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Avian Risk Assessment Methodology

by

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Overview of Project

This project will establish and test an innovative avian risk assessment methodology involving wind energy development. Phase I studies are focused on the key question of determining if a developed and operating Wind Resource Area (WRA) results in an increased risk of bird mortality. While this approach may not entirely exclude the need for additional studies, it should allow researchers to focus quickly on key areas for further inquiry and uncover potential relation-ships that could be verified through follow up studies.

This methodology will determine the relative abundances of birds in the WRA and their utilization of the area, and will sample for bird mortality. From these data the study will determine indices of bird risk and attributable risk due to the WRA. The methodology lends itself to the comparison of multiple sites from around the nation.

Although this approach is not entirely new, its application to bird/wind energy studies is ground breaking and should yield results valuable to many WRAs throughout the U.S. It is possible to conduct such a project only in California because of the extensive wind develop-ment there. The results from this study should be available in time to help guide the planned development of WRAs elsewhere in the U.S.

Because WRAs are not all alike, research at one or a few locations should not be used to characterize the issues at all WRAs. The limited number of areas already studied may not be representative for California or for the United States as a whole, and may give an undeserved nega-tive impression of the impacts of wind energy developments on birds. The California Energy Commission considers it important that credible, comprehensive avian mortality monitoring studies be con-duct-ed in Tehachapi Pass WRA and San Gorgon-io Pass WRA (Fig. 1).

The study is being conducted as a result of the combined interest of local, state and federal agencies, the wind industry, environmental organizations, landowners, and utilities. There is agreement among these parties that comprehensive, credible studies are needed to provide a broader base of data and reports from a larger and more representative selection of WRAs. Therefore, an extensive review process has been undertaken to ensure that all stakeholders have had opportunities to review the methods and to recommend modifications.

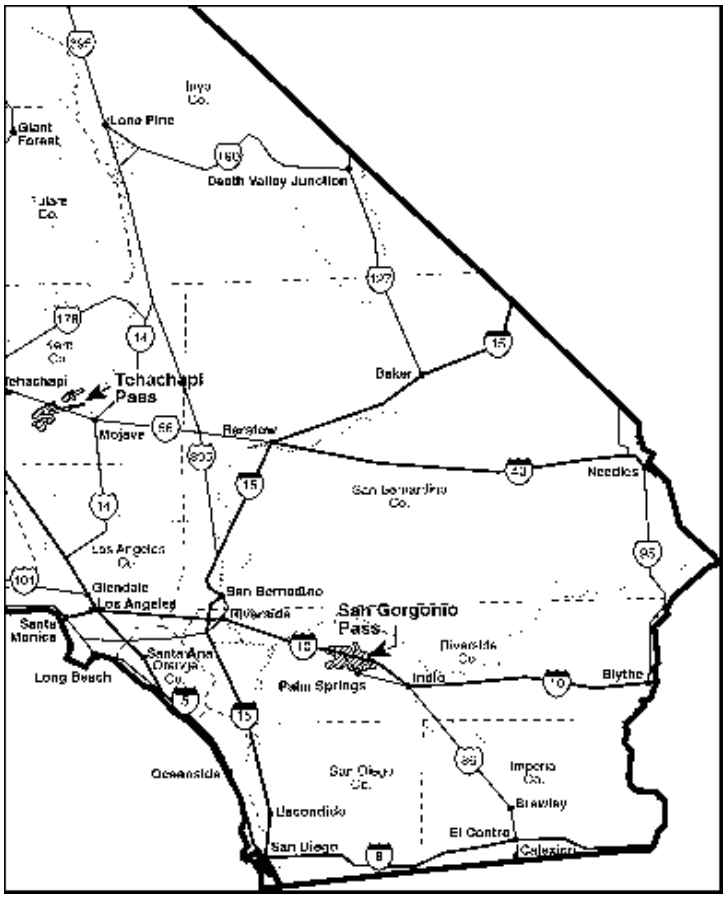


FIGURE 1. Developed Wind Resource Areas of southern California.

Phase I of this specific project is not designed to determine the absolute number of birds dying in the WRA nor the absolute net difference in mortality levels between the WRA and an undeveloped comparison area. Such numbers, in isolation, are of little value without also knowing the larger context of avian activity in the area and the "natural" mortality levels. We assume that all birds die eventually but we are interested in knowing if an operating wind plant in the WRA causes an increase in mortality. We believe it is prudent to start with a research design that can identify the *relative risk* caused by an existing and operating wind plant. The results of this type of research can be used as both a screen to determine if further research is warranted and as a guide for more focused research.

Methodology Development

An extensive effort to develop methodologies acceptable to all stakeholders has been undertaken. The "Measurements/Concepts" technical discussion found below is a consensus approach developed by several biostatisticians and field methodology experts representing federal, state, utility, and environmental organizations. (See the chapter by M. Morrison and H. Davis in these Proceedings [p. ff] for further discussion of the development of this methodology.) The method-ol-ogy described here was current as of mid-1995; it will receive addi-tional review as the project continues. A very desirable aspect of this project and its methodology is our willingness to be adaptive and to modify the proposed methodology in order to meet reason-able consen-sus standards. During the anticipated several years of research at Tehach-api Pass and San Gorgonio Pass WRAs, addition-al methodologies will be developed in a similar consensus manner to resolve more focused problems (Phases II and III). This approach will result in credible, comprehensive, objective studies providing standard methods that can be considered for application during subsequent studies elsewhere.

A. Key Questions.-The goal of the project is to determine if an operating wind plant results in an increased risk of bird mortality compared to the surrounding nondeveloped area. The key questions are as follows:

1. What influence does the operation of a wind plant have upon birds?
2. Does the wind plant operation influence the level of bird activ-ity, called "utilization rate", compared to that of nearby undeveloped areas?
3. Does the wind plant operation influence the rate of bird mortal-ity, called "mortality rate", compared to that of nearby undeveloped areas?
4. When comparing the utilization rates and bird mortality rates in the operating wind plant and surrounding undeveloped areas, is there any change in the risk to birds that is attribut-able to the operating wind plant?
5. Does utilization rate, mortality rate, or attributable risk vary depending on the type of technology (e.g., different wind tur-bine types, infield powerlines, transformers, etc.), the environmental conditions, or the species of bird?

B. Measurements/Concepts.-Several of the key measurements to be taken during the study need to be defined carefully:

1. Bird Utilization Rate

   "Bird utilization rate" of the developed WRA and nearby non-developed areas will be documented. The bird utilization rate is the number of birds detected utilizing the area during 5 and 10 minute variable point counts. The 5 and 10 minute variable point counts will be compared for effectiveness. The variable point counts must be conducted during standard time peri-ds and (in California) during all seasons for comparison purposes. Because of the noise of turbines and wind in general, sound (bird calls) will not be used to detect birds utilizing the area. Observers are directed to ignore bird calls. Some observers may choose to wear ear plugs. The observer slowly turns around to monitor a full 360 (normal search pattern). If a bird sound is heard, the observer continues the 360 scan and only records the bird if it is seen during the observer's normal search pattern. This will insure that turbine noise will not bias the counts and calculated utilization rates from undeveloped comparison areas vs. developed WRAs. Utilization rates can be calculated for individual species, taxonomic groups and all birds combined, and for various natural communities, seasons, distances from the nearest turbine, etc. Bird activities will also be documented including flying, perching, soaring, hunting, foraging, height above ground, and behavior close to WRA structures. Both the height above ground and the horizontal distance to each bird will be estimated.

2. Bird Mortality

   The number of dead birds or bird parts found at each search site (a 100 meter diam-eter/50 m radius circle centered on each variable point

count site) will be documented. Dead birds or bird parts of any age will be counted. Dead birds and bird parts will not be collect-ed because, under the chosen sampling design (random-ized samp-ling with replacement), a given area may be sampled more than once. The number of dead birds or bird parts documented per search site will be called "bird mortality". Ancillary information is collected to facilitate later analyses, including estimated time since death, cause of death, type of injury, distance to nearest turbine, and distance to nearest structure.

3. Bird Risk

   Bird risk relates the birds found dead in the area to those utilizing the area. Bird mortality will be used as the numerator and the bird utilization rate as the denominator to develop an index of "bird risk". Bird risk establishes a relation-ship between bird use and bird death; it does not represent absolute numbers of dead birds. If absolute numbers of dead birds and bird use increase commensurately, the bird risk will not change. Bird risk can be used to define and compare risk at varying distances from developed WRA facil-it-ies for species, taxonomic groups and all birds combined, and for various natural communities, seasons, and turbine designs. Bird risk can be used for comparisons with other WRAs and other types of facilities such as highways, powerlines, and transmitter towers.

4. Attributable Risk

   The differences in bird risk will be used to discuss "attributable risk". This is the risk that may be attributable to a specific location or situation, such as risk to the birds associated with the developed WRA vs. non-developed nearby comparison areas or other comparisons. Locations and situations for which risk differs substantially would be candidates for more focused studies.

5. Scavenging Rate

   Scavenging activity can be quantified and calculated as a rate comparing a developed WRA with non-developed near-by comparison areas or other WRAs. In Phase I of this study, scavenging levels that differ between comparison areas will affect or bias the ability to detect and relate relative numbers of dead birds. If not detected, significant differences in scavenging rate would result in misleading bird risk. In Phase I of this study, if scavenging rates are equal in different parts of the same WRA or in different WRAs, then scavenging rate will have no effect when comparing bird mortality, bird risk, and attributable risk.

6. Observer Bias

   Differences between observers' abilities to perceive and record bird utilization parameters and find dead birds or bird parts need to be determined in order to minimize and account for this potential bias.

C. Sampling Design.-The sampling design for Phase I studies has been defined and tested. Some possible Phase II and III studies have been identified but their specific sampling designs have not yet been defined.

Phase I Studies

Starting points were selected at random within strata representing all natural communities within the developed WRA and non-developed comparison areas. Fi each starting point, a randomly selected angle determines the transect direction along which variable point counts and dead bird searches are conducted (Fig. 2 Five and ten minute variable point counts to determine bird utilization rates (species, numbers, and behavior) are conducted every 300 meters along the transec Bird vocalizations are not used; detection will be by sight. Other acceptable methods can be used, such as transects or permanent point count sites.

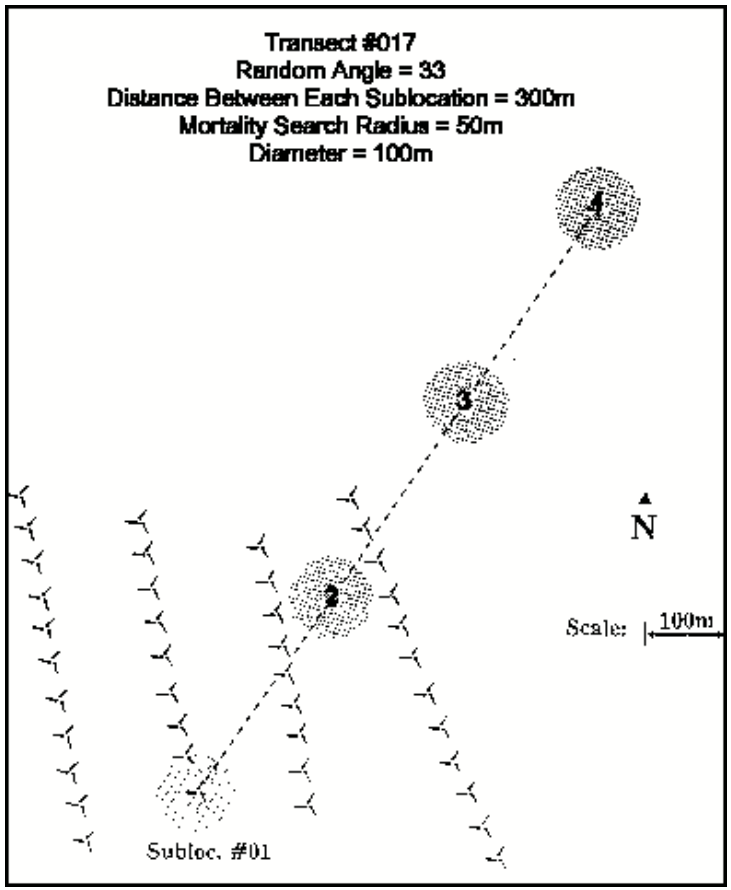


FIGURE 2. Avian risk assessment methodology, California Energy Commission (Sept. 1995).

A minimum of 250 points will be sampled each season, and a minimum of 1000 each year. The results of the 5 and 10 minute variable point counts will be ana to determine whether the 10 minute variable point counts provide significantly more information. Variable point counts will be conducted during standardized hours. All-day bird activity counts will be conducted seasonally in order to determine if and when there are significant hour-to-hour differences in activity and detectability. From these data correction factors will be developed, as needed, for different activity levels during different times of day.

- Phase I studies will be conducted at least until all four seasons have been sampled. The anticipated Phase I study length will be one to two years.
- Dead bird and bird part searches will be conducted at each variable point count location within a circle 100 meters in diameter (Fig. 2). The field researchers w conduct a complete search of the area. Detection distances will vary by season, natural community, and condition of vegetation. Dead birds and bird parts will be collected but will be left in place, for the reason previously noted. Time since death and cause of death will be estimated for each dead bird.
- Scavenging studies will be conducted at randomly-selected points at varying distances from turbines. These points will be established as permanent scavengin study points. A minimum of three general distances (1 km, 500 m, near turbine) will be tested. Large and small dead birds will be marked, placed, documentec monitored daily for 10 days. The rate and extent at which these dead birds are scavenged will be documented. If scavenging rate differences are detected, they assumed to be due to scavenger numbers and activity, and/or differing scavenger species--not to study design or conduct. If significant differences in scavengi rates exist, an adjust-ment factor will be developed to equilibrate the sites. Replicate scavenging studies will be conducted seasonally.
- Observer bias factors will be determined. Dead bird detection bias will be determined by placing a known number of small and large dead native birds in a dea bird search area unknown to the observers. The birds will be placed just before the searches and removed immediately following the last search each day to av the possibility of scavenging. Dead bird detection bias factors will be based on number of dead birds detected in an area in proportion to number of dead birds Sampling is being conducted first in Tehachapi Pass WRA at four major wind com-pany sites: Cannon Energy Corporation, FloWind Corporation, SeaWest of Tehach-api Inc., and Zond Systems Inc. These locations include the major turbine designs and the major natural communities found in the area. These compan turbines constitute approximately 75 percent of the 5500 turbines in the Tehachapi Pass WRA. Sampling is anticipated to start in San Gorgonio Pass WRA dur late 1996.

Phase II and Phase III Studies

Results of Phase I studies will identify and focus the Phase II studies and the Phase III studies (as needed). The following potential studies would start with a planning workshop of invited experts to assist in creating an acceptable study design and methodology for each study. These methods would be reviewed by all stakeholders.

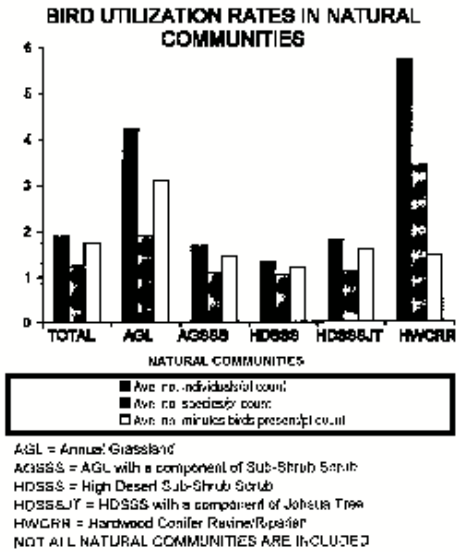
- Over-sampling areas - If there are areas where dead birds are found more frequently, oversampling could be conducted. This would concentrate study on speci areas in order to obtain sufficient data to determine mortality factors.
- Other facility monitoring - Other facilities such as power poles and meteorological towers could be sampled using an appropriate sampling design to determine contribution to overall bird deaths.
- Perching Documentation - This study would focus on all birds perched on turbines. Perching will be documented using sampling designs appropriate to detect perching preferences by species, turbine structure type, and other facility type (i.e. power pole). The correlations of these data with mortality rate and utilizatio information can then be determined.
- Prey Availability - Relative prey levels in the various natural communities within the developed WRA and nearby non-developed areas will be determined for correla-tion with bird utilization rate and mortality rate.
- Nocturnal bird utilization rates may be determined using night vision equipment and/or radar as necessary and possible. Intensive studies of nocturnal bird util tion are desirable and, if funding allows, will be conducted for resident and migrat-ing birds active at night. At this time, radar or other nocturnal work is beyo funding scope of this study.

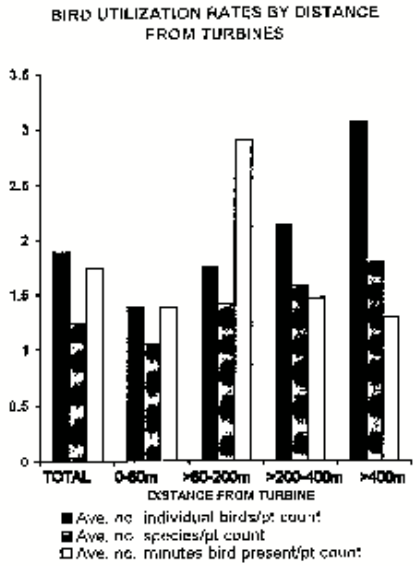
Results and Discussion

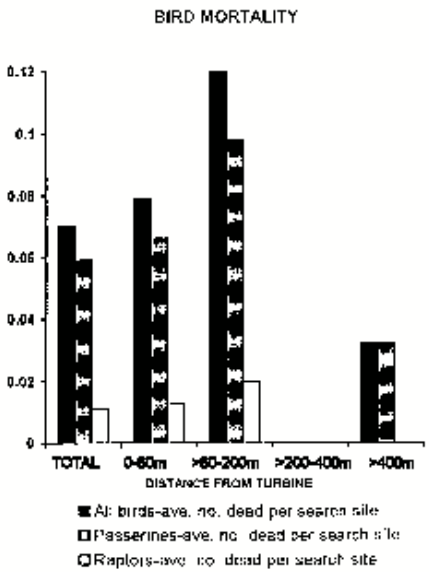
This study was started in May 1995, with field level modifications to data sheets and methods occurring through July 1995. Data discussed below are

from only two months of field work and are for discussion purposes only. Data from only 186 variable point counts (includ-ing both bird utilization counts and dead bird searches at the same locations) have been summarized. This includes detections of 352 individual birds of 24 species. The mor-tality data represent the total mortalities detected (n = 13). Figure 3 illustrates the types of data collected and the information that can be obtained using this "Avian Risk Assessment Method-ology". No real results are available at this time, and the data analyzed are a small sample that may not be represent-ative of the final study results. Readers are requested not to reproduce or use these graphs without this or a similar warning discussion.

With the above cautions in mind, the following discussion describes how the Bird Util-iza-tion Rates, Bird Mortality, and Bird Risk were calculated.







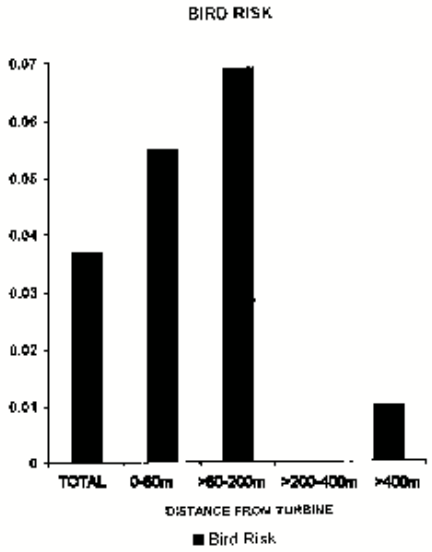


FIGURE 3. Types of data that can be collected with Avian Risk Assessment Methodology (based on small and possibly non-representative sample).

Utilization Rates.-Three utilization rates were calculated for illustration:

 # Birds/Point Count: This is the total number of birds observed divided by the total number of point counts conducted. The results are average birds observed per point count:

Formula: Total number of birds/total point counts

Early Results: 352 birds/186 point counts = 1.89 birds/point count

Average # Species/Point Count: One variation of the utilization rate calculated and illustrated on Figure 3 is the average number of species observed per point count. This rate provides species diversity information for the study area:

Formula: $\sum$ (number of bird species in each count)/(total point counts)

Early Results: 230 bird species/186 point counts = 1.24 bird species/point count

Utilization Duration: This is the number of minutes each bird was observed during a five minute point count. If observed briefly, the minimum duration

is recorded as one minute even though the bird may have passed out of sight within seconds. This measure provides an index of the amount of time birds spend in an area, which may have value in project siting or in understanding project effects:

Formula: Total # of birds/total # of minutes observed

Early Results: 352 birds/617 minutes observed = 1.75 minutes/bird

Figure 3 illustrates additional ways to analyze the data on bird utilization and utilization duration, e.g. by natural communities or by varying distances from wind turbines. A partial list of potentially useful comparisons of bird utilization rates would be by

- distance from turbines or other structures,
- season,
- time of day,
- bird species,
- natural community,
- defined area (company site, section of land),
- topography or topographical position,
- climatic conditions, including
    - temperature,
    - wind conditions and/or direction,
    - weather (i.e., rain, snow, cloud cover),
- turbine type or structure type (i.e., powerlines, highways, towers, etc.), and
- combinations of the above

The utilization rate information has great potential to provide valuable information in both pre-construction/pre-permitting applications and post-operational applications.

Bird Mortality.-Bird mortality is the number of dead birds and bird parts found per search site:

Formula: Total # of dead birds/total search sites

Early Results: 13 dead birds/186 search sites = 0.07 dead birds/search site

Other comparisons can be made for different species, natural communities, distances from turbines, structure types, etc. Most comparisons that can be done based on utilization rates can also be done for Bird Mortality. This measure can be used to estimate dead birds/square kilometer for subareas or for the whole study area, but caution must be used.

Bird Risk.-Bird Risk establishes a relationship between bird utilization and bird death. Bird Risk can be used to compare differences between various locations and situations. If Bird Risk is high or increases in certain situations, these situations would be focal areas for more concentrated studies:

Formula: Bird Mortality/Bird Utilization Rate = Bird Risk

Early Results: $\frac{\text{0.07 dead birds/search site}}{\text{1.89 birds detected/point count}} = 0.037$

Bird Risk can be calculated for any of the specific situations listed above for utilization rates. Bird Risk must be considered in the perspective of the local situation. An increased Bird Risk may or may not be of concern, depending upon the species and numbers of individuals involved. These are determinations that must be made based upon local knowledge and by the appropriate authorities and stakeholders.

Conclusions

We are in the early stages of testing the "Avian Risk Assessment Methodology". However, it appears that it has a great potential to provide the types of data and information that will be valuable in decision making and impact assessment. This methodology can be used throughout the nation in regards to wind energy development and other types of activities (powerlines, towers, highways, etc.) during prepermitting and post-operational monitoring. This methodology lends itself to the Before-After Control-Impact (BACI) sampling design, and will work well for comparisons between WRA areas. In some situa-tions, the results will require calibration by additional studies in order to give perspective to the observed rates (Bird Utilization Rate, Bird Mortality, and Bird Risk). If this methodology is applied consistently in different areas, within a few years the rate relationships can provide a national standard for decision making. The methodology is also well designed to provide data that can assist in developing forecasting (predictive) models.

Overall, this methodology shows great promise. It deserves an adequate testing period with sufficient time for data collection and data analysis. This will determine the utility and value of the methodology and its phased approach to the avian/wind energy issue.

Acknowledgements

The dedicated efforts of Dr. Michael Morrison, Dr. Larry Mayer, and Dr. Sheila Byrne are gratefully acknowledged. Without their wisdom, insight, and knowledge this methodology would not have been developed. These persons deserve the credit for this methodology. Any shortcomings are because the investigators failed to fully develop their concepts, direction, and advice. We also thank Cannon Energy Corp., FloWind Corp., SeaWest of Tehachapi Inc., and Zond Systems Inc. for their cooperation and support.

Discussion

This presentation evoked much discussion among the meeting attendees, mainly on the following topics:

Most Appropriate "Control" or "Reference" Sites.-An attendee noted that wind plants are sited in the windiest parts of Wind Resource Areas, and individual turbines are sited in the windiest locations within a given wind plant. Does this cause bias in sampling birds? Mr. Anderson noted that, with the proposed methodology, sampling locations are randomized relative to turbine locations. Bird utilization, mortality, and related variables can be examined in relation to distance from turbines.

Are Repeat Sightings a Problem?-In this study, birds that are seen from more than one sampling point are counted each time. Sampling points are 300 m apart. Attendees noted that, with this spacing, repeated sightings are unlikely in forest or for small birds in open country, but may be common for large raptors. Mr. Anderson indicated that successive point counts are about 1½ hours apart, mainly because of the time required for the dead bird search at each point. He suggested that, if the methodology is applied consistently in different studies, results should be comparable. Repeated sightings would be most likely to cause complications if statistical methods treating each point as independent were applied.

Should Point Counts be "Bounded"?-Point counts can include all birds detected at any distance, or can be limited to some maximum distance ("bounded"). In this study, bird counts to determine utilization rate are not bounded, but the distance to each bird is estimated. It was noted that

- use of a fixed distance can cause complications if birds close to the point tend to avoid the observer,
- the most appropriate fixed distance would depend on the habitat and type of bird, and use of a fixed distance reduces sample size,
- unbounded point counts are commonly used in other studies, and
- with unbounded counts, analyses of detection distances can be used to evaluate sightability (see Laake et al. 1993, DISTANCE user's guide, Colorado Coop. F Wildl. Unit, Col. State Univ., Fort Collins).

Fixed Radius During Mortality Searches.-Some attendees asked whether, in estimating Bird Risk, it was appropriate to relate dead birds found within a fixed radius (numerator) to a utilization rate based on unbounded point counts (denominator). It was suggested that this is not a problem because the resulting ratio is recognized to be an index, not an absolute estimate. However, the same method would need to be used in all studies being compared. It was agreed that complica-tions could arise if sightability during point counts differs among the various situations being compared. If so, the sighting distance data could be used to truncate the utilization data to the same radius as used for dead bird searches, but then the problems associated with "bounded" counts (see above) would be of concern.

Rationale for Leaving Dead Birds in Place.-Mr. Anderson explained that, during dead bird searches, carcasses are left in place because some locations may be resampled later. During Phase I, obvious injuries are noted, but necropsy is not feasible when the dead bird is left in place. The priority during the Phase I study is to determine whether mortality varies from place to place, not to determine the causes of specific deaths. Attendees discussed the advantages and disadvantages of this approach, and the complications that may arise because of requirements to report dead birds to the Fish & Wildlife Service. If Phase I shows that dead birds are common enough to be a concern, it may be a high priority to collect dead birds for necropsy during a followup Phase II study.

Rationale for Various Measures.-There was considerable discussion about the merits of some proposed measures and analysis approaches, e.g.

- whether Bird Risk is a useful index when the numerator (dead birds found within fixed radius) and denominator (birds seen in unbounded area) are in differen and in areas of different sizes; and
- whether the categories used in preliminary analyses (e.g., the "Distance from Turbine" categories in Fig. 3) are the best choices.

It was noted that the analysis procedures are still being developed, and that comments such as these are being sought in order to improve the analysis approach.

Objectives and Relevance of the Phase I Study.-Several attendees made sugges-tions about additional types of data that might be desirable, including

- necropsies of dead birds to better define causes of death,
- focused dead-bird searches near turbines,
- determination of bird "passage rates" by day and by night, and
- use of surrogate variables for utilization, deaths, or both, if surrogates that are meaningful and easier to measure can be identified and measured.

It was pointed out that the goal of the Phase I study is "to determine if an operating wind plant results in an increased risk of bird mortality compared to the surrounding non-developed area". Determining the specific reasons for any differences is beyond the scope of Phase I. There would be complications and costs in implementing any of the extra tasks suggested above. However, Phase I is expected to identify the topics on which subsequent effort should be focused.

A key feature of the Phase I methodology is that it provides data on bird utilization and bird deaths in the same areas at approximately the same times. This approach may reduce the necessary study duration and level of effort because it allows one to calculate risk rates that take account of unavoidable fluctuations in bird utilization.

It was also noted that the Phase I study will provide data on the extent of inherent variability in utilization, bird deaths, etc. With this information, statistical power analyses can be done

- to document the effectiveness of the Phase I study in detecting differences in utilization, mortality, and risk between different situations, and
- to estimate the sample sizes necessary to achieve a specified level of precision during future related studies.

The inherent variability in biological systems cannot be avoided, but uncertainty in conclusions can be reduced by selecting an appropriate study design and sample size. The Phase I study should provide data useful in evaluating the effectiveness of Phase I and proposed follow-up Phase II studies in addressing questions of interest to decision-makers and other stakeholders.

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