Bird Fatalities at Wind Energy Facilities
- An Overview -

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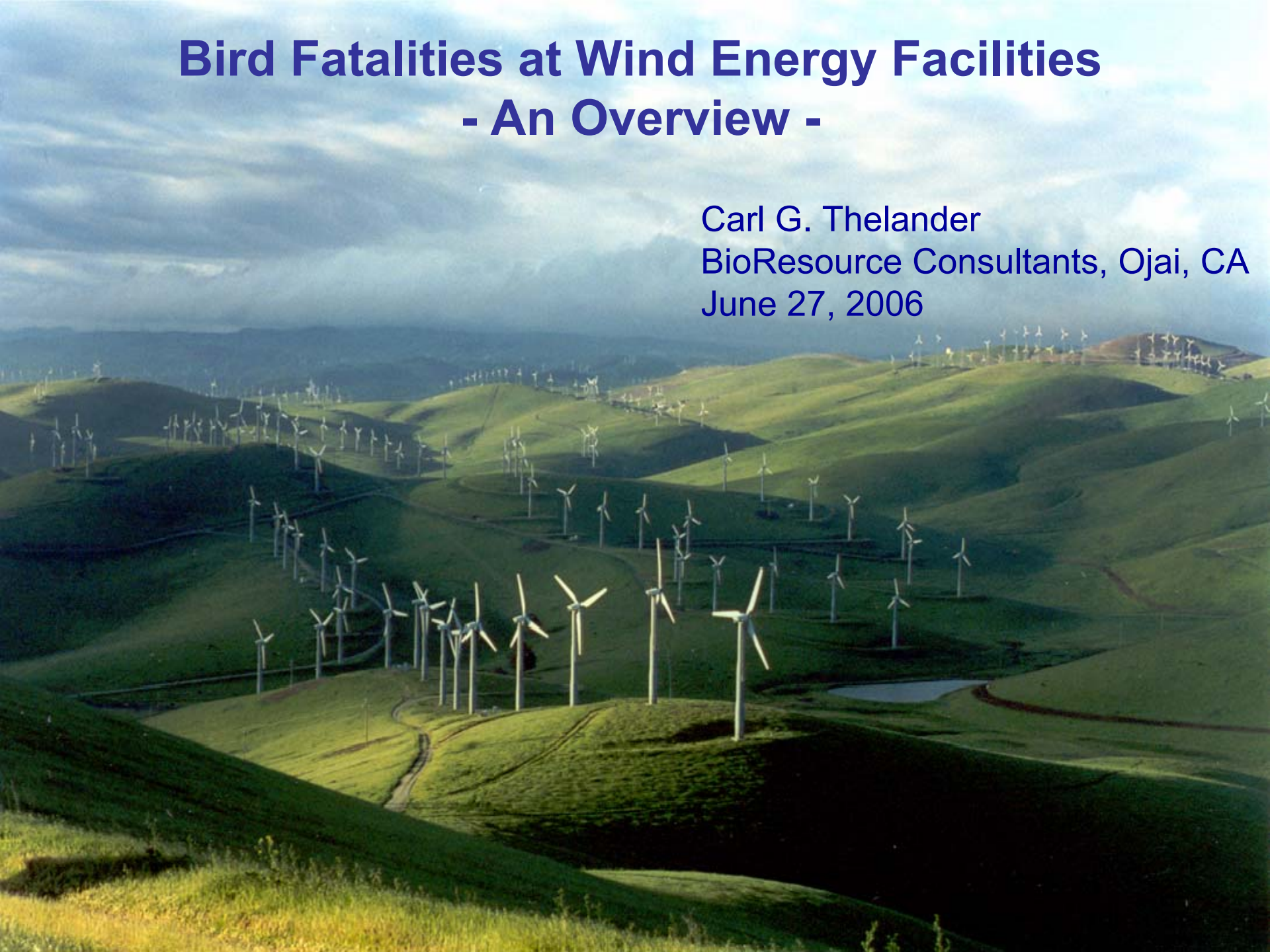


The Basic Premise…

Americans accept the scientific finding that CO^2 and other 'greenhouse gas' emissions are causing global climate changes.

Moving to renewable energy sources like wind energy can help to lessen these emissions.

Current trends toward the rapid development of wind energy resources (on- and off-shore) have elevated concerns about the industry's potential impacts on wildlife, especially birds and bats.

See Huntley et al. (2006), Ibis 148 (Suppl 1): 8-28 for a review.

What Benefits Do Birds Provide?

Americans *love* birds! There are 700+ species native to the US.

Birds offer outdoor recreation opportunities.

- 69 million US adults (33%) set aside time to enjoy birds.
- 18 million US adults travel > 1 mile out of their way to see birds.
- $32 billion spent annually in US on birding gear, services, and trips.
- 1.6 million people read *Audubon Magazine* monthly.

Birds eat their weight everyday in rodents, insects, weed seeds and other pests.

Birds serve as indicators of ecological conditions, imbalances, and environmental problems.

What are the Main Effects of Wind Energy on Birds?

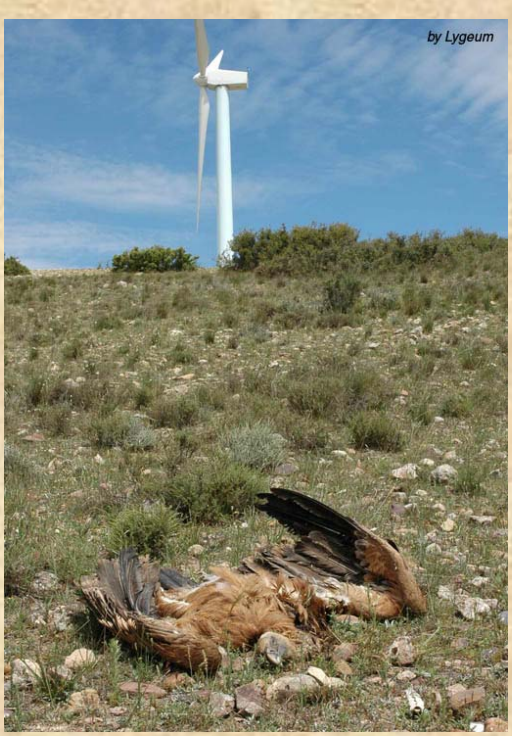
- **Displacement due to disturbance,**
- **Barrier effects to migration and local movements,**

- **Habitat loss, and**
- **Collisions with turbines causing fatalities.**

Bird Fatalities Are Affected By Many Variables

- **Species diversity and richness, especially differing flight behaviors, affect avian risk at wind energy facilities.**

  - Grassland birds moving close to the ground (Low Risk).
  - Migrants flying above turbine rotor-swept area (Moderate Risk).
  - Raptors foraging for ground-based prey (High Risk).



Bird Fatalities Are Affected By Many Variables

- **Turbine size and configuration.**
  - Early (1980s) wind turbines in CA were small, ~100 kW machines.
  - Today, 1.5+ MW machines (1,500 kW) are the standard, with the next generation of offshore turbines going to 5 MW each.

Bird Fatalities Are Affected By Many Variables

- **Topography of the surrounding landscape affects risk.**

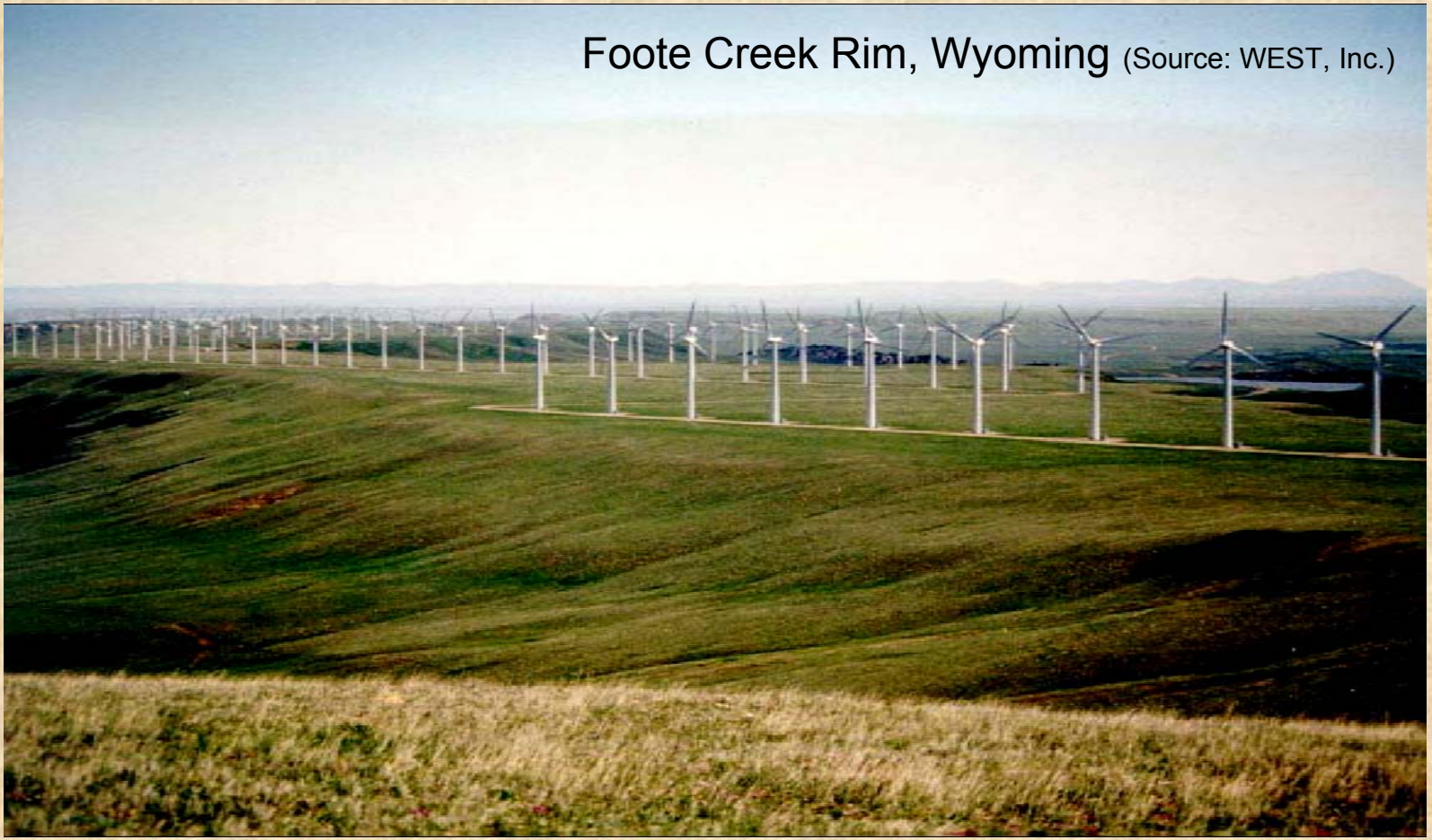
- **Local land use and habitat conditions affect risk.**

- **Understanding the ecological processes and species-habitat relationships at wind farms can lead to optimal siting of turbines.**

- **Optimal siting, operations, and maintenance at facilities can effectively *minimize* risk to birds.**

- **Achieving this goal requires that research be conducted pre- and post-construction.**

There Are Many 'Success Stories'



Pre-construction surveys showed that ~85% of all raptor use was at the height of the proposed rotor swept area and within 50 meters of the rim edge. The solution? …install the turbines away from the rim. It worked. Post-construction monitoring confirmed low mortality.

At Altamont Pass WRA, cattle grazing is the predominant land use. The cattle congregate around the wind turbines.

The turbines provide some limited shade and the ranchers use the turbine access roads to run their cattle operations.

The cattle defecate where they congregate.

The cattle feces provide a rich source of food for arthropods, including ‘blooms’ of grasshoppers. Raptors are, in turn, attracted to these concentrations of readily available prey species. The result is raptors like Burrowing Owls, American Kestrels, and Red-tailed Hawks are drawn very close to the turbine strings to forage, which greatly increases their risk of collision.

Burrowing rodents flourish in areas of disturbed soils. We showed that where these disturbances occurred, like the creation of roads and tower pads, that raptor use increased, risk increased, and fatalities increased.

The frequency and density of rodent burrows were *higher* near turbine strings and disturbed soils than in undisturbed soil areas away from turbine strings.

The turbine tower pads became habitat for cottontails, which are a primary prey species for Golden Eagles, Red-tailed Hawks, Great Horned Owls and other raptors. Raptors hunting for cottontails residing at the bases of turbines greatly increased their risk of collision.

Altamont Pass WRA – The Worst-case Scenario?

20+ years of operations. Old, small turbines. Over 40 different bird species killed.

Solutions have focused largely on raptors, mainly Golden Eagles, Burrowing Owls, Red-tailed Hawks and American Kestrels.

Rated Output Capacity = 580 MW (~5400 turbines over ~75 mi^2)

Estimated Mortality = ~3 – 8 total bird fatalities / MW / year.

Estimated Annual Bird Fatalities (all species) = ~ 1,700 – ~ 4,700 individuals
Of these: 881 – 1,300 are raptors (1.5 – 2.2 raptors / MW / year), including:

75 – 116 Golden Eagles
209 – 300 Red-tailed Hawks
99 – 380 Burrowing Owls
73 – 333 American Kestrels

The lower ends of these estimates are very conserative - the mortality adjusted for fatalities that were likely missed due to search radius limits. The upper ends of these estimates are adjusted for fatalities missed due to undetected carcass removal by scavengers. Applying additional factors would simply increase the estimates.

Tarifa, Spain (Straits of Gibraltar)

- Highlights the need for pre-construction surveys and careful turbine siting.
- Located along important migration funnel between Europe and Africa.
- Two raptors mainly involved: Griffon Vultures and Common Kestrels
- Griffon Vultures:

  Mortality ~0.15/turbine/year

  Mostly killed in autumn-winter

  Mostly killed at just two turbine strings where risk was greatest
- Common Kestrels:

  Mortality reported at ~ 0.19/turbine/year

  Mostly killed in summer

  Mostly killed at turbines in open habitats within one wind farm
- Large numbers representing many species of migrants were NOT killed because of their flight behaviors. Only a small fraction at risk. Flight pattern research data are being used to site new turbines in low risk areas.

Ref: Barrios and Rodriguez (2004)

Navarre, Spain

- Important migration area for many species.
- ~400 turbines studied at two locations.
- Weather conditions apparently affected risk.
- 88 Griffon Vulture carcasses found.
- With correction factors (scavenging and searcher efficiency) estimated mortality at 8 Griffon Vultures/turbine/year.
- Passerine (small bird) mortality estimated at 64 birds/turbine/year.
- For ALL birds, estimated mortality = ~22 birds/turbine/year at the Salajones facility.

Ref: Lekuona 2001

Comparing Collision Rates Can Be Difficult and Confusing

- Collision rates are extremely variable between facilities, with averages ranging from 0.01 to 20.0+ bird collisions / turbine / year.
- Most wind farms probably have relatively low bird kill rates, but not all are monitored using independent monitors and statistically comparable methods.
- For example, Texas has surpassed California in wind energy MW output, yet reports of bird fatalities there are rare and incidental. Why? Apparently no post-construction monitoring or reporting are required by the permitting agencies.
- Are California's Altamont Pass WRA and Tarifa/Navarre in Spain extraordinary situations? Each location involves many species, but special concern exists for relatively rare, long-lived species (e.g.,Golden Eagles at Altamont; Griffon Vultures in Spain.
- At the Altamont WRA, as in Spain, the collision rate per turbine is relatively low due to the relatively large number of smaller, 'old generation' turbines that were installed. Fatalities tend to be concentrated among a subset of the turbines.

- Most studies report data based on different assumptions. Some report 'raw' data (i.e., carcasses found) only, which results in under-reporting actual numbers killed.
- Mortality data reported as fatalities/turbine/year is often not comparable because of the differences between turbines.
- Fatalities/MW/year and fatalities/m^2 of rotor-swept area/year are more suitable to comparisons.
- Estimates of mortality incorporate a variety of 'correction factors' and not all are applied consistently, again making comparisons difficult.
- Fatality data and mortality estimates for small birds much less reliable, and under-reported, than for larger birds like raptors. Small birds are quickly scavenged at most wind farms. Often too costly to conduct thorough monitoring.
- However, as the number of wind farms increases, and more data are reported, trends are emerging and 'problem' facilities may become more easily identified.
- Efforts continue toward standardizing study designs, data analysis methods, and data reporting.

Biologists Count Carcasses to Estimate Mortality

Estimated Total Collisions = TDBF (Total Dead Birds Found) + SD + SRB + CB + BFB

- **Searcher Detection Bias (SD)**

Seasonal detection differences, terrain/vegetation differences, visibility of small birds vs. large birds, searcher ability/experience.

- **Scavenging or Removal Bias (SRB)**

Scavengers and/or people removing birds between search events.

- **Crippling Bias (CB)**

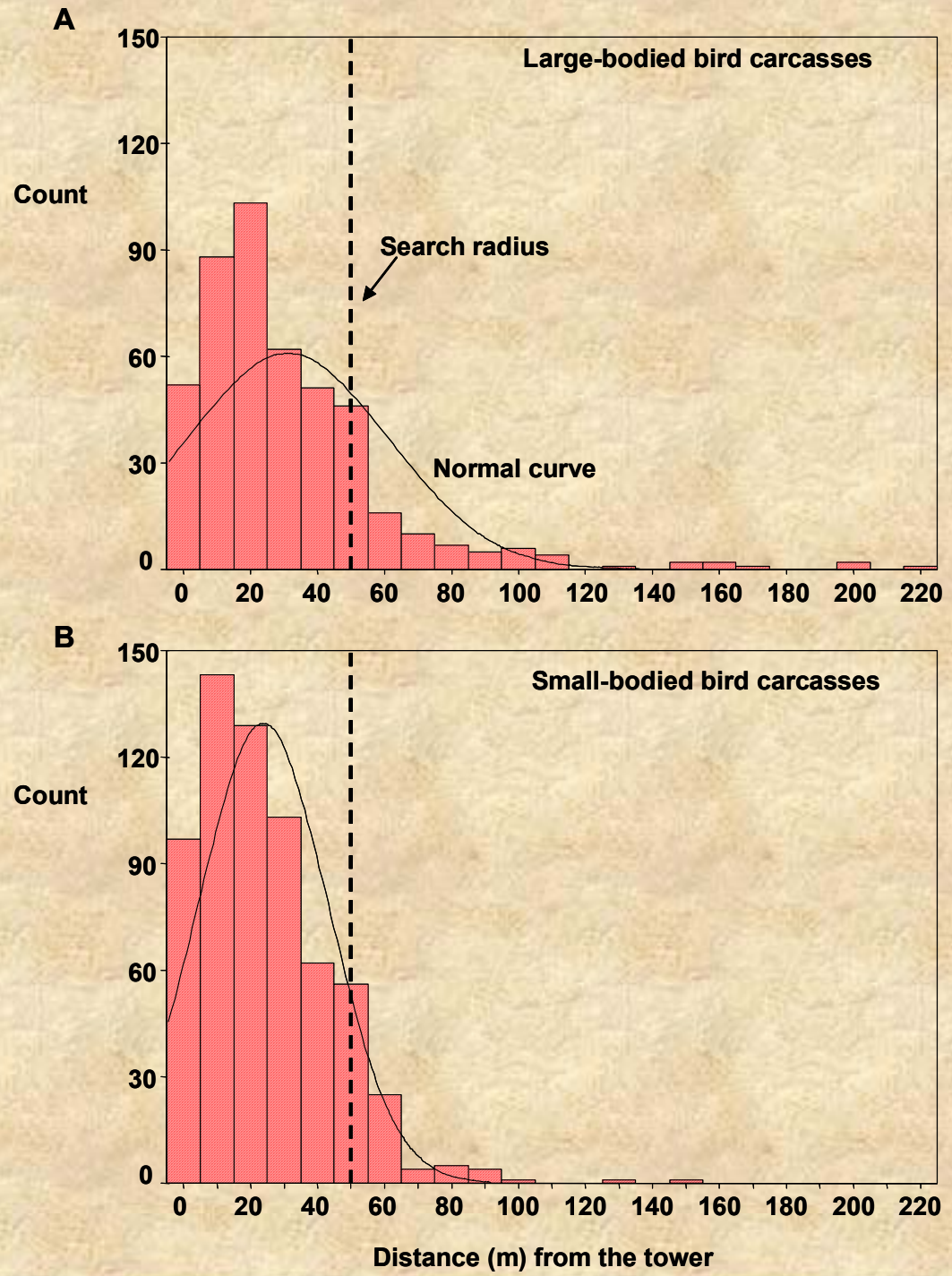
Birds that either fall outside of search area and go undetected, or that fall injured inside the search area but then move from the area and subsequently die.

Birds Found Immediately Adjacent to Search Area – We found relatively small numbers of birds (~10%) within a short distance of our outer 50-meter search limit. We developed a modest correction factor for this bias, too.

- **Background Fatality Bias (BFB)**

Deaths due to natural causes as if no turbines present. Johnson et al (2000) believed there to be too few to justify adjusting for the effect.


Rotor plane
Rotor zone
50 meters

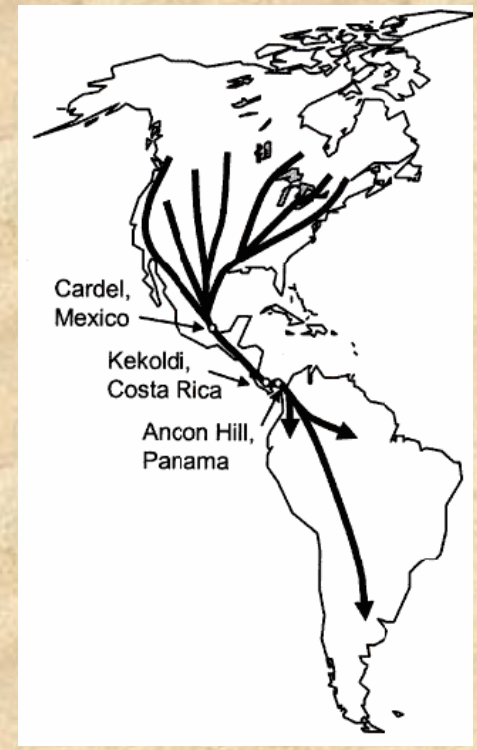


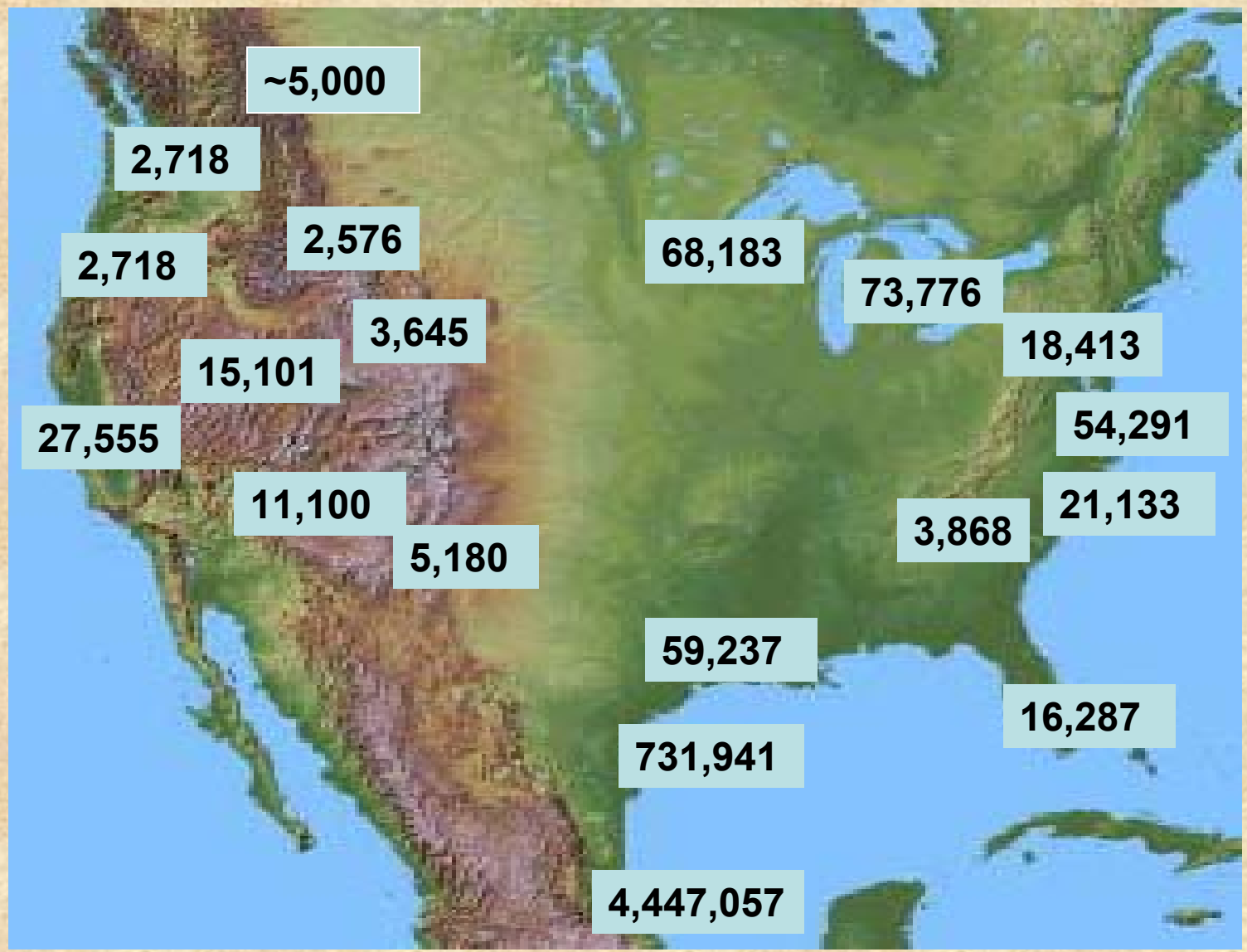
Is The Search Area Sufficient?

Frequency distribution of the distances (in meters) that we found carcasses away from turbine towers.

Since not all birds killed by turbines are found during searches, correction factors are calculated and applied to derive the overall mortality *estimates.*

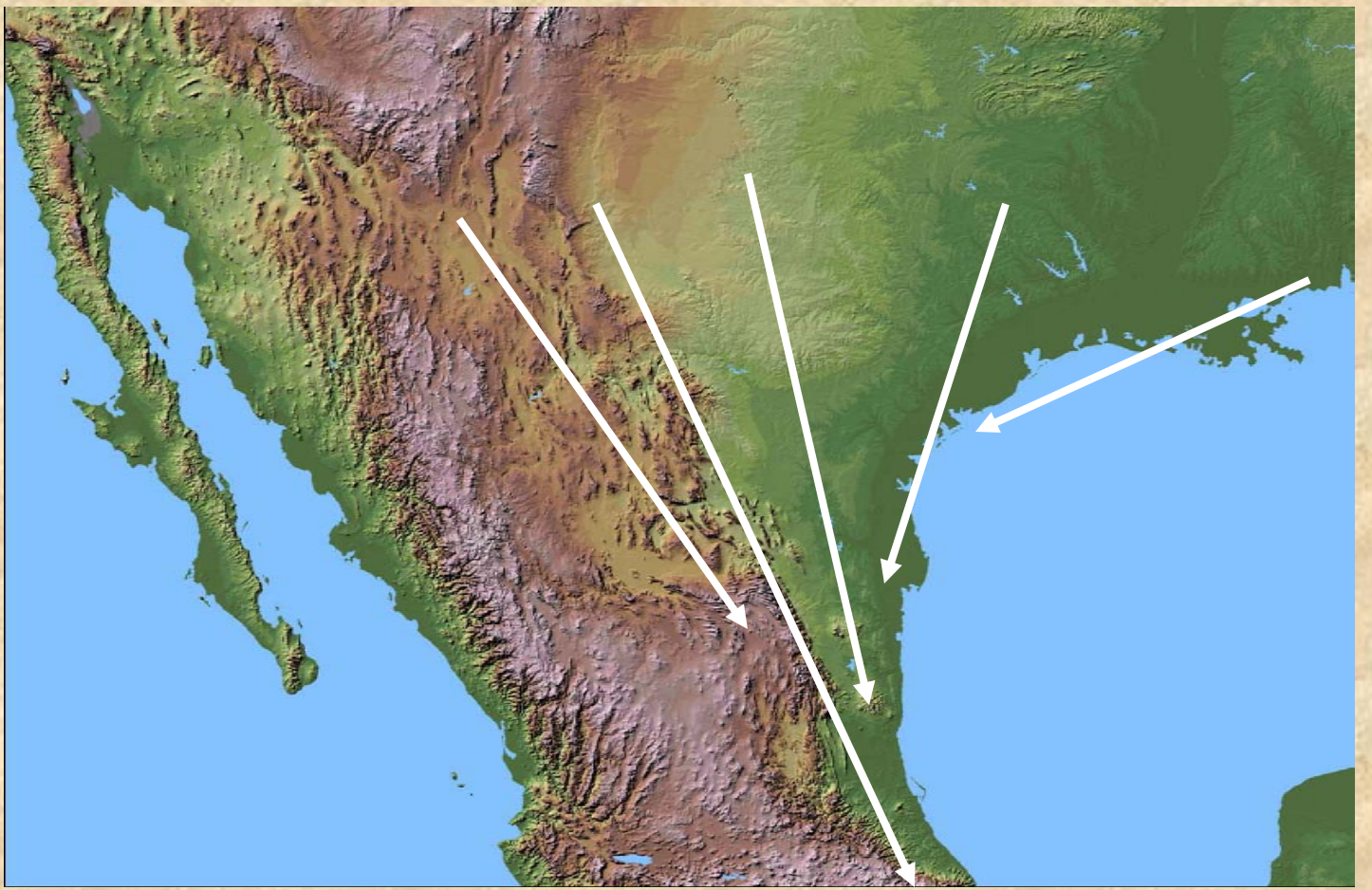
- ***What Are the Local/Regional Cumulative Impacts of Bird Mortality at Individual Wind Energy Facilities?***
- ***Are They Biologically Significant?***
- ***What Will Be the Broader Cumulative Impacts to Birds?***
- ***Will They Become Biologically Significant for Certain "At Risk" Species?***





Magnitude of autumn raptor migration at selected ‘watchsites’.

(source: HawkWatch International)



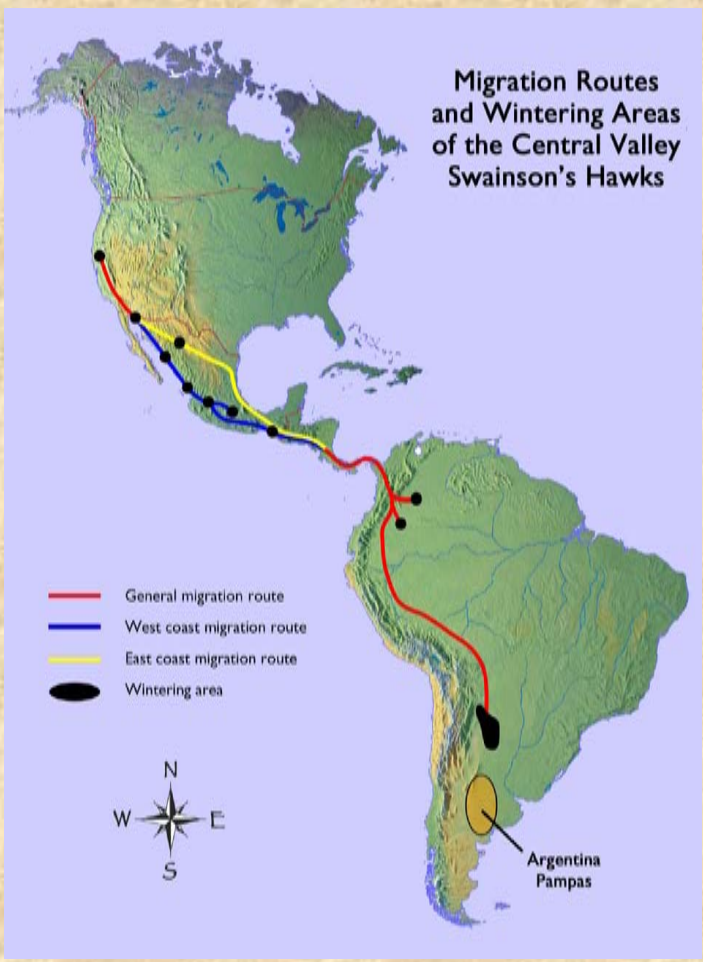
Veracruz, Mexico, where the world's largest flights are recorded, is a significant migratory funnel on a continental scale, especially for Broad-winged Hawks, Swainson's Hawks, Turkey Vultures, and Mississippi Kites.

Each autumn ~ 5,000,000 raptors migrate south from North America into Central and South America.

Broad-winged Hawks migrating near Veracruz, Mexico

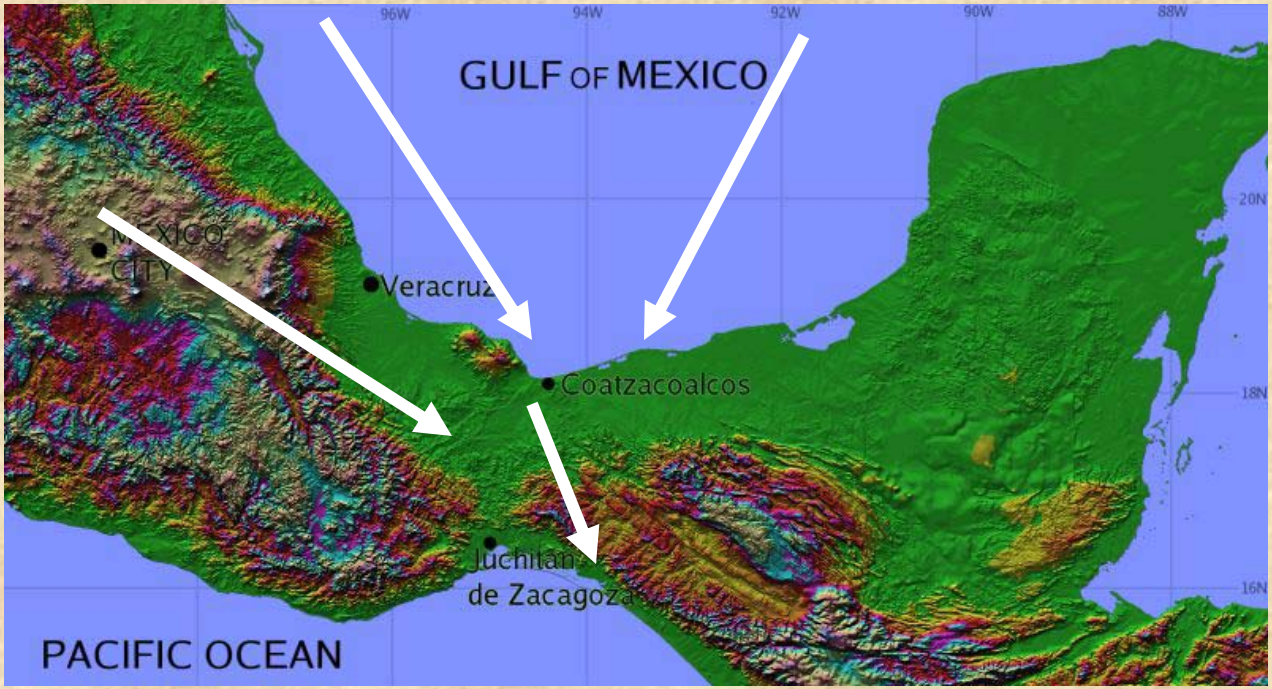
Selected Raptors and Estimated Numbers Sighted Along the Mesoamerican Land Corridor During Autumn Migration *(Ref: Bildstein and Zalles 2000)*

Broad-winged Hawk (Buteo platypterus)	**1- 2 Million**
Turkey Vulture (Cathartes aura)	**1- 2 Million**
Swainson's Hawk (Buteo swainsonii)	**~ 1 Million**
Mississippi Kite (Ictinia mississippiensis)	**< 200,000**
American Kestrel (Falco sparverius)	**< 30,000**
Sharp-shinned Hawk (Accipiter striatus)	**< 20,000**
Cooper's Hawk (Accipiter cooperii)	**< 10,000**
Osprey (Pandion haliaetus)	**< 10,000**
Peregrine Falcon (Falco peregrinus)	**< 4,000**
Swallow-tailed Kite (Elanoides forficatus)	**< 2,000**
Plumbeous Kite (Ictinia plumbea)	**< 2,000**
Northern Harrier (Circus cyaneus)	**< 2,000**
Merlin (Falco columbarius)	**< 2,000**
Red-tailed Hawk (Buteo jamaicensis)	**< 1,000**
White-tailed Kite (Elanus leucurus)	**< 500**
Black Vulture (Coragyps atratus)	**< 500**
Zone-tailed Hawk (Buteo albonotatus)	**< 500**
Hook-billed Kite (Chondrohierax unicinatus)	**< 500**
Gray Hawk (Asturina nitida)	**< 100**
Common Black Hawk (Buteogallus anthracinus)	**< 100**
Harris' Hawk (Parabuteo unicinctus)	**< 100**
Red-shouldered Hawk (Buteo lineatus)	**< 100**
White-tailed Hawk (Buteo albicaudatus)	**< 100**
Roadside Hawk (Buteo magnirostris)b	**< 100**
Short-tailed Hawk (Buteo brachyurus)	**< 100**
Crested Caracara (Polyborus plancus)	**< 100**
Golden Eagle (Aquila chrysaetos)	**< 50**
Aplomado Falcon (Falco femoralis)	**< 50**
Prairie Falcon (Falco mexicanus)	**< 50**



Swainson's Hawks nest in relatively low densities over a broad region of North America. But nearly all migrate through geographic 'funnels'.

The Isthmus of Tehuantepec in Oaxaca, Mexico, is one such location.



Mexico's Oaxaca region has the potential to produce ~30,000 MW of wind energy and this resource is actively being developed (Ref: NREL/TP-500-34519)

What Is Now Generally Accepted?

- Wind energy is growing rapidly, extensively, and over a wide geographic area, including onshore and offshore, and in some 'critical' bird migration areas.

- Birds are at risk somewhat at essentially every wind farm, and in numbers that some believe represent significant environmental impacts. Few individual wind farms pose significant threats to local bird populations.

- Most wind farms lack sufficiently study to determine their individual impacts, or their cumulative impacts. Difficult to make informed decisions.

- The biological significance of these impacts is difficult to assess and to define. Little is known about the ability of certain species to sustain new sources of mortality. What will the long term, cumulative effects be?

- Very few studies have identified ways to reduce bird fatalities. More research is needed. Some solutions have been challenged as too costly.

- Regulatory processes for permitting projects, including whether to require conducting pre-construction assessments and post-construction monitoring studies, vary greatly between states and/or counties within states. Effective and enforceable guidelines are needed.

Ref: GAO-05-906; *Wind Power: Impacts on Wildlife and Government Responsibilities for Regulating Development and Protecting Wildlife.*

Some Characteristics of Bird Mortality at Wind Farms

- **Mortality tends to be site-specific -**

  What happens at one facility is rarely an accurate predictor of what will happen at another facility. Wind and topographic patterns vary greatly from site to site. Often only certain turbines cause the majority (all?) of the mortalities. Their identification can result in selected turbine decommissioning to greatly reduce mortality.

- **Mortality is species-specific -**

  Each species using a particular area will have its own mortality estimate, and these will vary from region to region depending on local numbers and densities.

- **Mortality usually varies seasonally -**

  At wind farms reporting fatalities, invariably there are seasonal peaks, and seasonal lows. Bird use varies over time on annual cycles. These cycles can be used to predict risk and to implement impact avoidance techniques (e.g. seasonal shutdowns)

What Are The Potential Impacts of Offshore Wind Energy?

- In May 2006, a technical White Paper by the U.S. Department of Interior's Minerals Management Service reported that the U.S. Department of Energy estimates that 900,000 MW of potential energy exists along the US coasts.
- This equals the current installed US electrical capacity.
- 900,000 MW could be generated by ~250,000 turbines averaging ~ 4 MW / turbine.
- Assuming only 4 bird mortalities / turbine / year, the potential impact to bird populations reaches ~1,000,000+ killed per year.
- Currently, only about 600 MW of offshore generating capacity is installed worldwide.
- Currently, proposed offshore facilities through 2010 amount to 11,000 MW.
- The Texas Gulf Coast is currently slated for intensive wind energy development, an area recognized for extensive off-shore bird migration.

Some Recent News…

June 23, 2006, BBC News reported that 9 White-tailed Eagles have been killed at Norway's Smola Island Wind Energy Facility over a 10-month period. Smola is located off the Norwegian coast where a key population of Europe's largest bird or prey resides.

Since the 68-turbine facility was built, reproductive output has plummeted, with breeding pairs at the site down from 19 to just one.

The Royal Society for the Preservation of Bird's Conservation Director (M. Avery) noted, *"So this colony that is very important – was very important – has been practically wiped out because this wind farm was built in exactly the wrong place."*

The RSPB supports renewable energy and wind energy specifically, but it is urging developers and government agencies to take the potential impact on wildlife properly into consideration when planning new wind farms.

In Summary…

- Encourage states to develop their own guidelines and engage independent and credible wildlife experts in the process. Identify 'red zones' to avoid entirely, or seasonally?

- Candidate wind energy sites with predicted low avian risk may pose a *significant* risk to a small number of highly-vulnerable species.

- Research and monitoring needs to be independent, credible, transparent, published, and peer-reviewed as much as possible.

- Only through more research, better planning, and enforceable regulations can a *potential* conservation disaster be avoided over the coming decades.

In Summary…

- Avian risk at wind farms differs greatly from site to site, with the majority of sites likely being 'low risk', at least for most of the year.
- The greatest long term issue may be the *cumulative impact* of wind energy, not the local impacts caused by individual facilities. Biological significance may become a factor if too many facilities are constructed where migration numbers are highest. Seasonal shutdowns may be needed.
- What long-term, cumulative effect will "Great Lakes + Texas Gulf + Oaxoca" have on North American bird populations, or certain vulnerable species?
- Protocols and guidelines are needed *to identify high risk areas* and to discourage wind energy development, if warranted, in those areas.

"I'm not going to shoot the messenger, but I'm also not going to renew his grant."

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