APPENDIX B

POTENTIAL IMPACTS OF WILDLIFE/WIND TURBINE INTERACTIONS

By far the greatest amount of information available pertaining to wildlife interactions with wind turbines is concerned with birds that are the most frequently and obviously impacted.

POTENTIAL MORTALITY – BIRDS

Most studies do not provide mortality rates for particular groups of species, but only overall avian mortality at a site. However, there is pertinent information that can be extracted with respect to various groups.

LOONS AND GREBES

Loons have never been identified as victims of turbines in available literature, and grebes have seldom ever been found. When low enough to be within range of turbine blades they would almost certainly be offshore, and when flying overland, would be well above turbine height. They are among the least likely to be expected victims at the proposed Toronto turbine sites.

CORMORANTS

At a Minnesota wind farm with 73 turbines, Double-crested Cormorants were identified as being at high risk spring and autumn because of numbers observed flying through the area from the nearby lake where they congregated in migration. But, in two years of biweekly searches, none were found dead (Strickland et al. 1998).

At Blyth Harbour in Britain with 9 turbines along a breakwall of the harbour, a large population of Great Cormorants was present. But, they did not appear to be at any risk, and no mortality was indicated. Birds were observed to avoid flying close to the turbines (Still et al. 1994, Lowther, in press).

While different species may react differently, the British experience suggests very low risk to cormorants from wind turbines. Most cormorant activity would likely be offshore, and there would not be much chance of collision with a turbine situated back somewhat from the shoreline, as in the Toronto proposed sites..

HERONS

Little information is available. They are seldom mentioned in literature, despite many studies being done in shoreline areas.

In California, in the San Gorgonio pass with 3750 turbines, weekly searches over 11 months at 630 turbines found one egret carcass. It was decayed to the point of being unidentified, so the real cause of death was uncertain (Anderson et al., in press).

In Minnesota at a wind farm with 73 turbines, waterbirds (not waterfowl or shorebirds0 were identified as using the area, but no mortality was ever reported in 2 years of biweekly searches (Strickland et al. 1998).

Little can be said with certainty, but the absence of information suggests that these normally wary birds are at very low risk from turbines in any situation.

WATERFOWL

In the Yukon, a single tower was placed on the side of the Yukon River valley where tens of thousands of waterfowl migrate, following the river valley. The tower was situated on the inside of a turn which the birds had to navigate. There was great concern for this site because about 10% of the worlds Trumpeter Swans fly down this corridor. In five years of searches (daily during peak migration and weekly over the year) and observations of flying birds (on 24 hour watches), not only were no waterfowl killed, but also none were observed flying close to the turbine (Mossop 1998).

In Minnesota at a wind farm with 73 turbines, Greater White-fronted Geese, Snow Geese, Canada Geese, and Mallards were all considered at high risk because of numbers flying through the site at rotor height both spring and autumn during migration. Careful searches over two years found none killed (Strickland et al. 1998).

In the Montezuma Hills of California, 600 turbines were erected in a pass between two wildlife sanctuaries used by thousands of waterfowl. The construction was originally opposed by hunters fearing the loss of birds to turbines. In two years of intensive post construction searches, no waterfowl were killed. More than 15000 observations of birds flying through the pass indicated that waterfowl were not at risk as they followed the watercourse and avoided going near the turbines (Howell and Noone 1992, Gipe 1995).

In Sweeden a wind farm hosts large numbers of Barnacle Geese that forage among the turbines when on migration. No mortality was indicated (Percival 1998).

In Denmark, 10 turbines were located offshore in shallow water, in an area where about 40% of the north Atlantic population of Common Eiders winters, along with large numbers of Black Scoters. A three-year study indicated that waterfowl clearly avoided flying close to the turbines; 80% fewer eiders landed within 100 m of a turbine than at 300 to 500 m (Guillemette et al. 1998 in Lowther in press).

At Blythe Harbour in Britain, with 9 turbines on a breakwater, there is also a large population of wintering waterfowl, particularly Common Eiders. Weekly searches below turbines since 1992 revealed 12 waterfowl believed to have been killed by turbines in the first 2.5 years, and subsequently the mortality has dropped to zero (Lowther, in press).

In the Netherlands, studies at six small coastal wind farms indicated that the greatest avoidance response to operating turbines was shown by ducks and geese. Only 3% of diurnal migrants came close to towers (Winkelman 1985a).

Also in the Netherlands, a study of nocturnal flight behaviour of waterfowl was conducted in a location with 4 turbines on a dike between offshore feeding areas and inshore resting areas. The area is well known for the large numbers of wintering and migrating diving ducks. Daily movements of waterfowl were generally below 100 m, with nocturnal flights averaging somewhat higher. Birds were obviously aware of towers and avoided them. On moonlit nights they flew between the towers, and on moonless nights just flew around them (Dirksen et al. 1997).

A third study in the Netherlands, with five turbines along a dike near the coast, was in an area of heavy use by waterfowl. Searches conducted every other day over the course of one year around each turbine found 4 dead waterfowl (Musters et al. 1996).

Waterfowl are clearly among the most wary of turbines and readily learn of the presence of obstacles to be avoided in flight (see also Disturbance Effects). Waterfowl can be numerous in close proximity to turbines in coastal and harbour situations yet suffer little mortality. Although relatively numerous in Toronto harobur areas, the proposed turbine locations are not such as to enhance the chance of a strike.

DIURNAL RAPTORS

In what has been perceived as perhaps the worst situation anywhere, particularly for raptors, a detailed study in the Altamont Pass of California over 2 years found Golden Eagles, Red-tailed Hawks and American Kestrels among the birds killed (Orloff and Flannery 1992). However, it was what was being killed, ie raptors, particularly the federally protected Golden Eagles, that generated the controversy, and not the rate at which they were being killed (estimated at 0.024 to 0.059 birds/turbine/year) (Gipe 1995).

The Altamont Pass, with 7000 turbines spread over about 190 sq. km., has a high raptor population with a high prey base of ground squirrels on grazing lands. Raptors are living among the towers and become familiar enough with them to perch on inactive ones. Surrounding areas have eliminated raptor populations through residential development displacing more birds into the pass. Ranchers in the Altamont were poisoning ground squirrels, possibly secondarily impairing the raptors abilities, if not completely killing them. Poisoned raptors have been found. The location of kills suggested that the raptors were concentrating on catching prey when hit, and not paying enough attention to turbines. Birds that are simply soaring/flying about amongst the towers have no trouble seeing and avoiding towers (Howell 1990, Howell and DiDonato 1991, Orloff 1992, Colson and Associates 1995, Gipe 1995, Howell 1995, Orloff and Flannery 1995).

In the Altamont Pass Golden Eagles were found to be at the highest densities ever recorded in North America. But, breeding birds mainly stayed out of the wind farm. It was the immature and unmated birds that were being hit, and despite the mortality, production of young was high enough that a population decline is not evident (Howell and DiDonato 1991, Hunt 1994, Hunt et al. 1998).

Other California wind farms, among the largest in the world, were not experiencing similar problems. At Tehachapi Pass, with 5200 turbines, nine raptors were found over four years (1984-1988), and four from 1988 to 1991 -- 80% of the number of turbines as the Altamont Pass, there was only 13% of the mortality (Sagrillo 1995). A single search in 1991 found no dead birds there (Orloff 1992). An extensive survey with 830 carcass searches at 180 towers over the course of one year found 18 raptors (Anderson et al., in press).

At San Gorgonio Pass, California, with 3750 turbines, a 1985 search for dead birds found none (Kirtland 1985). An extensive series of 630 searches at 180 sites over one year found only one dead raptor (Anderson et al., in press).

In the Montezuma Hills, California, with 600 turbines, five raptors were found over one year of searches (Howell et al. 1991a). Another study found 12 raptors in 5 months of searches (Howell 1995).

At the Sea West site, California, with 300 turbines, no raptors were found after 2 years of searches (Mitchell et al. 1993).

In Wales, at a wind farm with 22 turbines in an upland area of ornithological interest because of species such as Red Kites, Hen Harriers and Merlins, no effect of the turbines was found on numbers present, and no mortality was mentioned (Phillips 1994).

In France, at Port La-Nouvelle, five turbines were placed in an important bird conservation zone where thousands of migrants including raptors migrate through. The French Bird Protection League made observations over a five year period and found no dead birds. Large birds were observed to fly around the turbines (Percival 1999).

In Spain, at Tarifa District, several wind farms totaling 256 turbines were constructed in the National Park of Alcornocales, an area declared a special protection area for birds because of the huge numbers of migrants, particularly raptors, that migrate through this area near Gibraltar. Following reports of significant mortality, the Spanish Ornithological Society undertook studies over a one-year period. Kestrels and Griffin Vultures were killed, some by turbines, some by power lines and meteorological towers. Although overall numbers were higher than at other European sites, the number of raptors killed by turbines was still a small (0.34 birds/turbine/year) (Lowther, in press).

A subsequent study over 14 months covering two autumn and one spring migration season, estimated that 45000 Griffon Vultures and 2500 Short-toed Eagles annually migrate through the area, and numerous of the vultures winter in the area. One of each was killed by turbines (Guyonne and Clave, in press).

Raptors are most commonly associated with mortality at wind energy sites in North America because most facilities have been placed in inland arid grassland areas where raptor populations are highest. But, mortality is often species specific regardless of numbers present. Bald Eagles, Northern Harriers, and Rough-legged Hawks seem seldom if ever affected (Orloff 1992). But, Red-tailed Hawks and American Kestrels are very susceptible (Colson and Associates 1995, Orloff 1992). It is birds living among the turbines that are susceptible, not migrant birds. Some resident birds seem less likely to show avoidance behaviour and apparently do not perceive rotating blades as dangerous. Raptors have even been seed flying through the blades of slowly operating turbines (Rogers et al. 1977). And studies show that there is a correlation between the tip speed of rotors and mortality (Orloff and Flannery 1995). All turbines for which mortality of raptors has been reported had variable speed rotors. Any fixed speed rotor should have much lower expected mortality.

The response of raptors to turbines is always been one of avoidance (Curry and Kerlinger, in press), and even among experienced resident birds, most still show avoidance (Rogers et al. 1977). No birds have been seen perched on operating turbines. There has been a high degree of avoidance shown as birds moved away from turbines that were starting up (Colson and Associates 1995). Although the behaviour of some species of raptors often brings them into close proximity to turbines they are still considered to be at relatively low risk, migrants less so than residents.

Although no longer classified as raptors, Turkey Vultures are much less prone to being killed by turbines. They were numerous in the Altamont Pass area, but suffered significantly less than expected (Orloff and Flannery 1992). In the Montezuma Hills, where they were the most abundant species identified, mortality was particularly zero (Howell and Noone 1992). Ravens, another scavenging species, also were killed much less than expected on the basis of numbers seen.

Although numerous raptors migrate through the Toronto area, they are less likely to be casualties than would birds staying in the area of the turbines. But, near the proposed turbine sites, there are going to be relatively few raptors present in a long term basis. The risks are low in the Toronto waterfront sites.

PEREGRINE FALCONS

Peregrines are susceptible to collisions with transmission lines. In California, between 1975 and 1985, there were at least 17 reported collisions with power lines (during which time the California population of peregrines increased from 10 to 80 known breeding pairs) (Olendorff and Lehman 1986). However, in California, a state that in 1989 was producing 90% of the worlds wind energy with more than 17000 turbines, there has never been a reported peregrine collision with a turbine. In North America there were no reported peregrine collisions with wind turbines (Gipe 1995).

In Europe, only one reference to a single peregrine kill has been noted, in the Orkney Islands over the course of an 8-year study there (Meek et al. 1993). In Britain, one or two pairs of peregrines were nesting near a wind farm of 22 turbines, one within 250 m of turbines with no apparent problem (Percival 1998, Lowther, in press).
(see also comments on Rare Species) Overall there would appear to be very low risk to a pair of Peregrines that might nest in Toronto's downtown area.

RAILS, GALLINULES, COOTS

Rails, gallinules, or coots have seldom ever been identified as turbine victims (Anderson et al., in press). They seldom fly during the breeding season, and when they do are not high enough to approach rotors. Migratory flights would be expected to be well above turbine height.

SHOREBIRDS

In the Yukon, with a single turbine placed on the side of the Yukon River valley, that is used by thousands of migrating shorebirds as a major migration route, none were found dead after five years of weekly searches (daily in peak migration times) (Mossop 1998).

In Minnesota at a wind farm with 73 turbines, sandpipers of several species were identified as being at high risk, both spring and autumn, as large numbers congregated at the nearby lake, and flew through the farm site. However, after two years of biweekly searches at 21 turbines, none were found dead (Strickland et al. 1998).

Blythe Harbour, in Britain, is a site of special scientific interest, because of an internationally significant wintering population of Purple Sandpipers and Sanderlings that gather in the harbour area. Weekly searches of 9 turbines on a breakwater since 1992, have shown no adverse impact on the sandpipers (Still et al. 1994, Lowther, in press). Over the first four years of operations there were only 34 collisions of all species – fewer than one bird per turbine per year. (see also Disturbance Effects)

In The Netherlands, where 4 turbines had been installed along a dike by the sea, radar, visual, and auditory observations were made of migrating and wintering shorebirds during day and night. This area was known as an important staging area for migrant shorebirds. Large migratory movements generally stayed offshore, and birds which roosted inland past the turbines in daytime, tended to stay in tidal areas at night. They appeared to be at very low risk (Dirksen et al. 1997).

In another study in the Netherlands on the North Sea, in an area intensively used by waders, 5 turbines were placed along a dike. Searches every other day for a year found only one dead oystercatcher, and one snipe that probably also was probably killed by turbines (Musters et al. 1996).

In Denmark, on the Wadden Sea, a single turbine was installed in an area that is a major staging area of international significance for shorebirds. It was found that staging shorebirds clearly avoided the tower, flying birds staying farther away than foraging birds (Petersen and Poulsen 1991).

Shorebirds are reported more frequently in European studies than North American, as most wind energy sites are in coastal locations that have high concentrations of shorebirds (Colson and Associates 1995). However, mortality is low enough that numbers are seldom mentioned in study summaries. Shorebird activity is in the immediate area of shorelines, and turbines even marginally inland are unlikely to be of concern with respect to mortality. They are wary and not likely to be at any risk from turbines at proposed sites on the Toronto waterfront.

GULLS

In Minnesota, at a wind farm with 73 turbines situated near a lake, Franklin's and Ring-billed Gulls were identified as being at high risk spring and autumn because of numbers flying through the area. The ground around 21 turbines was carefully searched every 2 weeks for 2 years and no gulls were found dead. One Herring Gull was a casualty (Strickland et al. 1998).

In California, in the Altamont Pass, with 5000 turbines, California Gulls were identified as the 5th most common species flying through the area, and Ring-billed Gulls were 6th on the list (of 39 species). At least once a week over an 11-month period a sample of 685 turbines sites were searched and one gull was found dead (Thelander and Rugge, in press).

At Blythe Harbour, Britain, with 9 turbines in a harbour breakwater, there is a large population of resident and wintering Gulls. The "very few" that were killed were hit during kleptoparasitic attacks by resident birds on winter visitors. There was fewer than one bird per turbine per year killed in the harbour of all species, including gulls (Lowther, in press).

In Scotland, on the Orkney Islands, there were a small colonies of Black-headed Gulls (to 200 pairs), and Common Gulls (to 20 pairs). Three turbines were checked every two weeks in summer, and over 8 years, three dead gulls were found (Meek et al. 1993).

In the Netherlands, 5 turbines were placed along a dike in an estuary site near the North Sea, heavily used by gulls. Searches every other day over a one-year period found one gull certainly, and one possibly killed by turbines (Musters et al. 19960.

Another study in The Netherlands indicated that all gulls showed avoidance reactions to turbines when in flight. Gulls going to roosts reacted at greater distances than migrants (residents were aware of the presence of the turbines and avoided them more readily). Gulls in groups also reacted at greater distances than single birds (Winkelman 1992c).

Despite the close presence of large numbers of gulls moving past turbines, even in harbour and shoreline areas, none of the above authors considered that gulls were very likely to be victims. Most of the European wind energy facilities are coastal where gulls are a main component of avian populations, but gulls are seldom mentioned as being actually or potentially adversely affected. (see also Disturbance Effects).

TERNS

Little information is available. They are seldom mentioned in literature, perhaps because their primary activities are offshore were they would seldom be in an area where they could interact with a turbine.

In California, in the Altamont Pass with 5000 turbines, Caspian Terns were identified by observations as being 21st among 39 species in terms of abundance in the area. In 11 months of weekly searches at 685 turbines, none were found dead (Thelander and Rugge, in press).

Despite the great number of coastal wind energy facilities in Europe, terns have not been mentioned as ever being at risk in the papers available. Their activities are primarily offshore and unlikely to be near turbines at the proposed sites.

PIGEONS/DOVES

In California, in the Altamont Pass, in an effort to find out how birds were interacting with turbines, homing pigeons were flown to lofts behind banks of turbines. In some 7000 flights, they had experienced one death (Asmus 1994). The normal response was to avoid them. Birds clearly recognized the difference between inactive and actively rotating turbines. They flew through gaps or around the turbines (Curry and Kerlinger, in press).

In another study in the same area, in one year of weekly searching at 685 turbines, only one Mourning Dove was found. Rock Doves were 18 times more numerous in the area, and 15 were found dead (Thelander and Rugge, in press).

In the Tehachapi Pass, with 5000 turbines, 830 carcass searches were made at turbines over a one-year period and 6 Mourning Doves were found. In the San Gorgonio Pass, with 3750 turbines, 630 carcass searches over a one-year period found 1 Mourning Dove (Anderson et al., in press). Pigeons and doves are fast and agile fliers that should not be at risk in any situation.

OWLS

In California, in the Altamont Pass, an 11-month study, at a sample of 685 turbines (of 5000), with weekly searches, found 4 Burrowing Owls, and 4 Barn Owls (Thelander and Rugge, in press). At Tehachapi Pass (with 5000 turbines) a one-year study at a sample of 180 turbines and 830 carcass searches, found 2 Barn Owls, 1 Flammulated Owl, 1 Longeared Owl, and 10 Great Horned Owls (Anderson et al., in press). At San Gorgonio Pass (with 3750 turbines) a one year study, at a sample of 120 turbines and 830 carcass searches found 1 Burrowing Owl (Anderson et al., in press).

In Wales, at a wind farm of 22 turbines situated in an upland area with breeding Short-eared Owls, there was no indication that the wind farm affected the population (no mortality mentioned) after one year of study (Phillips 1994).

In Spain, at Tarifa, at a wind farm of 260 turbines, a 14-month study of migrant and resident birds found one Eagle Owl nest in the farm. No mortality was reported during the study; one Eagle Owl was reported killed the winter prior to the study (Guyonne and Clave, in press).

Their acute hearing that should alert them to the presence of operating turbines, and they are among the species best equipped for night vision. While some have been hit in areas where they are numerous, mortality was still relatively low. The greatest risk at the Toronto waterfront is likely to be to Northern Saw-whet Owls that are the most numerous in autumn migration. They may be largely below operating turbines, however, as they are low fliers subject to automobile collisions.

NOCTURNAL MIGRANTS

In Ohio a single tower near the coast of Lake Erie at Sandusky, south of the Lake Erie Archipelago, was studied over four migration seasons. Radar indicated that during peak migration times an average of more than 5000 birds/hour/mile of front were passing the area. But, only one dead bird was found. Observations indicated that birds readily avoided the tower. Authors indicated that only if blades were above a height of 150 m would the probably of strikes be significant (Rogers et al. 1977).

In California, the San Gorgonio Pass (with 3750 turbines), is a major migration route with an estimated 32 million birds passing in spring and 37 million in autumn. An initial study revealed no dead migrants (Kirtland 1985). Subsequent more extensive searches did find carcasses and estimated mortality at 0.0057 to 0.0088 percent of all migrants (Pearson 1992). Visual observations indicated that at least 9 percent of migrants were passing at a height where potential impacts were possible (McCrary et al. 1983, McCrary et al. 1994).

In Vermont, where 11 turbines were placed on a mountain ridge, no dead birds were found in a one year post-construction survey period (weekly searches during migration season) (Kerlinger, in press).

In Spain, the Tarifa wind farms with 260 turbines, are placed in a national park, an area declared a special protection area for birds under the European Birds Directive of 1979. Internationally significant numbers of migrants pass through this area on migration. Yet no passerine carcasses were found over the course of four migration seasons (Guyonne and Clave, in press; Lowther, in press).

In The Netherlands, at the Sep wind park with 18 turbines on 55 ha of arable land, detailed studies were conducted from 1987 to 1991 during six spring and 4 autumn migrations. Tower sites were searched on 2907 occasions in this area of high nocturnal migration. A total of 76 birds were found dead, 44 associated with turbines, most after nights of poor flying conditions. Very few daytime migrants were killed. A comparison of the estimated number of birds passing through the wind farm at rotor height (from radar, passive image intensifiers, and infrared spotlights), with the estimated number of bird victims, suggested that on average, less than 0.1% of nocturnal migrants, less than 0.01% of diurnal and nocturnal, and less than 0.008% of resting, feeding, and diurnal and nocturnal migrants, would be expected to collide in this situation. Thus, at worst, 1 in 1000 nocturnal migrants passing through the farm at rotor height might be expected to collide (Winkelman 1992a, 1992b).

When this wind farm was fully operational, the number of birds migrating through the farm was reduced by up to 67% (Winkelman 1992d). Birds were completely avoiding the wind farm.

Observations of birds trying to fly through rapidly moving variable speed rotors noted that during the day only one of 14 birds was hit, and at night 14 of 51 birds collided. But, of these 14, four recovered and flew away. Thus, the maximum kill rate would be about 20% of those actually passing through rapidly spinning blades (Winkelman 1992b).

In the Netherlands also, studies at two wind farms with 18 and 25 turbines, estimated that during migration season collision victims per turbine per day would range from 0.04 to 0.09 (Winkelman 1995). These are the highest rates ever reported anywhere, and are based on a few days of study during migration season. There were no nights of large kills, even during periods of poor flying conditions when most birds were collected. Even at the level of mortality reported, collisions were considered to be insignificant (Winkelman 1995). Most nocturnal migrants fly at heights that would see them pass harmlessly overhead (Able 1999, Kerlinger and Moore 1989).

Nocturnal migrants are considered to be at greater risk than any other types of birds because of their numbers and nocturnal flying. However, they are still considered to be at low risk (Winkelman 1995). Only in a few days during heavy migration, if weather suddenly deteriorated are mortality rates elevated, and even them mortality has been a tiny fraction of passing birds (Crockford 1992, Winkelman 1985, 1995, Pearson 1992). They are at much less risk of collision at wind turbines on the Toronto waterfront than at tall buildings in the downtown area.

(see also Other Structures and Siting Guidelines)

LOGGERHEAD SHRIKES

In California, in the Altamont Pass, Loggerhead Shrikes were identified as the 16th most common species (of 39). But, in 11 months of weekly searches at a sample of 685 turbines, none were found dead (Thelander and Rugge, in press).

In Minnesota they were seen as migrants through a wind farm of 73 turbines, but none were found dead in 2 years of searches They are very unlikely to collide with wind turbines on the Toronto waterfront.

(see also Rare Species)

AVIAN MORTALITY RATES

In Table B-1 avian mortality rates are presented. These rates are from previously cited studies, and include mortality of all birds of any species, unless otherwise indicated. Mortality rates are not available for all studies. Rates were calculated on a sample of turbines searched (except for Yukon, Ohio and Vermont) and search effort varied. However, these were thorough searches, and most used predator removal rates and search efficiency rates to adjust figures. All rates are expressed as birds per turbine per year.

Table 1: Avian Mortality Rates

Place	# turbines	Mortality	Study Period	Reference
North America				
Yukon	1	0.0	5 years	Mossop 1998
Minnesota	73	1.4	1 year	Strickland et al. 1998
		1.9	1 year	"
Ohio	1	0.25	2 years	Rogers et al. 1977
Vermont	11	0.0	1 year	Kerlinger, in press
California	600	0.2	2 years	Howell and Noone 1992 Gipe 1995
	6500	0.02-0.06 raptors only	2 years	Orloff and Flannery 1992
		0.05 raptors only	1 year	Howell and DiDonato 1991
	5000	0.15	1 year	Thelander and Rugge in press
		0.06	1 year	" raptors only
		0.03	1 year	Howell 1995
	3750	0.049	1 year	Anderson et al. in press
	5200	0.11	1 year	"
Europe				
Scotland	3	0.17	8 years	Meek et al. 1993
Denmark	1	1.7	1 year	Pederson and Poulsen 1991
	1	0.0	1 year	Moller and Poulsen 1984
	3	0.0	1 year	"
France	5	0.0	5 years	Percival 1999
Spain	260	0.03	1.25 years	Guyonne and Clave, in press
		0.05-0.45	?	Barrios and Aguilar 1995
Netherlands	6 sm farms	0.0	0.5 years	Winkelman 1985a
	20	3.6	1 year	Musters et al. 1991
	5	2-7	1 year	Musters et al. 1996
	18	22-33	6 years	Winkelman 1995*
	25	15-18	3 years	Winkelman 1995*

*These rates were calculated mainly from a few days of spring and autumn migration, and originally were expressed as birds per turbine per day; rate over a year long period would be expected to be lower.

POTENTIAL MORALITY - BATS

Studies of the impact of wind turbines have primarily focused on birds. There have been no studies published specifically on bats, although a study is underway in Wisconsin at a wind resource area with a major bat hibernaculum (Ugoretz et al. in press). The following information has been incidental to bird studies.

In California in the Altamont Pass, searches at 685 turbines over the course of one year found 1 bat (Thelander and Rugge, in press); and searches at 359 turbines over one year found 1 bat dead (Howell and Didonato 1991). In the Tehachapi Pass, 850 searches over one year found 1 bat, and 850 searches in the San Gorgonio Pass over one year found 1 bat (Anderson et al., in press).

In a Minnesota wind farm with 73 turbines, searches over 8 months found 5 bats presumably killed by turbines (Strickland et al. 1998).

The European literature seems virtually devoid of reference to bats, as if they were not of any concern, but it could be that the abstracted comments just failed to take note of the few there may have been.

Overall, however, mortality rates for bats seem lower than for birds. Their echolocating abilities should make them less susceptible to collision. Although bats have been reported to have struck lighted buildings, they have not been found among Toronto's tall building kills (Evans Ogden 1996). This suggests that they are at very low risk from turbines on the Toronto waterfront.

POTENTIAL MORTALITY - SMALL MAMMALS

Very little information is available on small mammals. In general there may be a slight disturbance very close to turbines (Orloff 1992). However, it is high ground squirrel populations in the Altamont Pass that attracts the high numbers of raptors, including the highest densities of Golden Eagles reported in North America (Mitchell et al. 1993, Hunt 1994, Hunt et al. 1998), and no significant impacts have been noted or expected.

POTNETIAL MORTALITY - INSECTS

Very little information is available on insects. In Germany, the North German Academy for Nature Protection examined 11 wind farm sites on the North Sea, measuring the density of insect splatters on turbine blades. This was more an attempt to assess the removal of food supply for birds than concern for insects, but the conclusion was that the effect was negligible (Gipe 1995). In Ohio, the U. S. Dept. of Energy filmed the release of honeybees and blowflies near the turbine at Sandusky, to try to destermine the interaction. There was little observed impact (Gipe 1995).

It seems unlikely that turbines kill more insects than the windshields and hoods of cars and trucks. Butterflies and dragonflies are rather adept at avoiding anything that chases them.

DISTURBANCE EFFECTS - BREEDING BIRD POPULATIONS

While studies of the effect of wind turbines have generally focused on mortality rates, a number of studies were concerned with effects on breeding bird populations.

A 5-year monitoring study near two large turbines in Wyoming found no effect on Sage Grouse "strutting grounds", and no effect on raptor nesting and productivity (Bureau of Reclamation 1984). Nesting studies of raptors in the California Montezuma Hills were 600 turbines were operating over a 2-year study, indicated that the turbines would not likely have any impact on raptor populations if the region (Howell and Noone 1994). In Vermont, with 11 turbines on a ridge in a forested area, there were more breeding species found after construction of the turbines, associated with habitat changes at the sites (Kerlinger, in press).

In Sweden, a 3-year study near 2 large wind turbines found no differences in local breeding populations before or after construction, either in diversity or abundance (Karlsson 1983). Another Swedish study compared shorebirds within and in surrounding areas of a wind farm (number of turbines not given). The high densities of breeding birds were similar on and off the farm, and there was no loss of reproductive success on the farm. Nests of six species of shorebirds were all placed within 40 m of operating turbines, some as close as 0.7 m (Percival 1998).

In an 8-year study in the Orkney Islands, near a 2.5 ha loch and a 6 ha bog where 3 turbines were installed, there was not considered to have been any significant affect of the turbines on local breeding populations of waterfowl, grouse, shorebirds, gulls, or passerines (Meek et al. 1993). In Wales (Bryn Titli), there were no significant changes in populations of diurnal raptors, shorebirds, grouse, or owls following erection of a 22 turbine wind farm in an upland area of ornithological significance (Phillips 1994). There was also no demonstrable effect on breeding birds at four other wind facilities in British uplands (Carno, Cemmaes, Ovenden Moore and Windy Standard), with increasing numbers of examples of breeding birds in close proximity to turbines (Percival 1998).

In Germany, eleven small wind farms were studied from 1989 to 1990, with no indication of any effect on breeding birds (Vauk 1990). In Spain, at Tarifa, over two summer seasons, breeding bird numbers within a 66-turbine facility were compared to those in surrounding areas. On average, there were more nesting birds in the farm and mean productivity of young was the same in or outside the farm (Guyonne and Clave in press).

In The Netherlands, at the Sep wind park, with 18 turbines, from 1984 to 1991, studies showed no significant influence of the turbines on breeding shorebird populations (Winkelman 1992d).

There have been a couple studies that indicated breeding bird populations were considerably reduced by the installation of wind turbines. However, the loss of breeding birds was largely the result of extensive alteration to the site or the continued presence of people and vehicles on the area, rather than the turbines themselves (Leddy et al. 1999, Percival 1999). Few if any breeding birds are going to be found on the actual proposed turbine sites on the Toronto waterfornt, and no effects of installation or operation are likely. Breeding colonies are more than 2 km away where the turbines would have no effect at all.

OTHER DISTURBANCE EFFECTS

In Europe, where reviews have generally concluded that there are few and acceptable losses to migrant and breeding birds to wind turbines, there has been concern that the most important impact may be disturbance to resting or staging birds (Berkhuizen and Postma 1991; Benner et al. 1993, Crockford 1992, Winkelman 1994). Considerable effort has been directed at elucidating disturbance effects.

ROOSTING/FEEDING

In Germany, studies at 11 sites 1989-1990 found that the number of birds resting near turbines was considerably lower than at other similar places (Vauk 1990).

In Denmark, studies have shown that waterfowl usually react at greater distances than other birds and change course to avoid towers. There were 80% fewer birds landing within 100 m of towers than farther away. But, while they clearly avoided flying near the towers, they were not disturbed by them when feeding where they did land (Peterson and Nohr 1989, Lowther, in press).

In Britain, at Blyth Harbour, with 9 turbines on the harbour breakwater, there is an internationally significant wintering population of Purple Sandpipers. There were no adverse effects shown by the birds, and they were remarkably tolerant even of the construction activity as the turbines were installed. Likewise, there were no adverse effects shown on gull populations in the harbour (Lowther, in press).

In Sweden, studies at a wind farm where large numbers of Barnacle Geese congregate, indicated that they were generally unaffected, feeding around the turbines to within 25 m of the bases, some much closer (Percival 1998).

In Spain, at Tarifa, in an area with 66 turbines, no difference was found between the wind farm and surrounding areas with respect to the numbers of wintering birds (Guyonne and Clave, in press).

However, most work on disturbance effects has taken place in The Netherlands. Initial studies at six small wind farms at or near the coast in the autumn and winter if 1983-1984 indicated that of 12 species groups of birds studied, waterfowl showed the greatest avoidance response when in flight. However, the disturbance effect on feeding birds of all types was negligible (Winkelman 1985).

A study at the Urk wind park, with 25 turbines along a dike near the coast, found that some species were found in significantly smaller numbers within the wind park. The response was obviously different for different species. Waterfowl as a group showed the greatest avoidance within 300 m. Most susceptible were Mallard, Pochard, Tufted Duck and goldeneye, but scaup, 3 species of geese and 3 species of swans showed no effect. Gulls of all species, Great Crested Grebe, and coot showed no effects (Winkelman 1989).

At the Sep wind park, with 18 turbines in an inland agricultural area, there were significantly smaller numbers of birds feeding or resting in the wind park and immediately surrounding area. Decreases were 60 to 90%, but never to 100%, and varied with species. Most of the disturbance effect was limited to 100 to 250 m, but varied with species. Waterfowl were fewer up to 250 m (Mallard most sensitive), shorebirds up to 100 m (except curlew and Golden Plover up to 500 m), and gulls up to 250 to 500 m (except Black-headed Gull which showed no avoidance). Crows and starlings also showed no avoidance (Winkelman 1990b, 1992d).

A study by Dirksen et al. (1997) looked at waterfowl and shorebirds at several wind farms in coastal areas of The Netherlands. Flights of flocks were at turbine heights and there was no difference between areas with or without turbines. Birds moving to feeding or roosting areas were not disturbed. They were well aware of and readily avoided turbines. Ducks roosted mainly more than 500 m from turbines and showed no disturbance at that distance.

There may well be disturbance effects to roosting or feeding birds, in that they tend to remain some distance from wind turbines when flying to feeding or resting sites. This can be viewed as a negative effect, but it can also be positive in that there is much less chance of collision with turbines. And any disturbance effect if there is any, is likely to be limited mainly to a distance of less than 250 m, sometimes to 500 m. At the same time, these studies indicate that birds will often continue to feed close to towers, even when avoiding them in flight.

It should also be noted that even where there are disturbance effects noted for roosting/feeding birds at a site, there has been no effect noted on breeding birds at the same site (Winkelman 1990b, 1992d, Vauk 1990). Resident birds seem to be able to habituate readily to turbines and return to former haunts (Petersen and Nohr 1989, Dirksen et al. 1997, Guyonne and Clave, in press).

Disturbance effects of the type studied above are particularly relevant to the European situation were turbines have often been placed in tidal estuaries, where rich food sources form major staging areas for birds. Such situations are not typical of North American situations. The wind turbines at the proposed sites on the Toronto waterfront are not situated in areas of high feeding activity of birds, and would be expected to have negligible disturbance effects.

MIGRANTS

Disturbance/avoidance reactions may also affect migrant birds, and again much of the study was done in The Netherlands. At six small wind farms near the coast indicated that diurnal migrants were more responsive, than local birds. Of the migrants 13% showed a change of flight path, as opposed to only 5% of local birds. The greatest response was by ducks and geese. Of the diurnal migrants only 3% came close to towers (Winkelman 1985).

Another study at an inland wind farm with 18 turbines indicated that 92% of diurnal migrants approached operating turbines without hesitation, whereas only 43% of nocturnal migrants did so. There was an obvious avoidance reaction when visibility is reduced (Winkelman 1990c). All species (or groups) except the largest ones avoided the rotors and the near vicinity of the rotors when they were active. A gradual calm reaction of changing flight path long before passing the turbines was the normal behaviour in about 75% of all observations. More than 75% of all reactions within 200-300 m of the nearest turbine took place within 100 m, and nearly 50 % were within 50-100m. Ducks reacted at the greatest distances, songbirds at the smallest distances. But, only 8% of those approaching completely avoided entering the wind park at all (Winkelman 1992c). Regular disturbance was shown by a decrease in the number of migrants passing through the wind farm, by up to 67% when fully operational (Winkelman 1992d). Such a decrease by migrants would be of benefit in reducing collisions.

In Spain, at Tarifa, in a wind farm with 66 turbines, birds flying through the farm obviously made more flight changes than those passing elsewhere, in an effort to avoid close approach to the turbines (Guyonne and Clave, in press).

An analysis of studies at several small wind parks in Denmark indicated that migrant birds were often changing course at a greater distance than were local birds when approaching turbines (Peterson and Nohr 1989).

In North American studies there is also some evidence of avoidance of turbines by migrants. In Vermont, 11 turbines on a ridge were apparently avoided by both raptors and nocturnal migrants. Numbers were lower in visual and celiometer studies post construction. The study was for only one year post construction, however (Kerlinger, in press).

In the Yukon with a single tower on the side of a river valley, many passerines used the site as breeding and wintering birds, but the thousands of migrants passing down the valley were never seen near the turbines (Mossop 1998).

Avoidance can also be shown in the height of passage. In The Netherlands, daily movements of wintering waterfowl and shorebirds were generally at turbine height, but migrants flew higher and were at less risk (Dirksen et al. 1997). In Spain, the average flight altitude of migrants over the wind farm was more than 100 m, whereas in surrounding areas it was about 60 m (Guyonne and Clave, in press).

Although the disturbance aspect to wintering and migratory birds may limit to some extent the area available to birds for foraging or resting, that effect is generally limited to the area near the turbines. Flying birds may avoid turbines at several hundred metres, but most at distances less than 250 m. Foraging birds may approach much closer, avoiding only the immediate area of the turbines. For migrants on the move, the avoidance reaction is obviously positive in that it reduces the chances of collision. Overall there seems likely to be no noticeable disturbance effect on migrant birds from turbines placed on the proposed sites on the Toronto waterfront.

SITING GUIDELINES

Siting guidelines set by English Nature in Britain are that sites should be: 1) at least 800 m from areas of high ornithological interest, 2) away from bird migration routes, and 3) away from features that will attract high densities of birds. However, the 800 m distance was apparently derived from the maximum distance at which it was shown that any bird changed flight course approaching the turbine, in a study done at a single large turbine in Denmark, sited in poor habitat relative to the rest of the study area. Other studies have shown disturbance up to 500 m, but there was usually a confounding effect of much increased human disturbance, and in several other studies no significant effects were shown (Percival 1998).

Concern over collision risks in the British guidelines (2 and 3 above) come mainly from two sources. 1) the Altamont Pass in California, where collision occurrences are in fact relatively rare events, but have attracted undue attention because of the loss mainly of one species (Golden Eagles), not typical of any other area. And 2) the Sep wind farm in The Netherlands located in a main migration route. This was not a coastal location and even here mortality rates were calculated to be about 0.01 to 0.02 percent during peak bird movements (Percival 1998).

Percival (1998, 1999) argues that the English Nature guidelines are no longer valid. There is increasing evidence that the majority of wind farms have no effect on local bird populations, either in disturbance effects or collisions, that increasing numbers of examples are being recorded of birds breeding close to turbines, even those that may initially show avoidance at considerable distances (eg. Golden Plover), and that the greatest effects shown often have confounding factors such as increased human disturbance.

Other siting guidelines from California (California Energy Commission 1982), Oregon (Sadler et al. 1984), Wisconsin (Wisconsin Dept. of Natural Resources 1995), and Britain (Royal Society for the Protection of Birds 1994) all suggest not siting near such places as wilderness areas, national parks, critical habitat for endangered species, major migration concentrations, areas of national or international importance, bird sanctuaries, marshes and water bodies. However, how close is “near” was not defined. Most European wind energy developments are near coastlines (Colson and Associates 1995) even in offshore areas, and there is a push to develop offshore wind energy potential, putting towers in water bodies (Lowther, in press). Studies in tidal and offshore facilities have not found significant problems (Dirksen et al. 1999, Guillemette et al. 1998). Wind turbines situated even on harbour breakwaters have not caused significant problems for local bird populations; the turbine related mortality represented less than 4% of all recorded harbour mortality (Still et al. 1995, Lowther, in press). The highest mortality rates ever recorded anywhere have been in an inland location 2-3 km from the coast (Winkelman 1992a).

Bird mortality in the San Gorgonio Pass, where an estimated 32 to 37 million migrants pass each migration season, have been low; only about 9% of migrants were low enough to be in possible contact with turbines, and overall mortality represented about 0.006 to 0.009% (Pearson 1992, McCrary et al. 1983). Casualties to nocturnal migrants even in areas of high passage rates have generally not been high as most nocturnal migrants fly too high (Rogers et al. 1977, Kerlinger and Moore 1989, Able 1999, Guyonne and Clave, in press). A turbine located on the edge of a large marsh in California found insignificant mortality (Byrne 1983). Huge numbers of migrants can pass close to turbines without incident as long as a tower is not placed in the middle of the flight corridor at the height at which birds are flying (Mossop 1998, Gipe 1995).

In Denmark, exemptions to build were necessary in nature reserves, marshes/wetlands >0.5 ha, salt marshes >0.3 ha, and closer tham 150 m from large streams, 150 m from lakes >3 ha, and closer than 100 m from the coast (Benner et al. 1993). However, while marshes and sanctuaries may have been avoided, offshore and coastal areas have not, and as indicated, problems have not been serious (Dirksen et al. 1997, Guillemette et al. 1998).

The most reasonable guidelines are reflected in those of the American Wind Energy Association, and the Spanish Ornithological Society, which are similar (Colson and Associates 1995, Montes and Jaque 1995). In these guidelines turbines should not be placed in the middle of areas of high concentrations, ie. In the centres of valleys, ridges, swales, or other microhabitats where large numbers of birds are known to fly or concentrate. And most importantly, careful siting studies beforehand to elucidate any potential problems are necessary.

Putting up any structure is eventually going to cause some avian mortality. But, collisions with wind turbines are statistically rare events, particularly when compared to other human caused mortality (see Other Structures). Even in California in the Altamont Pass, considered the worst case situation in North America, to witness a collision with any one randomly selected tower could take as long as 31 years (Curry 1994). Studies have shown that during daylight in good weather, even in coastal locations, the chance of collisions is almost zero (Crockford 1992, Winkelman 1985a).

The most potentially serious mortality is likely to occur during nocturnal migration, when unusual weather conditions suddenly create poor flying conditions. But, the location and timing of such weather is not predictable. Collisions can not be avoided or mitigated with wind turbine location alone (Hanowski and Hawrot, in press). Even in such conditions, there has never been a mass kill at any turbine anywhere in the world, even where the highest mortality has been recorded (Gipe 1995, Winkelman 1992a).

RARE SPECIES

In a study in The Netherlands, a correlation was found between the number of victims and the estimated number of visitors to the area per species, suggesting that rare species were not endangered by turbines (Musters et al. 1996). In the most extensive European studies in The Netherlands, virtually none of the victims were scarce or rare species (Winkelman 1995). In the San Gorgonio Pass in California, with an estimated 32 million migrants in spring and 37 million in autumn, no sensitive or endangered species were found (Pearson 1992, Anderson et al., in press). Given that collision events are statistically rare events to start with (Curry 1994) a rare species is very unlikely to ever suffer mortality at a wind turbine.

TURBINE TYPES

Information available does not clearly link turbine height, type, or number or type of blades with avian mortality (Colson and Associates 1995). Initial studies suggested that lattice type towers were more likely to kill birds, probably because they offered more perch sites for birds (Orloff 1992). Subsequent studies indicated that only the speed of turbine rotation and the amount of time they were in operation were correlated with raptor mortality (Orloff and Flannery 1995). Where there were no lattice type towers, birds perched on tubular towers, and mortality rates can be similar (Thelander and Rugge, in press).

Much of the mortality recorded in wind farms has been associated with electrocution at transmission lines, and/or guy wires at adjacent meteorological towers (Bureau of Reclamation 1984, California Energy Commission 1989, Orloff and Flannery 1992, Luke and Watts 1994, Winkelman 1995). Turbines have generally been considered less dangerous than power lines (Buurma and van Gasteren 1989, Winkelman 1995) or guy wires (Bonneville Power Administration 1987, Jones and Stokes Associates 1987, Orloff and Cheslak 1987, Evans 1998).

Birds tend to avoid towers, flying through the space between them striking transmission lines there (Faanes 1983, Ivanov and Sedunova 1993). The towers are larger and more visible, and readily seen and avoided, wereas thinner less visible lines are a bigger hazard (Bevanger 1994). The type of tower proposed for the Toronto waterfront has no guy wires, and all transmission lines will be underground.

Some behavioural observations have indicated that birds can recognize inactive vs. actively rotating turbine blades, and will avoid the active ones (Curry and Kerlinger, in press, Colson and Associates 1995). However, there is some evidence that the active ones are less likely to be hit (Winkelman 1992c). They are more visible because of the motion, and therefore should be more evident (Sorensen 1980). Even at high rotation speeds of 90 RPM visual acuity of American Kestrels may not be compromised. Kestrels should be able to resolve rotating blades of a turbine at twice the speed of the proposed turbines for the Toronto waterfront (Morrison, in press).

In fact, whether the turbines are active or inactive may make little difference. Some birds will avoid them in any event (Pederson and Poulsen 1991). Most collisions are likely to occur near the hub where there is little space between blades (Tucker 1996), or even against the tower itself.

Where more than one turbine is to be placed, it is preferable that they be located in groups, as groups are more visible than solitary ones, and birds avoiding one will not be directed toward a distant turbine after avoiding one (Winkelman 1992c).

Almost all studies have involved variable speed turbines. Since the speed of rotation of blades has a direct connection to mortality rates (Orloff and Flannery 1995) the mortality experienced at a fixed speed unit of the type proposed should be less than reported elsewhere.

The turbines to be placed on the Toronto waterfront have to have some lighting to meet requirements for hazards to aircraft. However, the towers are not to be floodlit. The minimum red or strobe lights will be employed to meet Transport Canada regulations, and these should have minimal impact on migratory birds (Evans Ogden 1996).

NOISE

A number of studies have addressed the issue of noise from wind turbines. The noise is different from that of other machines and is generally confined to the low frequencies (Wells 1981, Towne and Associates 1974, Shepherd and Hubbard 1989). Noise levels from older variable speed units have been considered too low to affect wildlife populations with respect to disturbance, behaviour or health (Rogers 1977, Leitner 1982).

The amount of noise emitted depends upon the type of turbine. Modern turbines of the type proposed for the Toronto waterfront and already installed at the Bruce Generation

Station are quiet machines that could scarcely be heard beyond 250 m. At 200 m the noise would be well below ambient noise levels in the city (Toronto Renewable Energy Cooperative 1999).

The noise involved in construction activity will be situated more than 2 km from colonially-breeding birds, farther away than the daily truck and bulldozer activity that has been present for years nearby on the Eastern Headland. Such construction activity is not of any more significance to bird populations on the lakeshore than present waterfront construction in the city of Toronto.

OTHER STRUCTURES/MORTALITY FACTORS

Tall communications towers, such as TV towers, were estimated to be killing more than 1000 birds each per year in Canada (Weir 1976). Any guy-wired tower with some lights more than 200 feet high can kill birds if conditions are right, and across North America somewhere between 2 and 4 million birds a year are estimated to be dying at such towers (Evans 1998).

Tall buildings in Toronto kill more than 10 000 birds per year (FLAP), depending upon height. The potential at individual buildings is much higher if lighted at night (Evans Ogden 1996). Single buildings in other North American cities have killed close to 1500 birds per year, and across North America some 1 250 000 are estimated to die at tall buildings (Banks 1991, in Asmus 1994).

It is estimated that windows in low buildings, such as individual residences, kill from 100 million to 1 billion birds a year across North America (Klem 1989, Dunn 1993). Thus each household would kill from 1 to 10 birds per year or considerably more than the average of most wind turbines in North America.

Highways in North America are estimated to kill about 60 million birds a year (Banks 1991, in Asmus 1994). In the highest bird mortality site at wind turbines ever reported, the mean number of deaths per km of wind park are estimated to be comparable to the number killed by traffic per km of highway (Winkelman 1995).

Power transmission lines have been estimated to kill an average of 8 birds/year/km (Herder 1980, in Ivanov and Sedunova 1993). And if the transmission lines run through forest the estimate rises as high as 400 per km (Hoerschelmann et al. 1988, in Ivanov and Sedunova 1993). If transmission lines run along a sea coast estimates reach 1200 a year/km (Scott 1972). In unusual circumstances up to 70,000 per km of transmission line have been reported (McNeil et al. 1985). Power transmission lines were estimated to kill half as many or more birds per year as highways (Winkelman 1995). We have many hundreds of kilometres of power lines in Ontario. In North America as many as 30 million birds a year may be killed using the above estimate. Even in a situation of very high mortality at wind turbines, a whole kilometre of turbines would likely kill far fewer birds than a kilometre of transmission lines (Winkelman 1995).

There are an estimated 60 to 70 million cats roaming North America (Coleman and Temple 1993), each of which is capable of killing more than 1000 small animals a year. Each free roaming cat in Toronto is probably responsible for more bird deaths per year than any average wind turbine anywhere in North America.

Every structure that is put up is going to kill some birds. It should be obvious from the above figures that even every house directly or indirectly is going to kill on average more birds per year than any average wind turbine in any situation.

Coal-fired power plants not only have smoke stacks that may cause avian mortality in poor flying conditions, but also are one of the main sources of sulphur dioxide, nitrogen oxide, and fine particulate pollution. These air pollutants are principal components of acid rain, greenhouse gasses contributing to global warming, and low level ozone.

Acid rain has already destroyed 31 000 lakes and threatens 10 000 more fish and wildlife habitats, and threatens 15 million hectares of forests. The economic losses to Canadians are immense, as well as the loss of countless numbers of animals. Global climate change is one of the most serious environmental issues to be faced today, affecting agriculture, forestry, fish and wildlife populations, water supply, and human health. It threatens the very life support system of the planet as we know it and all living organisms. Low level ozone damages vegetation, lowering crop productivity that is estimated to cost up to $70 million a year now in Ontario. The effects on wildlife habitat have scarcely been addressed. There is a clear link between smog and hospital admissions and reduced lung function in people. The city of Toronto's medical officer of health has suggested 400 people die each year here from air pollution contributed by coal-fired power plants (Environment Canada 1992, 1995, 1997, 1999; International Joint Commission 1998).

The effects of airborne pollutants are not as direct as picking up a dead bird below a tower, but they are far more insidious and far reaching. The aim of wind turbine installation is to help reduce airborne pollutants, and help Canada meet commitments to air quality standards which are not presently attainable without additional reductions in airborne pollutants.

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