NINA Rapport 413

Forholdet mellom fugler og vindmøller og andre lufthindringer

En litteraturoversikt

Torgeir Nygård
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Norsk institutt for naturforskning

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Havørn i flukt foran vindmølle på Smøla. Foto: Torgeir Nygård

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Sammendrag

Nygård, T., Bevanger, K. & Reitan, O. 2008. Forholdet mellom fugler og vindmøller og andre lufthindringer. En litteraturoversikt. - NINA Rapport 413. 167 s.

Rapporten er en trykt versjon av en nettbasert referansedatabase om forholdet mellom fugl og flaggermus og vindmøller, kraftledninger, tårn, bygninger og andre lufthindringer. Den er en database som blir jevnilig oppdatert, og som er tilgjengelig over nettet via EndNote Web. Referansedatabasen inneholder i skrivende stund 1224 referanser til litteratur som omhandler denne problematikken. Databasen blir stadig utvidet etter hvert som ny litteratur blir tilgjengelig. Basen kan brukes som søkeverktøy mot andre litteraturdatabaser så som ISI Web of knowledge, Biosis og lignende, avhengig av brukertilgang. .

I denne trykte utgaven er referansene sortert tematisk, deretter på trykkeår og forfatter. Basen har fått navnet ”Birdwind”. og oppdateres og administreres av NINA. Basen er ment som er verktøy som gjør det lettere å finne fram til relevant litteratur innenfor disse raskt voksende temaene.

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Abstract

Nygård, T., Bevanger, K. & Reitan, O. 2008. The relation between birds and wind turbines and other aerial obstacles. A literature survey. - NINA Report 413. 167 pp.

The report is a printed version of an internet-based reference database on the relation between birds and bats and aerial obstacles such as wind turbines, utility structures, towers and buildings. The database will be updated regularly, and is accessible via EndNote Web. At the date of printing it contains 1224 references on these topics. The database can also be used as a search engine for other databases such as ISI Web of knowledge, Biosis and others, depending on the access rights of the user.

In this printed version, the references are sorted by theme, thereafter by year of printing and author. The database is named “Birdwind”, and is administered and updated by NINA. The database is meant to be a tool that will make it easier to find relevant literature within these rapidly growing topics.

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Innhold

Forord

I dagens samfunn øker kunnskapstilfanget dramatisk hvert år, og mer og mer blir gjort tilgjengelig over nettet. En trykt framstilling over kunnskapsstatus innen ethvert emne blir derfor fort utdatert. Da NVE bestilte en kunnskapsstatus om forholdet mellom fugl og vindkraft av NINA våren 2008, var det naturlig for oss å foreslå å lage denne som en søkbar database med jevnlig oppdatering av ny litteratur. Med det nettbaserte referansebaseprogrammet EndNote Web (Thomson-Reuters), som er gratis og kan lastes ned over nettet, er det nå blitt enkelt å dele databaser. Denne basen kan også brukes som søkeverktøy mot andre litteraturdatabaser så som ISI Web of knowledge, BIOSIS og lignende.

I tillegg til å omhandle problematikken mellom fugl (samt flaggermus) og vindmøller, omfatter basen også litteratur på forholdet mellom fugl og andre lufthindringer, så som kraftledninger, tårn, master og bygninger, samt flytrafikk. På disse områdene hadde vi tidligere samla mye litteratur, og vi fant det naturlig å ta med disse nært beslektede emneområdene også. I skrivende stund omfatter basen 1224 referanser. I denne trykte rapporten er referansene sortert tematisk, deretter på trykkeår og forfatter. Basen har fått navnet ”Birdwind”, og oppdateres og administreres av NINA. Adgangen styres av basens administrator, som for tiden er Torgeir Nygård.

Brukere må registrere en konto med passord hos EndNote Web,
http://www.myendnoteweb.com/EndNoteWeb/2.4 .

Trondheim, 18.11 2008

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1 Innledning

Forskning på forholdet mellom vindmøller og fugler er relativt nytt, selv om utnyttelsen av vind som kraftkilde er eldgammel. Økt fokus på behovet for fornybar energi har imidlertid ført til en sterk ny satsing på vindkraft, særlig i kontinentale Europa. Nye turbiner har ofte en diameter på over 40 m, og sveiper et areal større enn en fotballbane. Økt størrelse og antall har til sammen ført til økt risiko for kollisjoner mellom flygende vesener og disse nye lufthindringene. Norge har energipolitiske målsettinger på området fornybar energi som involverer utbygging av en betydelig mengde vindkraft. De fleste planene er utarbeidet for kystlokaliteter, men også offshore og i fjellet blir det utviklet prosjektskisser. For å kunne utrede mulige konsekvenser i forbindelse med de ulike planene, en det viktig å ha en god oversikt over hva som er kjent av effekter fra andre studier. For forskerne er det særdeles viktig å vite hva andre har kommet fram til gjennom systematiske studier, eksperimenter og teoretiske vurderinger.

Vi håper at denne sammenstillingen kan være til nytte for forvaltere og forskere gjennom å gjøre kjent kilder som det ellers kunne koste mye arbeid å lete fram. Spesielt gjelder dette den eldre litteraturen, da denne i regelen ikke finnes i databaser som er søkbare på nettet. Som regel vil imidlertid biblioteket vær behjelpelig med å skaffe slike. Vi håper å ha bidratt til at det blir lettere å finne relevant litteratur på dette fagfeltet gjennom den nettbaserte versjonen av litteraturbasen.

Der hvor sammendrag har vært tilgjengelig, er dette trykt under hver innførsel.

2 Referanser

2.1 Vindkraft og fugl

National Wind Technology Center. "Avian Literature Database." from http://www.nrel.gov/wind/avianlit.html.

Rogers, S. E., M. A. Duffy, et al. (1976). Evaluation of the potential environmental effects of wind energy conversion systems development. Final interim report. Columbus, Ohio, Prepared by Battelle Columbus Laboratories. Prepared for the National Science Foundation under contract with the U.S. Energy Research and Development Administration, Division of Solar Technology: 108 pp. + appendices.

Rogers, S. E., B. W. Cornaby, et al. (1977). Environmental studies related to the operation of wind energy conversion systems: final report., Prepared by Battelle's Columbus Laboratories. Prepared for the U.S. Department of Energy, Division of Solar Technology, Wind Systems Branch: 108 pp. + appendices.
The environmental consequences of emerging wind energy conversion technology are assessed. Field studies were done at the DOE/NASA 100-kW Experimental Wind Turbine located at Lewis Research Center's Plum Brook Station near Sandusky, Ohio. During four migratory seasons of searching (spring and fall 1975, fall 1976 and spring 1977), two birds were found dead near the meteorological tower and one was found near the turbine. Night-migrating bird collisions were the only type considered significant enough for field studies. "The wind turbine has not proved to be a high risk to airborne fauna, including the most vulnerable night-migrating songbirds. Behavioral studies indicate the birds will avoid the turbine if they can see it."

Phillips, P. D. (1979). "NEPA and alternative energy: wind as a case study." Solar Law Reporter **1**(1): 29-54.
This article examines the issue of whether and when the National Environmental Policy Act (NEPA) applies to alternative energy sources, using wind as a case study. Potential environmental impacts of wind development are discussed, and construction of a 1.5-megawatt wind turbine is used for illustrative purposes. The hazard of bird collision is noted, especially with regard to migratory birds; "[t]he risk would be small for high flying migratory waterfowl, but would increase for low flying nocturnal migrants, such as many songbirds."

Lawrence, K. A. and C. L. Strojan (1980). Environmental effects of small wind energy conversion systems (SWECS). Golden, Colorado., Solar Energy Research Institute (now called National Renewable Energy Laboratory). Prepared for the U.S. Department of Energy: 16.
The authors conclude that the possibility of birds colliding with rotors and towers of Small Wind Energy Conversion Systems (SWECS) is "extremely small" based on the relatively low height of the rotors and towers (an exception might be a very large wind machine sited on a migratory route). Contributing factors noted are solidity of the rotor design; airfoil design; number of organisms flying through the sweep area; behavior of organisms within the sweep area, *e.g.*, flight speed or evasive flight patterns; weather conditions; and total structure height.

Mead, C. J. (1982). The possible impact of wind power generators on flying birds., British Trust for Ornithology Report to the Nature Conservancy Council.

Medsker, L. (1982). Side effects of renewable energy sources., National Audubon Society**:** 73 pp.
"Barriers to wildlife movement" are cited as direct impacts of Wind Energy Conversion Systems (WECS), with the consequence of "possible destruction of birds and insects colliding with wind machines." Choosing sites to avoid migration and flight patterns is recommended.

Byrne, S. (1983). "Bird movements and collision mortality at a large horizontal axis wind turbine." Cal-Neva Wildlife Transactions: 76-83.
This study was conducted as a part of Pacific Gas and Electric Company's performance monitoring program for a Boeing MOD-2 wind turbine located at the edge of Suisun Marsh in Solano County, California. Bird mortality was monitored for one year beginning in September 1982. As of January 1, 1983, five dead birds had been found at the turbine site.

Karlsson, J. (1983). Fåglar och vindkraft: resultat rapport 1977-1982 (Birds and wind power: result report 1972-1982). 12 pp.
Two large wind generators were erected in Sweden in 1980-82 on arable land and in grazed bushland habitat. Census results did not indicate any effect on bird species diversity or abundance up to 1982. Reactions of migrating birds were to be studied in fall 1983, when the generators would be in continuous operation.

Karlsson, J. (1983). Fåglar och vindkraft: resultat rapport 1977-1982. U.S. Government Reports. Available from National Technical Information Service (NTIS) as DE84751012. (In Swedish; English summary.)
1-12.

Manning, P. T. (1983). "The environmental impact of the rise of large wind turbines." Wind Engineering **7**(1): 1-11.

McCrary, M. D., R. L. McKernan, et al. (1983). Nocturnal avian migration assessment of the San Gorgonio Wind Resource Study Area, spring 1982. Los Angeles, Los Angeles County Natural History Museum, Section of Ornithology. Prepared for Southern California Edison, Research and Development, Rosemead, California: 121.
Research was conducted on spring 1982 bird migration in the San Gorgonio Wind Resource Study Area (WRSA) to examine characteristics of nocturnal migration in the area and to assess the potential collision impact on birds. It was determined that the WRSA is heavily utilized by birds as a migratory flyway. "From these studies avian collisions with wind turbines in the WRSA will almost undoubtedly occur." Approximately 182,000 birds per km could potentially come into contact with wind turbine generators each spring in the WRSA. "Although only a small fraction of these birds is likely to collide with wind turbines in the WRSA, even a collision rate of 0.5 percent would yield several thousand deaths per spring season." Recommendations for further study and mitigation measures are included.

Moller, N. W. and E. Poulsen (1984). Vindmøller og fugle, Vildtbiologisk Station, Denmark**:** 73.

Møller, N. W. and E. Poulsen (1984). Vindmøller of fugle (windmills and birds). (In Danish; English summary.). Kalø, Rønde, Danmark, Vildtbiologisk Station**:** 73.
In 1983 studies were conducted at Jutland, Denmark, to illustrate any conflicts between wind turbines and birds. There were no birds found killed by wind turbine collision. However, it "cannot be excluded that collisions may occur, *e.g.*, under special weather conditions in connection with illumination of the turbines." From U.S. Govt. Rep. 85(20): 83

Pacific Gas and Electric Company (1984). Solano County MOD-2 wind turbine field experience: interim report. San Ramon, California, PG&E's Department of Engineering Research. Prepared for Electric Power Research Institute, Palo Alto, California: 50 + appendices.
The objective of this project was to document and evaluate Pacific Gas and Electric Company's experiences while testing, operating, and maintaining a megawatt-scale wind turbine in Solano County, California. This interim report covers the first year, ending 31 August 1983. Bird mortalities were monitored to measure the wind turbine's impact. A total of seven birds (unlisted) were found, all between mid-summer and mid-fall; collisions occurred during all lighting and weather conditions. Avian mortality was considered "insignificant."

Waco, D. and M. D. Batham (1984). Wind resource assessment of California: a summary of CEC-sponsored studies. Sacramento, California, California Energy Commission: 20.
In 1977, an extensive series of wind resource assessment studies was begun by the California Energy Commission (CEC) to identify the locations and extent of potential wind energy areas. "The Energy Commission studies indicate that California possesses one of the most abundant and developable wind resources in the world." Although avian mortality problems had not yet been identified, this document offers information on locations of California's wind resource.

Kirtland, K. (1985). Wind implementation monitoring programs: a study of collisions of migrating birds with wind machines. Riverside, California, Tierra Madre Consultants. Riverside County Planning Department: 12.
Three wind parks in San Gorgonio Pass, California, were studied to determine the potential for bird collisions. Surveys were conducted 22 April to 14 May 1985 during the spring migration. No dead migratory birds were observed during the surveys; possible reasons include scavenger removal, observer ability, timing of surveys, sample location, sample size/sampling time, and "the strong possibility ... that no birds may be colliding with the machines on the study plots." The results of this study were not extrapolated to other wind parks. It is noted that Southern California Edison conducted a similar study concurrent with this one and found that migratory birds *had* been killed in collisions on a number of wind parks. Recommendations include charging fees to developers to obtain necessary monies for continued monitoring studies.

Pacific Gas and Electric Company (1985). MOD-2 wind turbine field experience in Solano County, California: final report. San Ramon, California, PG&E's Department of Engineering Research. Prepared for Electric Power Research Institute, Palo Alto, California: 100 + appendices.
This two-year field study of a 2.5-megawatt MOD-2 wind turbine in Solano County, California, was conducted to evaluate performance and environmental impacts, including the effects on bird populations. Avian collision mortality was monitored for one year (September 1982 through August 1983). Seven dead birds were found, five under the wind tower (three passerines, a waterbird, and a raptor) and two beneath the meteorological tower (passerines). Collisions occurred during all lighting and weather conditions. Low rates of waterfowl movement and nocturnal passerine migration were noted over the site, and raptor use of the area was moderate. The report concludes that the impact of the wind tower on birds is "minimal."

Ultrasystems Inc. (1985). Potential effects of the proposed Fayette Manufacturing Corporation Bald Mountain wind energy project on the California condor: preliminary draft report. Irvine, California, Ultrasystems Inc., Environmental Systems Division, Irvine, California. Submitted to Fayette Manufacturing Corporation, Tracy, California: 37.

Wind turbine collision is a principal issue concerning the California condor. "The loss of a single individual is considered significant by persons associated with the recovery effort" because of the bird's critical status. A table of persons contacted regarding wind farm development effects on raptors and other biota is given.

Winkelman, J. E. (1985). "Impact of medium-sized wind turbines on birds: A survey on flight behaviour, victims, and disturbance." Netherlands Journal of Agricultural Science **33**(1): 75-78.
In the autumn and winter of 1983/1984, a study was made on the possible danger of medium-sized wind turbines (tower height 10-30 m, rotor diameter 7-25 m, power 50-300 kW) to birds. The main points studied were flight behaviour of birds approaching turbines in daylight, and number of birds killed at night. Some attention was paid to possible loss of breeding and feeding habitat around present sites of turbines.

Winkelman, J. E. (1985). "Bird impact by middle-sized wind turbines on flight behavior, victims, and disturbance." Limosa **58**: 117-121.

Winkelmann, J. E. (1985). "Vogelhinder door middelgrote windturbines - over vlieggedrag, schlachtoffers en verstoring. (Bird impact by middle-sized wind turbines on flight-behaviour, victims, and disturbance.)." Limosa **58**: 117-121.
In the fall and winter of 1983-84, possible impact of medium-sized wind turbines on birds was studied at six sites in the coastal areas of Holland. Changes in flight behavior that could be attributable to the turbines were observed; no collisions were seen. The results cannot be extrapolated to predict the danger of collisions at night or in daylight during inclement weather; the hindrance caused by other types of turbines (particularly large ones), by turbines at sites in open fields, or by large groups of wind turbines; or the risk at sites other than those studied.

Moretti, P. M. and L. V. Divone (1986). "Modern Windmills." Scientific American(June): 110-118.
Evolution of windmills, windmill structure and components, economic factors, and various design configurations are reviewed. Wind farm development and the future of wind energy are seen as promising means to meet the energy demands of developing countries. Although this article contains no information about avian mortality problems, it offers background information on wind as an energy source and a description of the aerodynamics of wind turbines.

Portland General Electric Company (1986). Cape Blanco wind farm feasibility study. Portland, Oregon, Bonneville Power Administration: 56.
This report evaluates the potential terrestrial ecology impacts of the construction and operation of a wind energy conversion system located near Cape Blanco in Curry County, Oregon. "All three Cape Blanco wind farm alternatives under consideration pose a potential threat of collisions for birds flying at low altitudes." Nocturnal songbirds are especially expected to be impacted. Guy wires and lighting of the units are identified as probable collision hazards. Potential impacts of support facilities (two transmission line routes to an existing Bonneville Power Administration 230-kV line) are evaluated. "The potential for electrocution of large birds would be small because the lines would be designed with adequate space between conductors to prevent a bird from simultaneously touching two phases. Neither alternative route would be located where bird collisions would be expected." Mitigation measures are discussed, including building the wind farm in increments and monitoring for bird kills after each phase as a condition for building the next.

Portland General Electric Company (1986). Cape Blanco wind farm feasibility study. Technical Report No. 11: Terrestrial ecology. Portland, Oregon, Bonneville Power Administration: 1-56.

Airola, D. (1987). Bird abundance and movements at the Potrero Hills wind turbine site, Solano County, California. Sacramento, California, Jones and Stokes Associates. Prepared for the Solano County Department of Environmental Management, Fairfield, California: 43 pp.
"The proposed wind turbine site at the Potrero Hills, Solano County [California], was studied to determine use of the area by waterfowl, other waterbirds, raptors, and songbirds, and to assess potential for project-related impacts." Primary flight altitudes for the various bird groups were estimated through observations. Birds, especially raptors, songbirds, and gulls, often flew below the 30 m height of the proposed turbines, and collisions were determined likely for some species. The author finds the sites adequate as experimental and control sites for future monitoring if turbines are installed.

Association of Bay Area Governments (1987). Small but powerful: a review guide to small alternative energy projects for California local decisions. Oakland, California: 66 pp.
Bird collisions and electrocutions with wind turbines and associated wires are cited as wind energy development impacts. "Although bird mortality rates are relatively low, even these rates may be significant for endangered raptors," notably the California condor, peregrine falcon, and bald eagle. Power lines near water have been found to be more hazardous than in other areas. Appropriate mitigation measures are discussed and techniques for protecting birds are given. Special attention is given to the California condor as a major source of conflict with wind farm development.

Bonneville Power Administration (1987). Cape Blanco wind farm feasibility study: final report. Portland, Oregon, U.S. Department of Energy: 187 pp.
Bird collision with wind turbines and transmission lines is discussed in this assessment of wind energy development impacts. Collisions with turbines are likely, with weather, flight altitude, and number and height of operating turbines as contributing factors. Turbine collisions are most likely to occur during the first two hours of night at the initiation of migration (climbing altitude). Because of limited visibility and increased collisions at night, the impact on nocturnal migrant populations is a primary concern. The author concludes that bird avoidance behavior is likely to be high (about 95 percent) over the Cape Blanco Wind Farm.

Lindell, L. (1987). "Ornitogiska erfarenheter från vindkraftverken på Gotland och i Skåne." Calidris **4**: 191.

Orloff, S. and E. Cheslak (1987). Avian monitoring study at the proposed Howden windfarm site, Solano County, Phase I: draft report. Sausalito, California, BioSystems Analysis, Inc: 34.
A proposed wind park would be located in the Benicia Hills, Solano County, California, in close proximity to the Suisun Marsh. Suisun Marsh is an important wetland wintering area for waterfowl along the Pacific Flyway, as well as an important raptor winter-foraging area. Ten avian species with special legal or management status, including bald eagle, peregrine falcon, and golden eagle, occur or may occur at the site. Observation data on bird species, age, sex, flight behavior, and other environmental variables were collected between 27 November 1985 and 14 November 1986. It was concluded "that there is a potential for bird collisions with the proposed wind turbines."

Alameda, C. Costa, et al. (1988). Request for proposals: a study of wind turbine effects on avian activity and habitat use. California: 17.

This request for proposal represents a joint effort by Alameda, Contra Costa, and Solano Counties (California) "to provide information necessary for predicting and mitigating the potential impact to avifauna resulting from wind turbine construction and operation in wind resource areas." A summary of a California Energy Commission (CEC) workshop on wind turbine effects on avian activity and habitat use is included.

Alameda, Contra Costa and Solano C. (1988). Request for proposals: a study of wind turbine effects on avian activity and habitat use., Alameda, Contra Costa, and Solano Counties, California**:** 17 pp.
This request for proposal represents a joint effort by Alameda, Contra Costa, and Solano Counties (California) "to provide information necessary for predicting and mitigating the potential impact to avifauna resulting from wind turbine construction and operation in wind resource areas." A summary of a California Energy Commission (CEC) workshop on wind turbine effects on avian activity and habitat use is included.

Anderson, R. L. and J. A. Estep (1988). Wind energy development in California: impacts, mitigation, monitoring, and planning. Sacramento, California, California Energy Commission**:** 12 pp.
Of 147 documented avian collision and electrocution incidents at California wind energy facilities from 1985 to 1988, 101 have been raptors. Of these, 34 were eagles and 58 were hawks. In the Altamont Pass, an average of 11 eagle and 17 hawk incidents occurred annually. Ninety-one percent of all documented avian mortality incidents resulted in mortality. This mortality information identified the need for further studies to better understand and resolve biological effects of wind projects.

Davidson, R. (1988). "Bird study could clip wings of operators." Windpower Monthly News Magazine **4**(5): 20-21.

Davidson, R. (1988). "Bird death figures shake windplant operators." Windpower Monthly News Magazine **4**(6): 16.

Haussler, R. B. (1988). Avian mortality at wind turbine facilities in California. Sacramento, California, California Energy Commission**:** 7 pp.
Data obtained by the California Energy Commission indicates that bird collisions and electrocutions are occurring at wind turbine facilities in California. Most documented incidents are due to collision and are from the Altamont Pass area in Alameda County. "Because there is concern over stability of raptor populations, ways to avoid and reduce losses must be incorporated into [hu]man's development activities....Each wind resource area should be considered specifically to determine (1) the significance of ongoing effects, (2) potential for adverse effects due to future development, and (3) the potential to mitigate and/or avoid adverse effects upon avian populations in the future."

Karlsson, J. (1988). Vindkraft Fåglar. Stockholm, Bostadsdepartementet**:** 92.

Maehr, D. S. and J. Q. Smith (1988). "Bird casualties at a Central Florida power plant: 1982-1986." Florida Field Naturalist **16**(3): 57-64.

Buurma, L. S. and H. Van Gasteren (1989). Trekvogels en obstakels langs de Zuidhollandse kust. Radarwaarnemingen van vogeltrek en het aanvaringsrisico bij hoogspanningsleidingen en windturbines op de Maasvlakte. s Gravenhage.

Estep, J. A. (1989). Avian mortality at large wind energy facilities in California: identification of a problem. Sacramento, California, California Energy Commission**:** 30.

Avian mortality data resulting from collision or electrocution with wind energy-related structures were solicited and compiled from a variety of sources in 1988. The incidents occurred between November 1984 and April 1988 at Altamont Pass and Tehachapi Pass, California. One hundred eight raptors of seven species were reported. Causes of mortality, injuries, age class, season, and other results are discussed.

Karlsson, J. (1989). Fåglar och vindkraft. (Vindkraft Fåglar, Vindkraftsutredningens Betänkande).

Musters, C. J. M., M. A. W. Noordervliet, et al. (1989). Bird casualties and wind turbines near the Kreekrak sluices of Zeeland. Milieubiologie. Leiden, R.U. Leiden**:** 1-28.

Pedersen, M. B. and E. Poulsen (1989). "Fugle og store vindmøller." Dansk Or. Foren. Tidsskr. **83**(3/4): 107-108.

Petersen, B. S. and H. Nøhr (1989). Konsekvenser for fuglelivet ved etableringen af mindre vindmøller. (Consequences of minor wind mills for bird fauna; English summary.). København, Ornis Consult**:** 73.

Winkelmann, J. E. (1989). Vogels en het windpark nabij Urk (NOP): Aanvaringsschlachtoffers en Verstoring van Pleisterende Eenden, Ganzen en Zwanen. (Birds and the wind park near Urk: collision victims and disturbance of ducks, geese and swans; English summary.). RIN-rapport. Arnhem, The Netherlands, Rijksinstituut voor Natuurbeheer.

BioSystems Analysis (1990). Wind turbine effects on the activities, habitat, and death rate of birds. Sacramento, California, Alameda, Contra Costa, and Solano Counties, California**:** 2.
A two-year study to evaluate the extent and significance of the impact of wind turbines on bird life was started in 1989 in Altamont Pass, California. The study site included about 16 percent of the approximately 7,000 turbines in the Pass. One hundred fourteen dead birds were found between February 1989 and February 1990. Eighty-one were raptors, the majority of which were red-tailed hawks, American kestrels, and golden eagles. Sixty-three percent of all deaths were attributed to turbine collision, 12 percent to electrocution, 5 percent to wire collision, and 20 percent to unknown causes. Most deaths resulted from amputation injuries. "It was estimated that over 300 raptors were killed by windfarm-related injuries within the Altamont Pass area during the first year of study (1989-1990)."

BioSystems Analysis Inc. (1990). Wind turbine effects on the activities, habitat, and death rate of birds, Prepared for Alameda, Contra Costa, and Solano Counties, California**:** 1-2.
A two-year study to evaluate the extent and significance of the impact of wind turbines on bird life was started in 1989 in Altamont Pass, California. The study site included about 16 percent of the approximately 7,000 turbines in the Pass. One hundred fourteen dead birds were found between February 1989 and February 1990. Eighty-one were raptors, the majority of which were red-tailed hawks, American kestrels, and golden eagles. Sixty-three percent of all deaths were attributed to turbine collision, 12 percent to electrocution, 5 percent to wire collision, and 20 percent to unknown causes. Most deaths resulted from amputation injuries. "It was estimated that over 300 raptors were killed by windfarm-related injuries within the Altamont Pass area during the first year of study (1989-1990)."

Hartwig, E. (1990). Erste Ergebnisse zum problem de vogelslages und zum verhalt von vögeln an vindkraftanlagen., NNA.

Vauk, G. (1990). Biologisch-ökologische Begleituntersungen zum Bau und Betrieb von Windkraftanklagen - Endbericht. (Biological and ecological study of the effects of construction and operation of wind power sites; English summary.), Schneverdingen, Norddeutsche Naturschutz-akademie**:** 124.

Winkelmann, J. E. (1990). Vogelschlachtoffers in de Sep-proefwindcentrale te Oosterbierum (Fr.) tijdens bouwfase en half-operationele situaties (1986-1989). (Bird collision victims in the experimental wind park near Oosterbierum (Fr.) during building and partly operative situations (1986-1989); English summary.). Arnhem, Rijksinstituut voor Natuurbeheer.

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Winkelmann, J. E. (1990). Nachtelijke aanvaringskansen voor vogels in de Sep-proefwindcentrale te Oosterbierum (Fr.). (Nocturnal collision risks for and behaviour of birds approaching a rotor in operation in the experimental wind park near Oosterbierum, Friesland, The Netherlands; English summary.). Arnhem, Rijksinstituut voor Natuurbeheer.

Cooper, B. A., R. H. Day, et al. (1991). "An improved marine radar system for studies of bird migration." Journal of Field Ornithology **62**: 367/377.

Howell, J. A. and J. E. DiDonato (1991). Assessment of Avian Use and Mortality Related to Wind Turbine Operations, Altamont Pass, Alameda and Contra Costa Counties, California, September 1988 through August 1989. Final report prepared for U.S. Windpower, Inc. Livermore, CA.

Howell, J. A. and J. E. DiDonato (1991). Assessment of avian use and mortality related to wind turbine operations: Altamont Pass, Alameda and Contra Costa Counties. Livermore, California, U.S. Windpower, Inc: 1-72.

Howell, J. A., J. Noone, et al. (1991). Visual experiment to reduce avian mortality related to wind turbine operations: Altamont Pass, Alameda and Contra Costa Counties. Livermore, California, Submitted to U.S. Windpower, Inc: 28.
Three hypotheses about bird collision and wind turbines in the Altamont Pass were tested from August 1988 to August 1989: birds can not see the blades under specific conditions, collisions tend to occur at ends of turbine strings, and collisions tend to occur at swales or hill shoulders. During the study, ten dead birds were found beneath turbines. Increasing turbine blade visibility appeared to reduce the number of collisions. It was not clearly determined that specific locations are foci for mortality, although site-specific variation did exist. "Additional trials with more sample plots, different painting patterns, and colors will confirm or deny these results."

Musters, C. J. M., G. J. C. Van Zuylen, et al. (1991). Vogels en windmollens bij de kreekraksluizaen. (Bird casualties casued by a wind energy project in an estuary; English translation.). Leiden, The Netherlands, Vakgroep Milieubiologie, Rijksuniversiteit Leiden.

Pedersen, M. B. and E. Poulsen (1991). En 90m/2 MW vindmølles indvirkning på fuglelivet. Fugles reaktioner på opførelsen og idriftsættelsen af Tjæreborgmøllen ved det Danske Vadehav. (Impact of a 90m/2MW wind turbine on birds. Avian responses to the implementation of the Tjæreborg Wind Turbine at the Danish Wadden Sea.). Kalø, Miljøministeriet, Danmarks Miljøundersøgelser**:** 44.

Pedersen, M. B. and E. Poulsen (1991). "En 90 m/2 MW vindmølles indvirkning på fuglelivet. Fugles reaktioner på opførselen og idriftsættelsen af Tjæreborgmøllen ved Det Danske Vadehav." Danske Viltundersøgelser **47**: 1-44.

Crockford, N. J. (1992). A review of the possible impacts of wind farms on birds and other wildlife. Peterborough, UK, Joint Nature Conservation Committee**:** 65 pp.

Howell, J. A. and J. Noone (1992). Examination of avian use and mortality at a U.S. Windpower wind energy development site, Montezuma Hills, Solano County, California. Final report., Prepared for Solano County Department of Environmental Management, Fairfield, California: 41.

Orloff, S. (1992). Tehachapi wind resource area avian collision baseline study. Tiburon, California, BioSystems Analysis, Inc. Prepared for California Energy Commission, Sacramento: 40.
The goal of this study was to evaluate the potential for avian collisions by comparing baseline field data collected at the Tehachapi Wind Resource Area (WRA) to data from BioSystem's Altamont Pass WRA study. Mortality at Tehachapi was significantly lower than at Altamont; no dead or injured birds were found during the Tehachapi surveys. Turbine location, site elevation, and structure density were identified as factors contributing to higher mortality at Altamont. Lower raptor abundance and susceptibility to collision (defined as perching on turbines and flying lower to the ground) were observed in Tehachapi; ground squirrels, a common prey species for raptors, were less abundant. The risk of avian mortality at Tehachapi may increase in the near future for three reasons: (1) new windfarm development expanding into areas frequented by golden eagles; (2) increase in ground squirrels in the area; and (3) re-introduction of the California condor into its former range, including Tehachapi.

Orloff, S. and A. Flannery (1992). Wind turbine effects on avian activity, habitat use, and mortality in Altamont Pass and Solano County Wind Resource Areas, 1989-1991. Final Report to Alameda, Costra Costa and Solano Counties and the California Energy Commission. Tiburon, California, Biosystems Analysis, Incorporated.

Orloff, S. and A. Flannery (1992). Wind turbine effects on avian activity, habitat use, and mortality in Altamont Pass and Solano County wind resource areas. Tiburon, California, BioSystems Analysis, Inc: 1-150 (plus appendices).

Winkelman, J. E. (1992). De invloed van de Sep-proefwindcentrale te Oosterbierum (Fr) op vogels, 1: aanvaringsslachtoffers, 2: nachtelijke aanvaringskansen, 3: aanvlieggedrag overdag, 4: verstoring. Arnhem, Instituut voor Bos- en Natuuronderzoek (IBN-DLO).

Winkelman, J. E. (1992). The impact of the Sep wind park near Oosterbierum (Fr.), the Netherlands, on birds, 1: collision victims. RIN-rapport, DLO-Instituut voor Bos- en Natuuronderzoek.

Winkelman, J. E. (1992). The impact of the Sep wind park near Oosterbierum (Fr.), the Netherlands, on birds, 2: nocturnal collision risks., DLO-Instituut voor Bos- en Natuuronderzoek.

Winkelman, J. E. (1992). The impact of the Sep wind park near Oosterbierum (Fr.), the Netherlands, on birds, 3: flight behavior during daylight, DLO-Instituut voor Bos-en Natuuronderzoek.

Winkelman, J. E. (1992). The impact of the Sep wind park near Oosterbierum (Fr.), the Netherlands, on birds, 4: disturbance, DLO-Instituut voor Bos- en Natuuronderzoek.

Ferguson, R. (1993). "Birds and wind turbines: can they co-exist?" CEERT Coalition Energy News **1993**(Spring): 9-10.

Ivanov, K. P. and E. V. Sedunova (1993). "Action of wind-power plants (WWP) on ornithofauna." Russian Journal of Ecology **24**(5): 315-320.

Lago, C., A. Prades, et al. (1993). Study of environmental aspects of the wind parks in Spain. European community wind energy conference, Lubeck-Travemunde, Germany, H.S. Stephens and Associates.

Meek, E. R., J. B. Ribbands, et al. (1993). "The effects of aero-generators on moorland bird populations in the Orkney Islands, Scotland." Bird Study **40**(2): 140-143.

Orloff, S. and A. Flannery (1993). Wind turbine effects on avian activity, habitat use, and mortality in Altamont Pass and Solano County wind resource areas. Avian interactions with utility structures. International workshop, Miami, Electric Power Research Institute.

Tamkins, T. (1993). "Tilting at wind power: Wind is clean and efficient - and it can kill eagles." Audubon **95**(3): 24.

Davidson, R. (1994). "Bird watching." Windpower Monthly **10**(11): 18.

Howell, J. A. and J. Noone (1994). Examination of avian use at the Sacramento Municipal Utility District, proposed wind energy development site, Montezuma Hills, Solano County, California: 1992/94 preconstruction report., Prepared for Kenetech Windpower (formerly U.S. Windpower, Inc.), Department of Permits & Environmental Affairs, San Fransisco, California.

Hunt, G. (1994). A Pilot Golden Eagle Population Project in the Altamont Pass Wind Resource Area, California. Prepared by the Predatory Bird Research Group, University of California, Santa Cruz, for the National Renewable Energy Laboratory. Golden, CO, USA.

Kenetech Windpower (1994). Avian Research Program Update. Washington, USA, Kenetech Windpower**:** 22.
This pamphlet describes the goals and research efforts of Kenetech Windpower, Inc. [formerly U.S. Windpower Inc.], to provide effective, long-term measures to reduce turbine-related impacts to birds. In 1992, Kenetech established an Avian Research Task Force composed of nationally known research biologists to develop and oversee a multiphase research program focusing on the interaction of birds and turbines at Kenetech turbines in the Altamont Pass WRA. The goals of the research program are to develop and implement appropriate siting procedures to identify and resolve potential conflicts, to develop mitigation to offset avian losses, and to develop research-based modifications to wind turbines. Specific research programs currently underway include: (1) examining the sensory capacities of raptors common to the Altamont Pass to determine what visual stimuli are most effective in improving their recognition of a wind turbine as an obstacle to be avoided, (2) monitoring and evaluating controlled flights of trained birds using a 3-D video tracking system to study their evasive actions around turbines, (3) initiating a telemetry study to ascertain the dynamics of the golden eagle population in the Altamont Pass WRA and vicinity, (4) developing anti-perching devices to deter avian use of turbines as hunting and roosting sites, and (5) operating a remote video camera monitoring system to try to record bird deaths, located where multiple bird collisions have occurred.

Luke, A. and A. W. Hosmer (1994). "Bird deaths prompt rethink on wind farming in Spain." Windpower Monthly **10**(2): 14-16.
This article discusses the environmental impacts and politics of a controversial wind development located at Tarifa along the southern tip of Spain. The windfarm, consisting of 269 lattice turbines, is situated along a major migratory route which traverses the Straits of Gibraltar. **Birds** stop over at Tarifa before and after they make the 14-km journey between Africa and Europe. Preliminary findings from independent experts and local conservation groups indicate that the number of **birds** killed by the project turbines is far higher than originally believed. Caused by both collision with turbines and electrocution on power cables, **birds** killed were of 13 species, most of which were raptors. A random count of dead **birds** revealed that approximately 30 griffon vultures were victims. Long-term plans could result in expansion to as many as 2,000 turbines at the site. A long-term study on the impacts of this project and future projects in this area should be completed by the end of 1994.

Phillips, J. F. (1994). The effects of a windfarm on the upland breeding bird communities of Bryn Tytli, Mid Wales. 1993-1994. The Bank, Newtown, Powys, Royal Society for the Protection of Birds, The Welsh Office, Bryn Aderyn, (RSPB) report to National Windpower Ltd: 105.
Pre- and post-construction data were collected on the breeding birds of an upland area in mid Wales, where the Bryn Titli windfarm is now sited, to determine whether the 22 wind turbines affected the upland breeding bird community. The windfarm site is located in an area of ornithological importance. The primary wildlife value of the site is its use by such species as red kites, hen harriers, merlins, golden plovers, lapwings, dunlins, snipes, curlews, red grouse, and short-eared owls. Data were collected on two plots: one within the area containing the wind farm and a control site in an adjacent area. Sample sizes were small, but the study showed no significant changes in the populations found on the windfarm site between pre- and post-construction phases, suggesting that the operational windfarm is having no significant effect on the breeding populations of the birds found on the site. The authors state, however, that the data set may be too small to draw such conclusions.

Pollock, K. (1994). Assessing avian - wind power interaction: Sampling, study design and statistical issues. 1994 national avian - wind power planning meeting proceedings. http://www.nationalwind.org/pubs/avian95/avian95-03.htm.

Winkelmann, J. E. (1994). Bird/Wind turbine investigations in Europe. Proceedings of the National Avian-Wind Power Planning Meeting, 20-21 July 1994, Lakewood, Colorado, , DLO-Instituut voor Bos- en Natuuronderzoek.
Presented at the National Wind Avian Windpower Planning Meeting at Golden, Colorado, July 20, 1994.
This paper provides an overview of research carried out in Europe with special emphasis on the results of the two most in-depth studies (Winkelman 1989, 1992 parts 1-4). Winkelman provides data and tables that are not available in any of the English summaries of these reports. Up to 1994, 14 studies have been finalized in Europe, covering 108 different sites. Most studies include small, solitary turbines (100 150 kW). Studies on bird collisions were mostly carried out by searches for dead **birds**. The proportion of **birds** colliding in relation to the total number passing the wind turbines was studied at 13 sites. Estimates of the total number of bird victims could only be made in two studies. At the 108 sites, 303 dead **birds** were found, of which at least 41 percent were proven collision victims. The estimated average number of collision victims in the two in-depth studies by Winkelman varied between 0.04 to 0.09 **birds**/turbine/day, depending on site and season. Of 14 collisions observed, 43 percent were caused by **birds** swept down by the wake behind a rotor, 36

percent by a rotor, and 21 percent unknown. The author states that total numbers likely to be killed per 1,000 MW of wind power capacity are low relative to other human-related causes of death. Findings on disturbance and the effect of turbines on flight behavior, which were investigated in most studies, were summarized. Up to 95 percent reduction in bird numbers has been shown to occur in the disturbance zones (250 500 m from nearest turbines). From the European point of view, in most circumstances disturbance/habitat loss is thought to be of much more importance than bird mortality. New or ongoing research in Spain, The Netherlands, and Denmark was also mentioned.

Beyea, J. (1995). Principles for a national avian-wind power research plan. Proceedings of National Avian-Wind Power Planning Meeting . Denver, Colorado, RESOLVE, Inc.; Washington D.C. & LGL, Ltd.; King City, Ontario.

Cade, T. J. (1995). Industry research: Kenetech windpower. Proceedings of National Avian-Wind Power Planning Meeting . Denver, Colorado, RESOLVE, Inc.; Washington D.C. & LGL, Ltd.; King City, Ontario.

Clausager, I. and H. Nøhr (1995). Vindmøllers indvirkning på fugle. Status over viden og perspektiver. Kalø, Danmarks Miljøundersøgelser**:** 50 pp.

Colson and Associates (1995). Avian interactions with wind energy facilities: a summary. Washington, D.C., Prepared for the American Wind Energy Association**:** 61.
This report summarizes worldwide research on the interactions of birds with wind energy developments, considering both positive and negative impacts. The authors present a comparison between European and U.S. studies regarding mortality rates, species affected, and issues of concern. The environmental (e.g., weather), engineering (e.g., turbine type, turbine placement), and biological (e.g., species, habitat use, behavior) characteristics that may increase the potential for bird collisions are summarized. To date, the authors state, most researchers report that mortalities are not biologically significant to local, regional, or migratory populations. The probability of adverse bird interactions appears to be both site-specific and species-specific. Mitigation ideas from past and ongoing studies are presented. The authors state that "the most important step that can be taken to avoid future adverse bird interactions is to locate facilities based on careful siting studies and away from critical habitat." They remind us that the apparent negative issues associated with avian interactions with wind energy developments must be carefully weighed against the negative issues of other forms of energy development. A summary of various current, future, and suggested research plans is also presented.

Cooper, B. A. (1995). Use of Radar for Wind Power-Related Avian Research. 1994 national avian - wind power planning meeting proceedings. http://www.nationalwind.org/pubs/avian95/avian95-08.htm.

Davis, H. e. (1995). A pilot Golden Eagle population study in the Altamont Pass Wind Resource Area, California., Golden, CO (USA), National Renewable Energy Laboratory.

Gauthreaux, S. A., Jr. and **Abstract:** (1995). Standardized assessment and monitoring protocols. Proceedings of the national avian-wind power planning meeting, Denver, Colorado, 20-21 July 1994., LGL Ltd., environmental research associates, King City, Ontario, Canada.
This is a summary of a presentation given on the techniques that can be employed to study avian-wind turbine interactions. Emphasis was placed on appropriate methods to monitor bird movements during the day and at night, and to assess bird injury and mortality during pre- and post-construction studies. The need for development of observation and monitoring protocols was stressed. Several recommendations were included, such as con-

ducting searches for dead and injured birds before and after construction, expressing collision rates in terms of the percentage of birds passing through the envelope of risk, and using standardized methods so that data can be compared.

Gauthreaux, S. A. j. (1995). The history of wind-related avian research in the USA. Proceedings of National Avian-Wind Power Planning Meeting . Denver, Colorado, RESOLVE, Inc.; Washington D.C. & LGL, Ltd.; King City, Ontario.

Gauthreaux, S. A. j. (1995). Standardized assessment and monitoring protocols. Proceedings of National Avian-Wind Power Planning Meeting . Denver, Colorado, RESOLVE, Inc.; Washington D.C. & LGL, Ltd.; King City, Ontario.

Higgins, K. F., C. D. Dieter, et al. (1995). Monitoring of seasonal bird activity and mortality on Unit 2 at the Buffalo Ridge Windplant, Minnesota. Preliminary progress report for the research period May 1-December 31, 1994. Brookings, S.D., Prepared by the South Dakota Cooperative Fish and Wildlife Research Unit, National Biological Service, South Dakota State University**:** 42.
This report summarizes results of an avian monitoring program associated with the near completion of the first phase (25 MW) of the Kenetech Windpower 100-MW Buffalo Ridge Windplant in Minnesota. The purpose of the research was to conduct a systematic avian monitoring program to measure seasonal movements, relative abundance, temporal flight patterns, and incidence of nesting and bird mortality associated with Unit 2 of the Buffalo Ridge site, the unit encompassing the Buffalo Ridge Windplant (Units 1 and 3 comprised lands under easement for potential future wind turbine sites). Unit 2 had 73 wind turbines located in 10 turbine strings varying in length from 3 to 20 turbines per string. During roadside, site specific, and raptor surveys, 66 bird species were observed. Bird numbers were higher during spring and fall migrations than during summer. No threatened or endangered birds were seen. Eighty-four percent of birds seen during site-specific surveys flew at heights above or below the height range of wind turbine blades (70-170 ft). Three dead birds and five dead bats were found during mortality searches in wind turbine plots. No bird deaths were attributed to collision with turbines, but all bats were presumed to have died as a result of collision with turbines.

Howell, J. A. (1995). Avian mortality at rotor swept area equivalents, Altamont Pass and Montezuma Hills, California. Sausalito, California, Judd Howell & Associates. Prepared for Kenetech Windpower, Inc. (formerly U.S. Windpower, Inc.), San Fransisco, California: 12.
This study was designed to test the hypothesis that the newer KVS-33 turbines with a large blade diameter (33 m) would potentially kill more birds than the older KCS-56 (18.5 m blade diameter) turbines because the blades sweep more area. The ratio of the rotor swept area (RSA) of the KVS-33 to that of the KCS-56 is 3.46:1. Based on this hypothesis, it was predicted that a KVS-33 turbine would be three times as likely to cause an avian collision as a KCS-56. The study was designed so that within study sites the combined RSAs were equal between KVS-33 and KCS-56 sample turbines: in the Altamont Pass sample there were 36 of the larger KVS-33 turbines and 130 of the smaller KCS-56 turbines, and in the Montezuma Hills sample there were 17 of the larger and 59 of the smaller turbines. The number of sample turbines in each group at each site approximated the 3.46:1 RSA ratio. Bird deaths between the small and large turbine types were compared within study sites. A total of 70 bird deaths, 45 of which were raptors, were identified during the 13-month sampling period in Altamont Pass. In Montezuma Hills, surveyors found 13 dead birds, 12 of which were raptors, in five months of sampling. In Altamont Pass, avian mortality per turbine was roughly the same at both small and large turbines; the turbines appeared to present an obstacle to birds regardless of RSA. The evidence from Altamont Pass, the author states, does not support the hypothesis that the larger RSA of the KVS-33 turbines contributes to higher mortality. In the Montezuma Hills, however, avian mortal-

ity per turbine at the larger KVS-33 turbines was three times higher than at the smaller KCS-56 turbines, but the author states that this may be due to the smaller sample size and short duration of the Montezuma study.

Hunt, G. (1995). A pilot golden eagle population project in the Altamont Pass Wind Resource Area, California. Golden, Colorado, Prepared by Predatory Bird Research Group, University of California, Santa Cruz; for National Renewable Energy Laboratory**:** 218.
The primary purpose of this pilot study was to lay the groundwork for determining whether or not wind energy development in the Altamont Pass WRA may affect golden eagles on a population basis. To determine whether the golden eagle population in the Altamont Pass is sufficient to absorb losses caused by turbine-related deaths, the study needed to: (1) identify the population at risk, (2) quantify the reproductive rate (natality), and (3) estimate the annual survivorship of each population segment. Golden eagles were radio-tagged and regularly censused to establish resident population levels and determine the rate of survival. Nesting surveys were conducted to estimate the productivity of the breeding population in the region. Data from 31 radio-tagged eagles suggested that at least 75 percent of the eagles present in the Altamont Pass in the winter are resident to the region surrounding the WRA. Nesting productivity and success in this region were higher than normal for golden eagles; nesting density in portions of the study area was among the highest reported for the species. At this time, however, data are insufficient to predict a population effect. In addition to gathering population data, observation surveys were conducted to identify factors and behaviors that might increase the risk of mortality to eagles and other raptors. Data indicated that lattice turbines had the highest "perchability" of any turbine type. End turbines were used for perching more than non-end turbines, which may explain the higher mortality rate found at end turbines in a previous study (Orloff and Flannery 1992). The author suggested mitigation measures, including reducing the raptor food availability in the WRA, avoiding constructing more lattice-type turbine towers, and improving nesting habitat potential outside the WRA.

Jones and Stokes Associates (1995). Avian use of proposed Kenetech and CARES wind farm sites in Klickitat County, Washington. Bellevue, Washington, USA, Jones and Stokes Associates, Inc. Prepared for R.W. Beck, Seattle.

Llamas, P. L. (1995). The environmental cost of wind energy in Spain. EWEA Special Topic Conference 1995, Helsinki, Finland.

Mariah Associates (1995). Final environmental impact statement, Kenetech/Pacificorp Windpower Projject, Carbon County, Wyoming. Rawlins, Wyoming, Prepared for Great Divide Resource Area, Rawlins District, BLM**:** 285.
This FEIS revises and supplements the DEIS (see Mariah Associates 1995) for the KENETECH/PacifiCorp Windpower Project and addresses comments and concerns expressed during the public comment period on the DEIS. An additional 3« months of field data on biological resources were incorporated into the FEIS, data that were not available at the time the DEIS was prepared. While there were extensive changes made to the Draft, a supplemental DEIS was not deemed necessary because the BLM did not make substantial changes to the proposed action that were relevant to environmental concerns, and there were no significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.

Mariah Associates (1995). Draft environmental impact statement, Kenetech/PacifiCorp windpower project, Carbon County, Wyoming. Rawlins, Wyoming, Prepared for the Bureau of Land Management, Great Divide Resource Area, Rawlins District**:** 478.
This DEIS assesses the environmental consequences of a proposed windpower development project in Carbon County, Wyoming. The project entails the erection of approximately

1,390 wind turbine generators and associated facilities such as roads, substations, and distribution and communications lines, as well as a 230-kV transmission line to connect a proposed substation with an existing one. Key issues identified include wind turbine effects on birds, direct and indirect wildlife habitat loss, big game winter range and migrations, special-status (threatened, endangered, sensitive, or priority) plants and animals and their habitats, cultural resources and Native American spiritual values, and reasonable access to public land. Additional issues identified during public scoping include visual and aesthetics, soils, noxious weed control, wetlands and riparian areas, surface water and groundwater, land uses, noise, social and economic effects on local communities, public safety, traffic, and others. Potential negative impacts to many of these resources were identified, and 22 project-wide mitigation measures are to be implemented from the outset. The DEIS concluded that impacts to most resources would be negligible to moderate during the life of the project. Potentially significant impacts identified include avian mortality, declining avian populations, mortality and/or habitat loss of special-status species, noise disturbance to nearby residents, changes in visual resources, disturbance of important Native American traditional sites, changes in plant community species composition due to snow redistribution, displacement of big game due to windfarm operation, and loss of sage grouse nesting habitat. The proposed project could have beneficial impacts such as increased revenues generated by taxes, increased employment, and benefits derived from using a nonpolluting resource for electric power generation.

Marti, R. (1995). Bird/wind turbine investigations in Southern Spain. Proceedings of National Avian-Wind Power Planning Meeting . Denver, Colorado, RESOLVE, Inc.; Washington D.C. & LGL, Ltd.; King City, Ontario.

Mayer, L. S. (1995). The Use of Epidemiological Measures to Estimate the Effects of Adverse Factors and Preventive Interventions. 1994 national avian - wind power planning meeting proceedings. http://www.nationalwind.org/pubs/avian95/avian95-04.htm.

Nelson, H. K. and R. C. Curry (1995). "Assessing avian interactions with windplant development and operation." Transactions North American Wildlife & Natural Resources Conference **60**: 266-277.

Predatory Bird Research Group. (1995). "A Pilot Golden Eagle Population Study in the Altamont Pass Wind Resource Area, California."

Richardson, W. J. e. (1995). Proceedings of National Avian-Wind Power Planning Meeting . Denver, Colorado, RESOLVE, Inc.; Washington D.C. & LGL, Ltd.; King City, Ontario.
Initial list of avian mortality questions
Toward a priorized list of research questions
Avian mortality at wind plants: Past and ongoing research:
The history of wind-related avian research in the USA.
Industry research: Kenetech windpower.
U.S. federal wind energy program avian research projects.
Lessons from utility structure environmental impacts.
Bird/wind turbine investigations in Europe.
Bird/wind turbine investigations in Southern Spain

Shenk, T., A. B. Franklin, et al. (1995). A Model to Estimate the Annual Rate of Golden Eagle Population Change at the Altamont Pass Wind Resource Area. 1994 national avian - wind power planning meeting proceedings.
http://www.nationalwind.org/pubs/avian95/avian95-06.htm.

Spaans, A. L., J. van der Winden, et al. (1995). Vogelhinder door windturbines. Landelijk onderzoekprogramma, deel 1: verkennend onderzoek naar nachtelijke vliegbewegingen in getijdegebieden. Bureau Waardenburg report. Culembourg & Wageningen, Bureau Waardenburg & Instituut voor Bos- en Natuuronderzoek (IBN-DLO).

Thresher, R. W. (1995). U.S. federal wind energy program avian research projects. Proceedings of National Avian-Wind Power Planning Meeting . Denver, Colorado, RESOLVE, Inc.; Washington D.C. & LGL, Ltd.; King City, Ontario.

Wilson, K. (1995). Population Models: Their Use and Misuse. 1994 national avian - wind power planning meeting proceedings. http://www.nationalwind.org/pubs/avian95/avian95-05.htm.

Winkelman, J. E. (1995). Bird/wind turbine investigations in Europe. Proceedings of National Avian-Wind Power Planning Meeting . Denver, Colorado, RESOLVE, Inc.; Washington D.C. & LGL, Ltd.; King City, Ontario.
This paper provides an overview of research carried out in Europe with special emphasis on the results of the two most in-depth studies (Winkelman 1989, 1992 parts 1-4). Winkelman provides data and tables that are not available in any of the English summaries of these reports. Up to 1994, 14 studies have been finalized in Europe, covering 108 different sites. Most studies include small, solitary turbines (100 150 kW). Studies on bird collisions were mostly carried out by searches for dead birds. The proportion of birds colliding in relation to the total number passing the wind turbines was studied at 13 sites. Estimates of the total number of bird victims could only be made in two studies. At the 108 sites, 303 dead birds were found, of which at least 41 percent were proven collision victims. The estimated average number of collision victims in the two in-depth studies by Winkelman varied between 0.04 to 0.09 birds/turbine/day, depending on site and season. Of 14 collisions observed, 43 percent were caused by birds swept down by the wake behind a rotor, 36 percent by a rotor, and 21 percent unknown. The author states that total numbers likely to be killed per 1,000 MW of wind power capacity are low relative to other human-related causes of death. Findings on disturbance and the effect of turbines on flight behavior, which were investigated in most studies, were summarized. Up to 95 percent reduction in bird numbers has been shown to occur in the disturbance zones (250 500 m from nearest turbines). From the European point of view, in most circumstances disturbance/habitat loss is thought to be of much more importance than bird mortality. New or ongoing research in Spain, The Netherlands, and Denmark was also mentioned.

Winkelman, J. E. (1995). Appendix 2B. Bird/wind turbine investigations in Europe. Proceedings of National Avian-Wind Power Planning Meeting . Denver, Colorado, RESOLVE, Inc.; Washington D.C. & LGL, Ltd.; King City, Ontario.

Winkelman, J. E. (1995). Appendix 2C. English-language summaries of reports on bird-wind power studies at the Urk and Oosterbierum wind parks, The Netherlands. Proceedings of National Avian-Wind Power Planning Meeting . Denver, Colorado, RESOLVE, Inc.; Washington D.C. & LGL, Ltd.; King City, Ontario.

Anderson, R. L., J. Tom, et al. (1996). Avian risk assessment methodology. Proceedings of National Avian-Wind Power Planning Meeting II., Palm Springs, California, Avian Subcommittee of the National Wind Coordinating Committee.
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Arnold, A. and C. Behr (1996). Stakeholder views on research questions regarding avian - wind power interactions. Proceedings of National Avian-Wind Power Planning Meeting II., Palm Springs, California, Avian Subcommittee of the National Wind Coordinating Committee.
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Dirksen, S., A. L. Spaans, et al. (1996). Vogelhinder door windturbines. Landelijk onderzoekprogramma, deel 2: Nachtelijke vlieghoogtemetingen van duikeenden in het IJsselmeergebied (with summary). Bureau Waardenburg report. Culembourg & Wageningen, Bureau Waardenburg & Instituut voor Bos- en Natuuronderzoek (IBN-DLO).

Gauthreaux, S. A. (1996). Suggested Practices for Monitoring Bird Populations, Movements and Mortality in Wind Resource Areas. Proceedings of National Avian-Wind Power Planning Meeting II. Prepared for the Avian Subcommittee of the National Wind Coordination Committee by RESOLVE Inc., Palm Springs, CA, Washington, DC, and LGL Ltd., King City, Ont.

Gill, J. P., M. Townsley, et al. (1996). Review of the impacts of wind farms and other aerial structures upon birds., Scottish Natural Heritage: 68.

Gaarder, G. and J. B. Jordal (1996). Biologisk mangfold på sørlige deler av Smøla: 55.

Higgins, K. F., R. G. Osborn, et al. (1996). Monitoring of seasonal bird activity and mortality at the Buffalo Ridge Wind Resource Area, Minnesota, 1994/1995. Completion Report. Brookings, Wildlife and Fisheries Sciences Department, South Dakota State University. Prepared for Kenetech Windpower, Inc. (formerly U.S. Windpower, Inc.), San Fransisco, California: 84.

Morrison, M. L. (1996). Protocols for Evaluation of Existing Wind Developments and Determination of Bird Mortality. Prepared for the Avian Subcommittee of the National Wind Coordination Committee by RESOLVE Inc., Washington, DC, and LGL Ltd., King City, Ont. Proceedings of National Avian-Wind Power Planning Meeting II, Palm Springs, CA, USA.

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Munsters, C. J. M., M. A. W. Noordervliet, et al. (1996). "Bird Casualties Caused by a Wind Energy Project in an Estuary." Bird Study **43**: 124-126.

Musters, C. J. M., M. A. W. Noordervliet, et al. (1996). "Bird casualties caused by a wind energy project in an estuary." Bird Study **43**(1): 124-126.

Orloff, S. and A. Flannery (1996). A Continued Examination of Avian Mortality in the Altamont Pass Wind Resource Area. Prepared by BioSystems Analysis, Inc., California, for the California Energy Commission, Sacramento.

Richardson, W. J. (1996). Proceedings of National Avian-Wind Power Planning Meeting II., Palm Springs, California, Avian Subcommittee of the National Wind Coordinating Committee.
Assessing avian - wind power interactions: Sampling, study design and statistical issues.
The use of epidemiological measures to estimate the effects of adverse factors and preventive interventions.
Population models: Their use and misuse.
A model to estimate the annual rate of Golden Eagle population change at the Altamount Pass Wind Resource Area.
Use of radar for wind power-related avian research.
Avian risk assessment methodology.
Suggested practices for monitoring bird populations, movements and mortality in wind resource areas.
Protocols for evaluation of existing wind developments and determination of bird mortality.

Tucker, V. A. (1996). "A mathematical model of bird collisions with wind turbine rotors." Journal of Solar Energy Engineering-Transactions of the Asme **118**(4): 253-262. <Go to ISI>://A1996VV39400011.
When a bird flies through the disk swept out by the blades of a wind turbine rotor, the probability of collision depends on the motions and dimensions of the bird and the blades. The collision model in this paper predicts the probability for birds that glide upwind, downwind, and across the wind past simple one-dimensional blades represented by straight lines, and upwind and downwind past more realistic three-dimensional blades with chord and twist. Probabilities vary over the surface of the disk, and in most cases, the tip of the blade is less likely to collide with a bird than parts of the blade nearer the hub. The mean probability may be found by integration over the disk area. The collision model identifies the rotor characteristics that could be altered to make turbines safer for birds.

Tucker, V. A. (1996). "Using a collision model to design safer wind turbine rotors for birds." Journal of Solar Energy Engineering-Transactions of the Asme **118**(4): 263-269. <Go to ISI>://A1996VV39400012.
A mathematical model for collisions between birds and propeller-type turbine rotors identifies the variables that can be manipulated to reduce the probability that birds will collide with the rotor. This study defines a safety index-the "clearance power density "-that allows rotors of different sizes and designs to be compared in terms of the amount of wind energy converted to electrical energy per bird collision. The collision model accounts for variations

in wind speed during the year and shows that for model rotors with simple, one-dimensional blades, the safety index increases in proportion to rotor diameter, and variable speed rotors have higher safety indexes than constant speed rotors. The safety index can also be increased by enlarging the region near the center of the rotor hub where the blades move slowly enough for birds to avoid them. Painting the blades to make them more visible might have this effect. Model rotors with practical designs can have safety indexes an order of magnitude higher that those for model rotors typical of the constant speed rotors in common use today. This finding suggests that redesigned rotors could have collision rates with birds perhaps an order of magnitude lower than today's rotors, with no reduction in the production of wind power. The empirical data that exist for collisions between raptors, such as hawks and eagles, and rotors are consistent with the model: the numbers of raptor carcasses found beneath large variable speed rotors, relative to the numbers found under small constant speed rotors, are in the proportions predicted by the collision model rather than in proportion to the areas swept by the rotor blades. However, uncontrolled variables associated with these data prevent a stronger claim of support for the model.

Van der Winden, J., S. Dirksen, et al. (1996). Nachtelijke vliegbewegingen van duikeenden bij het windpark Lely in het IJsselmeer. Wageningen, Bureau Waardenburg, Culemborg/Instituut voor Bos- en Natuuronderzoek (IBN-DLO).

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Hawker, D. (1997). Windy Standard wind farm: breeding bird survey 1997., Report to National Windpower Ltd.

Howell, J. A. (1997). "Avian Mortality at Rotor Swept Area Equivalents, Altamont Pass and Montezuma Hills, California." Transactions of the Western Section of the Wildlife Society **33**: 24-29.

Kerlinger, P. and R. Curry (1997). Analysis of Golden Eagle and Red-Tailed Hawk Fatalities at Kenetech Windpower's Altamont Wind Resource Area (APWRA). Unpublished status report on the Altamont Avian Plan to U.S. Fish and Wildlife Service and Kenetech, Inc.,. Livermore, CA, USA.

Morrison, M. L. and K. H. Pollock (1997). Development of a practical modeling framework for estimating the impact of wind technology on bird populations. Raleigh, North Carolina, National Renewable Energy Laboratory, Golden, Colo. Work performed by California State University, Sacramento, California and North Carolina State University.
One of the most pressing environmental concerns related to wind project development is the potential for avian fatalities caused by the turbines. The goal of this project is to develop useful, practical modeling framework for evaluating potential wind power plant impacts that can be generalized to most bird species. This modeling framework could be used to get a preliminary understanding of the likelihood of significant impacts to birds, in a cost-effective way. We accomplish this by (1) reviewing the major factors that can influence the persistence of a wild population; (2) briefly reviewing various models that can aid in estimating population status and trend, including methods of evaluating model structure and performance; (3) reviewing survivorship and population projections; and (4) develop-

ing a framework for using models to evaluate the potential impacts of wind development on birds.

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Westerberg, H. (1997). Havsbaserat vindkraftverk vid Nogesund: effekter på blankålsfisket. (In Swedish): 8.

Alameda County (1998). Repowering a Portion of the Altamont Wind Resource Area. Final Environmental Impact Report, Community Development Agency. State Clearinghouse No. 98022024.

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Harmata, A., K. Podruzny, et al. (1998). Avian use of Norris Hill wind resource area, Montana. Golden, Colorado, National Renewable Energy Laboratory**:** 118.

Hunt, W. G., R. E. Jackman, et al. (1998). A population study of golden eagles in the Altamont Pass Wind Resource Area: population trend analysis 1997. Report to National Renewable Energy Laboratory, Subcontract XAT-6-16459-01. Santa Cruz, Predatory Bird Research Group, University of California.

Johnson, G. D., D. P. Young, et al. (1998). Wildlife monitoring studies, Seawest Windpower Plant, Carbon County, Wyoming, 1995-1997: draft report. Rawlins, Wyoming, Prepared for SeaWest Energy Corporation, San Diego, California and Bureau of Land Management, Rawlins District Office**:** 184.
This report presents results of the first two years (March 1995 to March 1996, and February 1997 to February 1998) of data collection for wildlife risk assessment and monitoring studies associated with the SeaWest windpower plant in Carbon County, Wyoming. Monitoring includes data collection on the Wind Resource Area (WRA) and an offsite reference area located near Morton Pass (MPR) approximately 16 km northeast of Bosler Junction. The WRA is divided into two study areas: Foote Creek Rim (FCR) located north and west of Arlington, and Simpson Ridge (SR) located south of Hanna. The first phase of the development will occur on FCR. Wildlife included in the study were: Raptors and other large birds, Passerines and other small birds, Mountain Plover, Sage Grouse, and Raptor Prey.

Larsen, J. K. and P. Clausen (1998). Effekten på sangsvane ved etablering af en vindmøllepark ved Overgaard gods. Kalø, Ministry of Environment and Energy, National Environmental Research Institute**:** 25.

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During 1994-1995, we saw 70 species of birds on the Buffalo Ridge Wind Resource Area. In both years bird abundance peaked in spring. Red-winged blackbirds (Agelaius phoeniceus), mallards (Anas platyrhynchos), common grackles (Quiscalus quiscula), and barn swallows (Hirundo rustica) were the species most commonly seen. Most birds (82-84%) flew above or below the height range of wind turbine blades (22-55 m). The Buffalo Ridge Wind Resource Area poses little threat to resident or migrating birds at its current operating level.

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Follestad, A., O. Reitan, et al. (1999). "Vindkraftverk på Stad: Mulige konsekvenser for "rødlistede" fuglearter." NINA Oppdragsmelding **624**: 1-42.

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Grassland passerines were surveyed during summer 1995 on the Buffalo Ridge Wind Resource Area in southwestern Minnesota to determine the relative influence of wind turbines on overall densities of upland nesting birds in Conservation Reserve Program (CRP) grasslands. Birds were surveyed along 40 m fixed width transects that were placed along wind turbine strings within three CRP fields and in three CRP fields without turbines. Conservation Reserve Program grasslands without turbines and areas located 180 m from turbines supported higher densities (261.0-312.5 males/100 ha) of grassland birds than areas within 80 m of turbines (58.1-128.0 males/100 ha). Human disturbance, turbine noise, and physical movements of turbines during operation may have distrurbed nesting birds. We recommend that wind turbines be placed within cropland habitats that support lower densities of grassland passerines than those found in CRP grasslands.

Reitan, O., A. Follestad, et al. (1999). "Vindkraftberk på Hitra. Mulige konsekvenser for 'rødlistede' fuglearter." NINA oppdragsmelding **625**: 1-33.

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Tulp, I., H. Schekkerman, et al. (1999). Nocturnal flight activity of sea ducks near the windfarm Tunø Knob in the Kattegat., Bureau Waardenburg bv, Instituut voor Bos. En Natuuronderzoek**:** 69 pp.

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Clausager, I. (2000). Vindkraftproduktion og konsekvenser for det biologiske mangfold. Erfaringer fra Danmark. Konsekvenser av vindkraft for det biologiske mangfoldet. FoU-seminar 9.november 1999 i Folkets Hus, Youngsgt. 11, Oslo. Direktoratet for naturforvaltning. Trondheim, Direktoratet for naturforvaltning. **2000-1:** 30-40.

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Erickson, W. P., M. D. Strickland, et al. (2000). Examples of statistical methods to assess risk of impacts to birds from wind plants. Proceedings of National Avian - Wind Power Planning Meeting III., San Diego, California, Avian Subcommittee of the National Wind Coordinating Committee.

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Hanowski, J. M. and R. Y. Hawrot (2000). Avian issues in the development of wind energy in Western Minnesota. Proceedings of National Avian - Wind Power Planning Meeting III., San Diego, California, Avian Subcommittee of the National Wind Coordinating Committee.

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Rates and timing of bird passage in the proposed Norris Hill Wind Resource Area (NHWRA) and vicinity in southwesteren Montana were investigated using two marine surveillance radars between August 1995 and August 1996. The scanning radar array displayed movements in a horizontal plane within 360 degrees while the vertical radar displayed altitudes of bir dr in and out of the NHWRA to the east and west. Radars were also used to record raptor movements within NHWRA in summer. Spatio-temporal profile of migration was determined by adjusting observed number of events by detection probability by radar, derived from point- and line-transect bird sampling techniques. Autumn migration was more protracted than vernal migration. Altitude of birds flying in and within 2 km east and west of NHWRA averaged 209 m in autumn and 388 m in spring. Higher altitudes in spring were a function of birds ascending after leaving Ennis Lake, whereas birds were descending to visit the lake in autumn. More birds passed over valleys and swales than high points. Passage rate decreased with declining barometric trend in autumn (headwinds), but the reverse was true in spring (tailwinds).

Hunt, W. G. (2000). A population study of Golden Eagles in the Altamont Pass Wind Resource Area: Population trend analysis 1994-1997 - Executive summary. Proceedings of

National Avian - Wind Power Planning Meeting III., San Diego, California, Avian Subcommittee of the National Wind Coordinating Committee.

Janss, G. (2000). Bird behavior in and near a wind farm at Tarifa, Spain: Management considerations. Proceedings of National Avian - Wind Power Planning Meeting III., San Diego, California, Avian Subcommittee of the National Wind Coordinating Committee.

Kerlinger, P. (2000). An assessment of the impacts of Green Mountain Power Corporation's Searsburg, Vermont, wind power facility on breeding and migrating birds. Proceedings of National Avian - Wind Power Planning Meeting III., San Diego, California, Avian Subcommittee of the National Wind Coordinating Committee.

Kerlinger, P., R. Curry, et al. (2000). Ponnequin Wind Energy Project: Reference site avian study., Report to National Renewable Energy Laboratory, Golden, Colorado. Work performed by Predatory Bird Research Group, University of California, Santa Cruz, California.

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Larsen, J. K. and J. Madsen (2000). "Effects of wind turbines and other physical elements on field utilization by pink-footed geese (*Anser brachyrhyncus*): A landscape perspective." Landscape Ecology **15**: 755-764.

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Nordahl, E. (2000). Valuation of wind power development at Smøla. Institute for Applied Economics. Agricultural University of Norway. Master Thesis. WI.

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Recent technological advances hale made and power a viable source of alternative energy production and the number of windplant facilities has increased in the United States. Construction was completed on a 73 turbine, 25 megawatt windplant on Buffalo Ridge near Lake Benton, Minnesota in Spring 1994. The number of birds killed at existing windplants

in California caused concern about the potential impacts of the Buffalo Ridge facility on the arian community. From April 1994 through Dec. 1995 we searched the Buffalo Ridge windplant site for dead birds. Additionally, we evaluated search efficiency, predator scavenging rates and rate of carcass decomposition. During 20 mo of monitoring we found 12 dead birds. Collisions with wind turbines were suspected for 8 of the 12 birds. During observer efficiency trials searchers found 78.8% of carcasses. Scavengers removed 39.5% of carcasses during scavenging trials. All carcasses remained recognizable during 7 d decomposition trials. After correction for biases we estimated that approximately 36 +/- 12 birds (<1 dead bird per turbine) were killed at the Buffalo Ridge windplant in 1 y. Although windplants do not appear to be more detrimental to birds than other man-made structures, proper facility siting is an important first consideration in ol der to avoid unnecessary fatalities.

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Typically, ecological impact assessments (ETA) are conducted under time constraints, making the collection of baseline data and application of Before-After-Control-Impact (BACI) designs difficult. Here we report the results of three "postdevelopment" experiments testing the effects of a small wind park on the abundance, distribution, and behavior of wintering Common Eiders (Somateria mollissima), a large sea duck. Our approach was based on the rationale that the probability of detecting an impact should increase with decreasing distances from the wind park. Because prey abundance is likely to drive the distribution of wintering ciders, we removed that confounding variable by (1) randomizing its effect over the study area, and (2) incorporating the variable into the analysis. In the first experiment, we compared the abundance and distribution of eiders when wind turbines were switched on and off. This was complemented by investigating the escape behavior of flocks when wind turbines were switched on after they had been off for one full day. In a second experiment, we tested for any departure from the habitat-matching rule, which states that the proportion of eiders and the proportion of food should be equal at different distances from the park. In a third experiment, the flying behavior of eiders in relation to the wind park was analyzed by measuring the landing and flying rates for patches of decoys located at 100, 300, and 500 m from the wind park. We found little evidence for negative impacts, because we could not detect any effect in three tests out of four. Only in the decoy experiment did we observe eiders reducing their landing and flying near (100 m from) the wind park. We conclude, for the conditions under which our experiments were performed, that the wind park did not substantially affect wintering Common Eiders. However, many aspects of the potential impacts of offshore wind parks on sea ducks have not been covered by our study and, therefore, cannot be generalized to other species or other phases of the annual cycle. Nevertheless, we argue that the use of multiple postdevelopment experiments based on a gradient approach is a helpful complement to BACI studies.

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In 1994 Xcel Energy initiated a wind-power development project in southwestern Minnesota that will eventually produce 425 megawatts (MW) of electricity. During our study the wind farm consisted of 3 phases of development totaling 354 turbines capable of generating 236 MW, depending on wind speed. We assessed effects of the wind farm on birds from 1996 to 1999, with 55 documented collision fatalities. Recovered carcasses included 42 passerines, 5 waterbirds, 3 ducks, 3 upland game birds, 1 raptor, and 1 shorebird. Most fatalities (71%) were likely migrants through the area, 20% were species that likely were breeding in the study area, and 9% were permanent residents. Wind farm-related mortality was estimated by extrapolating the number of carcasses found at a sample of the turbines and adjusting for scavenger removal and searcher efficiency rates. We estimated total annual mortality at 72 (90% CI=36-108) in the Phase 1 wind farm, 324 (90% CI = 175-473) in the Phase 2 wind farm, and 613 (90% CI = 132-1093) in the Phase 3 wind farm. The Phase 3 wind-farm estimate was based on 1 year of data and was largely influenced by a single mortality event involving 14 passerines at 2 adjacent turbines during 1 night. Radar data indicated that approximately 3.5 million birds migrate over the wind farm each year; however, the proportion of birds flying at heights susceptible to turbine collisions is not known. Wind-power development will likely contribute to cumulative collision mortality of birds in the United States.

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Morning and evening flights of Whooper Swans (Cygnus cygnus) wintering near Overgaard, in eastern Jutland, Denmark, were studied to assess the potential risk of collisions with medium sized or with large turbines, should a proposed wind park be developed in the area. The birds could be particularly prone to collisions during evening flights, as these took place in rather poor light conditions. Recorded heights of swan flights indicated that a park consisting of medium sized wind turbines would be more critical in terms of collision risk than one with large turbines, with 38% of observed individuals flying within height range of the rotors in the former, only 13% in the latter.

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Sheep farming and forestry dominate land use over much of western Scotland, and these activities have important implications for the nesting density and reproductive success of Golden Eagles (Aquila chrysaetos). In some areas, secondary land uses such as wind energy developments and opencast quarrying are being considered. The additive effects of such developments have prompted concern among conservationists that eagles will be adversely affected. In this paper, we summarize an approach used to investigate and re-

duce to acceptable levels the impacts of sheep, forestry, and a planned wind energy development on a territorial pair of eagles in the Kintyre peninsula. Site-specific studies of eagle ranging, diet, and prey distribution indicated: (1) eagle activity was greatest in a contiguous area of high elevation moorland that included part of the proposed wind farm; (2) eagles avoided forest habitats, except where the trees were young, or the stands were small; (3) avian prey, particularly Red Grouse (Lagopus lagopus scoticus), was all important component of diet during a summer in which the eagles bred successfully; and (4) an important population of Red Grouse occupied the proposed wind farm. We concluded that avoidance of the wind farm by eagles would result in the forfeiture of an important prey resource. Alternatively, in the absence of any modification of ranging behavior, eagles were at considerable risk of collision with wind turbines. This paradigm led us to develop a large-scale management scheme with the aim of reducing the cumulative impacts of the various land uses. A key objective of the scheme is to increase the overall number of grouse available to eagles. We intend to achieve this through the conversion of forest habitat to moorland and extensive management of sheep. Simultaneously, the scheme seeks to discourage eagles from entering the wind farm by impoverishing the local habitat for grouse. We suggest that secondary developments such as wind farms sometimes represent all opportunity to enhance landscapes that have been degraded by previous land use decisions.

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Watson, J. and P. Whitfield (2002). "A conservation framework for the Golden Eagle (Aquila chrysaetos) in Scotland." Journal of Raptor Research **36**(1): 41-49. <Go to ISI>://000174979700010.
The current population of around 420 breeding pairs of Golden Eagles (Aquila chrysaetos) in Scotland has been relatively stable for the past two decades. A century ago, both the breeding population and breeding range were probably much less than now, although a century before that the range was much more extensive than it is even today. Current factors constraining the Golden Eagle in Scotland include illegal killing, disturbance at nests, loss of hunting range by conversion of open hills to closed forests, and loss of wild food sources such as grouse and hares as a result of of overgrazing of upland vegetation by large herbivores such as sheep and deer. Anticipated future constraints include the development of wind farms and the expansion of native woodlands. Current conservation legislation provides for the establishment of "protected areas" for valued habitats and species,

and further legislation makes it an offense to kill Golden Eagles or knowingly to cause disturbance at trust sites. International commitments such as the European Union Wild Birds Directive have placed additional conservation obligations on the government of the United Kingdom that will probably not be met solely by reliance on protected areas and species protection measures, Effective conservation of wider-distributed birds such as the Golden Eagle requires measures to address constraints in the wider environment. In this paper, we subdivide the current and historical range of Golden Eagles into a number of zones founded on the Natural Heritage Zones approach being developed by Scottish Natural Heritage. This zonal approach provides a geographical framework for identifying key constraints on the population and provides an objective basis for the identification of targeted conservation policies.

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Erickson, W. P., B. Gritski, et al. (2003). Nine Canyon wind power project avian and bat monitoring report, September 2002 - August 2003., West, Inc: iv + 32.

Everaert, J. (2003). "Windturbines en vogels in Vlaanderen: voorlopige onderzoeksresultaten en aanbevelingen." Natuur.oriolus **69**(4): 145-155.

Everaert, J. (2003). "Wind turbines and birds in Flanders: Preliminary study results and recommendations. (English text)." Natuur.oriolus **69**(4): 145-155.

Exo, K.-M., O. Hüppop, et al. (2003). "Birds and offshore wind farms: a hot topic in marine ecology." Wader Study Group Bulletin **100**: 50-53.

Hodos, W. (2003). Minimization of motion smear: Reducing avian collisions with wind turbines. Period of performance: July 12, 1999 - August 31, 2002. Golden, Colorado, National Renewable Energy Laboratory**:** 35 pp.

Johnson, G. D., W. P. Erickson, et al. (2003). "Mortality of bats at a large-scale wind power development at Buffalo Ridge, Minnesota." American Midland Naturalist **150**(2): 332-342. <Go to ISI>://000185772500013.
In 1994 a major wind power development project was initiated in southwest Minnesota that may eventually produce 425 megawatts (MW) of electricity. The wind plant currently consists of 3 phases that. total 354 turbines capable of generating 236 MW. During a study conducted from 1996-1999 to assess effects of wind power development on wildlife, 184 bat collision fatalities were documented within the wind plant. Hoary bats (Lasiurus cinereus) and eastern red bats (L. borealis) comprised most of the fatalities. After correcting bat fatality estimates for searcher efficiency and scavenger removal rates, we estimated that the number of bat fatalities per turbine ranged from 0.07 per y at the Phase 1 wind plant to 2.04 per y at the Phase 3 wind plant. The timing of mortalities, and other factors, suggest that most mortality involves migrant rather than resident breeding bats.

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Operational underwater noise emitted at 8 in s(-1) by a 550 kW WindWorld wind-turbine was recorded from the sea and modified to simulate a 2 MW wind-turbine. The sound was replayed from an audio CD through a car CD-player and a J-13 transducer. The maximum sound energy was emitted between 30 and 800 Hz with peak source levels of 128 dB (re 1 muPa(2) Hz(-1) at 1 m) at 80 and 160 Hz (1/3-octave centre frequencies). This simulated 2 MW wind-turbine noise was played back on calm days (<1 Beaufort) to free-ranging harbour porpoises Phocoena phocoena and harbour seals Phoca vitulina in Fortune Channel, Vancouver Island, Canada. Swimming tracks of porpoises and surfacings of seals were recorded with an electronic theodolite situated on a clifftop 14 m above sea level. Echolocation activity of harbour porpoises close to the sound source was recorded simultaneously via an electronic click detector placed below the transducer. In total we tracked 375 porpoise groups and 157 seals during play-back experiments, and 380 porpoise groups and 141 surfacing seals during controls. Both species showed a distinct reaction to wind-turbine noise. Surfacings in harbour seals were recorded at larger distances from the sound source (median = 284 vs 239 in during controls; p = 0.008, Kolmogorov-Smirnov test) and closest approaches increased from a median of 120 to 182 m (p < 0.001) in harbour porpoises. Furthermore, the number of time intervals during which porpoise echolocation clicks were detected increased by a factor of 2 when the sound source was active (19.6% of all 1 min intervals as opposed to 8.4% of all intervals during controls; p < 0.001). These results show that harbour porpoises and harbour seals are able to detect the low-frequency sound generated by offshore wind-turbines. Controlled exposure experiments such as the one described here are a first step to assess the impact on marine mammals of the new offshore wind-turbine industry.

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Langston, R. H. W. and J. D. Pullan (2003). Windfarms and Birds :An analysis of the effects of windfarms on birds, and guidance on environmental assessment criteria and site selection issues. Secretariat Memorandum of the Standing Committee, Convention on the

conservation of European wildlife and natural habitats, . Strasbourg, BirdLife International, RSPB**:** 1-58.
This report was commissioned by the Council of Europe for the Bern Convention as an update of the one commissioned by them last year and presented to the 22nd meeting of the Standing Committee for information. Its remit is to ‘analyse the impact of wind farms on birds, establishing criteria for their environmental impact assessment and developing guidelines on precautions to be taken when selecting sites for wind farms’. This revised version has, as an additional annex (Annex 2), a draft recommendation for consideration by the 23rd meeting of the Standing Committee.

Nicholson, C. P. (2003). Buffalo Mountain Windfarm. Bird and bat mortality monitoring report. October, 2001 - September, 2002. Preliminary results. Knoxville, Tennessee, USA, Tennessee Valley Authority**:** 1-15.

Parkinson, K. (2003). Environmental consequences of offshore wind power generation. Institute of Estuarine and Coastal Studies (ICES). Hull, UK. University of Hull. M.Sc. Dissertation in Estuarine and Coastal Science and Management. WI.

Percival, S. (2003). Birds and windfarms in Ireland: a review of potential issues and impact assessment: 1-25.

Reitan, O. and A. Follestad (2003). Forundersøkelser av fugl i forbindelse med vindmøllepark på Hitra. Notat. Trondheim, Norsk institutt for naturforskning. 3 vedlegg**:** 8. http://www.statkraft.no/archive/inter_nor_pdf/01/04/Havrn024.pdf.

Schmidt, E., A. J. Piaggio, et al. (2003). National Wind Technology Center Site Environmental Assessment: Bird and Bat Use and Fatalities - Final Report., National Renewable Energy Laboratory, Golden, Colorado**:** 1-21.

Sharman, H. (2003). The dash for wind. Hals, Incoteco (Denmark) ApS**:** 11. http://www.countryguardian.net/Danish%20Lessons.htm.

Thelander, C. G., K. S. Smallwood, et al. (2003). Bird risk behaviors and fatalities at the Altamont Pass Wind Resource Area. Period of performance: March 1998 to December 2000., Report to National Renewable Energy Laboratory, Golden, Colorado. Work performed by BioResource Consultants, Ojai, California**:** 1-86.

West, I. (2003). Final report, avian and bat mortality associated with the initial phase of the Foote Creek Rim Windpower Project, Carbon County, Wyoming. I. WEST. Cheyenne, WY, Prepared for Pacificorp, Inc., Portland, OR, SeaWest Windpower, Inc., San Diego, CA, and Bureau of Land Management, Rawlins, WY.

Young, D. P. j., W. P. Erickson, et al. (2003). Final report: Avian and bat mortality associated with the initial phase of the Foote Creek Rim Windpower Project, Carbon County, Wyoming. November 1998 - June 2002. Cheyenne, Wyoming, Western EcoSystems Technology Inc. (WEST, Inc.)**:** 46 pp.

Young, D. P. j., W. P. Erickson, et al. (2003). Comparison of avian responses to UV-light-reflective paint on wind turbines. Subcontract report July 1999 - December 2000. Golden, Colorado, National Renewable Energy Laboratory**:** 61 pp.

Barrios, L. and A. Rodriguez (2004). "Behavioural and environmental correlates of soaring-bird mortality at on-shore wind turbines." Journal of Applied Ecology **41**(1): 72-81. <Go to ISI>://000188541900007.

1. Wind power plants represent a risk of bird mortality, but the effects are still poorly quantified. We measured bird mortality, analysed the factors that led birds to fly close to turbines, and proposed mitigation measures at two wind farms installed in the Straits of Gibraltar, one of the most important migration bottlenecks between Europe and Africa.
2. Bird corpses were surveyed along turbine lines and an associated power line to estimate mortality rates. The behaviour of birds observed within 250 m of turbines was also recorded as a putative indicator of risk. The effects of location, weather and flight behaviour on risk situations (passes within 5 m of turbines) were analysed using generalized linear modelling (GLM).
3. Mortality caused by turbines was higher than that caused by the power line. Losses involved mainly resident species, mostly griffon vultures Gyps fulvus (0.15 individuals turbine(-1) year(-1)) and common kestrels Falco tinnunculus (0.19 individuals turbine(-1) year(-1)). Mortalities were not associated with either structural attributes of wind farms or visibility.
4. Vulture collisions occurred in autumn-winter and were aggregated at two turbine lines where risks of collisions were greatest. The absence of thermals in winter forced vultures to use slopes for lift, the most likely mechanism influencing both their exposure to turbines and mortality.
5. Kestrel deaths occurred during the annual peak of abundance in summer. Carcasses were concentrated in the open habitats around a single wind farm and risk may have resulted from hunting habitat preferences.
6. Synthesis and applications. We conclude that bird vulnerability and mortality at wind power facilities reflect a combination of site-specific (wind-relief interaction), species-specific and seasonal factors. Despite the large number of migrating birds in the study area, most follow routes that are displaced from the facilities. Consequently, only a small fraction of birds on migratory flights was actually exposed to turbines. New wind installations must be preceded by detailed behavioural observation of soaring birds as well as careful mapping of migration routes.

Bjerke, J. W., K.-B. Strann, et al. (2004). Konsekvensutredning for Andmyran vindpark i Andøy kommune, Nordland - berggrunn, vegetasjon, fugl og annet dyreliv. Trondheim, Norway, NINA**:** 29.
Andmyran Vindpark AS plans to construct a wind park at the north-eastern part of Andøya, Nordland, at the bog-dominated flatlands west of Ramsa and Breivik. An investigation area of c. 11.8 km2 is evaluated. Consequences of a construction are estimated by NINA's Department of Arctic Ecology in Tromsø. Estimations are based on values of vegetation, geology, bird fauna and other fauna. Aspects that were evaluated in relation to valuation is degree of production and continuity, biological function, occurrences of threatened (red-listed) species, in addition to rarity of nature types and vegetation types within the investigation area. Few registrations of valuable geological characters were made. A few minor areas with marine sediments increase the value to minor.
The landscape is totally dominated by wetlands, of which various bog and fen types are the most common. A site in the southern part of the investigation area is estimated to have high biological value, because it is covered by an intact, ombrotrophic, asymmetric concentric bog. This nature type is considered as valuable by the Norwegian Directorate for Nature Management, and in the report on threatened vegetation types in Norway, it is considered as endangered. A less developed concentric bog in the northern part of the investigation area, east of Storvatnet, is considered to be of intermediate value. The same value is given to a small site consisting of moderately rich lawn fen slightly east of Breivik. The intact ombrotrophic bogs within the investigation area, as well as the limnic vegetation in Storvatnet is considered be of minor value.
The investigation area's total value with regard to bird fauna is considered to be intermediate. Nevertheless, there is a site close to Storvatnet which is considered to be of high biological value. The reason for this is that its type of breeding bird fauna is valuated by the

Norwegian Directorate for Nature Management as valuable on a national scale. In particular, the occurrences of breeding red-listed species contribute to increase the value. Moreover, one of two flight corridors for red-listed raptors, as well as one corridor for a pair of breeding whooper swans and for red-breasted divers near Storvatnet, are also of high value. This is because these birds are totally dependent upon having the opportunity to move from their respective breeding areas to their important hunting areas by the coastline, and these movements generally take place at altitudes between 50 m and 200 m above ground. The last corridor for raptors, which runs between Sverigedalsvatnet and Breivika, is of intermediate value.
The overall evaluation shows that the highest values are centred in the southern and the northern parts of the investigation area, and that the consequences of the planned constructions will be less serious for the central parts.

Bloom, P. H., W. G. Hunt, et al. (2004). Alamont Biologists Letter to Contra Cost, Oakland, California, USA. O. Alameda County Board of Supervisors, California, USA. Oakland, California**:** 6 pp.

Brinkmann, R. (2004). Welchen Einfluss haben Windkraftanlagen auf jagende und wandernde Fledermäuse in Baden-Württemberg? Heft 15, Windkraftanlagen - eine Bedrohung für Vögel und Fledermäuse? Baden-Württemberg, Germany, Planungsbüro Brinkmann / Akademie für Natur- und Umweltschutz Baden-Württemberg**:** 26.

De Lucas, M., G. F. E. Janss, et al. (2004). "The effects of a wind farm on birds in a migration point: the Strait of Gibraltar." Biodiversity and Conservation **13**(2): 395-407. <Go to ISI>://000186971400008.
The interaction between birds and wind turbines is an important factor to consider when a wind farm is constructed. A wind farm and two control areas were studied in Tarifa (Andalusia Province, southern Spain, 30STF590000 - 30STE610950). Variables were studied along linear transects in each area and observations of flight were also recorded from fixed points in the wind farm. The main purpose of our research was to determine the impact and the degree of flight behavioural change in birds flights resulting from a wind farm. Soaring birds can detect the presence of the turbines because they change their flight direction when they fly near the turbines and their abundance did not seem to be affected. This is also supported by the low amount of dead birds we found in the whole study period in the wind farm area. More studies will be necessary after and before the construction of wind farms to assess changes in passerine populations. Windfarms do not appear to be more detrimental to birds than other man- made structures.

de Lucas, M., G. F. E. Janss, et al. (2004). "The effects of a wind farm on birds in a migration point: the Strait of Gibraltar." Biodiversity and Conservation **13**: 395-407.
The interaction between birds and wind turbines is an important factor to consider when a wind farm is constructed. A wind farm and two control areas were studied in Tarifa (Andalusia Province, southern Spain, 30STF90000-30STE610950). Variables were studied along linear transects in each area and observations of flight were also recorded from fixed points in the wind farm. The main purpose of our research was to determine the impact and the degree of flight behavioural change in birds flights resulting from a wind farm. Soaring birds can detect the presence of the turbines because they change their flight direction when they fly near the turbines and their abundance did not seem to be affected. This is also supported by the low amount of dead birds we found in the whole study period in the wind farm area. More studies will be necessary after and before the construction of wind farms to assess changes in passerine populations. Windfarms do not appear to be more detrimental to birds than other man-made structures.

Garthe, S. and O. Huppop (2004). "Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index." Journal of Applied Ecology **41**(4): 724-734. <Go to ISI>://000222721600013.
1. Marine wind farms have attracted substantial public interest. The construction of wind facilities offshore may become Europe's most extensive technical development in marine habitats. Due to political pressure to complete construction soon, assessments of possible wind farm locations, for example in the German sectors of the North Sea and Baltic Sea, have to be based on existing knowledge.
2. In this study, we developed a wind farm sensitivity index (WSI) for seabirds. We applied this index to the Exclusive Economic Zone and the national waters of Germany in the North Sea. We chose nine factors, derived from species' attributes, to be included in the WSI: flight manoeuvrability; flight altitude; percentage of time flying; nocturnal flight activity; sensitivity towards disturbance by ship and helicopter traffic; flexibility in habitat use; biogeographical population size; adult survival rate; and European threat and conservation status. Each factor was scored on a 5-point scale from 1 (low vulnerability of seabirds) to 5 (high vulnerability of seabirds). Five of these factors could be dealt with by real data but four could only be assessed by subjective considerations based on at-sea experience; in the latter cases, suggestions of the first author were independently modulated by experts.
3. Species differed greatly in their sensitivity index (SSI). Black-throated diver Gavia arctica and red-throated diver Gavia stellata ranked highest (= most sensitive), followed by velvet scoter Melanitta fusca, sandwich tern Sterna sandvicensis and great cormorant Phalacrocorax carbo. The lowest values were recorded for black-legged kittiwake Rissa tridactyla, black-headed gull Larus ridibundus and northern fulmar Fulmarus glacialis.
4. A WSI score for areas of the North Sea and Baltic Sea was calculated from the species-specific sensitivity index values. Coastal waters in the south-eastern North Sea had values indicating greater vulnerability than waters further offshore throughout the whole year.
5. Derived from the frequency distribution of the WSI, we suggest a 'level of concern' and a 'level of major concern' that are visualized spatially and could act as a basis for the selection of marine wind farm locations.
6. Synthesis and applications. The wind farm sensitivity index might be useful in strategic environmental impact assessments (EIA). Results of small-scale EIA from wind installations should be considered within a more global perspective, provided, for example, by large mapping projects and detailed behavioural studies. This is difficult in normal EIA, particularly in highly dynamic coastal/marine habitats, and the results of this study fill an important gap by providing information on the potential sensitivity of seabirds and the importance of locations of wind installations.

Gustafsson, R. (2004). "Vindkraftverk på lågfjället Sjisjka." Vår Fågelvärld **63**(5): 19-20.

Gustafsson, R. (2004). "Vindkraft på Ripaktjåkka och andra fjällnära områden." Vår Fågelvärld **63**(5): 20.

Hötker, H., K.-M. Thomsen, et al. (2004). Auswirkungen regenerativer Energiegewinnung auf die biologische Vielfalt am Beispiel der Vögel und der Fledermäuse - Fakten, Wissenslücken, ornithologische Kriterien zum Ausbau von regenerativen Energiegewinnungsformen., Michael-Otto-Institut in NABU**:** 80 pp.
Impacts on biodiversity of exploitation of renewable energy sources: the example of birds and bats – facts, gaps in knowledge, demands for further research, and ornithological guidelines for the development of renewable energy exploitation The purpose of this report is to compile and to evaluate the available information on the impacts of exploitation of renewable energy sources on birds and bats. The focus is on wind energy as there is only little information on the impact on birds and bats of other sources of renewable energy. The report aims at better understanding the size of the impact, the potential effects of repowering (exchanging small old wind turbines by new big turbines), and possible meas-

ures to reduce the negative impact on birds by wind turbines. In addition the need for further research is highlighted. The evaluation is based on 127 single studies (wind farms) in ten countries, most of them in Germany. Most studies were brief (not more than two years) und did not include the pre-construction period. Before-After Control Impact studies that combine data collection before and after, in this case construction of a wind farm, on both the proposed development site and at least one reference site were rare. In few cases only, the design of the study and the length of the study period would theoretically allow to find statistically significant effects of wind farms on birds and bats at all. Assessments of impacts, therefore, are usually based on few studies only. This report includes all studies readily available to the authors, independently of the length of the study period and the quality of the study design. In order to base the assessments on as many independent samples as possible even rather unsystematic observations were included. The information of the data was reduced to a level that justified the application of sign tests. The compilation of many different single studies gave following results: The main potential hazards to birds and bats from wind farms are disturbance leading to displacement or exclusion and collision mortality. Although there is a high degree of agreement among experts that wind farms may have negative impacts on bird populations no statistically significant evidence of negative impacts on populations of breeding birds could be found. There was a tendency for open nesting waders to be displaced by wind farms. Some passerines obviously profited from wind farms. They probably were affected by secondary effects, e.g. changes in land management or abandonment from agricultural use next to the wind plants. The impact of wind farms on non-breeding birds was stronger. Wind farms had significantly negative effects on local populations of geese, Wigeons, Golden Plovers and Lapwings. Hinsichtlich des Wissens über die Auswirkungen von Solarparks auf Vögel und Fledermäuse liegen derzeit kaum Erhebungen vor. Hierzu sollten gerade in Bezug auf die Nutzung von Solar-Freiflächenanlagen grundlegende Untersuchungen vorgenommen werden. With the exceptions of Lapwings, Black-tailed Godwits and Redshanks most bird species used the space close to wind plants during the breeding season. The minimal distances between observed birds and pylons rarely exceeded 100 m during the breeding season. Some passerines showed a tendency to settle closer to bigger than to smaller wind plants. During the non-breeding season many bird species of open landscapes avoided approaching wind parks closer than a few hundred metres. This particularly held true for geese and waders. In accordance to published information disturbance of geese may occur at least up to 500 m from wind turbines. In most species during the non-breeding season, the distances in which disturbance could be noted increased with the size of the wind plants. In Lapwings this relationship was statistically significant. There was no evidence that birds generally „habituated“ to wind farms in the years after their construction. The results of the few studies lasting longer than one season revealed about as many cases of birds occurring closer to wind farms (indications for the existence of habituation) in the course of the years as of birds occurring farer away from wind farms (indications for the lack of habituation). The question whether wind farms act as barriers to movement of birds has received relatively little systematic scientific attention yet. Wind farms are thought to be barriers when birds approaching them change their flight direction, both on migration or during other regular flights. There is evidence for the occurrence of a barrier effect in 81 bird species. Geese, Common Cranes, waders and small passerines were affected in particular. It remains unknown, however, to what extend the disturbances by wind farms of migrating or flying birds influences the energy budgets or the timing of migration of birds. Collision rates (annual number of killed individuals per turbine) have only rarely been studied with appropriate methods (e. g. with controls of scarvenger activities). Particularly in Germany such studies are missing. Collision rates varied between 0 and more than 50 for both birds and bats. Obviously the habitat influenced the number of collisions. Birds were in high risks at wind farms close to wetlands where gulls were the most common victims and in wind farms on mountain ridges (USA, Spain) where many raptors were killed. Wind farms in or close to forests posed high collision risks on bats. For

both, birds and bats, the collision risk increased with increasing size of the wind plant. The relationship, however, was not statistically significant. Gulls and raptors accounted for most of the victims. In Germany the relatively high numbers of killed White-tailed Eagles (13) and Red Kites (41) give reason for concern. Germany hosts about half of the world population of breeding Red Kites and has a particular responsibility for this species. Bird species that were easily disturbed by wind farms (geese, waders) were only rarely found among the victims. Bats were struck by wind turbines mostly in late summer or autumn during the period of migration and dispersal. Population models created by the software VORTEX revealed that significant decreases in size of bird and bat populations may be caused by relatively small (0,1 %) additive increases in annual mortality rates, provided they are not counter acted by density dependent increases in reproduction rates. Short-lived species with high reproductive rates are more affected than long-lived species with low reproductive rates. The latter, however, are less able to substitute additional mortality by increasing reproductive rates. The effects of „repowering“ (substitution of old, small turbines by new turbines with higher capacity) on birds and bats is assessed by the available data and by simple models. There is no information, however, on the effects of the newest generation of very big wind plants. According to present knowledge, repowering will reduce negative impacts on birds and bats (disturbance and mortality) if the total capacity of a wind farm is not changed (many small turbines are replaced by few big turbines). In a scenario in which the capacity of a wind farm is increased 1,5 fold, negative impacts start to dominate. In case of a doubling of wind farm capacity, repowering increases the negative impacts of the wind farm. Repowering offers the chance to remove wind farms from sites that are associated with high impacts or risks for birds and bats. New turbines could be constructed on sites that are likely to be less problematic in respect to birds and bats.
Among powerful methods to reduce the negative impacts on birds and bats of wind energy use are:
• choice of the right site for wind farms (avoidance of wetands, woodlands, important sites for sensitive non-breeding birds and mountain ridges with high numbers of raptors and vultures),
• measures to reduce the attractivity of wind farm sites for potential collision victims,
• configuration of turbines within wind farms (placement of turbines parallel to and not accross the main migration or flight directions of birds),
• construction of wind turbines: replacement of lattice towers, wire-cables and overhead power lines.
Measures to increase the visibility of wind turbines and to reduce the effects of illumination remain to be studied. In spite of many publications on windfarms and birds there still is a great demand for further research. First of all there is an urgent need for reliable data on collision rates at wind turbines of birds and bats in Germany. This holds true particularly for the new and big turbines which will replace the present generation of wind turbines. It is still unclear whether these big and necessarily illuminated turbines pose a high collision risk to nocturnal migrants which have not yet been very much affected by smaller turbines. The high collision rates of Red Kites in Germany also urgently deserve to be studied. The aim of the research has to be a quick reduction of the collision rates. The sensitiveness against wind farms of many other bird species that are of particular nature conservation interest (storks, raptors, Cranes) has not been sufficiently studies yet. There is hardly any information on the impacts of fields of solar panels on birds and bats. Studies should be initiated as soon as possible.

Johnson, G. D., M. K. Perlik, et al. (2004). "Bat activity, composition, and collision mortality at a large wind plant in Minnesota." Wildlife Society Bulletin **32**(4): 1278-1286. <Go to ISI>://000227585400032.
We examined bat activity levels, species composition, and collision mortality at a large wind plant in southwest Minnesota from 15 June-15 September, 2001 and 2002. We found

151 bat casualties, most of which were hoary bats (Lasiurus cinereus). We recorded 3,718 bat passes at bat foraging and roosting areas within 3.6 km of the wind plant ((x) over bar =48/detector-night) and 452 bat passes at wind turbines ((x) over bar =1.9/detector-night). Peak bat activity at turbines followed the same trend as bat mortality and occurred from mid-July through the end of August. Based on the timing of fall bat migration, we believe that most bat mortality involved migrating bats. There was no significant relationship between bat activity at turbines or the number of fatalities and presence of lights on turbines. We captured 103 bats comprised of 5 species in mist nets. Big brown bats (Eptesicus fuscus) comprised most of the captures. Our study indicated that there were relatively large breeding populations of bats near the wind plant when collision mortality was low to non-existent. Future research should concentrate on determining causes of bat collisions and methods to reduce or mitigate the mortality.

Johnson, G. D. and M. D. Strickland (2004). An Assessment of Potential Collision Mortality of Migrating Indiana Bats (Myotis sodalis) and Virginia Big-eared Bats (Corynorhinus townsendii virginianus) Traversing Between Caves. Supplement to: Biological Assessment for the Federally Endangered Indiana Bat (Myotis sodalis) and Virginia Big-eared Bat (Corynorhinus townsendii virginianus). NedPower Mount Storm Wind Project, Grant County, West Virginia. Cheyenne WY (USA), WEST inc: 24.

Johnson, N. H., T. Eggan, et al. (2004). Vindkraft og reindrift, Norges vassdrags- og energidirektorat / Reindriftsforvaltningen**:** 48.

Morrison, M. L. and K. Sinclair (2004). Environmental Impacts of Wind Energy Technology. Encyclopedia of Energy Elsevier Inc. **Vol. 6:** 435-448.
Wind energy offers a relatively environmentally benign source of electricity. However, issues have been raised concerning the feasibility of placing commercial wind developments in certain geographic locations and landscape settings. In specific situations, wind power developments have been shown to cause environmental impacts on animal habitat and movements, noise pollution, visual impacts, biological concerns, bird/bat fatalities from collisions with rotating blades, and health concerns. Of all the potential environmental impacts, biological concerns regarding birds and bats have been discussed and studied the most. Thus, although this article covers all potential environmental impacts, it focuses on avian-related issues.

Smallwood, K. S. and C. G. Thelander (2004). Developing methods to reduce mortality in the Altamont Pass Wind Resource Area. Final report. Final report by BioResource Consultants to the California Energy Commission, Public Interest Energy Research-Environmental Area, Contract no. 500-01-019 California, USA, BioResource Consultants to the California Energy Commission, Public Interest Energy Research-Environmental Area**:** 333 + appendices. http://www.energy.ca.gov/pier/final_project_reports/500-04-052.html.

Young, D. P. j., M. D. Strickland, et al. (2004). Baseline avian studies Mount Storm Wind Power Project, Grant County, West Virginia. Final report. Cheyenne, Wyoming - Athens, West Virginia - Forest Grove, Oregon, Western EcoSystems Technology, Inc. (WEST, Inc.) - Concord College - ABR, Inc**:** 81 + Appendix A.

Anderson, R., J. Tom, et al. (2005). Avian Monitoring and Risk Assessment at the San Gorgonio Wind Resource Area. Phase I Field Work: March 3, 1997 - May 29, 1998; Phase II Field Work: August 18, 1999 - August 11, 2000. National Renewable Energy Laboratory. Subcontract Report NREL/SR-500-38054**:** 128.
The primary objective of this study at the San Gorgonio Wind Resource Area was to estimate and compare bird utilization, fatality rates, and the risk index among factors including

bird taxonomic groups, wind turbine and reference areas, wind turbine sizes and types, and geographic locations. The key questions addressed to meet this objective include: 1) Are there any differences in the level of bird activity, called "utilization rate" or "use", with the operating wind plant and within the surrounding undeveloped areas (reference area)?; 2) Are there any differences in the rate of bird fatalities (or avian fatality) within the operating wind plant or the surrounding undeveloped areas (reference area)?; 3) Does bird use, fatality rates, or bird risk index vary according to the geographic location, type and size of wind turbine, and/or type of bird within the operating wind plant and surrounding undeveloped areas (reference area)?; and 4) How do raptor fatality rates at San Gorgonio compare to other wind projects with comparable data?

Arnett, E. B. e. (2005). Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines. A final report submitted to the Bats and Wind Energy Cooperative. Austin, Texas (USA), Bat Conservation International**:** 187.

British Ornithologists' Union (2005). Wind, Fire & Water: Renewable Energy & Birds, University of Leicester, Leicester, British Ornithologists' Union.

Christensen, T. K. and J. P. Hounisen (2005). Investigations of migratory birds during operation of Horns Rev offshore wind farm. Annual status report 2004. Kalø, Ministry of the Environment, National Environmental Research Institute**:** 35 pp.

de Lucas, M., G. F. E. Janss, et al. (2005). "A bird and small mammal BACI and IG design studies in a wind farm in Malpica (Spain)." Biodiversity and Conservation **14**(13): 3289-3303. <Go to ISI>://000233242500015.
Wind farms have shown a spectacular growth during the last 10 years. As far as we know, this study is the first where the relationship between wind power and birds and small mammals have been considered. Before-after control impact (BACI) study design to birds and Impact Gradient (IG) study design to small mammals to test the null hypothesis of no impact of a wind farm were used. In the BACI model Windfarm Area and a Reference Area were considered. Distance from turbines was considered in the IG model. Windfarm installations did not clearly affect bird and small mammal populations. Flight height of nesting and no nesting birds did not show a clear tendency. Small mammals populations suffered high variations in numbers through times by intrinsic population factors. There are many practical problems of detection of human influence on abundances of populations so sampling in the long run can be suggested.

Desholm, M. and J. Kahlert (2005). "Avian collision risk at an offshore wind farm." Biol. lett. **1**: 296-298.
We have been the first to investigate whether long-lived geese and ducks can detect and avoid a large offshore wind farm by tracking their diurnal migration patterns with radar. We found that the percentage of flocks entering the wind farm area decreased significantly (by a factor 4.5) from pre-construction to initial operation. At night, mighrating flocks were more prone to enter the wind farm but counteracted the higher risk of collision in the dark by increasing their distance from individual turbines and flying in the corridors between turbines. Overall, less than1% of the ducks and geese migrated close enough to the turbines to be at any risk of collision.

Drewitt, A. and R. Langston (2005). Birds and wind farms. Wind, Fire & Water: Renewable Energy & Birds. A BOU conference held at the University of Leicester, 1-3 April 2005., University of Leicester, Leicester, British Ornithologists' Union. Wind Fire Water abstracts.pdf.

Evans, R. (2005). Avoiding impacts of wind farms on upland breeding birds in Scotland--species behaviour and the precautionary principle. Wind Fire & Water: Renewable Energy & Birds
BOU Annual Spring Conference. University of Leicester, RSPB.

Follestad, A., T. M. Heggberget, et al. (2005). "Arealbruk på kysten påvirker dyrelivet." NINA Temahefte **32**: 47-53.

Gill, A. B. (2005). "Offshore renewable energy: ecological implications of generating electricity in the coastal zone." Journal of Applied Ecology **42**(4): 605-615. <Go to ISI>://000230602100001.
1. Global-scale environmental degradation and its links with non-renewable fossil fuels have led to an increasing interest in generating electricity from renewable energy resources. Much of this interest centres on offshore renewable energy developments (ORED). The large scale of proposed ORED will add to the existing human pressures on coastal ecosystems, therefore any ecological costs and benefits must be determined.
2. The current pressures on coastal ecology set the context within which the potential impacts (both positive and negative) of offshore renewable energy generation are discussed.
3. The number of published peer-review articles relating to renewable energy has increased dramatically since 1991. Significantly, only a small proportion of these articles relate to environmental impacts and none considers coastal ecology.
4. Actual or potential environmental impact can occur during construction, operation and/or decommissioning of ORED.
5. Construction and decommissioning are likely to cause significant physical disturbance to the local environment. There are both short- and long-term implications for the local biological communities. The significance of any effects is likely to depend on the natural disturbance regime and the stability and resilience of the communities.
6. During day-to-day operation, underwater noise, emission of electromagnetic fields and collision or avoidance with the energy structures represent further potential impacts on coastal species, particularly large predators. The wider ecological implications of any direct and indirect effects are discussed.
7. Synthesis and applications. This review demonstrates that ORED will have direct and, potentially, indirect consequences for coastal ecology, with these effects occurring at different scales. Ecologists should be involved throughout all the phases of an ORED to ensure that appropriate assessments of the interaction of single and multiple developments with the coastal environment are undertaken.

Greenwood, J. J. D. (2005). "Wind, fire and water: renewable energy and birds. A report on the BOU's annual conference held at the University of Leichester, 1-3 April 2005." Ibis **147**: 865-867.

Hoover, S. L. and M. L. Morrison (2005). "Behavior of red-tailed hawks in a wind turbine development." Journal of Wildlife Management **69**(1): 150-159. <Go to ISI>://000228650600015.
Birds flying within windfarms can be killed when they collide with wind turbines. Raptors, especially red-tailed hawks (Buteo jamaicensis), are more Susceptible to collisions than other birds, which may be attributable to their specific foraging and flight behavior. To more fully understand the problem, and to reduce raptor mortality, it is necessary to acquire more information on habitat use and flight behavior by raptors inhabiting windfarms. Between June 1999 and June 2000, we watched raptors for 346 hours in the Altamont Pass Wind Resource Area, the largest windfarm in North America. We recorded flight behavior in relation to characteristics of the topography such as slope aspect, elevation, and inclination and in relation to various weather variables including wind speed and wind direction. We found that red-tailed hawk behavior and their use of slope aspect differed according to

wind speed. Hawks perched more often in weak winds than in strong. Red-tailed hawks were more likely to soar during low wind conditions and kite during strong wind, particularly on hillsides that faced into the wind as opposed to hillsides shielded from the wind. This is likely a result of their use of deflection updrafts, for lift during flight. During our study, when winds were Strong and from the south-southwest, kiting behavior occurred on south-southwestern facing slopes with inclines of greater than 20% and peak elevations greater than adjacent slopes. Accordingly, mitigation measures to decrease red-tailed hawk fatalities should be directed specifically to these areas and Others fitting this general model. Wind farm managers can power down turbines at the top of these hazardous slopes when they pose the greatest danger-when winds are strong and facing perpendicularly to the slope.

Kingsley, A. and B. Whittam (2005). Wind turbines and birds: A background review for environmental assessment. Draft May 12 2005. Gatineau, Quebec, Canadian Wildlife Service**:** 81.

Pennycuick, C. J. (2005). Wind farms as obstacles to migrating birds. Wind, Fire & Water: Renewable Energy & Birds. , University of Leicester, Leicester, British Ornithologists' Union.

Percival, S. (2005). "Birds and windfarms: what are the real issues?" British Birds **98**: 194-204. vi0019.

Petterson, J. (2005). Havsbaserade vindkraftverks inverkan på fågellivet i södra Kalmarsund. En slutrapport baserad på studier 1999-2003. Uppdrag för Statens energimyndighet. Lund, Lunds Universitet**:** 125.

Roy, R. D. and S. K. Pelletier (2005). Estimating Risk of Avian and Bat Collision at Wind Farms. Topsham, ME (USA), Woodlot Alternatives inc.

Scottish Natural Heritage (2005). Survey methods for use in assessment of the impacts of proposed onshore wind farms on bird communities. Consultant draft v. 6.5., Scottish Natural Heritage**:** 69 pp.

Scottish Natural Heritage (2005). Survey methods for use in assessment the impacts of onshore wind farms on bird communities., Scottish Natural Heritage**:** 1-50.

Walker, D., M. McGrady, et al. (2005). "Resident Golden eagle ranging behaviour before and after contruction of a windfarm in Argyll." Scottish Birds **25**: 24-40.

Whitford, J. (2005). An Investigation of a New Monitoring Technology for Birds and Bats. Markham, Ontario, EchoTrack inc: 20.
Four wind energy companies (Suncor Energy Products Inc., Vision Quest Windelectric-TransAlta's Wind Business, Canadian Hydro Developers, Inc. and Enbridge Inc.) joined with Natural Resources Canada to provide funding and support for a research initiative with EchoTrack Inc. This initiative involved the study of night-time bird and bat activity during the fall of 2004 at six Alberta wind energy facilities and at six other (control) sites that were similar in topography and land use but without turbines. Using radar and high quality sound recording technology, EchoTrack was able to identify the movement of birds and bats at these sites, identifying some individuals to species. By comparing flight patterns, and studying the track of birds and bats as they flew toward the wind energy facilities, valuable insight was gained on the potential effect of wind turbines on night-migrating birds and bats.

This study was a test of the radar and sound recording technology developed by EchoTrack. The results of the study indicate that this technology is useful for observing night-time bird and bat activity at existing wind farms, which would be otherwise difficult to study. Over a million discrete flight tracks were recorded through radar during the study, with enough detail to note changes in flight height, flight speed and direction of travel. Additionally, the sound recording technology allowed for certain birds and bats to be identified to species, shedding some light on what species of birds and bats were tracked on radar. The success of this study confirms that this radar-microphone technology has the potential to be useful for monitoring bird and bat movement at wind farms, and offers an addition to our toolbox for assessing the potential impact of wind energy facilities on bird and bats. Beyond this testing of EchoTrack's technology were the results of the research itself. A number of interesting patterns of activity and movement were noted after the data were analysed, many of which confirmed the results of other studies or anecdotal evidence. The most significant finding of this research was the observation that birds and bats appear to detect wind farms at night and take action to avoid the wind turbines.The radar studies showed many birds increased their flight height and slowed their flight speed when they approached the wind turbines. Since no such behaviour was seen at the control sites, this suggests that it was the presence of turbines that led to this behaviour. By increasing altitude and flying well above the turbine blades, birds and bats avoided the wind turbines and effectively reduced the risk of collision. This important finding suggests that pre-construction surveys of night-migrating birds and bats may over-estimate collision risk if avoidance behaviour is not taken into account. Indeed, assumptions regarding the risk of night-flying birds and bats colliding with wind turbines may need to be refined based on the findings of this research.

Anonymous (2006). "Abstracts of communications presented at Wind, Fire and Water: Renewable Energy and Birds." Ibis **148**(s1): 206-209.
1. John Lanchbery: The impacts of current energy generation and the need for renewables.
2. Catherine Mitchell: Overview of renewable energy in the UK - policy drivers and market readiness.
3. Chris Tomlinson: Wind energy: Technology and capability.
4. Colin J. Pennycuick: Wind farms as obstacles to migrating birds.
5. Alv Ottar Folkestad: Experience of wind farms on Smøla (Norway) in relation to White-tailed Sea Eagle.
6. Andrew Brown & Aalastair Gill: Hydro technology in the UK.

Arnett, E. B. (2006). "A preliminary evaluation on the use of dogs to recover bat fatalities at wind energy facilities." Wildlife Society Bulletin **34**(5): 1440-1445. <Go to ISI>://000244071500027.
I assessed the ability of dog-handler teams to recover dead bats (Chiroptera) during fatality searches typically performed at wind energy facilities to determine fatality rates for birds and bats. I conducted this study at the Mountaineer and Meyersdale Wind Energy Centers in West Virginia and Pennsylvania, USA, respectively. Dogs found 71% of bats used during searcher-efficiency trials at Mountaineer and 81% of those at Meyersdale, compared to 42% and 14% for human searchers, respectively. Dogs and humans both found a high proportion of trial bats within 10 m of the turbine, usually on open ground (88% and 75%, respectively). During a 6-day fatality search trial at 5 turbines at Meyersdale, the dog-handler teams found 45 bat carcasses, of which only 42% (n = 19) were found during the same period by humans. In both trials humans found fewer carcasses as vegetation height and density increased, while dog-handler teams search efficiency remained high. Recommendations for evaluating the biases and efficiency when using dogs for bat fatality searches are provided.

Boone, J. (2006). Less for more: the Rube Goldberg nature of industrial wind development. Unpublished essay. Oakland, Maryland.

Bright, J. A., R. H. W. Langston, et al. (2006). Bird Sensitivity Map to provide locational guidance for onshore wind farms in Scotland. The Lodge, Sandy, Bedfordshire, The Royal Society for the Protection of Birds: 1-136.

Brinkmann, R. (2006). Survey of possible operational impacts on bats by wind facilities in Southern Germany. Baden-Württemberg, Ecological Consultancy Robert Brinkmann: 63.
On authority of the administrative district government of Freiburg and supported by the foundation “Stiftung Naturschutzfond Baden Württemberg”, a study on the possible operating-based effects of wind turbines on bats were conducted between August 2004 and October 2005. The main purpose of this study was to answer the question whether, in the administrative district of Freiburg, Southern Germany, bats collide with wind turbines and to what extent, as reported in other areas nationally and internationally. The study consisted of three different types of complementary surveys: searching for collision fatalities under working turbines, the examination of collision fatalities to determine the cause of death, and observations of bat behaviour at turbines using a thermal imaging camera. Between the end of July and the end of October 2005, searches for collision fatalities were conducted every five days at 16 selected, representative turbines located mainly in the Black Forest and its foothills of Southern Germany (altitudes between 470 and 1100 m above sea level). Additionally, two to three extra searches were conducted at 16 other turbines in the same area during the same time period. Between the beginning of April and mid-May, as well as between mid-July until mid-October 2005, eight of the turbines that had been checked in 2004 were searched again with the same search interval. Furthermore, specific experiments to determine the searcher efficiency and the carcass removal rate were carried out at selected turbines. Taking into account these error factors, the actual number of collision fatalities was projected. The following results were gained:

- A total of 50 bat carcasses were found, 45 during the systematic fatality searches and five more during extra searches. When comparing the results from the eight turbines that were searched in both years, the numbers differ significantly between the years: in 2004, 31 carcasses were found whereas in 2005, with the same search intensity, only 10 were documented.

- The species found were Common Pipistrelle Pipistrellus pipistrellus (39 spec.), Leisler’s Bat Nyctalus leisleri (8 spec.), Parti-coloured Bat Vespertilio murinus (2 spec.) and one Serotine Bat Eptesicus serotinus.

- Apart from bats, only nine bird carcasses were found: three House Martins Delichon urbic), three Swifts Apus apus, one Alpine Swift A. melba, one Goldcrest Regulus regulus and one Melodious Warbler Hippolais polyglotta. Overall, five times as many bats were found.

- Average searcher efficiency in the different ground coverage classes was: 84% in open areas, 77% in overgrown areas and 40% in heavily overgrown areas. The carcass removal rate differed between the sites; the average though for all experiments was rather high. For a five-day interval the average was 58.8%.

- Considering the searcher efficiency, the carcass removal rate and an area factor describing the relation of searchable to non-searchable area in a 40 m radius, it is possible to estimate the actual number of dead bats from the number of bat carcasses found. This projection results in 335 bats for the 16 turbines regularly checked in 2004 with a variation of the carcass removal rate from a minimum of 269 to a maximum of 446 bats. This equals

20.9 bats (16.6 - 27.9) per turbine. For the turbines surveyed in 2005, a total of 95 collision fatalities (75 - 125) were projected, which equals 11.8 bats (9.4 - 15.6) on average per turbine.
Survey of possible operational impacts on bats by wind facilities in Southern Germany II

- Most bats were found between the end of July and mid-August and at the beginning of September. Between the beginning of April and mid-May 2005, no bat carcasses were found at any of the eight surveyed turbines.

- The Common Pipistrelle Pipistrellus pipistrellus, the species which was mainly affected, is not a migratory species.

- All the fatalities were found at turbines either in forests or in wind throw areas, none were found in open areas.

The examination of the bat carcasses showed that some of the bats had broken wings or obvious head injuries. Other bats showed signs of skull fractures. The dissection proved that most bats had internal injuries which were beyond doubt of traumatic origin. The results of these examinations lead to the only plausible conclusion, that the bat fatalities are in causal relationship to wind turbines.
Using a thermal imaging camera, bat activity was observed at two turbine sites (one in forest, one in open area) and at a third site without a turbine (wind throw) as reference, for four half-nightly observations. Highest bat activity was recorded at the reference site. At both turbine locations, bat activity was similar at an altitude > 40 m. This is contrary to the search results, where a large number of bat carcasses were found at the forest site but none at the open area site.
Approximately 25% of the bats approaching a rotor showed evasive behaviour. A bat colliding with a rotor could not be observed with certainty. At an altitude > 40 m with wind speeds between 3.5 and 7.5 ms-1, slightly more bats – and at wind speeds higher than 7.5 ms-1 slightly fewer bats – were observed than would have been expected for the distribution of wind speeds. Bat activity could be observed near turbines at higher wind speeds of up to 10.9 ms-1.
Because of strict protection regulations for bats in the Habitats Directive (European Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora) and also in the German Federal Nature Conservation Act (Bundesnaturschutzgesetz), and due to the potentially high impact risk, it is recommended to carefully review the bat conservation issues during the planning and approval procedures for wind facilities. Especially important is impact avoidance, achieved most likely through site selection. According to current knowledge, turbine sites in forests and/or on ridges should be considered as potentially very problematic.
Another possibility for mitigation is restricting the operating times of the facility when bat activity is especially high. But current data is not specific enough and at times contradictory, so that generally valid guidelines to restrict operating times in specific seasons or at certain wind speeds cannot be established. Accordingly, the only solution at the moment is to carefully examine each location during the planning process and once approved, to monitor the effectiveness of the mitigation measures.

Brinkmann, R. and F. Bontadina (2006). Untersuchungen zu möglichen betriebsbedingten Auswirkungen von Windkraftanlagen auf Fledermäuse im Regierungsbezirk Freiburg. Gundelfingen, Germany, Plannungsbüro Dr Robert Brinkmann: 66.

Brinkmann, R., H. Schauer-Weisshahn, et al. (2006). Untersuchungen zu möglichen betriebsbedingten Auswirkungen von Windkraftanlagen auf Fledermäuse im Regierungsbezirk Freiburg. Freiburg, Regierungspräsidium Freiburg, Naturschutz und Landschaftspflege**:** 1-66.

Carstensen, J., O. D. Henriksen, et al. (2006). "Impacts of offshore wind farm construction on harbour porpoises: acoustic monitoring of echolocation activity using porpoise detectors (T-PODs)." Marine Ecology-Progress Series **321**: 295-308. <Go to ISI>://000241282700025.
Offshore wind farming is a new emerging technology in the field of renewable energies. This study investigates the potential impact of the construction of one of the first major, offshore wind farms (> 100 MW) on harbour porpoises Phocoena phocoena by means of acoustic porpoise detectors (T-PODs) monitoring porpoise echolocation activity. The monitoring program was established as a modified BACI (before, after, control, impact) design, with 6 monitoring stations equally distributed between the impact area and a nearby reference area. Mean waiting times, defined as the period between 2 consecutive encounters of echolocation activity, increased from 6 h in the baseline period to 3 d in the wind farm area during the construction. This increase was 6 times larger than changes observed in the reference area. One specific construction activity, involving the ramming and vibration of steel sheet piles into the seabed, was associated with an additional significant increase in waiting time of 4 to 41 h, in both the construction and reference areas. Assuming that echolocation activity is related to harbour porpoise density, the analysis shows that their habitat-use changed substantially, with the porpoises leaving the construction area of the offshore wind farm. Acoustic monitoring from fixed positions provides data with a high temporal resolution, but low spatial resolution, which can be analysed at a variety of scales, and can be applied to harbour porpoises and other echolocating cetaceans.

Chamberlain, D. E., M. R. Rehfisch, et al. (2006). "The effect of avoidance rates on bird mortality predictions made by wind turbine collision risk models." Ibis **148**(s1): 198-202. http://www.blackwell-synergy.com/doi/abs/10.1111/j.1474-919X.2006.00507.x
The model of Band et al. (2005) used data describing the structure and operation of the turbines: number of blades; maximum chord width and pitch angle of blades; rotor diameter; and rotation speed; and of bird size and flight: body length; wingspan; flight speed; flapping; or gliding flight, to derive a probability of collision. This approach was found to be generally sound mathematically (Chamberlain et al. 2005). Sensitivity analysis suggested that key parameters in determining collision risk were bird speed, rotor diameter and rotation speed, although variation in collision risk was still small within the likely range of these variables. Mortality is estimated by multiplying the collision probability by the number of birds passing through the area at risk height, determined from survey data. Crucially, however, the model assumes that an individual bird takes no avoiding action when encountering a turbine, so an adjustment must also be made for avoidance behaviour. In this paper, we examine critically the estimation and use of avoidance rates in conjunction with the collision risk model (CRM). The sensitivity of predicted mortality to errors in estimated avoidance rates is assessed in three studies that have used the CRM. It should be noted that we consider only direct mortality caused by wind turbine collisions, but we accept that there may be other indirect effects on bird populations such as disturbance, displacement and loss of habitat (Langston & Pullan 2003, Percival 2005, Fox et al. 2006) that are outside the scope of this paper.

Desholm, M. (2006). Wind farm related mortality among avian migrants - a remote sensing study and model analysis. Institute of Biology, Dept. of Wildlife Ecology and Biodiversity. Copenhagen. University of Copenhagen. PhD thesis. WI.

Desholm, M., A. D. Fox, et al. (2006). "Remote techniques for counting and estimating the number of bird-wind turbine collisions at sea: a review." Ibis **148, Suppl. 1**: 76-89. <Go to ISI>://000243474900007.

Since the early 1990s, marine wind farms have become a reality, with at least 13 000 offshore wind turbines currently proposed in European waters. There are public concerns that these man-made structures will have a significant negative impact on the many bird populations migrating and wintering at sea. We assess the degree of usefulness and the limitations of different remote technologies for studying bird behaviour in relation to bird-turbine collisions at offshore wind farms. Radar is one of the more powerful tools available to describe the movement of birds in three-dimensional space. Although radar cannot measure bird-turbine collisions directly, it offers the opportunity to quantify input data for collision models. Thermal Animal Detection System (TADS) is an infra red-based technology developed as a means of gathering highly specific information about actual collision rates, and also for parameterizing predictive collision models. TADS can provide information on avoidance behaviour of birds in close proximity to turbine rotor-blades, flock size and flight altitude. This review also assesses the potential of other (some as yet undeveloped) techniques for collecting information on bird flight and behaviour, both pre- and post-construction of the offshore wind farms. These include the use of ordinary video surveillance equipment, microphone systems, laser range finder, ceilometers and pressure sensors.

Drewitt, A. L. and R. H. W. Langston (2006). "Assessing the impacts of wind farms on birds." Ibis **148, Suppl. 1**: 29-42. <Go to ISI>://000243474900004.
The potential effects of the proposed increase in wind energy developments on birds are explored using information from studies of existing wind farms. Evidence of the four main effects, collision, displacement due to disturbance, barrier effects and habitat loss, is presented and discussed. The consequences of such effects may be direct mortality or more subtle changes to condition and breeding success. The requirements for assessing the impact of future developments are summarized, including relevant environmental legislation and appropriate methods for undertaking baseline surveys and post-construction monitoring, with particular emphasis on the rapidly developing area of offshore wind farm assessments. Mitigation measures which have the potential to minimize impacts are also summarized. Finally, recent developments in the monitoring and research of wind energy impacts on birds are outlined and some areas for future work are described.

Everaert, J. and E. W. M. Stienen (2006). "Impact of wind turbines on birds in Zeebrugge (Belgium). Significant effect on breeding tern colony due to collisions." Biodiversity and Conservation **DOI 10.1007/s10531-006-9082-1**: 14 pp.

Fielding, A. H., D. P. Whitfield, et al. (2006). "Spatial association as an indicator of the potential for future interactions between wind energy developments and golden eagles Aquila chrysaetos in Scotland." Biological Conservation **131**(3): 359-369. <Go to ISI>://000239139400002.
Despite their environmental benefits in generating electricity without emission of 'greenhouse' gases, wind farms have attracted controversy with regard to their impacts on birds, especially golden eagles Aquila chrysaetos. Evidence from USA studies suggest eagle fatalities through collision with turbines may be the main potential impact whereas for breeding eagles in Scotland, displacement from wind farm areas (indirect habitat loss) may be the primary impact. In this study, we examined the co-occurrence potential for golden eagles and wind farms in Scotland by documenting the spatial association between wind farm proposals and breeding eagle territories and areas potentially suitable for non-breeding eagles. Although there were records for over 500 wind farm proposals at various stages of development, relatively few coincided with eagle territories (ca. 4% of territories had a proposal within 3 km of territory Centre). Similarly, only 2% of habitat predicted to be suitable for non-breeding eagles overlapped with proposed or installed wind farm areas. Moreover, estimates of the potential for electricity generation from all wind farm proposals, with respect to government targets for renewable energy supplies, suggested most pro-

posals were unlikely to be constructed. We conclude that in comparison with other constraints on Scotland's golden eagles, notably persecution, wind farms should not represent a serious concern if best practice in planning their location and minimising their impact are maintained. Potential future regional pressures on breeding eagles from wind farms are highlighted, however, and uncertainty of impact with respect to displacement or collision fatalities requires continued scrutiny. (c) 2006 Elsevier Ltd. All rights reserved.

Fox, A. D., M. Desholm, et al. (2006). "Information needs to support environmental impact assessment of the effects of European marine offshore wind farms on birds." Ibis **148, Suppl. 1**: 129-144. <Go to ISI>://000243474900010.
European legislation requires Strategic Environmental Assessments (SEAs) of national offshore wind farm (OWF) programmes and Environmental Impact Assessments (EIAs) for individual projects likely to affect birds. SEAs require extensive mapping of waterbird densities to define breeding and feeding areas of importance and sensitivity. Use of extensive large scale weather, military, and air traffic control surveillance radar is recommended, to define areas, routes and behaviour of migrating birds, and to determine avian migration corridors in three dimensions. EIAs for individual OWFs should define the key avian species present; as well as assess the hazards presented to birds in terms of avoidance behaviour, habitat change and collision risk. Such measures, however, are less helpful in assessing cumulative impacts. Using aerial survey, physical habitat loss, modification, or gain and effective habitat loss through avoidance behaviour can be measured using bird densities as a proxy measure of habitat availability. The energetic consequences of avoidance responses and habitat change should be modelled to estimate fitness costs and predict impacts at the population level. Our present ability to model collision risk remains poor due to lack of data on species-specific avoidance responses. There is therefore an urgent need to gather data on avoidance responses; energetic consequences of habitat modification and avoidance flights and demographic sensitivity of key species, most affected by OWFs. This analysis stresses the importance of common data collection protocols, sharing of information and experience, and accessibility of results at the international level to better improve our predictive abilities.

Gauthreaux, S., D. VanBlaricom, et al. (2006). "The use of surveillance radar to monitor the exodus of birds from migration stopovers." Journal of Ornithology **147, Suppl 1**(5): 170-171. <Go to ISI>://000240313201071.

Huppop, O., J. Dierschke, et al. (2006). "Bird migration studies and potential collision risk with offshore wind turbines." Ibis **148, Suppl. 1**: 90-109. <Go to ISI>://000243474900008.
Worldwide, Germany is the leading country in the use of wind energy. Since sites for the erection of wind turbines became scarce on land, ambitious plans for the offshore regions have arisen. There have been applications for 33 sites within the German Exclusive Economic Zone in the North and Baltic Seas, some of which entail several hundred individual turbines. Eleven pilot projects are approved, and two others rejected. As several hundred million birds cross the North and Baltic Seas at least twice every year, the Offshore Installations Ordinance says that licensing will not be given if the obstacles jeopardize bird migration. Birds are potentially endangered by offshore wind farms through collisions, barrier effects and habitat loss. To judge these potential risks, the occurrence of birds in space and time as well as details on their behaviour in general (migration, influence of weather) and their behaviour when facing wind farms (flight distances, evasive movements, influence of light, collision risk) need to be determined. Furthermore, the influences of construction and maintenance works must be considered. Since 2003, we have investigated year-round bird migration over the North Sea with regard to offshore wind farms. The main objectives were to assess data on the aforementioned aspects of bird migration over sea. These data can contribute to, for example, estimations of collision risks at offshore wind farms, the possible impacts on bird populations and possible mitigation measures. Results

from measurements with different techniques, including radar, thermal imaging, and visual and acoustic observations, were compiled. The findings confirm that large numbers of diurnal and nocturnal migrants cross the German Bight. Migration was observed all year round but with considerable variation of intensity, time, altitude and species, depending on season and weather conditions. Almost half of the birds fly at 'dangerous' altitudes with regard to future wind farms. In addition, the number of individuals in reverse migration is considerable, which increases the risk of collision. We demonstrated that, especially under poor visibility, terrestrial birds are attracted by illuminated offshore obstacles and that some species collide in large numbers. Passerines are most frequently involved in collisions. Even if the findings regarding collisions at a research platform cannot be directly applied to offshore wind farms, they do show that on a few nights per year a large number of avian interactions at offshore plants can be expected, especially in view of the number and planned area of projected wind farms. We suggest abandonment of wind farms in zones with dense migration, turning off turbines on nights predicted to have adverse weather and high migration intensity, and actions to make wind turbines more recognizable to birds, including modification of the illumination to intermittent rather than continuous light, as the most appropriate mitigation measures. We further conclude that a combination of methods is necessary to describe the complex patterns of migration over the sea. The recordings are to be continued with the aim of refining the results presented here, and of developing a model for 'forecasting' bird migration over the German Bight. We expect more information on avoidance behaviour and collisions after the construction of a pilot wind park.

Hötker, H. (2006). Auswirkungen des "Repowering" von Windkraftanlagen auf Vögel und Fledermäuse. Bergenhusen, Germany, Michael-Otto-Institut im NABU - Forschungs- und Bildungszentrum für Feuchtgebiete und Voglschutz**:** 36.

Kaiser, M. J., M. Galanidi, et al. (2006). "Distribution and behaviour of Common Scoter Melanitta nigra relative to prey resources and environmental parameters." Ibis **148**(s1): 110-128. http://www.blackwell-synergy.com/doi/abs/10.1111/j.1474-919X.2006.00517.x
Offshore wind farms are proposed around the coast of the UK and elsewhere in Europe. These sites tend to be located in shallow coastal waters that often coincide with areas used by over-wintering Common Scoter Melanitta nigra. A large-scale study was undertaken to ascertain the relationship of the spatial distribution of Common Scoter in Liverpool Bay with prey abundance and environmental and anthropogenic variables that may affect foraging efficiency. The highest numbers of Common Scoter coincided with sites that had a high abundance and biomass of bivalve prey species. There was strong evidence that the maximum observed biomass of bivalves occurred at a mean depth of c. 14 m off the Lancashire coast and at c. 8 m off the north Wales coast. This coincided well with the distribution of Common Scoter at Shell Flat, but less well with the distribution of birds off North Wales. Common Scoters were observed in lowest numbers or were absent from areas in which anthropogenic disturbance (shipping activity) was relatively intense, even when these areas held a high prey biomass. Commercial fishing activities did not appear to contribute to this disturbance.

Kjær, J., J. K. Larsen, et al. (2006). Danish offshore wind - key environmental issues., DONG Energy, Vattenfall, The Danish Energy Authority and the Danish Forest and Nature Agency. **148:** 1-143.

Langston, R. H. W. (2006). "Wind, Fire and Water: Renewable Energy and Birds - Proceedings of the British Ornithologists' Union Annual Spring Conference 2005 University of Leicester, 1-3 April 2005." Ibis **148**: 1-3. <Go to ISI>://000243474900001.

Langston, R. H. W., A. D. Fox, et al. (2006). "Conference plenary discussion, conclusions and recommendations." Ibis **148**: 210-216.

Mabee, T. J., B. A. Cooper, et al. (2006). "Nocturnal bird migration over an Appalachian Ridge at a proposed wind power project." Wildlife Society Bulletin **34**(3): 682-690. <Go to ISI>://000242398700017.
Characteristics of nocturnal bird migration are poorly understood for many regions of the United States. This information will be critical in areas where wind power projects are proposed. We used portable marine radar to conduct a nocturnal bird migration study at multiple sites along the Allegheny Front, West Virginia, on 45 nights during autumn 2003, to document migration characteristics at a proposed wind power project. Nocturnal passage rates were highly variable among nights, ranging from 8 to 852 targets/km/hour, with a seasonal mean of 241 +/- 33 targets/km/hour at the primary (central) study site and 199 targets/km/hour for the entire proposed development. Mean flight altitudes also were highly variable among nights, ranging from 214 to 769 m above ground level (agl), with a mean flight altitude of 410 +/- 2 m agl. Flight directions indicated that most migrants crossed, rather than followed, the Allegheny Front ridgeline. We believe portable marine radars, when coupled with a rigorous study design, can collect important baseline information on avian migration and address site specific questions posed at proposed developments. Concurrent collection of low-altitude migration and avian fatality data could help elucidate which metrics are most useful for predicting avian fatalities at wind power developments.

Madders, M. and D. P. Whitfield (2006). "Upland raptors and the assessment of wind farm impacts." Ibis **148**(Suppl. 1): 43-56. <Go to ISI>://000243474900005.
Government targets on renewable energy coupled with anthropogenic constraints on development have resulted in a surge in proposals to locate wind farms in upland areas, where they may conflict with the wellbeing of scarce or rare bird species including raptors. European and UK legislation demand that the effects of wind farm developments, both individually and in combination, be assessed to determine the level of impact on these species. The principle adverse effects of wind farms on raptors, as for other terrestrial birds, potentially involve disturbance (displacement or barrier impacts) or collision fatality. Few long-term studies on such effects of wind farms have been undertaken. We review available research results on displacement of raptors, which primarily involve foraging birds, and conclude that most studies indicate that displacement appears to be negligible, although some notable exceptions occur and more research is needed. There is also a need for better understanding of the numbers of birds likely to be killed through collision with turbine rotors at the site level in order to inform planning decisions, although models of bird distribution at several spatial scales can be used to circumvent potential difficulties when locating turbines. Modelling approaches have also been developed that attempt to quantify the theoretical risk of collision. One such approach, the Band model, is a valuable tool for impact assessment and its use is now widespread in the UK. However, there are practical problems associated with gathering the data required to run the model and numerous assumptions must be made concerning bird behaviour. This can lead to deficiencies in the input parameters which potentially have a large effect on the model outputs. Hence, we make recommendations for potential improvements, such as quantifying error in flight height estimation, training of observers in acuity skills, quantifying bird detection-distance functions, and research on factors influencing activity budgets and flight behaviour. In addition, the model outputs are usually adjusted to take account of turbine avoidance by birds and this aspect of birds' behaviour is poorly understood. As a result of these limitations, collision predictions are only indicative, and more reliable in some situations, and for some species, than others.

Mjølsnes, K. R. (2006). Rovfugltrekket ved Lassaskaret høsten 2006. Oppdragsrapport. Bryne.

Morley, E. (2006). "Opening address to Wind, Fire and Water: Renewable Energy and Birds." Ibis **148**(s1): 4-7. http://www.blackwell-synergy.com/doi/abs/10.1111/j.1474-919X.2006.00504.x

Morrison, M. L. (2006). Bird movements and behaviors in the Gulf Coast Region: Relation to potential wind energy developments. November 22, 2000 - October 31, 2005. Golden, Colorado, National Renewable Energy Laboratory**:** 1-34.

Perrow, M. R., E. R. Skeate, et al. (2006). "Radio telemetry as a tool for impact assessment of wind farms: the case of Little Terns Sterna albifrons at Scroby Sands, Norfolk, UK." Ibis **148, Suppl. 1**: 57-75. <Go to ISI>://000243474900006.
Many seabirds travel widely to exploit variably distributed prey resources, utilizing even profitable patches only briefly as prey become available. Assessing the relative importance of areas occupied by wind farms relies on sufficient survey effort to increase the probability of detection and later assessment to an acceptable level. Conventional techniques suffer from high sampling costs and infrequent sampling of patches within larger areas. Remote techniques, which continuously sample habitat, may offer a solution although sufficient coverage may be difficult to achieve. In this paper, we outline experiences of the use of radio telemetry on LittleTerns Sterna albifrons at their most important UK breeding site, the Great Yarmouth North Denes Special Protection Area (SPA), in relation to a 30 turbine offshore wind farm on Scroby Sands, which encroaches to 2 km from the North Denes colony. Little Terns had not been radio-tagged previously in the UK, and the technical difficulties of tagging and subsequently following a small (55 g) diving seabird limited data collection. However, comparative data from 2 years (2003 and 2004), in which the abundance of the terns' preferred prey varied greatly, revealed striking differences in activity and foraging patterns, which changed the perception of the scope of the birds. With an active nest, birds occupied a range of < 6.3 km(2) with a range span of up to 4.6 km. In comparison, failed birds ranged widely, occupying ranges up to 52 km2 and travelling up to 27 km in a single foraging bout. As birds were recorded from 2 to 3 km offshore, the wind farm is within range of birds from the breeding colony at North Denes, although only a small proportion of foraging time was spent at such distance in the years of study. The potential value of radio (and satellite) telemetry in illustrating habitat use, perhaps to set precautionary distance limits for wind farms as well as defining actual use of particular areas including for collision risk assessment is discussed.

Petersen, J. K. and T. Malm (2006). "Offshore windmill farms: Threats to or possibilities for the marine environment." Ambio **35**(2): 75-80. <Go to ISI>://000237032400005.
A massive development of offshore windmill farms has been planned along the European coastline. This raises important questions about the possible effects on the marine environment. Effects during the construction period may be minimized to a negligible impact if care is taken to avoid areas containing rare habitats or species. Disturbance caused by noise, vibrations, and electromagnetic fields during windmill operation may, with present knowledge, be considered to be of minor importance to the marine environment. The reef effect (i.e. addition of a hard substratum), is believed to cause the largest impact on the marine environment and at different scales: the micro scale, which involves material, texture, and heterogeneity of the foundation material; the meso scale, which involves the revetments and scour protection; and the macro scale, which encompasses the level of the entire windmill farm. Effects on these scales are discussed in relation to results obtained from natural habitats, artificial reefs, and other man-made constructions at sea.

Petterson, J. (2006). Rovfågelsregistrering vid Glötesvalen 2006. Följingar av revirhållande rovfåglar med speciell inriktning på kungsörn. Färjestaden, JP Fågelvind**:** 1-25.

Rabin, L. A., R. G. Coss, et al. (2006). "The effects of wind turbines on antipredator behavior in California ground squirrels (Spermophilus beecheyi)." Biological Conservation **131**(3): 410-420. <Go to ISI>://000239139400006.
Electricity-generating wind turbines are an attractive energy source because they are renewable and produce no emissions. However, they have at least two potentially damaging ecological effects. Their rotating blades are hazardous to raptors which occasionally fly into them. And wind turbines are very noisy when active, a feature that may interfere with the lives of animals beneath them. We studied California ground squirrels (Spermophilus beecheyi) in the Altamont Pass Wind Resource Area of Northern California. These squirrels emit vocalizations that alert others to the presence of a predator, and so may be forced to compensate for turbine noise by modifying antipredator behavior. We compared the antipredator behavior of squirrels at two sites, one close to and the other far from turbines, and under two conditions, during baseline and playback of conspecific alarm calls. We generated composite two variables using principle components analysis, one representing vigilance and one representing another cautionary antipredator tactic, for further statistical comparisons. Animals at the Turbine site exhibited elevated levels of vigilance and showed increased caution demonstrated in part, by returning to the area near their burrows during alarm calling. We conclude that this site difference is probably caused by the disparity in turbine noise, since predator abundance, group size, and vegetation type and density were similar for the two sites. Though population level impacts of these behavioral differences remain to be explored, our results indicate that behavioral impacts of turbines on wildlife should be considered during future turbine development. (c) 2006 Elsevier Ltd. All rights reserved.

Schwartz, S. S., Ed. (2006). AWEA / AUdubon Workshop: Understanding and resolving bird and bat impacts. Understanding and Resolving Bird and Bat Impacts. Debs Park Audubon Center, Los Angeles, American Wind Energy Association & Audubon California, Center for Energy Efficiency and Renewable Technologies.

West, A. D. and R. W. G. Caldow (2006). "The development and use of individuals-based models to predict the effects of habitat loss and disturbance on waders and waterfowl." Ibis **148, Suppl. 1**: 158-168. <Go to ISI>://000243474900013.
Current commitments to increase renewable energy generation have led to concern about the possible effects of such developments on shorebirds and waterfowl. To assess the future impact of industrial developments-of changes in the intensity or type of activity on an estuary-or to evaluate the cost effectiveness of proposed mitigating measures, ecologists must be able to predict accurately to new environmental conditions. The difficulty with predicting to new circumstances is often that there is no way of knowing whether the empirical relationships upon which models are based will hold under the new conditions, and so predictions are of uncertain accuracy. Individuals-based models of shorebirds feeding on estuaries have been developed in an attempt to overcome this problem. These models follow the behavioural responses of individual animals to changes in the environment and predict variables such as population mortality rate from the fates of all individuals. Birds in these models use optimal decision rules to determine their behaviour, which means that model birds are likely to respond to environmental changes in the same way as real ones would and are therefore expected to provide a reliable means of predicting how animal populations will be influenced by environmental change. We describe previous approaches to predicting the effects of development in estuaries using two estuarine barrage schemes as examples. We then describe the development of individuals-based models to overcome the limitations of these approaches and discuss examples of how the models have already been used to predict the consequences of habitat loss and disturbance. Finally, we describe two current applications that demonstrate how individuals-based models are being used to predict the effects of barrages and offshore wind farm developments on waterbirds. We believe that individuals-based modelling has the potential to play an important

role in future investigations of the impacts of a wide range of renewable energy developments.

Whitfield, D. P. and M. Madders (2006). Deriving collision avoidance rates for red kites *Milvus milvus*. Natural Research Information Note. Banchory, UK, Natural Research Ltd. **3:** 1-14.

Wiggelinkhuizen, E. J., L. W. M. M. Rademakers, et al. (2006). WT-Bird. Bird collision recording for offshore wind farms. Petten, the Netherlands, Energy research Centre of The Netherlands (ECN)**:** 5.
A new method for registration of bird collisions has been developed using video cameras and microphones combined with event triggering by acoustic vibration measurement. Remote access to the recorded images and sounds makes it possible to count the number of collisions as well as to identify the species. Currently a prototype system is being tested on an offshore-scale land-based wind turbine using bird dummies. After these tests we planned to perform endurance tests on other land-based turbines under offshore-like conditions.

Ahlén, I., L. Bach, et al. (2007). Fladdermöss och havsbaserade vindkraftverk studerade i södra Skandinavien. Stockholm, Naturvårdsverket. **148:** 38 pp.

Ahlén, I., L. Bach, et al. (2007). Bats and offshore wind turbines studied in southern Scandinavia. Stockholm, Sweden, Swedish Environmental Protection Agency**:** 37.
A pilot study 2002-2003 at turbines on land showed that certain locations in the landscape could explain some of the casualty risks and the main reasons for collisions were found. During the 2005 introductory studies and in the project 2006 on bats in offshore areas in Kalmarsund we could confirm earlier known flyways from coastal points and found an extensive activity of passing migrants but also of resident species coming from various directions to areas with an abundance of insects. Observations were made at Utgrunden and Yttre Stengrund in Kalmarsund in the Baltic Sea and in Öresund between Sweden and Denmark. The observers onboard the boats and at the coastal points where bats take off used ultrasound detectors, strong portable spotlights and at special times also thermal camera. Boxes for automatic recording of bats were used on land, were placed on the turbines, and on the boat's cap. These methods resulted in a total of 12 354 observations of bats, 3 830 over the sea and 8 524 on land. Bats fly over the sea in winds up to about 10 m/s, a major part of the activity took place at wind speeds less than 5 m/s. Bats of 10 species were observed on the open sea and all of them were foraging at suitable weather conditions, which means calm weather or light breeze. The bats did not avoid the turbines. On the contrary they stayed for shorter or longer periods hunting close to the windmills because of the accumulation of flying insects. Hunting close to the blades was observed, why the risk of colliding might be comparable to land-based turbines. Bats also used wind turbines for resting.
Insects were collected at places and times when bats were observed feeding. Chironomids were dominating, but we also found many other flying species of other insect groups. Insects, but probably also crustaceans, were caught by bats in the water surface. Some terrestrial species occurred among the insects and spiders that were drifting in the air. At times we suppose that their origin was in the Baltic Republics or Russia. It was earlier completely unknown that many bat species, migratory and non-migratory, regularly use this food resource on the open sea far from the coasts in the late summer and early autumn.
With radar on Utgrunden's lighthouse data on movements of the largest bat species, mainly Nyctalus noctula, could be studied. This gave data on flyways, directions, movement patterns when foraging, especially near the turbines. With the radar it was possible to measure altitude and the results showed that almost all activity took place below 40 m

above sea level, while only a few cases of higher flight was recorded. Observations from boat showed that altitude was very variable according to the available insects. Bats were seen hunting from the water surface up to the upper part of the windmills.
Need of further research and developing methods is discussed in the report. An updated risk assessment is presented. A standpoint today is that areas with concentrated flyways and foraging habitats with an abundance of flying insects must be very carefully examined if new windmills are planned. The collision risk at offshore wind power parks is impossible to study as long as there are no such parks. Investigations on bats needed for environmental impact assessments are suggested.
To minimize the casualty risks at existing turbines further research is needed. Some measures to take have been discussed. In certain cases it is probably most effective to move a turbine a relative short distance because of the sometimes short edges of the flyways and also the insect rich habitats. Another method is to stop the turbine during periods of high risk. Because the accumulation of insects is the reason for bats hunting close to the blades methods to reduce the amount of flying insects at the turbines would be of interest. Methods to keep the bats away from the turbines do not exist and some such ideas might also have negative effects on other animals and also on humans.

Band, W., M. Madders, et al. (2007). Developing field and analytical methods to assess avian collision risk at wind farms. Birds and Wind Farms. Risk Assessment and Mitigation. M. de Lucas, G. F. E. Janss and M. Ferrer. Madrid, Servicios Informativos Ambientales/Quercus**:** 259-275.

Barclay, R. M. R., E. F. Baerwald, et al. (2007). "Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height." Canadian Journal of Zoology-Revue Canadienne De Zoologie **85**(3): 381-387. <Go to ISI>://000246264000010.
Wind energy is a rapidly growing sector of the alternative energy industry in North America, and larger, more productive turbines are being installed. However, there are concerns regarding bird and bat fatalities at wind turbines. To assess the influence of turbine size on bird and bat fatalities, we analyzed data from North American wind energy facilities. Diameter of the turbine rotor did not influence the rate of bird or bat fatality. The height of the turbine tower had no effect on bird fatalities per turbine, but bat fatalities increased exponentially with tower height. This suggests that migrating bats fly at lower altitudes than nocturnally migrating birds and that newer, larger turbines are reaching that airspace. Minimizing tower height may help minimize bat fatalities. In addition, while replacing older, smaller turbines with fewer larger ones may reduce bird fatalities per megawatt, it may result in increased numbers of bat fatalities.

Barrios, L. and A. Rodriguez (2007). Spatiotemporal patterns of bird mortality at two wind farms of Southern Spain. Birds and Wind Farms. Risk Assessment and Mitigation. M. de Lucas, G. F. E. Janss and M. Ferrer. Madrid, Servicios Informativos Ambientales/Quercus**:** 229-239.

de Lucas, M., G. Janss, et al. (2007). Wind farm effects on birds in the Strait of Gibraltar. Birds and Wind Farms. Risk Assessment and Mitigation. M. de Lucas, G. F. E. Janss and M. Ferrer. Madrid, Servicios Informativos Ambientales/Quercus**:** 219-227.

de Lucas, M., G. F. E. Janss, et al. (2007). Birds and Wind Farms. Risk Assessment and Mitigation. Madrid, Servicios Informativos Ambientales/Quercus.

Di Marcantonio, M., R. Brabant, et al. (2007). Milieueffectenbeoordeling van het BELWIND offshore windmolenpark op de Bligh Bank. Brussels, Belgium, Koninklijk Belgisch Instituut voor Natuurwetenschappen, Beheerseenheid Mathematisch Model van de Noordzee**:** 182.

Environmental Impact Assessment of a offshore ('nearshore') wind farm to be placed on the sandbank 'Bligh', 42 km off the shore of Belgium. The wind farm is planned to have 66 wind turbines.

Dirksen, S., A. L. Spaans, et al. (2007). Collision risks for diving ducks at semi-offshore wind farms in freshwater lakes: A case study. Birds and Wind Farms. Risk Assessment and Mitigation. M. de Lucas, G. F. E. Janss and M. Ferrer. Madrid, Servicios Informativos Ambientales/Quercus**:** 201-218.

Everaert, J. (2007). Windturbines en fauna. Onderzoek naar de impact op de fauna, Instituut voor Natuur- en Bosonderzoek**:** 45-63.

Everaert, J. and E. W. M. Stienen (2007). "Impact of wind turbines on birds in Zeebrugge (Belgium)." Biodiversity and Conservation **16**(12): 3345-3359. <Go to ISI>://000249805300008.
We studied the impact of a wind farm (line of 25 small to medium sized turbines) on birds at the eastern port breakwater in Zeebrugge, Belgium, with special attention to the nearby breeding colony of Common Tern Sterna hirundo, Sandwich Tern Sterna sandvicensis and Little Tern Sterna albifrons. With the data of found collision fatalities under the wind turbines, and the correction factors for available search area, search efficiency and scavenging, we calculated that during the breeding seasons in 2004 and 2005, about 168 resp. 161 terns collided with the wind turbines located on the eastern port breakwater close to the breeding colony, mainly Common Terns and Sandwich Terns. The mean number of terns killed in 2004 and 2005 was 6.7 per turbine per year for the whole wind farm, and 11.2 resp. 10.8 per turbine per year for the line of 14 turbines on the sea-directed breakwater close to the breeding colony. The mean number of collision fatalities when including other species (mainly gulls) in 2004 and 2005 was 20.9 resp. 19.1 per turbine per year for the whole wind farm and 34.3 resp. 27.6 per turbine per year for 14 turbines on the sea-directed breakwater. The collision probability for Common Terns crossing the line of wind turbines amounted 0.110-0.118% for flights at rotor height and 0.007-0.030% for all flights. For Sandwich Tern this probability was 0.046-0.088% for flights at rotor height and 0.005-0.006% for all flights. The breeding terns were almost not disturbed by the wind turbines, but the relative large number of tern fatalities was determined as a significant negative impact on the breeding colony at the eastern port breakwater (additional mortality of 3.0-4.4% for Common Tern, 1.8-6.7% for Little Tern and 0.6-0.7% for Sandwich Tern). We recommend that there should be precautionary avoidance of constructing wind turbines close to any important breeding colony of terns or gulls, nor should artificial breeding sites be constructed near wind turbines, especially not within the frequent foraging flight paths.

Follestad, A. r., Ø. Flagstad, et al. (2007). Vindkraft og fugl på Smøla 2003 - 2006. NINA Rapport. Trondheim, NINA. **248:** 78 s.

Higgins, K. F., R. G. Osborn, et al. (2007). Effects of wind turbines on birds and bats in Southwestern Minnesota, U.S.A. Birds and Wind Farms. Risk Assessment and Mitigation. M. de Lucas, G. F. E. Janss and M. Ferrer. Madrid, Servicios Informativos Ambientales/Quercus**:** 153-175.

Illinois Department of Natural Resources (2007). The Possible Effects of Wind Energy on Illinois Birds and Bats. Report of the Illinois Department of Natural Resources to Governor Rod Blagojevich and the 95th Illinois General Assembly**:** 1-20. http://dnr.state.il.us/publications/pdf/00000544.pdf.

Jacobsen, K.-O. and N. Røv (2007). Hubro på Sleneset og vindkraft. Trondheim, NINA**:** 1-33.

Johnson, G. D., M. D. Strickland, et al. (2007). Use of data to develop mitigation measures for wind power development impacts to birds. Birds and Wind Farms. Risk Assessment and Mitigation. M. de Lucas, G. F. E. Janss and M. Ferrer. Madrid, Servicios Informativos Ambientales/Quercus**:** 241-257.

Kunz, T. H., E. B. Arnett, et al. (2007). "Assessing impacts of wind-energy development on nocturnally active birds and bats: A guidance document." Journal of Wildlife Management **71**(8): 2449-2486. <Go to ISI>://000250853000002.
Our purpose is to provide researchers, consultants, decision-makers, and other stakeholders with guidance to methods and metrics for investigating nocturnally active birds and bats in relation to utility-scale wind-energy development. The primary objectives of such studies are to 1) assess potential impacts on resident and migratory species, 2) quantify fatality rates on resident and migratory populations, 3) determine the causes of bird and bat fatalities, and 4) develop, assess, and implement methods for reducing risks to bird and bat populations and their habitats. We describe methods and tools and their uses, discuss limitations, assumptions, and data interpretation, present case studies and examples, and offer suggestions for improving studies on nocturnally active birds and bats in relation to wind-energy development. We suggest best practices for research and monitoring studies using selected methods and metrics, but this is not intended as cookbook. We caution that each proposed and executed study will be different, and that decisions about which methods and metrics to use will depend upon several considerations, including study objectives, expected and realized risks to bird and bat populations, as well as budgetary and logistical considerations. Developed to complement and extend the existing National Wind Coordinating Committee document "Methods and Metrics for Assessing Impacts of Wind Energy Facilities on Wildlife" (Anderson et al. 1999), we provide information that stakeholders can use to aid in evaluating potential and actual impacts of wind power development on nocturnally active birds and bats. We hope that decision-makers will find these guidelines helpful as they assemble information needed to support the permitting process, and that the public will use this guidance document as they participate in the permitting processes. We further hope that the wind industry will find valuable guidance from this document when 1) complying with data requirements as a part of the permitting process, 2) evaluating sites for potential development, 3) assessing impacts of operational wind-energy facilities, and 4) mitigating local and cumulative impacts on nocturnally active birds and bats.

Kunz, T. H., E. B. Arnett, et al. (2007). "Wind Energy Development on Birds and Bats." Journal of Wildlife Management **71**: 2449-2486.

Kunz, T. H., E. B. Arnett, et al. (2007). "Ecological impacts of wind energy development on bats: questions, research needs, and hypotheses." Frontiers in Ecology and the Environment **5**(6): 315-324. <Go to ISI>://000248468500017.
At a time of growing concern over the rising costs and long-term environmental impacts of the use of fossil fuels and nuclear energy, wind energy has become an increasingly important sector of the electrical power industry, largely because it has been promoted as being emission-free and is supported by government subsidies and tax credits. However, large numbers of bats are killed at utility-scale wind energy facilities, especially along forested ridgetops in the eastern United States. These fatalities raise important concerns about cumulative impacts of proposed wind energy development on bat populations. This paper summarizes evidence of bat fatalities at wind energy facilities in the US, makes projections of cumulative fatalities of bats in the Mid-Atlantic Highlands, identifies research needs, and proposes hypotheses to better inform researchers, developers, decision makers, and other stakeholders, and to help minimize adverse effects of wind energy development.

Kuvlesky, W. P., L. A. Brennan, et al. (2007). "Wind energy development and wildlife conservation: Challenges and opportunities." Journal of Wildlife Management **71**(8): 2487-2498. <Go to ISI>://000250853000003.
Wind energy development represents significant challenges and opportunities in contemporary wildlife management. Such challenges include the large size and extensive placement of turbines that may represent potential hazards to birds and bats. However, the associated infrastructure required to support an array of turbines-such as roads and transmission lines-represents an even larger potential threat to wildlife than the turbines themselves because such infrastructure can result in extensive habitat fragmentation and can provide avenues for invasion by exotic species. There are numerous conceptual research opportunities that pertain to issues such as identifying the best and worst placement of sites for turbines that will minimize impacts on birds and bats. Unfortunately, to date very little research of this type has appeared in the peer-reviewed scientific literature; much of it exists in the form of unpublished reports and other forms of gray literature. In this paper, we summarize what is known about the potential impacts of wind farms on wildlife and identify a 3-part hierarchical approach to use the scientific method to assess these impacts. The Lower Gulf Coast (LGC) of Texas, USA, is a region currently identified as having a potentially negative impact on migratory birds and bats, with respect to wind farm development. This area is also a region of vast importance to wildlife from the standpoint of native diversity, nature tourism, and opportunities for recreational hunting. We thus use some of the emergent issues related to wind farm development in the LGC-such as siting turbines on cropland sites as opposed to on native rangelands-to illustrate the kinds of challenges and opportunities that wildlife managers must face as we balance our demand for sustainable energy with the need to conserve and sustain bird migration routes and corridors, native vertebrates, and the habitats that support them.

Larsen, J. K. and M. Guillemette (2007). "Effects of wind turbines on flight behaviour of wintering common eiders: implications for habitat use and collision risk." Journal of Applied Ecology **44**(3): 516-522. <Go to ISI>://000246621700006.
1.Wind energy is a fast-growing renewable energy source and many offshore wind parks will be erected in shallow waters (< 40 m deep) where various coastal bird species are found. The two main issues regarding offshore wind farms and birds are disturbance and collision risk. We studied the effect of wind turbines on the flight behaviour of wintering common eiders Somateria mollissima in order to identify the properties that cause disturbance and the factors that may increase their risk of collision.
2. The study was conducted at Tuno Knob offshore wind park in the Kattegat, Denmark. We attracted birds though the use of decoys located at increasing distances from the wind park. To discriminate between the potential disturbance effect of the standing towers from that of the revolving rotor blades, wind turbines were switched on or off alternately during 10 experimental trials.
3. Common eiders reacted strongly to the presence of wind turbines. The number of flying birds was significantly related to flight corridor location and position of the decoy group. That behavioural reaction was interpreted to be a consequence of their high speed and low-manoeuvrability flight occurring within the vertical height range of the wind turbines. The number of landing birds also reacted to the position of the decoy group in relation to proximity to the turbines, with the greatest effects observed within the wind park. Such avoidance behaviour might decrease use of otherwise suitable habitat.
4. The movement and noise of rotors affected neither the number of common eiders flying within corridors nor the number of birds reacting to decoys. This suggests that the avoidance behaviour observed was caused by the presence of the structures themselves and that eiders use vision when avoiding human-made structures.
5. Synthesis and applications. This study has demonstrated that common eiders avoid flying close to or into the Tuno Knob wind park. This behaviour may result in a reduction in habitat availability within and around wind parks, and raises concerns about the possible

impact of the extensive development of large-scale wind parks in shallow offshore waters, which are the main feeding areas for sea ducks and other marine birds. Our results indicate that the disturbance effect of revolving rotor blades is negligible during daylight hours but highlights the need for studies to be carried out during hours of darkness and conditions of poor visibility (e.g. fog and snow). Until more insight is gained, we recommend caution when planning wind parks in areas of high sea duck densities.

Lawrence, E. S., S. Painter, et al. (2007). Responses of birds to the wind farm at Blyth Harbour, Northumberland, UK. Birds and Wind Farms. Risk Assessment and Mitigation. M. de Lucas, G. F. E. Janss and M. Ferrer. Madrid, Servicios Informativos Ambientales/Quercus**:** 47-69.

Lekuona, J. M. and C. Ursua (2007). Avian mortality in wind power plants of Navarra (Northern Spain). Birds and Wind Farms. Risk Assessment and Mitigation. M. de Lucas, G. F. E. Janss and M. Ferrer. Madrid, Servicios Informativos Ambientales/Quercus**:** 177-192.

Limpens, H., H. Huitema, et al. (2007). Vleermuizen en windenergie. Analyse van effecten en verplichtingen in het spanningsveld tussen vleermuizen en windenergie, vanuit de ecologische en wettelijke invalshoek. Arnhem, Zoogdiervereniging VZZ**:** 85.

Marris, E. and D. Fairless (2007). "Wind farms' deadly reputation hard to shift." Nature **447**(7141): 126-126. <Go to ISI>://000246338700008.

Meek, E. R. (2007). Wind farms in the Orkney Islands, Scotland: Environmental impact, past, present and future. Birds and Wind Farms. Risk Assessment and Mitigation. M. de Lucas, G. F. E. Janss and M. Ferrer. Madrid, Servicios Informativos Ambientales/Quercus**:** 193-199.

Morrison, M. L., K. C. Sinclair, et al. (2007). A sampling framework for conducting studies of the influence of wind energy developments on birds and other animals. Birds and Wind Farms. Risk Assessment and Mitigation. M. de Lucas, G. F. E. Janss and M. Ferrer. Madrid, Servicios Informativos Ambientales/Quercus**:** 101-115.

Penteriani, V. (2007). From Don Quixote windmills to wind farms: A snake biting its tail. Birds and Wind Farms. Risk Assessment and Mitigation. M. de Lucas, G. F. E. Janss and M. Ferrer. Madrid, Servicios Informativos Ambientales/Quercus**:** 21-23.

Percival, S. M. (2007). Predicting the effects of wind farms on birds in the UK: The development of an objective assessment method. Birds and Wind Farms. Risk Assessment and Mitigation. M. de Lucas, G. F. E. Janss and M. Ferrer. Madrid, Servicios Informativos Ambientales/Quercus**:** 137-152.

Røv, N. and K.-O. Jacobsen (2007). Hubro på Karmøya og vindkraft. Trondheim, NINA**:** 1-36.

Seiche, K., P. Endl, et al. (2007). Fledermäuse und Windenergieanlagen in Sachsen 2006. Dresden, Sächsisches Landesamt für Umwelt und Geologie, Bundesverband WindEnergie e.V. (BWE) Vereinigung zur Förderung der Nutzung erneuerbarer Energien e.V. (VEE Sachsen e.V.)**:** 1-20.

Shimada, Y. and H. Matsuda (2007). "Risk management model of birds and a wind farm." Hozen Seitaigaku Kenkyu **12**(2): 126-142.

We propose the Adaptive Management model for Uncertain Strike Estimates for bir ds (AMUSE). Between February 2004 and January 2007,seven dead white-tailed sea eagles were found near wind turbines inHokkaido prefecture, Japan. We used this population as the target species in the management model. In the management model, we assumed that the bodies of any birds killed in collisions would disappear within 5 days, while the searches for carcasses were conducted every 30 days. The calculation period of the management model was 22 years, consisting of a 5-year planning period and a 17-year operation period. The operation management schedule was reviewed every three years. The utilized capacity was estimated from the data for 2003 to 2005 for Hokkaido. The operation rate multiplied by the utilized capacity gives the corrected utilized capacity. After the break-even point of the utilized capacity was determined, the time that fell below this was defined as the failure rate of the business. The results showed that the end point was achieved 99% of the time, while the failure rate was below 10%. An optimistic scenario was not affected by the two management scenarios or conditions used as protection measures. Conversely, a pessimistic scenario was achieved only under specific conditions in the management scenario. The main goals were to 1) estimate the number of days required for a carcass to disappear, 2) develop a search technique to improve the discovery rate of carcasses, 3) conduct regular surveys of carcasses, 4) determine the growth rate and population size by monitoring, 5) determine the results of breeding by breeding pairs in Hokkaido, and 6) examine risk hedging to deal with failure of the business.

Smallwood, K. S. (2007). "Estimating wind turbine-caused bird mortality." Journal of Wildlife Management **71**(8): 2781-2791. <Go to ISI>://000250853000038.
Mortality estimates are needed of birds and bats killed by wind turbines because wind power generation is rapidly expanding worldwide. A mortality estimate is based on the number of fatalities assumed caused by wind turbines and found during periodic searches, plus the estimated number not found. The 2 most commonly used estimators adjust mortality estimates by rates of searcher detection and scavenger removal of carcasses. However, searcher detection trials can be biased by the species used in the trial, the number volitionally placed for a given fatality search, and the disposition of the carcass on the ground. Scavenger removal trials can be biased by the metric representing removal rate, the number of carcasses placed at once, the duration of the trial, species used, whether carcasses were frozen, whether carcasses included injuries consistent with wind turbine collisions, season, distance from the wind turbines, and general location. I summarized searcher detection rates among reported trials, and I developed models to predict the proportion of carcasses remaining since the last fatality search. The summaries I present can be used to adjust previous and future estimates of mortality to improve comparability. I also identify research directions to better understand these and other adjustments needed to compare mortality estimates among wind farms.

Smallwood, K. S., C. G. Thelander, et al. (2007). "Burrowing owl mortality in the Altamont Pass Wind Resource Area." Journal of Wildlife Management **71**(5): 1513-1524. <Go to ISI>://000248027800016.
We estimated wind turbines in the Altamont Pass Wind Resource Area (APWRA), California, USA, kill > 100 burrowing owls (Athene cunicularia hypugaea) annually, or about the same number likely nesting in the APWRA. Turbine-caused mortality was up to 12 times greater in areas of rodent control, where flights close to the rotor plane were disproportionately more common and fatalities twice as frequent as expected. Mortality was highest during January through March. Burrowing owls flew within 50 m of turbines about 10 times longer than expected, and they flew close to wind turbines disproportionately longer within the sparsest turbine fields, by turbines on tubular towers, at the edges of gaps in the turbine row, in canyons, and at lower elevations. They perched, flew close to operating turbine blades, and collided disproportionately more often at turbines with the most cattle dung within 20 in, with the highest densities of ground squirrel (Spermopbilus beecheyi)

burrow systems within 15 in, and with burrowing owl burrows located within 90 in of turbines. A model of relative collision threat predicted 29% of the 4,074 turbines in our sample to be more dangerous, and these killed 71% of the burrowing owls in our sample. This model can help select the most dangerous turbines for shutdown or relocation. All turbines in the APWRA could be shut down and blades locked during winter, when 35% of the burrowing owls were killed but only 14% of the annual electricity was generated. Terminating rodent control and installing flight diverters at the ends of turbine rows might also reduce burrowing owl mortality, as might replacing turbines with new-generation turbines mounted on taller towers.

Sterner, D., S. Orloff, et al. (2007). Wind turbine collision research in the United States. Birds and Wind Farms. Risk Assessment and Mitigation. M. de Lucas, G. F. E. Janss and M. Ferrer. Madrid, Servicios Informativos Ambientales/Quercus**:** 81-100.

Stewart, G. B., A. S. Pullin, et al. (2007). "Poor evidence-base for assessment of windfarm impacts on birds." Environmental Conservation **34**(1): 1-11. <Go to ISI>://000246796700001.
Concerns about anthropogenic climate change have resulted in promotion of renewable energy sources, especially wind energy. A concern raised against widespread windfarm development is that it may negatively impact bird populations as a result of bird collision with turbines, habitat loss and disturbance. Using systematic review methodology bird abundance data were synthesized from 19 globally-distriuted windfarms using meta-analysis. The effects of bird taxon, turbine number, power, location, latitude, habitat type, size of area, time since operation, migratory status of the species and quality of evidence were analysed using meta-regression. Although the synthesized data suggest a significant negative impact of windfarms on bird abundance, there is considerable variation in the impact of individual windfarm sites on individual bird species, and it is unclear if the negative impact is a decline in population abundance or a decline in use owing to avoidance. Anscriformes experienced greater declines in abundance than other taxa, followed by Charadriiformes, Falconiformes and Accipitriformes, and Passeriformes. Time since windfarms commenced operation also had a significant impact on bird abundance, with longer operating times resulting in greater declines in abundance than short operating times. Other variables, including turbine number and turbine power either had very weak but statistically significant effects or did not have a significant effect on bird abundance. Windfarms may have significant biological impacts, especially over longer time scales, but the evidence-base is poor, with many studies being methodologically weak, and more long-term impact assessments are require. There is clear evidence that Anseriformes (wildfowl) and Charadriiformes (waders) experience declines in abundance, suggesting that a precautionary approach should be adopted to windfarm development near aggregations of these taxa in offshore and coastal locations. The impact of windfarm developments on bird populations must also be viewed in the context of the possible impact of climate change in the absence of windfarms.

Stienen, E. W. M., V. Waeyenberge, et al. (2007). Trapped within the corridor of the Southern North Sea: The potential impact of offshore wind farms on seabirds. Birds and Wind Farms. Risk Assessment and Mitigation. M. de Lucas, G. F. E. Janss and M. Ferrer. Madrid, Servicios Informativos Ambientales/Quercus**:** 71-80.

Stricklan, D., W. Erickson, et al. (2007). Selecting study designs to evaluate the effect of windpower on birds. Birds and Wind Farms. Risk Assessment and Mitigation. M. de Lucas, G. F. E. Janss and M. Ferrer. Madrid, Servicios Informativos Ambientales/Quercus**:** 117-136.

Thelander, C. G. and K. S. Smallwood (2007). The Altamont Pass Wind Resource Area's effects on birds: A case history. Birds and Wind Farms. Risk Assessment and Mitigation. M. de Lucas, G. F. E. Janss and M. Ferrer. Madrid, Servicios Informativos Ambientales/Quercus**:** 25-46.

Widemo, F. (2007). Vindkraftens inverkan på fågelpopulationer
kunskap, kunskapsbehov och förslag till åtgärder. På uppdrag av Sveriges ornitologiska förening**:** 42.

Ahlén, I. (2008). "Vindkraft - ett hot för fåglar och flaggermöss?" BioDiverse **13**(1): 10-11.

Altamont Pass Avian Monitoring Team (2008). Bird fatality study at Altamont Pass wind resource area October 2005 to September 2007. Draft Report, Jones & Stokes, Inc., Bio-Resource Consultants Inc., University of California at Santa Cruz, Predatory Research Group**:** 1-28.

Arnett, E. B., W. K. Brown, et al. (2008). "Patterns of bat fatalities at wind energy facilities in North America." Journal of Wildlife Management **72**(1): 61-78. <Go to ISI>://000252624700008.
Wind has become one of the fastest growing sources of renewable energy worldwide, but widespread and often extensive fatalities of bats have increased concern regarding the impacts of wind energy development on bats and other wildlife. We synthesized available information on patterns of bat fatalities from a review of 21 postconstruction fatality studies conducted at 19 facilities in 5 United States regions and one Canadian province. Dominance of migratory, foliage- and tree-roosting lasiurine species (e.g., hoary bat [Lasiurus cincreus]) killed by turbines was consistent among studies. Bat fatalities, although highly variable and periodic, consistently peaked in late summer and fall, coinciding with migration of lasiurines and other species. A notable exception was documented fatalities of pregnant female Brazilian free-tailed bats (Tadarida brasiliensis) in May and June at a facility in Oklahoma, USA, and female silver-haired bats (Lasionycteris noctivagans) during spring in Tennessee, USA, and Alberta, Canada. Most studies reported that fatalities were distributed randomly across turbines at a site, although the highest number of fatalities was often found near the end Of turbine strings. Two studies conducted simultaneously in the same region documented similar timing of fatalities between sites, which suggests broader patterns of collisions dictated by weather, prey abundance, or other factors. None of the studies found differences in bat fatalities between turbines equipped with lighting required by the Federal Aviation Administration and turbines that were unlit. All studies that addressed relationships between bat fatalities and weather patterns found that most bats were killed on nights with low wind speed (<6 m/sec) and that fatalities increased immediately before and after passage of storm fronts. Weather patterns may be predictors of bat activity and fatality; thus, mitigation efforts that focus on these high-risk periods could reduce bat fatality substantially. We caution that estimates of bat fatality are conditioned by length of study and search interval and that they are biased in relation to how searcher efficiency, scavenger removal, and habitat differences were or were not accounted for. Our review will assist managers, biologists, and decision-makers with understanding unifying and unique patterns of bat fatality, biases, and limitations of existing efforts, and it will aid in designing future research needed to develop mitigation strategies for minimizing or eliminating bat fatality at wind facilities.

Drewitt, A. L. and R. H. W. Langston (2008). "Collision effects of wind-power generators and other obstacles on birds." Ann NY Acad Sci **1134**: 233-266. <Go to ISI>://000257506400010.
There is extensive literature on avian mortality due to collision with man-made structures, including wind turbines, communication masts, tall buildings and windows, power lines,

and fences. Many studies describe the consequences of bird-strike rather than address the causes, and there is little data based on long-term, standardized, and systematic assessments. Despite these limitations, it is apparent that bird-strike is a significant cause of mortality. It is therefore important to understand the effects of this mortality on bird populations. The factors which determine avian collision risk are described, including location, structural attributes, such as height and the use of lighting, weather conditions, and bird morphology and behavior. The results of incidental and more systematic observations of bird-strike due to a range of structures are presented and the implications of collision mortality for bird populations, particularly those of scarce and threatened species susceptible to collisions, are discussed. Existing measures for reducing collision mortality are described, both generally and specifically for each type of structure. It is concluded that, in some circumstances, collision mortality can adversely affect bird populations, and that greater effort is needed to derive accurate estimates of mortality levels locally, regionally, and nationally to better assess impacts on avian populations. Priority areas for future work are suggested, including further development of remote technology to monitor collisions, research into the causes of bird-strike, and the design of new, effective mitigation measures.

Horn, J. W., E. B. Arnett, et al. (2008). "Behavioral responses of bats to operating wind turbines." Journal of Wildlife Management **72**(1): 123-132. <Go to ISI>://000252624700014.
Wind power is one of the fastest growing sectors of the energy industry. Recent studies have reported large numbers of migratory tree-roosting bats being killed at utility-scale wind power facilities, especially in the eastern United States. We used thermal infrared (TIR) cameras to assess the flight behavior of bats at wind turbines because this technology makes it possible to observe the nocturnal behavior of bats and birds independently of supplemental light sources. We conducted this study at the Mountaineer Wind Energy Center in Tucker County, West Virginia, USA, where hundreds of migratory tree bats have been found injured or dead beneath wind turbines. We recorded nightly 9-hour sessions of TIR video of operating turbines from which we assessed altitude, direction, and types of flight maneuvers of bats, birds, and insects. We observed bats actively foraging near operating turbines, rather than simply passing through turbine sites. Our results indicate that bats 1) approached both rotating and nonrotating blades, 2) followed or were trapped in blade-tip vortices, 3) investigated the various parts of the turbine with repeated fly-bys, and 4) were struck directly by rotating blades. Blade rotational speed was a significant negative predictor of collisions with turbine blades, suggesting that bats may be at higher risk of fatality on nights with low wind speeds.

Kikuchi, R. (2008). "Adverse impacts of wind power generation on collision behaviour of birds and anti-predator behaviour of squirrels." Journal for Nature Conservation **16**: 44-55.

Smallwood, K. S. and C. Thelander (2008). "Bird mortality in the Altamont Pass Wind Resource Area, California." Journal of Wildlife Management **72**(1): 215-223. <Go to ISI>://000252624700025.
The 165-km(2) Altamont Pass Wind Resource Area (APWRA) in west-central California includes 5,400 wind turbines, each rated to generate between 40 kW and 400 kW of electric power, or 580 MW total. Many birds residing or passing through the area are killed by collisions with these wind turbines, We searched for bird carcasses within 50 m of 4,074 wind turbines for periods ranging from 6 months to 4.5 years. Using mortality estimates adjusted for searcher detection and scavenger removal rates, we estimated the annual wind turbine-caused bird fatalities to number 67 (80% CI = 25-109) golden eagles (Aquila chrysaetos), 188 (80% CI 116-259) red-tailed hawks (Buteo jamaicensis), 349 (80% CI = -49 to 749) American kestrels (Falco sparverius), 440 (80% CI = -133 to 1,013) burrowing owls (Athene cunicularia hypugaea), 1,127 (80% CI = -23 to 2,277) raptors, and 2,710 (80% CI = -6,100 to 11,520) birds. Adjusted mortality estimates were most sensitive to

scavenger removal rate, which relates to the amount of time between fatality searches. New on-site studies of scavenger removal rates might warrant revising mortality estimates for some small-bodied bird species, although we cannot predict how the mortality estimates would change. Given the magnitude of our morolity estimates, regulatory agencies and the public should decide whether to enforce laws intended to protect species killed by APWRA wind turbines, and given the imprecision of our estimates, directed research is needed of sources of error and bias for use in studies of bird collisions wherever wind farms are developed. Precision of mortality estimates could be improved by deploying technology to remotely detect collisions and by making wind turbine power output data available to researchers so that the number of fatalities can be related directly to the actual power output of the wind turbine since the last fatality search.

2.1.1 Vindmøller og radar

Cooper, B. A. and R. J. Ritchie (1993). Wind power and birds: radar techniques for environmental assessment. Fairbanks, Alaska, ABR, Inc: 4.
This 4-page paper briefly describes the use and advantages of mobile marine radar labs, which consist of two marine radars, night-vision equipment, and video recording equipment in cab-over campers, for monitoring or assessing bird use of windfarm developments. The system is powered by batteries and moved via 4-wheel-drive truck. Equipment can be disassembled for movement to remote locations such as inaccessible ridges or shorelines. Marine radar can detect individual songbirds up to 1 km, individual hawks up to 3 km, and waterfowl or cranes up to 10 km away. Radar provides information on number, altitude, direction, speed, behavior, and location of birds, while night-vision equipment improves capability for species identification, monitoring bird behavior near structures, and helps to evaluate bird movements. Radar can also be used during the day to help visual observers locate easily-missed birds and to measure bird altitudes.

Harmata, A. R., K. M. Podruzny, et al. (2000). The use of radar in evaluations of avian-wind development projects: Norris Hill Wind Resource Area, Montana. Proceedings of National Avian - Wind Power Planning Meeting III., San Diego, California, Avian Subcommittee of the National Wind Coordinating Committee.

Kelly, T. A. (2000). Radar, remote sensing and risk management. Proceedings of National Avian - Wind Power Planning Meeting III., San Diego, California, Avian Subcommittee of the National Wind Coordinating Committee.

Gauthreaux, S. A. and C. G. Belser (2003). "Radar ornithology and biological conservation." Auk **120**(2): 266-277. <Go to ISI>://000183829200002.
IN THE APPROXIMATELY 60 years since the discovery that birds were responsible for some of the puzzling radar echoes dubbed "angels" by the British (Lack and Varley 1945, Buss 1946), radar has proven to be a useful tool for the detection, monitoring, and quantification of bird movements in the atmosphere (Eastwood 1967; Richardson 1979; Vaughn 1985; Bruderer 1997a, b). Radar has been a particularly valuable tool for descriptive studies of daily and seasonal patterns of bird migration, but the technique has also been used to answer important questions about how birds orient during migration and the role of atmospheric structure in shaping flight strategies of birds. Within the last two decades, radar ornithology has played an increasingly important role in conservation of species that are migratory, endangered, threatened, or of special concern.

Desholm, M., T. Fox, et al. (2004). Best practice guidance for the use of remote techniques for observing bird behaviour in relation to offshore wind farms, COWRIE**:** 94.

This report presents the work from a project that examined the ability and performance of remotely-operated techniques (such as radar) to observe the behaviour of birds when they are over the sea but near to the coast. The coastal and offshore waters of the UK are very important, on a world scale, for several species of birds. Large numbers of migratory birds use the airspace above these waters and the UK has obligations to protect these under international law and agreements. The advent of an ambitious offshore wind energy programme in the UK has underlined our current lack of knowledge of the species, number and distribution of birds at sea and their possible interactions with wind farms. As part of the required Environmental Impact Assessments (EIAs) for offshore wind farms, the extent to which birds will encounter newly constructed developments has to be estimated in advance of construction. In addition, an assessment of likely collision rates with turbines requires basic data on bird numbers, flight height and flight behaviour, including knowledge of the birds' abilities to avoid obstructions such as turbines. The high costs and practical constraints associated with undertaking human observations makes automated remote sensing systems essential in order to gather enough data on the three-dimensional movement and volumes of birds moving through a proposed wind farm before and after construction. Nevertheless, some verification (by eye, or using acoustic equipment in conditions of darkness or poor visibility) of species and flock sizes is essential when analysing the information derived from remotely-operated equipment. This study reviewed all potential applications of remote technologies, but specifically describes the ability of different radar systems to observe bird behaviour over the sea and the performance of the Thermal Animal Detection System (TADS) in detecting avoidance of turbines by birds and collisions between birds and turbines. The study concluded that conventional marine ships' navigation radar provides the simplest approach to the collection of data by tracking bird movements in two (horizontal) dimensions, throughout the day and night, to provide an overview of bird flight trajectories and hence movements within a proposed wind farm area. However, visual observations are essential to identify the species of birds involved. The report recommends the use of TADS to identify species and to measure flock size during poor visibility and during darkness. Vertically mounted radar can also provide information on the height of flying birds, although birds near the sea surface cannot be easily detected by such radar when the wind is strong enough to produce large wave reflections. More sophisticated radar systems have been developed specifically to detect and track birds and automatically record data. These offer improved detection range and performance in a wider range of weather conditions, but the cost of such devices is ten times the cost of traditional ships' navigational radar equipment. Further improvements in the performance of radar techniques for monitoring the behaviour of birds are possible using available military technology. These include: increasing the bird detection range, improved detection of birds in rain, an increase in the ability to discriminate birds in space, identification of species, three-dimensional bird location and automated recording and statistical analysis. However, these improvements would increase the equipment cost still further. The use of infrared imagery derived from TADS offers the best, if not the only, method of observing bird avoidance behaviours in close proximity to turbines and detecting actual collisions of birds with turbines. The method has been successfully tested in Denmark but has not so far detected any collisions during operations. Other remote techniques are reviewed and discussed in the report, but few other methods are as useful, at present, as radar and TADS for these specific applications.

Mabee, T., B. Cooper, et al. (2004). Radar study of nocturnal bird migration at the proposed Mount Storm Wind-power Development, West Virginia, fall 2003. Forest Grove, Oregon, ABR, Inc**:** 1-40.

Mabee, T. J. et a. (2005). A Radar and Visual Study of Nocturnal Bird and Bat Migration at the Proposed Flat Rock Wind Power Project, New York, Fall 2004. A report prepared for Atlantic Renewable Energy Corporation.

http://www.powernaturally.org/publications/Flat%20Rock%20Fall%20Migration%20Study_Final%20Rpt_NEW1.pdf.

2.1.2 Vindmøller, generelt

Lanchbery, J., C. Mitchell, et al. (2006). "Abstracts of communications presented at Wind, Fire and Water: Renewable Energy and Birds. The British Ornithologists' Union Annual Spring Conference 2005 University of Leicester, 1– 3 April 2005." Ibis **148**: 206-209.

Jordal-Jørgensen, J. (1995). Economic valuation of wind power. Visual effects and noise from windmills - quantification and valuation. Copenhagen, Denmark, AKF Forlaget.

Berg, P. (1996). The effects of avian impacts on the wind energy industry. Undergraduate Engineering Review. Department of Mechanical Engineering. Austin, TX (USA). University of Texas. BSc. BSc thesis. WI, GE.

Anderson, R. L., H. Davis, et al. (1997). Standard metrics and methods for conducting avian/wind energy interaction studies. Windpower "97 Proceedings, June 15-18, 1997. G. Miller. Austin, TX (USA), American Wind Energy Association**:** 265-272.

Andersen, P. D. (1999). "Review of historical and modern utilization of wind power."

Lindell, L. (1999). "Motvind, medvind eller stiltje för vindkraft?" Vår Fågelvärld **58**(2): 33.

Odland, A. (1999). Vindkraft på Smøla. En konsekvensutredning om flora og verneinteresser., ENCO Environmental Consultans.

Sinclair, K. C. (1999). Status of the U.S. Department of Energy/National Renewable Energy Laboratory Avian Research Program., National Renewable Energy Laboratory, Golden, Colo. Work performed by California State University, Sacramento, California and North Carolina State University**:** 9.

Manes, R., S. Harmon, et al. (2002). "Wind energy & wildlife: an attempt at pragmatism." Retrieved October, 2002, from http://www.wildlifemanagementinstitute.org/wmi/pages/windpower.html.

Shimmings, P. (2003). Vinsmøllepark i Svolværøyan/Sleneset, Lurøy kommune. Konsekvensutredning av tema Fugle- og dyreliv. Rapport til Nord-Norsk Vindkraft as. Tjøtta, Norway, Planteforsk**:** 142.

Bialek, J. (2004). How Green Will the Wind Blow? Audubon Naturalist News**:** 4.

Eftestøl, S., J. E. Colman, et al. (2004). Kunnskapsstsuts - effekter av vindparker på reindriften. Oslo, Norway, University of Oslo**:** 37.

Jacobsen, K. O., T. V. Johnsen, et al. (2004). Vindkraftverk på Fakken – Vannøya, Troms. Konseskvensutredning for fugl og annet dyreliv. Trondheim, Norway, NINA**:** 28.

Tombre, I. M., O. Andersen, et al. (2004). Båtsfjordfjellet vindpark Vurdering av konsekvenser for landskap, flora, fauna, friluftsliv, kulturminner og reindriftsnæring. Tromsø, Norway, NINA**:** 67.
The possible impact of a planned wind park at Båtsfjordfjellet, Båtsfjord municipality, is evaluated in the present report. The employer for the investigation is Hydro Energy. Impact assessments are conducted for the themes landscape, flora, fauna, outdoor recreation,

cultural heritage and reindeer herding. An area of 50km2 is assessed, and specific turbine locations will be decided by Hydro Energy at a later stage. The various themes addressed demonstrate variable values, and the extent and consequences are reflected in these findings. For the themes flora, fauna and outdoor activities consequences will be minimal if the roads and turbines are located in accordance to suggestions in this report. If the wind park is located more than 1-2 km away from a nature reserve in the region, the consequences for outdoor recreation will be reduced. A general assessment of the impacts from a landscape perspective is usually difficult to interpret. In the current project these were assessed to medium negative. For the theme cultural heritage, only the potential for findings within the park area was addressed. These were assessed as high, and if new findings appear at a later stage, consequences are assessed as highly negative. For findings outside the park area, but within a distance of influence, ten different cultural monuments/locations were found. Consequences for these varied between no consequences to medium negative consequences. For the theme reindeer herding, both the values and extent are assessed as large with highly negative consequences. This is basically based on the fact that the area in question is an important calving area, representing a highly vulnerable period for reindeer.

Global Energy Concepts NYS Department of Environmental Conservation (2005). Birds and Bats. Potential Impacts and Survey Techniques. Albany, NY (USA), NYSERDA**:** 14.

Rahall, N. J. and A. B. Mollohan (2005). WIND POWER. Impacts on Wildlife and Government Responsibilities for Regulating Development and Protecting Wildlife. Washington D.C. (USA), US Government Accountability Office**:** 64.

Tombre, I. M., O. Andersen, et al. (2005). Snefjord vindpark. Konsekvensvurderinger for landskap, flora, fauna, friluftsliv, kulturminner og rein-driftsnæring. Tromsø, Norway, NINA**:** 91.
This report summarises consequences of a planned wind park at the Snefjord peninsula, Måsøy municipality. Impact assessments are conducted for landscape perspectives, flora, fauna, outdoor recreation, cultural heritage and reindeer herding. The whole peninsula, 150 km2, is evaluated, with the main focus on higher parts where the potential wind turbines will be located. For the landscape, a wind park is assessed to involve medium negative consequences. This is based on pristine criteria of the landscape. No red-listed plants or plant communities were registered, and for the theme flora negative consequences were assessed as minimal. Also for outdoor activities, consequences were assessed as minimal, since there is relatively little outdoor activity on the peninsula. For fauna, on the other hand, the negative consequences are assessed as large due to several red-listed species (both bird of prey and others) that breed and use the open air on the peninsula. For the theme cultural heritage, consequences may be large if new findings appear at a later stage within the area. The potential for such findings is very large. For known cultural monuments and environments, which are located along the coast line around the peninsula, consequences are assessed from no consequences to large, negative consequences. In summary, however, consequences are assessed as medium negative for the known findings. Reindeer herding is assessed to be largely affected by a wind park. The whole peninsula is an important calving area, and during the calving period the animals are very vulnerable. The lack of available neighbouring sites also involves a negative pressure on larger parts of the region. Actions to reduce negative effects are suggested.

Tombre, I. M., E. Elverland, et al. (2005). Hammerfest vindpark. En vurdering av konsekvenser for naturmiljø. Tromsø, Norway, NINA**:** 33.

Tomlinson, C. (2005). Wind energy: Technology and capability. Wind, Fire & Water: Renewable Energy & Birds., University of Leicester, Leicester, British Ornithologists' Union.

Copestake, P. (2006). "Hydropower and environmental regulation – A Scottish perspective." Ibis **148**: 169-179.
This paper provides an overview of hydropower and the environmental legislative and regulatory frameworks, with particular reference to Scotland. Consideration is given to the environmental impacts of hydro schemes, with case examples of particular relevance to birds used for illustration. Impacts vary from run of river schemes which tend to have the lowest impact on biodiversity, to large impoundment schemes which have the greatest impact. Adverse impacts can be minimized by sensitive site selection and good scheme design.

Hötker, H., K.-M. Thomsen, et al. (2006). Impacts on biodiversity of exploitation of renewable energy sources: the example of birds and bats - facts, gaps in knowledge, demands for further research, and ornithological guidelines for the development of renewable energy exploitation. . Bergenhausen, Germany, Michael-Otto-Institut im NABU.

2.2 Fuglers syn og hørsel

Marler, P., M. Konishi, et al. (1973). "Effects of continuous noise on avian hearing and vocal development." Proc. Nat. Acad. Sci. USA **70**(5): 1393-1396.

Håstad, O. (2003). Plumage Colours and the Eye of the Beholder. The Ecology of Colour and its Perception in Birds. Uppsala, Sweden. University of Uppsala. PhD. PhD thesis. VI.

Hodos, W. and M. Ghim (2006). "The limits of spatial vision in birds." Journal of Ornithology **147**(5): 60-60. <Go to ISI>://000240313200197.

2.3 Kraftledninger og fugl

Emerson, W. O. (1904). "Destruction of birds by wires." Condor **6**(1): 37.

Graham, R. (1916). "Carolina rail accidentally killed." Oologist **33**(11): 187.

Grotli, S. (1922). "Fugledrap ved luftledninger." Norsk Orn. Tidsskr. **1**(3): 125-126.

Hallinan, T. (1922). "Bird interference on high tension electric transmission lines." Auk **39**: 573.

Bloeker, J. C. v. (1927). "Farallon cormorant killed by unusual accident." Auk **44**(July).

Lano, A. (1927). "Great blue heron (Ardea herodias) electrocuted." Auk **44**(2): 246.

Michener, H. (1928). "Where engineer and ornithologist meet: transmission line troubles caused by birds." Condor **30**(3): 169-175.

Bailey, A. M. (1929). "Bird casualties." Wilson Bulletin **41**(2): 106-107.
Two female woodcocks died from collisions, one against a building and the other with an overhead wire. A black-footed albatross on Laysan Island struck a wire and broke its leg.

Griepentrog, E. A. (1929). "Wire mortalities." Oologist **46**(2): 24.

Kaas, H. H. (1929). "De morderiske telefon- og telegraftråder." Norsk Ornitologisk Tidsskrift **10**: 210.

Anderson, A. H. (1933). "Electrocution of purple martins." Condor **35**(1): 204.
This article is an account of one male and one female purple martin found electrocuted by a power line at an irrigation reservoir near Tucson, Arizona.

Borell, A. E. (1939). "Telephone wires fatal to sage grouse." Condor **41**(1): 85-86.

Borell, A. E. (1939). "Telephone wires fatal to Sage Gronse." Condor **41**(1): 85-86.
Three dead sage grouse were found beneath telephone lines paralleling a road north of Beaver, Utah. It appeared that the collisions occurred as the birds flew back and forth from alfalfa pastures and grain fields to the sagebrush-covered mesas on the other side of the road.

McAtee, W. L. (1939). "The electric fence in wildlife management." J. Wildl. Manage. **3**: 1-13.

Quortrup, E. R. and J. E. Shillinger (1941). "3,000 wild bird autopsies on western lake areas." Journal of the American Veterinary Medical Association **99**: 382-387.

D'Ombrain, A. F. (1945). "Migratory birds and overhead wires." Emu **45**(2): 173-174.
Migrating shorebirds "become mystified by the bright city lights" which cause them to fly lower than usual, resulting in collisions with overhead wires. Two instances of mortality in Australia are recounted.

Dinesman, L. G. (1947). "On the destruction of some birds in hitting telegraph wires." Zoologiceskij zurnal **26**: 171-172.

Wilse, E. (1951). Hvilken rolle spiller kraft- og telefonledninger når det gjelder desimering av vår bestand av matnyttig fuglevilt? Noen generelle betraktninger. Jeger og Fisker. **80:** 197-198.

Johannessen, E. (1952). Ledningene dreper. Jeger og Fisker. **81:** 143-144.

Hiltunen, E. (1953). "Angående fugler som har fløyet inn i strøm- og telefonlednigner. (Norsk oversettelse)." Suomen Riista **8**: 1-6.

Hiltunen, E. (1953). "Om de förluster som flygning mot ledninger förorsakar hönsfåglarna. (På finsk, svensk sammendrag)." Suomen Riista **8**: 70-76, 200-201.

Benton, A. H. (1954). "Relationships of birds to power and communication lines." The Kingbird **4**(3): 65-66.
While acknowledging some losses of birds due to collisions with overhead wires, the author states that "power and communication lines now represent a valuable asset to bird life" in the form of nest and perch sites.

Dilger, W. C. (1954). "Electrocution of parakeets at Agra, India." Condor **56**(2 (March)): 102-103.
Rose-ringed parakeets were frequently electrocuted on power lines at an Army base at Agra, India, in the 1940s.

Dunbar, R. J. (1954). "Bird mortality - Oak Ridge." Migrant **25**(4): 63-64.

On the morning of 7 October, 1954, about 1,000 birds (22 species) were found dead on a parking lot at Oak Ridge, Tennessee. Losses were attributed to collisions with overhead power lines, light towers, cars, and pavement. Most carcasses were found beneath the parking lot lights.

Ström, G. (1954). "Fiskgjusar (Pandion haliaëtus) med ovanliga boplatser." Vår Fågelvärld **13**: 271-273.

Walkinshaw, L. H. (1956). "Sandhill cranes killed by flying into power line." Wilson Bulletin **68**(4): 325-326.

Dickinson, L. E. (1957). Utilities and birds. Audubon Magazine. **59:** 54-55, 86-87.
The author reviews the problem of bird strikes and electrocutions at power lines in the U.S. and cites examples of solutions to particular situations.

Rue, L. L. (1957). "High-tension redtails." Audubon Magazine **59**(July-August): 178-181.

Olsson, V. (1958). "Dispersal, migration, longevity and death causes of Strix aluco, Buteo buteo, Ardea cinerea and Larus argentatus. A study based on ringing recoveries of birds ringed in Fenno-Scandia." Acta Vertebratica **1**(2): 158-189.

Arnold, J. R. (1960). "Black rail in San Joaquin Valley of California." Condor **62**(5): 405.
A black rail was found dead on 26 August 1959 near Stockton, California, having apparently struck a fence or an overhead wire.

Banko, W. E. (1960). The trumpeter swan. Its history, habits, and population in the United States. Washington, D.C, U.S. Fish and Wildlife Service.
Known trumpeter swan accidents seemed to be confined largely to striking power, telephone, or fence wires in flight. Most swan collisions with overhead cables and fences occurred during winter fogs. Five instances of wire collisions in Montana are mentioned; four out of five strikes were fatal.

Boyd, H. (1961). "Reported casualties to ringed ducks in the spring and summer." Wildfowl Trust Annual Report **12**: 144-146.
Overhead wire collision was identified as the cause of death for 17 British-banded ducks (mostly mallard and teal species) recovered from March to August (no year given). In all, 87 "accidental" deaths were recorded. About 70 percent of the ducks killed were males.

Jennings, A. R. (1961). "An analysis of 1,000 deaths in wild birds." Bird Study **8**(1): 25-31.

Eltringham, S. K. (1963). "The British population of the mute swan in 1961." Bird Study **10**(1): 10-28.
Power disruption and mortality of mute swans in Britain are discussed. The author recommends re-siting the cables away from regular swan routes and increasing cable visibility in order to reduce collisions and power black-outs.

Harrison, J. (1963). "Heavy mortality of mute swans from electrocution." Wildfowl Trust 14th Annual Report: 164-165.
During a two-month period in spring 1962, 30 percent of local swan flocks (21 birds) in Romney Marsh, Kent, England, were killed along 1/4 mile of power lines 30 feet high. No distinction is made between deaths by electrocution or collision. The lines cross between feeding and roosting habitat.

Peterson, A. W. (1963). "Destruction of birdlife in Minnesota - Sept. 1963. Birds killed at Park Rapids." Flicker **35**(4): 113.

Boyd, H. (1964). "Wildfowl and other wader-birds found dead in England and Wales in January-March 1963." Wildfowl Trust Annual Report **15**.

Boyd, H. and M. Ogilvie (1964). Losses of mute swans in England in the winter of 1962-63, Wildfowl Trust 15th Annual Report**:** 37-39.
Losses of mute swans due to collisions with overhead wires were abnormally low in January and February 1963, accounting for only 35 of the 264 reported deaths.

Gollop, M. A. (1965). "Bird migration collision casualties at Saskatoon." Blue Jay **23**(1 (March)): 15-17.

Braaksma, S. (1966). "Vele draadslachtoffers in de ringverslagen." Het Vogeljaar **14**(4): 147-151.

Weston, F. M. (1966). "Bird casualties on the Pensacola Bay Bridge (1938-1949)." Florida Naturalist **39**(2): 53-54.
Irregular checks of the bridge produced 740 dead birds (75 species) during the twelve-year period. Kills occurred only in the fall; power cables above the roadway of the bridge apparently caused the mortalities. The cables were removed in 1949, and a new bridge with well-lit structural parts proved no hazard to birds

Hornberger, F. (1967). Der weisstorch (Ciconia ciconia). Wittenberg Lutherstadt, A. Ziemsen Verlag.

Mueller, H. C. and D. D. Berger (1967). "Wind drift, leading lines, and diurnal migrations." Wilson Bulletin **79**(1): 50-63.

Ogilvie, M. A. (1967). "Population changes and mortality of the mute swan in Britain." Wildfowl Trust 18th Annual Report **18**: 64-73.
Of 1,051 mute swans in England whose cause of death was known, 44 percent died from wire collision.

Perrins, C. M. and C. M. Reynolds (1967). "A preliminary study of the mute swan, Cygnus olor." Wildfowl Trust 18th Annual Report **18**: 74-84.
Approximately 58 mute swan deaths from collisions with wires and other objects were recorded by month of death from 1960 to 1966 in and around Oxford, England. The authors noted more deaths in spring and autumn than in summer.

Bölzing, G. (1968). Greifvogelschutz bei der Stromversorgung. Deutsche Falkenorden**:** 36.

Cornwell, G. W. (1968). "Needless duck deaths." Conservation Catalyst **2**(4): 15-18.
Data of 2,000,000 examples of non-hunting-related waterfowl mortality (including collision mortalities) in the U.S. and Canada were compiled. About half of 3,000 non-hunting deaths were due to striking wires. The author recommends that wires in areas of high waterfowl use be buried.

Graber, R. R. (1968). "Nocturnal migration in Illinois: different points of view." Wilson Bulletin **80**(1): 36-71.
This is an extensive analysis of nocturnal migration using radar, aural recordings, field observations, and tower kills. The kills occurred near Champaign, Illinois, in late September

from 1957 to 1962 and totalled 1,500 birds (41 species). Complete lists of kills are given, and the nature of bird mortality at towers is discussed.

Brady, A. (1969). "An electrocuted great horned owl." Cassinia **51**: 57.
An owl was found clutching a Norway rat and hanging from a power line in early November 1968 at Mechanicsville, Pennsylvania. The incident occurred presumably when the rat held by the owl touched the wire below the owl's perch and created a short circuit.

Ellis, D. H., D. G. Smith, et al. (1969). "Studies on raptor mortality in western Utah." Great Basin Naturalist **29**(3): 165-167.

Herren, H. (1969). The status of the peregrine falcon in Switzerland. Peregrine falcon populations: their biology and decline. J. Hickey. Madison, Wisconsin, University of Wisconsin Press**:** 231-238.
Of 14 peregrines found dead, 5 flew against wires, 4 were shot, 3 (nestlings) fell out of nest, 2 were wounded, 1 drowned

Arend, P. H. (1970). The ecological impact of transmission lines on the wildlife of San Francisco Bay. San Ramon, California, Wildlife Associates for Pacific Gas & Electric (PG&E)**:** 21.
This study of selected Pacific Gas and Electric steel tower transmission lines was conducted during June, July, and August 1970. While observing that "a few ducks obviously did occasionally hit the power lines," the author concludes, "...there can be no doubt that, qualitatively, the steel tower transmission line ecologically enhances rather than detracts from the wildlife environment."

Brooke, M. (1970). "Some aspects of mute swan movement and mortality." Cambridge Club report **44**: 44-47.

Burckhardt, D. and A. Studer-Thiersce (1970). "Über das Zugverhalten der schweizerischen Fischreiher Ardea cinerea aufgrund der Beringungsergebnisse." Der ornitologische Beobachter **67**(5/6): 230-255.

Coon, N. C., L. N. Locke, et al. (1970). "Causes of bald eagle mortality, 1960-1965." Journal of Wildlife Diseases **6**: 72-76.
Of 55 bald eagles that died of injuries during this U.S. study, seven had impact injuries, one was electrocuted, and 45 had been shot.

Fog, J. (1970). "Om andefugle contra elledninger." Flora og Fauna **76**(4): 141-144.

Halvorsen, O. (1970). "Fiskeørnrede i kraftledningsstolpe." Fauna **23**(4): 300.

Bartonek, J. C., J. King, et al. (1971). Problems confronting migratory birds in Alaska. Tirty-Sixth North American Wildlife and Natural Resources Conference, Wildlife Management Institute, Wire Building, Washington D.C.

Cadbury, C. J., R. E. Scott, et al. (1971). "Bird deaths from power lines at Dungeness, Kent." Ibis **113**: 415-416.

Cornwell, G. and H. A. Hochbaum (1971). "Collisions with wires - a source of anatid mortality." Wilson Bulletin **83**(3): 305-306.
A female pintail was found impaled on a barbed wire fence on 15 August 1966 in the Portage la Prairie, Manitoba, Canada, Community Pasture. An adult blue-winged teal drake was found in a barbed wire fence in August 1966 in North Dakota. Other incidences in-

cluded a drake pintail entangled by the neck from two telephone wires in July 1948 in Saskatchewan, Canada, and a female blue-winged teal impaled on a barbed wire fence. The authors note that barbed wire fences and overhead wires commonly kill ducks, but such incidents are seldom reported. It is recommended that barbed wire fences no longer needed be "removed from publicly-owned waterfowl production marshes; and, when overhead wires become a frequent local source of mortality, they should be placed underground or moved." Also, siting of fences and lines through marshes needs to be reevaluated.

Glue, D. E. (1971). "Ringing recovery circumstances of small birds of prey." Bird Study **18**(3): 137-146.
This study presents findings on analysis "of recovery details of those five British birds of prey ringed in greatest numbers" - kestrel, tawny owl, little owl, barn owl, and sparrowhawk. Kestrels were more prone to collisions with overhead wires, cables, and buildings than were barn, tawny, and little owls. There was a 3.3 percent mortality rate of band recoveries of the five species from telephone wire or cable collision. A higher percentage of collisions occurred in diurnal species such as kestrels due to hunting methods.

Holyoak, D. (1971). "Movements and mortality of Corvidae." Bird Study **18**: 97-106.

Kothman, H. G. (1971). High-rise roosts. Texas Park and Wildlife**:** 26-29.

Miranda, F. d. and E. Osieck (1971). "Hoe verminderen wij het aantal slachtoffers van hoogspannongsleidingen?" Vogeljaar **19**: 485-490.

Riegel, M. and W. Winkel (1971). "On death causes of white storks (C. ciconia) according to ringing recovery reports." Die Vogelwarte **26**(1): 128-135.

Weir, D. N. (1971). "Mortality of hawks and owls in Speyside." Bird Study **18**(3): 147-154.
Of 74 dead or seriously injured birds examined during 1964-69 in this British study, 33 suffered injuries through collisions with human-made objects, including overhead wires, windows, moving vehicles, and trains.

West, H. J., J. E. Brown, et al. (1971). Simulation of EHV transmission flashovers initiated by bird excretion. IEEE Winter Power Meeting, New York, N.Y., IEEE.

Markus, M. B. (1972). "Mortality of vultures caused by electrocution." Nature **238**(July): 228.

Olendorff, R. R. (1972). "Eagles, sheep and power lines." Colo. Outdoors **21**(1 (January-February)): 3-11.

Scott, P. and T. W. Trust (1972). The swans. Boston, Houghton Mifflin Company.
Overhead wire collision has undoubtedly been a major factor in limiting populations of swans in some areas. Some birds are killed by impact with power lines and other by electrocution. "Those which survive the collision are often stunned and fall heavily to the ground. In the absence of serious injury, they eventually recover and fly off, but for awhile they are vulnerable to foxes and other predators." Sixty-five percent of swans recovered died from collision; fifteen percent of those deaths were due to overhead wires. Swans have slow flight, low maneuverability, and poor forward vision, making them especially susceptible to collision with wires.

Scott, R. E., L. J. Roberts, et al. (1972). "Bird deaths from power lines at Dungeness." British Birds **65**(7): 273-286.

Smith, D. G. and J. R. Murphy (1972). "Unusual causes of raptor mortality." J Raptor Research **6**(2): 4-5.

Somerset, H. (1972). "Jabiru killed by power line." South Australian Ornithologist **26**(3): 55.

Stocek, R. F. (1972). "The occurence of osprey on electric power lines in New Brunswick." New Brunswick Naturalist **3**(3): 19-27.

Andersen-Harild, P. and D. Bloch (1973). "En foreløpig undersøkelse over fugle dræbt mod elledninger." Dansk Ornitologisk Forenings Tidsskrift **67**: 15-23.
During October 1971, bird losses were monitored along 13.1 km of power lines (60 kV, 150 kV, and smaller overhead wires) at four locations in Denmark. Most of the lines crossed reed beds or shallow water areas. Of the 105 casualties, 80 percent were found directly beneath the wires. The most lethal of the four sites had a "wall of wires" configuration (twelve wires at eight different levels) and averaged nine recovered birds per 24 hours per ten km of power line. About 60 percent of the total losses were of species nesting in the area (herons, ducks, shorebirds, gulls) and 40 percent were migrants (moorhens, owls, thrushes, starlings, songbirds). Swans, gulls, and certain shorebirds were particularly vulnerable but ducks were killed in relatively low numbers. One species of bittern that was involved, Botarus stellaris, is close to extinction in Denmark. Overhead wire systems should be regarded "as part of the correlation of the environmental factors which have a negative effect on bird populations."

Andersen-Harild, P. and D. Bloch (1973). "Fugle og elledninger." Fugleværn **5**: 12-13.

Anonymous (1973). "Eagle electrocution study underway." Idaho Wildlife Review(Sept./Oct.): 16.
A collaborative study by six Western state utility companies looked at power lines and eagle electrocutions. The research indicated that some eagle deaths were from being shot then electrocuted; in one area, "15 of 17 apparent electrocutions turned out to be shootings." Recommended measures for preventing electrocution include shortening the ground wires that run down utility poles to earth, covering transformers and other energized parts, replacing steel crossarm braces with wood braces, and lowering or lengthening a crossarm.

Drewien, R. (1973). Ecology of Rocky Mountain greater sandhill cranes. Moscow. University of Idaho. Dissertation. UT.
Collisions with power lines accounted for 37 percent of the observed sandhill crane mortality in the population that was studied in the western U.S.

Frey, H. (1973). "Zur Ökologie niederösterreichischer Uhupopulationen." Egretta **16**(1/2): 1-68.

Goodland, R. (1973). Ecological perspectives of power transmission. Biotic Management along Power Transmission Rights- of-Way colloquium, American Institute of Biological Science annual meeting, Amherst, Massachusetts, The Cary Arboretum of the New York Botanical Gardens, Millbrook, New York.

Goodland, R. (1973). Power lines and the environment. Biotic Management Along Power Transmission Rights of Way, Amherst, Massachusetts, The Cary Arboretum of the New York Botanical Gardens.

Ljung, H. and H. Liedholm (1973). Gynna djuren, fåglarna, dig själv och Vattenfall - gör kraftledningsgatan til viltgata. Svensk jakt. **111:** 560-563.

Romera-Sierra, C., J. A. Tanner, et al. (1973). "Interaction of electromagnetic fields and living systems with special reference to birds." National Research Council of Canada, Quarterly Bulletin of the Division Mechanical Engineering **4**: 27-49.

Schmidt, V. E. (1973). "Ökologische Auswirkungen von elektrischen Leitungen und Masten sowie deren Accessorien auf die Vögel." Beitr. Vogelkd. **19**(5): 342-362.

Gudmundsson, F. and B. Clausen (1974). Undersøgelse af dødsårsager blandt fritlevende islandske falke (Falco rusticolus). 12th Nordic Veterinary Congress.

Hannum, G., W. Anderson, et al. (1974). Power lines and birds of prey. Engineering and operating conference, Yakima, Washington.

Hannum, G., W. Anderson, et al. (1974). "Power lines and birds of prey. Paper presented at the Northwest Electric Light and Power Association." Wilson Bulletin **85**(4): 478.

Hilprecht, A. (1974). "Vogeltragödien I." Falke **21**: 294-297.

Jarvis, M. J. F. (1974). "High tension power lines as a hazard to larger birds." Ostrich **45**: 262.

Kitchings, J. T., H. H. Shugart, et al. (1974). Environmental impact associated with electric transmission lines. Oak Ridge, Tennessee, Oak Ridge National Laboratory, Environmetal Sciences Division**:** 100.

Krapu, G. L. (1974). "Avian mortality from collisions with overhead wires in North Dakota." Prairie Naturalist **6**(1): 1-6.
This is a review of the problem in North Dakota. Personal observations by the author and other experienced field researchers are related, and incidents from the literature are cited. The author notes that the increased construction of power plants and associated transmission lines may pose a significant hazard to birdlife in the state.

Lewis, J. C. (1974). Ecology of the sandhill crane in the southeastern central flyway. Stillwater. Oklahoma State University. Dissertation. UT.

Nero, R. W. (1974). "Great gray owl impaled on barbed wire." Blue Jay **32**(3): 178-179.
In March, near Winnipeg, Manitoba, Canada, a great gray owl became impaled by its wing on a barbed-wire fence and died. Two accounts of great horned owls injured by colliding with barbed wire fences are mentioned. The author remarks that there is a scarcity of records regarding such incidents and that they likely occur more than reported.

Weaver, D. K. and R. S. Ores (1974). Trumpeter swan mortality. Trumpeter Swan Society Conference, Martin, South Dakota.

Wilmore, S. B. (1974). Swans of the World. New York, Taplinger Publishing.
The cause of death was diagnosed for 1,051 of 2,156 mute swans recovered in Britain between 1960 and 1965, and "the greatest danger to their mortality was reported to be collision with overhead wires." During two months in 1963, a quarter-mile stretch of power line in Kent killed 21 swans, 30 percent of the total flock. Swans' weak frontal vision was noted as a contributing factor.

Anderson, W. W. (1975). "Pole changes keep eagles flying." Transmission and Distribution **27**(November): 28-31.
Proliferation across the United States of high voltage transmission lines is considered a significant cause for the dwindling eagle population due to electrocution. In 1973, an estimated 300 golden eagles died on the country's power lines; 98 percent were young birds just learning to fly. "It was found that electrocution occurred exclusively on a single pole crossarm type construction where the conductors were nearly horizontal and had insufficient spacing." Golden eagles preferred poles where the crossarm was perpendicular to the prevailing wind and in a commanding topographical position. This can be taken into account by the power company to reduce the number of poles requiring modification. Tower nesting sites are a benefit of power lines to eagles in areas where other natural nest sites do not occur. Rather than destroying tower eyries, line workers can trim long sticks used in nest-building to clear the conductor and prevent outages.

Baglien, J. W. (1975). Biology and habitat requirements of the nesting golden eagle in southwestern Montana. Bozeman. Montana State University. UT.
During the study (1972-1974), one bald eagle and one golden eagle were electrocuted during spring at power poles along the Madison Valley floor. The power poles may be considered preferred perching sites only during the wintering and spring seasons. Artificial perches were not found to be attractive to birds in mountainous areas where natural perches such as trees or rock outcroppings were readily available.

Boeker, E. L. and P. R. Nickerson (1975). "Raptor electrocutions." Wildlife Society Bulletin **3**(2): 79-81.
Use of power line poles by raptors depends on topography, prey abundance, and availability of natural perches. "Electrocutions are most critical in states with the largest eagle populations -- primarily the mountainous western states." During 1969-71, over 300 eagles died by electrocution in the western United States. Documented losses of raptors in 1972 and 1973 throughout the country totalled 281, 250 of which were golden eagles. Many victims were young birds and nearly all deaths occurred on small distribution lines where conductors were three to four feet apart. Particularly troublesome stretches of line were modified to alleviate the hazard.

Dean, W. R. J. (1975). "Martial eagles nesting on high tension pylons." Ostrich **46**(1): 116-117.
In the Kimberley area of the Cape Province, South Africa, martial eagles (Polemaetus bellicosus) have been recorded as nesting on high tension pylons. The nests were all in woodlands, although tree sites were available. In the Ottoshoop area of the western Transvaal, a tawny eagle (Aquila rapax) was recorded nesting on a high tension pylon.

Fitzner, R. E. (1975). "Owl mortality on fences and utility lines." Raptor Research **9**(3/4): 55-57.
In Washington and Idaho during the winter of 1973-74, the author found one great horned owl and one short-eared owl impaled on barbed wire fences and two short-eared owls hanging from overhead utility wires.

Hannum, G., W. Anderson, et al. (1975). "Raptor electrocutions." Wildlife Society Bulletin **3**(2): 79-81.

Holberger, R., L. Morrow, et al. (1975). Resource and land investigations program: considerations in evaluating utility line proposals. Contract 08550-CT5-3, Project No. 3500. Propared for U.S. Department of Interior. Maclean, Virginia, Mitre Corporation.

Haas, D. (1975). Electrische Stühle für Grossvögel. Wir und de Vögel**:** 17-19.

Haas, D. (1975). "Uhus enden auf dem "Elektrischen Stuhl"!" Tier **10**: 45-47, 55.

Marion, W. R. and R. A. Ryder (1975). "Perch-site preferences of four diurnal raptors in Northwestern Colorado." Condor **77**: 350-352.

Miller, D., E. L. Boeker, et al. (1975). Suggested practices for raptor protection on powerlines. Washington D. C., Provo, Utah, Edison Electric Institute, Raptor Research Foundations, Inc: 21.

Owen, M. and C. J. Cadbury (1975). "The ecology and mortality of swans at the Ouse Washes, England." Wildfowl **26**: 31-42.
Of 128 swan mortalities where the cause of death was known, 49 (38 percent) were due to collisions with power lines. Three species of swan were studied: Bewick's, Mute, and Whooper.

Roster, T. A. (1975). "Testimony on bird collision with power lines. Presented to the Public Utility Commission of Oregon, Salem, in the matter of Pacific Power and Light Company's proposed Midpoint, Idaho, to Medford, Oregon, 500-kV line." Docket No. UF-3182: 13.

Schüz, E. and J. Szijj (1975). "Bestandsveränderungen beim Weisstorch, fünfte Übersicht: 1959-1972." Die Vogelwarte **28**(1): 61-93.

Sisson, J. (1975). "Death trap." National Wildlife **13**(2): 18.
At least 50 mute swans were killed between 1959 and 1974 by colliding with power lines along the Jordan River in East Jordan, Wisconsin. The lines became a "death trap" when trees nearby that had previously diverted the birds away from the lines were cut down to build a bridge. An attempt to increase visibility by attaching large staggered wooden blocks to the lines failed.

Stahlecker, D. W. (1975). Impacts of a 230 kV transmission line on Great Plains wildlife. Fort Collins. Colorado State University. Ms. Sci. UT.

Bijleveld, M. F. I. J. and P. Goeldlin (1976). "Electrocution d'un couple de Buses." Nos Oiseaux **33**(6): 280-281.
A pair of hawks was electrocuted at a 17-kV power line in Switzerland.

Braaksma, S. and S. Langenhoff (1976). "Vogels in Lopik beveiligd tegen elektrocutie." Natuur en Landschap **29**: 196-198.

Carter, J. H. and J. F. Parnell (1976). "TV tower kills in eastern North Carolina." Chat **40**(1): 1-9.
Annotated list of 84 species (5,070 birds) tallied on 42 occasions, September-November 1971-1972, at 2 towers (WECT, Bladen County; WWAY, Brunswick County). Common Yellowthroat was most numerous species in kills. Also includes tabular summary of sample (290 individuals of 39 species) of estimated kill of 1,000 birds at WECT, 30 October 1970. A large bird kill occurred in October 1970 (over 1,000 birds, 39 species) at the 1,994-foot WECT tower in North Carolina. In fall 1971 and 1972, regular checks (after the passage of cold fronts and after mostly cloudy nights) were made at WECT and at the 1,188-foot tower 30 miles away. Losses in 1971 (2,683 birds) were typically associated with the passage of cold fronts when low ceilings and north winds prevailed. In 1972, cold fronts passed quickly through the area and only 387 casualties were found. The authors note that many carcasses were no doubt overlooked in the vegetation at the tower sites and there

was much evidence of predator/scavenger activity. A combined annotated species list is given.

Heijnis, R. (1976). Ornithological mortality and environmental aspects of aboveground high tension lines, Biological Environmental Research, The Netherlands**:** 1-66.

La Berge, W. E. (1976). Waterfowl power line collisions, Illinois Natural History Survey**:** 2-3.

McKenna, M. G. and G. E. Allard (1976). "Avian mortality from wire collisions." North Dakota Outdoors **39**(5): 16-18.

Nelson, M. W. and P. Nelson (1976). "Power lines and birds of prey." Idaho Wildlife Review **28**(March/April): 3-7.

Smith, W. E. and M. W. Nelson (1976). Constructing electric distribution lines for raptor protection. American Power Conference.

Stout, I. J. and G. W. Cornwell (1976). "Nonhunting mortality of fledged North American waterfowl." Journal of Wildlife Management **40**(4): 681-693.
Over two million cases of reported nonhunting mortality from 1930 to 1964 were analyzed. Collision mortality, including towers and power lines, accounted for 0.1 percent of the deaths and was most common in the Central Flyway (compared to the Pacific and Mississippi Flyways). Higher frequency of collisions in the Central Flyway may be due to geographical terrain. Factors that may contribute to wire strikes are migration patterns and inclement weather (especially fog). It is suggested that unnecessary fences and wires be removed from waterfowl marsh habitat to reduce collision mortality.

Tillman, R. (1976). Proceedings of the First National Symposium on Environmental Concerns in Rights-of Way Management. First National Symposium on Environmental Concerns in Rights-of Way Management, Mississippi State University, Mississippi State University.

Anderson, S. H., K. Mann, et al. (1977). "The effect of transmission-line corridors in bird populations." The American Midland Naturalist **97**(1): 216-221.
"Observations of bird populations were made along transmission-line corridors of four different widths (12, 30.5, 61, 91.5 m) in areas in which the transmission line rights-of-way traversed typical eastern Tennessee deciduous forest." Detailed grid-mapping of individual bird sightings was done. The 12-meter corridors showed reduced species diversity while the 30.5-m corridor had high bird density and diversity. Wider corridors "were less diverse but attracted several open country bird species not characteristic of surrounding forest." The forest habitat had the highest species diversity.

Anonymous (1977). Jungstörche fliegen: Schleswag sichert Störche und Stromversorgung. Schleswag Nachrichten. **92:** 13.

Gillard, R. (1977). "Unnecessary electrocution of Owls." Blue Jay **35**(4): 259.

Gilmer, D. S. and J. M. Wiehe (1977). "Nesting by ferruginous hawks and other raptors on high voltage powerline towers." Prairie Naturalist(March): 1-10.
Aerial searches for raptor nests were conducted in spring 1976 along U.S. Bureau of Reclamation 230-kV towers in North Dakota. Ferruginous hawks (21 total, twelve successful nests), red-tailed hawks (five total, three successful nests), and great horned owls (three total, two successful nests) were observed. Most ferruginous hawk nests were constructed

in the center of the tower where horizontal steel support members crossed at right angles; most red-tailed hawk nests were constructed near the tops of towers. Several nests were blown out of structures by the wind.

Grue, C. E. (1977). The impact of powerline construction on birds in central Arizona. Northern Arizona University. Ms. Sci. UT.

Nelson, M. W. (1977). "Preventing electrocution deaths and the use of nesting platforms on power poles." Hawk Trust Annual Report **8**: 30-33.

Nelson, M. W. and P. Nelson (1977). Power lines and birds of prey. World Conference on Birds of Prey, Vienna, Austria, International Council for Bird Preservation (ICBP).

Obst, J., A. Stich, et al. (1977). "Todesfälle und todesursachen beim Uhu (Bubo bubo) in Bayern." Garmischer Vogelkundlische Berichte **3**: 24-29.

Quigley, E. (1977). Utility line siting and wetlands preservation. Madison. University of Wisconsin. Dissertation. UT.

Schreiber, R. K. and J. H. Graves (1977). "Powerline corridors as possible barriers to the movements of small mammals." Am. Midl. Nat. **97**: 504-508.

Schroeder, C. H. (1977). "Geese hit power transmission line." North Dakota Outdoors **40**(2): (inside front cover).

Thompson, L. S. (1977). Overhead transmission lines: impact on wildlife. Research Report. Helena, Montana Department of Natural Resource and Conservation, Energy Planning Division**:** 1-51.

Willard, D. E. (1977). Hearing on waterfowl report. Salem, Oregon, Testimony to the Public Utility Commissioner of Oregon concerning Pacific Power and Light Company's proposal for a 500-kV transmission line**:** 35.

Willard, D. E., J. T. Harris, et al. (1977). The impact of a proposed 500 kV transmission route on waterfowl and other birds. Madison, Wisconsin, Institute for Environmental Studies, University of Wisconsin. Submitted to The Public Utility Commissioner of the State of Oregon**:** 1-89.

Anderson, W. L. (1978). "Waterfowl collisions with power lines at a coal-fired power plant." Wildlife Society Bulletin **6**(2): 77-83.
An estimated 400 birds per fall season (0.4 percent of the peak number present) were killed by colliding with overhead power lines at the Lake Sangchris/Kincaid, Illinois, power plant during 1973-75. Blue-winged teal were the most vulnerable and mallards the least vulnerable to collisions. Factors believed to be responsible for losses include the number and species of birds present, lack of visibility of the lines, disturbances that startle birds into flight, and the degree of familiarity of the birds with the area. To reduce waterfowl losses in general, it is recommended that lines not be built over water, that lines not cross places where waterfowl are known to congregate, that the visibility of lines be enhanced, and that waterfowl not be disturbed in the vicinity of existing lines

Avery, M. L. (1978). Impacts of transmission lines on birds in flight. Impacts of transmission lines on birds in flight, Oak Ridge Associated Universities, Oak Ridge, Tennessee, U.S. Fish and Wildlife Service, Biological Services Program.

Three major issues regarding the impact of transmission lines on birds are addressed: the magnitude of the problem, possible short-term solutions, and future (long-term) approaches. The proceedings include papers on migratory behavior and flight patterns, mitigation through engineering and design modification, studies of Bonneville Power Administration lines, impacts on waterfowl and eagles, transmission line engineering and its relationship to migratory birds, transmission line routes through water habitats, and a case study of the Klamath Basin. References, summaries, and a list of participants are included.

Colson, E. W. and E. H. Yeoman (1978). Routing transmission lines through water bird habitat in California. Impacts of transmission lines on birds in flight, Oak Ridge Associated Universities, Oak Ridge, Tennessee, U.S. Fish and Wildlife Service, Biological Services Program.

Craig, T. H. (1978). "A car survey of raptors in southeastern Idaho 1974-1976." J Raptor Research **12**(1/2 (Spring/Summer)): 40-45.
A survey of raptors was conducted by car over a 187 km route in southeastern Idaho during the non-nesting seasons from November 1974 to May 1976. Rough-legged hawks were the most numerous observed, followed by American kestrels and golden eagles. Perched raptors were commonly seen on power poles: 75.1 percent of rough-legged hawks, 94 percent of prairie falcons, 80.4 percent of American kestrels, and 73.7 percent of golden eagles. American kestrels preferred pole tops or wires; most golden eagles preferred the tops and crossarms.

Dunstan, T. C., J. H. Harper, et al. (1978). Final report: habitat use and hunting strategies of prairie falcons, red-tailed hawks, and golden eagles, Prepared for U.S. Bureau of Land Management, Denver, Colorado**:** 177.
Still-hunting from utility and power line poles and crossbars, trees, fence posts, shrubs, rocks, and the ground was the most extensively used prey-search technique for prairie falcons, red-tailed hawks, and golden eagles during the study.

Ellis, D. H., J. G. J. Goodwin, et al. (1978). Wildlife and electric power transmission. Effects of noise on wildlife. J. L. Fletcher and R. G. Busnel. New York, San Francisco, London, Academic Press, Inc: 81-104.

Fog, J. (1978). "Studies in migration and mortality of common snipe (Gallinago gallinago) ringed in Denmark." Danish Review of Game Biology **11**(1): 1-12.

Folkestad, A. O. (1978). Kraftlinjer og fugl. En oppsummering av problemer og erfaringer med merking av kollisjonsutsatte spenn. Fossekallen**:** 10-11.

Gauthreaux, S. A. J. (1978). Migratory behavior and flight pattern. Impacts of transmission lines on birds in flight, Oak Ridge Associated Universities, Oak Ridge, Tennessee, U.S. Fish and Wildlife Service, Biological Services Program.

Goodland, R. G. A. (1978). "Environmental assessment of the Tucurui Hydroelectric Project Rio Tocantins, Amazonas." Survival International Review **3**(2): 11-14.

Goodpasture, K. A. (1978). "Television tower casualties, 1976." Migrant **49**(3): 53-54.

Kroodsma, R. L. (1978). Evaluation of a proposed transmission line's impact on waterfowl and eagles. Impacts of transmission lines on birds in flight, Oak Ridge Associated Universities, Oak Ridge, Tennessee, U.S. Fish and Wildlife Service, Biological Services Program.

Lee, J. M. j. (1978). Effects of transmission lines on bird flights: Studies of Bonneville Power Administration Lines. Impacts of transmission lines on birds in flight, Oak Ridge, Tennessee, U.S. Fish and Wildlife Service, Biological Services Program.

Lee, J. M. j. and D. B. Griffith (1978). Transmission line audible noise and wildlife. Effects of noise on wildlife. J. L. Fletcher and R. G. Busnel. New York, Academic Press, Inc: 105-168.

Meyer, J. R. (1978). Effects of transmission lines on bird flight behavior and collision mortality. **Boulder, Colorado**, Intern, Western Interstate Commision for Higher Education (WICHE), Resource Development Internship Program (RDIP)**:** 220.

Miller, M. W. and G. E. Kaufman (1978). "High voltage overhead." Environment **20**(1): 6-36.

Miller, W. A. (1978). Transmission line engineering and its relationship to migratory birds. Impacts of transmission lines on birds flight, Oak Ridge Associated Universities, Oak Ridge, Tennessee, U.S. Fish and Wildlife Service, Biological Services Program.

Möckel, R. and K.-H. Bernhardt (1978). "10-kV-Freileitungen- eine Todesfalle für Greivögel." Falke **25**: 210.

Prevost, Y. A., R. P. Bancroft, et al. (1978). "Status of the osprey in Antigonish County, Nova Scotia." Canadian Field Naturalist **92**: 294-297.
Data were gathered from 1972 to 1976 on osprey nest sites, breeding pairs, and reproductive success in Nova Scotia, Canada. Twenty-two out of 26 nests were located on utility poles along power lines; the double "T" design of the poles seemed to provide excellent nest supports. Power lines seemed to provide the best locations for colonial nesting in northeastern Nova Scotia: "Human encroachment, the widespread practice of beaver-dam removal, and the overcut state of Antigonish County forests have presumably decreased the number of available natural nest sites."

Stahlecker, D. W. (1978). "Effect of a new transmission line on wintering prairie raptors." Condor **80**: 444-446.

Tacha, T. C., D. C. Martin, et al. (1978). Mortality of sandhill cranes associated with utility highlines. 2nd crane workshop, Rockport, Texas, National Audubon Society. Colorado State University Printing Service, Ft. Collins, Colorado.

Thompson, L. S. (1978). Transmission line wire strikes: Mitigation through engineering design and habitat modification. Impacts of transmission lines on birds in flight, Oak Ridge Associated Universities, Oak Ridge, Tennessee, U.S. Fish and Wildlife Service, Biological Services Program.

Willard, D. E. (1978). Keynote address.The impact of transmission lines on birds (and vice versa). Impacts of transmission lines on birds in flight, Oak Ridge Associated Universities, Oak Ridge, Tennessee, U.S. Fish and Wildl. Serv., Biol. Serv. Prog. Washington, D.C.

Willard, D. E. and B. J. Willard (1978). "The interaction between some human obstacles and birds." Environmental Management **2**(4): 331-340.
The history of avian interactions with human obstacles is discussed, citing various studies. Willard and Willard researched the non-lethal effects of power lines, such as how birds alter flight patterns in response to obstacles. TV towers can cause a high number of mortalities in a short amount of time, and "though this problem has often not been documented, it

is widespread." The authors note that Mayfield (1967) felt that the frequency of death is correlated to the frequency of that species' occurrence; however, the percent distribution of power line-caused fatalities is probably more than Mayfield predicts because "the amount of area over which utility lines may cause death or injury is immense, so that a large effect could be scattered so widely that each case is not notable."

Anonymous (1979). Rettet den Weisstorch!, Naturforschende Gesellschaft und Rheinaubund, Schaffhausen**:** kap. 10 + 28-29.

Bairlein, F. and G. Zink (1979). "Der Bestand des Weisstorchs Ciconia ciconia in Südwestdeutschland: eine Analyse der Bestandsentwiklung." Journal für Ornithologie **120**(1): 1-11.

Cassel, J. F., D. W. Kiel, et al. (1979). Relation of birds to certain power lines in central North Dakota. Prepared for the United Power Association, Environment and Lands Division, Elk River, Minnesota. Fargo, Zoology Department, North Dakota State University**:** 1-50.
Searches for dead birds were conducted under two 230-kV transmission lines in North Dakota. One was an old line and the other was recently relocated to a wetland/slough area. In fall 1977, 15 birds were found at the old line; in spring 1978, 17 were found at the old line and 21 at the new line; in fall 1978, 17 were found at the old line and 30 at the new. Impacts of the two lines are compared. The authors conclude that the new line "provides no greater hazard" than the old. "Although birds flying in the vicinity of the transmission lines studied did seem to be aware of the lines, the lines seem to provide little threat to their welfare."

Galvin, M. T., K. D. Hoover, et al. (1979). Management of transmission line rights-of-way for fish and wildlife. Washington, D.C., U.S. Deptartment of Interior, Fish and Wildlife Service, Off. Biol. Serv: 1-168.

Gylstorff, N.-H. (1979). Fugles kollisioner med elledninger. Århus. University of Århus. Master of Science. UT.

Haukeland, P. N. (1979). "Høyspent dreper hubro." Krompen **8**(3): 97.

James, B. W. and B. A. Haak (1979). Factors affecting avian flight behavior and collision mortality at transmission lines. Final report. Boulder, Colorado, Internship Western Interstate Commission for Higher Education (WICHE), Resourve Development Internship programme (RDIP)**:** 1-109.

Lee, J. M., T. D. Bracken, et al. (1979). Electric and magnetic fields as considerations in environmental studies of transmission lines. Eighteen Annual Hanford Life Science Symposium, Richland, Washington, Technical Information Center, US Department of Energy.

Lein, M. R. and G. A. Webber (1979). "Habitat selection by wintering snowy owls (Nyctea scandiaca)." Canadian Field Naturalist **93**: 176-178.
Habitat selection by wintering snowy owls was studied near Calgary, Alberta, Canada, from 1973 to 1976. "Owls tend to use elevated perches such as trees or utility poles early in the morning and toward sunset....It has been suggested that these high perches are hunting perches and that this represents a diurnal pattern of hunting behavior."

Madsen, J. O. (1979). Luftledninger eller jordkabler - hvad skal vi have i fremtiden? Elektro-teknikeren. **75:** 313-321.

McDonald, J. N. (1979). "Waterfowl collisions with utility wires: two observations on the southern plains." Texas Journal of Science **31**(4): 369-370.

Mead, C. J. (1979). "Mortality and causes of death in British sand martins." Bird Study **26**(2): 107-112.

Mead, C. J., P. M. North, et al. (1979). "The mortality of British grey herons." Bird Study **26**(1): 13-22.

Meents, J. K. and M. C. Delesantro (1979). Use of a 345-kV transmission line by raptors. Albuquerque, New Mexico, Prepared for Public Service Company.

Meyer, J. R. and J. M. J. Lee (1979). Effects of transmission lines on flight behavior of waterfowl and other birds. Second symposium on environmental concerns in rights-of-way management, University of Michigan, Ann Arbor.

NUS Corporation (1979). Impacts of overhead wires on birds: a review. Unpublished report. Palo Alto, California, Electric Power Research Institute**:** 1-47.

Services, A. E. (1979). Rights-of-way ecological effects bibliograph. Palo Alto, California, Electric Power Research Institute**:** 246.
This annotated bibliography contains 824 citations of documents describing ecological effects of overhead transmission line rights-of-way. The citations are other ed according to author, subject, and ecological region. Forty documents on bird mortality are included.

Stahlecker, D. W. (1979). "Raptor use of nest boxes and platforms on transmission towers." Wildl. Soc. Bull. **7**(1): 59-62.

Stapleton, J. and E. Kiviat (1979). "Rights of birds and rights of way." American Birds **33**(1): 7-10.

Anonymous (1980). "Encore un rapace électrocuté." Nos Oiseaux: 375.

Ansell, A. R. and W. E. Smith (1980). Raptor protection activities of the Idaho Power Company. Workshop on raptors and energy developments, Boise, Idaho, Idaho Chapter of the Wildlife Society, U.S. Fish and Wildlife Service, Bonneville Power Administration, Idaho Power Company.

Bell, H. L. (1980). "The effects of a power-line clearing on birds of dry sclerophyll forest at Black Mountain Reserve, Australian Capital Territory." Corella **4**(1): 8-19.

Benson, P. C. (1980). "Large raptor electrocution and powerpole utilization: a study in six western states." Journal of Raptor Research **14**(4): 125-126.
Subadult age classes of raptors suffer greater mortalities due to inexperience in flight ability and hunting methods. Habitat and season can have an effect on mortality rates. Hunting methods can affect electrocution risk: more electrocutions occur where the main prey base is cottontail rabbits than jackrabbits. More eagles were electrocuted in winter when snow caused feather-wetting and the birds "still-hunted" (perched and waited for prey to appear). The author recommends that pole configurations be modified where needed.

Benson, P. C. (1980). A study of large raptor electrocution and powerpole utilization in six western states. Workshop on raptors and energy developments, Boise, Idaho, Idaho Chapter of the Wildlife Society, U.S. Fish and Wildlife Service, Bonneville Power Administration, Idaho Power Company.

Board, M. E. Q. (1980). Considerations in transmission line routing: biological effects and physical characteristics of fields, ions, and shock. Berkeley, CA, Prepared by Dow Associates, Inc: 151.

Christensen, H. (1980). Undersøgelser over fuglekollisioner mod højspændingsledninger gennom det naturvidenskabelige reservat Vejlerne - efteråret 1979. Århus, Naturhistorisk Museum**:** 25.

Fiedler, G. and A. Wissner (1980). "Freileitungen als tödliche Gefahr für Störche Ciconia ciconia." Ökol. Vögel **2**(Sonderheft): 59-109.

Grosse, H. and W. Sykora (1980). "Eine 220-kV-Hochspannungstrasse im Überspannungsgebiet der Talsperre Windischleuba war Vogelfalle." Falke **27**(6): 247-248.

Heijnis, R. (1980). "Bird mortality from collision with conductors for maximum tension." Ökol. Vögel **2**(Sonderheft): 111-129.

Howard, R. P. (1980). Artificial nest structures and grassland raptors. Workshop on raptors and energy developments, Boise, Idaho, Idaho Chapter of the Wildlife Society, U.S. Fish and Wildlife Service, Bonneville Power Administration, Idaho Power Company.

Howard, R. P. and J. F. Gore (1980). Proceedings of workshop on raptors and energy developments, Boise, Idaho, 25-26 January 1980., Idaho Chapter of the Wildlife Society, U.S. Fish and Wildlife Service, and the Idaho Power Company.
Eleven papers on raptors and energy developments were presented at the 1980 meeting of the Idaho Chapter of the Wildlife Society. This symposium served "as a midstream review of where we are and what directions we want to explore." Topics covered include nuclear facility impacts, electrocution, raptor use of power poles, raptor protection activities, and positive and negative impacts of power structures. A list of workshop participants is given.

Howard, R. P. and J. F. Gore (1980). Workshop on raptors and energy developments. Workshop on raptors and energy developments, Boise, Idaho, Idaho Chapter of the Wildlife Society, U.S. Fish and Wildlife Service, Bonneville Power Administration, Idaho Power Company.

Huckabee, J. W. (1980). "Effects of power lines and poles on birds. R & D Status Report, Energy Analysis and Environment Division." EPRI Journal **March 1980**(March): 49-50.

Haas, D. (1980). "Gefährdung unserer Grossvögel durch Stromschlag - eine Dokumentation." Ökol. Vögel **2**(Sonderheft 1980): 7-57.

James, B. W. (1980). Impact of the Ashe-Slatt 500 kV transmission line on birds at Crow Butte Island: preconstruction study. Boulder, Colorado, Western Interstate Commision for Higher Education**:** 1-98.

Kjos-Hanssen, O. (1980). Registreringer av fugl og pattedyr under kraftlinjer. Vassdragsreguleringers virkninger på vilt, Oslo, NVE, DVF.

Kochert, M. N. (1980). Golden eagle reproduction and population changes in relation to jackrabbit cycles: Implications to eagle electrocutions. Workshop on raptors and energy developments, Boise, Idaho, Idaho Chapter of the Wildlife Society, U.S. Fish and Wildlife Service, Bonneville Power Administration, Idaho Power Company.

Lee, J. M. J. (1980). Raptors and the BPAtransmission system. Workshop on raptors and energy developments, Boise, Idaho, Idaho Chapter of the Wildlife Society, U.S. Fish and Wildlife Service, Bonneville Power Administration, Idaho Power Company.

Meyer, j. R. (1980). A study of wintering bald eagles to assess potential impacts from a proposed 230-kV transmission line. Workshop on raptors and energy developments, Boise, Idaho, Idaho Chapter of the Wildlife Society, U.S. Fish and Wildlife Service, Bonneville Power Administration, Idaho Power Company.

Nelson, M. (1980). Historic overview of raptor-powerline problems and raptor management priorities. Workshop on raptors and energy developments, Boise, Idaho, Idaho Chapter of the Wildlife Society, U.S. Fish and Wildlife Service, Bonneville Power Administration, Idaho Power Company.

Olendorff, R. R., R. S. Motroni, et al. (1980). Raptor management--the state of the art in 1980. Tech. Rep. Denver, CO, U.S. Bureau of Land Management**:** 1-56.

Peacock, E. (1980). Powerline electrocution of raptors. Workshop on raptors and energy developments, Boise, Idaho, Idaho Chapter of the Wildlife Society, U.S. Fish and Wildlife Service, Bonneville Power Administration, Idaho Power Company.

Strømsøe, B. (1980). Skjøtsel av vegetasjon i kraftledningsgater i skog. Vassdragsreguleringers virkninger på vilt, NVE, DVF, Oslo/Trondheim.

Van Dale, L. J. (1980). Osprey and power lines. Workshop on raptors and energy developments, Boise, Idaho, Idaho Chapter of the Wildlife Society, U.S. Fish and Wildlife Service, Bonneville Power Administration, Idaho Power Company.

Anonymous (1981). "500-kV towers are for the birds." Electrical World **195**(7): 27.
Large platforms were installed on Pacific Power and Light Company's 500-kV Oregon-Idaho AC line to prevent birds from nesting on the crossarm lattice members of utility poles and to protect insulators from excrement contamination and flashovers. The platforms became preferred nest sites for eagles.

Beaulaurier, D. L. (1981). Mitigation of bird collisions with transmission lines. Boulder, Colorado, Intern, Western Interstate Commission for Higher Education (WICHE)**:** 82.
"In this study removal of overhead groundwires was evaluated as a technique for mitigating bird collisions with transmission lines." Two sites were utilized: Lower Crab Creek, Washington (a 500-kV single circuit line), and Bybee Lake in Portland, Oregon (a 230-kV double circuit line). "Earlier studies at these sites had documented small but measurable collision rates (i.e., number of collisions per number of flights) attributed primarily to collisions with groundwires." From fieldwork conducted October 1980 through March 1981, a total of seven dead birds and eight feather spots were found after groundwire removal; species included green-winged teal, northern pintail, greater scaup, American wigeon, glaucous-winged gull, European starling, red-winged blackbird, and song sparrow. "During pre-removal studies at these two sites, a total of 53 dead birds and 22 feather spots were found over two years of study." Collision rates in every case were less after groundwire removal; for both sites studied, the average reduction in bird collision mortality was approximately one-half. Although methodologies differed among studies, wire marking seemed to reduce collision mortality about as effectively as groundwire removal (average reduction of 45 percent) where comparisons were possible. Airway marker balls and/or high intensity lights may cause decreased bird use of nearby habitat. It is important that markers do not cause wind or ice loading which can interfere with line reliability.

Benson, P. C. (1981). Large raptor electrocution and powerpole utilization: a study in six western states. Department of Zoology. Provo, Utah. Brigham Young University. PhD. UT.

Bromby, R. (1981). "Killer lines in Colorado present an electrocution hazard for raptors." Wildlife News **6**(3).
This report cites a Utah study in which 529 eagle carcasses were found under 250 miles of power lines. Of the 69 carcasses fresh enough to determine the cause of death, 58 had been electrocuted, 10 had been shot, and one had struck a power line. The author notes that entanglement of birds by loosely wrapped wires has surfaced as a major problem in recent years. "Killer wires" are described as those with loose wrapping of wire, short crossarms, ground wires that run to the top of the pole, and metal cross braces.

Clausen, B. and F. Gudmundsson (1981). "Causes of mortality among free-ranging gyrfalcons in Iceland." Journal of Wildlife Diseases **17**(1): 105-109.
Four dead gyrfalcons (of 38 studied at the Museum of Natural History in Reykjavik, Iceland) were found under telephone lines with fractured sternums or wings.

Europe, C. o. (1981). Birds in need of special protection in Europe. Strasbourg, France**:** 154.
Widespread power line collision is mentioned as a reason for the decline of eagle owls (Bubo bubo) in Europe. White storks (Ciconia ciconia) are also prone to overhead wire collision. Both species are given "vulnerable" status.

Fitzner, R. E., W. H. Rickard, et al. (1981). Raptors of the Hanford site and nearby areas of southcentral Washington. Richland, Washington, Pacific Northwest Laboratory. Prepared for the Department of Energy and Rockwell Hanford Operations. Contract DE-AC06-76RLO 1830: 61.
At Hanford, Washington, red-tailed hawks nested principally in utility towers 30 to 100 feet high. Fifty-two percent of nesting pairs observed in 1978 nested on transmission towers.

Gretz, D. I. (1981). Power line entanglement hazard to raptors. Denver, Colorado, U.S. Fish and Wildlife Service**:** 1-9.

Gülle, P. (1981). "Vogeltod an Starkstromfreileitungen." Charadrius **17**(4): 126-127.

Keran, D. (1981). "The incidence of man-caused and natural mortalities to raptors." J Raptor Research **15**(4): 108-112.

Ledger, J. A. and H. J. Annegarn (1981). "Electrocution hazards to the cape vulture (Gyps coprotheres) in South Africa." Biol. Conserv. **20**: 15-24.

Olendorff, R. R., A. D. Miller, et al. (1981). Suggested practices for raptor protection on power lines: the state-of-the-art in 1981. Raptor Res. Rep. . St. Paul, Minnesota, Raptor Research Foundation. Prepared for the Edison Electric Institute, Washington, D.C: 1-111.

Olsson, V. (1981). "Fågelskydd. SOF och el-ledningsdöden - en rapport om vidare studier och framsteg." Vår Fågelvärld **40**: 505-509.

Anderson, S. H. (1982). Birds in transmission line corridors. CRC Handbook of census methods for terrestrial vertebrates**:** 301-302.

Benson, P. C. (1982). Prevention of golden eagle electrocution. Provo, Utah, Bringham Young University, Department of Zoology**:** 90.

Frøstrup, J. C. (1982). "Konstaterte dødsårsaker hos norske knoppsvaner." Fauna **35**: 36-39.

Haukeland, P. and H. Haukeland (1982). "Høyspent dreper hubro." Vår Fuglefauna **5**(1): 20.

Kroodsma, R. L. (1982). "Bird community ecology on power-line corridors in East Tennessee." Biol. Conserv. **23**: 79-94.

Kroodsma, R. L. (1982). "Edge effect on breeding forest birds along a power-line corridor." Journal of Applied Ecology **19**(2): 361-370.
Territories of breeding forest birds in a rectangular, 21 multiplied by 4-ha forst plot adjacent to 800 m of a power-line corridor in East Tennessee were mapped in 1975, 1977, and 1979. Trends in density from the corridor edge to 268 m into the forest were examined for the bird community as a whole and for edge, deep forest, and unaffected species. Analysis of computer-generated, randomly distributed "species" indicated that most trends observed in individual bird species were real. Apparently due to a tendency for some birds to establish territories in a row along the straight corridor edge, peaks in total density occurred at the edge and again in deeper forest. In each year, total density was higher at some distance into the forest than at or near the edge. The contribution of five edge species to bird density on the plot as a whole was negated by lower densities of nine deep forest species in areas near the edge. Considered as a group, thirteen forest species that individually appeared unaffected by the corridor showed a significant decrease in density with increasing distance from the corridor edge; this may have been caused by higher bird density in a small amount of mixed forest habitat near the corridor.

Malcolm, J. M. (1982). "Bird collision with a power transmission line and their relation to botulism at a Montana wetland." Wildl. Soc. Bull. **10**: 297-304.

Nelson, M. W. (1982). "Human impacts on golden eagles: a positive outlook for the 1980s and 1990s." Raptor Research **16**(4): 97-103.

Willdan, A. (1982). Impact of the Ashe-Slatt 500 kV transmission line on birds at Crow Butte Island: Postconstruction study final report. Portland, Oregon, Willdan Associates. Report prepared for BPA under contract DE-AC 79-80BP21135**:** 1-155.

Bochkovskii, B. B., E. I. Udod, et al. (1983). "Protecting power lines against spark-over caused by large birds." Soviet Power Engineering **12**(4): 397-404.
Spark-overs (called 'flashovers' in the U.S.) were causing widespread power outages in 110- to 330-kV overhead lines in the Ukraine during summer. These electrical discharges passed from the utility pole crossbeam to a conductor via accumulated excrement from storks. This report includes recommendations for protecting the lines from storks and other large birds mainly by erection of special barriers to prevent birds from landing near insulators. Bird barrier design sketches are included.

Bylin, K. (1983). "Jordens tranor och den internationella tranforskningen." Vår Fågelvärld **42**: 256-262.

Fredrickson, L. H. (1983). "Bird response to transmission lines at a Mississippi river crossing." Transactions, Missouri Academy of Science **17**: 129-140.

Förstel, A. (1983). "Bestandsaufstockung des Uhus Bubo bubo in Bayern." Anz. orn. Ges. Bayern **22**(3): 145-167.

Gilmer, D. S. and R. E. Stewart (1983). "Ferruginous hawk populations and habitat use in North Dakota." Journal of Wildlife Management **47**(1): 146-157.
Ferruginous hawks (Buteo regalis) were studied in central North Dakota on a 1,259-km super(2) intensive study block and on a surrounding study area (16,519 km super(2)) from 1977 to 1979. Highest nest densities (0.08 nest/km super(2)) were in the Missouri Coteau in 1979. Few nests were found on the more intensively cultivated Drift Plain. The authors estimated the breeding population in the study area each year using 148 sample plots. Pairs that nested on the ground selected only sites on rugged landforms in isolated areas, mostly end and dead-ice moraines. Land use within 1.0 km of nests was mostly (76.5%) pasture and haylands. Nest success was related to the type of nest site and was highest (86.7%) in certain power line towers. Summer storms were a major cause of loss; tree nests were particularly vulnerable. Richardson's ground squirrels (Spermophilus richardsonii)) were taken as prey most often.

Herredsvela, H. (1983). "Dødsårsaker hos knoppsvana på Jæren." Vår Fuglefauna **6**(2): 118-120.

Lindberg, P., T. Järås, et al. (1983). "Fjällvråk, stenfalk och kråka häckande i kraftledningsstolpar." Vår Fågelvärld **42**: 97-98.

Pullin, B. P. (1983). "Great blue herons nest on transmission line tower in Henry County, Tennessee." The Migrant **54**(March): 18.

Ålbu, Ø. (1983). "Kraftlinjer og fugl." Rapp. Zool. Ser. **8**: 1-60.

Beaulaurier, D. L., B. W. James, et al. (1984). Mitigating the incidence of bird collisions with transmission lines. Third Annual International Symposium on Environmental Concerns in Rights-of-Way Management, San Diego, California,, State College, Mississippi.
Mortality was measurable at five of twelve transmission line sections studied "but was not a biologically significant cause of avian mortality." A prior study by Bonneville Power Administration showed that birds collided primarily with small-diameter overhead groundwires. These wires were removed from three lines to assess the effect on collision rates. Groundwire removal appeared to reduce collisions by about one-half. This is comparable to reductions attributed to marking of groundwires in other studies. "Because removal of groundwires is not practical in many cases, further development and testing of the effectiveness of various marking techniques is needed." A table of results of different studies marking groundwires and conductors is included.

Bevanger, K. (1984). Høgspentledninger - en trussel mot fuglelivet? Kraft, ledning og landskap. K. O. Hillestad. Oslo, NVE. **8:** 163-165.

Chronicle, S. F. (1984). Many eagles electrocuted, study by utility finds. San Francisco Chronicle.

Crabtree, A. F. (1984). Proceedings of the Third International Symposium on Environmental Concerns in Rights-of Way Management. Third International Symposium on Environmental Concerns in Rights-of Way Management, San Diego, California, Mississippi State University.

Craig, T. H. and E. H. Craig (1984). "A large concentration of roosting golden eagles in southeastern Idaho." Auk **101**(3): 610-613.
Communal roosting by bald eagles is a common occurrence, but this behavior has not been reported for golden eagles (Aquila chrysaetos). Thurow et al. (1980), however, ob-

served six immature golden eagles roosting in the same canyon in southern Idaho, although not communally, and immature golden eagles have been known to share roost sites with bald eagles. In this paper the authors describe a large concentration of nocturnally roosting golden eagles, some of which roosted communally on power line structures.

Faanes, C. A. (1984). Birds and powerlines in North Dakota. North Dakota Outdoors. **46:** 12-14.

Herredsvela, H. (1984). "Knoppsvaneundersøkelser på Jæren 1978-1983." Vår fuglefauna **7**: 94-96.

Hillestad, K. O. (1984). Kraft, ledning og landskap. Oslo, NVE.

Johnson, D. N. and J. C. Sinclair (1984). "A wattled crane moratality." Lammergeyer **34**: 64.

Kroodsma, R. L. (1984). "Ecological factors associated with degree of egde effect in breeding birds." J. Wildl. Manage. **48**(2): 418-425.

Kroodsma, R. L. (1984). "Effect of edge on breeding forest bird species." Wilson Bull. **96**(3): 426-436.

Kroodsma, R. L. (1984). Effects of power-line corridors on the density and diversity of bird communities in forested areas. Third International Symposium on Environmental Concerns in Rights of Way Management, San Diego, California.

Ledger, J. A. (1984). "Engineering solutions to the problem of vulture electrocutions on electricity towers." Cert. Engineer **57**(June): 92-95.

Lindgren, R. (1984). Fågelskydd. Vällingby, Vattenfall**:** 7.

Lindgren, R. (1984). Fågelskyddsåtgärder för kraftledningar. Stockholm, Vattenfall**:** 6.

Nicolaus, G. (1984). "Large numbers of birds killed by electric power lines." Scopus **8**(June): 42.

Cardoso, J. J. V. (1985). "A project to halt the decline of the great bustard in the Extremadura Plains." Bustard Studies **2**: 72-74.

Koops, F. B. J. (1985). Gemarkeerde bovengrondse hoogspanningslijnen in Nederland. Situatie in mei 1985. Arnhem, KEMA**:** 9.

Kroodsma, R. L. and J. W. v. Dyke (1985). Technical and environmental aspects of electric power transmission. Oak Ride Tennessee, Oak Ridge National Laboratory, Environmental Science Division**:** 85.

Ledger, J. and J. Hobbs (1985). "First record of African whitebacked vultures nesting on man-made structures." Bokmakierie **37**(4): 99-101.

Leshem, Y. (1985). "Griffon Vultures in Israel: Electrocution and other reasons for a declining population." Vulture News **13**: 14-20.

McNeil, R., J. R. Rodriguez S., et al. (1985). "Bird mortality at a power transmission line in northeastern Venezuela." Biological Conservation **31**(2): 153-165.

A survey of bird casualties resulting from collisions with cables in a section of the Margarita power transmission line at Chacopata Lagoon, northeastern Venezuela, where it runs between two expanses of water, was undertaken on 27 February 1983. A total of 611 birds skulls and freshly killed or crippled birds belonging to 10 species were counted. Brown pelicans Pelecanus occidentalis , neotropic cormorantsPhalacrocorax olivaceus , royal terns Sterna maxima , and black-crowned night-herons Nycticorax nycticorax , listed here in decreasing order of abundance, suffered the heaviest losses. The frequency of collisions with the power line is discussed in function of the species composition in the bird community, the behavior or the birds, the flight characteristics of flight directions, the familiarity with local features, and the interactions with local fishermen and poachers.

Moorehead, M. and L. Epstein (1985). Regulation of small scale energy facilities in Oregon: background report. Volume 2. Salem, Oregon Department of Energy.
Examination of the impacts of small energy facility construction includes the potential for birds colliding with towers or lines, leading to injury or death. This can be a significant problem in areas with large bird populations (particularly waterfowl). The following mitigations are recommended: (1) underground lines; (2) flags or marker balls on lines; (3) eliminating small lightning shield wires where lines cross wetlands and migration routes; (4) paralleling lines to prevailing wind directions; (5) constructing lines lower than flight corridors; and (6) placing lines crossing rivers at oblique rather than right angles. The probability of collision is lowered if trees are close to lines and if the lines are highly visible (larger than 230 kV). To avoid electrocution, proper design and construction techniques can be used such as building nesting platforms. Wind energy facilities are also discussed, as birds can collide with rotating blades or with tower guy wires. Large wetland birds (*e.g.*, geese or cranes) and low-flying migratory songbirds are especially susceptible. Collision potential varies with weather, terrain, turbine placement, rotor design, and rotor speed. The authors suggest that the Oregon Department of Fish and Wildlife ask wind energy applicants to monitor bird kills during operation. Mitigation could include setbacks, height limits, visual clues to alert birds, and choosing sites outside critical areas.

Snake River Birds of Prey Research Project (1985). Snake River Birds of Prey Research Project. **Boise, Idaho**, U.S. Department of the Interior, Bureau of Land Management**:** 161.

Stanghelle, E. (1985). Jo, høyspentlinjene tar mye fugl! Villmarksliv. **13:** 73.

Anonymous (1986). "Shriekers and bangers amongst new bird devices." International Pest Control(July/August): 106-107.

Hobbs, J. C. and J. A. Ledger (1986). "Powerlines, birdlife and the golden mean." Fauna & Flora **44**: 22-27.

Hobbs, J. C. A. and J. A. Ledger (1986). Some environmental impacts of electricity transmission and distribution lines. 11th Tech. Meeting, Port Eliazabeth, Association of Municipal Electricity Undertakings of South Africa.

Keran, D. (1986). "Bald eagle nest on a power pole." Loon **58**(3): 142.
This is an account of a bald eagle nest found on an osprey nest site on a power pole near Outing, Minnesota. The nest was sighted on 22 April 1986 and two young eagles were spotted in it two months later.

Koops, F. B. J. (1986). Draadslachtoffers in Nederland en effecten van markering. Arnhem, KEMA**:** 27.

Koops, F. B. J. (1986). Kraftlinjeofre i Nederland of effekten av markeering. Arnhem.

Larssen, R. (1986). Fordelingstransformatorer i mast. Elverksjefen. **52:** 14.

Longridge, M. W. (1986). The impacts of transmission lines on bird flight behaviour, with reference to collision mortality and systems reliability. Johannesburg, Electricity Supply Commission (ESCOM)**:** 279.

Olendorff, R. R. and R. N. Lehman (1986). Raptor collisions with utility lines: an analysis using subjective field observations. Final report. Submitted to Pacific Gas and Electric Company and U.S. Department of the Interior**:** 1-73.

Olendorff, R. R., R. N. Lehman, et al. (1986). Biological assessment: anticipated impacts of the geothermal public power line on federally listed threatened or endangered species, with emphasis on the bald eagle. Sacramento, California, U.S. Bureau of Land Management**:** 1-72.

Pyong-Oh, W. (1986). "Accidental collisions of birds against electricity wires supported by poles and their preventive measures." Bulletin of the Institute of Ornithology, Kyung Hee University **1**(June): 69-79.

Rusz, P. J., H. H. Prince, et al. (1986). "Bird collisions with transmission lines near a power plant cooling pond." Wildlife Society Bulletin **14**(4): 441-444.

Snyder, N. F. R. (1986). "California Condor recovery program." J Raptor Research **5**: 56-71.

Stolt, B.-O., T. Fransson, et al. (1986). Luftledningar och fågeldöd. Stockholm, Naturhistoriska Riksmuseet, Ringmärkningscentralen.

Vereinigung Deutscher Elekrizitätswerke VDEW (1986). Vogelschutz an Starkstrom-Freileitungen mit Nennspannungen über 1kV. Frankfurth (Main), Verlags- und Wirtschaftsgesellschaft der Elektrizitätwerke mbH**:** 16.

Association of Bay Area Governments (1987). Small but powerful: a review guide to small alternative energy projects for California local decisions. Oakland, California**:** 1-66.
Bird collisions and electrocutions with wind turbines and associated wires are cited as wind energy development impacts. "Although bird mortality rates are relatively low, even these rates may be significant for endangered raptors," notably the California condor, peregrine falcon, and bald eagle. Power lines near water have been found to be more hazardous than in other areas. Appropriate mitigation measures are discussed and techniques for protecting birds are given. Special attention is given to the California condor as a major source of conflict with wind farm development.

Bevanger, K. (1987). "Kraftlinjer dreper hundre-tusener av skogsfugl årlig!" Jakt & Fiske **116**(7): 10-12.

Bramble, W. C., W. R. Byrnes, et al. (1987). Management and environmental impacts of electric power transmission rights-of-way. Environmental consequences of energy production: Problems and prospects. S. K. Majumdar, F. J. Brenner and E. W. Miller, The Pennsylvania Academy of Science. **7:** 289-300.

Brown, W. M., R. C. Drewien, et al. (1987). Mortality of cranes and waterfowl from powerline collisions in the San Luis Valley, Colorado. The 4th Crane Workshop, Grand Island,

Nebraska, Platte River Whooping Crane Habitat Maintenance Trust and U.S. Fish and Wildlife Service.
The authors recommend that no new transmission lines be placed within two km of traditional roost or feeding sites. The static wire (the nonconducting topmost wire on a power line used to minimize power outages from lightning strikes) is normally smaller than the conductors and appears to be the wire most often struck by birds in flight. Static wire removal is recommended whenever possible, but modification and/or better marking are preferred methods.

Ferrer, M. and M. De La Riva (1987). Impact of power lines on the population of birds of prey in the Donana National Park and its environment. Mediterranean Birds of Prey III, National Institute of Game Biology.

Foit, G. (1987). "Graureiher (Ardea cinerea) verfing sich in Hochspannungsleitung." Charadrius **23**(4): 251.

Faanes, C. A. (1987). Bird behavior and mortality in relation to power lines in prairie habitats. Fish and Wildlife Technology Report, U.S: Dept. of the Interior, U.S. Fish and Wildlife Service**:** 1-24.

Hobbs, J. C. A. (1987). "Powerlines and gamebirds: North American experiences for southern Africa." South African Wildlife Research **Supplement 1**: 24-31.

Kroodsma, R. L. (1987). "Edge effect on breeding birds along power-line corridors in east Tennessee." American Midland Naturalist **118**(2): 275-283.
Breeding bird territories were mapped for 2 years along 1.75 km of forest edges bounding two power-line corridors through forest. Mean bird density (averaged over corridors and years) at the edge was 153 pairs/40 ha for a defined edge width of 37 m and 266 pairs/40 ha for a defined edge width of 5 m. Bird density averaged 236 pairs/40 ha in the corridor interior and 149 pairs/40 ha in the forest interior. Corridor species were less dense at the forest edge than in the corridor interior ($P < 0.05$), whereas densities of forest species at the edge and in the forest interior were similar ($P > 0.05$).

Ledger, J., J. Hobbs, et al. (1987). "First record of black eagles nesting on an electricity transmission tower." African Wildlife **41**(2): 60-66.

Schierer, A. (1987). "Electric power lines and white storks Ciconia ciconia." Alauda **55**(4): 306.

Stolt, B.-O. and T. Fransson (1987). "Vilka fågelarter drabbas värst av el- och ledningsolyckor?" Calidris **16**(4): 182-189.

Thingstad, P. G. and J. Sandvik (1987). Registreringer av trekkende fugl ved 132 kV kraftlinjetraséen på Bukkøya/Håstadengene, nedre del av Nea, 1984. Trondheim, UNIT, Museet**:** 1-20.

Anonymous (1988). "Presserunden - PEX-kabel, fugledød i Sverige, sangsvaner Vesterålen, svanedød Jæren." Vår fuglefauna **11**(1): 37-38.

Bevanger, K. (1988). "Fugledød ved kollisjoner mot kraftlednigner." Vår fuglefauna **11**(1): 15-20.

Bevanger, K. (1988). Skogsfugl og kollisjoner med kraftledninger i midt-norsk skogsterreng. Trondheim, NAVF, Økoforsk**:** 53.

Bevanger, K. (1988). "Tiltak mot spetteskader, electrocution og kollisjoner." Vår Fuglefauna **11**(1): 5-14.

Bevanger, K. (1988). Transmission line wire strikes of capercaillie and black grouse in central Norwegian coniferous forests (In Norwegian with English summary). Økoforsk Rapport. Trondheim The Applied Ecology Research Programme, University of Trondheim: 1-53.

Bevanger, K. and P. G. Thingstad (1988). "Forholdet fugl - konstruksjoner for overføring av elektrisk energi. En oversikt over kunnskapsnivået." Økoforsk utredning **1**: 1-133.

Bohm, R. T. (1988). "Three bald eagle nests on a Minnesota transmission line." Journal of Raptor Research **22**(1): 34.
One nest in 1986 and two in 1987 were found on 250-kV DC transmission lines. Each nest fledged two young successfully, was between 21 and 24 m from the ground, and was within one km of a lake or river. "An increasing bald eagle population, a lack of natural nest sites and a proliferation of transmission lines may interact to influence eagle use of powerlines in future years."

Callaghan, K. J. (1988). "Power lines and the environment - the electrical impact." Journal of Electrical and Electronics Engineering, Australia **8**(3): 177-183.
50 Hz AC Wiring, appliances, and powerlines constitute the major source of low frequency electric and magnetic fields existing in our modern environment. Power line fields interact negligibly with natural ecosystems but can create significant effects in the man made environment. Audible noise, radio noise, and field coupling with metallic systems are clearly defined effects which can be adequately catered for in the design process. Major concerns are now being expressed about the potential for interaction between these fields and biological systems. Conflicting arguments persist regarding the possible adverse effects of long term human exposure to these fields in spite of comprehensive scientific reviews which have consistently shown that no cause/effect relationship has been established.

Crivelli, A. J., H. Jerrentrup, et al. (1988). "Electric power lines: A cause of mortality in Pelecanus crispus Bruch, a world endangered bird species, in Porto-Lago, Greece." Colonial Waterbirds **11**(2): 301-305.
From October 1985 to March 1987, 28 Dalmatian Pelicans (Pelecanus crispus) were killed by flying into a power line located between their roosting island and their feeding grounds at Porto-Lago in northern Greece, a major wintering ground for this species. Ninety-three percent of the dead birds were immatures, sixty nine percent being first year birds. Using band recoveries of birds banded (color plastic engraved bands) in Greece and in Bulgaria, as part of an international study of the population dynamics of Dalmatian Pelican, the authors estimated that additional mortality due to the power line would cause a decrease of between 1.3 to 3.5% in the number of breeding pairs in Greece and Bulgaria by the time sexual maturity is reached (3 years old). Since the removal of the power line in November 1986, no dead bird has been found.

Crivelli, A. J., H. Jerrentrup, et al. (1988). "Electric-Power Lines - a Cause of Mortality in Pelecanus-Crispus Bruch, a World Endangered Bird Species, in Porto-Lago, Greece." Colonial Waterbirds **11**(2): 301-305. <Go to ISI>://A1988T179600017.

Direktoratet for naturforvaltning (1988). Prosjektet kraftledninger og fugl. Forprosjektets sluttrapport. Trondheim, Direktoratet for naturforvaltning: 1-19.

Goulty, C. A. (1988). Birds and power lines: a bibliography. Chicago, Council of Planning Librarians Bibliography: 1-11.

Hallet-Libois, C. and R. Libois (1988). "Pylons meurtriers pour les oiseaux." Aves (Belgium) **25**(1): 58-59.

Hoerschelmann, H., A. Haack, et al. (1988). "Verluste und Verhalten von Vögeln an einer 380 kV Freileitung (Bird casualties and bird behaviour at a 380-kV-power line)." Ökol. Vögel **10**: 85-103.

Larsen, R. S. and O. H. Stensrud (1988). "Elektrisitetsdøden - den største trusselen mot hubrobestanden i Sørøst-Norge?" Vår Fuglefauna **11**: 29-33.

Lemmon, W. P. (1988). "Virginia rail killed by striking a telephone wire." Auk **15**(1): 51.

Oatley, T. B. and M. A. M. Rammesmayer (1988). "Review of recoveries of ringed white storks Ciconia ciconia in Southern Africa." Ostrich **59**: 97-104.

O'Neil, T. A. (1988). " An analysis of bird electrocutions in Montana." Journal of Raptor Research **22**(1): 27-28.

Steenhof, K., M. N. Kochert, et al. (1988). Raptor and raven nesting on the PP&L Malin to Midpoint 500 kV transmission line. Snake river birds of prey research project. Annual report 1983. K. Steenhof. Boise, Idaho, Boise District, U. S. Dep. Int., Bur. Land Manage: 24-35.

Styringsgruppen for "Forprosjektet kraftledninger og fugl" (SFFKF) (1988). Prosjektet kraftledninger og fugl. Trondheim, Direktoratet for naturforvaltning**:** 20.

Williams, R. D. and E. W. Colson (1988). Associations of western raptors with linear rights-of-way. San Ramon, California, Pacific Gas and Electric (PG&E)**:** 49.

Windingstad, R. M. (1988). "Nonhunting mortality in sandhill cranes." J. Wildl. Manage. **52**(2): 260-263.

Bayer, R. D. (1989). "Great blue heron killed by striking an overhead power line at Coos Bay, Oregon." Oregon Birds **15**(3): 197-198.

Brown, C. J. and J. L. Lawson (1989). "Birds and electricity transmission lines in South West Africa/Namibia." Madoqua **16**(1): 59-67.

Dedon, M., S. Byrne, et al. (1989). Bird mortality in relation to the Mare Island 115-kV transmission line: progress report 1988/1989. San Bruno, California, Prepared by Technical and Ecological Services**:** 1-150.
The area surrounding the 115-kV transmission line serving the Mare Island Naval Shipyard in California was searched for associated bird mortalities from August 1988 through June 1989. Scavenging and predation biases are mentioned. During the study, 242 birds were collected in the salt evaporation pond transect and 68 birds and one bat were collected in the hay field transect, totaling 43 species. Correcting for scavenging and habitat biases showed that total estimated bird mortality associated with the power line was 310 for the hay field transect and 724 for the salt pond transect. The most common species collected were ruddy duck, western sandpiper, black-bellied plover, western meadowlark, and red-winged blackbird. A control transect produced 80 specimens of 15 species. The authors conclude that the "numerous dead birds found in this transect support the conclusion that collision mortality represents a small amount of the total mortality of the local bird populations." Overall mortality was high at times of low visibility and low during periods of "unset-

tling weather." Recommendations include improving sampling techniques and using more objective search bias tests, more frequent scavenger tests, and better vegetation control. A bird flight pattern study is recommended to provide perspective for mortality information and to learn which conductors contribute most to collisions. Suggestions to reduce bird mortalities due to power line collisions include the use of aerial markers, tree planting adjacent to the transmission line, and undergrounding the power line.

Frøstrup, J. C. (1989). Kraftlinjer dreper. Populærvitenskapelig magasin**:** 28-30.

Howe, M. A. (1989). Migration of radio-marked whooping cranes from the Aransas-Wood Buffalo population: patterns of habitat use, behavior, and survival. Technical Report. Laurel, Maryland, U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center**:** 1-21.

Leibl, F. (1989). "Power line losses of black stork Ciconia nigra." Anz. orn. Ges. bayern **28**(1): 72-74.

Rose, P. and S. Baillie (1989). The effects of collisions with overhead lines on British birds: An analysis of ringing recoveries, British Trust Ornithology**:** 227.

Small, M. F. and M. L. Hunter (1989). "Response of passerines to abrupt forest-river and forest-powerline edges in Maine." Wilson Bull. **101**(1): 77-83.

Thingstad, P. G. (1989). Kraftledning/fugl-problematikk i Grunnfjorden naturreservat, Øksnes kommune, Nordland. Trondheim, Univ. i Trondheim. Zool. avd., Vitenskapsmuseet**:** 1-18.

Williams, R. D. and E. W. Colson (1989). Raptor associations with linear rights-of-way. Western Raptor Management Symposium and Workshop, Boise, Idaho, National Wildlife Federation Scientific and Technical Series.

Armbruster, M. J. (1990). Characterization of habitat used by whooping cranes during migration, U.S. Fish and Wildlife Service.
Power lines were identified as influencing whooping cranes in their selection of roosting sites near rivers and wetlands in Nebraska. Participants in a workshop on this topic felt that power lines should be treated as a potential mortality factor for cranes with the minimum width of affected area at no less than 100 m.

Arnold, P. (1990). "Brutnachweis von Kohlkrabbe, Corvus corax, und baumfalk, Falco subbuteo, im gleichen Horst auf Hochspannungsmast." Beitr. Vogelkd. **36**(3/4): 191-192.

Bevanger, K. (1990). "Konflikt fugl/kraftledning i Polmak." NINA Oppdragsmelding **47**: 1-13.

Bevanger, K. (1990). "Rypekollisjoner mot høgspentlinjer i Hemsedal." Everket **56**(910-11): 1-15.

Bevanger, K. (1990). Rypekollisjoner mot kraftledninger i Hemsedal. Trondheim, Norwegian Institute for Nature Research (NINA)**:** 15.

Bevanger, K. (1990). "Topographic aspects of transmission wire collision hazards to game birds in the Central Norwegian coniferous forest." Fauna Norvegica Ser. C **13**(1): 11-18.
The power line strike hazards to game birds were investigated. Data was collected from sections of 66--132 kV transmission lines in the Central Norwegian coniferous forest. Identifications of wire-struck Black Grouse Tetrao tetrix , Capercaillie Tetrao urogallus , and

Willow Grouse Lagopus lagopus were made. The data indicate that areas where the phase conductors are located close to the treetops are high-risk wire-strike sites. The habitat of the wire-strike sites obviously reflects the habitat needs of the different species. E.g. the Capercaillie is especially vulnerable to wire-strikes in homogeneous coniferous (mainly spruce) forests and in the transitions from homogeneous coniferous forest to coniferous-deciduous mixed forest, while the Willow Grouse frequently have collisions in areas of homogeneous deciduous forest (mountain birch forest) or a homogeneous mixture of coniferous-deciduous forest.

Dedon, M., P. Hartman, et al. (1990). Bird mortality in relation to the Mare Island 115-kV transmission line: progress report 1989/1990. Prepared for Department of the Navy, Western Division, Naval Facilities Engineering Command, Office of Environmental Management, San Bruno, California. San Bruno, California, Technical and Ecological Services**:** 1-100.
In the second year of monitoring at this California site, 259 birds (53 species) were collected. Accounting for predation and scavenging biases, 334 birds were estimated to be killed by the transmission line in the hay field transect and 923 in the salt pond transect. Species found most were black-bellied plover, ruddy duck, western sandpiper, dunlin, savannah sparrow, and western meadowlark, accounting for 54 percent of all identified specimens. Two black rails (listed as threatened in California) were found. During the day, passerines generally flew below the height of the lower distribution lines and non-passerines flew mostly above the 115-kV transmission line. The authors recommend continuing surveys and implementing a study to assess the effectiveness of power line markers for reducing bird collisions. This 115-kV line is adjacent to wetlands frequented by birds.

Förstel, A. (1990). "Beobachtungen am Uhu Bubo bubo L. im Gehege, Zucht und Auswilderung in Nordbayern." Anzeiger der Ornithologischen Gesellschaft in Bayern **29**(1): 1-22.

Grischtschenko, V. and N. Gaber (1990). "Analyse der todesursachen des Weisstorchs in der Ukraine." Ornitologische Mitteilungen(5): 121-123.

Linjeservice (1990). Informasjon om merking av kraftledninger.

Milsom, T. P. (1990). "Lapwings Vanellus vanellus on aerodromes and the birdstrike hazard." Ibis **132**: 218-231.

Miquet, A. (1990). "Mortality in black grouse Tetrao tetrix due to elevated cables." Biol. Conserv. **54**: 349-355.

Munoz-Pulido, R. (1990). "Osprey killed by electrocution." British Birds **83**(3): 116-117.

Åse, H. (1990). "Kraftlinjer = mange døde ugler." Falco **1**: 28.

Bevanger, K. (1991). "Rypekollisjoner mot tråd- og nettinggjerder." NINA Oppdragsmelding **65**: 11.

Bevanger, K. (1991). Willow grouse and power-line collisions in Hemsedal, Southern Norway. XXth Congress of the International Union of game Biologists, Göddöllö, Hungary.

Cochrane, K. L., R. J. M. Crawford, et al. (1991). "Tern Mortality Caused by Collision with a Cable at Table Bay, Cape-Town, South-Africa in 1989." Colonial Waterbirds **14**(1): 63-65. <Go to ISI>://A1991FN82100012.

In March 1989 at least 172 Common (Sterna hirundo) and Sandwich (S. sandvicensis) Terns, predominantly the former, were killed by colliding with an electrical cable in Cape Town docks. Mortalities probably occurred early in the morning as birds left a nearby roost for their feeding grounds. The cable with which the birds collided was subsequently lowered by one metre and P.V.C. streamers were suspended from it to improve its visibility. Only two mortalities were recorded in 1990.

Ferrer, M., M. De La Riva, et al. (1991). "Electrocution of raptors on power lines in southwestern Spain." Journal of Field Ornithology **62**(2): 181-190.
Results of a survey of raptor electrocutions in and around Donana National Park since 1982 are reported. In 1982-1983 1127 pylons along a sample of 100 km of power lines were monitored and 233 dead individuals of 13 species of birds of prey were found. Allowing for loss to scavengers, it is estimated that about 400 raptors/yr die along this section of electric power system, and perhaps 1200/yr on the 300 km of power lines within and around Donana National Park. Mortality differed significantly among pylons of different designs and among habitats. The most dangerous pylons possessed exposed insulators above a crossbeam whereas the least dangerous have suspended insulators. Mortality was greater in natural areas within the park than in surrounding human-altered habitats. Electrocution was the cause of death of more than 50% of banded raptors recovered before the study began and the primary known cause of death for the endangered Spanish Imperial Eagle Aquila adalberti .

Ferrer, M., M. Delariva, et al. (1991). "Electrocution of Raptors on Power-Lines in Southwestern Spain." Journal of Field Ornithology **62**(2): 181-190. <Go to ISI>://A1991FY14700005.
Results of a survey of raptor electrocutions in and around Donana National Park since 1982 are reported. In 1982-1983 1127 pylons along a sample of 100 km of power lines were monitored and 233 dead indviduals of 13 species of birds of prey were found. Allowing for loss to scavengers, it is estimated that about 400 raptors/yr die along this section of electric power system, and perhaps 1200/yr on the 300 km of power lines within and around Donana National Park. Mortality differed significantly among pylons of different designs and among habitats. The most dangerous pylons possessed exposed insulators above a crossbeam whereas the least dangerous have suspended insulators. Mortality was greater in natural areas within the park than in surrounding human-altered habitats. Electrocution was the cause of death of more than 50% of banded raptors recovered before the study began and the primary known cause of death for the endangered Spanish Imperial Eagle Aquila adalberti.

Ferrer, M., M. D. L. Riva, et al. (1991). "Electrocution of raptors onpower lines in southwestern Spain." Journal of Field Ornithology **62**(2): 181-190.

Hirschi, W. (1991). "Elster (Pica pica) baut nest in die Drähte eines Strommastes." Ornithologische Mitteilungen **43**(8): 205.

Icanberry, J. (1991). Reducing bird-power line collisions. R & D Program Research Results (August). San Ramon, California, Pacific Gas and Electric**:** 1-2.

Morkill, A. E. and S. H. Anderson (1991). "Effectiveness of marking powerlines to reduce sandhill crane collisions." Wildl. Soc. Bull. **19**: 442-449.

Numers, M. v. (1991). "Sudden death of a flying mute swan (Cygnus olor)." Ornis Fennica **68**: 71.

Perrins, C. M. and J. Sears (1991). "Collisions with overhead wires as a cause of mortality in mute swans Cygnus olor." Wildfowl **42**: 5-11.

Seppälä, M. (1991). Viltvård på kraftlinjerna. Jägaren**:** 30-31.

Smith, J. R. and J. T. Schletz (1991). Bird/powerline collision detection system. San Ramon, California, Pacific Gas and Electric (PG&E)**:** 1-25 plus appendices.

Buehler, D. A., S. K. Chandler, et al. (1992). "Nonbreeding bald eagle perch habitat on the northern Chesapeake bay." The Wilson Bulletin **104**(3 (September)): 540-545.

Ferrer, M. and F. Hiraldo (1992). "Man-induced sex-biased mortality in the Spanish imperial eagle." Biological Conservation **60**(1): 57-60.
Sex-biased mortality in the Spanish imperial eagle Aquila adalberti was found, with more females than males dying. When classifying deaths by cause, very significant differences were found only in electrocution: females formed 78 multiplied by 12% of eagles killed on power lines. In other electrocuted dimorphic raptors, female mortality is also significantly higher than expected, which supports size difference as a possible cause of most mortality cases in females. Electrocution on power lines is the main known cause of death for the Spanish imperial eagle (60%). The development of a strong bias in the sex ratio of a small monogamous population with a low renewal rate could cause a rapid population decline.

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The causes of collision and electrocution accidents involving birds and power lines, and measures to mitigate such accidents, are reviewed. It is convenient to group the causes according to (1) biological, (2) topographical, (3) meteorological and (4) technical aspects. As regards collisions with power lines, the important biological variables are connected with the morphology, aerodynamic capability, physiology, behaviour and life-history strategies of birds. To understand the electrocution problem, the relationship between body size and electrocuting installations must be considered.
Removing earth wires (and modifying earthing methods), modifying line, pole and tower design, installing underground cables and conspicuous marking of lines, poles and towers are important measures for tackling the problems. The route planning process should include careful mapping of (1) topographical features which are leading lines and flight lanes for migrating birds and/or are important for local movements of resident species, (2) topographical elements such as cliffs and rows of trees that force birds to fly over power lines, (3) primary ornithological functions or uses of the area to avoid key areas for birds and avoid separating these areas and (4) local climatic conditions (including seasonal variations) like fog frequency and prevailing wind direction. The outcome depends largely on a combination of these factors.
Objective assessment of the effects of mitigating measures, in particular wire marking, is required. The mitigating efforts should be directed against species known to be potential

collision victims, and their design should be the result of a careful analysis of the biology and ecology of the target species.
Because of the cumulative effects of negative impacts on bird populations today and the alarming number of species with endangered or vulnerable status being killed in connection with utility structures, the problem deserves increased general awareness.

Bevanger, K. (1994). "Bird interactions with utility structures: Collision and electrocution, causes and mitigating measures." Ibis **136**(4): 412-425.
The causes of collision and electrocution accidents involving birds and power lines, and measures to mitigate such accidents, are reviewed. It is convenient to group the causes according to (1) biological, (2) topographical, (3) meteorological and (4) technical aspects. As regards collisions with power lines, the important biological variables are connected with the morphology, aerodynamic capability, physiology, behaviour and life-history strategies of birds. To understand the electrocution problem, the relationship between body size and electrocuting installations must be considered. Removing earth wires (and modifying earthing methods), modifying line, pole and tower design, installing underground cables and conspicuous marking of lines, poles and towers are important measures for tackling the problems. The route planning process should include careful mapping of (1) topographical features which are leading lines and flight lanes for migrating birds and/or are important for local movements of resident species, (2) topographical elements such as cliffs and rows of trees that force birds to fly over power lines, (3) primary ornithological functions or uses of the area to avoid key areas for birds and avoid separating these areas and (4) local climatic conditions (including seasonal variations) like fog frequency and prevailing wind direction. The outcome depends largely on a combination of these factors. Objective assessment of the effects of mitigating measures, in particular wire marking, is required. The mitigating efforts should be directed against species known to be potential collision victims, and their design should be the result of a careful analysis of the biology and ecology of the target species. Because of the cumulative effects of negative impacts on bird populations today and the alarming number of species with endangered or vulnerable status being killed in connection with utility structures, the problem deserves increased general awareness.

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Bevanger, K. (1994). "Three questions on energy transmission and avian mortality." Fauna Norvegica, Series C **17**(2): 107-114.
Three main questions on unintentional effects of energy transmission to birds are discussed: Which species are involved in electrocution and collision accidents? Which decisive biological and ecological factors make a bird into an electrocution or a collision victim? How may this type of additional mortality affect population development? Those species most frequently reported as electrocution victims belong to the Ciconiiformes, Falconiformes, Strigiformes and Passeriformes. Although still difficult to test statistically, it seems obvious that some Gruiformes, Pelecaniformes, Ciconiiformes and Galliformes species are reported in excessive numbers as collision victims. A review of 16 papers showed that 15 orders, 41 families, 129 genuses and 245 species were recorded among the victims. Morphology, biomechanics, vision, life history and behavioural patterns are crucial aspects for understanding why a bird become an electrocution or a collision victim. Although there is a lack of adequate demographic data to confirm that utility structures are a significant cause of death, empirical data indicate this to be a serious additional cause of mortality for some species listed in red data books. As regards small-game species like tetraonids, attention should be paid to local populations. The "power-line load" an area can endure before significant population damage occurs is difficult to predict and local wildlife management au-

thorities should map the mortality carefully and consider it together with other factors which may adversely affect population development.

Bevanger, K., Ø. Bakke, et al. (1994). "Corpse removal experiments with willow ptarmigan (Lagopus lagopus) in power-line corridors." Ökologie der Vögel **16**: 597-607.

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Bevanger, K. and K. Overskaug (1995). Utility structures as a mortality factor for raptor and owls in Norway. Holarctic Birds of Prey, Badajoz, Extremadura, Spain, ADENEX-WWBP.

Brown, W. M. and R. Drewien (1995). "Evaluation of two power line markers to reduce crane and waterfowl collision mortality." Wildlife Society Bulletin **23**(2): 217-227.

Brown, W. M. and R. C. Drewien (1995). "Evaluation of 2 Power-Line Markers to Reduce Crane and Waterfowl Collision Mortality." Wildlife Society Bulletin **23**(2): 217-227. <Go to ISI>://A1995RK41100019.
Collisions with power lines are a source of mortality to cranes (Grus americana and Grus canadensis), waterfowl, and other birds. We evaluated 2 power line markers for reducing crane and waterfowl mortality in the San Luis Valley, Colorado and examined factors contributing to collisions and marker effectiveness. Collision mortality rates at 8 segments (about 0.8 km each) of power lines marked with either yellow spiral vibration dampers or yellow fiberglass swinging plates were compared with 8 adjoining unmarked segments. During 3 spring and 3 fall migration periods (1988-1991), estimated mortality on study segments was 706, including greater than or equal to 35 species. Waterfowl and cranes constituted >80% of mortality. Both marker types reduced mortality ($P<0.005$). Birds reacted to marked lines at greater distances and increased their altitude as compared to unmarked lines ($P < 0.0001$). Factors affecting collisions or marker effectiveness included wind ($P = 0.008$), nocturnal flights and disturbance ($P < 0.005$), and age of sandhill cranes ($P < 0.001$). Neither marker performed better in all study seasons; each may have had unique benefits. Plates damaged distribution lines, precluding their continued use; however, a new marker from Europe which incorporates the benefits of both plates and dampers should be evaluated, as it may best protect against collision losses.

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Bevanger, K. and G. Henriksen (1996). "Faunistiske effekter av gjerder og andre menneskeskapte barrierer." NINA Oppdragsmelding **393**: 1-26.

Henderson, I. G., R. H. W. Langston, et al. (1996). "The response of common terns Sterna hirundo to power lines: An assessment of risk in relation to breeding commitment, age and wind speed." Biological Conservation **77**(2-3): 185-192. <Go to ISI>://A1996UT59400009.
Common terns breed within the industrial complex at Shotton Steel Works, North Wales. Each journey between the breeding colony and the main feeding areas on the Dee estuary requires the terns to negotiate two spans of power lines. Here we investigated the risk of collision with power lines in relation to the time demands on adults, the age of birds and wind speed.
Systematic observations were made of terns journeying to and from the estuary during four phases of the breeding season (courtship, incubation, nestling and juvenile). Casualty surveys of the ground beneath the power lines were also completed, and in order to quantify the potential removal rate of bird casualties by predators, bird corpses were placed underneath the power lines and recounted after two, five and 14 days.
There was a greater than three-fold increase in the frequency of combined journeys made by terns from courtship To the nestling phase and this increase coincided with an increase in the proportion of adult terns which passed under or between the wives of the power lines. Terns also flew closer on average to the top earth wire during the nestling and fledging phases than during the courtship or incubation phases. Juvenile terns flew consistently closer to wires than adults with most juvenile crossings being < 1 m above the top wire. Only 7% of adults flew this close. Only two common tern casualties were found beneath wires (during the nestling phase) representing only 0.4% of the colony population. Since the removal rate of corpses by predators was very slow (around 6% in 14 days), the mortality rate of terns due to collisions with wires was also considered low.
Common terns are agile birds and suffered only low rates of direct mortality through collisions with power lines. However, the demands placed on parent birds during the breeding season caused a significant increase in their vulnerability to collision. This is a factor which has not previously been studied and has implications for a wider range of species. (C) 1996 Published by Elsevier Science Ltd

Savereno, A. J., L. A. Savereno, et al. (1996). "Avian behavior and mortality at power lines in coastal South Carolina." Wildlife Society Bulletin **24**(4): 636-648.

Ballasus, H. and R. Sossinka (1997). "Auswirkungen von Hochspannungstrassen auf die Flächennutzung überwinternder Bläss- und Saatgänse Anser Albifrons, A. fabalis." Journal für Ornithologie **138**: 215-228.

Ariza, L. M. (1998). "The Eagles Have Landed." New Scientist **157**(2124): 25.
Ornithologists have solved a long-standing mystery about the fate of one of Spain's endangered birds. Young imperial eagles (Aquila adalberti) leave the nest within a year of hatching and return several years later to breed. No one knew where they spent the intervening years, but scientists did know that many of them died before they could return. A team of researchers, led by an engineer and imperial eagle expert who has his headquarters in Extremadura, has completed a 2-year survey of eight eagles. The birds were tracked from their nesting area in central Spain via satellite transmitters attached to their backs. In a separate survey the team tracked 40 birds with VHF radio transmitters. After they leave their nests, the team found that the young eagles fly hundreds of kilometers south to dispersion zones, where they stay until they reach sexual maturity, which may take up to 5 years. When they are ready to breed, the birds return to their original nesting area to find a mate. The young eagles may travel up to 400 kilometers to the dispersion zone. One eagle was tracked in Senegal. Many eagles never returned to breed because they were killed when they flew into or landed on electrical wires in the dispersion zones. Up to 60% died after being electrocuted. Fortunately, the mortality rate has dropped significantly (to 10%) since the study because local authorities moved the wires out of the birds' flight path. In one area, 84% of eagles were dying from electrocution but changes in wiring reduced mortality to a minimum.

Bevanger, K. (1998). "Biological and conservation aspects of bird mortality caused by electricity power lines: a review." Biological Conservation **86**(1): 67-76.
Empirical data and theoretical considerations indicate that species with high wing loading and low aspect run a high risk of colliding with power lines. These birds are characterised by rapid flight, and the combination of heavy body and small wings restricts swift reactions to unexpected obstacles. When the number of reported collision victims is considered relative to the abundance and population size of the species concerned, some Galliformes, Gruiformes, Pelecaniformes and Ciconiiformes species seem to appear in disproportionately high numbers. In contrast, species frequently affected by electrocution particularly seems to involve Ciconiiformes, Falconiformes, Strigiformes and Passeriformes. An alarmingly large number of species with endangered and vulnerable status are identified among the victims, but there are insufficient data at present for judging the significance of mortality caused by power lines at the population level.

Bevanger, K., H. Brøseth, et al. (1998). "Dødelighet hos fugl som følge av kollisjoner mot kraftledninger i Mørkedalen, Hemsedalsfjellet." NINA Oppdragsmelding **531**: 1-41.

Cooper, B. A. and R. H. Day (1998). "Summer behavior and mortality of Dark-rumped Petrels and Newell's Shearwaters at power lines on Kauai." Colonial Waterbirds **21**(1): 11-19. <Go to ISI>://000074050400002.
We studied crossing distances, behavior, and mortality of Dark-rumped Petrels (Pterodroma phaeopygia sandwichensis) and Newell's Shearwaters (Puffinus auricularis newelli) around a power line on Kauai, Hawaii, in thr summers of 1993-1994. Both species crossed this power line at significantly smaller distances in the morning (while flying to sea) than in the evening (while flying inland). In the morning, birds flew at higher flight altitudes at locations similar to 800 m inland than at nearby coastal locations. Approximately 5% of each species exhibited behavioral responses while crossing power lines; only Dark-rumped Petrels exhibited a significantly higher frequency of response in the morning than in the evening, however. Most of the Newell's Shearwaters that were killed ill summer collided with power lines while on their way to sea, primarily at power lines <100 m from the coast and in valleys. Approximately 20% of the shearwaters killed were adults; most of the remainder were subadult, nonbreeding birds.

Deem, S. L., S. P. Terrell, et al. (1998). "A retrospective study of morbidity and mortality of raptors in Florida: 1988-1994." J Zoo Wildl Med **29**(2): 160-164.
A retrospective study was conducted on 390 raptors admitted to the University of Florida Veterinary Medical Teaching Hospital (VMTH) during 1988-1994. Representatives of 20 species were admitted; the five most common species were the barred owl (Strix varia, 72), eastern sreech owl (Otus asio, 63), red-shouldered hawk (Buteo lineatus, 49), bald eagle (Haleaeetus leucocephalus, 43), and red-tailed hawk (Buteo jamaicensis, 38). A primary clinical diagnosis was determined in 340 (87%) of the 390 raptors admitted to the VMTH; a diagnosis was not made for the remaining 50 birds. Eighty-two percent (279) had traumatic injuries, and 87% (243) of those were directly related to human activity. The primary clinical diagnoses in the remaining 61 raptors included toxicosis (21), poor nutrition (15), infectious disease (11), orphaned young (11), and electrocution (3). The disposition of the 390 raptors was as follows: 61% (237) died or euthanized, 21% (80) released to the wild, 15% (57) outcome unknown, and 4% (16) permanent captives. Necropsies were performed on 32 of the 237 raptors that died.

Janss, G. F. E. and M. Ferrer (1998). "Rate of bird collision with power lines: Effects of conductor-marking and static wire-marking." Journal of Field Ornithology **69**(1): 8-17.
The number of birds killed (per km) by collision with power lines in west-central Spain did not differ between one transmission line and two distribution lines. For all three power lines, we tested the ability of different markers to reduce bird collision by comparing marked spans to unmarked spans along the same power line. A spiral (30 cm x 100 cm) reduced collisions (static wire marking). Black crossed bands (35 cm x 5 cm) were also effective, but not for the vulnerable Great Bustard (Otis tarda) (conductor marking). The third marker, consisting of thin black stripes (70 cm x 0.8 cm), did not reduce mortality (conductor marking). The highest mortality from power-line collision was recorded for the Great and Little Bustard (Otis tarda and Otis tetrax).

Statnett (1998). Vurdering av 420 (300) kV-ledning Kristiansand-Evjeområdet**:** 23.

Bevanger, K. (1999). Estimating bird mortality caused by collision and electrocution with power lines; a review of methodology. Birds and Power Lines: Collision, Electrocution and Breeding. M. Ferrer and G. F. E. Janss. Madrid, Servicios Informativos Ambientales/Quercus**:** 29-56.

Bevanger, K. (1999). Estimating bird mortality caused by collision with power lines and electrocution; a review of methodology. Birds and power lines. Collision, electrocution and breeding. M. Ferrer and G. F. E. Janss, Querqus.

Janss, G. F. E. and M. Ferrer (1999). "Mitigation of raptor electrocution on steel power poles." Wildlife Society Bulletin **27**(2): 263-273.

Janss, G. F. E., A. Lazo, et al. (1999). "Use of raptor models to reduce avian collisions with powerlines." Journal of Raptor Research **33**(2): 154-159. <Go to ISI>://000081084300012.
We evaluated the use of raptor models to decrease bird mortalities caused by collisions with powerlines. One realistic statue of a Golden Eagle (Aquila chrysaetos) and two Accipiter silhouettes were placed on top of utility towers. Flight behavior of both resident and migrating birds near these power structures was compared to flight behavior we observed at towers where models were not installed. Overall, the number of flocks, number of crossings, and flight altitudes were not affected by the models. Our results indicated that the models did not in any way reduce the risk of collisions. Potential collision victims such as waterfowl, storks, and lapwings were generally indifferent to the models. Most reactions were shown by raptors primarily because the eagle model provoked abundant attacks. We

felt that, due to the intensity of attacks on the eagle model, it may have actually increased the possibility of collisions by raptors with powerlines.

Statnett (1999). Kamuflasje av kraftledningen Kristiansand-Evjeområdet. Evalueringsrapport 03-1999. Oslo, Statnett**:** 1-16.

Janss, G. F. E. (2000). "Avian mortality from power lines: a morphological approach of a species-specific mortality." Biol. Conserv. **95**: 353-359.

Janss, G. F. E. and M. Ferrer (2000). "Common crane and great bustard collision with power lines: collision rate and risk exposure." Wildlife Society Bulletin **28**(3): 675.

Bevanger, K. and H. Broseth (2001). "Bird collisions with power lines - an experiment with ptarmigan (Lagopus spp.)." Biological Conservation **99**(3): 341-346. <Go to ISI>://000169162600009.
The number of ptarmigan (Lagopus lagopus and L. mutus) killed along three power-line sections through colliding with the overhead wires was recorded over a B-year period in a subalpine habitat in southern Norway. The effect of an experimental removal of the power-line earth wire (common neutral) was evaluated on one of the power-line sections, by comparing the number of mortalities found before removal with the number found afterwards. The two other power-line sections in the same area were used as control sections. The number of collisions was approximately halved after the Lower earth wire was removed, thus confirming the expectation that there is a connection between the number of overhead wire levels (vertically) and the collision rate. The results from this and earlier studies indicate that a reduction in overhead wire levels has a general positive effect by reducing the collision rate. The power companies should develop alternative engineering designs and critically assess constructing power lines with continuous earth wires. (C) 2001 Elsevier Science Ltd. All rights reserved.

Harness, R. E. and K. R. Wilson (2001). "Electric-utility structures associated with raptor electrocutions in rural areas." Wildlife Society Bulletin **29**(2): 612-623. <Go to ISI>://000169858100025.
Although numerous studies have documented raptor electrocutions on distribution lines, few ii any, studies have examined the differential mortality of various structure types. We compiled and analyzed electric utility data from 1986 to 1996 on the occurrence of raptor electrocutions along electric distribution lines to determine which electric structures were correlated with raptor electrocutions. We gathered raptor-mortality records from 58 electric utilities that distribute power in rural areas of the western United States (U.S.). Of 1,428 electrocutions recorded, 96% were eagles, hawks, and owls. As in other studies, eagles, in particular golden eagles (Aguila chrysaetos), were electrocuted most often (748), with 66% of those aged represented by juvenile birds. Most eagle electrocutions were detected in late winter to early spring, whereas most hawk and owl electrocutions were detected in late summer. Eagle detection dates occurred when carcasses were discovered, thus carcasses may have gone undetected for many months, especially those covered by snow. Hawk and owl electrocution dates were tied to outage records and represent a more accurate estimate of seasonal mortality. Of the 1,428 records, 421 eagle, hawk, and owl electrocutions were associated with specific utility structures. Transformers, especially banks of 3-phase transformers, were associated with a disproportionately large number of raptor electrocutions (53%), yet they commonly comprised few structure types 17-24% and 0-2.7% for 1- and 3-phase transformers, respectively). Certainly, there are potential biases associated with this type of observational data, but we argue that our results suggest that further research is warranted to quantify the relationships between raptor electrocutions and structure types. We conclude with recommendations to make transformers and other pole-

mounted equipment safer for raptors, and we discuss the need for improved data collection, mitigation, and future research.

Manosa, S. (2001). "Strategies to identify dangerous electricity pylons for birds." Biodiversity and Conservation **10**(11): 1997-2012. <Go to ISI>://000172590200012.
Bird electrocution rates in Secanos de Lerida, an important bird area in central Catalonia (northeast Spain), were estimated based on 804 visits to 507 electric pylons between 1995 and 1999. Electrocution caused a minimum of 160 victims on 67 pylons. Victims were corvids (36%), diurnal birds of prey (60%) and owls (4%). Electrocution rates ranged between <0.01 birds pylon(-1).year(-1), in the less risky areas, and 0.20 birds.pylon(-1).year(-1), in the areas with higher risk. The number of electrocution victims per killing pylon ranged from 1 to 12. Casualties occurred in a fairly contagious pattern, since 50% of deaths took place on only 2% of the visited pylons, and 50% of the killing pylons accumulated 80% of the victims. Univariate analysis revealed that the technical design of the pylons was very important in determining the potential danger of electrocution (metal crossbows were found to be the most dangerous design, followed by earthed flat pylons and vaults). Most mortality (97%) could be eliminated if all technically dangerous pylons were modified, but these would entail 67% of the pylons in the study area. Modelling the presence of carcasses under the pylons was used to identify the pylons which concentrate casualties, so that a 'preferred pylon' approach could be used to allocate mitigation resources. A single under-line inspection identified 78% of the pylons causing bird casualties in the area, which were responsible for 91% of the deaths. Information collected during this single inspection was used to build a logistic model which allowed the correct classification of most of the dangerous pylons missed in the first inspection. This approach revealed that geographical location and habitat setting were as important as technical design in determining the actual risk of electrocution. In that way, up to 99% of mortality can be eliminated by modifiying only 23% of the pylons in the area.

Manville, A. M. I. (2001). Communication towers, wind generators, and research: Avian conservation concerns. Proceedings of the National Avian-Wind Power Planning Meeting IV., Carmel, California, Avian Subcommittee of the National Wind Coordinating Committee.

Donazar, J. A., C. J. Palacios, et al. (2002). "Conservation status and limiting factors in the endangered population of Egyptian vulture (Neophron percnopterus) in the Canary Islands." Biological Conservation **107**(1): 89-97. <Go to ISI>://000176659500009.
Egyptian vulture populations have decreased sharply in the Western Palearctic: island populations are almost extinct in the Mediterranean and the Macaronesian regions. In the Canary archipelago, the species only survives in the islands of Fuerteventura and Lanzarote. During 1998-2001 we examined population parameters and evaluated some potential limiting factors for this isolated and sedentary population. The total population (breeding and non-breeding birds) was monitored annually. In addition, 26 fledglings and 33 immatures (< 6 years old) and adult birds were captured for individual marking with plastic rings. Twenty-three/twenty-four occupied territories were located in the island and the total population estimated at around 130 birds. Breeding success was lower than recorded elsewhere in the species' distribution area: only 0.43 fledglings/pair/year were produced. Adult (> 6 years old birds) and immature annual survival rates were similar, around 90%. Adult Survival was lower than expected as territorial birds seem more susceptible to poisoning. Immature survival could be favoured by the existence of regular feeding places. Casualties from power lines was the main cause of mortality (12 cases during the study period). Blood sampling revealed high frequencies of lead poisoning: 13.5 and 2.7% of individuals showed sub-clinical and clinical intoxication levels, respectively, probably caused by the ingestion of lead shot. Priority conservation measures should be directed to reduce electrocution risks, illegal poisoning, arid lead contamination. Population reinforcement with birds coining from other populations is not recommended as previous information re-

veals morphological and genetic differentiation of Canarian Egyptian vultures compared with continental populations. (C) 2002 Elsevier Science Ltd. All rights reserved.

Sergio, F., L. Marchesi, et al. (2004). "Electrocution alters the distribution and density of a top predator, the eagle owl Bubo bubo." Journal of Applied Ecology **41**(5): 836-845. <Go to ISI>://000224167700005.
1. Electrocution has frequently been suggested as a cause of territory abandonment and eventual population decline of threatened species, but this has been rarely tested. We investigated the impact of electrocution in two eagle owl Bubo bubo populations located in the Italian Alps and Apennines and subject to different levels of electrocution risk (i.e. low and high risk). The eagle owl is one of the species most affected by electrocution, to the point of causing local conservation and economic concern. In a review of 25 studies, electrocution was frequently cited as the major cause of death and has progressively increased in the last three decades, independently from other causes of mortality.
2. The impact of electrocution was tested by (i) comparing estimates of electrocution risk between currently occupied owl territories and infrequently occupied or abandoned territories; (ii) collecting information on the spatiotemporal frequency of electrocution incidents; (iii) measuring density, breeding success and post-fledging survival for populations and territories subject to different electrocution risk.
3. In the low-risk population electrocution casualties varied spatiotemporally, peaking in the period of immature dispersal and at pylons that were good hunting perches. Furthermore, eagle owls over-selected low-altitude habitats, which forced them into close contact with power lines. However, nest-site selection was independent of electrocution risk, although territories that were not occupied every year were nearer to power lines than stable territories.
4. In contrast, in the high-risk population, territories near to power lines, most of them at low altitude, were progressively abandoned during a 10-year period, leading to a steeply declining, scattered, low-density and increasingly high-altitude population.
5. Although there was no effect on long-term breeding success, the presence of pylons within 200 m of the nest increased the likelihood of partial or complete brood loss in the post-fledging period. We estimated that 17% of the fledged young were lost to electrocution.
6. At the population level, density was negatively related to electrocution risk in eight Alpine study areas. However, comparison between the two regions suggested that electrocution impact may interact with other factors, such as resource availability.
7. Synthesis and applications. Our results show how subtle anthropogenic disturbance may affect population breeding performance and quickly alter the gradient of environmental quality for an endangered bird, leading to potential population limitation. Conservation guidelines should prioritize the insulation of those pylons most likely to cause casualties (e.g. in good hunting habitat and close to nests), ensuring that all new lines are raptor safe.

Kelly, A. and S. Kelly (2005). "Are Mute Swans with elevated blood lead levels more likely to collide with overhead power lines?" Waterbirds **28**(3): 331-334. <Go to ISI>://000232329700009.
We retrospectively conducted a survey of blood lead levels in Mute Swans (Cygnus olor) admitted to a Royal Society for the Prevention of Cruelty to Animals wildlife centre with injuries caused by collision with power lines or other overhead cables. Of 72 birds admitted over a three-year period, four birds were dead on arrival and 14 were euthanased on arrival due to severe injuries or burns. Of the surviving 54 birds, 43 were sampled to determine blood lead levels and 63% of these had elevated lead levels (> 1.21 mu mol/l). We also blood sampled 260 swans admitted with symptoms consistent with exposure to lead that had not been involved in collisions and 620 birds admitted for all other reasons that had also not been in collisions. There was no significant difference in the proportion of col-

lision birds with low (< 1.21 mu mol/l) or intermediate (> 2 < 5 mu mol/l) lead levels compared to non-collision birds. However, a significantly larger proportion of birds admitted following collision with power lines had moderately elevated blood lead levels (1.21-2 mu mol/l) compared to non-collision birds and a significantly smaller proportion had high blood lead levels (> 5 mu mol/l). Adults accounted for 72% of admissions following collision and there was no significant difference between the proportion of collision and non-collision birds that were adults. Our data suggest that birds with elevated but moderate blood lead levels suffer an increase risk of collision, while those with intermediate to high levels have a much reduced risk of collision, possibly because they are too weak to fly. Inexperience does not appear to be a significant factor in determining the risk of collision.

Sundar, K. S. G. and B. C. Choudhury (2005). "Mortality of sarus cranes (Grus antigone) due to electricity wires in Uttar Pradesh, India." Environmental Conservation **32**(3): 260-269. <Go to ISI>://000235206300009.
Although overhead electrical wires are known to have caused severe declines of bird populations, there are no studies in India that address this danger, even for endangered species. Rates of mortality, factors affecting mortality and population effects of electrical wires on the globally endangered sarus crane (Grus antigone) were assessed for breeding and nonbreeding cranes in Etawah and Mainpuri districts, Uttar Pradesh, India. Non-breeding cranes were most susceptible to wires and, within territories, mortalities were higher for pre-dispersed young. Similar proportions of non-breeding and breeding cranes were killed, together accounting for nearly 1% of the total sarus crane population annually. Supply wires accounted for the majority of sarus crane deaths, and only non-breeding cranes were killed by both supply and high-tension power lines. Non-breeding crane deaths at roost sites were correlated with numbers of roosting birds and numbers of wires at each site. Over 40% of 251 known sarus crane territories had at least one overhead wire posing a risk to breeding adults and predispersed young. A risk index for wires over territories of cranes was computed; mortality was not affected by increasing the number and therefore risk posed by wires. Most crane deaths in territories occurred as a result of wires at edges of territories. Wires around roosting sites, territoriality and age of sarus cranes appear to be the most important factors affecting their mortality due to wires. Mitigation measures will be most effective around roost sites and for wires that border territories of breeding pairs.

Beck, J. L., K. P. Reese, et al. (2006). "Movements and survival of juvenile greater sage-grouse in southeastern Idaho." Wildlife Society Bulletin **34**(4): 1070-1078. <Go to ISI>://000243173600023.
Low recruitment has been suggested as a primary factor contributing to declines in greater sage-grouse (Centrocercus urophasianus) populations. We evaluated movements and survival of 58 radiomarked juvenile greater sage-grouse from 1 September(>= 10 weeks of age) to 29 March (>= 40 weeks of age) during 1997-1998 and 1998-1999 in lowland and mountain valley study areas in southeastern Idaho, USA. Juvenile sage-grouse captured in the mountain valley area moved an average of 2.2 km (20%) farther ((x) over bar = 13.0 km, SE = 1.2 km) from autumn to winter ranges than juvenile grouse captured in the lowland area ((x) over bar = 10.8 km, SE = 1.2 km). Ten of 11 deaths occurred from September to December. Fifty percent of deaths in the lowland population were attributable to human-related mortality including power-line collisions and legal harvest, while 33% and 17% of deaths were attributable to mammalian predators and unknown cause, respectively. All deaths in the mountain valley population were attributed to avian or mammalian predators. Survival was relatively high for birds from both populations, but was higher across years in the lowland ((S) over cap = 0.86, SE = 0.06, n = 43) than in the mountain valley population ((S) over cap = 0.64, SE = 0.13, n = 14). In our study-juvenile sage-grouse that moved farther distances to seasonal ranges experienced lower survival than juveniles from a more sedentary population. Moreover, high juvenile survival in our study suggests that if low re-

cruitment occurs in sage-grouse populations it may be due to other factors, especially poor nesting success or low early chick survival.

Lehman, R. N., P. L. Kennedy, et al. (2007). "The state of the art in raptor electrocution research: A global review." Biological Conservation **136**(2): 159-174. <Go to ISI>://000246829800001.
We systematically reviewed the raptor electrocution literature to evaluate study designs and methods used in raptor electrocution research, mitigation, and monitoring, emphasizing original research published in English. Specifically, we wondered if three decades of effort to reduce raptor electrocutions has had positive effects. The majority of literature examined came from North America, western Europe, and South Africa. In spite of intensive and often sustained effort by industry and governments across three continents for 30 years, reductions in the incidence of electrocution have been demonstrated in only a few studies. Reliable rate estimates of electrocution mortality generally are unavailable, with some exceptions. Nearly half of 110 studies we analyzed in detail were retrospective reviews of historical mortality records, banding data, or results of necropsies on dead birds received at pathology and veterinary facilities. Among prospective studies, less than half used unbiased approaches to sampling and many did not provide enough detail to assess the sampling design used. At this time, few researchers can demonstrate the reliability of standardized retrofitting procedures or the effectiveness of monitoring techniques. Future progress in reducing raptor mortalities on power lines will benefit from properly designed studies that generate rate estimates of mortality, address biasing factors, and include predictions concerning risk and techniques to reduce risk that can be tested in the field or laboratory. (C) 2006 Published by Elsevier Ltd.

2.3.1 Diverse tema, fugl og kraftledinger

Flydal, K. and E. Reimers (2002). Lokale effekter av kraftledninger og vindmøller. Rapport fra REIN-prosjektet. N. forskningsråd. Oslo, Norges forskningsråd**:** 11-19.

Harden, J. (2002). "An overview of anthropogenic causes of avian mortality." Journal of Wildlife Rehabilitation **25**(1): 4-11. <Go to ISI>://000227912900003.
The natural world presents many survival risks to avian populations. Examination of 5 years of wildlife rehabilitation data from Wildlife Rescue, Inc. of New Mexico suggest that anthropogenic (human-caused) threats to avian survival are perhaps equally common; a review of the published literature confirms those suspicions. This study provides background on the most common types of human-caused avian mortality, along with specific examples of each.

Buurma, L. S. and H. van Gasteren (1989). (Migratory birds and obstacles along the coast of the Dutch province of South Holland: radar observations from Hoek van Holland and victims of the electric power line over the Maasvlakte compared, also in relation to the allocation of windturbines.). The Hague, Koninklijke Luchtmacht.

Cooper, B. A., T. J. Mabee, et al. (1993). Radar studies of bird movements over power lines in the Monte Vista National Wildlife Refuge, Colorado. Avian interactions with utility structures, Miami, Electric Power Research Institute.

Knutson, T. (1969). "The effect of an electromagnetic field on early embryogenesis in quail." Iowa Academy of Science **76**: 510-516.

Trohjell, J. E. and I. H. Vognild (1993). Jordkabel som alternativ til luftledning. Sammenligning av økonomiske og tekniske forhold ved spenninger over 22 kV. Oslo, NVE**:** 62.

Smith, A. and T. Willebrand (1999). "Mortality causes and survival rates of hunted and unhunted willow grouse." Journal of Wildlife Management **63**(2): 722-730. <Go to ISI>://000080988900035.
Few studies have examined the effect of interactions between predation and hunting on the rate of game bird mortality throughout the year. We monitored 134 radiotagged willow grouse (Lagopus lagopus lagopus) on 3 contiguous areas, 2 nonhunted and 1 hunted, in central Sweden between 1992 and 1995. We recorded 100 known mortalities: 22 from hunting, 40 from raptors, 19 from mammalian predators, and 19 from other causes. Excluding hunting, cause of death was similar on hunted and nonhunted areas (P > 0.5), with raptors the most important cause of death in all seasons. We did not record any deaths due to mammalian predators in winter or spring, and deaths through collision with power lines only affected winter, but not annual, survival rates. Cox proportional hazard modeling revealed season (autumn, winter-spring, summer) and area (hunted, nonhunted) as the only variables to affect risk of death (P < 0.001). The greatest rates of hunting mortality (0.24) and natural predation (0.32) occurred on the hunted area during autumn. Autumn survival on the hunted area (0.49) was lower (P = 0.029) that on the nonhunted areas (0.71). Survival increased in winter-spring to 0.69 on the hunted area and 0.81 on the nonhunted areas, and remained high (>0.78) through the summer period. We believe hunting mortality was mostly, if not totally, additive to natural mortality in our study. The population density on the hunted area did not decline as expected from the results, and we suggest that immigration from beyond the neighboring nonhunted areas was sustaining the population. We conclude that a harvest model for willow grouse must take account for dispersal and predation rates at a landscape scale.

Jacobsen, K.-O. and T. V. Johnsen (2004). 132 kV-kraftlinje mellom Hessfjorden og Fakken, Karlsøy kommune, Troms. Konseskvensutredning for fugl og annet dyreliv. Trondheim, Norway, NINA**:** 30.

Olendorff, R. R. (1986). Raptor collisions with utility lines and fences: an annotated bibliography (review draft). Sacramento, California, U.S. Bureau of Land Management**:** 1-14.

Wolfe, D. H., M. A. Patten, et al. (2007). "Causes and patterns of mortality in lesser prairie-chickens Tympanuchus pallidicinctus and implications for management." Wildlife Biology **13**: 95-104. <Go to ISI>://000248626500012.
Life-history studies of prairie grouse have focused on reproductive ecology, habitat use, movement patterns and survivorship, with only cursory or anecdotal references to mortality causes, or they have been of insufficient duration or scale to infer mortality patterns. Because mortality causes and patterns affect other life-history traits, their determination adds to our overall understanding of grouse demographics. As part of a long-term study on lesser prairie-chicken Tympanuchus pallidicinctus natural history in Oklahoma and New Mexico, we recovered 322 carcasses of radio-tagged birds captured on leks. We were able to determine the cause of death for 260 of these birds. Predation by raptors accounted for the largest number of mortalities (91), followed by collisions with fences (86), predation by mammals (76), collisions with power lines (4), and collisions with automobiles (3). Mortality causes differed considerably between study sites and between sexes, with all collisions more frequent in Oklahoma than in New Mexico, in females than in males, and in older than in young females. Although predation is a major cause of mortality, we argue that predator control may not be effective for grouse conservation. Moreover, in cases where top predators reduce mesopredator population densities, for example those of red foxes Vulpes vulpes, indiscriminate removal of predators may hasten the decline of grouse populations. Land managers striving to conserve prairiechickens and other grouse species

should attempt to reduce or eliminate collision mortality risks in addition to efforts to improve nesting or broodrearing habitat. Collision risks should also be evaluated for potential release sites of translocated or captive-reared grouse.

2.4 Fugl og kollisjoner med tårn, bygninger, master og lignende

Bamberg, J. B., R. Warriner, et al. (1935). "Nocturnal migration in stormy weather." Migrant **6**(6): 77-80.
Birds heard and seen at an illuminated 100-foot water tower while migrating through Tennessee in poor weather are discussed. About 50 birds (10 species) were found dead in this late October incident.

Bamberg, J. B., R. Warriner, et al. (1935). "Nocturnal migration in stormy weather." Migrant **6**(4): 77-80.
Birds heard and seen at an illuminated 100-foot water tower while migrating through Tennessee in poor weather are discussed. About 50 birds (10 species) were found dead in this late October incident

Stoner, E. A. (1939). "Western red-tailed hawk nests on high voltage tower." Condor **41**(1): 215.
A red-tailed hawk nest was found on a tower in Benicia, California.

Aronoff, A. (1949). "The September migration tragedy." Linnaean Newsletter **3**(1): 1-2.
Mortality at the Empire State Building (over 200 birds, 30 species) on the night of 10 September 1948 is discussed, and a species list is provided. Also discussed are kills at a Nashville, Tennessee, airport ceilometer involving 248 birds of 35 species; at a Philadelphia, Pennsylvania, building (at least 11 species); and at a 450-foot tower in Baltimore, Maryland. A list of casualties from the Nashville incident is included.

Potter, J. K. and J. J. Murray (1949). "Fall migration: middle Atlantic coast region." Audubon Field Notes **3**(1): 8-10.
In a heavy fog on the morning of 11 September 1948, "hundreds and perhaps thousands" of birds, mostly warblers, struck tall buildings and towers in Philadelphia. At Cape May, New Jersey, 50 species were collected at telegraph wires and radio towers in September and October. Two barn owls were among the casualties.

Laskey, A. R. (1951). "Another disaster to migrating birds at the Nashville airport." Migrant **22**(4): 57-60.
On the night of 7 October, 476 birds of 40 species died at the airport ceilometer in Nashville, Tennessee. The sky was overcast with northerly winds. A kill list is given and the role of winds in the mass mortality is discussed.

Anonymous (1954). "Disaster in migration." Chat **18**(4): 104-105.
On 7 October 1954, a "rain" of small birds at several spots in the Southeast occurred. In Charleston, South Carolina, about 100 dead birds of 24 species were identified, and in Winston-Salem, North Carolina, 190 birds of 21 species were collected from near the respective airport ceilometers. Most of these birds were warblers. The catastrophe was attributed to a combination of "tumbling temperatures, overcast skies, ... stabbing beacons," and a cross-wind associated with a cold front.

Devlin, J. M. (1954). "Effects of weather on nocturnal migration as seen from one observation point at Philadelphia." Wilson Bulletin **66**(2): 93-101.

Three hundred avian migrants were killed on the night of 21-22 September 1953 when they crashed against the Empire State Building in New York City. The author notes that this event illustrates what happens if migrants on a following wind meet a warm front with strong southerly winds and are forced to fly very low under the frontal slope.

Tanner, J. T. (1954). "Bird mortality during night migration, October 1954." <u>Migrant</u> **25**(4): 57-59.
This is a general summary of the widespread avian mortality that occurred in the eastern U.S. on the nights of 6-7 and 7-8 October 1954. Special emphasis is placed on weather factors accompanying the losses.

Tanner, J. T. (1954). "Knoxville." <u>Migrant</u> **25**(4): 64-65.
Following the windy, overcast night of 6 October 1954, 267 birds (26 species) were recovered at the McGhee-Tyson Airport ceilometer near Knoxville, Tennessee. The author determined that the migrating birds were attracted not only by the ceilometer beam itself, but also by the light reflected from birds flying in and about the beam.

Chamberlain, B. R. (1955). "Fall migration: southern Atlantic coast region." <u>Audubon Field Notes</u> **9**(1): 17-18.
Heavy mortality at beacons, towers, ceilometers, and lighted windows was reported from several southeastern (U.S.) cities in October 1954. Red-eyed vireos and ovenbirds were the most common species

Johnston, D. (1955). "Mass bird mortality in Georgia, October 1954." <u>Oriole</u> **20**(2): 17-26.
Details of seven incidents in Georgia during 6-8 October 1954 are presented. The largest kill occurred at the Warner Robins Air Force Base ceilometer near Macon, Georgia, where an estimated 50,000 birds died. A widespread cold front was associated with these incidents.

James, P. (1956). "Destruction of warblers on Padre Island, Texas, in May 1951." <u>Wilson Bulletin</u> **68**(3): 224-227.
Following the rainy, stormy night of 5 May 1951, 2,421 dead birds (39 species, mostly warblers) were collected beneath light poles on this coastal island.

Stevenson, H. M. (1956). "Fall migration: Florida region." <u>Audubon Field Notes</u> **10**(1): 18-22.
Over 2,000 birds were killed on 8-9 October 1955 at a new 660-foot tower near Tallahassee, Florida. This marked the beginning of a long-term study of bird losses at the WCTV tower.

Tordoff, H. B. and R. M. Mengel (1956). "Studies of birds killed in nocturnal migration." <u>University of Kansas Publications, Museum of Natural History</u> **10**(1): 1-44.
This is an extensive analysis of 1,090 birds (61 species) killed at the 950-foot WIBW TV tower in Topeka, Kansas, during fall 1954. The losses are listed by date collected, and an annotated species list gives weights, fat conditions, and sex-age data. The author notes the kill was "not at all random" with respect to the actual relative abundance of species, since some birds (*e.*g., shorebirds) were common in the field but uncommon in the kill. However, an estimate is made of the volume of migration through the area by assuming the tower took a random sample of the overall migrant population. Differential migration by sex and age is discussed in certain species as are differences in wing length, tail length, and weight.

Bagg, A. M. (1957). "The changing seasons." <u>Audubon Field Notes</u> **11**(4): 312-325.

Avian mortality in spring at towers in Jacksonville (300 birds) and Leon County (46 birds, 14 species), Florida, are mentioned

Chamberlain, B. R. (1957). "Fall migration: southern Atlantic coast region." Audubon Field Notes **11**(1): 15-18.
About 2,500 birds, mostly warblers, were killed at the Chapel Hill, North Carolina, TV tower on 28-29 September 1956.

Johnston, D. W. (1957). "Bird mortality in Georgia, 1957." Oriole **22**(4): 33-39.
Fall bird losses totalling 4,189 (78 species) are listed from several towers, two ceilometers, and one lighthouse in Georgia and South Carolina. Most of the losses occurred on the night of 4 October when rain and cloudy weather prevailed.

Johnston, D. W. and T. P. Haines (1957). "Analysis of mass bird mortality in October, 1954." Auk **74**(4): 447-458.
During 5-8 October 1954, coinciding with an advancing cold front, 25 instances of mortality totalling over 100,000 birds (88 species) were reported from ceilometers, towers, and buildings in the eastern U.S. The most commonly killed species were the ovenbird, magnolia warbler, red-eyed vireo, and chestnut-sided warbler. Sex and age composition, weight, fat content, and subspecific composition were analyzed in 2,552 birds killed on 7-8 October at a ceilometer near Macon, Georgia, where an estimated total of 50,000 birds (53 species) died. The massive bird mortalities were primarily associated with nocturnal fall migration.

Laskey, A. R. (1957). "Television tower casualties, Nashville." Migrant **28**(4): 54-57.
Daily searches from 23 September to 15 November, 1957, at a 1,000-foot TV tower in Nashville, Tennessee, resulted in the collection of 704 dead birds (67 species). Cold fronts with overcast skies and north winds accompanied the peak kill dates. A list of the casualties is given. A 878-foot tower with fewer guy wires and an unsupported TV tower produced only a few dead birds.

Newman, R. J. (1957). "The changing seasons." Audubon Field Notes **11**(1): 4-6.
Mention is made of 2,500 birds killed at a Chapel Hill, North Carolina, TV tower.

Trott, J. (1957). "TV tower fatalities at Chapel Hill." Chat **21**(1): 28.
An estimated 2,500 birds (44 species) were killed on 28 September and 3 October at a 788-foot tower in North Carolina. Low cloud ceilings accompanied the incidents. A kill list is given.

Blake, C. H. (1958). "Skull injuries at a TV tower." Chat **1958**(September): 71.
Following the overcast night of 11 May 1958, ten freshly-killed passerines were picked up at the WUNC-TV tower in Hillsboro, North Carolina. Location of the carcasses suggested that "the birds were hitting the tower itself and not the guy wires and were deflected in falling by light wind from the southwest." Seven of the birds had skull injuries, including hemorrhages, suggesting a considerable proportion of glancing blows.

Breckenridge, W. J. (1958). "Fall migration: western Great Lakes region." Audubon Field Notes **12**(1): 32-33.
Between 31 August and 20 September 1957, three large kills were reported at a new 1,000-foot tower in Eau Claire, Wisconsin. The 2,972 casualties (42 species) found on 20 September included 23 species of warblers.

Brewer, R. and J. A. Ellis (1958). "An analysis of migrating birds killed at a television tower in east-central Illinois, September 1955-May 1957." Auk **75**(4): 400-414.

This is a comprehensive account of the occurrence of avian mortality resulting from impacts with a 983-foot tower near Champaign, Illinois. Analysis of seven mortality incidents includes species lists (486 dead birds, 51 species), weather data, comparisons with kills elsewhere, sex, age, and fat content of birds collected, spatial distribution of the carcasses around the tower, and a discussion of the attraction of birds to the tower.

Chamberlain, B. R. (1958). "Fall migration: southern Atlantic coast region." Audubon Field Notes **12**(1): 19-21.
During fall 1957, over 1,100 birds (80 species) were killed at an Aiken, South Carolina, tower. Smaller kills were reported from Raleigh and Charlotte, North Carolina, and Camp Cornelia and Atlanta, Georgia.

Cochran, W. W. and R. R. Graber (1958). "Attraction of nocturnal migrants by lights on a television tower." Wilson Bulletin **70**(4): 378-380.
Counts of flight calls on two nights at a 984-foot tower near Champaign, Illinois, indicated that migrants were concentrated in the vicinity of the structure. Turning off the red warning lights on the tower eliminated the aggregation. This article was the first to provide any experimental evidence that nocturnal migrants actually congregate around the red warning lights on towers.

Kemper, C. A. (1958). "Destruction at the TV tower." Passenger Pigeon **20**(1): 3-9.
In fall 1957, three large kills, including one estimated at 20,000 birds (based on 1,525 of 40 species collected), were reported from the 1,000-foot Eau Claire, Wisconsin, TV tower. Warblers dominated the kill lists.

Newman, R. J. (1958). "The changing seasons." Audubon Field Notes **12**(1): 4-9.
Included is a brief general discussion of the tower kill situation in the U.S. and an appeal for more systematic monitoring of towers and reporting of findings.

Stevenson, H. M. (1958). "Fall migration: Florida region." Audubon Field Notes **12**(1): 21-26.
As part of an ongoing study mentioned in entry #404, 2,000 dead birds were found at the WCTV tower near Tallahassee on 4-5 October 1957. Nearly 800 died at towers in Jacksonville.

Stevenson, H. M. (1958). "Spring migration: Florida region." Audubon Field Notes **12**(4): 344-348.
Kills were reported on 4 April (228 birds) and 11 April (220) at WCTV, Tallahassee, Florida, and on 21 April (297) at Jacksonville. The composition of the kills was very dissimilar between locations, and there was low correspondence between the species composition of the kills and field observations of migrants.

Baird, J., R. I. Emery, et al. (1959). "Fall migration: northeastern maritime region." Audubon Field Notes **13**(1): 11-13.
In Massachusetts, on the night of 19 September 1958, over 300 birds (mostly warblers and vireos) were killed at two Boston TV towers and over 200 (mostly warblers and flycatchers) died at a Springfield searchlight

Baumgartner, F. M. (1959). "Fall migration: southern Great Plains region." Audubon Field Notes **13**(1): 43-45.
On 11 October 1958, "a large box of birds" including marsh and sedge wrens was picked up at a TV tower in Dallas, Texas.

Breckenridge, W. J. (1959). "Spring migration: western Great Lakes region." Audubon Field Notes **13**(4): 371-373.
On 17 May, 284 birds were killed from colliding with a TV tower in Detroit, Michigan.

Kemper, C. A. (1959). "More TV tower destruction." Passenger Pigeon **21**(4): 135-142.
The tower at Eau Claire, Wisconsin, produced only light kills in 1958 and 300 deaths in spring 1959. Over 2,500 birds (65 species) were killed in fall 1959. The author lists the 1959 kills and discusses weather conditions during the five major kills in 1957 and 1959. He also presents a theory explaining massive tower kills involving the birds's supposed ability to detect geomagnetic lines of force.

Newman, R. J. and G. H. j. Lowery (1959). "The changing seasons." Audubon Field Notes **13**(4): 346-352.
In spring 1959, tower kills were quite light, but bird losses at windows and power lines "attracted notice all over the nation." In Detroit, Michigan, 284 birds were killed at a TV tower.

Parmalee, P. W. and B. G. Parmalee (1959). "Mortality of birds at a television tower in central Illinois." Bulletin of the Illinois Audubon Society **111**: 1-4.
During the foggy, cloudy night of 16 September 1958, at least 827 birds (40 species) were killed at the 1,000-foot WICS-TV tower at Springfield, Illinois. Weather conditions and a kill list are given.

Petersen, P. C., Jr. (1959). "TV tower mortality in western Illinois." Bulletin of the Illinois Audubon Society **112**: 14-15.

Petersen, P. C. j. (1959). "TV tower mortality in western Illinois." Bulletin of the Illinois Audubon Society **112**: 14-15.
Following a foggy, overcast night, 88 dead birds (32 species) were found at the 983-foot WHBF tower near Orion, Illinois.

Stevenson, H. M. (1959). "Fall migration: Florida region." Audubon Field Notes **13**(1): 21-25.
In fall 1958, 1,149 birds died at the WCTV tower, Tallahassee, Florida.

Laskey, A. R. (1960). "Bird migration casualties and weather conditions, autumns 1958-1959-1960." Migrant **31**(4): 61-65.
At Nashville, Tennessee's WSIX tower (940 feet tall), kill totals for the three seasons were 223 (55 species), 562 (59 species), and 1,553 (65 species), respectively. The new 1,369-foot WSM tower, seven miles NNW of WSIX, produced 2,130 casualties (59 species) during fall 1960. Kill lists and descriptions of the towers and weather conditions are given. The ceilometer at the Nashville airport, equipped with a filter permitting only ultraviolet light to pass through, produced no known deaths.

Norwood, J. R. (1960). "TV tower casualties at a Charlotte station." Chat **24**(4): 103-104.
In late September and early October 1960, 390 birds (32 species) were found dead at the 1,000-foot WSOC tower in Charlotte, North Carolina. A kill list is given.

Ogden, J. (1960). "Observations at a TV tower during a bird fall." Migrant **31**(4): 65-67.
During the night of 28 September, 321 birds (30 species) were killed at the WSM TV tower in Nashville, Tennessee. No chips (number of bird calls in a 60-second interval) were heard when the sky was clear. As clouds gathered, observers counted increasing numbers of chips and birds started falling. The chip count dropped when the sky partially cleared, but birds continued to fall at a steady rate; some were merely injured or stunned.

Stevenson, H. M. (1960). "Spring migration: Florida region." Audubon Field Notes **14**(4): 379-383.
Over 1,800 birds were killed at the WCTV tower, Tallahassee, Florida, during late April and early May 1960. Jacksonville reported 300 ovenbirds killed on a single night. There was no correspondence between the tower kills and field surveys of migrants in species composition.

Wray, D. L. (1960). "Parasitic jaeger at Raleigh TV tower." Chat **24**(4): 97-98.
An individual parasitic jaeger, an unusual species, was found dead on 26 August 1960 at a TV tower in Raleigh, North Carolina.

Anonymous (1961). "Large bird kills at TV towers." Bluebird **28**(1): 9.
A brief summary of two kills in Missouri is given: 658 birds (41 species) and one red bat at Columbia, on 24 September 1960, and about 100 birds (at least 16 species) at Cape Girardeau on 27 September 1960.

Barbour, R. W. (1961). "An unusual bird mortality at Lexington." Kentucky Warbler **37**(3): 55.
Following the stormy night of 7 May 1961, 82 dead birds (21 species) were collected at a 670-foot tower in Lexington, Kentucky

Baumgartner, F. M. (1961). "Fall migration: southern Great Plains region." Audubon Field Notes **15**(1): 54-56.
On 22 October 1960, of eleven yellow rails found beneath a Dallas, Texas, TV tower, eight were dead and three were injured.

Chamberlain, B. R. (1961). "Fall migration: southern Atlantic coast region." Audubon Field Notes **15**(1): 23-26.
From 28 September to 2 October 1960, tower casualties in Charlotte, North Carolina, exceeded 340 birds. Smaller kills were reported during 8-17 October.

Laskey, A. R. (1961). "[Tennessee] TV tower casualties." Inland Bird Banding News **33**: 1.
Reports kill of 3,683 birds of 77 species at 2 towers in Nashville, fall 1960; 5 species (Ovenbird, Red-eyed Vireo, Tennessee Warbler, Magnolia Warbler, Gray Catbird) accounted for 63% of kill.

Lupient, M. (1961). "Fall migration: western Great Lakes region." Audubon Field Notes **15**(1): 42-44.
An estimated 12,000 birds died at towers in the Western Great Lakes region on the night of 21 September 1960. Of these, 1,225 (42 species) were collected at Chippewa Falls, Wisconsin. Other kills in western Wisconsin occurred earlier in the month.

Nero, R. W. (1961). "Regina TV tower bird mortalities - 1961." Blue Jay **19**(4): 160-164.
At the 670-foot CKCK tower in Saskatchewan, Canada, 94 dead birds (22 species) were found on 3 September 1961, and 113 (20 species) were collected on 10 September. Kill lists and weather conditions are given. The possibility of substantial losses occurring in daylight hours is discussed.

Newman, R. J. (1961). "Fall migration: central southern region." Audubon Field Notes **15**(1): 46-51.
The total fall 1960 mortality at two Nashville, Tennessee, towers was 3,683 birds (77 species). Only 14 dead birds were collected at the WBRZ tower in Baton Rouge, LA.

Smith, V. M. (1961). "Tower casualties at Columbia, South Carolina." Chat **25**(1): 18-19.

On the last day of September and the first few days of October 1960, "hundreds" of birds were killed at the WIS transmitter tower at Columbia, South Carolina.

Baird, J. (1962). "The changing seasons: a summary of the fall migration." Audubon Field Notes **16**(1): 4-6.
Over 10,000 collision casualties were reported from around the country during fall 1961. A tower in Eau Claire, Wisconsin, caused 5,097 of these casualties while two TV towers in Boston, Massachusetts, caused very few. Reports of negative findings are urged

Ganier, A. F. (1962). "Bird casualties at a Nashville TV tower." Migrant **33**(4): 58-60.
Three incidents at the 1,369-foot WSM-TV tower in Nashville, Tennessee, in fall 1962 resulted in losses of 301 birds (39 species) and 2 red bats. Weather data are included.

Laskey, A. R. (1962). "Migration data from television tower casualties at Nashville." Migrant **33**(1): 7-8.
Daily searches at the WSIX tower in fall 1961 resulted in 228 dead birds (52 species) recovered. One collection at WSM totalled 183 birds (27 species). Kill lists are provided.

Lupient, M. (1962). "Fall migration: western Great Lakes region." Audubon Field Notes **16**(1): 34-35.
From 2 September to 10 October 1961, 5,097 birds were collected at the Eau Claire, Wisconsin, TV tower. These were estimated to be 10-20 percent of the actual total kill.

Stevenson, H. M. (1962). "Fall migration: Florida region." Audubon Field Notes **16**(1): 21-25.
During fall 1961, 1,212 birds were found dead at the WCTV tower near Tallahassee, Florida. On 17 September, 1,100-1,200 birds died at the Jacksonville towers.

Strnad, F. (1962). "Birds killed at the KROC-TV tower, Ostrander, Minnesota." Flicker **34**(1): 7-9.
Five kills during September and October 1961 totalled over 2,000 birds (66 species) at this 1,314-foot tower. During 3-4 September, 526 dead birds were collected out of an estimated 1,500-2,000 killed. Overcast conditions prevailed during the incidents.

Baumgartner, F. M. (1963). "Fall migration: southern Great Plains region." Audubon Field Notes **17**(1): 45-46.
An unspecified number of birds were killed at an Oklahoma City, Oklahoma, TV tower in September 1962.

Caldwell, L. D. and N. L. Cuthbert (1963). "Bird mortality at television towers near Cadillac, Michigan." Jack-Pine Warbler **41**(2): 80-89.
From 26 September to 16 October 1961, 812 birds (42 species) were collected at the 1,295-foot WWTV tower near Cadillac, Michigan. A comparison other revealed the fall mortality to be most like the kills reported from Nashville, Tennessee, and Eau Claire, Wisconsin. In spring 1962, 74 birds (27 species) were found at WWTV and 125 (36 species) were collected from a nearby 1,130-foot tower. The species composition was markedly different from the fall.

Feehan, J. (1963). "Destruction of birdlife in Minnesota - Sept. 1963. Birds killed at the Ostrander television tower." Flicker **35**(4): 111-112.
A list of 1,250 birds (28 species) killed in Minnesota on a cloudy night in September 1963 is presented.

George, W. (1963). "Columbia tower fatalities." Bluebird **30**(4): 5.

On the nights of 20 and 21 September 1963, 941 birds (46 species) were killed at the KOMU-TV tower, Columbia, Missouri. A species list is given.

Green, J. C. (1963). "Destruction of birdlife in Minnesota - Sept. 1963. Notes on kills at Duluth on September 18/19." Flicker **35**(4): 112-113.
At the Duluth, Minnesota, ceilometer, 92 birds (17 species) were killed. The light was turned off to prevent further losses. Casualties totalled 35 (12 species) at the WDSM tower.

Heye, P. L. (1963). "Tower fatalities." Bluebird **30**(1): 7.
Over 300 birds (47 species) are listed from the kill at the KFVS-TV tower in Cape Girardeau, Missouri, during fall 1962.199. *Hiltunen, E. 1953. On electric and telephone wire accidents in birds. Suomen Riista 8:70-76, 222-223. (In Finnish; English summary.) Capercallie, black grouse, and other game birds were killed in wire collisions primarily in the fall when fog and rain were frequent. Of 225 observed strikes, 76.8 percent were fatal. Over 76 percent of the accidents occurred at twilight.

Janssen, R. B. (1963). "Destruction of birdlife in Minnesota - Sept. 1963. Birds killed at the Lewisville television tower." Flicker **35**(4): 110-111.
On the nights of 18 and 19 September, 924 birds (47 species) were killed at the 1,116-foot KEYC-TV tower. The nights were cloudy with drizzle. A list of the casualties is given.

Janssen, R. B. (1963). "Destruction of birdlife in Minnesota - Sept. 1963. Television towers in Minnesota." Flicker **35**(4): 113-114.
A list of Minnesota TV towers 500 feet high and over is given. The author notes that these towers are the ones most likely to kill birds. "There are a total of 172 radio and television towers 200 feet in height and over in Minnesota."

Laskey, A. R. (1963). "Casualties at WSIX TV tower in autumn, 1962." Migrant **34**(1): 15.
Daily searches from 6 September to 11 November 1962 yielded 243 dead birds (43 species) at the tower. A species list is given.

Laskey, A. R. (1963). "Mortality of night migrants at Nashville TV towers, 1963." Migrant **34**(4): 65-66.
On daily visits to three towers in Nashville, Tennessee, in fall 1963, 630 dead birds (62 species) were collected. Two kills occurred on clear nights.

Laskey, A. R. (1963). "Mortality of night migrants at Nashville TV towers." Migrant **34**(4): 65-66.

Manuwal, D. D. (1963). "TV transmitter kills in South Bend, Indiana, fall 1962." Indiana Audubon Quarterly **41**(3): 49-53.
Two towers (1,074 and 650 feet tall) produced 289 casualties (46 species) during fall 1961 and spring and fall 1962. Species lists by tower and other data are given.

Parmalee, P. W. and M. D. Thompson (1963). "A second kill of birds at a television tower in central Illinois." Bulletin of the Illinois Audubon Society **128**: 13-15.
At the WICS tower in Springfield, Illinois, 219 birds (31 species) were killed in one night. Weather is discussed in detail and comparisons with an earlier incident are made. A kill list is included.

Petersen, A. W. (1963). "Destruction of birdlife in Minnesota - Sept. 1963. Birds killed at Park Rapids." Flicker **35**(4): 113.

Following the densely foggy night of 15 September 1963, the main street of Park Rapids, Minnesota, "was littered with dead or dying birds" probably as a result of migrants being attracted to street lights and smashing into buildings.

Bagg, A. M. and R. P. Emery (1964). "The fall migration: northeastern maritime region." Audubon Field Notes **18**(1): 7-17.
The casualties (over 488 birds, mostly warblers) and weather at a lighthouse in the Bay of Fundy during fall 1963 are discussed at length

Baird, J. (1964). "The changing seasons." Audubon Field Notes **18**(1): 4-6.
During fall 1963, 33,406 birds were reported killed at towers and 488 at lighthouses in the United States and Canada. Most losses resulted from a single cold front that passed through Minnesota and southern Ontario during 18-21 September.

Coffey, B. B., Jr. (1964). "Two bird kills at WMC-TV, Memphis." Migrant **35**(2): 53.
On 7 and 8 May 1961, 19 dead warblers and vireos (11 species) were collected at the WMC-TV tower in Memphis, Tennessee. A second incident involving 99 birds (21 species), including 57 red-eyed vireos, occurred on 11 May 1964.

Cunningham, R. L. (1964). "Fall migration: Florida region." Audubon Field Notes **18**(1): 24-28.
In September 1963, in Leon County, Florida, the largest kill ever (no data given) at the WFSU tower was reported. At the WCTV tower, 735 birds, including 80 bobolinks, were killed.

Cunningham, R. L. (1964). "Spring migration: Florida region." Audubon Field Notes **18**(4): 442-446.
In Leon County, Florida, 207 birds, including 150 thrushes, were found dead at the WCTV tower. The WFSU tower had small mortality numbers during the spring.

Green, J. C. (1964). "Fall migration: western Great Lakes region." Audubon Field Notes **18**(1): 33-34,39-42.
During 18-20 September 1963, extraordinary numbers of migrating birds passed through the Minnesota-Wisconsin area. At an Eau Claire, Wisconsin, tower, over 10,000 birds (45 species) were collected; total mortality was estimated at over 30,000. At Ostrander, Minnesota, an estimated 1,500 birds died based on 250 actually collected. In Lewisville, Minnesota, 924 birds (47 species) were collected, and about 100 more were killed at a ceilometer in Duluth. A slow-moving cold front with overcast skies was associated with these incidents.

Kemper, C. A. (1964). "A tower for TV: 30,000 dead birds." Audubon Magazine **66**(1): 86-90.
An estimated 30,000 birds were killed at the Eau Claire, Wisconsin, tower on the nights of 18 and 19 September 1963. Lists of the 10,195 birds (56 species) actually collected, and of 924 birds (47 species) killed on 20-21 September at Lewisville, Minnesota, are given. To explain the mass mortality of birds at towers, a theory is proposed in which migrants attempt to maintain a constant bearing with respect to the red tower lights (perceiving them as stars) and spiral closer to the structure, eventually striking guy wires.

Laskey, A. R. (1964). "Data from the Nashville TV tower casualties, autumn 1964." Migrant **35**(4): 95-96.
Kill totals in fall 1962 at WSM and WSIX were 1,275 (61 species) and 665 (58 species), respectively. The higher total from WSM may be due to its proximity to the city's bright lights and their attractive effect on migrants. Species lists of the kills are provided.

Bagg, A. M. (1965). "The changing seasons; spring migrants: the few and the many." Audubon Field Notes **19**(4): 438-446.
On the night of 26 April 1965, in thick fog, 150-175 birds landed on the deck of a tanker off the New Jersey coast. The only casualties were 23 Cape May warblers that apparently struck the ship's superstructure

Boso, B. (1965). "Bird casualties at a southeastern Kansas TV tower." Transactions of the Kansas Academy of Science **68**(1): 131-136.
The 1,200-foot KOAM-TV tower in Kansas was checked regularly for dead birds during the fall of 1963 (75 birds, 35 species) and spring 1964 (50 birds, 14 species). A species list, weather on the days of collection, and the distribution of casualties about the tower are given.

Case, L. D., H. Cruickshank, et al. (1965). "Weather causes heavy bird mortality." Florida Naturalist **38**(1): 29-30.
In early October 1964, 4,707 birds (37 species) were killed by striking brightly lit buildings, towers, cars, and other obstacles in Florida. "Clouds of birds" were reported circling buildings. Weather consisted of a low cloud ceiling, drizzle, and northerly winds. Warblers accounted for 98.7 percent of the casualties.

Cunningham, R. L. (1965). "Fall migration: Florida region." Audubon Field Notes **19**(1): 28-33.
Following the drizzly, hazy night of 6 October 1964, 4,707 birds (37 species) were found dead near the Indian River in Florida, the result of low-flying birds striking buildings, headlights and windshields; 98 percent were warblers (1,354 common yellowthroats and 322 blackpolls). Also, "moderate" bird kills were reported at towers in Daytona Beach and St. Augustine. Over 2,000 birds were killed during 6-8 October at two TV towers in Jacksonville; 95 percent of these fatalities were warblers.

Lahrman, F. W. (1965). "Regina and Lumsden TV tower bird mortalities, 1964." Blue Jay **23**(1): 18-19.
In Saskatchewan, Canada, six visits to towers in Lumsden and Regina from 20 August to 4 September resulted in the collection of over 500 dead birds (34 species). Kill lists are given.

Lister, R. (1965). "Fall Migration: Northern Great Plans Region." Audubon Field Notes **19**(1): 48-53.
Kills at three towers in Regina, Saskatchewan, Canada, are described. The towers were visited over a two-week period, with a total of 490 mortalities (36 species) recovered.

Scott, F. R. and D. A. Cutler (1965). "Fall migration: middle Atlantic coast region." Audubon Field Notes **19**(1): 21-24.
On the night of 11 September 1964, thousands of birds were killed at a 1,000-foot tower in Baltimore, Maryland. Over 300 ovenbirds were found among the 1,032 casualties (37 species) examined. More than 100 birds (23 species) died at a Lynchburg, Virginia, ceilometer on the night of 4 October.

Able, K. P. (1966). "Television tower mortality near Louisville." Kentucky Warbler **42**(2): 27-28.
Five kills totaling 25 birds of 16 species occurred at a 973-foot tower in Kentucky during fall 1965 in association with low pressure systems and frontal activity

Aldrich, J. W., R. R. Graber, et al. (1966). "Mortality at ceilometers." Auk **83**: 465-467.

Bernard, R. F. (1966). "Fall migration: western Great Lakes region." Audubon Field Notes **20**(1): 45-46.
On 6 September 1965, 7,085 dead birds (55 species) were collected at a tower near Eau Claire, Wisconsin. At least 500 birds died by striking lighted windows and a neon sign near Newberry, Michigan, on 26 September.

Caldwell, L. D. and G. J. Wallace (1966). "Collections of migrating birds at Michigan television towers." Jack-Pine Warbler **44**(3): 117-123.
The spring and fall species composition of dead birds found from 1959 to 1964 at seven sites are analyzed. Towers within 30 miles of each other had virtually the same species composition, while greater diversity of species occurred between more distant towers. Spring and fall species compositions were markedly different, possibly due to different migration routes for various species. Warblers and thrushes were the most common casualties.

Fisher, H. I. (1966). "Midway's deadly antennas." Audubon Magazine **68**(4): 220-223.
The effects of numerous antennas and guy cables on Midway Island's colony of Laysan albatrosses are discussed. At least 2,901 were killed in a 7-month period. Damage to other species is also mentioned.

Hall, G. A. (1966). "Fall migration: Appalachian region." Audubon Field Notes **20**(1): 41-45.
Several incidents were reported in fall 1965. A TV tower near Charleston, West Virginia, "produced a steady number of dead birds." On the foggy night of 24 September, "over a truckload" were killed at a microwave relay tower and a gasoline compressor station atop a mountain near Buckhannon, West Virginia. On 1 October, over 1,800 dead birds were found at a ski resort near Gatlinburg, Tennessee.

Hatch, D. R. M. (1966). "Fall migration: northern Great Plains region." Audubon Field Notes **20**(1): 61-64.
Mention is made of "large kills" of warblers, thrushes, and sparrows at TV towers in Winnipeg, Manitoba, Canada, in late September 1965.

Stevenson, H. M. (1966). "Fall migration: Florida region." Audubon Field Notes **20**(1): 30-35.
The largest November kill ever at WCTV, 770 birds, was recorded in 1965. November kills generally consist of wintering species.

Weston, F. M. (1966). "Bird casualties on the Penscola Bay Bridge (1938-1949)." Florida Naturalist **39**(2): 53-55.

Devitt, O. (1967). The birds of Simcoe County, Ontario. Barrie, Ontario, Canada, Brereton Field Naturalists' Club**:** 190.
Kills at the CKVR-TV tower at Barrie, Ontario, Canada, during 1960-67 are discussed. The numbers of deaths seemed to vary directly with the prevalence of fog and low ceiling during migration. In the seven years covered, 2,632 dead birds (63 species) were collected. The majority killed were thrushes, warblers, flycatchers and sparrows; a complete list is given.

Eaton, S. W. (1967). "Recent tower kills in upstate New York." Kingbird **17**(3): 142-147.
Bird mortality from collisions with towers on the Allegheny Plateau in New York is discussed, including a list of 57 species found dead during 1956. The author estimates that 10,000 songbirds are killed annually from tower collision in the area.

Elder, W. H. and J. Hansen (1967). "Bird mortality at KOMU-TV tower, Columbia, Missouri, fall 1965 and 1966." Bluebird **34**(1): 3-7.
A list of 851 dead birds (36 species) found in fall 1965 and 1966 at KOMU-TV, Columbia, Missouri, is given, with age and sex data on seven species from 1966. Some comparisons with data from other towers are included.

James, D. and H. H. J. Shugart (1967). "Fall migration: central southern region." Audubon Field Notes **21**(1): 45-47.
The comparatively low kill at the Nashville, Tennessee, towers in fall 1966 was attributed to mild weather.

Laskey, A. R. (1967). "Spring mortality of Blackpoll Warblers at a Nashville TV tower." Migrant **38**(2): 43.
Of the 160 birds (12 species) killed at the WSM tower on 14-15 May 1967, 115 (72 percent) were blackpoll warblers, an unusually high number for this species. During the entire spring, 173 birds (13 species) were killed. A list of the casualties is given.

Mayfield, H. (1967). "Shed few tears." Audubon Magazine **69**(3): 61-65.
Bird mortality is discussed in statistical terms. Tower losses may account for one million deaths annually, about 0.016 of 1 percent of the total estimated yearly mortality. Habitat destruction is cited as the main cause for concern for bird populations.

Petersen, P. C. j. (1967). "Fall migration: middlewestern prairie region." Audubon Field Notes **21**(1): 44-45.
At Columbia, Missouri, on 20 September 1966, 618 birds (32 species) were killed at the KOMU tower. In Floyd County, Indiana, on 22-23 September, 123 birds died. At a tower in Dayton, Ohio, 305 birds (49 species, mostly red-eyed vireos, golden-crowned kinglets, and ovenbirds), died during fall 1966.

Robbins, S. D. (1967). "Fall migration: western Great Lakes region." Audubon Field Notes **21**(1): 36-38, 42-44.
On 14 September 1966, 2,117 birds (37 species) died at a tower in Eau Claire, Wiscon-sin. Similarities were noted between the most abundant species in the kill and those recorded in the field. Robbins discusses the difficulty in judging migration by just one method.

Stoddard, H. L. s. and R. A. Norris (1967). Bird casualties at a Leon County, Florida TV tower: an eleven-year study. Tall Timbers Research Station Bulletin. Tallahassee, Florida**:** 104.
A study begun by Stoddard in 1955 is updated through 30 September 1966. In those eleven years, over 29,000 dead birds (170 species) were collected. Most losses were in the fall. Spring kills were composed of species that bred abundantly in that area. Dangerous weather may cause differential mortality among species, sexes, and age classes.

Hall, G. A. (1968). "Fall migration: Appalachian region." Audubon Field Notes **22**(1): 37-40.
On 7 October 1967, 380 birds (42 species) were killed at a tower atop a ridge near St. Alban's, West Virginia.

Laskey, A. R. (1968). "Television tower casualties at Nashville, autumn 1967." Migrant **39**(2): 25-26.
The fall kill in 1967 was the lowest to date: 251 birds (40 species) at WSM and 98 (27 species) at WSIX. Lists of the kills are given.

Petersen, P. C. j. (1968). "Fall migration: middlewestern prairie region." Audubon Field Notes **22**(1): 48-50.

At the WHIO tower in Dayton, Ohio, 348 birds (45 species, mostly red-eyed vireos and warblers) were killed from 9 September to 15 November 1967. At a tower in Floyd Knobs, Indiana, over 78 birds (mostly thrushes and warblers) died on 6 and 7 October.

Alsop, F. J., III and G. O. Wallace (1969). "Spring tower-kill in Knox County." Migrant **40**(3): 57-58.
Twenty casualties (ten species) were collected at the WTKV tower in Tennessee following the night of 7-8 May, 1969. A list of the losses is given including measurements of weight, length, tail, bill, tarsus, and gonad size. Weather data are also included.

Bagg, A. M. (1969). "The changing seasons." Audubon Field Notes **23**(1): 4-12.
During September and October 1968, kills were reported from towers in Manitoba, Canada, and the states of Wisconsin, New York, Ohio, Tennessee (1,800 ovenbirds among the casualties at Nashville), and Florida (853 birds of 80 species at WCTV near Tallahassee)

Kale, H. W., II, , M. H. Hundley, et al. (1969). "Tower-killed specimens and observations of migrant birds from Grand Bahama Island." Wilson Bulletin **81**(3): 258-263.
During the night of 21 October 1966, 136 birds (22 species) were killed at two small towers (200 and 400 ft). About half of the kill consisted of gray-cheeked thrushes and blackpoll warblers. Weather conditions are discussed.

Laskey, A. R. (1969). "TV tower casualties at Nashville in autumn 1968." Migrant **40**(2): 25-27.
Daily monitoring of WSM from late August through early November 1968 yielded 5,537 dead birds (73 species). Of these, 5,408 were killed on the night of 25 September, 81 percent of which were warblers. The WSIX tower was not checked daily; only 197 dead birds (39 species) were collected there.

Laskey, A. R. (1969). "Autumn 1969: TV tower casualties at Nashville." Migrant **40**(4): 79-80.
Kill lists are given from WSM (1,602 birds, 57 species) and WSIX (307 birds, 51 species).

Niles, D. M., S. A. Rohwer, et al. (1969). "An observation of midwinter nocturnal movement and tower mortality of tree sparrows." Bird-Banding **40**(4): 322-323.
In late January 1969, near Lawrence, Kansas, 19 tree sparrows were killed at a 600-foot tower and two died at a 300-foot microwave tower. This is taken as evidence for occasional extensive mass midwinter movements by this species, probably in response to bad weather.

Pierce, M. E. (1969). "Tall television tower and bird migration." South Dakota Bird Notes **21**(1): 4-5.
Two sizable kills occurred in 1965 at the 1,117-foot KSOO tower near Flandreau, South Dakota. During the night of 27 March, 578 horned larks died in a sudden snowstorm by colliding with the windows of the transmitter building or with the tower. Early in the morning of 14 September, 102 birds (32 species) were killed, mainly by striking windows on the building. A kill list is given. No other incidents involving more than a few birds occurred from July 1960 to May 1968.

Purrington, R. D. (1969). "Fall migration: central southern region." Audubon Field Notes **23**(1): 65-70.
At the WSM tower in Nashville, Tennessee, 5,408 birds (4,857 warblers) died the night of 25 September 1968. This figure is more than half of the total mortality from Nashville towers and ceilometers in the past 20 years.

Robbins, S. D. (1969). "Fall migration: western Great Lakes region." Audubon Field Notes **23**(1): 55-56, 64.
A kill of over 2,000 birds occurred at the WEAU tower in Eau Claire, Wisconsin, on 19-20 September 1968; 145 birds died on 18-19 October, two weeks later than any previous kill at this site. The October kill was composed chiefly of kinglets and late migrant warblers.

Robertson, W. B. j. and J. C. Ogden (1969). "Fall migration: Florida region." Audubon Field Notes **23**(1): 35-40.
In fall 1968, 853 birds (80 species) died at the WCTV tower, Tallahassee, Florida.

Fisher, H. I. (1970). "The death of Midway's antennas." Audubon Magazine **72**(1): 62-63.
Antennas on Midway Island were responsible for the deaths of more than 3,000 Laysan albatrosses in 1964 and 1965. Avian collision deaths stopped after the antennas were removed.

Herbert, A. D. (1970). "Spatial disorientation in birds." Wilson Bulletin **82**(4): 400-419.
The author proposes that bird collisions with human-made lighted structures occur when the birds become spatially disoriented within a bright light because of the loss of true visual cues to the horizontal. The light source may be either a direct beam, such as an airport ceilometer, or the refracted and reflected light from the aircraft warning lights on tall towers during rainy, misty weather. The author illustrates his theory using the case of 58 blackburnian warblers that were killed flying into brightly lit buildings at a Royal Canadian Air Force Base in September 1961 and published accounts by various authors in the literature.

Rosche, R. C. (1970). "The fall migration: western New York and northwestern Pennsylvania." Audubon Field Notes **24**(1): 43-47.
Over 300 casualties from the Elmira, New York, tower in fall 1969 are summarized. Bay-breasted warblers were the most common victims.

Bagg, A. M. (1971). "The changing seasons." American Birds **25**(1): 16-23.
Lists are given for 55 species killed during late September at the Empire State Building and eight towers in the eastern U.S.

Bellrose, F. C. (1971). "The distribution of nocturnal migrants in the airspace." Auk **88**(2): 397-424.
Following the overcast night of 30 September 1965, ten birds of eight species were picked up at a TV transmission tower near Peoria, Illinois.

Crawford, R. L. (1971). "Predation on birds killed at TV tower." Oriole **36**(4): 33-35.
To test the effects of scavengers at the WCTV tower near Tallahassee, Florida, 157 marked dead birds were placed out over a period of five nights. The nightly loss of test birds to scavengers was between 64 percent and 100 percent. The author concludes that serious attention must be paid to the predator/scavenger problem at towers if meaningful data are to be obtained.

Goodwin, C. E. and R. C. Rosche (1971). "The fall migration: Ontario." American Birds **25**(1): 49-54.
On the night of 13 September 1970, "extensive casualties" (mostly ovenbirds and other warblers) were recorded at London, Ontario, TV towers, and 136 birds were killed at the 1,000-foot Toronto-Dominion Centre.

Kale, H. I. (1971). "The spring migration: Florida region." American Birds **25**(4): 723-725,730-735.
Bird kills (2,500 birds, 42 species of mostly warblers) are reported from five towers and several buildings on Cape Kennedy in a one-month period.

Laskey, A. R. (1971). "TV tower casualties at Nashville: spring and autumn, 1970." Migrant **42**(1): 15-16.
Ten birds (nine species) were killed at WSM in the spring. Fall losses totalled 3,683 birds (66 species) at WSM and 104 (21 species) at WSIX. On the drizzly night of 28 September, 3,482 birds (54 species) died at WSM and 78 were killed at WSIX. Warblers dominated the fall losses: 845 Tennessee warblers, 632 ovenbirds, 429 black-and-white warblers, and 420 magnolia warblers.

Petersen, P. C. j. (1971). "Fall migration: middlewestern prairie region." American Birds **25**(1): 64-66.
At a tower near Springfield, Illinois, 212 birds (28 species) died on 22-23 September 1970, and 37 birds (16 species) were killed on 13-14 October.

Rosche, R. C. (1971). "The fall migration: western New York and northwestern Pennsylvania." American Birds **25**(1): 54-57.
Regular monitoring of three locations in New York and Pennsylvania in fall 1970 yielded over 2,100 avian casualties (70 species). At the Elmira, New York, tower, 220 dead birds (40 species) were collected.

Scott, F. R. and D. A. Cutler (1971). "The fall migration: middle Atlantic Coast region." American Birds **25**(1): 36-40.
On 28 September 1970, 1,965 birds (43 species) died at the WBAL-TV tower in Baltimore, Maryland. Ovenbirds (489) and red-eyed vireos (410) dominated the kill. Extensive mortalities were reported from the Chesapeake Bay Bridge-Tunnel.

Sharp, B. (1971). "Heavy mortality of migrating birds at Madison's TV towers." Passenger Pigeon **33**(4): 203-204.
On the night of 23 September 1968, 493 birds (33 species) were killed at four towers in Madison, Wisconsin. Weather data and kill lists are given. Thrushes, warblers, and vireos comprised 98 percent of the losses.

Avery, M. and T. Clement (1972). "Bird mortality at four towers in eastern North Dakota: Fall 1972." Prairie Naturalist **4**(3/4): 87-95.
During fall 1972, 561 dead birds (88 species) and five red bats were collected at four towers in North Dakota, two of which exceed 2,000 feet and are reportedly the tallest in the world. (The species most frequently killed at the Omega tower, farther south and west than the other three towers, were characteristic of marsh and prairie grassland areas. Species killed near the other three towers were characteristic of forest and forest edge habitats.) Species lists of the casualties are given and scavenger activity at the sites is discussed.

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Browne, M. M. and W. Post (1972). "Black rails hit a television tower at Raleigh, North Carolina." Wilson Bulletin **84**(4): 491-492.
A black rail was found dead at the 1,175-foot WRAL tower in Raleigh, North Carolina, on 19 September 1969 and anotheron 27 September 1970.

Knauth, O. (1972). Hundreds of birds die after hitting TV tower. Des Moines Sunday Register**:** 1,3.
On the night of 7 September, 1972, 726 birds, including 406 warblers (22 species), were killed at a 2,000-foot TV tower at Alleman, Iowa. The kill followed the passage of a cold front through the area. A kill of 226 birds (46 species) on 11-12 May is mentioned.

Rosche, R. C. (1972). "The fall migration: western New York and northwestern Pennsylvania." American Birds **26**(1): 60-62.
In the western part of the region, 313 birds (26 species) were found dead at five towers during 29-31 August 1971. At Elmira, New York, 540 casualties (55 species, mostly warblers), the highest total for fall ever recorded, were collected. Of the losses, 225 occurred on 29-30 September and 78 (kinglets, juncos, sparrows) on 25 October.

Scott, F. R. and D. A. Cutler (1972). "Fall migration: middle Atlantic coast region." American Birds **26**(1): 41-45.
A kill of 180 birds, mostly warblers, occurred at a Baltimore, Maryland, tower on 28-29 September 1973.

Teulings, R. P. (1972). "The fall migration: southern Atlantic coast region." American Birds **26**(1): 45-50.
Two towers were checked regularly for casualties during fall 1971. The 1,960-foot WECT tower at Bladen County, North Carolina, totalled 1,706 dead birds (75 species), and the 1,250-foot WWAY tower at Boiling Springs, North Carolina, accounted for 970 (with 958 on a single night). Partial kill lists and unusual records are given for the seven largest single-night kills. Warblers predominated overall.

Able, K. P. (1973). "The changing seasons." American Birds **27**(1): 19-23.
In fall 1972, single night kills exceeding 1,000 birds occurred at TV towers in Tennessee and Florida, and two events occurred at the floodlit chimneys of the Lanais, Ontario, Canada, power plant.

Ball, R. E. (1973). "Bird mortality at towers in Marysville, Missouri: Fall 1972." Transactions, Missouri Academy of Science **7/8**: 294.
Three small towers (250, 400, and 408 feet tall) were checked for dead birds from 5 September to 16 November 1972. No large single-night kills were recorded, and altogether 71 birds of 33 species, mostly sparrows, were recovered. Most were believed to have collided with guy wires rather than the towers themselves. (Abstr.)

Bierly, M. L. (1973). "1971 fall television tower casualties in Nashville." Migrant **44**(1): 5-6.
In what was described as an "average season," 990 birds (52 species) died at the WSM tower and 135 (24 species) at WSIX in Nashville, Tennessee.

Herndon, L. R. (1973). "Bird kill on Holston Mountain." Migrant **44**(1): 1-4.
At two installations near Elizabethton, Tennessee, 1,801 birds (44 species) were killed by colliding with floodlit buildings and two small (125 and 85 feet) towers. The weather was foggy with northwesterly winds on 30 September and 1 October 1972 when the losses occurred. A kill list is given.

Kleen, V. M. and L. Bush (1973). "The fall migration: middlewestern prairie region." American Birds **27**(1): 66-70.
During the night of 1 September 1972, tower kills occurred at Springfield (735 birds, 35 species) and Charleston (137 birds), Illinois.

Stevenson, H. M. (1973). "The fall migration: Florida region." American Birds **27**(1): 45-49.
In early October 1972, 193 birds (39 species) were killed at the WCTV tower near Tallahassee, Florida, and about 1,000 birds died at Jacksonville.

Taylor, W. K. and B. H. Anderso (1973). "Nocturnal migrants killed at a central Florida TV tower: autumns 1969-1971." Wilson Bulletin **85**(1): 42-51.

Taylor, W. K. and B. H. Anderson (1973). "Nocturnal migrants killed at a central Florida TV tower: autumns 1969-1971." Wilson Bulletin **85**(1): 42-51.
During the three fall seasons, 7,782 birds (82 species) were killed at the 1,481-foot WDBO tower near Orlando, Florida. The losses are listed by species in half-month intervals, and an annotated species list with sex and age information is given. One Florida yellow bat was also collected. Information on weather and lighting is included.

Crawford, R. L. (1974). Bird casualties at a Leon County, Florida TV tower: October 1966-September 1973. Tallahassee, Florida**:** 27.
During the seven years covered in this report, over 5,500 casualties and seven new species were collected at the WCTV tower in Florida, bringing the total losses to about 35,000 (177 species) in 18 years of continuous monitoring. Monthly species lists are given for the last seven years, and the total kill is presented by spring and fall months for each year 1955-1973. Much of this report is devoted to the problem of scavengers removing tower casualties. An extensive literature review is included in the introduction.

Edscorn, J. B. (1974). "The fall migration: Florida region." American Birds **28**(1): 40-44.
The unusually low kill at the WCTV tower near Tallahassee, Florida, in fall 1973 was attributed to very clear weather.

Goodpasture, K. A. (1974). "Fall 1972 television tower casualties in Nashville." Migrant **45**(2): 29-31.
At the WSM and WSIX towers in Nashville, Tennessee, 556 dead birds (58 species) were collected in fall 1972, the lowest fall total since 1967. The kills were associated with low ceilings and the passage of cold fronts. On 18 October, 141 birds were found dead at the WSM tower, but none were recorded at WSIX on that date. Complete species lists are given.

Goodpasture, K. A. (1974). "Fall 1973 television tower casualties in Nashville." Migrant **45**(3): 57-59.
Almost daily checks of the WSM and WSIX towers in Nashville, Tennessee, in September and October 1973 resulted in 165 dead birds found (42 species), the lowest seasonal total since regular monitoring began. Weather was generally mild throughout the fall. Following a clear night, 49 dead birds were collected on 6 October. The WSM tower had recently been painted bright orange and the guy wires were painted with aluminum paint, but it is doubtful if this had any effect on the kill. Lists of the losses are given.

Taylor, W. K. and B. H. Anderson (1974). "Nocturnal migrants killed at a central Florida TV tower: autumn 1972." Florida Field Naturalist **2**(2): 40-43.
During the fourth season of monitoring losses at an Orlando, Florida, tower, 1,347 birds (49 species) were collected, 89 percent of them warblers. The four-year total losses were

9,130 birds (89 species). A kill list for fall 1972 is provided by half-month periods. This tower collapsed in June 1973.

Teulings, R. P. (1974). "The fall migration: southern Atlantic coast region." American Birds **28**(1): 37-40.
A major kill consisting of about 600 casualties was reported from the WECT tower in Bladen County, North Carolina, on the night of 30 September 1973.

Weir, R. D. (1974). "Bird kills at the Lennox generating plant, spring and autumn 1974." Blue Bill **21**(4): 61-62.
Floodlights illuminating the 650-foot chimneys of the Ontario, Canada, power plant were dimmed from 15 April to 8 June and from 9 August to 2 October 1974, but birds were still killed, with 92 casualties in the spring and 1,188 in the fall (35 species overall). Since the first chimney was built in fall 1972, 5,288 birds were killed. In 1974, 98 percent of the casualties were warblers and vireos, with magnolia warblers (33 percent) and red-eyed vireos (11 percent) the most common casualties. Large kills occurred on the clear nights of 13-14 September (501 killed) and 14-15 September (508 killed). On both nights, winds were strong and flight call counts indicated that birds were flying lower than usual. Migrants were easily seen in the glow of city lights. In anotherincident on the weekend of 15 September, 1,524 birds were killed at a new 1,200-foot tower in Barrie, Ontario. Lists of casualties by date of collection and a summary of flight call counts and weather conditions are given.

Avery, M. L., P. F. Springer, et al. (1975). Progress report on bird losses at the Omega Tower, Southeastern North Dakota.

Edscorn, J. B. (1975). "The fall migration: Florida region." American Birds **29**(1): 44-48.
Included among the fall 1974 casualties at the WCTV tower in Florida were 971 birds on the night of 17 October.

Goodpasture, K. A. (1975). "Nashville tower casualties, 1974." Migrant **46**(3): 49-51.
A new low (123 birds, 34 species) in fall casualties was recorded at the WSM and WNGE (formerly WSIX) towers in Nashville, Tennessee. As in fall 1973, the weather was "without notable nocturnal violence or stormy force." No clear explanation of the low kills in 1973 and 1974 was obvious, but increased scavenger activity may have been partly responsible. A kill of about 700 birds on 15 September was reported at a tower in Decatur, Alabama. Lists of the Nashville kills are given.

Goodpasture, K. A. (1975). "Nashville television tower casualties, 1975." Migrant **47**(1): 8-10.

Goodwin, C. E. (1975). "The winter season: Ontario region." American Birds **29**(1): 48-57.
During fall 1974, kills at the Lennox power plant chimney and the Barrie and London TV towers in Ontario, Canada, totalled 7,550 birds. Red-eyed vireos (1129), ovenbirds (1038), and magnolia warblers (920) were the species most commonly killed.

Gregory, H. (1975). "Unusual fall tower kill." Bluebird **42**(4): 9-10.
On the night of 14 October 1975, over 98 birds (20 species) were killed at four towers in Missouri and Kansas. The KCMO tower in Kansas City, Missouri, accounted for 67 casualties including 32 mourning doves. The incidents were unusual because KCMO is free-standing (*i.e.*, no guy wires) and the cloud ceiling was rather high (5,000-10,000 feet). A listing of casualties by tower is given.

Hall, G. A. (1975). "The fall migration: Appalachian region." American Birds **29**(1): 57-61.

In fall 1974, tower kills were reported from Knoxville, Tennessee (no data), and Youngstown, Ohio (268 birds).

Hoskin, J. (1975). "Casualties at the CKVR-TV tower, Barrie." Nature Canada **4**(2): 39-40.
During August and September 1974, 4,900 dead birds were collected at the newly constructed, 1,000-foot tower in Ontario, Canada. Large kills occurred in September on the 10th (409 birds), 13th (704), 14th (371), and 21st (1,523). Among the casualties were 1,000 bay-breasted warblers and 900 ovenbirds. Other species with high losses were the northern parula, northern waterthrush, Cape May warbler, and rose-breasted grosbeak.

Kibbe, D. P. (1975). "The fall migration: western New York and northwestern Pennsylvania." American Birds **29**(1): 53-57.
On the cloudy evening of 21 September 1974, the largest recorded tower kill at the Elmira, New York, TV tower occurred. At least 844 birds (35 species) were killed, bringing the season's total kill at that tower to over 1,200 (44 species).

Mosman, D. (1975). "Bird casualties at Alleman, Iowa TV tower." Iowa Bird Life **45**(3): 88-90.
Casualties at this 2,000-foot tower numbered 1641 (67 species) in fall 1973, 212 (37 species) in spring 1974, and 3,521 (57 species) in fall 1974. The tower was usually checked following overcast nights. However, 496 birds were killed on the night of 13 September 1974 when visibility was excellent. The author estimates 10 percent of the kill was not found due to heavy ground cover. Very few dead birds were found beyond 200 feet from the tower. Complete kill lists for all three seasons are provided.

Norman, J. L. (1975). "Birds killed at a TV tower near Coweta, Oklahoma." Bulletin of the Oklahoma Ornithological Society **8**(3): 25-27.
Among the 177 birds (28 species) killed at the KTUL tower on 9 October 1974 were 64 Nashville warblers. Smaller kills (24 birds, 12 species) were recorded in late September. All casualties are listed.

Strnad, F. (1975). "More bird kills at KROC-TV tower, Ostrander, Minnesota." Loon **47**(1): 16-21.
The author summarizes previous mortality at this tower and adds findings from the autumns of 1972 (185 birds, 32 species), 1973 (726, 59), and 1974 (801, 38). Complete kill lists from 1961, 1962, and the present study are given. Among the 3,507 casualties (84 species) listed, northern waterthrushes (619) and red-eyed vireos (516) were the most common. A description of the 1,300-foot tower and its lights and guy wires, details of the method of search, and weather conditions on kill nights are also provided.

Teulings, R. P. (1975). "The fall migration: southern Atlantic coast region." American Birds **29**(1): 40-43.
An estimated 4,000 birds were killed on the night of 4 September 1974 at a tower in Bladen County, North Carolina.

Zimmerman, D. A. (1975). "The changing seasons." American Birds **29**(1): 23-28.
In fall 1974, thousands of birds died at TV towers in nine states and two Canadian provinces, and 150 birds were killed at a 600-foot smokestack at a New Mexico smelter.

Avery, M. L., P. F. Springer, et al. (1976). "The effects of a tall tower on nocturnal bird migration - a portable ceilometer study." Auk **93**(2): 281-291.

Bartolo, B. (1976). "Bird kill at [Ohio] TV tower." Redstart **43**: 109.

Reports kill of 1,057 birds of at least 39 species (30% Ovenbirds) due to collision with 1,085-ft WFMJ-TV tower in Youngstown, 18-27 September 1975.

Carter, J. H. I. and J. F. Parnell (1976). "TV tower kills in eastern North Carolina." Chat **40**(1): 1-9.
A large bird kill occurred in October 1970 (over 1,000 birds, 39 species) at the 1,994-foot WECT tower in North Carolina. In fall 1971 and 1972, regular checks (after the passage of cold fronts and after mostly cloudy nights) were made at WECT and at the 1,188-foot tower 30 miles away. Losses in 1971 (2,683 birds) were typically associated with the passage of cold fronts when low ceilings and north winds prevailed. In 1972, cold fronts passed quickly through the area and only 387 casualties were found. The authors note that many carcasses were no doubt overlooked in the vegetation at the tower sites and there was much evidence of predator/scavenger activity. A combined annotated species list is given.

Crawford, R. L. (1976). "Some old records of TV tower kills from southwest Georgia." Oriole **41**(4): 45-51.
This article presents previously unreported data, originally collected by H.L. Stoddard, Sr., and R.A. Norris, on bird losses at the WALB and WRBL-WTVM towers in southwestern Georgia. On 28 visits to the WALB tower from 1959 to 1963, 613 birds (no total species count) were collected. Many of the carcasses were disturbed by scavengers, and tall grass around the station grounds made it impossible to find birds over much of the area. Frontal activity and other weather conditions associated with kills on 12-13 September 1959, 7-8 September 1962, and 17-18 October 1962 are described. The species composition between kills at WALB and WCTV in Tallahassee, Florida (about 80 km SW), were significantly similar on the first two nights, but not on the third. Species lists for the three dates at both towers are given. Two kills were recorded at the WRBL-WTVM tower: 18 birds on 23 April and 60 on 18 September 1962.

Goodpasture, K. A. (1976). "Nashville tower casualties, 1975." Migrant **47**(1): 8-10.
Casualties numbered 513 (53 species) at the WSM and WNGE towers in Nashville, Tennessee, in fall 1975. The weather was generally mild, with fronts of low intensity. Warblers (22 species) accounted for two-thirds of the losses. Cats were noticeable scavengers. A complete kill list is given.

Hall, G. A. (1976). "The fall migration: Appalachian region." American Birds **30**(1): 67-71.
In fall 1975, 1,031 dead birds were collected at a Youngstown, Ohio, TV tower and 364 were found at a Pittsburgh, Pennsylvania, tower. Near Morgantown, West Virginia, a small kill occurred at a mountaintop fire tower. There was partial correspondence between the tower kills and other migration indicators, such as banding results.

Kibbe, D. P. (1976). "The fall migration: Niagara-Champlain region." American Birds **30**(1): 64-66.
Over 800 dead birds (40 species) were collected at the Elmira, New York, TV tower on 19 September 1975 following a night of low overcast. Included were 198 bay-breasted warblers, 110 magnolia warblers, and 78 ovenbirds. A kill at an Erie County, New York, tower on 8 September included five pine warblers.

Norman, J. L. (1976). "Birds killed at a TV tower near Coweta, Oklahoma." Bulletin of the Oklahoma Ornithological Society **9**(3): 20.
During 12-15 September 1975, 99 birds (27 species) were collected at the KTUL tower. Casualties are listed by date.

Weir, R. D. (1976). Annotated bibliography of bird kills at man-made obstacles: a review of the state of the art and solutions. Ottawa, Canadian Wildlife Services, Ontario Region**:** 85.
A 28-page introduction to this bibliography summarizes what is known about bird migration and the effects of weather on migration and mortality. It also includes a literature review on bird losses at lighthouses, ceilometers, floodlit obstacles, towers, tall buildings, and telephone and power lines. A list of TV towers of various heights throughout the United States is included. "Nocturnal bird kills are virtually certain wherever an obstacle extends into the air space where birds are flying in migration. The time of year, siting, height, lighting and cross-sectional area of the obstacle and weather conditions will determine the magnitude of the kill." Four hundred seventy-one references, most with brief descriptions, are included.

Whelan, P. (1976). "The bird killers." Ontario Naturalist **16**(4): 14-16.
Known sites of bird mortality in Toronto, Canada, are reviewed. Forty buildings and two towers are listed, including an 1,815-foot tower where 274 dead and injured birds were found on 30 August 1976. (This article was reprinted from the *Toronto Globe and Mail,* 17 September 1976).

Alerstam, T. and J. Karlsson (1977). Fåglarnas flyghöjder och fågelkollisioner med byggnadsverk. En utredning för bedömning av risken för fågelkollisioner med vindkraftverk. Lund, Department of Zoology, Univ. of Lund**:** 29.

Avery, M., P. F. Springer, et al. (1977). "Weather influences on nocturnal bird mortality at a North Dakota tower." Wilson Bulletin **89**(2): 291-299.
Mortality at the 366-meter Omega tower in North Dakota in 1972 and 1973 is examined relative to nightly cloud and wind conditions. Most fall losses occurred under overcast skies associated with the passage of cold fronts as migrant species milled about the tower. However, 58 percent of the spring losses took place on non-overcast nights, mainly through collisions with outlying guy wires: rails and fringillids were killed mostly on non-overcast nights, while warblers died in greater numbers on overcast nights; warblers tended to be killed much closer to the central, lighted structure than were fringillids; and non-passerines suffered substantially greater losses far from the tower than did passerines, especially on non-overcast nights. Behavioral differences noted by other investigators are included as well.

Barkley, R., C. Elk, et al. (1977). "Recent TV tower kills at Goodland, Kansas." Kansas Ornithol. Soc. Bull: 10-12.
Of 390 birds of 30 species found dead at 700-ft KLOE-TV tower in Sherman County, 28-30 August 1976, 40% were Yellow-headed Blackbirds and Wilson's Warblers.

Hall, G. A. (1977). "The fall migration: Appalachian region." American Birds **31**(2): 176-179.
About 200 birds died at the Youngstown, Ohio, tower in fall 1976, and a kill was reported (no data) at a Morgantown, West Virginia, fire tower on 3 October.

Karlsson, J. (1977). "Fågelkollisioner med master och andra byggnadsverk. (Bird collisions with towers and other man-made constructions.)." Anser **16**: 203-216.

Karlsson, J. (1977). "Fågelkollisioner med master och andre byggnadsverk." Anser **16**: 203-216.

Lid, G. (1977). "Fugler brennes ihjel av gassflammer i Nordsjøen." Fauna **30**: 185-190.

Mehlum, F. (1977). "Innsamling av fyrfalne trekkfugler fra Færder fyr og noen betraktninger om årsakene til fuglekollisjoner mot lysende installasjoner." Fauna **30**: 191-194.

Norman, J. L. (1977). "Birds killed at a TV tower near Coweta, Oklahoma in the fall of 1976." Bulletin of the Oklahoma Ornithological Society **10**(1): 6-8.
During September and October 1976, 166 dead birds (49 species) were collected at the KTUL tower. A list of the casualties by date of collection is given.

Rudström, P. (1977). "Något om fågelkollisioner med TV-masten i Sunne." Värmlandsornitologen **5**: 53-54.

Seets, J. W. and H. D. Bohlen (1977). "Comparative mortality of birds at television towers in central Illinois." Wilson Bulletin **89**(3): 422-433.
From August to December 1972, seven towers ranging from 185 to 484 meters tall were checked for dead birds on mornings following nights of fog or overcast. A total of 5,465 dead birds (79 species) was collected, with 60 percent of the losses occurring on the night of 26 September. Most birds were killed on nights with cloud ceilings of 550 m or less. There was "no consistent relationship between tower height, terrain, or tower location and number of birds killed." It is believed that the number of birds killed on a given night is dependent on local weather conditions and the number of birds aloft.

Weir, R. D. (1977). "Bird kills at the Lennox generating plant, spring and autumn 1977." Blue Bill **24**(4): 40-42.
For the sixth straight year, kills were reported at the chimneys of the Ontario Hydro plant at Bath, Ontario, Canada. The total of 2,699 (61 species) casualties, of which 2,575 were fall migrants, was the largest since the first chimney was constructed in 1972. Due to a change in floodlighting procedures, the lights were inadvertently left on during nights of heavy migration and several large kills resulted. On 23 August, 908 birds were killed under overcast skies before the lights were extinguished at 0117. Similarly, 1,172 birds died on the night of 19 September, during a driving rain. The lights were not turned off until 0500. The sky was clear on the night of 12 September and the floodlights were not used, partly in response to the public reaction to the kills that were reported in the *Toronto Globe and Mail.* The system of turning off floodlights during the spring and fall migration periods was in force prior to 1977 and will be resumed beginning spring 1978. A complete list of casualties is provided, and the 11,230 casualties recorded since fall 1972 are totalled by season.

Weir, R. D. (1977). "Bird kills at the Lennox generating station, spring and autumn 1977." Blue Bill **24**(4): 40-42.

Avery, M. L., P. F. Springer, et al. (1978). "The composition and seasonal variation of bird losses at a tall tower in Southeastern North Dakota." American Birds **32**(6): 1114-1121.

Benning, W. E. (1978). "Region 3: Finger Lakes." Kingbird **28**(1): 42-44.
During the cloudy, rainy period of 20-24 September 1977, a record 3,862 birds were found dead at the Elmira, New York, TV tower. On the night of 19 September alone, 1,817 birds of 39 species were collected. Of the 48 total species, 24 were warblers.

Crawford, R. L. (1978). "Autumn bird casualties at a northwest Florida TV tower: 1973-1975." Wilson Bulletin **90**(3): 335-345.
In fall 1973, 261 individuals of 57 species were collected at the 308-meter WCTV tower at Tall Timbers Research Station, Leon County, Florida. The following fall, 1,832 dead birds (87 species) were gathered. In 1975, 1,771 of 90 species were collected, totaling 3,864 individuals of 109 species for the three autumns. Age and sex classes were noted. In 1974 and 1975, a rigorous program of predator control was instituted.

Crawford, R. L. (1978). "Autumn bird casualties at a northwest Florida TV tower." Wilson Bulletin **90**(3): 335-345.
In fall 1973, 261 individuals of 57 species were collected at the 308-meter WCTV tower at Tall Timbers Research Station, Leon County, Florida. The following fall, 1,832 dead birds (87 species) were gathered. In 1975, 1,771 of 90 species were collected, totaling 3,864 individuals of 109 species for the three autumns. Age and sex classes were noted. In 1974 and 1975, a rigorous program of predator control was instituted.

Goodpasture, K. A. (1978). "Nashville tower casualties, 1976." Migrant **49**(3): 53-54.
In September and October 1976, 406 dead birds (43 species) were collected at two towers in Nashville, Tennessee. Ovenbirds had the highest count (63), followed by magnolia and bay-breasted warblers.

Welles, M. (1978). "TV tower kill at Elmira." Kingbird **28**(3): 159-161.
The bird mortality during 20-24 September 1977 at the WSYE TV tower, Elmira, New York, is documented. Weather during the period was rainy with low cloud ceilings. Daily kills for the five dates were 1,817, 1,358, 375, 132, and 180, respectively, totaling 3,862 birds of 44 species. Many more birds were killed but were not recoverable from fields and wooded areas surrounding the tower which is supported by 30 guy wires. Some carcasses were taken by crows. Bay-breasted warblers (1,226), Tennessee warblers (375), magnolia warblers (326), ovenbirds (311), and Swainson's thrushes (218) were the most numerous species. A Syracuse, New York, tower reported reduced losses following the installations of two telephone relay towers nearby.

Banks, R. C. (1979). Human related mortality of birds in the United States. Washington, D.C., U.S. Fish and Wildlife Service**:** 16.
Reports of mass mortality at radio and TV towers usually occur as a result of a particular weather pattern affecting a geographic area. Most reports of avian mortality at towers are based on single incidents of mass death, or at best, recoveries of dead birds over a short period of time. These are considered of little value in establishing an estimate of the number of birds that may be killed on an annual basis under "normal" conditions (*i.e.*, "a single instance of spectacular mass mortality may far exceed the normal annual mortality"). Several studies cited support an annual mortality rate of 2,500 birds per tower on average.

Stahlecker, D. W. and H. J. Griese (1979). "Raptor use of nest boxes and platforms on transmission towers." Wildlife Society Bulletin **7**(1): 59-62.
In 1974, nest boxes and platforms were placed on a 230-kV transmission line in semi-arid plains of east-central Colorado to evaluate their use by locally breeding raptors. Nest boxes increased the local breeding population of American kestrels from a minimum of six pairs to at least 25 pairs in three years. Raptors did not utilize the nesting platforms between 1975 and 1977, possibly due to an adequate number of natural nest sites and platforms being placed too low on the towers. Management issues surrounding artificial raptor nest sites are mentioned.

Avise, J. C. and R. L. Crawford (1981). "A matter of lights and death." Nat. Hist. **90**: 6-14.
This popular account, which draws heavily on data gathered at the WCTV tower in Leon County, Florida, emphasizes the beneficial uses made of tower-killed birds in a variety of scientific investigations.

Crawford, R. L. and W. W. Baker (1981). "Bats killed at a north Florida television tower: a 25-year record." J. Mammal. **62**: 651-652.
Summary of information on 7 species (54 individuals) found dead on 49 occasions at the WCTV tower in Leon County, Florida, 1955-1980.

Verheijen, F. J. (1981). "Bird kills at lighted man-made structures: not on nights close to full moon." Am. Birds **35**: 251-254.
Provides essentially identical analyses and discussion of the 2 data sets reported by Verheijen (1981b). Additionally, an independent analysis of the distribution, in relation to moon phase, of 47 nights on which bird kills were reported in North America, 1886-1975 (from Weir 1976), revealed a significant clustering between the new moon and the first quarter moon, with none of the kills occurring on or near the full moon. Suggests that "moonlight, whether weakend and scattered by clouds or not" can mitigate the disorienting effects of artificial light sources on migratory birds.

Verheijen, F. J. (1981). "Bird kills at tall lighted structures in the USA in the period 1935-1973 and kills at a Dutch lighthouse in the period 1924-1928 show similar lunar periodicity." Ardea **69**: 199-203.
The distribution, in relation to moon phase, of 62 nights on which bird kills were reported in the United States, 1935-1973, was non-uniform, with a highly significantly clustering around the new moon; none of the kills occurred on or near the full moon. Concludes that moon phase may be as important as weather conditions (e.g., cloud cover, visibility) in determining timing and magnitude of major kills.

Maehr, D. S., A. G. Spratt, et al. (1983). "Bird casualties at a central Florida power plant." Florida Field Naturalist **11**: 45-68.
On 23 September 1982, 1,265 birds (30 species from an estimated kill of 3,000) were collected below chimneys at the Crystal River Generating Facility, Citrus County, Florida. The most abundant numbers were white-eyed vireos (49 percent), northern parula (12 percent), red-eyed vireos (9 percent), common yellowthroat (7 percent), and palm warbler (5 percent). On 24 September, an estimated 2,000 birds were involved in chimney collisions. "A fan-shaped distribution of dead birds reflected the prevailing northerly winds." The authors stress the need to investigate lighting alternatives; lighting appears to attract birds under overcast conditions. Only 5 percent of deaths occurred at shorter chimneys (152 m) painted with alternating red and white bands and with flashing red lights. The taller chimneys were unpainted and had flashing white "strobe" lights.

Benson, P. C. and J. C. Dobbs (1985). Collisions of cape vultures (Gyps coprotheres) with towers. Annual Meeting, Raptor Research Foundation, Sacramento, California.
Forty-nine cape vulture carcasses were found at the base of a tower at the Kransberg (Republic of South Africa) vulture colony. Orange spheres were attached to the guy wires "to warn the vultures" and during the following fledging season, collisions decreased.

Smith, J. C. (1985). "Perching and roosting patterns of raptors on power transmission towers in SE Idaho and SW Wyoming." Raptor Research **19**(4): 135-138.
"As part of an ongoing raptor management program, 45 km of 345-kV transmission lines were surveyed from 5 June to 31 September 1983 to determine diurnal and nocturnal raptor use patterns." Golden eagles and red-tailed hawks perched mostly on upper, outer sections of towers at day and roosted on lower, inner sections at night.

Boshoff, A. and C. Fabricius (1986). "Black eagles nesting on man-made structures." Bokmakierie **38**(3): 67-70.
The authors believed this to be the first report of black eagles, Aquila verreauxii, nesting on human-made structures. Several eagles were found electrocuted in 1984 and 1985 at a communications tower near Hopetown, South Africa. Subsequent attention to the matter of bird use of towers for nesting resulted in greater awareness "of the need to preserve raptor nests on ... structures and to keep disturbance to an absolute minimum during the critical stages of the breeding season."

Larkin, R. P. and B. A. Frase (1988). "Circular paths of birds flying near a broadcasting tower in cloud." Journal of Comparative Psychology **102**: 90-93.

Klem, D., Jr. (1989). "Bird-window collisions." Wilson Bull. **101**(4): 606-620.
Survey reveals that about 25% (225) of 917 bird species in the U.S. and Canada have been documented striking windows. Birds fail to see windows as barriers and are vulnerable to them wherever they mutually occur.

Klem, D., Jr. (1990). "Collisions between birds and windows: mortality and prevention." J. Field Ornithol. **61**(1): 120-128.
The annual mortality resulting from window collisions in the United States is estimated to be at least 98 million, and possibly as many as 976 million, birds. Offers solutions for preventing collisions.

Klem, D. J. (1990). "Bird injuries, cause of death, and recuperation from collisions with windows." J. Field. Ornithol. **61**(1): 115-119.

Klem, D., Jr. (1991). Glass and bird kills: an overview and suggested planning and design methods of preventing a fatal hazard. Wildlife conservation in metropolitan environments.
Reviews the bird-glass issue and recommends that the building industry give serious consideration to the mortality of birds due to collision with glass windows.

Payn, W. H. (1991). "Magpies nesting on television aerials." British Birds **84**(11): 513.

Ball, L. G., K. Zyskowski, et al. (1995). "Recent bird mortality at a Topeka [Kansas] television tower." Kansas Ornithol. Soc. Bull. **46**: 33-36.
Summarize 4 major mortality events at a 439-m KTKA-TV tower in Shawnee County: 919 individuals of 54 species, 25-26 September 1985; 635 individuals of 49 species, 30 September-1 October 1986; 834 individuals of 64 species, 11-12 October 1986; 420 individuals of 45 species, 8-9 October 1994; cumulative totals of 2,808 individuals of 91 species. Gray Catbird and Sora were the most abundant species on both September dates, while Orange-crowned Warbler dominated on the October dates.

Ogden, L. J. E. (1996). Collision course: The hazards of lighted structures and windows to migrating birds. Toronto, Canada, World Wildlife Fund Canada (WWF) & Fatal Light Awareness Program (FLAP)**:** 46 pp.

Ogden, L. J. E. (1996). Collision Cource: The hazards of lightened structures and windows to migrating birds. Toronto, Ontario, World Wildlife Fund Canada/Fatal Light Awareness Program**:** 46.

Trapp, J. L. (1998). "Bird kills at towers and other man-made structures: An annotated partial bibliography (1960-1998)."

Jones, J. and C. M. Francis (2003). "The effects of light characteristics on avian mortality at lighthouses." Journal of Avian Biology **34**(4): 328-333. <Go to ISI>://000187792000003.
The generation of artificial light by human activity can have far-reaching detrimental impacts upon a wide variety of organisms. A great deal of attention has been paid to well-lit buildings, television towers, and communication towers as sources of mortality for nocturnally migrating songbirds. However, despite being among the first human structures known to generate migratory bird kills, little is known about the current impact of lighthouses on birds, or the impact of light design. We examined the impact of a lighthouse on nocturnal avian migrants at Long Point, Lake Erie, Ontario, Canada. From 1960-1989, mean annual

kills were 200 birds in spring, and 393 in autumn, with kills of up to 2000 birds in a single night. In 1989, the Long Point lighthouse was automated, with a simultaneous change in beam characteristics - the new beam is narrower and less powerful. This change brought about a drastic reduction in avian mortality at the lighthouse to a mean of only 18.5 birds per year in spring, and 9.6 in autumn from 1990-2002. Our results highlight the effectiveness of simple changes in light signatures in reducing avian light attraction and mortality during migration.

Avery, M. L. and A. C. Genchi (2004). "Avian perching deterrents on ultrasonic sensors at airport Wind-Shear Alert Systems." Wildlife Society Bulletin **32**(3): 718-725. <Go to ISI>://000224767400012.
Preventing birds from perching on the sensor units of the Federal Aviation Administration's Low Level Wind-shear Alert System (LLWAS) is crucial to its successful operation. In this study we evaluated, under controlled conditions, responses of brown-headed cowbirds (Molothrus ater), fish crows (Corvus ossifragus), great horned owls (Bubo virginianus), barred owls (Strix varia), and black vultures (Coragyps atratus) to several anti-perching devices. No device was totally successful against every species. Of the 5 original test devices, the most effective perching deterrent was a set of 17 stout spikes ("AgSpikes") secured to the central portion of the sensor unit that point up 00 to 300 from the vertical. The central spikes were subsequently redesigned and combined with 9 metal bushings (3 for each arm of the sensor unit) that fit loosely on the sensor arms and that were armed with 5 sharp spikes each. This "AgSpikes and SpikedSpinner" combination unit was as effective as the original AgSpikes for all birds except owls, which were able to place their feet within the open spaces of the redesigned AgSpike portion of the device and perch on the 3 horizontal spikes. The combination units should adequately discourage most large and small birds from perching on LLWAS sensors. The availability of alternate perches in the field will likely enhance the effectiveness of the deterrent. Monitoring performance of the combination units deployed in the field is recommended to verify that they are working as expected.

2.5 Fugl og solenergiinstallasjoner

McCrary, M. D., R. McKernan, et al. (1986). "Avian mortality at a solar energy power plant." Journal of Field Ornithology **57**: 135-141.

2.6 Fugl og radar

Able, K. P. (1970). "A radar study of the altitude of nocturnal passerine migration." Bird Banding **41**(4): 282-290.

Alerstam, T. (1972). "Nocturnal bird migration in Skåne, Sweden, as recorded by radar in autumn 1971." Ornis Scandinavica **3**(2): 141-152.

Alerstam, T. and S. Ulfstrand (1972). "Radar and field observations of diurnal bird migration in South Sweden, autumn 1971." Ornis Scandinavica **3**(2): 99-140.

Bruderer, B. and P. Steidinger (1972). "Methods of quantitative and qualitative analysis of bird migration with a tracking radar." NASA Spec. Publ. **262**: 151-167.

Alerstam, T., A. Lindgren, et al. (1973). "Nocturnal passerine migration and cold front passages in autumn - a combined radar and field study." Ornis Scandinavica **4**(2): 103-112.

Alerstam, T., C.-A. Bauer, et al. (1974). "Fält och radar studier av Östersjöejdrarnas *Somateria mollissima* vårsträck." Vår Fågelvärld **33**: 15-27.

Alerstam, T. and S. Ulfstrand (1974). "A radar study of the autumn migration of wood pigeons Columba palumbus in southern Sweden." Ibis **116**: 522-542.

Bruderer, B. (1976). "Zum Thema des Vogelzuges: Radarbeobachtungen - Orienterung - Zugphysiologie." Universitas **31**(2): 175-180.

Alerstam, T. (1977). "Fågelsträckets höjd." Anser **16**: 189-202.

Alerstam, T. (1977). Radarstudier av fågelflyttningen. Sveriges Naturs Årsbok**:** 225-232.

Larkin, R. P. and P. J. Sutherland (1977). "Migrating birds respond to Project Seafarer's electromagnetic field." Science **195**(2): 777-779.
Radar tracking of individual migrating birds flying over a large alternating current (AC) antenna showed that birds turned or changed altitude more frequently when the antenna system was operating than when it was not. These results suggest that birds sense low-intensity AC electromagnetic fields during nocturnal migratory flight.

Pennycuick, C. J., T. Alerstam, et al. (1979). "Soaring migration of the common crane Grus grus observed by radar and from an aircraft." Ornis Scand. **10**: 241-251.

Korschgen, C. E., W. L. Green, et al. (1984). "Use of radar with a stationary antenna to estimate birds in a low-level flight corridor." J. Field Ornithol. **55**(3): 369-375.

Perdeck, A. C. and G. Speek (1984). "A radar study of the influence of expected ground speed, cloudiness, and temperature on diurnal migrating intensity." Ardea **72**: 189-198.

Alerstam, T. (1985). Radar. A dictionary of birds. B. Campbell and E. Lack, T. & A.D. Poyser**:** 492-494.

Gauthreaux, S. A., Jr. (1985). Radar, electro-optical, and visual methods of studying bird flight near transmission lines. Clemson, South Carolina, Clemson University**:** 1-76.

Gauthreaux, S. A. (1991). "The Flight Behavior of Migrating Birds in Changing Wind Fields - Radar and Visual Analyses." American Zoologist **31**(1): 187-204. <Go to ISI>://A1991FD12300015.
This paper examines the influence of atmospheric structure and motion (principally winds aloft) on the flight behavior and altitudinal distribution of migrating song-birds. Bird migration data that I gathered using surveillance radars operated by the United States National Weather Service and the Federal Aviation Administration and a vertically directed fixed-beam marine radar mounted on a mobile laboratory are analyzed in relation to winds aloft. Migrating birds appear to fly at altitudes where winds will minimize the cost of transport and assist movements in seasonally appropriate directions. When migratory flights occur at altitudes that are higher than usual, a significant correlation exists between the altitude of densest migration and the altitude of most favorable wind. Lower altitudes may be favored over slightly more favorable winds at much higher altitudes. Radar data on the flight behavior of migrating birds in the vicinity of frontal systems is also examined. The flight strategies of migrants (fly over the front, change the direction of flight, or land and terminate the flight) differ depending on season and the "thickness" of the front. Recent migration studies that are related to atmospheric structure and motion are summarized and related to atmospheric processes operating simultaneously at vastly different spatial and temporal scales.

Bruderer, B. (1994). "Nocturnal Bird Migration in the Negev (Israel) - a Tracking Radar Study." Ostrich **65**(2): 204-212. <Go to ISI>://A1994QN10600020.
The present publication summarizes the methodological possibilities of tracking radar and describes some features df nocturnal migration at two sites in the Negev, which include anwers to basic questions of bird migration. The directions of spring and autumn migration were practically opposite; only the headings in spring indicated some more compensation for stronger westerly winds. The volume df nocturnal spring migration was only about 65% of autumn migration, which may be an indication of mortality outside the breeding area. Highest densities of migration at the two radar sites in the Negev Highlands (450 m above sea level) and in the Arava Valley (150 m below sea level) indicated flightlevels adjusted to atmospheric conditions aloft, and not to ground level. Due to the trade-wind system, the birds heading southward in autumn flew mainly below 1 500 m above sea level, while in spring they tended to make use of the anti-trades at higher altitudes. The decisive factor for altitude choice was the speed of tailwind in spring and autumn; other factors. such as temperature, humidity and pressure had no significant influence on the altitude distributions. With respect to the question of non-stop or intermittent flight across large desert areas, the data show that between the eastern deserts of Egypt and the Sinai/Negev complex the nocturnal migrants maintained their schedule of nocturnal flight and diurnal rest. A few exceptions of nocturnal migrants continuing migration at high altitudes into the day were identified mainly as heron- and gull-type birds. The proportion of waders and waterfowl identified by wing-beat pattern in nocturnal migration is nearly the same at both sites, indicating broad-front migration across the desert. The numbers of birds with continuous wingbeats is, however, so large compared to available estimates of waders and waterfowl wintering in Africa that careful reconsideration of the underlying assumptions in the radar and field estimates is necessary.

Cooper, B. A. (1996). Use of radar for wind power-related avian research. Proceedings of National Avian-Wind Power Planning Meeting II., Palm Springs, California, Avian Subcommittee of the National Wind Coordinating Committee.
Abstract
Introduction
Stakeholder questions, interests and concerns
Fundamental methodologies
Observation protocols
Subcommittee sessions
Meeting sumamry and next steps to be taken
Meeting Agenda
Regulators' Key Points

Gauthreaux, S. A. and C. G. Belser (1998). "Displays of bird movements on the WSR-88D: Patterns and quantification." Weather and Forecasting **13**(2): 453-464. <Go to ISI>://000075402600018.
The WSR-88D can readily detect birds in the atmosphere in both clear air and precipitation mode, and echo reflectivities of 30-35 dBZ may be realized during heavy migration events or when birds are departing a roosting site. This paper describes the appearance of birds on base reflectivity, base velocity, and velocity azimuth display wind profile products, and presents a calibration curve that relates decibel values of reflectivity to bird migration traffic rates. The recognition of bird displays in WSR-88D products is essential for the accurate interpretation of data gathered by the radar and its use in the development of forecasts. The findings also document the importance of the WSR-88D as a remote sensing tool for biological studies of birds and insects in the atmosphere and the application of such information in the avoidance of bird-aircraft collisions.

Gauthreaux, S. A., D. S. Mizrahi, et al. (1998). "Bird migration and bias of WSR-88D wind estimates." Weather and Forecasting **13**(2): 465-481. <Go to ISI>://000075402600019.
Migrating birds can greatly influence base velocity, velocity azimuth display (VAD), and VAD wind profile products of the WSR-88D. This is documented by comparing estimates of wind velocity and direction from these products with corresponding radiosonde and pilot balloon data. Mean absolute differences between wind velocities estimated from base velocity products and the corresponding radiosonde data were significantly greater on days with bird migration than on days with no migration. Even low-density migrations can increase VAD wind velocities relative to winds measured simultaneously by balloon. Because birds usually migrate with following winds, wind directions measured by VAD are less affected, but in some cases the difference can be as much as 128 degrees. Consequently, when winds aloft are nearly calm and variable in direction, the data in the VAD wind profile and base velocity products may pertain almost exclusively to migrating birds.

Russell, K. R. and S. A. Gauthreaux (1998). "Use of weather radar to characterize movements of roosting purple martins." Wildlife Society Bulletin **26**(1): 5-16. <Go to ISI>://000075141500002.
Radar can supply reliable data about the origin, timing, extent, and volume of movements of birds over large spatial scales and in situations where visual observations are constrained. We evaluated the performance of a National Weather Service WSR-88D radar for tracking the morning and evening flights of roosting purple martins (Progne subis) in South Carolina and developed a procedure for estimating number of birds aloft from the radar display. WSR-88D radar detected 80% of roost departures observed during ground surveys, but no evening arrivals. Radar showed that martins first departed from the roost 41.4 +/-4.0 minutes before sunrise, and dispersed in an annular pattern (360 degrees) that extended 50-100 km from the roost ((x) over bar = 77.9 +/- 14.1 km). We determined martin flight speeds (less than or equal to 13.4 m/sec) using WSR-88D radial velocity images. We found a significant relationship between numbers of martins aloft counted during ground surveys and radar echo intensity for morning (r(2) = 0.66; P < 0.0001) but not evening (r(2) = 0.01; P = 0.091) flights. However, a large percentage (34%) of the variation in numbers of martins remained unaccounted for by our best correlative model. Precise estimation of numbers of birds aloft with the WSR-88D requires further calibration of the displays. Weather conditions and behaviors of birds in flight also limit the use of radar for tracking bird flights and estimating numbers of birds aloft. Despite these limitations, WSR-88D radar can provide wildlife biologists with an important tool for detecting and studying mass movements of birds.

Russell, K. R., D. S. Mizrahi, et al. (1998). "Large-scale mapping of Purple Martin pre-migratory roosts using WSR-88D weather surveillance radar (vol 69, pg 316, 1998)." Journal of Field Ornithology **69**(3): 509-509. <Go to ISI>://000075830900017.

ABR inc. environmental research & services (2001). Avian Collision Studies and Radar Ornithology. Fairbanks, AK (USA), ABR inc: brochure.

Williams, T. C., J. M. Williams, et al. (2001). "Bird migration through a mountain pass studied with high resolution radar, ceilometers, and census." Auk **118**(2): 389-403. <Go to ISI>://000169466700010.
Autumnal migration was studied with high-resolution radar, ceilometer, and daily census in the area of Franconia Notch, a major pass in the northern Appalachian Mountains. Under synoptic conditions favorable for migration, broadfront movements of migrants toward the south passed over the mountains, often above a temperature inversion. Birds at lower elevations appeared to be influenced by local topography. Birds moving southwest were concentrated along the face of the mountain range. Birds appeared to deviate their flights to follow local topography through the pass. Specific migratory behavior was not associated

with species or species groups. Under synoptic conditions unfavorable for southward migration, multimodal movements probably associated with local flights were as dense as the southward migrations described above. Avian migrants reacting to local terrain may result in concentrations of migrants over ridge summits or other topographic features.

Erni, B., F. Liechti, et al. (2002). "Wind and rain govern the intensity of nocturnal bird migration in central Europe - A log-linear regression analysis." Ardea **90**(1): 155-166. <Go to ISI>://000176332600015.
For the first time an almost complete sample of the seasonal course of nocturnal autumn migration was recorded by a conically scanning pencil-beam radar and was analysed with respect to weather, using a log-linear regression model. A variable aiming to estimate the number of birds ready to depart for migration due to preceding precipitation was included in the model. The density of nocturnal migration was strongly influenced by wind and by rain. It appears that birds distinguished between favourable and unfavourable wind conditions rather than to grade wind on a continuous scale from least to most favourable. The final model, including variables for actual wind, rain, previous precipitation, and the general seasonal trend explained 70% of the total deviance. Thus, the low correspondence of empirical data with predictions from models on stopover duration and optimal fuel loads with respect to fat deposition rates may be caused by the high impact of local weather conditions on the take off decision of the majority of nocturnal migrants passing through central Europe.

Krijgsveld, K. L., S. M. J. v. Lieshout, et al. (2003). Baseline studies North Sea wind farms: strategy of approach for flying birds, Bureau Waardenburg bv /Alterra / National Institute for Coastal and Marine Managemant (RIKZ): 50.
Bureau Waardenburg and Alterra in cooperation will study the effects of the Near Shore Wind Farm on flight paths, flight altitudes and flux of marine birds and non-marine migrating birds. In this publication we present the study design of the first part of this study, in which the flight patterns of birds are determined in the reference situation before the construction of wind turbines has started.

In chapter 1 we introduce the project by describing its background and the research goals. In chapter 2 we present the specific study aims; separated in fluxes, flight altitudes, and flight paths of birds. Subsequently we discuss which species of birds are of interest. In chapter 3 we give a brief overview of the methods that will be used to measure the flight patterns. These consist of three main components: radar observations, visual observations and ship-based observations on seaducks. In chapter 4 the methods and techniques that will be used are described in full detail. We start with a description of the study site and the location where measurements will be performed, and how we deal with spatial and temporal variation in flight patterns (§4.1). Secondly the radar equipment used for the observations is described (§4.2 and §4.3). This includes an elaboration on the techniques involved and on the necessities for calibration of echoes. In § 4.5 we describe the methods used to perform visual observations, and in §4.6 subsequently the methods to link the radar and visual observation in order to add species information to the radar signals. The chapter is concluded by discussing effects of environmental conditions and the ways to mobilise existent data on marine birds. Chapter 5 deals with the techniques used for data analysis. In Chapter 6 we summarize the research activities in a time frame.

Krijgsveld, K. L., R. Lensink, et al. (2005). Baseline studies North Sea wind farms: fluxes, flight paths and altitudes of flying birds 2003 - 2004, Bureau Waardenburg bv /Alterra / National Institute for Coastal and Marine Managemant (RIKZ): 192.
Background
To build knowledge and experience with the construction and exploitation of offshore wind farms, a large research program was set up to study the economical, technological, social

and ecological effects of a near shore wind farm in the coastal waters of the Dutch North Sea. The report at hand concerns the ecological effects, and deals with effects specifically on flying birds (Lot 6). It describes the 'reference situation', i.e. the situation prior to construction of the wind farm, and serves as a reference to which the situation during and after construction of the wind farm can be compared in the subsequent effect study. Effects of the future wind farm may range from avoidance behaviour to collision of birds with turbines. Only by determining the undisturbed flight patterns in the reference situation, can we assess the effects resulting from the presence of the wind farm in the future.

Study aims

We quantified flight patterns of flying birds in the undisturbed situation before construction of the wind farm, to be able to assess collision risks and disturbance of flight patterns of the future wind farm. Flight patterns studied were:

- fluxes; i.e. intensity of flying birds
- flight paths, i.e. flight directions
- flight altitudes

All three aspects were studied in relation to seasonal and diurnal variation, as well as weather conditions. Birds studied included migrating marine and non-marine birds as well as local marine birds.

Methods used

Flight patterns were studied by using two radars and various visual observation techniques. The radars operated both in the horizontal and in the vertical plane, and allowed automatic and continuous registration of signals in a database using Merlin software supplied by DeTect Inc. (Panama City, FL, USA). Observations covered the period from October 2003 through November 2004. Visual observations ended June 2004.

Fluxes

The majority of flying birds were gulls. They comprised ca. 90% of all flight movements in the study area. Gull occurrence was highly correlated with occurrence of fishing vessels. Gulls were most abundant in October–December and in May–June (no obervations July-August). Abundance of seabirds varied between species. Abundance of alcids, divers, Gannets and skuas was high in late autumn–winter. In April–June, Gannets again and tubenoses had a high abundance. Migratory non-marine birds were most abundant in October–December and in March–May, conform migratory patterns. Bird abundance decreased with increasing wind speeds. This was true in general (MTR vertical radar) and for Gannets, gulls and landbirds specifically. Fluxes, expressed as mean traffic rate (MTR, nr of birds/hr/km, i.e. flight intensity), were highest in late autumn-early winter, with a lower peak in April through June. Fluxes at lower altitudes up to 250 m were higher during day than at night, reflecting high activity of gulls mostly but not exclusively during day time. At higher altitudes, fluxes were higher at night, especially during migration periods in October and April-June. Fluxes did not show a consistent pattern throughout the day. Some species such as gulls were more active in the middle of the day, whereas others were mostly active at dawn and dusk or at night. Fluxes of migratory birds were considerable both at night and during day, but in general showed higher levels at night. During autumn migration in September-October, a strong peak in MTR occurred around sunset, of thrushes and other nocturnally migrating passerines that started migration simultaneously at dusk from the nearby coast. Such concentrations were also observed visually at dawn, from diurnal migrant passerines.

Fluxes recorded by the vertical radar were of low magnitudes compared to the levels recorded by moon watching in autumn. This is mainly due to the fact that during peak nights of autumn migration the radar was not working. Most observations with the vertical radar were gathered in spring. The fluxes obtained by moon watching were of the same magnitude as found in other studies. They reflect peak MTR's as they were collected during

nights with intense autumn migration. Possibly, the vertical radar may also have missed small birds due to a large range setting.
Possible differences in flight patterns between the observation platform and the actual NSW site 40 km to the north where the wind farm will be constructed, were evaluated based on observations over sea conducted from the shore at both sites. The following differences in flight patterns of bird groups are presumed: Smaller numbers of geese and swans, grebes, ducks during frost-flights, landbirds (passerines) migrating parallel to the coastline, and foraging flights of gulls during the breeding season. Larger numbers of pelagic seabirds (tubenoses, alcids, Gannet; unknown to what extent) and possibly of Brent Goose, divers, seaducks and Little Gull. Similar numbers of other groups like terns, skuas, waders, and landbirds migrating in directions perpendicular to the coastline.

Flight paths
Flight paths of the majority of birds, gulls flying to and from fishing vessels, were oriented in all directions, determined by the position of these fishing vessels. At dawn and dusk, flight paths of gulls included (Herring and) Black-backed Gulls flying from and to the breeding colonies at Voornes Duin and the Maasvlakte. Flight paths of local marine birds such as divers, Gannets and alcids were mostly oriented parallel to the coastline.
Migratory non-marine birds flew in southwesterly directions in autumn, cutting off to the Maasvlakte and Belgium semi-parallel to the coast. Some waterbirds, mainly geese and swans, followed a west-southwesterly direction towards England. In spring, flight paths of migrating birds were oriented east-northeast.

Flight altitudes
Flight altitudes during daytime were mostly low, up to 100 m, reflecting flight altitudes of gulls, as well as of seabirds, geese, swans, ducks and waders. At night, flight altitudes were much higher, at altitudes of 150 m and more. Flight activities at night were mostly of migrating waders and larger passerines. The vertical radar did not operate in autumn, during fall migration. It is likely that under favourable tailwind conditions crossings during the day also occurred, but at higher altitudes, similar to the night. Gulls flew mostly below 50m, occasionally higher up to 200m. Seabirds (alcids, divers, sea ducks, skuas and tubenoses) flew mostly low above the sea, at altitudes up to 50 m, and mostly below 15 m. Most cormorants, geese and swans flew up to 100 m, occasionally higher. Migrant birds flew at altitudes up to 50 m during daytime, but higher at night (over 150 m).
Flight altitudes varied largely in especially cormorants, geese & swans, gulls, ducks other than sea ducks, and waders. In these species, flight altitudes commonly varied between 0 and 200 m. In migrating birds such as geese & swans and waders, this variation may be caused by differences in wind direction and wind speed.

Sea ducks
Flight patterns of scoters, which were studied in a separate study within the program, are reported in Dirksen et al (2005). The NSW site is situated relatively close to a known major sea duck wintering area, and sea ducks may therefore be an important impacted group. Research was carried out north of the Wadden Islands. Especially after disturbance, e.g. by ships, birds fly away from the original feeding area. At night, these distances may be smaller than during the day. Flight altitudes in part lay below rotor height. However, a smaller but substantial part flew at rotor level, in conditions without turbines present. How presence of turbines will affect flight patterns is as yet unclear.

Radar issues
Currently, radar is by far the best method available to obtain information on flight patterns of birds that needs to be obtained around the clock and throughout the year. Especially at night and at higher altitudes, only radar allows such data to be obtained. Thus, the radar

measurements performed at Meetpost Noordwijk, with the resulting data on fluxes and flight altitudes, have contributed importantly to our knowledge of flight patterns of birds flying near shore over the North Sea.
To allow continuous registration of flight patterns, 24 hours a day, throughout the year, radar signals were recorded by an automated hard- and software system. Signals detected by the radar were stored into a database, after filtering out signals generated by waves based on characteristics of these signals. Clutter from waves is a serious problem when operating radars that are fine-tuned to detect birds over sea. Although we were able to remove a high percentage of clutter from the horizontal radar data (over 90%), data remained highly polluted with clutter. Resulting horizontal data, used to determine flight directions, showed high correlations with wave height and wave directions. In addition, tracks of birds were split up into many different ID's in the record, thus reducing total track length of bird-signals and therewith the main characteristic that set birds apart from sea clutter. As a consequence, patterns of flight paths based on horizontal radar data were masked to a high extent by clutter. The problems of both clutter removal and track recognition need to be improved significantly for future measurements. The visual observations that were performed largely to back up observations by horizontal radar, proved essential to attain conclusions regarding flight paths of birds.
The vertical radar also generated large amounts of records from waves. Because these were restricted to levels below 1,8 m above sea level, clutter could be removed relatively easily from the data. Because many birds, especially local marine birds, fly at very low altitudes above sea, deleting records below 1,8 m implies that many of these flight movements were lost for analysis. The resulting data were still polluted with an unknown percentage of records of objects other than birds. Despite this pollution, the vertical data did reflect fluxes patterns in the right order of magnitude, and could therefore be used successfully to quantify flight altitudes and to determine fluxes. Severe technical difficulties were experienced with both radars. The hardware repeatedly broke down as a result of strong winds out at sea. Especially the vertical radar proved to be sensitive to strong winds, probably as a consequence of the manner in which it was attached to the platform.

Results and recommendations in light of the effect study

To be able to assess collision risks and barrier effects of flying birds resulting from the presence of the future wind farm, we established fluxes, flight paths and flight altitudes of birds in the ‘undisturbed’ situation. By means of vertical radar and additional visual observations, fluxes and flight altitudes of the various species were determined adequately. During and after construction of the wind farm, these data will be indispensable to gain insight not only in the level of barrier effects of the wind farm, but also in collision risks. The data will allow us to relate the fluxes measured in the reference situation with the collision rate measured in the effect study. Information on species level is largely limited to daylight, and nocturnal migrating birds. Nocturnal activity of the various species of local marine birds deserves further attention in the effect study. Behaviour of the birds in response to the wind farm, such as avoidance of the turbines or the entire farm either by changing flight altitude and/or changing flight paths, will be established in the effect study. Occurrence of barrier effects can then be determined by comparing the results of the effect study with the findings in the reference study. Flight paths however have been difficult to obtain, as the horizontal radar has largely failed to result in quantifiable data, and visual observations of flight paths are restricted to daylight hours. To be able to accurately measure occurrence of barrier effects, clutter removal and track recognition in the horizontal radar needs to be improved.
To prevent interruptions in data recording and high costs of repair, the manner in which the vertical radar is mounted on the platform needs to be improved in the effect study in order to withstand the harsh climatic conditions out at sea.
Dwyer, E. (2004). “The Other Side” - Using Radar To Target Birds. Furuno Waypoints Newsletter. **3:** 1-2.

Farnsworth, A., S. A. Gauthreaux, et al. (2004). "A comparison of nocturnal call counts of migrating birds and reflectivity measurements on Doppler radar." Journal of Avian Biology **35**(4): 365-369. <Go to ISI>://000223085900011.
Several studies have found that the peak in bird density in the atmosphere during nocturnal migration occurs before midnight, while the peak in vocalizations from migrating birds occurs after midnight, in the hours just before dawn. In a recent study, the patterns of calling from a single species of migrating birds correlated well with the patterns of density estimates of migrating birds. We test the null hypothesis that the patterns of reflectivity measurements and number of vocalizations during nocturnal migration are not related. We sampled radar data and nocturnal flight calls during spring and fall 2000 in northwestern South Carolina and southeastern New York. We analyzed changes in the hour-to-hour patterns of bird density and vocalizations for 556 hours on 58 nights. We also analyzed the night-to-night changes in the patterns of peak hour bird density and peak hour of vocalizations on 32 nights. We found that most of the hour-to-hour and night-to-night patterns of density and vocalization counts are significantly related and reject the null hypothesis. However, despite significant relationships between reflectivity measurements and vocalization counts, a great deal of variation in vocalization counts remains unexplained. These results suggest that factors other than bird density are responsible for the variation in vocalizing by migrating birds.

Walls, R. and M. Parnel (2005). Bird Detection Radar. A Tool for Monitoring White-fronted Goose Movements. Groningen, the Netherlands, WindTech International.

Gauthreaux, S. A., C. G. Belser, et al. (2006). "Atmospheric trajectories and spring bird migration across the Gulf of Mexico." Journal of Ornithology **147**(2): 317-325. <Go to ISI>://000236646700021.
We examined the relationship between the longitude of peak arrival of trans-Gulf migrants on the northern coast of the Gulf of Mexico in spring and wind trajectories over the Gulf at three different altitudes (500, 1,500, and 2,500 m above ground level). We used data from 10 WSR-88D radars (weather surveillance radar-1988-Doppler) from Brownsville, Texas, to Key West, Florida, to record the time and longitude of peak arrival on the northern Gulf coast for four spring migrations (2001-2004). We used the National Oceanic Atmospheric Administration Air Resources Laboratory HYSPLIT transport and dispersion model at the READY Web site to generate backward, 24-h atmospheric trajectories based on archived atmospheric data for each trans-Gulf flight. The trajectories began at the geographic location where radar indicated the greatest concentrations of arriving migrants. Although the longitude of peak arrival varied, peak densities of most trans-Gulf migrants arrived on the northern coast near longitude 95 degrees W. Regression analyses showed that the relationship between the longitude of peak trans-Gulf arrival and the direction of atmospheric trajectory was significant but weak at the 500-m level, where few migrants occurred, and was insignificant for the 1,500- and 2,500-m altitudes, where migrant densities were greater. We conclude that winds aloft over the Gulf have little influence on the longitude of peak trans-Gulf arrival on the northern coast of the Gulf of Mexico, and we speculate that the arrival pattern may reflect the trans-Gulf migration pathways that evolved during the Last Glacial Maximum.

Gauthreaux, S. A. and J. W. Livingston (2006). "Monitoring bird migration with a fixed-beam radar and a thermal-imaging camera." Journal of Field Ornithology **77**(3): 319-328. <Go to ISI>://000240730200012.
Previous studies using thermal imaging cameras (TI) have used target size as an indicator of target altitude when radar was not available, C this approach may lead to errors if birds that differ greatly in size are actually flying at the same altitude. To overcome this potential difficulty and obtain more accurate measures of the flight altitudes and numbers of individ-

ual migrants, we have developed a technique that combines a vertically pointed stationary radar beam and a vertically pointed thermal imaging camera (VERTRAD/TI). The TI provides accurate counts of the birds passing through a fixed, circular sampling area in the TI display, and the radar provides accurate data on their flight altitudes. We analyzed samples of VERTRAD/TI video data collected during nocturnal fall migration in 2000 and 2003 and during the arrival of spring trans-Gulf migration during the daytime in 2003. We used a video peak store (VPS) to make time exposures of target tracks in the video record of the TI and developed criteria to distinguish birds, foraging bats, and insects based on characteristics of the tracks in the VPS images and the altitude of the targets. The TI worked equally well during daytime and nighttime observations and best when skies were clear, because thermal radiance from cloud heat often obscured targets. The V-ERTRAD/TI system, though costly, is a valuable tool for measuring accurate bird migration traffic rates (the number of birds crossing 1609.34 in [I statute mile] of front per hour) for different altitudinal strata above 25 in. The technique can be used to estimate the potential risk of migrating birds colliding with man-made obstacles of various heights (e.g., communication and broadcast towers and wind turbines)-a subject of increasing importance to conservation biologists.

Shamoun-Baranes, J., E. van Loon, et al. (2006). "A comparitive analysis of the influence of weather on the flight altitudes of birds." Bulletin of the American Meteorological Society **87**(1): 47-+. <Go to ISI>://000235140400015.
Birds pose a serious risk to flight safety worldwide. A Bird Avoidance Model (BAM) is being developed in the Netherlands to reduce the risk of bird-aircraft collisions. In order to develop a temporally and spatially dynamic model of bird densities, data are needed on the flight-altitude distribution of birds and how this is influenced by weather. This study focuses on the dynamics of flight altitudes of several species of birds during local flights over land in relation to meteorological conditions.
We measured flight altitudes of several species in the southeastern Netherlands using tracking radar during spring and summer 2000. Representatives of different flight strategy groups included four species: a soaring species (buzzard Buteo buteo), an obligatory aerial forager (swift Apus apus), a flapping and gliding species (black-headed gull Larus ridibundus), and a flapping species (starling Sturnus vulgaris).
Maximum flight altitudes varied among species, during the day and among days. Weather significantly influenced the flight altitudes of all species studied. Factors such as temperature, relative humidity, atmospheric instability, cloud cover, and sea level pressure were related to flight altitudes. Different combinations of factors explained 40%-70% of the variance in maximum flight altitudes. Weather affected flight strategy groups differently. Compared to flapping species, buzzards and swifts showed stronger variations in maximum daily altitude and flew higher under conditions reflecting stronger thermal convection. The dynamic vertical distributions of birds are important for risk assessment and mitigation measures in flight safety as well as wind turbine studies.

Alpert, J. C. and V. K. Kumar (2007). "Radial wind super-obs from the WSR-88D radars in the NCEP operational assimilation system." Monthly Weather Review **135**(3): 1090-1109. <Go to ISI>://000245214600022.
The spatial and temporal densities of Weather Surveillance Radar-1988 Doppler (WSR-88D) raw radar radial wind represent a rich source of high-resolution observations for initializing numerical weather prediction models. A characteristic of these observations is the presence of a significant degree of redundant information imposing a burden on an operational assimilation system. Potential improvement in data assimilation efficiency can be achieved by constructing averages, called super-obs. In the past, transmission of the radar radial wind from each radar site to a central site was confined to data feeds that filter the resolution and degrade the precision. At the central site, super-obs were constructed from this data feed and called level-3 super-obs. However, the precision and information con-

tent of the radial wind can be improved if data at each radar site are directly utilized at the highest resolution and precision found at the WSR-88D radar and then transmitted to a central site for processing in assimilation systems. In addition, with data compression from using super-obs, the volume of data is reduced, allowing quality control information to be included in the data transmission. The super-ob product from each WSR-88D radar site is called level-2.5 super-obs. Parallel, operational runs and case studies of the impact of the level-2.5 radar radial wind super-ob on the NCEP operational 12-km Eta Data Assimilation System (EDAS) and forecast system are compared with Next-Generation Weather Radar level-3 radial wind super-obs, which are spatially filtered and delivered at reduced precision. From the cases studied, it is shown that the level-3 super-obs make little or no impact on the Eta data analysis and subsequent forecasts. The assimilation of the level-2.5 super-ob product in the EDAS and forecast system shows improved precipitation threat scores as well as reduction in RMS and bias height errors, particularly in the upper troposphere. In the few cases studied, the predicted mesoscale precipitation patterns benefit from the level-2.5 super-obs, and more so when greater weight is given to these high-resolution/precision observations. Direct transmission of raw (designated as level 2) radar data to a central site and its use are now imminent, but this study shows that the level-2.5 super-ob product can be used as an operational benchmark to compare with new quality control and assimilation schemes.

Farnsworth, A. and R. W. Russell (2007). "Monitoring flight calls of migrating birds from an oil platform in the northern Gulf of Mexico." Journal of Field Ornithology **78**(3): 279-289.
<Go to ISI>://000249179900006.
Millions of birds migrate across the Gulf of Mexico each year. However, most studies of migration in this region involve sampling onshore locations during the day, potentially underrepresenting the diversity and abundance of migrants passing the region. We evaluated a potential solution to this problem by recording the flight calls of passing migrants from an oil platform located southeast of the Alabama coast in the Gulf of Mexico. We detected 2762 calls during 30 nights from 9 September to 2 November 1999, and were able to identify 2329 calls to species. Flight calls by nine species of birds represented 23% of all identified calls. The greatest number of calls during one night (1017 calls) and during a 1-h period (257 calls) were recorded on 10 September. The greatest number of calls was recorded 8 h after sunset, with a secondary peak 2 h after sunset. The peak prior to sunrise may indicate the formation of flocks at dawn, and the peak after sunset may have been caused by the first wave of migrants reaching the platform. However, call counts varied extensively, with 98% of all calls recorded during 13 nights and 40% on a single night, possibly resulting from hourly and nightly differences in bird numbers aloft, atmospheric conditions, and artificial lighting conditions. Although recording on oil platforms can be difficult because of mechanical, wind, and wave noise, our results suggest great potential for describing the species composition of passing vocal migrants and the temporal patterns of flight-calling behavior if quiet recording locations can be found. Moreover, flight call monitoring could be a critically important tool for bird conservation in this region, given recent proposals to develop wind power and the potential bird mortality associated with such developments.

Schmaljohann, H., F. Liechti, et al. (2008). "Quantification of bird migration by radar – a detection probability problem." Ibis. doi: 10.1111/j.1474-919x.2007.00797.x.
Besides the scientific interest in the quantification of bird migration, there is an increasing need to quantify bird movements for the assessment of bird collision risk with artificial structures. In many environmental impact studies, the radar method is used in an inappropriate manner. The processing of echoes consists often of counting blips within defined screen fields, and the surveyed volume is estimated without reference to the detection probabilities of different ‘target sizes’ (radar cross-sections). The aim of this paper is to present a procedure to quantify bird migration reliably using radar by stating the theoretical

requirements of every single step of this procedure and presenting methodological solutions using our own radar data from extensive field studies. Our methodological solutions can be applied to various radar systems, including widely used ship radar. The procedure presented involves discriminating the echoes of birds and insects and estimating the different detection probabilities of differently ‘sized’ birds (radar cross-sections). By ignoring the different detection probabilities, density estimations may be wrong by as much as 400%. We fear that quantification of bird migration and predicted bird numbers affected by collisions with artificial structures
are in many cases based on unreliable estimates.

2.7 Fugletrekk

Bellrose, F. C. and R. R. Graber (1963). A radar study of the flight directions of nocturnal migrants. XIII th International Ornithological Congress.

Alerstam, T. and S. Ulfstrand (1975). "Diurnal migration of passerine birds over South Sweden in relation to wind direction and topography." Ornis Scandinavica **6**(2): 135-149.

Alerstam, T. (1977). "Why do migrating birds fly along coastlines?" Journal of Theoretical Biology **65**: 699-712.

Alerstam, T., G. A. Gudmundsson, et al. (1990). "Orientation, migration routes and flight behaviour of Knots, Turnstones and Brant Geese departing from Iceland in spring." Arctic **43**(3): 201-214.

Alerstam, T. and Å. Lindström (1990). Optimal bird migration: the relative importance of time, energy and safety. Physiology and Ecophysiological Aspects of Bird Migration. E. Gwinner. Heidelberg, Springer-Verlag**:** 331-351.

Alerstam, T., G. A. Gudmundsson, et al. (1995). Migration patterns and flight routes of tundra birds. Swedish-Russian Tundra Ecology Expedition-94. E. Grönlund and O. Melander. Stockholm, Swedish Polar Research Secretariat**:** 252-263.

2.8 Fugl og flytraffikk

Blokpoel, H. (1973). "Bird migration forecasts for military air operations." Canadian Wildlife Service Occasional Paper **16**: 1-18.

Blokpoel, H. (1976). Bird hazards to aircraft. London, Books Canada Limited.

Blokpoel, H. and D. R. M. Hatch (1976). "Snow geese, disturbed by aircraft, crash into power lines." Canadian Field Naturalist **90**(2): 195.
On 8 May 1974, several thousand snow and blue geese were feeding in a stubble field in Manitoba, Canada, when a low-flying aircraft caused them to take wing. In the "chaotic" rush into the air, 25-75 birds were killed or injured by striking power lines that bordered one side of the field. It is not known whether death resulted from collision or electrocution.

Linnell, M. A., M. R. Conover, et al. (1999). "Biases in bird strike statistics based on pilot reports." Journal of Wildlife Management **63**(3): 997-1003. <Go to ISI>://000081441500026.
Collisions between birds and aircraft are a concern because they threaten human safety and result in costly repairs. Most data on bird strikes have been provided by pilots and may

be incomplete or biased. To assess whether bird strike statistics derived from pilot reports are biased, we compared the number of pilot-reported bird strikes at a Hawaiian airport during 1900-94 to the number of bird strikes obtained from regular runway searches for dead birds. We documented 526 bird strikes, of which only 25% were reported by pilots. Pilot reporting rates (percentage of all strikes reported by pilots) varied by species involved, number of birds struck, season, time of day, location on the runway during the landing phase, and the bird's mass. Reporting rates were not, however, correlated to size of the bird. Pilot reporting rates were independent of wind speed, wind direction, and percent cloud cover, and reporting rates were similar during landings and takeoffs. We found that bird strike statistics derived from pilot reports were biased. A sole reliance on such data can lead to incorrect conclusions and may cause airports to select inappropriate measures and times to reduce bird strikes.

Van Belle, J., J. Shamoun-Baranes, et al. (2007). "An operational model predicting autumn bird migration intensities for flight safety." Journal of Applied Ecology **44**(4): 864-874. <Go to ISI>://000247667100016.
1. Forecasting migration intensity can improve flight safety and reduce the operational costs of collisions between aircraft and migrating birds. This is particularly true for military training flights, which can be rescheduled if necessary and often take place at low altitudes and during the night. Migration intensity depends strongly on weather conditions but reported effects of weather differ among studies. It is therefore unclear to what extent existing predictive models can be extrapolated to new situations.
2. We used radar measurements of bird densities in the Netherlands to analyse the relationship between weather and nocturnal migration. Using our data, we tested the performance of three regression models that have been developed for other locations in Europe. We developed and validated new models for different combinations of years to test whether regression models can be used to predict migration intensity in independent years. Model performance was assessed by comparing model predictions against benchmark predictions based on measured migration intensity of the previous night and predictions based on a 6-year average trend. We also investigated the effect of the size of the calibration data set on model robustness.
3. All models performed better than the benchmarks, but the mismatch between measurements and predictions was large for existing models. Model performance was best for newly developed regression models. The performance of all models was best at intermediate migration intensities. The performance of our models clearly increased with sample size, up to about 90 nocturnal migration measurements. Significant input variables included seasonal migration trend, wind profit, 24-h trend in barometric pressure and rain.
4. Synthesis and applications. Migration intensities can be forecast with a regression model based on meteorological data. This and other existing models are only valid locally and cannot be extrapolated to new locations. Model development for new locations requires data sets with representative inter- and intraseasonal variability so that cross-validation can be applied effectively. The Royal Netherlands Air Force currently uses the regression model developed in this study to predict migration intensities 3 days ahead. This improves the reliability of migration intensity warnings and allows rescheduling of training flights if needed.

2.9 Fugl og kollisjoner med gjerder

Nesbitt, S. A. and D. T. Gilbert (1976). "Powerlines and fences: hazards to birds." Florida Naturalist **49**(2): 23.

Bevanger, K. (1995). "Reingjerder som dødelighetsfaktor for fugl i Finnmark." NINA Fagrapport **4**: 1-32.

Bevanger, K. (1996). Effekter av gjerder på fugle- og dyreliv. Artikkel sendt Erik Næss i Kautokeino: 24.9.1996.

Bevanger, K. and H. Broseth (2000). "Reindeer Rangifer tarandus fences as a mortality factor for ptarmigan Lagopus spp." Wildlife Biology **6**(2): 121-127. <Go to ISI>://000087928600006.
To assess how important reindeer Rangifer tarandus fences are as a mortality factor for ptarmigan Lagopus spp. we collected data during 1991-1994. Our fieldwork covered 12 different sections of reindeer fence (totalling 71.1 km) in the county of Finnmark, northern Norway. The sections consisted of steel wire, steel netting or a combination of these, and ranged in height from 100 to 250 cm. The fieldwork took the form of spring patrols during which dead birds and their remains were searched for along the fences immediately after snow melt. We covered a total of 179.9 km and found 253 collision victims belonging to at least 20 species. Of the 253 victims found, 215 were willow ptarmigan Lagopus lagopus and rock ptarmigan L. mutus; thus these two species comprised 85% of the victims. During the winters of 1992/93 and 1993/94, we carried out experiments with dummy willow ptarmigan which were placed along fence sections and monitored serving as artificial fence-strike victims. Our experiments showed that approximately 64% of the total number of ptarmigan killed by the fences during winter would be detected during spring patrols along the fences. The type and height of the fence had no effect on the ptarmigan collision rate. In contrast, both the fence section and year factor contributed significantly to the observed variation in collision rate. We estimate that on average 1.4 +/- 0.5 (SE) ptarmigan are being killed per kilometre of reindeer fence in Finnmark annually, with a greater variation between fence sections than between years.

Baines, D. and M. Andrew (2003). "Marking of deer fences to reduce frequency of collisions by woodland grouse." Biological Conservation **110**(2): 169-176. <Go to ISI>://000180818400001.
Recent studies of the effects of deer fences on tetraonids have concluded that fences are an important cause of mortality in woodland grouse. This 2-year study involving 16 sections of fences in the Scottish Highlands evaluates the effectiveness of making fences highly visible by using orange netting to reduce bird collisions with fences. A total of 437 collisions involving 13 bird species were recorded. Red grouse (Lagopus lagopus scoticus) formed 42% of all collisions, with black grouse (Tetrao tetrix) 29% and capercaillie (T. urogallus) 20%. Allowing for corpse removal by scavengers, an estimated 70% of red grouse and 29% of black grouse collisions were fatal. Black grouse and capercaillic both collided with I I of the 16 fences at mean rates of 1.3 and 0.9 collisions km(-1) year(-1), red grouse collisions occurred at 13 fences, with a mean rate of 1.6 collisions km(-1) year(-1). Fewer grouse collisions occurred in the summer. Three quarters of black grouse collisions were by males. Collision rates were positively correlated with indices of black grouse and capercaillie abundance. Fence marking reduced capercaillie collisions by 64%, black grouse by 91% and red grouse by 49%. Although marked fences reduced capercaillie collision rates, they still remained an important cause of mortality. To conserve capercaillie, fences need to be removed altogether pending increased deer culls that would allow woodland regeneration without fences, or "grouse friendly" fences designed. (C) 2002 Elsevier Science Ltd. All rights reserved.

2.10 Generelle artikler

Boeker, E. L. and T. D. Ray (1971). "Golden eagle population studies in the southwest." Condor **73**: 463-467.

Boeker, E. L. (1974). "Status of golden eagle surveys in the Western States." Wildlife Society Bulletin **2**(2).

Giarola, A. J. and W. F. Krueger (1974). "Continous exposure of chicks and rats to electromagnetic fields." IEEE Transactions on Microwawe Theory and Techniques **22**(4): 432-437.

Giarola, A. J., W. F. Krueger, et al. (1974). Effect on fecundity in birds exposed to various electromagnetic fields. Biomed. Symp. 13, San Diego, California.

Giarola, A. J., W. F. Krueger, et al. (1974). Exposure of Gallus domesticus to various electromagnetic fields. Microwawe Power Symp., Milwaukee, Wisc., Int. Microwawe oer Inst.

Alerstam, T. and S.-G. Pettersson (1976). "Do birds use waves for orientation when migrating across the sea?" Nature **259**(22 January): 205-207.

Curry-Lindahl, K. (1977). Identification of the main problems facing birds of prey. World Conference on birds of prey, Vienna, Austria, ICBP.

Avery, M. L., P. F. Springer, et al. (1978). Avian mortality at man-made structures: an annotated bibliography, U.S. Fish and Wildlife Service, Biological Services Program, National Power Plant Team**:** 108.
Annotated bibiliography of 853 references pertaining to bird mortality due to collision and electrocution at man-made structures such as power transmission lines, radio and TV towers, lighthouses, cooling towers, buildings, and airport ceilometers. Includes subject, taxonomic, and geographic indexes

This bibliography on avian mortality and human-made structures contains 853 international entries. Citations are other ed according to subjects, kinds of birds, and locations. "The majority of the reports include the number of individuals and species killed, with some observations of weather conditions at the time of the incident, bird behavior near the structure, or comments on the attraction of birds to lights."

Jaroslow, B. (1979). A review of factors involved in bird-tower kills, and mitigative procedures. The mitigation symposium: a national workshop on mitigation losses of fish and wildlife habitats. G. A. Swanson**:** 469-473.
Estimated losses of between 5 million and 80 million birds annually, due to collisions with human-made structures, are attributed to three major factors: invisibility, deception, and confusion. An overhead wire or other structure becomes "invisible," and hence hazardous, when a bird's attention is directed elsewhere, such as toward the pursuit of prey. Deception is exemplified by birds colliding with windows because the reflected image is perceived as an actual flight path or habitat. Confusion results in large single-night kills at tall, lighted structures when, under overcast conditions, birds are deprived of celestial cues and lose their orientation. Behavioral aspects of the collision problem are discussed in the contexts of various theories of bird navigation on orientation. Mitigative measures include better siting of overhead wires, altering the reflectivity of glass surfaces, eliminating unnecessary structure illumination, and developing an appropriate on-off cycle for warning lights on tall structures.

Avery, M. L., P. F. Springer, et al. (1980). Avian mortality at man-made structures: an annotated bibliography (revised), U.S. Fish and Wildlife Servive. Biological Services Program, National Power Plant Team**:** 152.

Compilation of 1,042 references through February 1980, including 189 not in the original publication (Avery et al. 1978). Includes subject, taxonomic, and geographic indexes

This revised version of the 1978 bibliography contains 189 new international annotations for a total of 1,042 entries. Citations are other ed according to subjects, kinds of birds, and locations. "The majority of the reports include the number of individuals and species killed, with some observations of weather conditions at the time of the incident, bird behavior near the structure, or comments on the attraction of birds to lights."

Bridges, J. M. (1980). Raptor nesting platforms and the need for further studies. Workshop on raptors and energy developments, Boise, Idaho, Idaho Chapter of the Wildlife Society, U.S. Fish and Wildlife Service, Bonneville Power Administration, Idaho Power Company.

Fitzner, R. E. (1980). Impacts of nuclear energy facility on raptorial birds. Workshop on raptors and energy developments, Boise, Idaho, Idaho Chapter of the Wildlife Society, U.S. Fish and Wildlife Service, Bonneville Power Administration, Idaho Power Company.

Kennedy, P. L. (1980). "Raptor baseline studies in energy development." Wildlife Society Bulletin **8**(2): 129-135.
Accurate assessment of the impacts of energy development on raptor populations in the U.S. are examined, focusing mainly on land disturbance caused by surface coal mining. In order to properly assess the long-term impacts on raptor populations, site-specific studies must be conducted. The author recommends ecological studies on these populations as raptors are good indicator species of total ecosystem health. In addition, since several raptor species are threatened or endangered, industrial impacts may accelerate population decline and ultimately bring about extinction.

Bruce, A. M., R. J. Anderson, et al. (1982). "Observations of golden eagles nesting in western Washington." Raptor Research **16**(4): 132-134.

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Klem Jr., D. (1989). "Bird-window collisions." Wilson Bulletin **101**(4): 606-620.
Collisions of birds with windows were studied by reviewing the literature, collecting data from museums and
individuals, monitoring man-made structures, and conducting field experiments. Approximately 25% (225/917) of the avian
species in the United States and Canada have been documented striking windows. Sex, age, or residency status have little
influence on vulnerability to collision. There is no season, time of day, and almost no weather condition during which birds elude
the window hazard. Collisions occur at windows of various sizes, heights, and orientations in urban, suburban, and rural

environments. Analyses of experimental results and observations under a multitude of conditions suggest that birds hit windows
because they fail to recognize clear or reflective glass panes as barriers. Avian, manmade structural, or environmental features
that increase the density of birds near windows can account for strike rates at specific locations. A combination of interacting
factors must be considered to explain strike frequency at any particular impact site.

Buehler, D. A., J. D. Fraser, et al. (1991). "Survival rates and population dynamics of bald eagles on Chesapeake Bay." Journal of Wildlife Management **55**(4): 608-613.

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Abstract
Introduction
Stakeholder questions, interests and concerns
Fundamental methodologies
Observation protocols
Subcommittee sessions
Meeting sumamry and next steps to be taken
Meeting Agenda
Regulators' Key Points

Westerberg, H. (1996). Impact studies of sea-based windpower in Sweden. Technische Eingriffe in marine Lebensraum, Int. Naturschutzakademie, Insel Vilm.

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Harmata, A. R., G. J. Montopoli, et al. (1999). "Movements and survival of bald eagles banded in The greater Yellowstone ecosystem." Journal of Wildlife Management **63**(3): 781-793. <Go to ISI>://000081441500003.
Movements and survival of immature Laid eagles (Haliacetus leucocephalus) beyond their first winter remain largely unknown, and lack of information may impede strategies for effective conservation. We analyzed encounters, sightings, and radio detections of bald eagles auxiliary marked as nestlings in the Greater Yellowstone Ecosystem (GYE) between June 1979 and July 1987 to determine movements, survival, and role of Yellowstone National Park in the ecology of CTE bald eagles. Of 344 bald eagles Landed, 17% were encountered to June 1998. Most (84%) were encounters of bald eagles >1 year old. Half of encounters were external to the GYE and occurred in 7 western states and 1 Canadian province. All sightings of color-landed bald eagles (n = 76) were of bald eagles >1 year old, and 76% occurred in the GYE. Location and timing of encounters and detections of radio-tagged bald eagles indicated most (>90%) juveniles left the GYE in autumn, traveled as far west as coastal stales to winter, and returned to natal areas the following spring. Natal dispersal appeared female-biased, and bald eagles produced in the GYE recruited into breeding populations both in and out of the ecosystem. Mortality of 49 bald eagles recovered was from unknown causes (31%), electrocution or collision with power lines (20%), known or suspected poisoning (16%), and gunshot wounds (14%). Eighteen percent was distributed among 3 other causes. Recovery rates indicated Laid eagles 3-5 years old experienced the highest mortality Kaplan-Meir analysis of detections of radiotagged Laid eagles indicated first-lear survival of 87%, followed by a constant decrease in survival rate over 7 years. Survival estimates determined by radio-tracking were consistent Midi Land recovery results in illustrating low survival in 3- to 5-year-old age classes. Radiotracking of immature bald eagles suggested habitat in Yellowstone National Park was important in promoting survival of eventual recruits to the GYE population.

Cooper, B. A. and T. A. Kelly (2000). Night vision and thermal imaging equipment. Proceedings of National Avian - Wind Power Planning Meeting III., San Diego, California, Avian Subcommittee of the National Wind Coordinating Committee.

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Klem Jr., D., D. C. Keck, et al. (2004). "Effects of window angling, feeder placement, and scavengers on avian mortality at plate glass." Wilson Bulletin **116**(1): 69-73.
Extensive observations and experiments suggest that collisions with plate glass result in more avian mortalities than any other human-associated factor. We tested the effects of

window angling and the distance of bird feeders from windows on bird-glass collisions. Strike frequency differed among windows oriented vertically (control) and those angled 20 and 40 degrees from vertical; as the angle of orientation increased, strikes and fatalities decreased. Strike frequency and fatalities at windows also increased as the distance between bird feeders and the glass surface increased. No fatalities were recorded when feeders were located within 1 m of a window, but a marked increase in mortality occurred when feeders were placed 5 and 10 m from the glass. Most glass-collision victims may go unnoticed, hidden by vegetation where they remain out of view or are removed by scavengers. We found that scavengers frequently removed baits from beneath windows at six buildings, but no baits were taken from a site without windows that served as a control. The importance of window strikes as an avian mortality factor, and the likelihood that it will increase over time, compel us to recommend a reevaluation of the Migratory Bird Treaty Act (MBTA). Angling panes in new and remodeled buildings and placing bird feeders closer to windows can potentially reduce avian mortality.

Melby, M. (2004). Selbjørn Vindpark, Austvoll kommune. Konsekvensutredning - Friluftsliv og reiseliv. Tingvoll, Norway, Miljøfaglig Utredning AS**:** 56.

Mitchell, C. (2005). Overview of renewable energy in the UK - policy drivers and market readiness. Wind, Fire & Water: Renewable Energy & Birds. A BOU conference held at the University of Leicester, 1-3 April 2005., University of Leicester, Leicester, British Ornithologists' Union. Wind Fire Water abstracts.pdf.

Clark, N. A. (2006). "Tidal Barrages and Birds." Ibis **148**: 152-157.
This paper reviews the main effects that building tidal power barrages would have on the bird populations using Britain's estuaries. The changes in the tidal prism that would occur after a tidal power barrage is built are discussed in the context of their effect on the ecology of the estuary. Three main issues are discussed; the effect of changes in size and nature of the intertidal areas of the estuary, effects on saltmarshes, and the displacement of birds at closure. Recently, tidal stream technologies have been developed which are individually likely to have small effects on birds. However the cumulative effects of large scale tidal stream arrays need to be investigated. Finally, the effects of tidal barrages are put in the context of Britain's energy policy and the need to reduce greenhouse gas emissions. Should tidal power barrages be considered in the future, there will be a need for strategic assessments to be used to select sites that maximize the energy produced while minimizing the impacts on bird populations.

Fraenkel, P. L. (2006). "Tidal Current Energy Technologies." Ibis **148**: 145-151.
This paper sets the context for the development of tidal current technology in the face of impending climate change and so called 'peak oil'. Siting requirements are specified for tidal turbines and a general overview of the different technologies under development is given. Specific and detailed descriptions of leading Marine Current Turbine's technology are also highlighted. The paper considers the likely environmental impact of the technology, considering in particular possible (perceived and real) risks to marine wildlife, including birds. It concludes by indicating the planned future developments, and the scale and speed of implementation that might be achieved.

Huntley, B., Y. C. Collingham, et al. (2006). "Potential impacts of climatic change upon geographical distributions of birds." Ibis **148**: 8-28.
Potential climatic changes of the near future have important characteristics that differentiate them from the largest magnitude and most rapid of climatic changes of the Quaternary. These potential climatic changes are thus a cause for considerable concern in terms of their possible impacts upon biodiversity. Birds, in common with other terrestrial organisms, are expected to exhibit one of two general responses to climatic change: they may adapt

to the changed conditions without shifting location, or they may show a spatial response, adjusting their geographical distribution in response to the changing climate. The Quaternary geological record provides examples of organisms that responded to the climatic fluctuations of that period in each of these ways, but also indicates that the two are not alternative responses but components of the same overall predominantly spatial response. Species unable to achieve a sufficient response by either or both of these mechanisms will be at risk of extinction; the Quaternary record documents examples of such extinctions. Relationships between the geographical distributions of birds and present climate have been modelled for species breeding in both Europe and Africa. The resulting models have very high goodness-of-fit and provide a basis for assessing the potential impacts of anthropogenic climatic changes upon avian species richness in the two continents. Simulations made for a range of general circulation model projections of late 21st century climate lead to the conclusion that the impacts upon birds are likely to be substantial. The boundaries of many species' potential geographical distributions are likely to be shifted ≥ 1000 km. There is likely to be a general decline in avian species richness, with the mean extent of species' potential geographical distributions likely to decrease. Species with restricted distributions and specialized species of particular biomes are likely to suffer the greatest impacts. Migrant species are likely to suffer especially large impacts as climatic change alters both their breeding and wintering areas, as well as critical stopover sites, and also potentially increases the distances they must migrate seasonally. Without implementation of new conservation measures, these impacts will be severe and are likely to be exacerbated by land-use change and associated habitat fragmentation. Unless strenuous efforts are made to address the root causes of anthropogenic climatic change, much current effort to conserve biodiversity will be in vain.

Liechti, F. (2006). "Birds: blowin' by the wind?" Journal of Ornithology **147**(2): 202-211. <Go to ISI>://000236646700008.
Migration is a task that implies a route, a goal and a period of time. To achieve this task, it requires orientation abilities to find the goal and energy to cover the distance. Completing such a journey by flying through a moving airspace makes this relatively simple task rather complex. On the one hand birds have to avoid wind drift or have to compensate for displacements to reach the expected goal. On the other hand flight costs make up a large proportion of energy expenditure during migration and, consequently, have a decisive impact on the refuelling requirements and the time needed for migration. As wind speeds are of the same order of magnitude as birds' air speeds, flight costs can easily be doubled or, conversely, halved by wind effects. Many studies have investigated how birds should or actually do react to winds aloft, how they avoid additional costs or how they profit from the winds for their journeys. This review brings together numerous theoretical and empirical studies investigating the flight behaviour of migratory birds in relation to the wind. The results of these studies corroborate that birds select for favourable wind conditions both at departure and aloft to save energy and that for some long-distance migrants a tail-wind is an indispensable support to cover large barriers. Compensation of lateral wind drift seems to vary between age classes, depending on their orientation capacities, and probably between species or populations, due to the variety of winds they face en route. In addition, it is discussed how birds might measure winds aloft, and how flight behaviour with respect to wind shall be tested with field data.

Shamoun-Baranes, J., E. van Loon, et al. (2006). "A comparitive analysis of the influence of weather on the flight altitudes of birds." Bulletin of the American Meteorological Society **87**(1): 47-+. <Go to ISI>://000235140400015.
Birds pose a serious risk to flight safety worldwide. A Bird Avoidance Model (BAM) is being developed in the Netherlands to reduce the risk of bird-aircraft collisions. In order to develop a temporally and spatially dynamic model of bird densities, data are needed on the flight-altitude distribution of birds and how this is influenced by weather. This study focuses

on the dynamics of flight altitudes of several species of birds during local flights over land in relation to meteorological conditions.
We measured flight altitudes of several species in the southeastern Netherlands using tracking radar during spring and summer 2000. Representatives of different flight strategy groups included four species: a soaring species (buzzard Buteo buteo), an obligatory aerial forager (swift Apus apus), a flapping and gliding species (black-headed gull Larus ridibundus), and a flapping species (starling Sturnus vulgaris).
Maximum flight altitudes varied among species, during the day and among days. Weather significantly influenced the flight altitudes of all species studied. Factors such as temperature, relative humidity, atmospheric instability, cloud cover, and sea level pressure were related to flight altitudes. Different combinations of factors explained 40%-70% of the variance in maximum flight altitudes. Weather affected flight strategy groups differently. Compared to flapping species, buzzards and swifts showed stronger variations in maximum daily altitude and flew higher under conditions reflecting stronger thermal convection. The dynamic vertical distributions of birds are important for risk assessment and mitigation measures in flight safety as well as wind turbine studies.

Farnsworth, A. and R. W. Russell (2007). "Monitoring flight calls of migrating birds from an oil platform in the northern Gulf of Mexico." Journal of Field Ornithology **78**(3): 279-289. <Go to ISI>://000249179900006.
Millions of birds migrate across the Gulf of Mexico each year. However, most studies of migration in this region involve sampling onshore locations during the day, potentially underrepresenting the diversity and abundance of migrants passing the region. We evaluated a potential solution to this problem by recording the flight calls of passing migrants from an oil platform located southeast of the Alabama coast in the Gulf of Mexico. We detected 2762 calls during 30 nights from 9 September to 2 November 1999, and were able to identify 2329 calls to species. Flight calls by nine species of birds represented 23% of all identified calls. The greatest number of calls during one night (1017 calls) and during a 1-h period (257 calls) were recorded on 10 September. The greatest number of calls was recorded 8 h after sunset, with a secondary peak 2 h after sunset. The peak prior to sunrise may indicate the formation of flocks at dawn, and the peak after sunset may have been caused by the first wave of migrants reaching the platform. However, call counts varied extensively, with 98% of all calls recorded during 13 nights and 40% on a single night, possibly resulting from hourly and nightly differences in bird numbers aloft, atmospheric conditions, and artificial lighting conditions. Although recording on oil platforms can be difficult because of mechanical, wind, and wave noise, our results suggest great potential for describing the species composition of passing vocal migrants and the temporal patterns of flight-calling behavior if quiet recording locations can be found. Moreover, flight call monitoring could be a critically important tool for bird conservation in this region, given recent proposals to develop wind power and the potential bird mortality associated with such developments.

Dillingham, P. W. and D. Fletcher (2008). "Estimating the ability of birds to sustain additional human-caused mortalities using a simple decision rule and allometric relationships." Biological Conservation **141**(7): 1783-1792. <Go to ISI>://000258306300006.
Many bird species are subject to human-caused mortality, either through direct harvest (e.g. game birds) or through incidental mortalities (e.g. fisheries-related bycatch of seabirds, impact with vehicles, wind turbines, or power lines). In order to assess the impact of additional mortalities on birds, both the number of birds killed and their ability to sustain those deaths must be estimated. Niel and Lebreton [Niel, C., Lebreton, J.-D., 2005. Using demographic invariants to detect overharvested bird populations from incomplete data. Conservation Biology 19, 826-835] applied a simple decision rule [Wade, P.R., 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Marine Mammal Science 14, 1-37] to estimate the level of additional human-caused mortality

or potential biological removal (PBR) that can be sustained for bird species given only (1) estimates of the population size, adult survival, and age at first breeding, and (2) the current population status and management goals. We provide guidelines for appropriate use of the method and case studies comparing results from this method to other approaches. Particular focus is placed on applying the method to Procellariiformes. PBR limits may then be set without a population model and when monitoring levels are minimal, and in a computationally straightforward manner. While this approach has many advantages, there are limitations. The PBR rule was initially developed for cetaceans and pinnipeds and there have been no adaptations for the unique biology of birds which may need further consideration. Additionally, because this is a simplifying method that ignores differences in life stages, it may not be appropriate for very small populations or for those listed as 'critically endangered', and further work is needed for situations where mortalities have large gender or age bias. (C) 2008 Elsevier Ltd. All rights reserved.

McCarthy, M. A., R. Citroen, et al. (2008). "Allometric scaling and Bayesian priors for annual survival of birds and mammals." American Naturalist **172**(2): 216-222. <Go to ISI>://000257986200009.
Allometric theory predicts that instantaneous mortality rates scale with body mass with a negative quarter power. Such a relationship would mean that the survival rate of one species is partly predictable from the survival rate of other species. We develop allometric regression models for annual adult survival of birds and mammals, using data collected from the literature. These models conform to the predictions of the allometric theory; the value of negative one-quarter for the scaling parameter is within the 95% credible interval, which is [- 0.31, -0.10] for birds and [-0.35, -0.15] for mammals. The predictions are very well supported when evaluated using an independent set of data. The regression models can be used to provide objective and informative Bayesian priors for annual adult survival rates of birds and mammals or to act as a point of comparison in new studies.

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