit of harmful substances in any waters or any area frequented by migratory birds anywhere in Canada**.**

In 1996, signatory federal, provincial and territorial governments endorsed the *Accord for the Protection of Species at Risk,* and committed to a national approach to protect Species at Risk. Governments agreed to develop complementary legislation, regulations, policies and programs to identify and protect species at risk and their habitats. In June 2003, the federal *Species at Risk Act* (SARA) was proclaimed.

SARA protects plants and animals listed in Schedule 1 of the Act (the List of Wildlife Species at Risk). SARA prohibitions apply to aquatic species and migratory birds protected under the *Migratory Birds Convention Act*, *1994* wherever they are found and to all listed wildlife species on federal lands. For other listed species located outside of federal lands, the provinces and territories are given the first opportunity to protect them through their laws. If those measures are not in place or are insufficient, the *Species at Risk Act* has a "safety net" whereby certain prohibitions may apply by order of the Governor in Council. SARA prohibitions make it an offence to kill, harm, harass, capture or take an individual of a listed endangered, threatened or extirpated species; and to possess, collect, buy, sell or trade an individual of a listed endangered, threatened or extirpated species, or its parts or derivatives. As well, SARA prohibitions make it an offence to damage or destroy the residence of one or more individuals of a listed endangered or threatened species, or a listed extirpated species if a recovery strategy has recommended its reintroduction into the wild in Canada. SARA also provides a way for the government to take immediate action to protect a wildlife species in an emergency. In addition, SARA provides for the protection of critical habitat of listed species through various means.

SARA also requires that every person required by law to conduct a federal EA must (1) notify the competent minister(s) in the likelihood that a project will affect a listed wildlife species or its critical habitat; (2) identify the adverse effects of the project on the listed wildlife species; and, if the project is carried out, (3) ensure that measures are taken to avoid or lessen the effects and to monitor them. The measures must be taken in a way that is consistent with any applicable recovery strategies and action plans.

Besides the MBCA, MBR, SARA and the *Canadian Environmental Assessment Act*, other relevant legislation, policies and initiatives at the national level as well as the provincial/territorial level should be considered when assessing the effects of wind turbines on migratory birds. These may include consideration of the following:

- *Canada Wildlife Act*
- *Oceans Act*
- Various provincial/territorial legislation (e.g., *Endangered Species Act*s, *Fish and Wildlife Act*s)
- The Federal Policy on Wetland Conservation
- Migratory Bird Sanctuary regulations
- North American Bird Conservation Initiative (NABCI)
- Important Bird Areas (IBAs)
- Ducks Unlimited Canada projects
- North American Waterfowl Management Plan

3. Existing Information on Bird and Wind Turbine Interactions

3.1 Summary

With a few important exceptions, studies that have been completed to date suggest very low numbers of bird fatalities at wind energy facilities. The observed mortality caused by wind energy facilities is also very low compared to other existing sources of human-caused avian mortality on a per-structure basis. However, these numbers are often based only on found corpses, leading to probable under-recording of the actual number of collisions. Even when collision rates per turbine are low, collision mortality may be considered high, especially in wind farms composed of hundreds or thousands of turbines (Langston and Pullan 2003). Furthermore, even relatively small increases in mortality rates may have an impact on some populations of birds, such as species at risk or large, long-lived species with generally low annual productivity and slow maturity, such as raptors (Langston and Pullan 2003). However, in some situations, disturbance effects may be more significant than collision effects, especially in offshore situations and in natural prairie habitat.

There are several documents available that review known studies and evaluate how wind turbines compare to other sources of bird mortality, such as communication towers and transmission wires [Crockford (1992), Colson and Associates (1995), Gill *et al.* (1996), Erickson *et al.* (2001), Kerlinger (2001), Percival (2001) and Langston and Pullan (2002)]. The American National Wind Coordinating Committee (NWCC) estimates 2.3 birds killed per turbine per year in the U.S. outside of California, correcting for searcher efficiency and scavenging rate, although rates vary from a low of 0.63 birds per turbine per year at an agricultural site in Oregon to a high of 10 birds per turbine per year at a fragmented mountain forest site in Tennessee (NWCC 2004).

Erickson *et al.* (2001) calculate that 33,000 birds are killed each year by wind turbines in the U.S.A., 26,600 of which are killed in California. Although this may seem to be a large number of bird deaths, the impact is relatively small compared to the millions of birds that travel through wind farms each year and the millions of birds that die due to collision with transmission lines, vehicles, buildings and communication towers; for example, it is estimated that a total of 80 million birds are killed on American roads each year (Erickson *et al.* 2001, Erickson *et al.* 2002).

Even though the number of collisions with other structures is currently much greater than at wind farms, this may be partially due to the relative scarcity of windfarms in the landscape (Evans 2004), and on the methodologies used to estimate bird kills in some of the studies. This is suggested by looking at how mortality with other structures is broken down on a per structure basis. For example, using the numbers provided by Erickson *et al.* in their executive summary, it appears that roads result in 9-12 bird-deaths/km/yr, buildings/windows result in 1-10 bird-deaths/structure/yr, and communication towers result in 50-625 bird-deaths/tower/yr. Given currently documented mortality rates of about 2 to 10 birds per turbine per year, the projected impact of turbines in could be in the range of 1-5 million birds per year by 2025 if large numbers of wind turbines become part of the landscape (Evans 2004). Even though wind turbines generally do have lower collision rates than other structures, clearly the relative scarcity of wind turbines on the landscape has an influence on the overall number of birds killed. As wind power becomes more popular and wind farms become more abundant, collision numbers will increase, making proper siting imperative to help reduce or eliminate bird collisions.

There appear to be three main (and often interactive) factors that contribute to avian mortality at a particular site. These three factors, which are described in greater detail through the remainder of this document, include:

1. *Density of birds in the area*. In general, there are more opportunities for birds to collide with turbines when there is an abundance of birds. Indeed, the only way to guarantee no bird deaths is to place turbines where there are no birds, which is virtually impossible. This is not to say, however, that high bird density necessarily translates into greater bird mortality. A direct relationship between the numbers of birds in an area and collision rates has only been documented by one study in Belgium (Everaert 2003).

2. *Landscape features in the area*. Landforms such as ridges, steep slopes and valleys located at wind farm sites may increase the degree of interaction between the turbines and birds using or moving through the area (e.g. Neotropical migrants and raptors), although some debate exists around this point. The presence of other landforms such as peninsulas and shorelines can funnel diurnal bird movement, which may also affect collision rates, although this has yet to be studied. These features can combine with high bird abundance to create high collision risk.

3. *Poor weather conditions*. At many sites, nocturnal migrant collisions tend to occur during episodes of poor weather with low visibility. Although most examples appear to be isolated incidences, weather conditions should be kept in mind if a site is being proposed in an area that has a large number of poor visibility days (<200m) during the spring and fall, and has other confounding factors (e.g. large numbers of nocturnal migrants and landform features such as

ridges present).

Additionally, differences in technology have been thought to contribute to differences in numbers of bird deaths. For example, it is often stated that newer turbines have reduced collision rates, but there is very little information that clearly shows this to be the case. Older turbine technology may increase collision risk due to faster rotation of the turbine blades, but these older turbines are not solely responsible for high bird mortality observed at sites such as Altamont Pass (Anderson *et al.* 2000). More research is necessary in this area before firm conclusions can be drawn, however, since most information concerning the effect of turbine technology on birds is speculative at this time.

3.2 Documented Impacts of Wind Turbines

To serve as background to the issues, a review of the observed **disturbance impacts** and key conclusions relating to documented **collision impacts** of wind turbines on six groups of birds is described below. A more systematic summary of **collision impacts** is also provided in the Appendix. (It should be noted that numbers in the appendix reflect raw numbers of collisions reported and do not include corrections for observer efficiency and scavenging rate).

Although collision rates are the primary focus for research and monitoring in North America, the effects of disturbance may have a greater impact on birds. Unfortunately, this is the least studied aspect of wind farm impacts on birds. The limited available information suggests that some groups of birds appear to be more sensitive to disturbance from wind energy facilities than other bird groups. In particular, seabirds and prairie grouse appear to be readily disturbed by operating wind turbines and deserve particular care in planning wind energy facilities.

Behavioural research on disturbance impacts is seriously lacking for all bird groups, and in many cases there are no studies available. In addition, it should also be noted that many studies appear to show little or no behavioural impact of wind turbines on various bird species. In some cases, this apparent lack of evidence may be an artefact of such things as the type and intensity of monitoring.

3.2.1 Waterbirds

This group of birds includes species that are typical of water habitats, including marine environments, lakes, rivers, and wetlands, but excludes waterfowl and shorebirds, which are discussed separately (Sections 3.2.2 and 3.2.3).

Collision Impacts

Very few waterbird fatalities have been reported at wind energy facilities. Gulls have been identified as being especially vulnerable to mortality due to wind turbines because they often fly within the height of the turbine blade sphere (Airola 1987). Despite their perceived vulnerability, very low numbers of gulls have been reported to collide with turbines, except at three sites in Belgium (Everaert 2003). Additional information on waterbird collision impacts is available in Appendix Tables A6, A7, A12, A13, A15, and A16.

Disturbance Impacts

There is little information available regarding the behavioural effects of turbines on waterbirds, which may interact with wind turbines located offshore, near bodies of water or near staging areas (where birds gather to feed before or during migration).

There is a range of potential adverse effects that may occur at offshore wind farms, including changes in sedimentation patterns and prey species composition (Percival 2001, Merck and Nordheim 1999). In addition, offshore turbines may cause long-term habitat loss as birds are disturbed from using an area. Offshore installations may also act as a barrier to seasonal and local migrations, disconnecting ecological units, such as foraging and roosting sites (Exo *et al.* 2003). These problems have the potential to cause important population-level impacts, but due to the infancy of offshore wind farms, they are still hypothetical. There are some indications that offshore wind facilities may benefit waterbirds in some circumstances. Turbine foundations may act as artificial reefs, and reduced human fishing activity in the area may in some cases increase fish and shellfish (i.e. waterbird prey) availability.

Wind farms could have a greater negative impact on waterbirds when a significant proportion of a local resource is displaced. Potentially sensitive areas may include those close to breeding colonies, and/or linked to distribution of food supply (Percival 2001). Some species feed close to their breeding colonies while others forage over great distances.

In summary, the effect of disturbance from wind turbines on waterbirds has not been a subject of study at most locations, but it may be a legitimate concern at certain sites. More research is needed to examine these potential effects, particularly on nesting herons and other colonial waterbirds. The greatest threat that wind facilities pose to herons is the potential disturbance to nesting colonies, if turbines are located close enough to interfere with their breeding (e.g., Bowman and Siderius 1984).

3.2.2 Waterfowl

The effects of wind turbines on waterfowl (ducks, geese and swans) have been examined at a few wind sites, particularly in Europe. Interactions have been examined in both freshwater and marine environments, studying the effects of wind turbines near staging areas, on migration routes and at offshore sites.

Collision Impacts

The presence of large numbers of waterfowl near wind energy facilities does not necessarily indicate that large numbers of fatalities will occur (Erickson *et al.* 2002). In some cases, seaducks are believed to learn to avoid turbines, resulting in fewer collisions over time (Percival 2001). In terms of dabbling ducks, sites reporting the most fatalities are those with year-round waterfowl use, with waterfowl making up to 10% or more of the total number of fatalities. However, numbers of fatalities are still very small, especially in relation to the number of ducks that use the areas (Erickson *et al.* 2002). Additional information on waterfowl collision impacts is available in Appendix Table A8.

Disturbance Impacts

It appears that disturbance effects are the most important factor to consider when siting wind turbines near significant waterfowl areas. The most comprehensive study of the effect of offshore wind turbines on ducks took place at Tunø Knob in Denmark, where a small, modern, ten-turbine offshore wind site was constructed in an area where large numbers of Common Eider (*Somateria mollissima*) and Black Scoter (*Melanitta nigra*) feed. Studies examining the disturbance effects of these turbines on diving ducks found that the birds exhibited avoidance behaviour, which was accentuated in poor weather conditions (Guillemette *et al.* 1999, Tulp *et al.* 1999). Eiders generally avoided flying or landing within 100 m of the turbines and avoided flying between turbines that were spaced less than 200 m apart, preferring to fly around the outer turbines (Guillemette *et al.* 1998, Guillemette *et al.* 1999, Tulp *et al.* 1999). Apart from this behaviour, no other difference in abundance or in foraging or movement behaviour was detected.

Similar findings are presented by Larsson (1994) for a study at Nogersund in Sweden, and Dirksen *et al.* (1998) for studies conducted at Lely in the Netherlands. At Lely, four 500kW turbines were examined and two diving duck species, Common Pochard (*Aythya ferina*) and Tufted Duck (*A. fuligula*), were tracked at night using radar to determine their flight behaviour around wind turbines (Dirksen *et al.* 1998). Results from this study showed that most birds avoided flying near the turbines, passing around the outer turbines rather than flying between them. Studies in Germany also suggest that lines of turbines may act as barriers to movement for waterfowl and other groups of birds (NABU 2004). Further evidence of this is suggested by the reaction of scoters to the Confederation Bridge in the Northumberland Strait between New Brunswick and Prince Edward Island during spring and fall migration. It was found that birds were very reluctant to approach the bridge and only small numbers of scoters would cross after several failed attempts. Rather than fly under the bridge (where there is ample room to pass) the birds flew very high above it (Hicklin and Bunker-Popma 2003).

The observation of avoidance behaviour is not restricted to studies at offshore wind sites. In the Yukon, a single tower was placed along the edge of the Yukon River valley where very large numbers of waterfowl migrate, including 10% of the world's Trumpeter Swans (*Cygnus buccinator*) (Mossop 1998). No collisions of any species were recorded, but it was observed that birds avoided flying close to the turbine (Mossop 1998). There appear to be very species-specific reactions to wind turbines, with even closely related species showing very different reactions. For example, Pink-footed Geese are reluctant to forage within approximately 100 m of turbines, whereas Barnacle Geese have been found to forage within 25-50 m of turbines (Larsen and Madsen 2000). At Pickering, Ontario, James (2003) observed Canada Geese walking and foraging on the grass near the base of the single large turbine present at the site.

Different species of waterfowl may also react differently to offshore turbines, making it difficult to predict potential impacts upon local populations. However, potential impacts of offshore turbines on waterbirds (Section 3.2.1) apply similarly to waterfowl using this habitat type.

3.2.3 Shorebirds

Collision Impacts
Shorebirds have been the focus of studies in Europe when turbines are located in coastal environments where high numbers and movements of these birds occur. Unfortunately, records of carcass searches done in these studies could not be obtained and mortality in North America is very low (possibly because there are no sites located in shorebird habitat). Information on shorebird collision impacts is available in Appendix Table A14.

Disturbance Impacts
At the Blyth Harbour wind site in the UK, Purple Sandpipers (*Calidris maritima*) overwinter in globally significant numbers (Lowther 2000). Despite this, the sandpipers did not seem disturbed by either the construction process or the operation of wind turbines (Lowther 2000). Studies in the Netherlands (Dirksen *et al.* 1997) and Denmark (Pedersen and Poulsen 1991) examined the effect of

turbines placed near important staging areas for many species of shorebirds, and found that the birds readily avoided the turbines and were at low risk of collision.

Some studies have shown that shorebirds avoid turbines up to 500m away (Winkelman 1995), while others have shown no significant effect of turbines on shorebird distribution (Thomas 1999). It is intuitive that each species will have a different threshold for disturbance, but there may be other reasons for this observed inconsistency. For example, if there is an abundance of suitable habitat near the project site, shorebirds may be more likely to move away from the turbines. If habitat is limited, birds may not have the option of relocating and therefore will remain in close proximity to the turbines (Landscape Design Associates 2000). This may also be true for other bird groups with specific habitat requirements.

Different species of shorebird may also react differently to offshore and near-shore turbines, making it difficult to predict potential impacts upon local populations. Shorebirds will probably be most affected by offshore turbines acting as a barrier to seasonal and local migrations, disconnecting ecological units such as foraging and roosting sites (Exo *et al.* 2003). There is a range of potential adverse effects that may occur at offshore wind farms, including changes in the sedimentation pattern and forage species composition (Percival 2001, Merck and Nordheim 1999). Even if a wind farm is located well offshore, it may possibly have a negative effect upon shorebirds that forage along the shoreline if changes in sedimentation pattern change the composition of mud (or other substrate) along the shore, which could affect availability or abundance of food supply.

3.2.4 Diurnal Raptors

Diurnal raptors found in Canada include eagles, buteos, accipiters, Northern Harrier, Osprey and falcons. Turkey Vultures are also included within this group due to their similarity to many soaring raptors with respect to flight behaviour and habitat use, although taxonomically New World vultures are more closely related to storks.

Collision Impacts

Collision, rather than disturbance, has been the focus of raptor studies at wind farms. Collision impacts are summarized in Appendix Tables A9 and A10. The focus on raptor collision rate at wind farms is due to the high raptor collision rate observed at a small number of wind power sites. Altamont Pass and Tehachapi Pass in California contain thousands of turbines, making them some of the largest in North America. In 1989, the California Energy Commission issued a report that reviewed data on bird collisions with wind turbines in this state between 1984 and 1988 (California Energy Commission 1989). A total of 108 individuals of seven species were found, most of which were raptors protected by both California and U.S. law. Most of the collisions were recorded during winter when large numbers of raptors occupy the area while hunting for mammalian prey.

To address these findings a two-year study was undertaken by BioSystems Analysis Inc. (Orloff and Flannery 1992). Observations and mortality searches were conducted for six seasons examining a sample of approximately 16% of the 7000 turbines at Altamont. Of the 183 dead birds found during this study, 119 (65%) were raptors, the majority of which were Red-tailed Hawks (*Buteo jamaicensis)*, American Kestrels (*Falco sparverius)*, and Golden Eagles (*Aquila chrysaetos)*. In total, approximately 55% of all raptor deaths were attributed to turbine collision, 8% to electrocution, 11% to wire collision, and 26% could not be determined (Orloff and Flannery 1992).

Several factors were proposed as posing the greatest risk to raptors: end-row turbines, turbines within 500m of a canyon and turbines with a lattice-type tower (Orloff and Flannery 1992). High raptor mortality in the Altamont Pass area continues to be seen. Between 1998 and 2000, 256 dead birds were found, 139 (54.3%) of which were raptors (Erickson *et al.* 2002, Hunt 2002).

Another wind energy site that has had significant raptor mortality is in Tarifa, Spain. This site is on the edge of the Strait of Gibraltar and forms a “bottleneck” that concentrates bird migration in the Mediterranean basin. Soaring birds are generally of greatest concern, since at least 30,000 individual raptors and huge numbers of storks pass through the area in the autumn. The raptors and storks that pass through Tarifa comprise a large proportion of the populations that nest in Western Europe and winter in Africa. The most common soaring species that pass through the area include the Honey Buzzard (*Pernis apivorus*), Black Kite (*Milvus migrans*), and White Stork (*Ciconia ciconia*), but many non-soaring species also migrate through the area (Marti 1995).The Tarifa area has been internationally recognised as an “Important Bird Area” by Bird Life International, has been declared a “Special Protection Area” by the European Union and is a Natural Park as designated by the Andalusian government (Marti 1995). There are several wind facilities in the area with a total of 268 older wind turbines in operation (Marti 1995). Some of these facilities are aligned roughly parallel to the main migration direction, but some turbine strings cross the migration pathway at an angle. Thousands of soaring birds land and roost on the ground or promontories in the area, including areas with wind turbines. Many collisions with the turbines have been recorded, including those of 14 protected species. A total of 106 individuals were estimated to have been killed over the span of one year (Marti and Barrios 1995). Almost all recorded deaths occurred on days with high visibility (Marti and Barrios 1995). However, not all studies have reported such high mortality at Tarifa. A subsequent study over 14 months including 2 autumn migration periods recorded over 72 000 birds during 1000 hours of observation. But, only 2 bird carcasses were found, including one Griffon Vulture (of 45 000 seen) and one Short-toed Eagle (*Circaetus gallicus* – of 2500 seen). This indicates that death rates can vary year to year and from area to area (Janss 2000).

The most important factor that influences raptor collision appears to be topography. A good example exists when comparing Tehachapi Pass and the San Gorgonio Pass Wind Resource Areas (WRA). Tehachapi Pass is located in south-central California at elevations of 1000-1600m above sea level. It contains many ridges and slopes and approximately 5,000 turbines of various makes and sizes. San Gorgonio Pass is a narrow, low elevation pass situated 180-850m above sea level in California, containing 3,750 turbines, also of various makes and sizes. At each site, 830 carcass searches occurred over one year and it was found that raptor mortalities were much higher at Tehachapi Pass than at San Gorgonio Pass, suggesting that landform features such as elevation, ridges and slopes are likely very important in determining the amount of raptor mortality in areas where raptors are abundant (Anderson *et al.* 2000).

There have been very few raptor fatalities reported at wind sites other than Altamount and Tarifa. In the U.S. outside of California, raptors comprise only 2.7% of turbine-related deaths (Erickson *et al.* 2001, Kerlinger 2001). It is therefore surprising that at the McBride Lake Windfarm in Alberta Canada, a total of seven Swainson’s Hawks was found to have collided with turbines (6 in 2003 and 1 in 2004; Brown and Hamilton 2004). The birds killed were young-of-the-year or juveniles, suggesting that their inexperience may have contributed to the collisions. The lower number of collisions in the second year indicates that collision rate may vary from year to year (Brown and Hamilton 2004).

The low numbers of fatalities observed at most wind sites is most likely due to improved siting of turbines, away from problem topography and high raptor concentrations. It has been speculated that the construction of tubular (as opposed to lattice-type) towers and slower blade speeds may also have helped to lower raptor fatalities, but studies that have examined mortality levels at different types of turbines have shown no significant difference between technologies (Anderson *et al.* 2000).

Disturbance Impacts
There is no information on how raptor species react behaviourally to turbines.

3.2.5 Owls

Collision Impacts
There is little information on collision impacts for owls; known information is summarized in Appendix Table A19.

Disturbance Impacts
There is no information on how owl species react behaviourally to turbines.

3.2.6 Landbirds

Collision Impacts
Amongst the landbirds, songbirds (passerines) comprise the bird group most commonly affected by wind energy facilities in North America, outside of California. Although disturbance and habitat loss associated with turbine construction are adverse effects, songbird fatalities due to turbine collision have been most often studied. Protected songbirds comprise 78% of all fatalities documented at wind energy sites in the U.S. (Erickson *et al.* 2001). This proportion would be even higher if it included legislatively unprotected species such as the non-native European Starling (*Sturnus vulgaris*) and House Sparrow (*Passer domesticus*). In comparison, raptors comprise only 2.7% of all turbine-related fatalities in the U.S. (Erickson *et al.* 2001). Additional information on shorebird collision impacts is available in Appendix Tables A11, 17, 18, and 20-42.

Grassland bird species with aerial courtship displays such as Horned Lark (*Eremophila alpestris*), Vesper Sparrow (*Pooecetes gramineus*) and Bobolink (*Dolichonyx oryzivorus*) may be particularly at risk from wind turbines. These species are known to fly high enough at times during these displays to potentially collide with turbines and they are frequent collision victims at western wind energy sites where these birds are very common (Kerlinger and Dowdell 2003). At the Nine Canyon wind power project in Washington, Horned Larks comprised 47% (17 individuals) of all collision victims found during 19 searches conducted over a year at each of the 37 1.3-MW turbines and one un-guyed meteorological tower (Erickson *et al.* 2003b). Horned Larks are also the most common fatality at the Stateline wind project, which is located close to the Nine Canyon project (Erickson *et al.* 2003). See Appendix Table A26, A37 and A39 for further examples of known collisions by grassland species. The greater risk to these birds will generally not be a concern in areas where they are common, but this issue should be taken seriously in areas such as British Columbia where the local subspecies of the Horned Lark is listed as endangered under SARA.

Disturbance Impacts
The greatest threat to Neotropical migrant songbirds is habitat loss and destruction. The impact of turbines on forest nesting birds has only been examined once in North America, during a short-term

study at Searsburg, Vermont (Kerlinger 2003b). It was found that disturbance to most birds was low, with several species nesting in the forest within 20-30m of the turbines. A few species were, however, found to avoid the clearing where the turbines were located and some appeared to move further into the forest (notably Swainson's Thrush). It is unclear whether this movement was related to avoidance of the turbines or of the clearing (Kerlinger 2003b). There is a need for further study to determine how wind turbines may affect forest nesting birds.

In general, there is very little detailed information about the effects of wind energy developments on other groups of landbirds, with the exception of grassland species (especially grouse). It has been shown that turbines may displace many (but not all) grassland species. Leddy *et al.* (1999) found that there were fewer nesting grassland birds within 100-200 meters of turbines in southwestern Minnesota. Densities decreased by more than 50% in the area within approximately 50 m of turbines. It remains unknown if nesting grassland birds will become habituated to turbines and return to areas from where they were previously displaced. Not all grassland species are displaced by turbines: at the Ponnequin Wind Energy Facility in Colorado, grassland songbirds like Horned Larks forage directly beneath turbines and Western Meadowlarks were also found to forage directly beneath turbines at Altamont in California (Curry and Kerlinger, LLC studies in progress, cited in Kerlinger 2003b; but see below regarding collision risk associated with species with aerial courtship flights.)

Probably the greatest potential threat that wind facilities pose to game birds is habitat destruction, fragmentation and disturbance of local breeding populations. Of particular concern are threats to prairie grouse (Sage Grouse *Centrocercus urophasianus* and Sharp-tailed Grouse *Tympanuchus phasianellus*). Prairie grouse and other ground-dwelling grassland species have been shown to be very vulnerable to human changes in the landscape, and they are generally known to avoid any elevated structure (e.g., trees, power poles) as raptors (their predators) often use them as perches. It has been shown that Lesser Prairie-Chickens (*T. pallidicinctus*) will not nest or brood within 400m of a road or 300m from power lines, and will also avoid areas that have humans present, such as inhabited dwellings (Manes *et al.* 2002). Due to their strong avoidance of tall structures, prairie grouse could abandon extensive areas around wind turbines despite the presence of otherwise suitable habitat.

Prairie grouse species require large expanses of contiguous suitable habitat, such as short grass, mixed grass and sage brush prairie. Humans have long influenced grasslands and over 90% of the native prairie has been eliminated by agricultural land use (Manes *et al.* 2002). The result is that populations of many grassland species are rapidly declining in North America, which makes remaining habitat very important to the survival of these sensitive species. Much of this remaining suitable habitat is located in remote areas or where topography makes agriculture difficult. However, some of these sites may have suitable wind resources, and there is the potential for wind facilities to be constructed in these healthy and pristine locations. Introducing wind turbines and other structures to these sites can adversely affect already sensitive and vulnerable grassland species.

4. How birds are affected throughout the year

4.1 Breeding Birds

Onshore Facilities

In general, it has been found that birds breeding in the area of wind turbines have lower collision rates than non-residents. In part, this is probably because local birds become familiar with the turbines and know how to avoid them, whereas individuals passing through the area would not have that familiarity, and due to poor weather conditions such as fog, may be unable to detect the turbines before a collision occurs. Most available literature regarding the effects of wind energy on birds deals with numbers of birds killed and reasons for their collisions. However, the greatest impacts that wind energy facilities may have on breeding birds include habitat loss, destruction of active nests, obstruction of regular flight paths, disturbance caused by turbines or human activities around breeding sites, and obstruction of important feeding areas (particularly important for offshore or coastal areas).

Avian productivity (i.e., nesting success) does not appear to be negatively affected at many wind facilities, although it has not been the subject of many studies. At one 66-turbine site, mean productivity of breeding birds was the same as in surrounding areas (Guyonne and Clave 2000). However, reduced breeding bird populations have been noted at a few wind farms where breeding habitat was destroyed by the installation of the turbines, and where people and vehicles were continuously present in the area (Percival *et al.* 1999). It has also been found that grassland birds avoid nesting within 100m to 200m of turbines (Leddy *et al.* 1999). It should be emphasised that results of productivity studies in relation to turbines likely vary a great deal from site to site.

Offshore Facilities

Offshore facilities pose two main threats to breeding birds: disturbance to breeding colonies and changes in food supply and/or access to it. Many seabirds are readily disturbed by human activity near breeding colonies and the presence of wind turbines may cause abandonment of the site. Although there is currently no case study to support this hypothesis (due to the low number of offshore turbine sites), English Nature has recommended that turbines should not be located within 20km of sensitive or important colonies of seabirds (e.g., auks, tubenoses) and should not be within 1km of sensitive or important gull or tern colonies (Percival 2001).

Prey availability is another important factor that must be considered in offshore situations. There is the potential that offshore wind facilities may act as artificial reefs. As a result, availability of fish and shellfish prey may increase at the site due to the change in habitat, and due to reduced fishing activity in the area. Adverse effects may include changes in the sedimentation pattern of the area, and the composition of forage species near the site (Merck and Nordheim 1999, Percival 2001). So far, none of these potentially positive or negative effects have been documented at existing wind farms due to the relative infancy of the offshore industry.

4.2 Birds in Migration

Onshore Facilities

Although long-distance migratory movements can occur in any month of the year, the periods of peak migration in most regions are in spring and fall, with the timing of migration being weakly related to latitude (Richardson 2000). Migration occurs over several weeks, especially in the fall. Different species, and often different age and sex categories of the same species, migrate through the same area over different dates (Richardson 2000). Migration can also occur during the winter; in some years, there may be southward movements that follow unusually cold periods, or food shortages (e.g. owl irruptions; Richardson 2000). In summer, there can also be movements of subadult birds that are too young to reproduce or early movements of failed breeders to staging areas or other places where they will spend the remainder of the summer (Richardson 2000).

The pattern and timing of migration can be highly unpredictable, especially at a fine scale. The broader the spatial and temporal scale (i.e., greater area and longer time-frame), the more predictable migration movements appear. As we scale down to a particular local area on a given day or hour, it is very difficult to predict whether migrants will be present (Mabey 2004). There are several factors that determine the migratory patterns of birds, only some of which are controlled by birds (Mabey 2004). One factor over which birds have no influence is weather, but they can and do respond to it. They also cannot control the geography of the landscape. As birds respond to weather (i.e. warm and cold fronts), their choices of where to stop are constrained by geography (Mabey 2004).

Many collisions reported at wind farms involve migrating birds, as most fatalities are reported during spring and fall migration. For example, Johnson *et al.* (2002) noted that 71% of the 55 carcasses recorded at Buffalo Ridge from 1996 to 1999 were migrants. Sites in different regions differ in the magnitude of bird migration and in the influences on this migration. For example, in western North America there is little evidence that tall human-made structures kill large numbers of night migrating birds (Evans 2003), whereas this is a well documented phenomenon in eastern North America**.** The reason for this regional difference is unclear, although it may be due to lower densities of nocturnal migrants in the west, or differing meteorological conditions leading to different avian behaviour. Whatever the reason, this is an important point that must be considered when comparing mortality studies from sites outside of the area of the proposed wind farm. For example, studies from the western U.S. may have little bearing on how a wind farm in northeastern North America may impact migrating birds (see also Section 6).

Landform features can increase the potential risk to migrating birds. Besides concentrating diurnal migrants, topography can increase the likelihood of bird-turbine interaction. Features that rise abruptly in the landscape, such as high ridges and mountains, can influence bird movement and, if wind farms are sited at high elevations, turbines may end up at a height that enters the altitudinal strata typically used by migrants (although this still needs much study, see Section 6). For example, the turbine blade sphere of 100m towers located on a ridgeline 200m above the surrounding landscape are effectively placed 300m in the air, at an altitude where nocturnal migrants may be flying. Few existing studies are available, but Tennessee Valley Authority (2002), Johnson *et al.* (2002), and Kerns and Kerlinger 2004 provide information for high elevation sites in the eastern U.S.A.

Inclement weather can increase the risk of bird collision with wind farm structures (see Section 5.9). For example, clouds have an influence on the altitude of migrants by forcing higher flying migrants to lower altitudes, which increases the density of migrants near the ground and increases the probability of collisions with tall obstacles. A cloud ceiling that drops to near or below the height of the turbines will affect high altitude migration, inducing migrants to move at or below treetop level (Robbins 2002). Drizzle and fog impair visibility and also cause birds to fly at lower altitudes, to follow topographical clues. Combined with lighting that may attract migrating birds, migrants may collide with turbines, other wind farm structures (including guyed anemometers), or each other, or they may circle the structures until exhausted, falling to the ground where they are at risk of dying due to exposure or predation. If there is a high proportion of fog days during migration at the project site, there may be an increased risk of collision.

Diurnal migrants

Although many birds that migrate mostly at night (e.g., many songbirds) also migrate during the day, there are some groups of birds that are principally diurnal migrants, including raptors, vultures, certain waterbirds (e.g., loons), blackbirds, hummingbirds and jays (e.g., Blue Jays often move in huge, low-flying flocks during the day). The numbers of landbird migrants aloft in the daytime tend to decline in the latter part of the morning and through the afternoon.

Many raptors and vultures use thermals (rising warm air caused by the sun heating the earth, especially in locations lacking tall vegetation) to increase altitude, which facilitates soaring and conserves energy. Depending on the weather and local physical conditions, raptors and other soaring birds may be migrating at any height during the day. The take off of soaring raptors is often delayed until mid-morning when thermal updrafts become stronger. Raptors such as falcons that are less dependent on soaring tend to take off earlier in the day than the soaring species (Richardson 2000).

Diurnal migrants are more constrained by topographical features than are nocturnal migrants. Birds tend to concentrate along linear topographic features such as coastlines, rivers, ridges, valleys, and peninsulas (Richardson 2000). It has been shown that birds will often divert as much as ~45º from their “preferred” course in order to fly along such a “leading line” (Richardson 2000). The greatest concentration of birds often occurs at these features when there is a crosswind relative to that feature (Richardson 2000).

Nocturnal Migrants

Many songbirds migrate at night, particularly Neotropical migrants. There are three main (and often interrelated) reasons that these migrants collide with wind turbines and other structures, including: height of the structure (both the actual turbine height and the height of the landform it is located on), lighting, and weather. Lighting is a very important factor in collision risk and will be dealt with in section 5.3. The incidence of poor weather makes the effect of lighting greater and it also lowers the flight height of migrants so that greater numbers are flying at turbine height (see Section 5.9).

Birds tend to fly in broad fronts over water and land, although individual species may concentrate in particular migration corridors even when the overall migration (all species combined) is on a broad front (Evans 2000). The flight heights of nocturnal migrants is quite variable and not well understood. The following is a summary of selected available research. Able (1999) stated that most night-migrating songbirds are usually below 600 m when flying over land. However, depending on wind direction, they can fly much higher or lower. Kerlinger (2003) believes that nocturnal migrants fly 92 to 615 m, although only a small percentage of them passing over a wind power site with large (100 m) turbines will fly within the altitude range of the turbine rotors. Cooper (2004) conducted a study at a West Virginia energy site in Fall 2003 (45 nights, 6-9 hrs/night). He used mobile radar labs set up at five locations. He found that 16% of migrants flew at or below turbine height (<125 m) and that most passed at 250 – 750m. Richardson (2000) has spent about 15 years conducting radar and visual studies of bird migration by day and night. He believes that most nocturnal migrants fly well above turbine height (50-1000 m above ground and sometimes higher). However, migration altitudes are affected by weather; migrating birds tend to move lower when heading into opposing winds than when flying with tail-winds. Therefore, numbers of migrating birds flying at low altitudes (turbine height) may be as high or higher when winds are opposing as when they are following, even though total number of birds aloft are much reduced with opposing winds.

Large topographical features (e.g., mountains and high ridges) may concentrate birds along relatively narrow pathways, and the altitudes of migrants tends to be lower than usual when birds are crossing a ridge or pass, either by night or day, putting them in the height range of wind turbines (Richardson 2000, Evans 2000,Williams et al. 2001). This behaviour, however, is not well understood, and there is some debate about it. During the day, most nocturnal migrants tend to stay within 20-30m of the ground (within or near vegetation) to avoid predation and to rest and feed. Many nocturnal migrants will continue to migrate for at least part of the day, but will do so at these lower altitudes. On a typical day during migration, birds move between higher and lower altitudes at dawn and dusk, and it is during these times that birds may be at risk of colliding with wind farm structures (Richardson 2000, Langston and Pullan 2002).

At or just before daybreak, nocturnal migrants drop rapidly from higher altitudes (>200m) and fly at or above treetop level (<200 m) until they find a suitable location for landing, which would depend on the conditions and the requirements of the individual birds (Kerlinger 1995).

Staging areas

When birds migrating over land or water encounter a coastline, they often turn along that coastline and form a concentrated stream of migration along the coast. Some types of migrants (e.g. shorebirds and waterfowl) concentrate in restricted areas of suitable habitat while resting and feeding between migratory flights. These are often interior lakes or marshes, coastal estuaries, mud flats, or other areas that can provide food and/or shelter for large numbers of birds (Richardson 2000). Once a bird makes the decision to stop, migrants are constrained by the availability (or lack of availability) of habitat and resources within the local landscape (Mabey 2004). Stopover sites are not necessarily large expanses of high quality habitat, such as pristine mudflats where thousands or millions of birds congregate; they can also include marginal habitat where nothing else is available. For example, large numbers of birds may be forced to stop under emergency conditions. This generally occurs near an ecological barrier such as the Great Lakes where birds may become highly concentrated during bad weather (Mabey 2004). Birds are also often forced to use poorer quality stopover sites within a patchy, ecologically unsuitable habitat matrix (Mabey 2004).

At staging areas, flights of large numbers of migrants are often concentrated into corridors when the birds are either taking off or approaching to land (Richardson 2000). The flight height of these migrants is often at the height of wind turbines and the distance from the stopover area within which flight altitudes will be low enough to be at risk of collisions with turbines will depend on the type of bird and other factors. Some birds, like swans, typically climb only very gradually, and may remain low for a considerable distance after takeoff from the stopover area. Other birds climb (or descend) more rapidly (Richardson 2000).

Collision with wind farm structures is not the only potential effect on migrating birds. Disturbance can be a factor for migrants if wind turbines are located near important staging areas, where large numbers of birds concentrate to rest or feed (e.g., beaches in the Upper Bay of Fundy in Nova Scotia and New Brunswick, where hundreds of thousands of Semipalmated Sandpipers *Calidris pusilla* stage during fall migration). Additionally, the alteration or destruction of habitat used by birds on migration can also contribute to adverse environmental effects (see Milko 1998a).

Offshore Facilities
As with many locations on land, nocturnal migrants are not likely to be significantly affected by wind turbines located offshore. Migrant landbirds typically fly higher over water than over land (generally between 300m and 1,200m above the surface), and only drop altitude in poor weather or when they are descending from their night flights (Kerlinger 1995). If at daybreak migrants find themselves still over water, they will orient themselves to the closest land, remaining high in altitude or climbing higher until they are closer to shore. Sites located within 1km of land, especially landforms that concentrate migrants during post-dawn movements, may pose a greater collision risk than facilities further offshore (Percival 2001).

Migrating waterfowl and other waterbirds generally show the opposite tendency to landbirds, flying lower over water (generally 30-60m) than over land (300-1,800m) (Kerlinger 1995), putting them at risk of collision with turbine blades. There are no current studies that have indicated that waterfowl and seabirds will collide with turbines, but there is very little information on the effects of offshore wind turbines, and it is extremely difficult to collect data on bird collisions in the offshore environment.

Disrupting important flight paths may be a more important issue than collision risk in the offshore environment. Turbines may create a barrier to movement, especially between landforms, which could cause deleterious energy losses due to stress or to the extra travel needed to fly around the barrier. Scoters have had this reaction to the Confederation Bridge in the Northumberland Strait between New Brunswick and Prince Edward Island during spring and fall migration. It was found that birds were very reluctant to approach the bridge and only small numbers of scoters would cross after several failed attempts. Rather than fly under the bridge (where there is ample room to pass) the birds flew very high above it (Hicklin and Bunker-Popma 2003).

4.3 Wintering Birds

Onshore Facilities
During the winter, bird numbers and movement are generally reduced. Simply by having fewer birds using an area, the number of collisions should be minimal at land-based sites. However, physical or biological features, such as localised habitat and/or food supplies, may act to concentrate birds such as waterfowl, raptors and owls.

Offshore Facilities
Offshore and near shore wind facilities are more likely to pose problems for wintering birds. For example, in ice-free areas, large concentrations of wintering ducks and seabirds may be found during winter months. In particular, disturbance and interference with local prey species have the potential to be significant adverse effects to wintering birds.

5. Factors that may contribute to Avian Impact

Below are descriptions of several key aspects of wind energy developments or their associated sites that have the potential to cause adverse environmental effects. This list is not exhaustive, but provides an indication of some of the factors that may contribute to environmental effects on wintering, breeding and migrating birds.

5.1 Scale of Facility

Onshore Facilities

The scale of the facility can impact the amount of bird mortality and disturbance. Simply put, under comparable conditions, a large facility has the potential to affect more birds than a small one. Table 1 presents information on the number of carcasses reported at a number of wind farms in the U.S., in relation to the number of turbines sampled. The table includes both older facilities (e.g., Altamont Pass) and newer facilities, and is ordered from few turbines surveyed up to many turbines surveyed. The total wind farm size is not presented in the table as mortality is unknown at turbines not sampled and extrapolation is avoided. What the table shows is that, in general, more sampled turbines equate to more observed fatalities. This can then be used to see that more dead birds will be found at a site as the number of turbines (or number sampled) increases. Numbers of carcasses were not corrected for searcher efficiency or carcass removal (via scavenging or any other means), but the data show that there is a trend for more turbines to kill more birds in a year even if numbers are underestimated. This does not necessarily mean that more turbines kill *disproportionately* more birds per year, on a per turbine basis, but it does show simply that more turbines will result in more avian collisions and more bird deaths.

A small properly sited wind farm is not likely to kill a large number of birds. If one takes the estimated average number of birds killed per turbine per year in the United States, as reported by the National Wind Coordinating Committee (NWCC 2004), a ten-turbine facility may be expected to kill approximately 23 birds per year if the average is extrapolated. Table 1 shows that many wind farms where up to 30 turbines were sampled report fewer casualties than this. Nevertheless, considered in isolation, it is unlikely that small numbers of fatalities per year at a wind farm each year would be considered significant, unless some of those fatalities were of species at risk. However, a larger facility with more than 100 turbines may kill many more birds, approaching or exceeding levels that could affect the broader population (especially when vulnerable species are impacted). The number and siting opportunities of existing and future wind farms in an area is a factor that will affect the overall risk to birds. It would, for example, be better to have one very large wind farm in one well-sited location instead of many small poorly-sited farms. As such, it is important to consider both the average effect of each turbine and the cumulative effect of the total number of turbines in the area. The total should include existing and proposed turbines associated with other projects within the same area.

As the size of the facility increases, the potential for adverse effects other than fatalities also increases. Larger facilities may cause more bird habitat to be lost or disturbed, and foraging and breeding birds may more readily avoid the area.

Table 1 Number of bird carcasses found at different sizes of wind farms in the United States.

Wind Farm Site	Number of turbines sampled	Number of carcasses found (#/yr)	Reference
Sandusky, OH	1	2	Gauthreaux 1994
IDWGP, IA	3	0	Demastes and Trainer 2000
Buffalo Mountain, TN	3	12	Nicholson 2001
Somerset Co., PA	8	0	Erickson *et al.* 2002
Green Mountain, VT	11	0	Kerlinger 2000
Klondike, OR	16	8	Johnson *et al.* 2003
Buffalo Ridge Phase 1, MN	21	3.5	Johnson *et al.* 2000
Ponnequin, CO	29	4.5	Kerlinger and Curry 2000

Buffalo Ridge Phase 3, MN	30	28.6	Johnson *et al.* 2000
"Wisconsin", WI	31	8.4	Erickson *et al.* 2002
Foote Creek Rim Phase 2&3, WY	36	9.3	Young *et al.* 2003
Vansycle Ridge, OR	38	12	Erickson *et al.* 2000
Buffalo Ridge Phase 2, MN	40	12.9	Johnson *et al.* 2000
Buffalo Ridge Phase 1, MN	50	7.1	Osborn *et al.* 2000
Foote Creek Rim Phase 1, WY	69	47.5	Young *et al.* 2001
Montezuma Hills, CA	76	14.4	Howell 1997
Stateline, OR/WA	125	10	WEST & Northwest Wildlife Consultants 2002
Altamont Pass, CA	150	10	Howell *et al.* 1991
Altamont Pass, CA	165	42.4	Howell 1997
Montezuma Hills, CA	237	10.5	Howell and Noone 1992
Altamont Pass, CA	359	42	Howell and DiDonato 1991
San Gorgonio, CA	360	35	Erickson *et al.* 2002
Altamont Pass, CA	785	284.4	Erickson *et al.* 2002
Altamont Pass, CA	1169	91	Orloff and Flannery 1992
Note: Largely based on data presented by Erickson *et al*. (2002). Data are not corrected for searcher efficiency, scavenging.			

Offshore Facilities

Currently, there is no information available regarding how size of offshore wind energy facilities affects bird collisions and disturbance.

5.2 Tower Dimensions and Turbine Design

Onshore Facilities

As the industry has grown and technology has advanced, rotor diameters, generator ratings and tower heights have all increased. During the 1980s, small turbine towers were being installed, with few exceeding 18m in height. Today, the average commercial turbine tower height is 30-50m, with some towers twice as high. Large modern turbines can have a rotor sweep area three times greater than older, smaller models, but it seems that they result in similar numbers of casualties (Howell 1995). This means that if one larger turbine replaces three smaller ones, avian mortality per wattage may be reduced by two-thirds (Erickson *et al.* 1999).

Size may become an issue for migrating birds if turbines become much taller. Currently, the tallest turbines in Canada (Vestas V80-1.8MW) are approximately 120m in height, from the ground to the upper tip of the blade sweep. Towers higher than this have the potential to interact more frequently with migratory birds. Generally, objects less than 150m in height appear to pose less of a threat to nocturnal migrants (see Section 3.6), but taller objects can cause mass bird kills, as found at communication towers and skyscrapers.

Wind turbines can be mounted on either lattice or tubular steel towers. Taller towers allow the turbines to intercept wind that is more consistent and less turbulent. Because of their weight and resistance to wind, tubular towers are anchored to concrete foundations 5-10m deep, while lattice towers usually require three or four piers instead of a massive concrete pad. Depending on how close the bedrock is to the surface, both types of towers can also be bolted directly to the bedrock, eliminating the need for concrete pads. It is generally believed that lattice-type towers encourage raptor perching, which may increase the number killed (although this remains unproven).

Smaller turbines are often used in more remote areas. The technology of these turbines is quite variable, and the electricity needs for each settlement or field station also varies considerably. These turbines can have tubular or lattice towers and often range between 18m to 40m in height. They also tend to be variable speed turbines with quickly turning blades (10-50 rpm, but can be as high as 310 rpm (e.g., 10 kW Bergy turbine). Typically, the use of turbines to supplement diesel power in remote areas would be on a small scale and the effect upon birds is likely to be small when sited correctly. However, birds that use aerial flight displays may be at particular risk from such smaller turbines, as the blades are more likely to be at the height that displays are performed.

Offshore Facilities

There is no information currently available examining the different turbine technologies in offshore situations. The size of turbines used in new offshore developments is likely to be larger than those used onshore, however, potentially approaching 200m above sea level by 2010 (projected for a 10 MW machine; OPET 2002).

5.3 Turbine Lighting

Onshore Facilities

Turbines need to be lit according to Transport Canada guidelines. Lighting is required only for those structures that are over 150m total height (which currently excludes all turbines). For structures between 90 and 150m, a Transport Canada assessment is required to determine lighting requirements, and for structures below 90m, lighting is only required if they fall within a certain "airport obstacle limitation surface". Transport Canada regulations also allow for the Transportation Minister to individually assess any structure and modify lighting requirements as needed (see Transport Canada's website, Section 2.2 Obstructions Requiring Marking and/or Lighting).

For turbines requiring lighting based on the above guidelines, Transport Canada requires red flashing beacons, but medium intensity white flashing obstruction lighting systems may be used instead of red obstruction lighting. However, for structures less than 60m, an aeronautical evaluation is required to determine if the substitution of white lights will interfere with motorists, landing airplanes, etc. The U.S. Fish and Wildlife Service recommends that only flashing white lights should be used on towers at night, and that these should be the minimum number, have the minimum intensity, and have the minimum number of flashes per minute (i.e., longest duration between flashes) allowable. Solid red or flashing red lights should be avoided as they appear to attract nocturnal migrants more than white flashing lights (U.S. Fish and Wildlife Service 2003). These lights also appear to disrupt night-migrating birds (causing circling or hovering behaviour) at a much higher rate than white flashing lights (Gauthreaux and Belser 1999, Gauthreaux 2000).

There is currently little information on the risk posed by turbine lighting to migratory birds. Most information regarding tower lighting refers to communications towers, which are generally much taller than turbines and often have guy wires. These structures are also much more likely to be lit with steady burning lights (especially sodium vapour lights) which appear to be much more attractive to birds (Kerlinger 2004). In addition, almost all collision events at communication towers appear to be at towers over 500 feet (152 m) and with guy wires, acting like "large bird nets in the sky" (Kerlinger 2004). Wind turbines, on the other hand, are not yet higher than 120 m (see Section 5.2), are lit primarily with red flashing lights, and are almost always un-guyed. As a result, they do not kill as many birds. See Section 5.3.1 for more information on the impact of communication tower lighting on birds.

Wind farms should avoid the use of steady burning lights, such as sodium vapour lamps, on any structures, including substations. A relatively large fatality event was detected at a wind farm in Mountaineer, WV, but fatalities were clustered around the turbine closest to a substation, as well as around the substation, that was lit with sodium vapour lamps. Severe fog the same night may have contributed to the fatalities (Kerns and Kerlinger 2004; and see below).

5.3.1 A review of information on bird collisions related to lighting

Large scale collisions of birds (thousands of individuals in one night) have been recorded at many communication towers in Eastern North America. There are three main differences between communication towers and wind turbines, as noted above. Communication towers are generally much taller than turbines, they have more lights (or different types than those used on turbines) and most (especially the tallest structures) have guy wires. Despite these differences, it is important that this document review bird collisions with communication towers in order to emphasize features to avoid in wind turbines.

In the U.S., mass mortality of birds has occurred at some communication towers, the cause of which is generally believed to be lighting. For example, an estimated 30,000 birds of 56 species were killed at the Eau Claire, Wisconsin, tower on the nights of 18 and 19 September 1963 (Kemper 1964). Less drastic but just as concerning, over 2,808 individuals of 91 species were killed in four major mortality events at a 439m KTKA-TV tower in Shawnee County, Kansas; 919 individuals on 25-26 September 1985; 635 individuals, 30 September-1 October 1986; 834 individuals 11-12 October 1986; and, 420 individuals 8-9 October 1994 (Ball *et al.* 1995). Although mass kills appear to be exceptional, smaller numbers of deaths are frequent at communication towers, and cumulative numbers of mortalities are often substantial. For example, an average of 1,517 birds per year were killed over a 29-year period from 1955 to 1983 at a single television tower in Tallahassee, Florida, with most fatalities occurring in the spring (20%) and fall (65%) (Crawford and Engstrom 2001). On days during which at least one bird was killed, the median number of birds killed was 3 and the mean was 12.3 (Crawford and Engstrom 2001). Only 0.1% of the days studied had kills of more than 500 birds (Crawford and Engstrom 2001). Birds that are most often affected are songbirds, including warblers, vireos, thrushes and sparrows (Case *et al.* 1965, Caldwell and Wallace 1966, Crawford and Engstrom 2001).

A few multiple bird collision events have occurred at wind farms, although none have yet come close to the numbers killed at communication towers. The largest in North America was 27 birds at the Mountaineer site in West Virginia on a foggy night in late May 2003. The birds were found at three turbines and a brightly lit substation. It appears that the sodium vapour lights at the substation attracted the migrants and was the main cause of the collisions, as there were many other turbines that were lit with red strobe lights (12 of a total of 44 turbines at the site) and no fatalities were found at these turbines, only the ones adjacent to the substation (Kerlinger 2003). It should be noted that, although there was only one multiple collision event, a total of an additional 28 night migrants were found during the year (a total of 65 fatalities of 21 species). When corrected for searcher efficiency and scavenging, a total of 180 birds were killed a year at 44 turbines (4 birds/turbine/year; Kerlinger 2003), which is a high number for a wind farm. It was also found that no subsequent multiple fatalities occurred once the substation light was turned off (Kerlinger 2003).

Although nocturnal migration typically occurs at heights above most wind farm structures and even above many communication towers, collisions still occur with structures less than 100m in height (see Avery *et al.* 1980 for a review). On October 7, 1954 about 1000 birds (22 species) were found on a parking lot at Oak Ridge, Tennessee (Dunbar 1954). Birds had collided with overhead power lines, light towers, cars, and pavement, with most carcasses found beneath the parking lot lights (Dunbar 1954). Lights also appeared to be a factor in the collision of 144 birds (30 species) with a brightly lit ski lift in Gatlinburg between September 21 and 22, 1963 (Savage 1963). However, lights are not always a factor in mass kills at low structures. For example, Wylie (1977) found 73 dead birds of 21 species at a fire tower in West Virginia, following a night of fog and rain. The 30m Sand Springs Fire Tower sits atop Chestnut Ridge, approximately 800m in elevation. The tower is not lit and no lights occur anywhere in that part of the Cooper's Rock State Forest, in which it is located. In this example, inclement weather and siting on a ridge at a high elevation contributed to the risk of collision even with an unlit and relatively short structure.

Cochran and Graber (1958) were the first to experimentally show that birds are attracted to the red warning lights of towers. Their counts of avian flight calls on two nights at a 303m tower near Champaign, Illinois indicated that migrants were concentrated near the structure. Turning off the red warning lights on the tower eliminated this gathering of birds. Several hypotheses have been proposed to explain why birds are attracted to the lights. One suggests that migrants perceive the red tower lights as stars, and subsequently attempt to maintain a constant bearing with respect to them. As a result, they spiral closer to the structure and eventually strike the guy wires (Kemper 1964).

It is believed that the number of birds killed on any given night is dependent on local weather conditions and the number of birds aloft, with mass fatalities usually occurring during poor weather conditions such as fog, low cloud cover (Seets and Bohlen 1977), and precipitation (Case *et al.* 1965, Seets and Bohlen 1977, Elkins 1988). The refraction and reflection of the emitted light by water droplets in the air increase the "sphere of illumination" and ultimately confuse the migrant songbirds (Elkins 1988). Another hypothesis suggests that birds become spatially disoriented by refracted and reflected light from aircraft warning lights on tall towers during rainy, misty weather because of the loss of true visual cues to the horizontal (Herbert 1970). Yet another hypothesis suggests that birds become confused by tall, lighted structures when, under overcast conditions, birds are deprived of celestial cues and lose their ability to orient (Jaroslow 1979). Research delving into the causes and mechanisms of light attraction is in relative infancy. While there are many published reports of this phenomenon, none provide conclusive data to support a hypothesis of cause.

Offshore Facilities

There is little information available on how lighting affects birds offshore, but it is well known that light from oil and gas platforms and large ships attracts seabirds and migrants. This is especially important when visibility is poor, as it can cause thousands of migrating birds to circle for long periods of time around brightly-lit objects. The circling birds waste a lot of precious energy, which sometimes leads to premature death (Wahl and Heinemann 1979, Bakker 2001, Wiese *et al*. 2001).

The lighting required offshore will generally be site-specific and dependent upon the size of the project, determined by an evaluation of the Canadian Coast Guard, and an Aeronautical Evaluation by Transport Canada. Sections 8 and 9 of the Navigable Water Works regulations will most likely apply to warn boaters of the turbines. These regulations state that installed lights are to be white with a quick flash of 60 flashes per minute, be visible for at least 12.8km and installed no less than 6m above the water. A sounding device is also required. It should emit a sound in two second intervals (with an 18-second pause during every period of 20 seconds), that can be heard 3.2km away whenever visibility is less than 8km. The effects that these requirements may have upon birds are unknown.

5.4 Blade Speed

There are several reasons why birds may collide with wind turbines, with one of the most important and obvious being that they are unable to detect the spinning blades. Two main hypotheses are used to explain this difficulty, applying principally to raptors (Hodos *et al.* 2001, Hodos 2003): 1) motion smear (the degradation of visibility of rapidly moving objects); and 2) the inability of the birds to divide their attention between hunting and monitoring the horizon for obstacles. With regards to the latter, it seems unlikely that hunting raptors cannot focus both on the ground and on the horizon, as their eyes have two foveal regions, one for frontal vision and one for looking down (Hodos *et al.* 2001, Hodos 2003). Motion smear, therefore, is likely to be the main reason raptors (and perhaps other birds) cannot see the blades of turbines during days of good visibility (Hodos *et al.* 2001, Hodos 2003, McIsaac 2001). Motion smear is more pronounced near the tips of the blades where velocity is greater (Hodos *et al.* 2001, Hodos 2003).

To date, most of the studies of the effects of turbine blades on bird mortality have been based on older, variable-speed turbines. This kind of turbine can have very high blade speeds with the blades moving at 60+ revolutions per minute (rpm) (e.g., 10 kW Bergy up to 310 rpm), making motion smear an important issue. Fortunately, wind turbine technology has improved significantly, and new turbines rotate with a much slower speed of 15-30 revolutions per minute (rpm). Although the tips of the blades are still moving very fast (up to 250 km/h), the blades are more visible to birds, lessening the potential risk of collision. Nonetheless, there are no currently available studies that have examined the effect of slower blade rpm on birds. Studies have examined whether painting blades with various coloured paint in different patterns reduces motion smear to birds. To date no conclusions have been made and due to aesthetic and cost reasons, painting probably will not be a real solution to this problem.

During the night, movement of the blades is not believed to affect collision risk. It appears that most collisions would occur regardless of whether or not the turbine is in operation. For example, a migrant Wood Thrush (*Hylocichla mustelina*) collided with the Pickering Vestas V80 turbine one night when it was not in operation, and a Philadelphia Vireo (*Vireo philadelphicus*) collided with the same turbine on another night when it was suspected that the turbine was not in operation (James 2003). Another example occurred in Nasudden, Sweden, where 43 birds were found dead near one turbine during very poor weather conditions. The turbine was not operational at the time, but it was lit with a single lamp 10m above the ground (Gill *et al.* 1996). This is also supported by large collision events that have occurred at towers and structures that lack moving rotors (see Section 3.2.6). Regardless, all new wind energy developments should ensure that blade revolutions per minute are minimised to avoid motion smear to help increase visibility during the day.

5.5 Mortality Caused by Wires

Onshore Facilities

Since the late 1800s, high-tension lines have been noted as a cause of avian mortality in North America. The U.S. Fish and Wildlife Service (Manville 2000) estimates that there are tens of thousands of bird fatalities a year due to collision with overhead wires. However, this estimate may be too low if a study by Koops (1987) in the Netherlands is applicable to the North American situation. Based on estimates of Koops (1987), approximately 174 million birds could be killed annually by transmission wires in the U.S.

Many studies have examined the problem of birds colliding with power lines and other overhead wires but, unfortunately, very few of these are quantitative. Several groups of birds appear to be the most susceptible to collision with wires, most notably waterfowl, shorebirds and raptors (Stout and Cornwell 1976, Curtis 1977, Anderson 1978, Enderson and Kirven 1979, NUS Corporation 1979, Olsen and Olsen 1980, Moorehead and Epstein 1985, Faanes 1987). Raptors are frequent victims of wire collisions (Enderson and Kirven 1979, Olsen and Olsen 1980). For example, overhead wires are believed to be one of the main causes of injury and death to Merlins (*Falco columbarius*) in Great Britain (Olsen and Olsen 1980). Waterfowl and shorebirds may show avoidance behaviour to turbines, but significant numbers have been known to collide with associated power lines, especially when located near wetlands (Anderson 1978, NUS Corporation 1979, Moorehead and Epstein 1985). At a power plant in Illinois, an estimated 400 birds each autumn (0.4% of the peak number present) were killed by colliding with overhead power lines; most of the known victims were Blue-winged Teal (*Anas discors*; Anderson 1978). Powerline strikes are the cause of up to 64% of collision fatalities for certain waterfowl species, but wires also take a toll on shorebirds. At Trinidad, California, more than 150 Red-necked Phalaropes (*Phalaropus lobatus*) were killed on 6 May 1969 by striking electric wires along the coast (Gerstenberg 1972).

Reducing the amount of aboveground wire at wind energy projects will reduce the potential risk of collision to birds in the area. However, placing cables underground may be impractical where bedrock is at or near the surface, in the arctic where permafrost is present, and in other areas where there is not sufficient soil to permit burial. In areas where the risk of bird collision is low, and where sensitive habitat exists, the placement of wires underground may cause more damage to local bird populations through habitat destruction than overhead wires would cause through collisions.

Offshore Facilities

Although there is currently no information about how overhead transmission wires would affect birds in offshore situations, these wires would probably pose a significant collision risk. Most proponents, however, would likely prefer to lay the cable along the sea/lake floor bed where conditions permit for many other reasons.

5.6 Facility Configuration

Onshore Facilities

The configuration of turbines at onshore facilities is most often dictated by the wind resource, and thus far, no one has examined how overall wind farm configuration may affect birds. Generally, spacing between turbines should be greater than 200m in order to avoid inhibiting movement (Percival 2001). This recommended distance is often the amount of spacing required by industry to reduce wake effects of large turbines on neighbouring turbines.

Offshore Facilities

The least intrusive configuration of turbines within an offshore site is open to debate. There are many possible turbine configurations, and each likely has its advantages and disadvantages. For example, long strings of turbines may act as a flight barrier to birds. However, spacing the turbines out widely in an attempt to reduce the likelihood of blocking bird movement may potentially increase the area from which the birds will be displaced by disturbance. Is it better to situate turbines closely together in groups to minimise the area affected? It has been suggested that some species are more disturbed by clusters of turbines than strings, but clusters may have an advantage as mortality could subsequently be reduced (Percival 2001). For large projects, a possible solution is to allow wide corridors between clusters of closely spaced turbines (Langston and Pullan 2003).

5.7 Facility Construction

Onshore Facilities

The amount of time it takes to build a wind energy facility is dependent upon several factors, including the scale of the project, the terrain, and climate. However, construction typically is completed within nine to 18 months (or less). Due to the time needed to construct a facility, it is likely that some construction will occur during the bird breeding season; however, the high degree of disturbance normally associated with construction is temporary.

Construction usually begins by laying out the roads to the turbine locations, and grading them with heavy equipment. Once the roads are completed, the concrete foundations for the towers are excavated and poured. This work is typically followed by digging trenches and laying underground electrical cables where soil conditions allow. Substations and any other buildings (e.g., maintenance buildings) are erected and finally the wind turbines are assembled and tested. The actual erection of a turbine usually takes one day.

As most wind facilities are almost completely automated, human disturbance at a site is minimal once construction is completed, with only a few onsite personnel required on an occasional basis. Some wind energy facilities are being promoted as ‘tourist’ sites, however, which may result in substantial human disturbance.

Offshore Facilities

In offshore situations, disturbance associated with construction has the potential for significant impacts. For example, noise is created when pilings are being drilled/driven, which may upset local birds and disturb prey fish populations. There is also the potential that hazardous materials such as oil will be spilled from the equipment used to install the turbines. Moulting seabirds, particularly loons and scoters, are very sensitive to disturbance. To help minimise disturbance, it was suggested that cable-laying for the Horns Rev wind farm be done outside of this important moult period (Langston and Pullan 2003).

5.8 Facility Operations and Maintenance

Turbines are generally automated which reduces the amount of time humans need to be present at a site, thus lessening the amount of disturbance to birds in the area. Wind energy, although considered ‘clean and green’, does produce waste materials during all phases of a facility’s life cycle (construction, operation and decommissioning). Potential pollutants include various lubricants such as gearbox oils, hydraulic fluids and insulating fluids that are used in the turbines. The amount of these fluids is dependent upon the different models of turbine used, but is generally less than 250 litres. These materials pose little threat to birds if they are handled appropriately. Aside from spills during routine maintenance procedures, contamination can also occur if the turbines are not regularly inspected to minimise fluid leaks.

As with the construction of a facility, the activities associated with decommissioning of turbines could disturb birds at the site. Decommissioning creates a great deal of waste as all of the turbines must be dismantled, any aboveground wires removed (underground wires should be left in place) and any other equipment and waste removed from the site and disposed of appropriately.

5.9 Meteorological Considerations

In Canada, weather changes from day to day as High and Low pressure systems move across the country, generally from west to east. At temperate latitudes, numbers of birds aloft often vary 10-fold or even 100-fold from one day or night to the next, depending largely on weather (Richardson 2000). An individual bird may migrate several hundred kilometers on a day or night with favorable weather, and then may not migrate for several days in poor weather (Richardson 2000). Each species differs, but migrant numbers appear to be greater at times with or following light winds than when winds are strongly opposing. This allows birds to travel a given distance more quickly and with less energy expenditure than would be necessary to cover the same distance while flying into a headwind (Richardson 2000). In the Northern Hemisphere, winds blow clockwise around areas of high pressure and counterclockwise around areas of low pressure. Therefore, southerly winds are very likely when there is a High to the east and/or a Low to the west. In spring, those are the weather conditions during which the largest numbers of birds migrate. However, in the fall, northerly winds are very likely when there is a Low to the east and/or a High to the west, and it is under these conditions when peak numbers of autumn migrants tend to fly (Richardson 2000). Other weather variables such as temperature, humidity and pressure react closely together, and it is not well established which specific variables are the ones which cue birds to migrate versus remain on the ground (Richardson 2000).

Many studies have shown that certain weather conditions (e.g. reduced visibility) increase the occurrence of collisions with human-built structures, especially communication towers (Case *et al.* 1965, Seets and Bohlen 1977, Elkins 1988; see Section 5.3.1). Even in poor weather conditions, however, it is worth noting that there have been very few multiple-bird kills reported at wind energy sites. The most collisions reported in North America on a single night was 27 birds at the Mountaineer site in West Virginia on a foggy night in late May 2003. The dead birds were found at three turbines and a brightly lit substation (Kerlinger 2003; see Section 5.3.1).When collisions occur at wind farms, the majority have involved single birds. Another large mortality event at a North American wind farm was a total of 14 birds found at two adjacent turbines, which occurred during a severe thunderstorm (Erickson *et al.* 2001, Johnson *et al.* 2002).

Another example of a multiple bird collision event at a wind farm also occurred during a period of inclement weather during spring migration. A combined total of 14 birds collided with two unlit wind turbines at Buffalo Ridge, Minnesota, on the night of May 16/17, 1999 (Johnson *et al.* 2002). Elsewhere, an estimated total of 170 birds were killed at 18 wind turbines at Oosterbierum, Netherlands, during seven consecutive nights in the fall of 1988 (Winkelman 1995). A third example of multiple bird kills occurred at a wind turbine in Nasudden, Sweden, where 43 birds were found dead near one turbine during very poor weather conditions; the turbine was not operational at the time, but was lit with a single lamp 10m above the ground (Gill *et al.* 1996). Overall, mortality events of this magnitude are seldom recorded and continue to be a rare phenomenon, but can occur during periods of poor weather.

The behaviour of migrating birds was examined at a 366m communication tower in North Dakota during various weather conditions (Avery *et al.* 1977). Most losses in the autumn occurred during nights of reduced visibility as migrants circled the tower, while most spring mortalities occurred on clear nights as birds struck guy wires (Avery *et al.* 1977). Taxonomic groups also showed differences in mortality: rails and finches were killed mostly on clear nights, while warblers died in greater numbers on overcast nights (Avery *et al.* 1977).

Interestingly, moon phase may play as important a role as weather in collision risk. A study of bird collisions with towers in the USA was compared with a study of bird kills at a Dutch lighthouse; the distribution of bird kills was non-uniform, with a significant clustering of kills around the new moon. No kills occurred during the full moon (Verheijen 1981).

5.10 Physical Features of the Landscape

Physical features of the landscape can strongly influence bird movement and behaviour (see Sections 4.2 and 6 for details). For example, diurnal migrants tend to follow shorelines of lakes, rivers, ridges and other linear features. During the day, peninsulas and islands can host concentrations of nocturnal migrants that had been migrating over large bodies of water, and coastal islands and headlands provide essential resting and feeding habitat during layover times for these migrating birds. Islands of habitat (e.g., woodlots) can act in a similar fashion, concentrating migrants in otherwise hostile environments, such as in open agricultural landscapes and in industrial areas.

6. Analysis of Knowledge Gaps

This document has highlighted many areas where there are gaps in our current understanding of the potential impact of wind turbines on bird conservation. This section lists a few of the greatest gaps in knowledge.

Bird Migration: The published literature on bird migration is very large, amounting to many thousands of references. However, much of the information about migration is very general, and specific information relating to migration paths and timing for particular species or species groups is lacking.

The following questions, in particular, need answering in Canada and in eastern North America in general:

- Do migrant birds follow, or concentrate their flights, along ridges and/or mountains?
- What height do nocturnal migrants fly during different weather conditions?
- When do fatalities occur?
- How do different lights affect the behaviour of nocturnal migrants?
- What is the ‘height threshold’ of towers or turbines that cause mass collision events? How does this threshold relate to other factors such as lighting, weather and siting?
- Are there specific, identifiable migration pathways in Canada that should be avoided when siting wind farms?

The issue of identifying important migration locations in Canada (and across North America) is a crucial one. Environment Canada’s Meteorological Service is currently working on mapping wind corridors in Canada for use by the wind industry. The Canadian Wildlife Service of Environment Canada is likewise hoping to quantify the importance of these wind corridors to migrating birds, with the final product being a predictive mapping tool for assessing the best site for wind farms at the local and regional levels while minimizing potential impacts on migratory birds (Melanie Cousineau, CWS, Tall Structures Birds and Bats Working Group, pers. comm.). Required for this project are:

1. A geographically-based migration chronology table for major bird groups across Canada;
2. Characterization of various migration variables, specifically along wind corridors, including direction and height of flight, relative number of migrants, and special use (if any) of topographical features such as ridges and mountains.

The migration chronology could be drafted with data from member stations of the Canadian Migration Monitoring Network (CMMN; see www.bsc-eoc.org/national/cmmn.html). The characterization of migration variables is a more difficult task requiring the use of audio recordings and marine and meteorological (i.e. Nexrad or Doppler) radars. Marine radar can be used at a regional or local scale, in conjunction with audio recordings, to identify species, altitude, and direction of flight. Meteorological radars can be used on a larger scale to determine the relative size and direction of migrating flocks. These data should ideally then be correlated with mortality at known wind farms.

The Canadian Wildlife Service Wind Power Working Group is coordinating these efforts amongst a variety of partners, including government, NGOs, industry, and university researchers.

Geographical Gaps: Bird collisions have been studied at very few wind plants in Eastern North America, such that statistical power is inadequate for comparing with results from research that has been carrid out in western North America and in Europe. Furthermore, responses of birds in the Arctic are also largely unknown. Even though the Arctic will probably not have substantial wind farm growth in the near future, studies should examine disturbance effects and mortality at new sites to ensure that there is not an unacceptable effect.

Technology: Much remains to be learned about impacts of various technologies on bird collision rates. For example, lighting appears to play a role in collision risk, especially during poor weather. Studies are required to determine the impacts of colour, type, duration on, and intensity of lights. A controlled study currently underway at collision towers in Michigan (Gehring 2004) may help answer some of the existing questions surrounding impacts of lighting (albeit from a communication tower perspective).

Other questions related to technology include: What part of the wind turbine are birds colliding with? Are most birds flying into the tower directly or are they being hit by the blades? This is an important question, as it has been suggested that a mitigation measure is to shut turbines off during peak migration periods. If birds are primarily flying into the towers, temporarily shutting turbines off will not make a significant difference in collision numbers. Quantifying the avian risk with respect to turbine size is also needed. It is not known whether larger (i.e. 750 KW to 2+ MW) or smaller (i.e.40 KW to 400 KW) developments kill similar numbers of birds based on either rotor swept area or per megawatt (NWCC 2004). Finally, differences in mortality between towers of tubular construction versus lattice-type towers have not been adequately studied, although it is often stated that lattice-type towers are more dangerous because they provide perching opportunities for raptors and other birds.

Offshore and coastal wind development: With only about a dozen offshore sites present worldwide (and none yet in North America), there is obviously a large information gap regarding the risk of offshore wind farms. Some basic questions that need to be answered include:

- What is the average avian collision rate (overall, and by species groups) for offshore wind turbines? This requires adopting a technique to measure collision rates where carcass searches are not possible.
- What is the behavioural impact of offshore wind turbines on migrating seaducks and other seabirds with known migration pathways? Is there an acceptable spacing between, and layout for, offshore wind turbines?
- What is an acceptable "buffer" distance (if any) between known migration pathways and offshore wind farms?
- Offshore turbines have the potential to be much larger (i.e. taller) than onshore turbines as their transportation is not restricted by highway size. What are the implications of taller turbines in the offshore?

7. Canadian Information

Canada is relatively new to the wind energy scene; as a result, there are very few publicly available Canadian studies on the impacts of wind turbines on birds. This section reviews the few existing studies.

Castle River, Alberta

The Castle River Wind Farm is composed of 60 turbines with a rotor diameter of 47m, mounted on a 50m tubular steel tower. It was found that turbines at the Castle River Wind Farm were not a major hazard to birds. Few birds closely approached turbines and most did not need to change their flight paths to avoid collision. Ducks responded most vigorously by flying over turbines although adequate space was available to fly under or around them (Brown and Hamilton 2002). Few raptors were observed within the wind farm; however, of 52 raptors we observed within the wind farm, only 10% (*n* = 5) appeared close enough to turbines to change their flight path to avoid possible collision (Brown and Hamilton 2002).

Four bird carcasses were recovered at the Castle River Wind Farm during 35 surveys over 9 months (Brown and Hamilton 2002). Later surveys found that Red-tailed Hawks and American Kestrels were numerous yet only two raptor collisions (one American Kestrel, one Red-tailed Hawk) were observed during the 96 carcass surveys done over two years of study(out of a total of 15 collision victims; W.K.Brown, pers.comm. 2003, Brown and Hamilton 2004). Searcher efficiency and scavenging trials were not performed, but frequent visits to turbines by site personnel (every 1-2 days) and observing tracks of potential scavengers it was believed that most birds would have been recovered (Brown & Hamilton 2002)

Sunbridge Wind Power Generation Project, Gull Lake, Saskatchewan

This project was constructed in the summer and fall of 2001 and has the capacity to generate 11.2 MW of electricity. Six mortality surveys were preformed at 17 turbines in each of the spring and fall migration seasons. No collisions were reported, site characteristics would make finding victims relatively easy but searcher efficiency was not tested, and no scavenging work was completed(Golder Associates Ltd. 2002).

North Cape, Prince Edward Island

In November 2001, the 5.28 Megawatt wind farm that is located at North Cape, Prince Edward Island was fully operational. The major components of this facility are eight 660 kilowatt (V-47) utility-grade wind turbines that were supplied by Vestas-Canada Wind Technology (PEI Energy Corporation 2002), in addition to various other types of test turbines that make up the Atlantic Wind Test Site (Kingsley and Whittam personal observation). Eight turbines and four control points were sampled on a twice weekly basis, starting on May 14, 2002 and continuing through to June 13, 2002 to coincide with the spring migration. Outside of this time frame, through to the end of November 2002, only bi-monthly sampling was performed (PEI Energy Corporation 2002). During these surveys one unidentified bird collided with a turbine and one dead bird was also found in a control site (PEI Energy Corporation 2002). Neither searcher efficiency nor scavenging rate were calculated in this study, and carcass removal rate was subsequently found to be very high (90% of carcasses disappeared after four days; Rachel Gautreau, pers. comm.).

Le Nordais, Gaspe, Quebec

A modern (133 turbines) wind facility located in forest. Two seasons of surveys examining 26 turbines found no collision victims.

Mc Bride Lake, Alberta

At the McBride Lake wind farm in Alberta there are 114 turbines with rotor diameters of 47m mounted on 50m tubular towers. From July 2003 through to June 2004, 69 surveys were conducted at all 114 turbines. There were a total of 41 bird carcasses found including 7 Swainson's Hawks, 1 Western Grebe, 2 Sharp-tailed Grouse, and 2 Short-eared Owls (Brown and Hamilton 2004). Searcher efficiency was determined to be approximately 70%, and scavenging rates are to be assesed in future studies, however, few potential scavengers (or their sign) were located near turbines (Brown & Hamilton 2004).

Pickering, Ontario

There is a single Vestas V80, 1.8 MW turbine at this site. The rotation of the blades is a constant 15.3 rpm and the tower stands approximately 78m high. Located in an area of many habitats including industrial, parkland and marsh, there are a fair number of birds that use the area. Carcass searches were made about every two weeks from January until early March, and between the end of October and mid December. From 10 March to 4 May, 2 June to 17 August, and 22 September to 26 October, searches were made once per week. Search frequency was increased to three times a week from 5 May to 1 June and from 18 August to 21 September. These searches found 3 birds that collided with the turbine and it was shown that scavenging appeared to be low at this site (James 2003).

Bird behavior did not appear to be negatively affected by the turbine. For example, Canada Geese are abundant throughout most of the year and they would forage directly under the turbine and would routinely fly back and forth past the turbine most days without incident (James 2003). Ring-billed Gulls were also common in the area all year and regularly flew past the turbine to forage, typically passing wide of the turbine by at least 75 m, but at times passed within a few meters of the turning blades without showing any apparent alarm (James 2003). Smaller numbers of Black-crowned Night Herons were in the marsh most of the summer and fall, and regularly flew past the turbine, usually passing more than 100 m away (James 2003). A pair of Killdeers nested within 60m of the turbine tower and other species such as Mourning Dove were suspected to have nested nearby as well (James 2003).

Exhibition Place, Ontario

There is a single 94m high, 750 kW wind turbine at the Canadian National Exhibition grounds in Toronto. It was placed in an area surrounded immediately by paved roadways and parkland (James and Coady 2003). Mortality searches were made twice a week over a 5-week period in late April and May, and three times a week over a 6-week period mid August to the end of September. A comprehensive predator removal study was completed and found that in spring, 35% were removed by predators within 10 days and only 18% were removed within one week. In the fall, only three percent were removed within three days (greater time than the search interval) (James and Coady 2003). Only two dead birds were found, one in spring and one in autumn. Both species involved were probably local resident birds (James and Coady 2003). However, most local birds appeared to have adapted easily to the presence of the turbine, and simply avoided the turbine. It was determined that the rate of mortality was insignificant when compared to the thousands of birds that are killed each year in Toronto at tall buildings (James and Coady 2003).

8. Acknowledgements

Thanks to Environment Canada and the Environmental Assessment Branch, especially John Fischer, Rob Dobos, Louise Kingsley, Diane Campbell and Lise Poulin, for funding and supervising this work.

Earlier drafts of this document were reviewed by members of governmental and non-governmental organisations, as well as industry stakeholders. Comments and/or information were provided by Matt Holder and Al Leggett (Jacques Whitford Environment Limited), Jason Edworthy and Justin Thompson (Vision Quest Windelectric Inc.), Marc Belisle (Université de Sherbrooke), Wally Erickson (WEST Inc.), Ansar Gafur (AIM PowerGen), Ramsey Hart (Bird Studies Canada), Ross James (AIM PowerGen), Marc Johnson (Canadian Nature Federation), Philippe Junger (CHI Canada Inc.), Albert Manville (U.S. Fish and Wildlife Service, and on behalf of the Avian Subcommittee of the National Wind Coordinating Committee), Michael Mesure (Fatal Light Awareness Program), Murray Paterson (Ontario Power Generation – Evergreen Energy), Marc Sheeran, Grietje Van Dijk (BC Hydro), Edward Alf (Transport Canada), Kent Brown (Terrestrial and Aquatic Environmental Management), Everett Marshall (Nongame & Natural Heritage Program, VT Dept. of Fish & Wildlife), Richard Curry and Paul Kerlinger (on behalf of the Canadian Wind Energy Association), two anonymous reviewers from Natural Resources Canada, and the Canadian Wind Energy Association Standards Committee (consisting of Samit Sharma, Gaia Power Inc; Glen Estill, Sky Generation Inc.; Justin Thompson, Vision Quest Windelectric Inc.; Daniel Charette, NEG-Micon Canada Inc.; Doug Duimering, Vestas Canadian Wind Technologies). Comments were also received from the following Environment Canada employees: Sheila Allan, Madeline Austen, Kevin Blair, Dave Broadhurst, Erica Dunn, Richard Elliot, Denise Fell, Warren Fenton, Lyle Friesen, A.J. Gaston, Rachel Gautreau, Paul Gregoire, Keith Keddy, Serge Lemieux, Jeff Robinson, Michael Shaw, Ruth Thoms, Les Welsh, and Chip Weseloh. Marianne Kingsley graciously provided information on German studies.

Thanks also to the following individuals for their help in reaching reviewers and/or providing information: Abby Arnold (RESOLVE), Carl Brothers (Atlantic Wind Test Site), Stephen Glendinning (Golder Associates Ltd.), Iannick Lamirande (Natural Resources Canada), Rachel Permut (NWCC Outreach Associate, National Wind Coordinating Committee), and Samit Sharma (Board Director of CanWEA. Finally, special thanks should go to Matt Holder (Jacques Whitford

Environment Limited) for the substantial amount of assistance he provided with respect to research and review for this document.

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Appendix. Detailed information on bird collisions with turbines from around the world.

Table A1. List of Canadian studies that have reported bird collisions with wind turbines and included species information.

Site	Number of turbines	# Sampled	Habitat	Survey period	collisions recorded	Reference
Alberta - Castle River	23-60 Vestas V47-660	5	cropland	35 surveys over 9 months	4	Brown & Hamilton 2002
Alberta - Castle River	60 Vestas V47-660		cropland	96 surveys Apr. 2001-Dec. 2002	15	Brown unpubl. data
Exhibition Place, Toronto, Ontario	1 750Kw turbine	1	parkland / industrial	twice weekly searches 5 wks spring, 6wks fall 2002	2	James & Cody 2003
McBride Lake Wind Farm, Alberta	114 Vestas V47-660	114	pasture and cropland	69 surveys Jul. 2003-Jun. 2004	41	Brown & Hamilton 2004
Pickering, Ontario	1 Vestas V80 (1.8MW) turbine	1	parkland/ nuclear plant	Jan 2001 -sept. 2002	3	James 2003

Table A2. List of American studies that have reported bird collisions with wind turbines and included species information.

Site	Number of turbines	# Sampled	Habitat	Survey period	collisions recorded	Reference
Altamont Pass Wind Resource Area, CA	5,400 older turbines	685	grazing and tilled land	Mar 1988- Feb 1999	95	Thelander & Rugge 2000
Altamont Pass Wind Resource Area, CA	5,400 older turbines		grazing and tilled land	88 months	52 radio tagged eagles	California Energy Commission 2002
Altamont Pass Wind Resource Area, CA	7340 older turbines	359	grazing and tilled land	9/88-9/89	42	Howell and Didonato 1991
Altamont Pass Wind Resource Area, CA	7340 older turbines		grazing and tilled land		10	Howell *et. al.* 1991
Altamont Pass Wind Resource Area, CA	7340 older turbines	125	grazing and tilled land	89-90	182	Orloff & Flannery 1992
Altamont Pass Wind Resource Area, CA	7340 older turbines		grazing and tilled land		38 eagles and 58 hawks	Anderson &. Estep 1988
Altamont Pass Wind Resource Area, CA	7340 older turbines		grazing and tilled land	May 1998-May 2003	1159	Smallwood & Thelander 2004

Buffalo Ridge, MN Phase 1	73 Kenetech Model 33-MVs	50	agricultural crops, pasture	4/94-Dec 95	12	Osborne *et. al.* 2000
Buffalo Ridge, MN Phase 1	73 Kenetech Model 33-MVs	21	agricultural crops, pasture	3/96-Nov 99	13	Johnson *et. al.* 2000b
Buffalo Ridge, MN Phase 1	73 Kenetech Model 33-MVs	21	agricultural crops, pasture	7mo.s in 1996, 8mo.s 1997	6	Strickland *et. al.* 2000
Buffalo Ridge, MN Phase II	143 Zond Z-750	40	agricultural crops, pasture	3/98-Nov 99	20	Johnson *et. al.* 2000b
Buffalo Ridge, MN Phase II	143 Zond Z-750	30	agricultural crops, pasture	3/98-Nov 99	22	Johnson *et. al.* 2000b
Buffalo Ridge, Phases combined	216 turbines		agricultural crops, pasture		55	Johnson *et. al.* 2002
Foote Creek Rim, WY Phase 1	69 Mitsubishi 600 kW tubular	69	rangeland	11/98-Dec 00	95	Young *et. al.* 2001
Foote Creek Rim, WY Phase II & III	36 Mitsubishi 600 kW 33 NEG 750	36	rangeland	7/99-Dec 00	13	Young *et. al.* 2002
Klondike, Oregon	16 x 1.5MW turbines	16	grassland & scrub	1 year (13 searches per turbine)	7	Johnson *et. al.* 2003
Montezuma Hills, CA	600 mostly older turbines	249	farmland	89-90	30+	Howell & Noone 1992
Mountaineer, West Virginia	44 x 1.5-MW turbines.	44	forest, mountain top	Apr.-Nov 2003 (22 searches per turbine)	69	Kerns & Kerlinger 2004
Nine Canyon, Washington	37x 1.3Mw Bonus turbines	37	wheat fields, grassland	Sept.2002-Aug. 2003 (19 searches/per turbine)	38	Erickson *et. al.* 2003
Ponnequin, Colarado	29 (+15 new turbines in 2001)(Micon 750)		rangeland	1999-2001	14	Erickson *et. al.* 2001
San Gorgonio Pass Wind Resource Area, CA	3750 various types of turbines	180	mountainous desert	830 carcass searches	40	Anderson *et. al.* 2000
Solano Wind Resource Area, CA				88 months	One radio tagged eagle	California Energy Commission 2002
Stateline, OR/WA	181 (OR) & 273 (WA) Vestas V-47 turbines		arid grassland	1162 searches 2002 (OR) 1176 searches 2002 (WA)	>200	West Inc. & North West Wildlife consultants Inc., 2004
Tehachapi Pass Wind Resource Area, CA	5000 various types of turbine	180	ridges and grasslands	830 carcass searches	94	Anderson *et. al.* 2000
Top of Iowa Wind	89 x 235 foot	26	cropland, near	Apr. 5 2003-Dec.	2	Koford 2003

Farm, Iowa	tubular turbines		important wildlife areas	2003 (searched every 3 days)		
Vansycle Ridge, OR	38 x 660 kW Vestas	38	agricultural crops, pasture	surveys every 28 days, Jan 1 1999-Dec 1999)	12	Strickland *et. al.* 2000c
Wisconsin	31 x 660 kW Vestas	31	farmland	98-12/00	21	Erickson *et. al.* 2002

Table A3. List of Spanish studies that have reported bird collisions with wind turbines and included species information.

Site	Number of turbines	# Sampled	Habitat	Survey period	collisions recorded	Reference
Alaiz, Spain	75	28?	inland hills	Mar. 2000-Mar. 2001- weekly searches	13	Lekuona 2001
E3 windfarm, Energia Eolica del Estrecho	50 x 150Kw, 16 x 180Kw turbines	34% of turbines	mountain top	Dec.93 - Dec. 94	90	Marti & Barrios 1995
El Perdon, Spain	40	15?	inland hills	Mar. 2000-Mar. 2001- weekly searches	25	Lekuona 2001
Guennda, Spain	145	49?	inland hills	Mar. 2000-Mar. 2001- weekly searches	22	Lekuona 2001
Izco, Spain	75	19?	inland hills	Mar. 2000-Mar. 2001- weekly searches	22	Lekuona 2001
Leitza, Spain	32	9?	inland hills	Mar. 2000-Mar. 2001- weekly searches	1	Lekuona 2001
PESUR windfarm, Parque Eolico del Sur, Spain	150 x 100w, 34 x 150Kw turbines	34% of turbines	mountain top	Dec.93 - Dec. 94	125	Marti & Barrios 1995
Salajones, Spain	33	16?	inland hills	Mar. 2000-Mar. 2001- weekly searches	58	Lekuona 2001

Table A4. List of German studies that have reported bird collisions with wind turbines and included species information.

Site	Number of turbines	# Sampled	Habitat	Survey period	collisions recorded	Reference
Baden-Wurttemberg, Germany	NA	NA	NA	NA	1	Durr 2004
Brandenburg, Germany	NA	NA	NA	NA	90	Durr 2004
Hessen, BW, Germany	NA	NA	NA	NA	6	Durr 2004
Mecklenburg-Vorpommern, Germany	NA	NA	NA	NA	6	Durr 2004
Niedersachsen, Germany	NA	NA	NA	NA	35	Durr 2004
Nordrhein-Westfalen, Germany	NA	NA	NA	NA	8	Durr 2004
Sachsen, Germany	NA	NA	NA	NA	9	Durr 2004
Sachsen-Anhalt, Germany	NA	NA	NA	NA	30	Durr 2004

Schleswig-Holstein, Germany	NA	NA	NA	NA	28	Durr 2004
Thüringen, Germany	NA	NA	NA	NA	1	Durr 2004

Table A5. List of studies from the Netherlands that have reported bird collisions with wind turbines and included species information.

Site	Number of turbines	# Sampled	Habitat	Survey period	collisions recorded	Reference
Boudewijn-canal, Brugge	5 turbines 600kWs	5	industrial buildings	May 2000 - Dec. 2002		Everaert *et. al.* (2003)
East-dam, Zeebrugge	23 turbines 200, 400, 600kWs	23	dike along water	May 2000 - Dec. 2002		Everaert *et. al.* (2003)
Kreekrak, Netherlands	5 250 KW turbines	5	coastal on dyke wall	April 1990-April 1991	26	Musters *et. al.* 1996
Schelde river	3 turbines 1.500kWs	3	industrial land	April 2001 - Dec. 2002		Everaert *et. al.* (2003)

Table A6. Summary list of Loon and Grebe species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Eared Grebe *Podiceps nigricollis*	McBride Lake, AB	1	Brown & Hamilton 2004
Grebe sp.	San Gorgonio	1	Anderson *et. al.* 2000
Pied-billed Grebe *Podilymbus podiceps*	Buffalo Ridge	2	Johnson *et. al.* 2002
Pied-billed Grebe *Podilymbus podiceps*	Buffalo Ridge	1	Strickland *et. al.* 2000
Red-throated Loon *Gavia stellata*	Niedersachsen, Germany	1	Durr 2004
Western Grebe *Aechmophorus occidentalis*	McBride Lake, AB	1	Brown & Hamilton 2004
Western Grebe *Aechmophorus occidentalis*	Foote Creek Rim	1	Johnson *et. al.* 2001

Table A7. Summary list of Pelican and Cormorant (Phalacrocoracidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Brown Pelican *Pelecanus occidentalis*	Altamont Wind Resource Area	1	Erickson *et. al.* 2001
Double-crested Cormorant P*halacrocorax auritus*	Altamont Wind Resource Area	1	Smallwood & Thelander 2004
Great Cormorant *Phalacrocorax carbo*	Niedersachsen, Germany	2	Durr 2004

Table A8. Summary list of Duck, Geese and Swan (Anatidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Barnicle Goose *Branta leucopsis*	Schleswig-Holstein, Germany	6	Durr 2004
Bean Goose *Anser fabalis*	Sachsen, Germany	1	Durr 2004
Bean Goose *Anser fabalis*	Sachsen-Anhalt, Germany	1	Durr 2004
Blue-winged Teal *Anas discors*	Buffalo Ridge	1	Johnson *et. al.* 2002
Blue-winged Teal *Anas discors*	Castle River, Alberta	1	Brown pers comm.
Brent goose *Branta bernicla*	Kreekrak, Netherlands	1	Musters *et. al.* 1996
Bufflehead *Bucephala albeola*	McBride Lake, AB	1	Brown & Hamilton 2004
Canada Goose *Branta canadensis*	Klondike, Oregon	2	Johnson *et. al.* 2003
Canvasback *Athya valisineria*	McBride Lake, AB	1	Brown & Hamilton 2004
Domestic Goose	Boudewijn-canal, Brugge	1	Everaert *et. al.* 2003
Duck sp.	Altamont Wind Resource Area	2	Erickson *et. al.* 2001
Gadwall *Anas strepera*	McBride Lake, AB	1	Brown & Hamilton 2004
Gadwall *Anas strepera*	Kreekrak, Netherlands	1	Musters *et. al.* 1996
Mallard *Anas platyrhynchos*	Schleswig-Holstein, Germany	3	Durr 2004
Mallard *Anas platyrhynchos*	Niedersachsen, Germany	3	Durr 2004
Mallard *Anas platyrhynchos*	Sachsen, Germany	1	Durr 2004
Mallard *Anas platyrhynchos*	Altamont Wind Resource Area	35	Smallwood & Thelander 2004
Mallard *Anas platyrhynchos*	Altamont Wind Resource Area	1	Thelander & Rugge 2000
Mallard *Anas platyrhynchos*	Altamont Wind Resource Area	5	Erickson *et. al.* 2001
Mallard *Anas platyrhynchos*	Wisconsin	2	Erickson *et. al.* 2001
Mallard *Anas platyrhynchos*	Montezuma Hills	2	Howell & Noone 1992, Howell 1997
Mallard *Anas platyrhynchos*	Buffalo Ridge	2	Johnson *et. al.* 2002
Mallard *Anas platyrhynchos*	Boudewijn-canal, Brugge	1	Everaert *et. al.* 2002
Mallard *Anas platyrhynchos*	Boudewijn-canal, Brugge	8	Everaert *et. al.* 2003
Mallard *Anas platyrhynchos*	Schelle	2	Everaert *et. al.* 2003
Mallard *Anas platyrhynchos*	Kreekrak, Netherlands	4	Musters *et. al.* 1996
Mallard *Anas platyrhynchos*	McBride Lake, AB	1	Brown & Hamilton 2004
Mallard *Anas platyrhynchos*	Stateline, OR	1	West Inc., & Northwest Wildlife Consultants 2004
Mallard *Anas platyrhynchos*	San Gorgonio	3	Anderson *et. al.* 2000
Mute Swan *Cygnus olor*	Niedersachsen, Germany	5	Durr 2004
Mute Swan *Cygnus olor*	Sachsen, Germany	1	Durr 2004
Mute Swan *Cygnus olor*	Sachsen-Anhalt, Germany	1	Durr 2004
Mute Swan *Cygnus olor*	Brandenburg, Germany	1	Durr 2004

Ring-necked Duck *Aythya collaris*	Altamont Wind Resource Area	1	Smallwood & Thelander 2004
Shelduck *Tadorna tadorna*	Niedersachsen, Germany	1	Durr 2004
Teal *Anas crecca*	Niedersachsen, Germany	1	Durr 2004
Teal sp.	Ponnequin, CO	1	Erickson *et. al.* 2001
Teal sp.	Kreekrak, Netherlands	1	Musters *et. al.* 1996
Teal sp.	San Gorgonio	1	Anderson *et. al.* 2000
Tufted Duck *Aythya fuligula*	Niedersachsen, Germany	1	Durr 2004
unidentified waterbird	Altamont Wind Resource Area	2	Erickson *et. al.* 2001
Whooper Swan *Cygnus cygnus*	Schleswig-Holstein, Germany	1	Durr 2004
Wood Duck *Aix sponsa*	Mountaineer	1	Kerns & Kerlinger 2004

Table A9. Summary list of Vultures (Cathartidae), Eagles and Hawks (Accipiridae) that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Black Kite *Milvus migrans*	PESUR	2	Marti & Barrios 1995
Black Kite *Milvus migrans*	Brandenburg, Germany	4	Durr 2004
Booted Eagle *Hieraaetus pennatus*	Izco, Spain	1	Leukuona 2001
Buteo sp.	Altamont Wind Resource Area	24	Smallwood & Thelander 2004
Buteo sp.	Altamont Wind Resource Area	9	Erickson *et. al.* 2001
Buteo sp.	Tehachapi Pass	1	Anderson *et. al.* 2000
Buzzard *Buteo buteo*	Brandenburg, Germany	11	Durr 2004
Buzzard *Buteo buteo*	Sachsen-Anhalt, Germany	5	Durr 2004
Buzzard *Buteo buteo*	Thüringen, Germany	2	Durr 2004
Buzzard *Buteo buteo*	Niedersachsen, Germany	2	Durr 2004
Buzzard *Buteo buteo*	Nordrhein-Westfalen, Germany	1	Durr 2004
Buzzard *Buteo buteo*	Hessen, BW, Germany	1	Durr 2004
Eagle sp.	Altamont Wind Resource Area	38	Anderson &. Estep 1988
Ferruginous Hawk *Buteo regalis*	Altamont Wind Resource Area	2	Erickson *et. al.* 2001
Ferruginous Hawk *Buteo regalis*	Altamont Wind Resource Area	2	Smallwood & Thelander 2004
Ferruginous Hawk *Buteo regalis*	Stateline, OR	1	West Inc., & Northwest Wildlife Consultants 2004
Ferruginous Hawk *Buteo regalis*	Tehachapi Pass	1	Anderson *et. al.* 2000
Golden Eagle Aquila chrysaetos	Altamont Wind Resource Area	4	Thelander & Rugge 2000
Golden Eagle Aquila chrysaetos	Altamont Wind Resource Area	52	California Energy Commission 2002
Golden Eagle Aquila chrysaetos	Solano Wind Resource Area	1	California Energy Commission 2002
Golden Eagle Aquila chrysaetos	Altamont Wind Resource Area	30	Erickson *et. al.* 2001

Golden Eagle Aquila chrysaetos	Montezuma Hills	1	Howell & Noone 1992, Howell 1997
Golden Eagle Aquila chrysaetos	Altamont Wind Resource Area	54	Smallwood & Thelander 2004
Golden Eagle *Aquila chrysaetos*	Izco, Spain	1	Leukuona 2001
Goshawk *Accipiter gentilis*	Brandenburg, Germany	1	Durr 2004
Griffon Vulture *Gyps fulvus*	Tarifa	1	Janss 2000
Griffon Vulture *Gyps fulvus*	PESUR	67	Marti & Barrios 1995
Griffon Vulture *Gyps fulvus*	E3	6	Marti & Barrios 1995
Griffon Vulture *Gyps fulvus*	Salajones, Spain	53	Leukuona 2001
Griffon Vulture *Gyps fulvus*	Izco, Spain	11	Leukuona 2001
Griffon Vulture *Gyps fulvus*	Alaiz, Spain	11	Leukuona 2001
Griffon Vulture *Gyps fulvus*	Guennda, Spain	8	Leukuona 2001
Griffon Vulture *Gyps fulvus*	Leitza, Spain	1	Leukuona 2001
Griffon Vulture *Gyps fulvus*	El Perdon	4	Leukuona 2001
Hawk sp.	Altamont Wind Resource Area	58	Anderson &. Estep 1988
Montagu's Harier *Circus pygargus*	Nordrhein-Westfalen, Germany	1	Durr 2004
Northern Harrier *Circus cyaneus*	Altamont Wind Resource Area	2	Erickson *et. al.* 2001
Northern Harrier *Circus cyaneus*	Foote Creek Rim	1	Johnson *et. al.* 2001
Northern Harrier *Circus cyaneus*	Altamont Wind Resource Area	3	Smallwood & Thelander 2004
Old Raptor Carcass	Altamont Wind Resource Area	12	Thelander & Rugge 2000
Raptor spp.	PESUR	2	Marti & Barrios 1995
Raptor spp.	Altamont Wind Resource Area	16	Smallwood & Thelander 2004
Raptor spp.	Altamont Wind Resource Area	12	Erickson *et. al.* 2001
Raptor spp.	Altamont Wind Resource Area	1	Thelander & Rugge 2000
Red Kite *Milvus milvus*	Brandenburg, Germany	17	Durr 2004
Red Kite *Milvus milvus*	Sachsen-Anhalt, Germany	10	Durr 2004
Red Kite *Milvus milvus*	Sachsen, Germany	4	Durr 2004
Red Kite *Milvus milvus*	Niedersachsen, Germany	1	Durr 2004
Red Kite *Milvus milvus*	Hessen, BW, Germany	3	Durr 2004
Red Kite *Milvus milvus*	Mecklenburg-Vorpommern, Germany	1	Durr 2004
Red Kite *Milvus milvus*	Thüringen, Germany	1	Durr 2004
Red Kite *Milvus milvus*	Nordrhein-Westfalen, Germany	1	Durr 2004
Red-tailed Hawk *Buteo jamaicensis*	Altamont Wind Resource Area	19	Thelander & Rugge 2000
Red-tailed Hawk *Buteo jamaicensis*	Altamont Wind Resource Area	181	Erickson *et. al.* 2001
Red-tailed Hawk *Buteo jamaicensis*	Montezuma Hills	13	Howell & Noone 1992, Howell 1997
Red-tailed Hawk *Buteo jamaicensis*	Buffalo Ridge	1	Johnson *et. al.* 2002
Red-tailed Hawk *Buteo jamaicensis*	Altamont Wind Resource Area	213	Smallwood & Thelander 2004
Red-tailed Hawk *Buteo jamaicensis*	Castle River, Alberta	1	Brown & Hamilton 2004

Red-tailed Hawk *Buteo jamaicensis*	Mountaineer	1	Kerns & Kerlinger 2004
Red-tailed Hawk *Buteo jamaicensis*	Stateline, OR	2	West Inc., & Northwest Wildlife Consultants 2004
Red-tailed Hawk *Buteo jamaicensis*	Stateline, WA	4	West Inc., & Northwest Wildlife Consultants 2004
Red-tailed Hawk *Buteo jamaicensis*	Tehachapi Pass	8	Anderson *et. al.* 2000
Red-tailed Hawk *Buteo jamaicensis*	San Gorgonio	1	Anderson *et. al.* 2000
Short-toed Eagle *Circaetus gallicus*	Tarifa	1	Janss
Short-toed Eagle *Circaetus gallicus*	PESUR	6	Marti & Barrios 1995
Sparrowhawk *Accipiter nisus*	Boudewijn-canal, Brugge	1	Everaert *et. al.* 2002
Sparrowhawk *Accipiter nisus*	Izco, Spain	1	Leukuona 2001
Swainson's Hawk *Buteo swainsoni*	McBride Lake, AB	7	Brown & Hamilton 2004
Swainson's Hawk *Buteo swainsoni*	Stateline, WA	1	West Inc., & Northwest Wildlife Consultants 2004
Swainson's Hawk *Buteo swainsoni*	Altamont Wind Resource Area	1	Erickson *et. al.* 2001
Turkey Vulture *Cathartes aura*	Altamont Wind Resource Area	4	Erickson *et. al.* 2001
Turkey Vulture *Cathartes aura*	Altamont Wind Resource Area	6	Smallwood & Thelander 2004
Turkey Vulture *Cathartes aura*	Mountaineer	2	Kerns & Kerlinger 2004
White-tailed Eagle *Haliaeetus albicilla*	Sachsen-Anhalt, Germany	1	Durr 2004
White-tailed Eagle *Haliaeetus albicilla*	Mecklenburg-Vorpommern, Germany	4	Durr 2004
White-tailed Eagle *Haliaeetus albicilla*	Schleswig-Holstein, Germany	6	Durr 2004
White-tailed Eagle *Haliaeetus albicilla*	Brandenburg, Germany	2	Durr 2004
White-tailed Kite *Elanus leucurus*	Altamont Wind Resource Area	1	Smallwood & Thelander 2004

Table A10. Summary list of Faclon (Falconidae) that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
American Kestrel *Falco sparverius*	Altamont Wind Resource Area	4	Thelander & Rugge 2000
American Kestrel *Falco sparverius*	Altamont Wind Resource Area	49	Erickson *et. al.* 2001
American Kestrel *Falco sparverius*	Foote Creek Rim	3	Johnson *et. al.* 2001
American Kestrel *Falco sparverius*	Montezuma Hills	11	Howell & Noone 1992, Howell 1997
American Kestrel *Falco sparverius*	Solano Wind Resource Area	1	Bryne 1983
American Kestrel *Falco sparverius*	Altamont Wind Resource Area	59	Smallwood & Thelander 2004
American Kestrel *Falco sparverius*	Castle River, Alberta	2	Brown pers. comm.
American Kestrel *Falco sparverius*	Nine Canyon, Wyoming	1	Erickson *et. al.* 2003
American Kestrel *Falco sparverius*	Stateline, OR	3	West Inc., & Northwest Wildlife Consultants 2004
American Kestrel *Falco sparverius*	Stateline, WA	1	West Inc., & Northwest Wildlife Consultants 2004
American Kestrel Falco sparverius	Tehachapi Pass	7	Anderson *et. al.* 2000

Hobby *Falco subbuteo*	Brandenburg, Germany	1	Durr 2004
Kestrel *Falco tinnunculus*	PESUR	24	Marti & Barrios 1995
Kestrel *Falco tinnunculus*	Brandenburg, Germany	5	Durr 2004
Kestrel *Falco tinnunculus*	Sachsen-Anhalt, Germany	4	Durr 2004
Kestrel *Falco tinnunculus*	Nordrhein-Westfalen, Germany	1	Durr 2004
Kestrel *Falco tinnunculus*	Boudewijn-canal, Brugge	2	Everaert *et. al.* 2003
Kestrel *Falco tinnunculus*	Guennda, Spain	1	Leukuona 2001
Lesser Kestrel *Falco naumanni*	PESUR	18	Marti & Barrios 1995
Merlin *Falco columbarius*	Brandenburg, Germany	1	Durr 2004
Peregrine Falcon *Falco peregrinus*	East-dam, Zeebrugge	1	Everaert *et. al.* 2002
Peregrine Falcon *Falco peregrinus*	Schelle	1	Everaert *et. al.* 2003
Peregrine Falcon *Falco peregrinus*	Burgar Hill, Orkney	1	Meek *et. al.* 1993
Prairie Falcon *Falco mexicanus*	Montezuma Hills	1	Howell & Noone 1992, Howell 1997
Prairie Falcon *Falco mexicanus*	Altamont Wind Resource Area	2	Thelander & Rugge 2000
Prairie Falcon *Falco mexicanus*	Altamont Wind Resource Area	3	Smallwood & Thelander 2004
Prairie Falcon *Falco mexicanus*	Tehachapi Pass	1	Anderson *et. al.* 2000

Table A11. Summary list of Game Bird (Phasianidae & Odontophoridae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
California Quail *Callipepla californica*	Tehachapi Pass	2	Anderson *et. al.* 2000
Chukar *Alectoris chuckar*	Vansycle, OR	1	Strickland *et. al.* 2000c
Chukar *Alectoris chuckar*	Tehachapi Pass	2	Anderson *et. al.* 2000
Chukar *Alectoris chuckar*	Stateline WA	4	West Inc., & Northwest Wildlife Consultants 2004
Chukar *Alectoris chuckar*	Stateline OR	3	West Inc., & Northwest Wildlife Consultants 2004
Gray Partridge *Perdis perdis*	Vansycle, OR	2	Strickland *et. al.* 2000c
Gray Partridge *Perdis perdis*	McBride Lake, AB	1	Brown & Hamilton 2004
Gray Partridge *Perdis perdis*	Buffalo Ridge	1	Johnson *et. al.* 2002
Gray Partridge *Perdis perdis*	Stateline OR	4	West Inc., & Northwest Wildlife Consultants 2004
Gray Partridge *Perdis perdis*	Stateline WA	3	West Inc., & Northwest Wildlife Consultants 2004
Partidge sp.	Vansycle, OR	1	Strickland *et. al.* 2000c
Partridge *Perdix perdix*	Brandenburg, Germany	1	Durr 2004
Ring-necked Phesant *Phasianus colchicus*	Buffalo Ridge	2	Johnson *et. al.* 2002
Ring-necked Phesant *Phasianus colchicus*	Boudewijn-canal, Brugge	3	Everaert *et. al.* 2003
Ring-necked Phesant *Phasianus colchicus*	Nine Canyon, Washington	5	Erickson et. al 2003

Ring-necked Phesant *Phasianus colchicus*	Stateline WA	3	West Inc., & Northwest Wildlife Consultants 2004
Ring-necked Phesant *Phasianus colchicus*	Stateline OR	14	West Inc., & Northwest Wildlife Consultants 2004
Ring-necked Phesant *Phasianus colchicus*	Niedersachsen, Germany	2	Durr 2004
Ring-necked Phesant *Phasianus colchicus*	Guennda, Spain	1	Lekuona 2001
Ruffed Grouse *Bonasa umbellus*	Mountaineer	1	Kerns & Kerlinger 2004
Sharp-tailed Grouse *Tympanuchus phasianellus*	McBride Lake, AB	2	Brown & Hamilton 2004
Wild Turkey *Melegris gallopavo*	Altamont Wind Resource Area	1	Smallwood & Thelander 2004

Table A12. Summary list of Coot species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
American Coot *Fulica americana*	McBride Lake, AB	1	Brown & Hamilton 2004
American Coot *Fulica americana*	Buffalo Ridge	2	Johnson *et. al.* 2002
American Coot *Fulica americana*	San Gorgonio	8	Anderson *et. al.* 2000
American Coot *Fulica americana*	Castle River, Alberta	1	Brown pers. comm.
Coot *Fulica atra*	Kreekrak, Netherlands	possible 2	Musters *et. al.* 1996
Coot *Fulica atra*	Boudewijn-canal, Brugge	1	Everaert *et. al.* 2002
Coot *Fulica atra*	Boudewijn-canal, Brugge	6	Everaert *et. al.* 2003
Sora *Porzana carolina*	San Gorgonio	1	Anderson *et. al.* 2000

Table A13. Summary list of Heron (Ardeidae) and Stork (Ciconidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Black Crowned Night Heron *Nycticorax nycticorax*	Altamont Wind Resource Area	1	Erickson *et. al.* 2001
Black Crowned Night Heron *Nycticorax nycticorax*	Pickering	1	James 2003
Black Crowned Night Heron *Nycticorax nycticorax*	Altamont Wind Resource Area	2	Smallwood & Thelander 2004
Black Stork *Ciconia nigra*	Hessen, Germany	1	Durr 2004
Black Stork *Ciconia nigra*	Hessen, Germany	1	Durr 2004
Cattle Egret *Bubulcus ibis*	Altamont Wind Resource Area	1	Smallwood & Thelander 2004
Egret sp.	San Gorgonio	1	Anderson et. al 2000
Gray Heron *Ardea cinerea*	Boudewijn-canal, Brugge	1	Everaert *et. al.* 2003
Great Blue Heron *Ardea herodias*	Nine Canyon, Wyoming	1	Erickson *et. al.* 2003
Great Blue Heron *Ardea herodias*	Stateline, WA	1	West Inc., & Northwest Wildlife

			Consultants 2004
White Stork *Ciconia ciconia*	Brandenburg, Germany	1	Durr 2004
White Stork *Ciconia ciconia*	Brandenburg, Germany	1	Durr 2004
White Stork *Ciconia ciconia*	Mecklenburg-Vorpommern, Germany	1	Durr 2004
White Stork *Ciconia ciconia*	Sachsen, Germany	1	Durr 2004

Table A14. Summary list of Shorebird species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
American Avocet *Recurvirostra americana*	Altamont Wind Resource Area	3	Smallwood & Thelander 2004
Grey Plover *Pluvialis squatarola*	Kreekrak, Netherlands	1	Musters *et. al.* 1996
Killdeer *Charadrius vociferus*	Buffalo Ridge	1	Johnson *et. al.* 2002
Lesser Yellowlegs *Tringa flavipes*	Altamont Wind Resource Area	1	Smallwood & Thelander 2004
Ostercatcher *Hamatopus ostralegus*	Kreekrak, Netherlands	1	Musters *et. al.* 1996
Ostercatcher *Haematopus ostralegus*	Niedersachsen, Germany	1	Durr 2004
Ostercatcher *Haematopus ostralegus*	Schleswig-Holstein, Germany	2	Durr 2004
Redshank *Tringa totanus*	Boudewijn-canal, Brugge	1	Everaert *et. al.* 2003
Snipe *Gallinago gallinageo*	Mynydd Cemmaes	1	Dulas Engineering Ltd. 1995
Snipe sp.	Kreekrak, Netherlands	1	Musters *et. al.* 1996

Table A15. Summary list of gull and tern species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Black-headed Gull *Larus ridibundus*	Boudewijn-canal, Brugge	8	Everaert *et. al.* (2002)
Black-headed Gull *Larus ridibundus*	Boudewijn-canal, Brugge	47	Everaert *et. al.* 2003
Black-headed Gull *Larus ridibundus*	East-dam, Zeebrugge	1	Everaert *et. al.* 2003
Black-headed Gull *Larus ridibundus*	Burgar Hill, Orkney	3	Meek *et. al.* 1993
Black-headed Gull *Larus ridibundus*	Kreekrak, Netherlands	1	Musters *et. al.* 1996
Black-headed Gull *Larus ridibundus*	Brandenburg, Germany	4	Durr 2004
California Gull *Larus californicus*	Altamont Wind Resource Area	1	Thelander & Rugge 2000
California Gull *Larus californicus*	Altamont Wind Resource Area	2	Erickson *et. al.* 2001
California Gull *Larus californicus*	Altamont Wind Resource Area	7	Smallwood & Thelander 2004
Common Gull *Larus canus*	Boudewijn-canal, Brugge	3	Everaert *et. al.* 2003

Common Gull *Larus canus*	Sachsen, Germany	1	Durr 2004
Common Gull *Larus canus*	Niedersachsen, Germany	4	Durr 2004
Common Gull *Larus canus*	Brandenburg, Germany	2	Durr 2004
Common Tern *Sterna hirundo*	East-dam, Zeebrugge	3	Everaert *et. al.* 2002
Common Tern *Sterna hirundo*	Boudewijn-canal, Brugge	1	Everaert *et. al.* 2003
Common Tern *Sterna hirundo*	East-dam, Zeebrugge	4	Everaert *et. al.* 2003
Great Black-backed Gull *Larus marinus*	East-dam, Zeebrugge	1	Everaert *et. al.* 2002
Great Black-backed Gull *Larus marinus*	East-dam, Zeebrugge	5	Everaert *et. al.* 2003
Herring Gull *Larus argentatus*	Wisconsin	1	Erickson *et. al.* 2001
Herring Gull *Larus argentatus*	Buffalo Ridge	1	Johnson *et. al.* 2002
Herring Gull *Larus argentatus*	East-dam, Zeebrugge	34	Everaert *et. al.* 2002
Herring Gull *Larus argentatus*	Boudewijn-canal, Brugge	7	Everaert *et. al.* 2002
Herring Gull *Larus argentatus*	Boudewijn-canal, Brugge	97	Everaert *et. al.* 2003
Herring Gull *Larus argentatus*	East-dam, Zeebrugge	34	Everaert *et. al.* 2003
Herring Gull *Larus argentatus*	Kreekrak, Netherlands	1	Musters *et. al.* 1996
Herring Gull *Larus argentatus*	Sachsen, Germany	4	Durr 2004
Herring Gull *Larus argentatus*	Niedersachsen, Germany	3	Durr 2004
Herring Gull *Larus argentatus*	Buffalo Ridge	1	Strickland *et. al.* 2000
Kittiwake *Rissa tridactyla*	East-dam, Zeebrugge	1	Everaert *et. al.* 2002
Lesser Black-backed Gull *Larus fuscus*	Niedersachsen, Germany	1	Durr 2004
Lesser Black-backed Gull *Larus fuscus*	East-dam, Zeebrugge	8	Everaert *et. al.* 2002
Lesser Black-backed Gull *Larus fuscus*	Boudewijn-canal, Brugge	1	Everaert *et. al.* 2002
Lesser Black-backed Gull *Larus fuscus*	Boudewijn-canal, Brugge	25	Everaert *et. al.* 2003
Lesser Black-backed Gull *Larus fuscus*	East-dam, Zeebrugge	10	Everaert *et. al.* 2003
Little Gull *Larus minumus*	Kreekrak, Netherlands	1	Musters *et. al.* 1996
Little Tern *Sterna albifrons*	East-dam, Zeebrugge	2	Everaert *et. al.* 2002
Little Tern *Sterna albifrons*	East-dam, Zeebrugge	2	Everaert *et. al.* 2003
Ring-billed Gull *Larus delawarensis*	Altamont Wind Resource Area	4	Smallwood & Thelander 2004
gull sp.	McBride Lake, AB	2	Brown & Hamilton 2004
gull sp.	Altamont Wind Resource Area	4	Erickson *et. al.* 2001
gull sp.	Altamont Wind Resource Area	18	Smallwood & Thelander 2004

Table A16. Summary list of Auk species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference

Guillemot *Uria aalge*	Niedersachsen, Germany	1	Durr 2004

Table A17. Summary list of Pigeon and Dove species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Columba sp.	Guennda, Spain	1	Lekuona 2001
Columba sp.	Izco, Spain	1	Lekuona 2001
Domestic Dove	Boudewijn-canal, Brugge	2	Everaert *et. al.* (2002)
Mourning Dove *Zenaida macroura*	Altamont Wind Resource Area	1	Thelander & Rugge 2000
Mourning Dove *Zenaida macroura*	Alberta - Castle River	2	Brown & Hamilton 2002
Mourning Dove *Zenaida macroura*	Montezuma Hills	1	Howell & Noone 1992, Howell 1997
Mourning Dove *Zenaida macroura*	Altamont Wind Resource Area	34	Smallwood & Thelander 2004
Mourning Dove *Zenaida macroura*	Foote Creek Rim	1	Johnson *et. al.* 2001
Mourning Dove *Zenaida macroura*	Tehachapi Pass	6	Anderson *et. al.* 2000
Mourning Dove *Zenaida macroura*	San Gorgonio	1	Anderson *et. al.* 2000
Mourning Dove *Zenaida macroura*	Castle River, Alberta	2	Brown pers. comm.
Rock Pigeon *Columba livia f. domestica*	Brandenburg, Germany	3	Durr 2004
Rock Pigeon *Columba livia f. domestica*	Brandenburg, Germany	3	Durr 2004
Rock Pigeon *Columba livia f. domestica*	Boudewijn-canal, Brugge	2	Everaert *et. al.* 2003
Rock Pigeon *Columba livia f. domestica*	East-dam, Zeebrugge	2	Everaert *et. al.* 2003
Rock Pigeon *Columba livia f. domestica*	Schelle	3	Everaert *et. al.* 2003
Rock Pigeon *Columba livia*	Stateline OR	1	West Inc., & Northwest Wildlife Consultants 2004
Rock Pigeon *Columba livia*	Altamont Wind Resource Area	15	Thelander & Rugge 2000
Rock Pigeon *Columba livia*	Alberta - Castle River	1	Brown & Hamilton 2002
Rock Pigeon *Columba livia*	Altamont Wind Resource Area	92	Erickson *et. al.* 2001
Rock Pigeon *Columba livia*	Altamont Wind Resource Area	196	Smallwood & Thelander 2004
Rock Pigeon *Columba livia*	Montezuma Hills	3	Howell & Noone 1992, Howell 1997
Rock Pigeon *Columba livia*	Castle River, Alberta	1	Brown pers. comm.
Rock Pigeon *Columba livia*	Tehachapi Pass	9	Anderson *et. al.* 2000
Rock Pigeon *Columba livia*	Mountaineer	1	Kerns & Kerlinger 2004
Rock Pigeon *Columba livia*	San Gorgonio	8	Anderson *et. al.* 2000
Stock Dove *Columba oenas*	Boudewijn-canal, Brugge	1	Everaert *et. al.* 2003
Wood Pigeon *Columba palumbus*	Boudewijn-canal, Brugge	1	Everaert *et. al.* 2003
Wood Pigeon *Columba palumbus*	Brandenburg, Germany	1	Durr 2004
Wood Pigeon *Columba palumbus*	Sachsen-Anhalt, Germany	1	Durr 2004
Wood Pigeon *Columba palumbus*	Sachsen-Anhalt, Germany	1	Durr 2004

Wood Pigeon *Columba palumbus*	Brandenburg, Germany	1	Durr 2004
Wood Pigeon *Columba palumbus*	Guennda, Spain	1	Lekuona 2001

Table A18. Summary list of Cuckoo and Roadrunner (Cuculidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Black-billed Cuckoo *Coccyzus erythropthalmus*	Mountaineer	2	Kerns & Kerlinger 2004
Cuckoo *Cuculus canorus*	El Perdon, Spain	1	Lekuona 2001
Greater Roadrunner *Geococcyx californianus*	Tehachapi Pass	2	Anderson *et. al.* 2000
Yellow-billed Cuckcoo *Coccyzus americanus*	Mountaineer	4	Kerns & Kerlinger 2004

Table A19. Summary list of owls that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Barn Owl *Tyto alba*	Altamont Wind Resource Area	4	Thelander & Rugge 2000
Barn Owl *Tyto alba*	Altamont Wind Resource Area	25	Erickson *et. al.* 2001
Barn Owl *Tyto alba*	Montezuma Hills	1	Howell & Noone 1992, Howell 1997
Barn Owl *Tyto alba*	Altamont Wind Resource Area	50	Smallwood & Thelander 2004
Barn Owl *Tyto alba*	Tehachapi Pass	2	Anderson *et. al.* 2000
Burrowing Owl *Athene cunicularia*	Altamont Wind Resource Area	27	Erickson *et. al.* 2001
Burrowing Owl *Athene cunicularia*	Altamont Wind Resource Area	4	Thelander & Rugge 2000
Burrowing Owl *Athene cunicularia*	Altamont Wind Resource Area	70	Smallwood & Thelander 2004
Burrowing Owl *Athene cunicularia*	San Gorgonio	1	Anderson *et. al.* 2000
Eagle Owl *Bubo bubo*	Nordrhein-Westfalen, Germany	3	Durr 2004
Eagle Owl *Bubo bubo*	Baden-Wurttemberg, Germany	1	Durr 2004
Eagle Owl *Bubo bubo*	Salajones, Spain	1	Leukuona 2001
Eagle Owl *Bubo bubo*	PESUR	2	Marti & Barrios 1995
Eagle Owl *Bubo bubo*	E3	2	Marti & Barrios 1995
Flammulated Owl *Otus flammeolus*	Tehachapi Pass	1	Anderson *et. al.* 2000
Great Horned Owl *Bubo virginianus*	Altamont Wind Resource Area	7	Erickson *et. al.* 2001
Great Horned Owl *Bubo virginianus*	Montezuma Hills	2	Howell & Noone 1992, Howell 1997
Great Horned Owl *Bubo virginianus*	Altamont Wind Resource Area	18	Smallwood & Thelander 2004
Great Horned Owl *Bubo virginianus*	Tehachapi Pass	10	Anderson *et. al.* 2000
Long-eared Owl *Asio otus*	Tehachapi Pass	1	Anderson *et. al.* 2000

Short-eared Owl *Asio flammeus*	McBride Lake, AB	2	Brown & Hamilton 2004
Short-eared Owl *Asio flammeus*	Foote Creek Rim	1	Johnson *et. al.* 2001
Short-eared Owl Asio flammeus	Nine Canyon, Wyoming	1	Erickson *et. al.* 2003
Unidentified Owl	Altamont Wind Resource Area	10	Erickson *et. al.* 2001

Table A20. Summary list of Nighthawk and Nightjar (Caprimulgidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Common Nighthawk *Chordeiles minor*	Foote Creek Rim	1	Johnson *et. al.* 2001
Common Poorwill *Phalaenoptilus nuttallii*	Foote Creek Rim	1	Johnson *et. al.* 2001

Table A21. Summary list of Woodpecker (Picidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Great-spotted Woodpecker *Dendrocopus major*	Brandenburg, Germany	1	Durr 2004
Lewis Woodpecker	Vansycle, OR	1	Strickland *et. al.* 2000c
Northern Flicker *Colaptes auratus*	Altamont Wind Resource Area	6	Smallwood & Thelander 2004
Northern Flicker *Colaptes auratus*	Montezuma Hills	1	Howell & Noone 1992, Howell 1997
Northern Flicker *Colaptes auratus*	Tehachapi Pass	3	Anderson *et. al.* 2000
Northern Flicker *Colaptes auratus*	Castle River, Alberta	1	Brown pers. comm.
Northern Flicker *Colaptes auratus*	Stateline OR	1	West Inc., & Northwest Wildlife Consultants 2004
Yellow-bellied Sapsucker *Sphyrapicus varius*	Wisconsin	1	Erickson *et. al.* 2001

Table A22. Summary list of Flycatcher (Tyrannidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Eastern Kingbird *Tyrannus tyrannus*	Wisconsin	1	Erickson *et. al.* 2001
Flycatcher sp.	Buffalo Ridge	2	Johnson *et. al.* 2002
Least Flycatcher *Empidonax minimus*	Buffalo Ridge	1	Johnson *et. al.* 2002
Pacific-slope Flycatcher *Empidonax difficilis*	Altamont Wind Resource Area	1	Smallwood & Thelander 2004
Pied Flycatcher *Ficedula hypoleuca*	Brandenburg, Germany	1	Durr 2004
Say's Phoebe *Sayornis nigricans*	Altamont Wind Resource Area	1	Smallwood & Thelander 2004

Western Kingbird *Tyrannus verticalis*	Altamont Wind Resource Area	1	Smallwood & Thelander 2004

Table A23. Summary list of Shrike (Laniidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Loggerhead Shrike *Lanius ludovicianus*	Altamont Wind Resource Area	1	Erickson *et. al.* 2001
Loggerhead Shrike *Lanius ludovicianus*	Altamont Wind Resource Area	5	Smallwood & Thelander 2004

Table A24. Summary list of Vireo (Vireonidae)species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Red-eyed Vireo *Vireo olivaceus*	Mountaineer	21	Kerns & Kerlinger 2004
Warbling Vireo *Vireo gilvus*	Foote Creek Rim	1	Johnson *et. al.* 2001
Warbling Vireo *Vireo gilvus*	Buffalo Ridge	1	Johnson *et. al.* 2002
Yellow-throated Vireo *Vireo flavifrons*	Iowa	1	Koford 2003

Table A25. Summary list of Crow and Jay (Corvidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
American Crow *Corvus brachyrhynchos*	Altamont Wind Resource Area	7	Smallwood & Thelander 2004
Black-billed Magpie Pica pica	Schelle	1	Everaert *et. al.* 2003
Black-billed Magpie Pica pica	Sachsen-Anhalt, Germany	1	Durr 2004
Black-billed Magpie Pica pica	Stateline OR	1	West Inc., & Northwest Wildlife Consultants 2004
Common Raven *Corvus corax*	Altamont Wind Resource Area	12	Smallwood & Thelander 2004
Common Raven *Corvus corax*	Tehachapi Pass	3	Anderson *et. al.* 2000
Common Raven *Corvus corax*	San Gorgonio	1	Anderson *et. al.* 2000
Common Raven *Corvus corax*	Montezuma Hills	1	Howell & Noone 1992, Howell 1997
Common Raven *Corvus corax*	Altamont Wind Resource Area	9	Erickson *et. al.* 2001
Corvus sp.	Niedersachsen, Germany	1	Durr 2004
Hooded Crow *Corvus corone*	Hessen, BW, Germany	1	Durr 2004
Hooded Crow *Corvus corone*	Brandenburg, Germany	1	Durr 2004
Raven *Corvus corax*	Brandenburg, Germany	3	Durr 2004
Rook *Corvus frugilegus*	Sachsen-Anhalt, Germany	1	Durr 2004

Western Scrub-jay *Aphelocoma californica*	Tehachapi Pass	1	Anderson *et. al.* 2000

Table A26. Summary list of Lark (Alaudidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Horned Lark *Eremophila alpestris*	Stateline OR	48	West Inc., & Northwest Wildlife Consultants 2004
Horned Lark *Eremophila alpestris*	Stateline WA	33	West Inc., & Northwest Wildlife Consultants 2004
Horned Lark *Eremophila alpestris*	Altamont Wind Resource Area	23	Smallwood & Thelander 2004
Horned Lark *Eremophila alpestris*	Nine Canyon, Washington	17	Erickson et. al 2003
Horned Lark *Eremophila alpestris*	McBride Lake, AB	4	Brown & Hamilton 2004
Horned Lark *Eremophila alpestris*	Wisconsin	1	Erickson *et. al.* 2001
Horned Lark *Eremophila alpestris*	Altamont Wind Resource Area	5	Thelander & Rugge 2000
Horned Lark *Eremophila alpestris*	Altamont Wind Resource Area	14	Erickson *et. al.* 2001
Horned Lark *Eremophila alpestris*	Foote Creek Rim	28	Johnson *et. al.* 2001
Horned Lark *Eremophila alpestris*	Ponnequin, CO	5	Erickson *et. al.* 2001
Horned Lark *Eremophila alpestris*	Tehachapi Pass	2	Anderson *et. al.* 2000
Horned Lark *Eremophila alpestris*	Vansycle, OR	1	Strickland *et. al.* 2000c
Sky Lark *Alauda arvensis*	Brandenburg, Germany	4	Durr 2004
Sky Lark *Alauda arvensis*	El Perdon, Spain	2	Lekuona 2001
Woodlark *Lullula arborea*	Guennda, Spain	1	Lekuona 2001
Woodlark *Lullula arborea*	El Perdon, Spain	4	Lekuona 2001

Table A27. Summary list of Swallow (Hirundinidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Barn Swallow *Hirundo rustica*	Wisconsin	1	Erickson *et. al.* 2001
Barn Swallow *Hirundo rustica*	Buffalo Ridge	1	Strickland *et. al.* 2000
Barn Swallow *Hirundo rustica*	Buffalo Ridge	4	Johnson *et. al.* 2002
Barn Swallow *Hirundo rustica*	El Perdon, Spain	1	Lekuona 2001
Chimney Swift *Chaetura pelagica*	Wisconsin	1	Erickson *et. al.* 2001
Cliff Swallow *Hirundo pyrrhonota*	Altamont Wind Resource Area	5	Smallwood & Thelander 2004
Cliff Swallow *Hirundo pyrrhonota*	Altamont Wind Resource Area	2	Thelander & Rugge 2000
Cliff Swallow *Hirundo pyrrhonota*	Altamont Wind Resource Area	3	Erickson *et. al.* 2001
Cliff Swallow *Hirundo pyrrhonota*	Foote Creek Rim	1	Johnson *et. al.* 2001

House Martin *Delichon urbica*	Brandenburg, Germany	1	Durr 2004
House Martin *Delichon urbica*	Guennda, Spain	1	Lekuona 2001
Purple Martin *Progne subis*	Buffalo Ridge	1	Johnson *et. al.* 2002
Swallow spp.	Foote Creek Rim	1	Johnson *et. al.* 2001
Swift *Apus apus*	Brandenburg, Germany	3	Durr 2004
Swift *Apus apus*	Sachsen-Anhalt, Germany	2	Durr 2004
Swift *Apus apus*	Sachsen-Anhalt, Germany	2	Durr 2004
Swift *Apus apus*	Brandenburg, Germany	3	Durr 2004
Swift *Apus apus*	Izco, Spain	1	Lekuona 2001
Swift *Apus apus*	East-dam, Zeebrugge	2	Everaert *et. al.* (2002)
Tree Swallow *Tachycineta bicolor*	Foote Creek Rim	1	Johnson *et. al.* 2001
Tree Swallow *Tachycineta bicolor*	Wisconsin	2	Erickson *et. al.* 2001
Tree Swallow Tachycineta bicolor	Iowa	1	Koford 2003
Violet-green Swallow *Tachycineta thalassina*	Altamont Wind Resource Area	1	Erickson *et. al.* 2001
Violet-green Swallow Tachycineta thalassina	Altamont Wind Resource Area	1	Smallwood & Thelander 2004
White-throated Swift *Apus apus*	Vansycle, OR	1	Strickland *et. al.* 2000c
White-throated Swift *Apus apus*	Ponnequin, CO	2	Erickson *et. al.* 2001
White-throated Swift *Apus apus*	San Gorgonio	1	Anderson *et. al.* 2000

Table A28. Summary list of Chickadee (Paridae), Creeper (Certhiidae), and Nuthatch (Sittidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Brown Creeper *Certhia americana*	Foote Creek Rim	2	Johnson *et. al.* 2001
Great Tit *Parus major*	Brandenburg, Germany	1	Durr 2004
Red-breasted Nuthatch *Sitta canadensis*	Stateline OR	2	West Inc., & Northwest Wildlife Consultants 2004
Red-breasted Nuthatch *Sitta canadensis*	Nine Canyon, Washington	1	Erickson et. al 2003

Table A29. Summary list of Wren (Troglodytidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
House Wren *Troglodytes aedon*	Foote Creek Rim	2	Johnson *et. al.* 2001
House Wren *Troglodytes aedon*	Stateline OR	1	West Inc., & Northwest Wildlife Consultants 2004
House Wren *Troglodytes aedon*	Klondike, Oregon	1	Jonson *et. al.* 2003
House Wren *Troglodytes aedon*	Stateline WA	2	West Inc., & Northwest Wildlife Consultants 2004

Rock Wren *Salpinctes obsoletus*	Foote Creek Rim	4	Johnson *et. al.* 2001
Rock Wren *Salpinctes obsoletus*	Tehachapi Pass	1	Anderson *et. al.* 2000
Sedge Wren *Cistothorus platensis*	Buffalo Ridge	2	Johnson *et. al.* 2002
Winter Wren *Troglodytes troglodytes*	Stateline WA	2	West Inc., & Northwest Wildlife Consultants 2004
Winter Wren *Troglodytes troglodytes*	Stateline OR	2	West Inc., & Northwest Wildlife Consultants 2004
Winter Wren *Troglodytes troglodytes*	Nine Canyon, Washington	1	Erickson et. al 2003

Table A30. Summary list of Kinglet (Regulidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Firecrest *Regulus ignicapillus*	Brandenburg, Germany	1	Durr 2004
Firecrest *Regulus ignicapillus*	Izco, Spain	1	Lekuona 2001
Goldcrest *Regulus regulus*	Brandenburg, Germany	1	Durr 2004
Goldcrest *Regulus regulus*	East-dam, Zeebrugge	1	Everaert *et. al.* 2003
Golden-crowned Kinglet *Regulus satrapa*	Wisconsin	2	Erickson *et. al.* 2001
Golden-crowned Kinglet *Regulus satrapa*	Castle River, Alberta	1	Brown pers. comm.
Golden-crowned Kinglet *Regulus satrapa*	Klondike, Oregon	1	Johnson *et. al.* 2003
Golden-crowned Kinglet *Regulus satrapa*	Stateline OR	10	West Inc., & Northwest Wildlife Consultants 2004
Golden-crowned Kinglet *Regulus satrapa*	Stateline WA	10	West Inc., & Northwest Wildlife Consultants 2004
Ruby-crowned Kinglet *Regulus calendula*	Stateline OR	1	West Inc., & Northwest Wildlife Consultants 2004
Ruby-crowned Kinglet *Regulus calendula*	McBride Lake, AB	1	Brown & Hamilton 2004
Ruby-crowned Kinglet *Regulus calendula*	Buffalo Ridge	1	Strickland *et. al.* 2000
Ruby-crowned Kinglet *Regulus calendula*	Foote Creek Rim	1	Johnson *et. al.* 2001
Ruby-crowned Kinglet *Regulus calendula*	Buffalo Ridge	1	Johnson *et. al.* 2002
Ruby-crowned Kinglet *Regulus calendula*	Nine Canyon, Washington	1	Erickson et. al 2003
Ruby-crowned Kinglet *Regulus calendula*	Klondike, Oregon	1	Johnson *et. al.* 2003

Table A31. Summary list of Thrush (Turdidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
American Robin *Turdus migratorius*	Foote Creek Rim	1	Johnson *et. al.* 2001
American Robin *Turdus migratorius*	Castle River, Alberta	1	Brown pers. comm.
American Robin *Turdus migratorius*	Mountaineer	1	Kerns & Kerlinger 2004

American Robin *Turdus migratorius*	Exhibition Place, Toronto	1	James & Cody 2003
Black Redstart *Phoenicurus ochruros*	El Perdon, Spain	2	Lekuona 2001
Blackbird *Turdus merula*	Izco, Spain	1	Lekuona 2001
Blackbird *Turdus merula*	Guennda, Spain	1	Lekuona 2001
Blackbird *Turdus merula*	El Perdon, Spain	1	Lekuona 2001
Blackbird *Turdus merula*	Boudewijn-canal, Brugge	1	Everaert *et. al.* 2003
Fieldfare *Turdus pilaris*	Sachsen-Anhalt, Germany	1	Durr 2004
Hermit Thrush *Catharus guttatus*	Foote Creek Rim	1	Johnson *et. al.* 2001
Mountain Bluebird *Sialia curruccoides*	Altamont Wind Resource Area	2	Erickson *et. al.* 2001
Mountain Bluebird *Sialia curruccoides*	Foote Creek Rim	2	Johnson *et. al.* 2001
Mountain Bluebird *Sialia curruccoides*	Altamont Wind Resource Area	5	Smallwood & Thelander 2004
Redwing *Turdus iliacus*	Schleswig-Holstein, Germany	1	Durr 2004
Robin *Erithacus rubecula*	East-dam, Zeebrugge	1	Everaert *et. al.* (2002)
Song Thrush *Turdus philomelos*	East-dam, Zeebrugge	2	Everaert *et. al.* (2002)
Song Thrush *Turdus philomelos*	Boudewijn-canal, Brugge	1	Everaert *et. al.* 2003
Song Thrush *Turdus philomelos*	East-dam, Zeebrugge	1	Everaert *et. al.* 2003
Stonechat *Saxicola torquata*	El Perdon, Spain	1	Lekuona 2001
Swainson's Thrush *Catharus ustulatus*	Stateline WA	1	West Inc., & Northwest Wildlife Consultants 2004
Veery *Catharus fuscescens*	Mountaineer	1	Kerns & Kerlinger 2004
Western Bluebird *Sialia mexicana*	Altamont Wind Resource Area	2	Erickson *et. al.* 2001
Winchat *Saxicola rubetra*	Brandenburg, Germany	1	Durr 2004
Wood Thrush *Hylocichla mustelina*	Mountaineer	3	Kerns & Kerlinger 2004

Table A32. Summary list of Mimic (Mimidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Gray Catbird *Dumetalla carolinensis*	Buffalo Ridge	1	Johnson *et. al.* 2002
Northern Mockingbird *Mimus polyglottos*	Altamont Wind Resource Area	1	Smallwood & Thelander 2004
Sage Thrasher *Oreoscoptes montanus*	Foote Creek Rim	1	Johnson *et. al.* 2001

Table A33. Summary list of Starling (Sturnidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
European Starling *Sturnus vulgaris*	Nine Canyon, Washington	1	Erickson et. al 2003

European Starling	*Sturnus vulgaris*	Altamont Wind Resource Area	67	Smallwood & Thelander 2004
European Starling	*Sturnus vulgaris*	McBride Lake, AB	5	Brown & Hamilton 2004
European Starling	*Sturnus vulgaris*	Tehachapi Pass	1	Anderson *et. al.* 2000
European Starling	*Sturnus vulgaris*	San Gorgonio	1	Anderson *et. al.* 2000
European Starling	*Sturnus vulgaris*	Altamont Wind Resource Area	4	Thelander & Rugge 2000
European Starling	*Sturnus vulgaris*	Altamont Wind Resource Area	17	Erickson *et. al.* 2001
European Starling	*Sturnus vulgaris*	Wisconsin	3	Erickson *et. al.* 2001
European Starling	*Sturnus vulgaris*	Solano Wind Resource Area	1	Bryne 1983
European Starling	*Sturnus vulgaris*	Buffalo Ridge	1	Johnson *et. al.* 2002
European Starling	*Sturnus vulgaris*	Kreekrak, Netherlands	1	Musters *et. al.* 1996
European Starling	*Sturnus vulgaris*	Exhibition Place, Toronto	1	James & Cody 2003
European Starling	*Sturnus vulgaris*	Mountaineer	1	Kerns & Kerlinger 2004
European Starling	*Sturnus vulgaris*	Stateline OR	4	West Inc., & Northwest Wildlife Consultants 2004
European Starling	*Sturnus vulgaris*	Stateline WA	1	West Inc., & Northwest Wildlife Consultants 2004
European Starling	*Sturnus vulgaris*	Boudewijn-canal, Brugge	8	Everaert *et. al.* 2003
European Starling	*Sturnus vulgaris*	Schelle	1	Everaert *et. al.* 2003
European Starling	*Sturnus vulgaris*	Brandenburg, Germany	2	Durr 2004
European Starling	*Sturnus vulgaris*	Sachsen, Germany	1	Durr 2004
European Starling	*Sturnus vulgaris*	Niedersachsen, Germany	1	Durr 2004
European Starling	*Sturnus vulgaris*	Klondike, Oregon	1	Johnson *et. al.* 2003

Table A34. Summary list of Wagtail and Pipit (Motacillidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
American Pipit *Anthus rubescens*	Foote Creek Rim	1	Johnson *et. al.* 2001
American Pipit *Anthus rubescens*	Stateline WA	1	West Inc., & Northwest Wildlife Consultants 2004
American Pipit *Anthus rubescens*	Montezuma Hills	1	Howell & Noone 1992, Howell 1997
Tawny Pipit *Anthus campestris*	Guennda, Spain	2	Lekuona 2001
White Wagtail *Motacilla alba*	Brandenburg, Germany	1	Durr 2004
White Wagtail *Motacilla alba*	East-dam, Zeebrugge	1	Everaert *et. al.* 2003
Yellow Wagtail *Motacilla flava*	Brandenburg, Germany	1	Durr 2004

Table A35. Summary list of Old World Warbler (Sylviinae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Blackcap *Sylvia atricapilla*	Izco, Spain	1	Lekuona 2001
Blackcap *Sylvia atricapilla*	Alaiz, Spain	1	Lekuona 2001
Blackcap *Sylvia atricapilla*	Guennda, Spain	2	Lekuona 2001
Marsh Warbler *Acrocephalus palustris*	Niedersachsen, Germany	1	Durr 2004
Whitethroat *Sylvia communis*	Guennda, Spain	1	Lekuona 2001

Table A36. Summary list of Wood Warbler (Parulidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
American Redstart *Setophaga ruticilla*	Mountaineer	2	Kerns & Kerlinger 2004
Black-and-white Warbler *Mniotilta varia*	Buffalo Ridge	3	Johnson *et. al.* 2002
Blackpoll Warbler *Dendroica striata*	Buffalo Ridge	1	Johnson *et. al.* 2002
Blackpoll Warbler *Dendroica striata*	Mountaineer	3	Kerns & Kerlinger 2004
Black-throated Blue Warbler *Dendroica caerulescens*	Mountaineer	1	Kerns & Kerlinger 2004
Black-throated Gray Warbler *Dendroica nigrescens*	Altamont Wind Resource Area	1	Smallwood & Thelander 2004
Black-throated Gray Warbler *Dendroica nigrescens*	Altamont Wind Resource Area	1	Thelander & Rugge 2000
Canada Warbler *Wilsonia canadensis*	Mountaineer	1	Kerns & Kerlinger 2004
Chestnut-sided Warbler *Dendroica pensylvanica*	Mountaineer	1	Kerns & Kerlinger 2004
Common Yellowthroat *Geothlypis trichas*	Buffalo Ridge	7	Johnson *et. al.* 2002
Common Yellowthroat *Geothlypis trichas*	Mountaineer	1	Kerns & Kerlinger 2004
Hooded Warbler *Wilsonia citrina*	Mountaineer	1	Kerns & Kerlinger 2004
Macgillivray's Warbler *Oporonis tolmiei*	Foote Creek Rim	1	Johnson *et. al.* 2001
Macgillivray's Warbler *Oporonis tolmiei*	Stateline OR	1	West Inc., & Northwest Wildlife Consultants 2004
Magnolia Warbler *Dendroica magnolia*	Buffalo Ridge	1	Johnson *et. al.* 2002
Magnolia Warbler *Dendroica magnolia*	Mountaineer	5	Kerns & Kerlinger 2004
Orange-crowned Warbler *Vermivora celata*	Buffalo Ridge	4	Johnson *et. al.* 2002
Towsend's Warbler *Dendroica towsendi*	Altamont Wind Resource Area	1	Thelander & Rugge 2000
Towsend's Warbler *Dendroica towsendi*	Foote Creek Rim	3	Johnson *et. al.* 2001
Towsend's Warbler *Dendroica towsendi*	Altamont Wind Resource Area	1	Smallwood & Thelander 2004
Wilson's Warbler *Wilsonia pusilla*	Foote Creek Rim	3	Johnson *et. al.* 2001
Yellow Warbler *Dendroica petechia*	Altamont Wind Resource Area	1	Smallwood & Thelander 2004
Yellow-rumped Warbler *Dendroica coronata*	Tehachapi Pass	1	Anderson *et. al.* 2000
Yellow-rumped Warbler *Dendroica coronata*	Castle River, Alberta	1	Brown pers. comm.
Yellow-rumped Warbler *Dendroica coronata*	Foote Creek Rim	1	Johnson *et. al.* 2001

Yellow-rumped Warbler	*Dendroica coronata*	Solano Wind Resource Area	1	Bryne 1983
Yellow-rumped Warbler	*Dendroica coronata*	Stateline OR	3	West Inc., & Northwest Wildlife Consultants 2004
Yellow-rumped Warbler	*Dendroica coronata*	Stateline WA	1	West Inc., & Northwest Wildlife Consultants 2004
Yellow-rumped Warbler	*Dendroica coronata*	Buffalo Ridge	1	Johnson *et. al.* 2002
Yellow-rumped Warbler	*Dendroica coronata*	Nine Canyon, Washington	1	Erickson et. al 2003

Table A37. Summary list of Emberizid (Emberizidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Brewer's Sparrow *Spizella breweri*	Foote Creek Rim	5	Johnson *et. al.* 2001
Chipping Sparrow *Spizella passerina*	Buffalo Ridge	1	Johnson *et. al.* 2002
Chipping Sparrow *Spizella passerina*	Foote Creek Rim	5	Johnson *et. al.* 2001
Corn Bunting *Emberiza calandra*	Brandenburg, Germany	9	Durr 2004
Dark-eyed Junco *Junco hyemalis*	Foote Creek Rim	1	Johnson *et. al.* 2001
Dark-eyed Junco *Junco hyemalis*	Stateline WA	2	West Inc., & Northwest Wildlife Consultants 2004
Dark-eyed Junco *Junco hyemalis*	McBride Lake, AB	2	Brown & Hamilton 2004
Dark-eyed Junco *Junco hyemalis*	Tehachapi Pass	1	Anderson *et. al.* 2000
Dark-eyed Junco *Junco hyemalis*	Klondike, Oregon	1	Johnson *et. al.* 2003
Dark-eyed Junco *Junco hyemalis*	Stateline OR	1	West Inc., & Northwest Wildlife Consultants 2004
Golden-crowned Sparrow *Zonotrichia atricapilla*	Stateline OR	1	West Inc., & Northwest Wildlife Consultants 2004
Golden-crowned Sparrow *Zonotrichia atricapilla*	Stateline WA	2	West Inc., & Northwest Wildlife Consultants 2004
Grasshopper Sparrow *Ammodramus savannarum*	Stateline OR	1	West Inc., & Northwest Wildlife Consultants 2004
Green-tailed Towhee *Pipilo chlorurus*	Foote Creek Rim	2	Johnson *et. al.* 2001
Lark Bunting *Calamospiza melanocorys*	Foote Creek Rim	1	Johnson *et. al.* 2001
Lincoln's Sparrow *Melospiza lincolnii*	Buffalo Ridge	1	Strickland *et. al.* 2000
Lincoln's Sparrow *Melospiza lincolnii*	Buffalo Ridge	1	Johnson *et. al.* 2002
McCown's Longspur *Calcarius mccownii*	Ponnequin, CO	1	Erickson *et. al.* 2001
Savannah Sparrow *Passerculus sandwichensis*	Wisconsin	2	Erickson *et. al.* 2001
Savannah Sparrow *Passerculus sandwichensis*	Altamont Wind Resource Area	2	Smallwood & Thelander 2004
Savannah Sparrow *Passerculus sandwichensis*	Stateline WA	1	West Inc., & Northwest Wildlife

			Consultants 2004
Savannah Sparrow *Passerculus sandwichensis*	Stateline OR	1	West Inc., & Northwest Wildlife Consultants 2004
Sparrow spp.	Stateline OR	1	West Inc., & Northwest Wildlife Consultants 2004
Sparrow spp.	Alberta - Castle River	1	Brown & Hamilton 2002
Sparrow spp.	Vansycle, OR	1	Strickland *et. al.* 2000c
Sparrow spp.	Castle River, Alberta	2	Brown pers. comm.
Sparrow spp.	McBride Lake, AB	3	Brown & Hamilton 2004
Sparrow spp.	Tehachapi Pass	1	Anderson *et. al.* 2000
Spotted Towhee *Pipilo maculatus*	Nine Canyon, Washington	1	Erickson et. al 2003
Swamp Sparrow *Melospiza georgiana*	Mountaineer	1	Kerns & Kerlinger 2004
Vesper Sparrow *Pooecetes gramineus*	Buffalo Ridge	2	Johnson *et. al.* 2002
Vesper Sparrow *Pooecetes gramineus*	Stateline WA	2	West Inc., & Northwest Wildlife Consultants 2004
Vesper Sparrow *Pooecetes gramineus*	Foote Creek Rim	7	Johnson *et. al.* 2001
White-crowned Sparrow *Zonotrichia albicollis*	Stateline WA	3	West Inc., & Northwest Wildlife Consultants 2004
White-crowned Sparrow *Zonotrichia albicollis*	Foote Creek Rim	2	Johnson *et. al.* 2001
White-crowned Sparrow *Zonotrichia albicollis*	Vansycle, OR	4	Strickland *et. al.* 2000c
White-crowned Sparrow *Zonotrichia albicollis*	Stateline OR	2	West Inc., & Northwest Wildlife Consultants 2004

Table A38. Summary list of Cardinal (Cardinalidae) and Finch (Fringillidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
American Goldfinch *Carduelis tristis*	Wisconsin	1	Erickson *et. al.* 2001
Chaffinch *Fringilla coelebs*	Izco, Spain	1	Lekuona 2001
Crossbill *Loxia curvirostra*	Alaiz, Spain	1	Lekuona 2001
Dickcissel *Spiza americana*	Buffalo Ridge	1	Strickland *et. al.* 2000
Dickcissel *Spiza americana*	Buffalo Ridge	1	Johnson *et. al.* 2002
Greenfinch *Carduelis chloris*	Brandenburg, Germany	2	Durr 2004
House Finch *Carpodacus mexicanus*	Altamont Wind Resource Area	3	Erickson *et. al.* 2001
House Finch *Carpodacus mexicanus*	Stateline WA	1	West Inc., & Northwest Wildlife Consultants 2004
House Finch *Carpodacus mexicanus*	Altamont Wind Resource Area	18	Smallwood & Thelander 2004
Indigo Bunting *Passerina cyanea*	Mountaineer	1	Kerns & Kerlinger 2004

Linnet *Carduelis cannabina*	El Perdon, Spain	3	Lekuona 2001
Rose-breasted Grosbeak *Pheucticus ludovicianus*	Mountaineer	3	Kerns & Kerlinger 2004

Table A39. Summary list of Blackbird (Icteridae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Blackbird spp.	Altamont Wind Resource Area	1	Smallwood & Thelander 2004
Blackbird spp.	Altamont Wind Resource Area	1	Thelander & Rugge 2000
Blackbird spp.	Foote Creek Rim	2	Johnson *et. al.* 2001
Brewer's Blackbird *Euphagus caroilnus*	Altamont Wind Resource Area	13	Smallwood & Thelander 2004
Brewer's Blackbird *Euphagus caroilnus*	Tehachapi Pass	1	Anderson *et. al.* 2000
Brewer's Blackbird *Euphagus caroilnus*	Altamont Wind Resource Area	8	Erickson *et. al.* 2001
Brown-headed Cowbird *Molothrus ater*	Altamont Wind Resource Area	2	Smallwood & Thelander 2004
Brown-headed Cowbird *Molothrus ater*	Klondike, Oregon	1	Johnson *et. al.* 2003
Common Grackle *Quiscalus quiscula*	Buffalo Ridge	1	Johnson *et. al.* 2002
Red-winged Blackbird *Agelaius phoeniceus*	Altamont Wind Resource Area	2	Erickson *et. al.* 2001
Red-winged Blackbird *Agelaius phoeniceus*	Stateline WA	1	West Inc., & Northwest Wildlife Consultants 2004
Red-winged Blackbird *Agelaius phoeniceus*	Montezuma Hills	2	Howell & Noone 1992, Howell 1997
Red-winged Blackbird *Agelaius phoeniceus*	Wisconsin	1	Erickson *et. al.* 2001
Red-winged Blackbird *Agelaius phoeniceus*	Castle River, Alberta	1	Brown pers. comm.
Red-winged Blackbird Agelaius phoeniceus	Altamont Wind Resource Area	12	Smallwood & Thelander 2004
Tricolored Blackbird *Agelaius tricolor*	Altamont Wind Resource Area	1	Smallwood & Thelander 2004
Western Meadowlark *Sturnella negecta*	Solano Wind Resource Area	1	Bryne 1983
Western Meadowlark *Sturnella negecta*	Altamont Wind Resource Area	8	Thelander & Rugge 2000
Western Meadowlark *Sturnella negecta*	Altamont Wind Resource Area	40	Erickson *et. al.* 2001
Western Meadowlark *Sturnella negecta*	Foote Creek Rim	1	Johnson *et. al.* 2001
Western Meadowlark *Sturnella negecta*	Montezuma Hills	1	Howell & Noone 1992, Howell 1997
Western Meadowlark *Sturnella negecta*	Buffalo Ridge	1	Johnson *et. al.* 2002
Western Meadowlark *Sturnella negecta*	Tehachapi Pass	6	Anderson *et. al.* 2000
Western Meadowlark *Sturnella negecta*	San Gorgonio	1	Anderson *et. al.* 2000
Western Meadowlark *Sturnella negecta*	Stateline OR	5	West Inc., & Northwest Wildlife Consultants 2004
Western Meadowlark *Sturnella negecta*	Stateline WA	7	West Inc., & Northwest Wildlife Consultants 2004
Western Meadowlark *Sturnella negecta*	Nine Canyon, Washington	2	Erickson *et. al.* 2003
Western Meadowlark *Sturnella negecta*	Altamont Wind Resource Area	99	Smallwood & Thelander 2004

Table A40. Summary list of Tanager (Thraupidae) species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Western Tanager *Piranga olivacea*	Foote Creek Rim	1	Johnson *et. al.* 2001

Table A41. Summary list of Old World Sparrow (Passeridae)species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
House Sparrow *Passer domesticus*	Altamont Wind Resource Area	1	Smallwood & Thelander 2004
House Sparrow *Passer domesticus*	Buffalo Ridge	1	Johnson *et. al.* 2002
House Sparrow *Passer domesticus*	Brandenburg, Germany	1	Durr 2004
House Sparrow *Passer domesticus*	Mountaineer	1	Kerns & Kerlinger 2004
Tree Sparrow *Passer montanus*	Brandenburg, Germany	1	Durr 2004

Table A42. Summary list of other species that have been reported to have collided with wind turbines in studies outlined in Appendix Tables 1-5. Note: Numbers reported are only birds found, and are not expected numbers of collisions at each wind farm, therefore numbers presented are minimums.

Species	Site	# fatalities	Reference
Cockatiel	Altamont Wind Resource Area	1	Smallwood & Thelander 2004
Passerine sp.	Altamont Wind Resource Area	16	Thelander & Rugge 2000
Passerine sp.	Altamont Wind Resource Area	29	Erickson *et. al.* 2001
Passerine sp.	Foote Creek Rim	5	Johnson *et. al.* 2001
Passerine sp.	Vansycle, OR	1	Erickson *et. al.* 2001
Passerine sp.	Buffalo Ridge	1	Johnson *et. al.* 2002
Passerine sp.	Altamont Wind Resource Area	16	Smallwood & Thelander 2004
Passerine sp.	Tehachapi Pass	16	Anderson *et. al.* 2000
Passerine sp.	San Gorgonio	9	Anderson *et. al.* 2000
Passerine sp.	Altamont Wind Resource Area	11	Erickson *et. al.* 2001
Passerine sp.	Montezuma Hills	1	Howell & Noone 1992, Howell 1997
Passerine sp.	Altamont Wind Resource Area	42	Smallwood & Thelander 2004
Passerine sp.	Tehachapi Pass	4	Anderson *et. al.* 2000
Passerine sp.	Castle River, Alberta	1	Brown pers. comm.
Passerine sp.	Nine Canyon, Washington	1	Erickson *et. al.* 2003
Passerine sp.	McBride Lake, AB	6	Brown & Hamilton 2004

Passerine sp.	Mountaineer	9	Kerns & Kerlinger 2004
Passerine sp.	Stateline OR	3	West Inc., & Northwest Wildlife Consultants 2004
Passerine sp.	Stateline WA	4	West Inc., & Northwest Wildlife Consultants 2004