AVIAN MORTALITY ASSOCIATED WITH THE TOP OF IOWA WIND FARM

Progress Report
Calendar Year 2003

Principle Investigator:
Dr. Rolf Koford
Iowa Coop. Fish and Wildl. Res. Unit
Science Hall II
Iowa State University
Ames, IA 50011

Graduate Student
Aaftab Jain
Dept. of Natural Resource Ecology and Management.
Science Hall II
Iowa State University
Ames, IA 50011

Co-Investigators
Guy Zenner, Natural Resource Biologist
Alan Hancock, Natural Resource Technician
Iowa Dept. of Natural Resources
1203 N. Shore Drive
Clear Lake, IA 50428

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Abstract
We examined bird and bat mortality at a new 89-turbine windfarm constructed in an environmentally sensitive area in north-central Iowa. The windfarm became operational in November 2001. It is located in cropland between three Wildlife Management Areas (WMA's) with historically high bird use. In the past, migrant and resident waterfowl, shorebirds, raptors, and songbirds moved between the WMA's through the area now occupied by the windfarm. Studies of bird collision mortality in California and elsewhere raised concerns about the possibility of mortalities in this area. From April 15, 2003 and December 15, 2003 we searched for dead animals under 26 randomly selected turbines. Six 76.2 m by 3.0 m transects were maintained as bare ground under each of these turbines. Access roads and construction pads under turbines were also searched. We found two birds (a yellow-throated vireo and a tree swallow) and 31 bats (hoary, red, little brown, big brown and silver-haired bats). Spring and summer search efficiency and scavenge rates were evaluated. During observer efficiency trials, observers found 77% of bird carcasses. In spring and summer and fall scavenging trials, scavengers removed 7%, 12% and 7% of carcasses respectively, within the duration of observer search cycles (i.e., 2 days). Point counts were conducted to compare bird activity in fields with and without turbines. We monitored waterfowl activity and behavior in the fall. 1.2 million total goose-use days and 194,029 total duck-use days were recorded in the WMA's, from September 15 to December 25, 2003. Canada goose foraging behavior was monitored for a total of 270 flocks, from September 27 to December 1, 2003. Bat detectors were used to compare bat activity at turbine versus adjacent non-turbine sites. No significant differences were found between relative bird and bat activity at turbine, turbine with transect and non-turbine sites. Results presented are preliminary. The study will continue until December 2004. While we have yet to evaluate the significance of the mortality data, proper siting of these facilities remains a priority.

Introduction
Electrical generation in the Midwest has historically been accomplished through the burning of fossil fuels. Burning fossil fuels, however, can have negative environmental impacts such as increasing atmospheric CO^2 emissions, which are known to contribute to global warming, or degrading air quality through release of particulate matter. Additionally, fossil fuels are a non-renewable limited source of energy. In northern Iowa, wind power is a financially competitive alternative source of renewable energy, as it is in other parts of the U.S., that is generally viewed as having few negative effects on the environment (Erickson *et al.* 2001). There are, however, concerns that bird and bat mortality resulting from collisions with wind turbines could be substantial in some areas (Orloff and Flannery 1992).

Study Area:
In December 2001, construction was completed on the 89-turbine Top of Iowa Wind Farm near Joice in Worth County, Iowa. Turbines are located on private land in Sections 14, 15, 16, 21, 22, 23, 24, 25, 26, 35 and 36 of Bristol Twp. (T- 99N, R-22W) and Sections 1, 2, and 11 of Fertile Twp. (T-98N, R-22W), an area comprising about 2,137 ha (5,280 acres) (Fig. 1). Turbines are mounted on 71.6 m (235-foot) high tubular towers and turned by three 25.9 m (85-foot) blades. Blade speed at the tips is approximately 337 kmph (130 mph).

Unlike other wind farms in Iowa, the Top of Iowa Wind Farm is located in an area that historically has had very high bird use, particularly water bird use. The wind farm is situated between three large state-owned WMA's that are complexes of wetland, grassland and forest habitat: the Rice Lake (~2,500 acres), Elk Creek (~2,500 acres) and Hanlontown Slough (~1,000 acres) WMAs (Fig. 1). The close proximity of these three large WMAs provides attractive habitat on a large scale, for north-central Iowa, and offers islands of strategic habitat. In addition to hosting numerous migrating birds during spring and fall, the Rice Lake – Elk Creek – Hanlontown Slough complex (RL-EC-HS) provides habitat for many breeding birds during the spring and summer, particularly wetland and grassland birds. In the past, migrant and resident shorebirds, rails, raptors, sparrows and icterids moved freely between the WMAs, their flight paths routinely taking them through the area that is now occupied by the wind farm. Additionally, part of the wind farm is contained within an area that has been closed to Canada goose hunting for 30 years to increase Canada goose use in the area. Finally, 2 of the adjacent WMA's contain inviolate waterfowl refuges that attract up to 40,000 Canada geese and 20,000 ducks to the area each year, resulting in 2.5 million waterfowl-use days in the vicinity of the wind farm. There is no other existing wind farm site in Iowa with higher potential bird use.

Objectives:

1. Determine bird and bat mortality resulting from impacts with wind-generator towers and turbine blades, with emphasis on mortality during the spring and fall migration periods.
2. Determine bird and bat species composition, relative abundance, habitat use, flight patterns and the relative mortality risk at turbine sites versus non-turbine sites.
3. Determine impacts of the wind turbines on waterfowl use of croplands by comparing waterfowl use of quarter sections containing wind turbines to similar quarter sections without turbines during the fall, with emphasis on Canada goose use of the area closed to Canada goose hunting around the Rice Lake WMA.

Methods:

Researchers looked for evidence of collision-induced mortality under 26 of 89 wind towers. Six 3m-wide transects were maintained vegetation free, using herbicides and manual weeding techniques, on each 76m x 76 m search plot under each of the 26 randomly selected towers. Transects were parallel to existing corn/soybean rows. Total transect area searched under each tower was 1371.6 m^2 (6 x 3m x 76.2m). This area comprised 24% of the search plot. Access roads and construction pads under turbines were also searched. Starting March 15, the turbine sites were being set up, and standardized searches of all mortality transects began April 15, 2003. Searching under each tower started immediately after transects were setup at its base. The search frequency was once every three days. From June 13 onwards, the search pattern was standardized to once every two days, in order to increase accuracy of the searches. Scavenger removal rates of collision evidence were measured during spring, summer, and fall by placing birds of 3 sizes (house sparrow, mallard/pigeon and Canada goose) on mortality transects under each of the 26 monitored wind towers. Carcasses were monitored daily for two weeks for evidence of scavenging. The status of each carcass was reported as intact, partially scavenged, or completely removed. Search efficiency trials were conducted for each observer by having an independent DNR wildlife technician place small birds, such as house sparrows, on transects without the field assistants' knowledge. The field assistants recorded all evidence of bird or bat collisions that they discovered, including evidence planted by the independent wildlife technician. Planted evidence of collisions was later removed from the database and a search efficiency rate calculated for each field assistant.

We estimated relative avian abundance and activity using fixed radius (100m) point counts from May 1, 2003 to December 1, 2003 (Ralph et al. 1995). Starting March 15, observers standardized their point counting techniques to reduce variance between observers. Additional point count sites were added as landowner permission was obtained until by May 1, all point count sites were in place in accordance with the experimental design. Observers recorded species, activity, and location of all birds within a 100m radius of the point count site. The duration of each point count was 10 minutes. Point counts were conduced in the morning from one-half an hour after sunrise until 4.5 hours after sunrise, during mid-day from 11 AM to 2:00 PM, in the evening from 4:00 PM to 7:30 PM, and at night from half an hour before sunset to an hour and a half after sunset. These times were periodically adjusted to account for changes in daylight hours. During morning and evening point count periods, observers usually completed 10 point counts. Due to the shorter time frame for conducting mid-day and night point counts, observers usually only completed 8 point counts for those periods. We conducted point counts under wind towers without mortality transects, as well as wind towers with mortality transects, and in adjacent fields without wind towers. We also conducted point counts in crop fields in an area approximately 4 miles southwest of the windfarm to contrast bird activity within the windfarm to similar sites outside the windfarm. Each site was visited approximately once every 6 days for each of the four time periods (morning, mid-day, evening and night).

Due to difficulties in acquiring functional bat monitoring equipment (shipping delays, malfunctioning equipment) we did not begin remotely monitoring bat activity around wind turbines until September. Prior to that time, bat activity was monitored in conjunction with evening and night point counts. Anabat ultrasonic bat detectors were used to monitor bat activity from September 4, 2003 to October 9, 2003 (O'Farrell 1999). Monitors were placed at wind tower sites as well as in adjacent fields without wind towers. The bat detectors were waterproofed for passive monitoring (O'Farrell 1998) and left overnight at each site. The collected data was downloaded (in a digital format) the following morning onto a computer. Using software programs and statistical analysis, the digital information was used to estimate relative bat activity and species on the windfarm (Jolly 1997).

Waterfowl activity was monitored in the fall, from September 15 to December 25, 2003. Waterfowl use of crop fields within the area closed to Canada goose hunting around Rice Lake was estimated twice weekly. Waterfowl behavior was also observed during morning and evening foraging periods in the same area. Behavior noted was time spent foraging (stationary and mobile) versus time spent vigilant (stationary and mobile) using scan sampling techniques (Altmann 1974). A flock was scanned for 2 minutes, and each bird observed was assigned a combination of behaviors (foraging, vigilant, mobile, stationary or other). For both activity and behavior, observations were made from county roads using a vehicle and spotting scope to keep disturbance to a minimum. Cropping and/or tillage practices and turbine activity were recorded for each field during each count along with any observations of other human activity that may have influenced waterfowl use of quarter sections. Fields with and without wind turbines in the area closed to Canada goose hunting were sampled for waste grain to estimate the relative amounts of grain available for foraging waterfowl in the fields. This was done to determine if the fields with wind turbines had similar amounts of waste grain in them, i.e., were as attractive to feeding geese, as fields without wind turbines, an important consideration in goose use of these fields. Farming practices were also documented for sampled fields. Farmers whose fields were not sampled were contacted to determine the farming practices they used in 2003 to predict the attractiveness of unsampled fields to foraging geese.

In addition, numbers of waterfowl using Rice Lake, Elk Creek and Hanlontown Slough were estimated twice weekly between 10:00 AM and 2:00 PM to get a relative picture of waterfowl use of the WMA's adjacent to the wind farm. These counts were conducted in a manner similar to past waterfowl counts, thereby providing indices to waterfowl populations that were comparable to previous years. To examine the feasibility of classifying waterfowl flight behavior relative to the wind turbines and to provide ideas for future observation methods, observations of waterfowl morning flight patterns into the wind farm area were made from October 1 through November 1. Observation data have been entered into a computer database (Excel) and/or ArcGIS and analysis is ongoing.

Results:

Between April 15, 2003, and December 15, 2003, we found two birds (a yellow-throated vireo and a tree swallow) and 31 bats (11 hoary, 9 little brown, 6 eastern red, 3 big brown and 2 silver-haired bats) on our mortality search transects. All appeared to have died as a result of collisions with the wind turbines.

The following adjustments have been made to extrapolate the mortality findings to the entire wind turbine. The mortality findings were adjusted for:

a) Proportion of the total plot area searched (76 m by 76 m plots for 89 towers)
b) Percent of test carcasses removed by scavengers within the search period
c) Percent of carcasses missed by observers in the search efficiency trials

Approximately 26% of the 76 m by 76 m plot under 26 towers was searched. Spring, summer and fall scavenging trials indicated scavengers removed 7%, 12% and 7% of carcasses, respectively, within the duration of the search frequency (2 days) in this study. Observer efficiency trials for mortality transect searches indicated that, as a group, observers found 77% of bird carcasses, although efficiency ratings varied from 40% to 95% for individual observers. Adjusted estimates of bird and bat mortality for the Top of Iowa Windfarm during the 2003 field season indicated that 10.8 birds and 167.2 bats died as a result of collisions with the wind turbines between April 15 and December 15, 2003 (Table 1).

Table 1. Adjustments for estimating total mortality at the Top of Iowa Windfarm.

Adjustment level	Bats	Birds
Raw mortality findings	31	2
Area adjusted	119.23	7.69
Scavenge Study adjusted	128.77	8.31
Search Efficiency adjusted	167.23	10.79

Preliminary analysis of point count data using ANOVA (Analysis Of Variance, SAS Institute Inc, 2001.) indicated there was no significant difference between bird activity for any combination of the three treatments (wind turbine site, wind turbine site with transects, and crop field without wind turbine) when analyzed for all bird species combined or for the 5 most common bird species observed at the windfarm (Table 2).

Table 2. Results of bird activity comparisons between 3 sites.

Category	P Value
All species	0.46
Common Grackle	0.67
Brown-headed Cowbird	0.79
Horned Lark	0.53
Vesper Sparrow	0.67
Red-winged Blackbird	0.15

The pilot study using Anabat ultrasonic bat detectors also indicated there was no significant difference between bat activity at wind turbine sites and crop fields without turbines (Paired T-test, $p = 0.63$, SAS Institute Inc, 2001).

Fall waterfowl use observations are currently being analyzed for the 270 flocks of geese that were observed foraging in fields with and without wind turbines. Approximately 1.2 million goose-use days and 194,000 duck-use days were recorded from September 15 to December 25, 2003 for the adjacent RL-EC-HS complex (Figure 2). Waterfowl use of the adjacent WMA's was below average for both ducks and geese in 2003 compared to historical counts due to a late summer drought in 2003. To compare goose use of fields with wind turbines to those without turbines, GIS analysis will be used to overlay goose counts in fields within the area that is closed to Canada goose hunting around Rice Lake WMA.

RECOMMENDATIONS FOR 2004 FIELD SEASON:

Mortality search methodology, including measurements of observer efficiency and scavenging rates, appeared to be satisfactory and will be continued as in 2004 as conducted in 2003. A substantial amount of staff time was needed for weeding and mowing during the 2003 field season to maintain transects vegetation-free. Transect maintenance will be reduced in 2004 by removing all crops immediately after germination and making transects more accessible for mowing (i.e., paying the landowners for some additional crop loss to maintain a 1 meter wide path to connect the transects on one end).

The pilot bat study indicated various problems with identifying bats by their calls. Several bat biologists have been contacted to provide assistance and advice for this aspect of the study.

The point counts serve to answer two questions. First, to estimate bird-use in the windfarm using on-windfarm point counts in the morning, mid-day, evening and night. Second, to contrast bird abundance on the windfarm with abundance at similar sites off the windfarm. For the later comparison, the accepted methodology is to conduct only morning point counts, since bird activity is highest at that time (Ralph *et al.* 1995). In 2004, only morning counts will be conducted to make comparisons of bird activity on and off the windfarm. To ensure a better comparison of bird activity on and off the windfarm, more morning counts will be conducted in 2004.

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Fig 1. Location of the Top of Iowa Wind Farm relative to the Rice Lake, Elk Creek and Hanlontown Slough Wildlife Management Areas in northern Iowa.

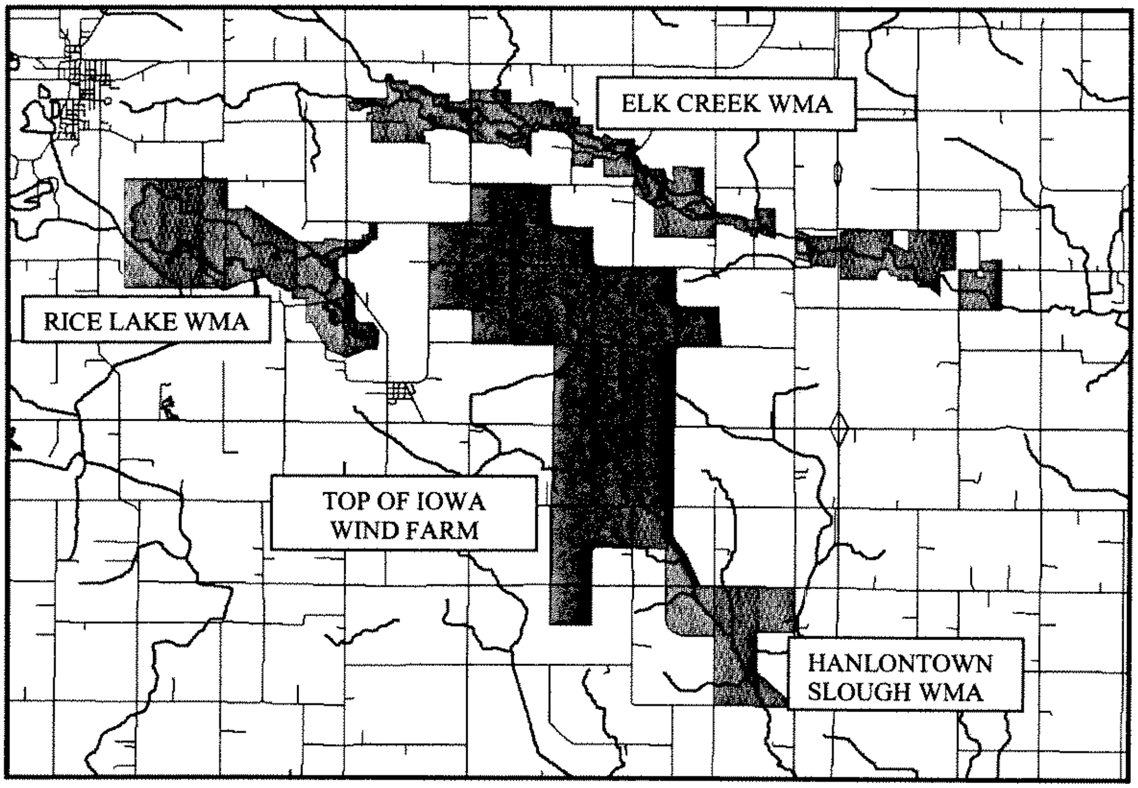
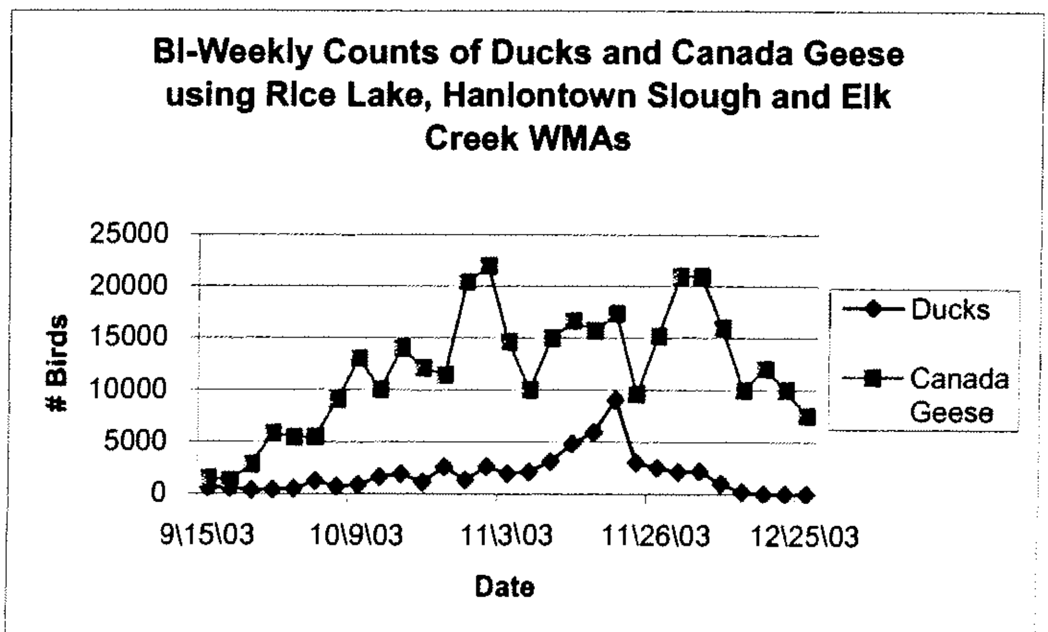


Fig 2. Bi-Weekly counts of Canada geese and ducks using Rice Lake, Hanlontown Slough and Elk Creek WMAs.



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We examined bird and bat mortality at a new 89-turbine windfarm constructed in an environmentally sensitive area in north-central Iowa. The windfarm became operational in November 2001. It is located in cropland between three Wildlife Management Areas (WMA's) with historically high bird use. In the past, migrant and resident waterfowl, shorebirds, raptors, and songbirds moved between the WMA's through the area now occupied by the windfarm. Studies of bird collision mortality in California and elsewhere raised concerns about the possibility of mortalities in this area. From April 15, 2003, to December 15, 2003, and from March 24, 2004, to December 10, 2004, we searched for dead birds and bats under 26 randomly selected turbines. Six 76.2 m by 3.0 m (250 ft by 10 ft) transects were maintained as bare ground under each of these turbines. Access roads and construction pads under turbines were also searched. In 2003, we found two birds (a yellow-throated vireo and a tree swallow) and 30 bats (hoary, red, little brown, big brown and silver-haired bats) and in 2004, we found five birds (yellow-headed blackbird, red-tailed hawk, golden-crowned kinglet and two carcasses of unidentifiable bird species) and 44 bats (hoary, red, little brown, big brown, silver-haired and eastern pipistrelle bats). Spring and summer search efficiency and scavenge rates were evaluated. During observer efficiency trials, observers found 77% of bird carcasses in 2003 and 70% of bird carcasses in 2004. In spring, summer and fall scavenging trials, scavengers removed 5% and 8% of carcasses in 2003 and 2004 respectively, within the duration of observer search cycles (i.e., 2 days). Point counts were conducted on and near the windfarm to compare bird activity in fields with and without turbines. We monitored waterfowl activity and behavior in the fall. Approximately 1.2 million total goose-use days and 194,000 total duck-use days were recorded in the WMA's, from September 15 to December 25, 2003, and 904,200 total goose-use days and 66,300 total duck-use days were recorded from September 27 to December 22, 2004. Canada goose foraging behavior was monitored for a total of 447 flocks in 2003 and 587 flocks in 2004 and the presence of wind towers on goose activity was estimated to have a negligible effect. Bat detectors were used to compare bat activity at turbine versus adjacent non-turbine sites. No consistent significant differences were found between relative bird and bat activity at turbine, turbine with transect and non-turbine sites. Results presented are preliminary. While the evidence of avian mortality is minimal, bat mortality during the fall migratory period was substantial, and may be a source of concern. Proper siting of these facilities should remain a priority, and future research in this region should concentrate on determining the causes of collisions, potential population effects, and strategies to reduce or avoid bat mortality at wind farms.

Introduction
Electrical generation in the Midwest has historically been accomplished through the burning of fossil fuels. The burning of fossil fuels, however, can have negative environmental impacts, such as degrading air quality through release of particulate matter or increasing atmospheric CO_2 emissions, which are known to contribute to global warming. Additionally, fossil fuels are a non-renewable resource. In northern Iowa, wind power is a financially competitive alternative for generating electricity that is generally viewed as having few negative impacts on the environment (Erickson *et al.* 2001). There are, however, concerns that bird and bat mortality resulting from collisions with wind turbines could be substantial in some areas (Orloff and Flannery 1992).

Study Area:

Construction on the 89-turbine Top of Iowa Wind Farm near Joice in Worth County, Iowa was completed in December 2001. Turbines are located on private land in Sections 14, 15, 16, 21, 22, 23, 24, 25, 26, 35 and 36 of Bristol Twp. (T- 99N, R-22W) and Sections 1, 2, and 11 of Fertile Twp. (T-98N, R-22W), an area comprising about 2,137 ha (5,280 acres) (Fig. 1). Turbines are mounted on 71.6 m (235-foot) high tubular towers and turned by three 25.9 m (85-foot) blades. Blade speed at the tips is approximately 337 kmph (130 mph).

Unlike other wind farms in Iowa, the Top of Iowa Wind Farm is located in an area that historically has had very high bird use, particularly water bird use. The wind farm is situated between three large state-owned WMA's that are complexes of wetland, grassland and forest habitat: the Rice Lake (~2,500 acres), Elk Creek (~2,500 acres) and Hanlontown Slough (~1,000 acres) WMAs (Fig. 1). The close proximity of these three large WMAs provides attractive habitat for migrating birds in the intensively farmed region of northern Iowa. In addition to hosting numerous migrating birds during spring and fall, the Rice Lake – Elk Creek – Hanlontown Slough complex (RL-EC-HS) provides habitat for many breeding birds during the spring and summer, particularly wetland and grassland birds. In the past, migrant and resident shorebirds, rails, raptors, sparrows and icterids moved freely between the WMAs, their flight paths routinely taking them through the area that is now occupied by the wind farm. Additionally, part of the wind farm is contained within an area that has been closed to Canada goose hunting for 30 years to increase Canada goose use in the area. Finally, two of the adjacent WMA's contain inviolate waterfowl refuges that attract up to 40,000 Canada geese and 20,000 ducks to the area each year, resulting in 2.5 million waterfowl-use days in the vicinity of the wind farm. There is no other existing wind farm site in Iowa with higher potential bird use.

Objectives:

1. Determine bird and bat mortality resulting from impacts with wind-generator towers and turbine blades, with emphasis on mortality during the spring and fall migration periods.
2. Determine bird and bat species composition, relative abundance, habitat use, flight patterns and the relative mortality risk at turbine sites versus non-turbine sites.
3. Determine impacts of the wind turbines on waterfowl use of croplands by comparing waterfowl use of quarter sections containing wind turbines to similar quarter sections without turbines during the fall, with emphasis on Canada goose use of the area closed to Canada goose hunting around the Rice Lake WMA.

Methods:

1. Mortality

Researchers looked for evidence of collision-induced mortality under 26 of 89 wind towers. Six 3m-wide transects were maintained vegetation free, using herbicides and manual weeding techniques, on each 76m x 76 m (250 ft by 250 ft) search plot under each of the 26 randomly selected towers. Transects ran parallel to existing corn/soybean rows. Access roads and construction pads under turbines were also searched. The average total area searched under each tower was 1742m^2 (18750 ft^2) which was about 30% of the 5,776m^2 (62170 ft^2) search plot. Standardized searches of all mortality transects began April 15, 2003, immediately after transects were set up. The search frequency was once every three days. From June 13, 2003, the search pattern was standardized to once every two days, in order to increase accuracy of the searches. Starting March 15, 2004 the turbine sites were set up again, and standardized searches of all mortality transects began on March 24, 2004. The search frequency was once every two days.

Scavenger removal rates of collision evidence were measured during spring, summer, and fall by placing birds of three sizes (house sparrow, mallard/pigeon and Canada goose) on mortality transects under each of the 26 monitored wind towers. Carcasses were monitored daily for two weeks for evidence of scavenging. The status of each carcass was reported as intact, partially scavenged, or completely removed.

Search efficiency trials were conducted for each observer by having an independent DNR wildlife technician place small birds, such as house sparrows, on transects without the field assistants' knowledge. The field assistants recorded all evidence of bird or bat collisions that they discovered, including evidence planted by the independent wildlife technician. Planted evidence of collisions was later removed from the database and a search efficiency rate calculated for each field assistant.

2. Bird and Bat Species Composition and Activity.

We estimated relative avian abundance and activity using fixed radius (100m or 328 ft) point counts from May 1, 2003 to December 1, 2003 and from March 24, 2004 to December 14, 2004 (Ralph et al. 1995). Observers standardized their point counting techniques to reduce variance between observers. Observers recorded species, activity, and location of all birds within a 100m radius of the point count site. The duration of each point count was 10 minutes. Point counts were conducted in the morning from one-half hour after sunrise until 4.5 hours after sunrise, during mid-day from 11 AM to 2:00 PM, in the evening from 4:00 PM to 7:30 PM, and at night from half an hour before sunset to an hour and a half after sunset. These times were periodically adjusted to account for changes in daylight hours. During morning and evening point count periods, observers usually completed 10 point counts. Due to the shorter time frame for conducting mid-day and night point counts, observers usually only completed 8 point counts for those periods. We conducted point counts under wind towers without mortality transects, as well as wind towers with mortality transects, and in adjacent fields without wind towers. We also conducted point counts in crop fields in an area approximately 4 miles southwest of the windfarm to contrast bird activity within the windfarm to similar sites outside the windfarm. Each site was visited approximately once every 6 days for each of the four time periods (morning, mid-day, evening and night). In 2004, point counts in the area southwest of the windfarm were only conducted in the morning, as an improvement to the study design. It was determined that, to contrast bird abundance on the windfarm with abundance at similar sites off the windfarm, the accepted methodology was to conduct only morning point counts, since bird activity is highest at that time (Ralph *et al.* 1995). Thus, for the remaining three time periods, only on-windfarm point counts were conducted.

We divided the 100m fixed radius point counts by species and season, i.e. Summer 2003 and Spring and Summer 2004, and analyzed each species-season combination separately. We analyzed the seven most common bird species observed. We conducted point counts at four types of sites, lettered A through D. A point count under a wind tower was called site type A. If the tower had mortality transects under it, from the previous objective, it was called Site type B. This was to estimate the effect, if any, of manipulating the ground cover at the site. It was thought that Horned Larks and Killdeer might respond to the extra available bare ground. Site type C was a point count conducted in adjacent fields within the windfarm area, which did not have a wind tower centered within it. Thus, we compared the relative avian activity under wind towers and adjacent non-tower sites i.e. Comparison 1: A, B and C. (Table 1) Site type D was also an open field without wind towers. However, these sites were outside the windfarm, in a region approximately 4 Km to the southwest of the windfarm. We chose this site to test whether avian activity differed between fields within the windfarm and a comparable region just outside the windfarm. Thus comparison 2 was between site types A and D (Table 2).

Due to difficulties in acquiring functional bat monitoring equipment (shipping delays, malfunctioning equipment) we did not begin remotely monitoring bat activity around wind turbines until September 2003. Prior to that time, bat activity was monitored in conjunction with evening and night point counts. Anabat ultrasonic bat detectors were used to monitor bat activity from September 4, 2003 to October 9, 2003 and from May 26, 2004 to September 24, 2004 (O'Farrell 1999). Monitors were placed at wind tower sites as well as in adjacent fields without wind towers. The bat detectors were waterproofed for passive monitoring (O'Farrell 1998) and left overnight at each site. The collected data was downloaded (in a digital format) each day. Using software programs and statistical analysis, the digital information was used to estimate relative bat activity and species on the windfarm (Jolly 1997).

3. Waterfowl Behavior and Activity.

Waterfowl activity was monitored in the fall, from September 15 to December 25, 2003 and from September 27 to December 22, 2004. Waterfowl use of crop fields within the area closed to Canada goose hunting around Rice Lake was estimated twice weekly. Observations were made from vehicles on county roads using a spotting scope to keep disturbance to a minimum. Cropping and/or tillage practices and turbine activity were recorded for each field during each count along with any observations of other human activity that may have influenced waterfowl use of quarter sections. Other relevant parameters recorded were Field Area, Distance from Rice Lake and Presence/Absence of wind turbines in each field, using ArcGIS software. In addition, a number of fields with and without wind turbines in the area closed to Canada goose hunting were sampled for waste grain to estimate the relative amounts of grain available for foraging waterfowl in the fields. This was done to determine if the fields with wind turbines had similar amounts of waste grain in them, i.e., were as attractive to feeding geese, as fields without wind turbines, an important consideration in goose use of these fields. Farming practices were also documented for sampled fields. Farmers whose fields were not sampled were contacted to determine the farming practices they used in 2003 and 2004 to predict the attractiveness of unsampled fields to foraging geese.

Waterfowl behavior was also observed during morning and evening foraging periods in the same area. Behavior noted was time spent foraging (stationary and mobile) versus time spent vigilant (stationary and mobile) using scan sampling techniques (Altmann 1974). A flock was scanned for 2 minutes, and each bird observed was assigned a combination of behaviors (foraging, vigilant, mobile, stationary or other). Observations were made in a similar manner to the foraging activity study.

In addition, numbers of waterfowl using Rice Lake, Elk Creek and Hanlontown Slough were estimated twice weekly between 10:00 AM and 2:00 PM to get a relative picture of waterfowl use of the WMA's adjacent to the wind farm in 2003 and 2004. These counts were conducted in a manner similar to past waterfowl counts, thereby providing indices to waterfowl populations that were comparable to previous years. To examine the feasibility of classifying waterfowl flight behavior relative to the wind turbines and to provide ideas for future observation methods, observations of waterfowl morning flight patterns into the wind farm area were made from October 1 through November 1, 2003.

Results:

1. Mortality

Between April 15, 2003, and December 15, 2003, we found two birds (a yellow-throated vireo and a tree swallow) and 30 bats (11 hoary, 9 little brown, 6 eastern red, 3 big brown and 2 silver-haired bats) on our mortality search transects. Between April 1 and December 10, 2004 we found five birds (a yellow-headed blackbird, a red-tailed hawk, a golden-crowned kinglet and two unidentifiable bird species) and 44 bats (21 hoary, 18 red, 18 little brown, 9 big brown, 9 silver-haired and one eastern pipistrelle bat). All appeared to have died as a result of collisions with the wind turbines.

The following adjustments have been made to extrapolate the mortality findings to the entire wind farm. The mortality findings were adjusted for:

a) Proportion of the total plot area searched (76 m by 76 m plots)
b) The number of towers sites searched (26) relative to the entire wind farm (89 towers)
c) Percent of test carcasses removed by scavengers within the search period
d) Percent of carcasses missed by observers in the search efficiency trials

Spring, summer and fall scavenging trials indicated scavengers removed an average of 5% and 8% of carcasses within the duration of the search frequency (2 days) in this study, in 2003 and 2004 respectively. Observer efficiency trials for mortality transect searches indicated that, as a group, observers found 77% and 70% of bird carcasses, in 2003 and 2004 respectively.

Calculations to adjust for Scavenge rate, Search Efficiency and Proportion of area searched:

$$1)\ \overline{C} = \frac{\mu C}{(1-R)*E*P}$$

Where $\overline{C}$ = Adjusted total number of carcasses found.
μC = Actual number of carcasses found
R = Scavenge Rate
E = Search Efficiency
P = Proportion of area searched to total potential area for entire windfarm.

The variance was calculated using the variance of a product formula (Goodman, 1960) and the variance of a ratio formula (Pochran, 1977). The variance of the product of R, E and P is:

$$2)\ \text{Variance of } \overline{C} = \overline{C}^2 * \left[\frac{\text{var C}}{\text{C}^2} + \frac{\text{var}(R*E*P)}{((1-R)*E*P)^2} \right]$$

Using the estimate of $\overline{C}$ and its **variance**, adjusted estimates of bird and bat mortality for the Top of Iowa Windfarm indicated that **35 ± 47.67** birds and **526 ± 192.87** bats died as a result of collisions with the wind turbines between April 15 and December 15, 2003 and that **80 ± 74.18** birds and **905 ± 264.69** bats died as a result of collisions with the wind turbines between March 24 and December 15, 2004. These are mortality estimates adjusted for the entire windfarm.

2. Bird and Bat Species Composition and Activity.

Analysis of point count data using ANOVA (Analysis Of Variance, SAS Institute Inc, 2001.) indicated there was no consistent significant difference between relative avian sites in and adjacent to the windfarm.

Comparison 1 (Tower vs. NonTower): None of the 15 species-season analyses varied among site types A, B and C (**p values > 0.12, df = 2, 22).** (Table 1)

Comparison 2 (Windfarm vs. Nonwindfarm): Out of 15 species-season analyses, the abundance of Three species, Common Grackles and Song Sparrows (Summer 2004), and Red-winged Blackbirds (Summer 2003) varied between A and D in different directions (**p values < 0.05, df = 2, 22).** For all other analyses, **p values > 0.29 (df = 2, 22).** (Table 2)

Table 1. Results of bird activity comparisons between sites A, B and C.

Season	Sp. No	Species	P Value	Direction
Summer 2003	1	Brown-headed Cowbird	0.44	N/A
Summer 2003	2	Common Grackle	0.67	N/A
Summer 2003	3	Red-winged Blackbird	0.58	N/A
Summer 2003	4	Vesper Sparrow	0.97	N/A
Summer 2003	5	Horned Lark	0.98	N/A
Spring 2004	1	Brown-headed Cowbird	0.12	N/A
Spring 2004	2	Common Grackle	0.13	N/A
Spring 2004	3	Red-winged Blackbird	0.84	N/A
Spring 2004	6	American Robin	0.34	N/A
Spring 2004	5	Horned Lark	0.98	N/A
Summer 2004	1	Brown-headed Cowbird	0.21	N/A
Summer 2004	2	Common Grackle	0.53	N/A
Summer 2004	3	Red-winged Blackbird	0.71	N/A
Summer 2004	7	Song Sparrow	0.97	N/A
Summer 2004	5	Horned Lark	0.16	N/A

Table 2. Results of bird activity comparisons between sites A and D.

Season	Sp. No.	Species	P Value	Direction
Summer 2003	1	Brown-headed Cowbird	0.83	N/A
Summer 2003	2	Common Grackle	0.43	N/A
Summer 2003	**3**	**Red-winged Blackbird**	**0.05**	**D>A**
Summer 2003	4	Vesper Sparrow	0.75	N/A
Summer 2003	5	Horned Lark	0.93	N/A
Spring 2004	1	Brown-headed Cowbird	0.67	N/A
Spring 2004	2	Common Grackle	0.58	N/A
Spring 2004	3	Red-winged Blackbird	0.79	N/A
Spring 2004	6	American Robin	0.32	N/A
Spring 2004	5	Horned Lark	0.94	N/A
Summer 2004	1	Brown-headed Cowbird	0.29	N/A
Summer 2004	**2**	**Common Grackle**	**0.05**	**A>D**
Summer 2004	3	Red-winged Blackbird	0.38	N/A
Summer 2004	**7**	**Song Sparrow**	**0.01**	**A>D**
Summer 2004	5	Horned Lark	0.52	N/A

In order to give an idea of bird flight in the region until more complete results are available, the following is an approximate of birds seen and heard during point counts under wind tower:
An approximate abundance number of birds seen during the morning point counts in the summer of 2003 and 2004 was 1.76 birds and 1.95 birds every ten minutes that an observer was at the site.
An approximate abundance number of birds seen during the morning point counts in the fall of 2003 was 19 birds every ten minutes that an observer was at the site. It must be noted that these high numbers were primarily driven by rare sightings of large flocks of blackbirds (with numbers as high as 1000 and 5000 birds in one sighting). An approximate abundance number of birds seen during the morning point counts in the spring of 2004 was 1.6 birds every ten minutes that an observer was at the site.

The 2003 pilot study using Anabat ultrasonic bat detectors also indicated there was no significant difference between bat activity at wind turbine sites and adjacent crop fields without turbines (Paired T-test, $p = 0.63$, SAS Institute Inc, 2001). The 2004 study (May to September 2004) also found no significant difference between bat activity at wind tower sites and adjacent crop fields without towers (Paired T-test, $p = 0.78$, SAS Institute Inc, 2001).

Approximately 1.2 million goose-use days and 194,000 duck-use days were recorded from September 15 to December 25, 2003 (Figure 2) and approximately 904,200 goose-use days and 66,300 duck-use days were recorded from September 27 to December 22, 2004 for the adjacent RL-EC-HS complex (Figure 3). Waterfowl use of the adjacent WMA's was below average for both ducks and geese in 2003 and 2004 compared to historical counts due to a late summer drought in 2003_and an unusual migration in 2004.

Fall waterfowl use observations were analyzed for the 447 and 587 flocks of geese that were observed foraging in fields with and without wind turbines in 2003 and 2004, respectively. Multiple Subset model selection was performed using Proc Logistic (SAS Institute Inc, 2001) to determine the effect of the presence or absence of wind turbines on the use of fields by Canada geese. For both years, the model that best fitted the data was selected using AIC selection criteria (Burnham & Anderson 2002). Then, presence/absence of wind turbines was entered into the best model to determine its effect. In 2003 a field with a wind turbine was 0.04 ± 0.3573 less likely to have Canada geese forage in it during the season and in 2004, a field with a wind turbine was 0.1326 ± 0.3271 less likely to have Canada geese forage in it during the season. Since the confidence intervals for these estimates crossed zero, the effects are considered negligible.

Ongoing Analyses and Writing Preparations:

Ongoing analyses include

a) Incorporating waste grain data into the goose foraging models,
b) Combining both years (2003 and 2004) of data for the same model,
c) Using flight/abundance data from avian point counts to determine bird-risk.
d) The next three months will include final analyses, thesis writing, completing the final report and submitting a manuscript for publication.

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Fig 1. Location of the Top of Iowa Wind Farm relative to the Rice Lake, Elk Creek and Hanlontown Slough Wildlife Management Areas in northern Iowa.

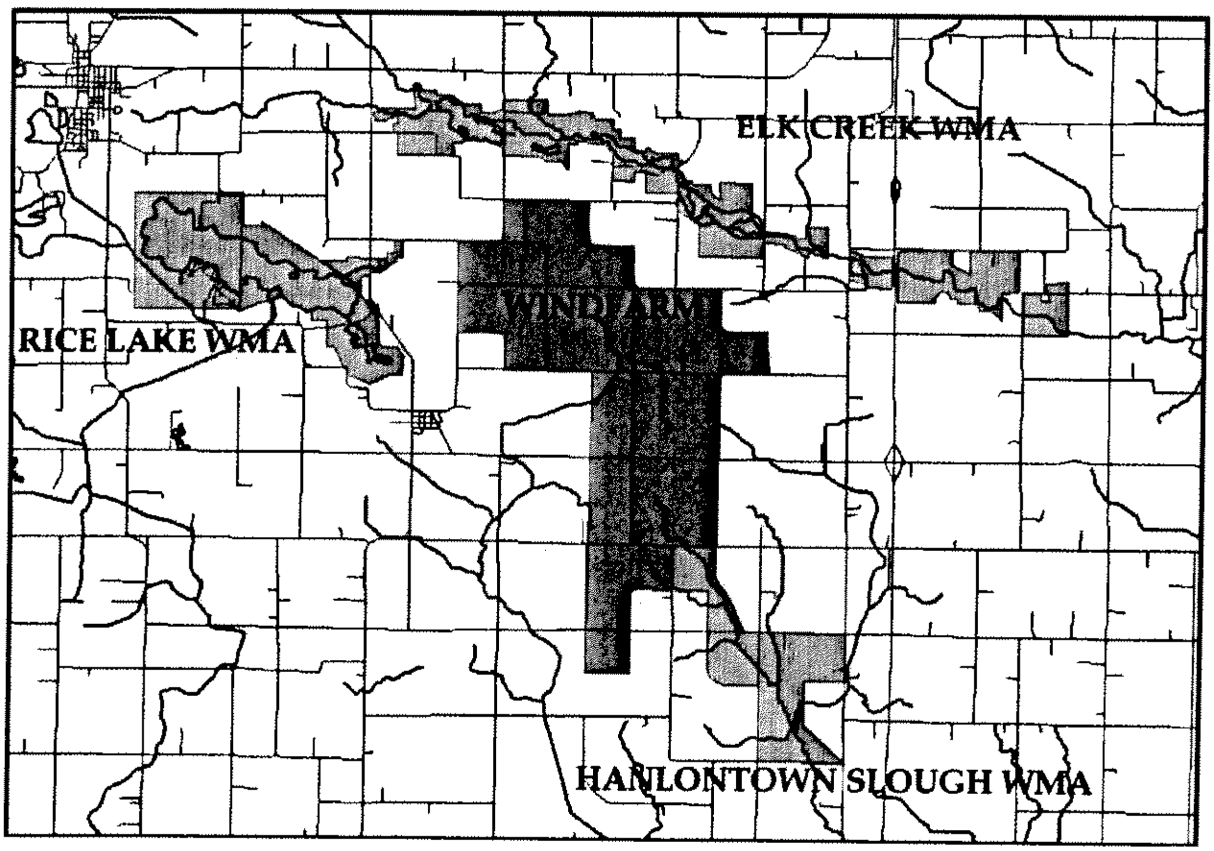

Fig 2. Bi-Weekly counts of Canada geese and ducks using Rice Lake, Hanlontown Slough and Elk Creek WMA's (2003).

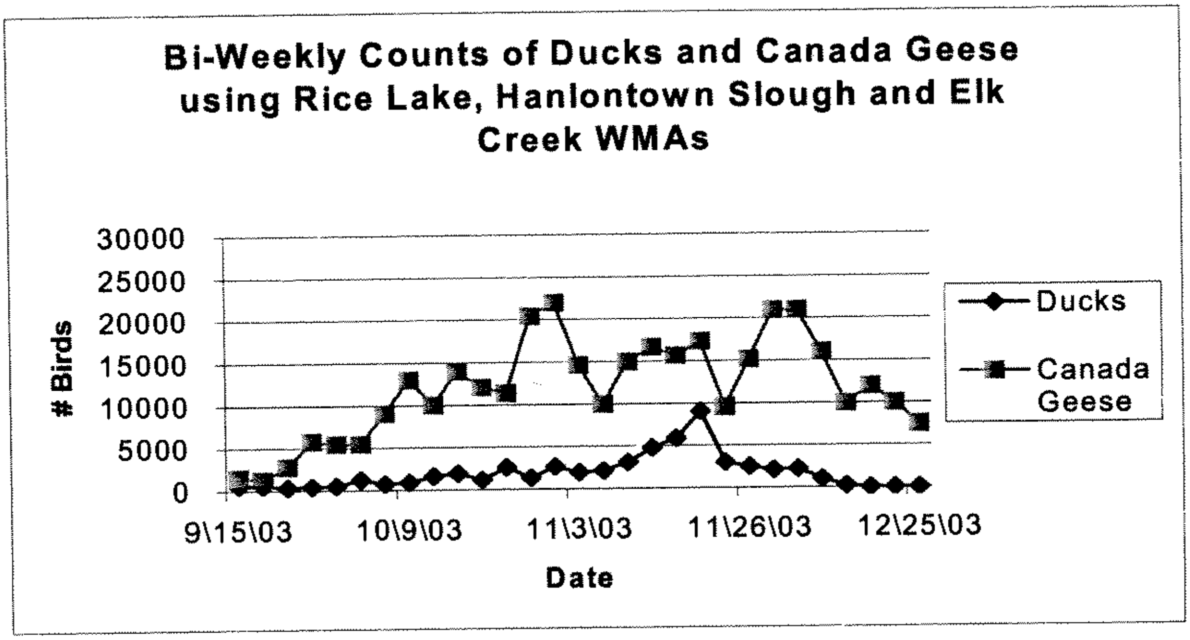

Fig 3. Bi-Weekly counts of Canada geese and ducks using Rice Lake, Hanlontown Slough and Elk Creek WMA's (2004).