Synthesis and Comparison of Baseline Avian and Bat Use, Raptor Nesting and Mortality Information from Proposed and Existing Wind Developments

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EXECUTIVE SUMMARY

Purpose/Need

Primarily due to concerns generated from observed raptor mortality at the Altamont Pass (CA) wind plant, one of the first commercial electricity generating wind plants in the U.S., new proposed wind projects both within and outside California have received a great deal of scrutiny and environmental review. A large amount of baseline and operational monitoring data have been collected at proposed and existing wind plants throughout the United States. The primary use of the avian baseline data collected at wind developments has been to estimate the overall project impacts (e.g., low, moderate, and high) on birds, especially raptors and sensitive species (e.g., state and federally listed species). In a few cases, these data have also been used for guiding placement of turbines within a project boundary. This new information has strengthened our ability to accurately predict and mitigate impacts for new projects.

This report should assist various stakeholders in the interpretation and use of this large information source in evaluating new projects. This report also suggests that the level of baseline data required to adequately assess expected impacts of some projects may be reduced. The current push by industry for a more expedited permitting process results from the renewable energy production tax credit (PTC), which was recently reauthorized as part of the Federal economic stimulus package, signed by President Bush in March 2002. This current reauthorization extends the PTC until December 31, 2003, but will likely be extended to 2006[1]. In order to qualify for this credit, a wind project must be fully operational by the expiration date. In addition, this report provides an evaluation of the ability to predict direct impacts on avian resources (primarily raptors and waterfowl/waterbirds) using less than an entire year of baseline avian use data (one season, two seasons, etc.). This evaluation is important because pre-construction wildlife surveys are one of the most time-consuming aspects of permitting wind power projects.

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[1] U.S. Senate passed a five-year extension on April 26, 2002. The House version includes a five-year extension.

Data Used in This Analysis

Erickson *et al.* (2001) recently summarized the operational fatality monitoring data available through the middle of 2001. This report contains a meta-analysis[2] that extends the Erickson *et al.* (2001) mortality summary to include both baseline data on avian and bat use[3], raptor nesting[4], and operational avian and bat fatality monitoring data, including recently collected data at the Foote Creek Rim (WY), Stateline (OR/WA), Klondike (OR), and Buffalo Mountain (TN) wind plants. Over 30 study areas from 15 Wind Resource Areas were used in at least one of the following components of this synthesis: avian mortality, avian use, raptor nesting, bat mortality and bat use.

Results

Raptor Mortality at Altamont Pass (CA) - Reported raptor mortality at Altamont Pass (CA), has ranged from 0.05 to 0.10 fatalities per turbine per year (Erickson *et al*. 2001). Pre-construction raptor use is generally lower at other wind projects compared to the Altamont area. Over 50 percent of the turbines at Altamont Pass (CA) (approximately 3000 out of 5400) are Kenetech 56-100 turbines equipped on 18 m lattice towers, high turbine density, with rotor diameters of 18 m, blades spinning at approximately 60 revolutions per minute (rpm), down-wind blades, and with tips within 9 meters of the ground. These turbines appear to cause higher golden eagle mortality than other turbine types (Hunt 2002, in press). The cause of the increased lethality of the turbines is likely a combination of several of the factors listed above and raptor use. Raptor use and prey availability are very high at Altamont Pass (CA), relative to the surrounding area. These fatality rates (an estimated 30 to 70 fatalities per year), coupled with the large number of turbines in one area (approximately 5,400 within a 60 mile^2 tract), have contributed to the concerns over possible population level effects on golden eagles (Orloff and Flannery 1992, Hunt 2002 in press).

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[2] combining or synthesizing information

[3] use or utilization refers to a measure of relative abundance of a site by a species or group of species as measured by a standard survey methodology

[4] nest surveys targeting species that are efficiently surveyed from the air

Raptor Mortality at New Generation Wind Projects - In contrast to Altamont Pass (CA), raptor mortality has been absent to relatively low at all newer generation wind plants in the U.S. These wind plants are made up of fewer larger, slower moving turbines (> 40 m rotor diameter, with < than 30 rpm's) (Erickson *et al.* 2001). Fatality estimates expressed as the number of raptor fatalities per turbine per year have ranged from 0 to 0.04 for new generation wind turbines. In addition, it would take approximately 3-10 average Altamont Pass (CA) turbines[5] to produce the same amount of electricity as a single typical new generation wind turbine (600 kW – 1.5 MW per turbine). Information gained regarding wind energy siting and design at both old and new wind plants strongly suggests that the level of raptor mortality at Altamont is quite unique and can be avoided at other locations.

Raptor Nesting - There has been low raptor mortality observed at new wind projects, especially for the species that are targeted for the nest surveys (buteos and other species visible from the air). Empirical data relating raptor nest density to mortality are insufficient to detect any relationship between nest density and collision mortality. Raptors nesting closest to turbines likely have higher probabilities of being impacted from disturbance (construction and operation) or from collision with turbines, but data on nests very close to turbines (e.g., within ½ mile) is currently inadequate to determine the level of these impacts. The eagle fatalities at Altamont Pass (CA) have been comprised primarily of non-breeders (subadults[6] and floaters[7]) that tend to have larger home ranges. The population of golden eagles studied by Hunt (2002, in press) appears to be increasing even with the 30-70 estimated annual golden eagle fatalities from the Altamont Pass (CA) wind plant. Occupancy rates of established golden eagle territories have been 100% in all but one of the years of study. The existing wind plant with the highest nest density of target raptors (species that are effectively sampled from the air) is Foote Creek Rim (WY), with red-tailed hawks the most common nesting raptor within two miles of the turbines. No red-tailed hawk mortalities have been observed at this site.

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[5] Assumes an average Altamont turbine is 200 kW; the Kenetech 56-100 turbine is a 100 kW machine.

[6] 1-3 year-olds (non-breeders)

[7] non-breeding adults

Waterfowl Mortality - Some waterfowl mortality has been documented at several wind plants, although in relatively low numbers. Wind plants with significant sources of open water near turbines (San Gorgonio (WA) and Buffalo Ridge (MN)) have the highest documented waterfowl mortality, with 10-20% of all fatalities consisting of waterfowl and waterbirds. We are aware of only one Canada goose fatality documented at wind projects. Waterfowl and waterbird use at most native sites with the exception of San Gorgonio was relatively low. Waterfowl and waterbird use at the agricultural sites (except for Buffalo Ridge) was low except for winter, with some sites showing higher use during this season due to occasional observations of large flocks of Canada geese.

Passerine Mortality – Protected passerines[8] have been the most common group of birds killed at new wind plants, comprising over 80% of the fatalities reported (Table 5). The mortality involves both resident and migrant species (Erickson *et al.* 2001). It is estimated that about half of the passerine fatalities involve nocturnal migrants, although no large episodic mortality event has occurred (largest single incident reported was 14 migrants found at two turbines during a single search). Many species are represented in the fatality lists, and data don't show distinct patterns indicating a species or groups of species are more susceptible to collision. The level of nocturnal migrant mortality observed appears insignificant relative to nocturnal passage rates of birds at the wind plants where both mortality and nocturnal radar studies were conducted.

Bat Mortality - Some bat mortality can be expected at most wind plants, with a very large majority of the fatalities involving migratory tree and foliage roosting bats such as hoary and silver-haired bats in the western U.S. and hoary and eastern red bats in the Midwest and eastern U.S. Bat collision mortality during the breeding season is virtually non-existent, despite the fact that relatively large populations of some bat species have been documented in close proximity to wind plants. These data indicate that wind plants do not currently impact resident breeding bat populations in the U.S. All available evidence indicates that most of the bat mortality at U.S. wind plants involves migrant or dispersing bats in the late summer and fall.

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[8] "perching" birds; includes songbirds and a few other species that are protected by the Migratory Bird Treaty Act.

Bat echolocation and collision mortality studies indicate that only a small fraction of detected bat passes near turbines result in collisions, and that there appears to be little relationship between bat activity at turbines and subsequent collision mortality likely because many of the migrant species involved are either not echolocating or are flying too high for the bat detectors to pick up. One of the largest estimates of bat fatalities are from the wind plant at Buffalo Ridge (MN), where preliminary data indicate that the numbers of bats susceptible to turbine collisions is large enough that the observed mortality is not sufficient to cause declines in numbers of potential affected bats. The effect on migrant populations of sustained collision mortality over several years is not known, however.

Seasonal Avian Use - The relative abundance of raptors and other groups of birds at a site appears to be an important factor contributing to direct impacts of a wind plant on these species. High correlations between seasonal use by a particular target group such as raptors and use estimates based on four seasons combined would suggest that impact predictions using less than four seasons would be similar to predictions from the four season study. These high correlations would indicate that sites with higher use in a single season or combination of seasons typically have higher overall use.

In most cases, baseline avian use data collected during one season appear adequate for making overall wind plant direct impact predictions (e.g., low, moderate or high relative mortality). Sites can be accurately ranked in terms of overall raptor, buteo and eagle use reasonably well based on one season of data. High correlations between seasonal use estimates and overall use estimates exist for most of the raptor groups considered, especially all raptors/vultures, buteos[9], eagles[10], accipiters[11], and harriers[12]. Information regarding habitat and raptor nesting would strengthen these predictions. Buteo use at some newer projects such as Buffalo Ridge (MN) is similar to buteo use at Altamont Pass (CA), where a relatively large number of red-tailed hawk

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[9] any of a genus of large, broad-winged hawks; broad winged hawk, red-tailed hawk , ferruginous hawk, rough-legged hawk, Swainson's hawk, that prey mainly on rodents

[10] includes both bald and golden eagles, although golden eagles in these data sets comprise 95% of the observations

[11] any of a genus of hawks characterized by short wings and long tails; Cooper's hawk, sharp-shinned hawk, Northern goshawk

[12] Northern harrier

and other buteo fatalities have been documented. Buteo mortality at most new projects, including Buffalo Ridge (MN) has been very low. Buffalo Ridge (MN) is the only newer generation wind plant with any observed buteo mortality. Using Buffalo Ridge (MN) as a basis, we estimate only one buteo fatality per year for every 100-500 turbines.

Estimates of falcon[13] use tend to vary more among seasons and study areas with weaker correlations between seasonal and overall estimates. Winter falcon use in most areas tended to be lower than during other seasons. Most documented falcon mortality has been to American kestrels (~95%), based on studies at Altamont Pass (CA), Tehachapi Pass (CA), San Gorgonio (CA), Montezuma Hills (CA) and Foote Creek Rim (WY).

Baseline raptor use has also been used in some cases to guide placement of turbines and facilities ("micro-siting") within a wind project. Some proposed turbine locations were voluntarily moved or dropped by developers based on patterns in raptor use at the Foote Creek Rim (WY), Condon (OR), and Stateline (OR/WA) wind plants. The ability to identify concentration areas or patterns in raptor use on a site is related to several factors, including topography, habitat types, amount of bird use, and amount of data that are collected. The ability to micro-site turbines to reduce mortality is improved as more data are collected, although distinct patterns are not always apparent, even with multiple years of information. We believe that sites with high raptor use, and comprised of large tracts of high quality native habitat, high topographic relief (e.g., distinct ridges) and/or containing other features (e.g., significant water sources, high prey base) that may lead to distinct patterns in raptor use, are the strongest candidates for effective micro-siting. Many of the agricultural sites do not typically meet any of these criteria and are therefore not strong candidates for effective micro-siting.

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[13] any genus of small hawks characterized by long pointed wings; American kestrel, merlin, peregrine falcon, prairie falcon

Overall Conclusions

1. Raptor mortality has been absent to very low at all newer generation wind plants studied in the U.S. This and other information regarding wind turbine design and wind plant/wind turbine siting strongly indicates that the level of raptor mortality observed at Altamont Pass is quite unique (e.g., number and arrangement of turbines in small area, turbine types, prey availability, raptor use) and can be avoided at other locations.
2. In most cases, baseline avian use data collected during one season (spring, summer or fall) appear adequate for making overall wind plant direct impact predictions (e.g., low, moderate or high mortality). Sites can be accurately ranked in terms of overall raptor, buteo and eagle use reasonably well based on one season of data. This appears to be especially true for sites in agricultural settings.
3. In many cases where baseline data or other information (e.g., historic data or habitat) indicate a site has levels of raptor use considered high (e.g., between Foote Creek Rim and Altamont Pass estimates), we recommend collecting more than one season of data to refine predictions and to make micro-siting decisions that might reduce impacts. Impact predictions collected after one season for these situations are likely adequate for draft permitting documents (e.g., a draft Environmental Impact Statement (EIS)), with refinements to these predictions and decisions regarding micro-siting strengthened from additional data (e.g., a final EIS). Sites with high raptor use, and comprised of large tracts of high quality native habitat, high topographic relief (e.g., distinct ridges) and/or containing other features (e.g., significant water sources) that may lead to distinct patterns in raptor use are likely candidates for effective micro-siting. Many of the agricultural sites do not typically meet any of these criteria and are therefore typically not strong candidates for effective micro-siting.
4. Raptor use (e.g., eagle use) may be a predictor of raptor risk (e.g., likelihood of mortality) when comparing several sites and when comparing different areas with a site. However, low raptor mortality at newer generation wind plants has lead to little correlation between use and fatality rates at these new projects. It is possible that the new turbine designs and turbine-siting decisions within new plants based on avian use have resulted in reduced avian mortality. However, this has not been experimentally tested.

5. Wind plants with year-round waterfowl use have shown the highest waterfowl mortality, although the levels of waterfowl/waterbird mortality appear insignificant compared to the waterfowl/waterbird use of the sites. Sites within native landscapes have shown very low waterfowl use, except when significant water sources are available (e.g., San Gorgonio). No waterfowl mortality has been documented at the Klondike (OR) wind plant since January, although several Canada goose flocks have been observed during surveys, and only one Canada goose fatality has been reported at any U.S. wind plant.
6. Passerines comprise a large proportion of the fatalities at new wind plants, and involve both residents and migrant species. Studies of nocturnal migration at several wind plants indicate the mortality compared to the rates of bird targets passing through the area is insignificant.
7. Since few raptor species targeted during nest surveys have been observed as fatalities at newer wind plants, correlations are very low between fatalities and overall raptor nest density (e.g., within 2 miles of project facilities). Raptors nesting closest to turbines likely have higher probabilities of being impacted from disturbance (construction and operation) or from collision with turbines, but data on nests very close to turbines (e.g., within ½ mile) are currently inadequate to determine the level of these impacts. The existing wind plant with the highest reported nest density is Foote Creek Rim (WY). Most of the nests within 2 miles of the wind plant are red-tailed hawks, but no red-tailed hawk fatalities have been documented at this site.
8. Bat collision mortality during the breeding season is virtually non-existent, despite the fact that relatively large numbers of some bat species have been documented in close proximity to wind plants. These data indicate that wind plants do not currently impact resident breeding bat populations where they have been studied in the U.S.
9. Bat echolocation and collision mortality studies indicate that only a small fraction of detected bat passes near turbines result in collisions, and that there appears to be little relationship between documented bat activity at turbines and subsequent collision mortality likely because many of the migrant species involved are either not echolocating or flying too high for the bat detectors to pick up.
10. All available evidence indicates that most of the bat mortality at U.S. wind plants involves migrant or dispersing bats in the late summer and fall.

11. Preliminary data (Buffalo Ridge (MN)) indicate that the numbers of bats susceptible to turbine collisions is large but that the observed mortality is not sufficient to cause declines in numbers of potential affected bats. The effect on migrant bat populations of sustained collision mortality over several years is not known, however.

INTRODUCTION

Although generally considered environmentally friendly, wind power has been associated with the death of birds colliding with turbines and other wind plant structures, especially in California (Orloff and Flannery 1992, Erickson *et al.* 2001). Early wind energy facilities in the U.S. were often constructed in areas without an understanding of the level of avian use at those locations. Consequently some of these facilities are located where birds are abundant and the risk of turbine collisions is high (AWEA 1995).

High raptor mortality documented at Altamont Pass (CA) (Howell and Didonato 1991, Orloff and Flannery 1992, Orloff and Flannery 1996), has resulted in a great deal of scrutiny of other wind plant developments. In the mid 1990's, development of wind projects were delayed, sometimes to a point that the project was not developed, due in part to avian collision concerns.

Wind plant design has changed significantly since the first large wind plants were developed in California; many of these changes have reduced risk to birds. Turbines are now typically installed on tubular steel towers instead of lattice towers and without open platforms at the top of the tower, eliminating perching opportunities for raptors and other birds. No observations have been made of raptors perched on the new turbine types during studies at Foote Creek Rim (WY) (Johnson *et al.* 2000a), Buffalo Ridge (MN) (Johnson *et al.* 2000b), Vansycle (OR) (Erickson *et al.* 2000b) and Stateline (OR/WA) (Jeffrey 2002, pers. comm.). The nacelle, which houses the generator, drive train and gearbox on top of the tower, is typically completely enclosed. American kestrels were even observed nesting inside the nacelle of older turbines, and kestrel mortality was high, likely due to this increased use near the turbines (Howell 1997). Electrical lines between turbines and from the turbine strings to substations in new generation wind plants are often buried underground to eliminate perching opportunities, collisions with wires, and electrocutions, a common source of mortality at Altamont Pass (CA) (Orloff and Flannery 1992) and other older wind projects. Overhead lines within the wind plant have often been designed to be raptor safe and anti-perching devices are often installed (e.g., Stateline (OR/WA) wind plant (Walla Walla Regional Planning Department 2000). Turbines are much larger, with blades moving at lower revolutions per minute (rpm) and presumably more visible than the smaller older turbines. For example, the blades of the 1.5 MW turbines installed at the Klondike (OR) wind plant, turn at approximately 20 rpm's, contrasted to 60 rpm's for the Kenetech 56-100 downwind turbine, the most common turbine at the Altamont Pass (CA) wind plant. Blade tip speeds of both large and small turbines are still fast (200+ mph). Studies by Howell (1997) and Hunt (2002, in press) provide some evidence indicating the Kenetech 56-100 turbines (100 kW) have a higher associated raptor mortality rate than other turbine types, including larger turbines. Hunt (2002, in press) attributes the higher risk in part to the blade proximity to the ground and the low altitude foraging behavior of golden eagles. The 56-100 model is a downwind turbine, with the blades on the downwind side of the nacelle, which some researchers believe may also increase risk of collision of perched birds. Birds perched on this downwind turbine may be blown towards the blades when leaving the perch.

In addition to changes in technology, significant effort has been devoted to developing standardized methods for siting wind plants (NWCC 1999), and monitoring for avian impacts resulting from the wind plants (Anderson *et al.* 1999, Erickson *et al.* 2000a). Primarily due to the avian collision concerns and through the development of siting and monitoring guidelines, baseline avian use, raptor nesting and operational monitoring data (Erickson *et al.* 2001) have been collected at many of the new developments outside California. The data have been used for prediction and estimation of impacts of wind projects on wildlife and habitats, and in some cases, for micrositing[14] wind turbines at a particular site. This large and significant source of information has greatly improved our ability to predict impacts for new projects and to aid in wind plant/wind turbine siting. Raptor mortality at these new wind projects has been absent or low in all cases. Intensive monitoring programs in place at newly constructed wind projects such as the Stateline (OR/WA), Klondike (OR), and the Buffalo Mountain (TN), continue to add to the already available information for other new wind projects (e.g., Buffalo Ridge (MN), Foote Creek Rim (WY), and Vansycle (OR)). Other wind projects such as Nine Canyon (WA) and Condon (OR), will add more information in the near future.

Erickson *et al.* (2001) recently summarized the operational avian fatality data available through

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[14] Placement of turbines within a wind plant

the middle of 2001. This report contains a "meta-analysis[15]" that extends the mortality summary to include both baseline data (avian use and raptor nesting) and operational avian and bat fatality monitoring data, including very recently collected fatality data at projects mentioned above. This report also provides an evaluation of the ability to predict direct impacts on avian resources using less than an entire year of baseline avian use data (one season, two seasons etc.). This report should assist the various stakeholders in the interpretation and use of this large information source in evaluating new projects. This report also suggests that the level of baseline data required to adequately assess expected impacts of some projects may be reduced.

The current industry-push for a more expedited process for permitting wind plants relates to the renewable energy production tax credit (PTC). This federal tax credit is designed as an incentive to produce more of our nation's electricity from renewable sources. The tax credit accrues to the owner of renewable energy generating plants and is currently 1.8 cents per kWh of electricity produced. The PTC extends for 10 years on a project to which it applies. It is indexed to inflation via the consumer price index (CPI).

The tax credit was originally passed a decade ago and has been renewed several times since. After expiring at the end of December 2001, the PTC was reauthorized as part of the Federal economic stimulus package signed by President Bush in March 2002. This current reauthorization extends the PTC until December 31, 2003 , but will likely be extended to 2006[16]. In order to qualify for this credit, a wind project must be fully operational by the expiration date. Meeting this deadline of December 31, 2003 is of paramount importance for wind energy developers. The federal PTC helps close the gap between the cost of electricity from wind and conventional fossil sources at today's fuel prices. Without the PTC, most grid-connected wind energy projects would not be able to compete with fossil fuel resources, primarily combined cycle natural gas plants.

The combination of this deadline and the long lead time for equipment orders for wind turbines and substation transformers complicates the permitting schedule for wind projects. Most wind

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[15] The combining or synthesis of information

[16] U.S. Senate passed a five-year extension on April 26, 2002. The House version includes a five-year extension.

turbine manufacturers require up to six months after an order is placed to deliver equipment; sub-station transformers can take up to 9 months. Without a permit in hand, few developers are willing to risk ordering millions of dollars worth of equipment. Finally, weather conditions and environmental constraints (e.g., the need to avoid construction during calving or nesting periods, etc.) can dictate that construction of wind projects take place only during summer and fall months, further reducing the window of opportunity for projects built before the expiration of the PTC.

METHODS

Avian Mortality

Complete descriptions of most of the fatality data used in this meta-analysis are provided in Erickson *et al.* (2001). In addition, we include some very recent information from the Foote Creek Rim (WY), Stateline (OR/WA), Klondike (OR), and Buffalo Mountain (TN) wind plants. Fatality data collected using systematic carcass searches for 14 U.S. wind plants are included in this meta-analysis.

Avian Use

A total of 27 different avian use data sets from 13 Wind Resource Areas (WRA) were used in this meta-analysis (Tables 1 and 2). Several wind resource areas had multiple study areas. For example, two reference areas (Morton Pass and Simpson Ridge) were studied to compare to the Foote Creek Rim (WY) wind plant, and all are designated for this report as part of the Foote Creek Rim WRA. Original avian baseline data were used in all but two cases; data for these two cases were generated from graphs and tables in reports (Altamont Pass (CA) and Columbia Hills (WA)). One additional wind resource area, Montezuma Hills (CA), was included only for qualitative comparisons, because original data were unavailable, and the report summarizing the results did not provide standardized comparable data.

Point count surveys were conducted to describe the relative abundance of bird species within each study area. Survey methodologies differed in duration of survey (e.g., 5-minute versus 20-minute surveys) and radius of viewshed (unlimited versus fixed distance). For most of the analyses, data were standardized to an 800 m viewshed and 20-minute survey by limiting observations to those recorded within 800 m of the observer, and by standardizing the use estimates up to or down to a 20-minute period.

These standardization methods were applied to make data reasonably comparable among projects. Some biases still likely exist. For example, avian use from a 40-minute survey like Foote Creek Rim (WY) standardized to 20-minutes is likely conservative, since one would expect fewer new observations on average later in the survey, especially for stationary bird observations (e.g., perched). Likewise, use from a 5-minute survey standardized to 20-minutes might be liberal (overestimate) for the very same reasons. Biases such as these are likely reduced by comparing sites using ranks instead of standardized estimates. Furthermore, evaluating seasonal differences at a study area is not subject to the same biases, since methods for a particular project did not vary among seasons.

We concentrated on raptors and the waterfowl/waterbird group because survey methodologies would appear to be most appropriate for those larger birds. Study areas were classified onto two general landscape scale classes, cultivated agricultural, or native habitat landscape. Most of the sites in the agricultural landscapes have some component of native habitat within their boundaries and in some cases, there may have been some agricultural component within the boundaries of the sites within the native landscapes.

Correlations were used to evaluate relationships between:

1) spring, summer, fall and winter study area use estimates (i.e., correlations among seasonal use of the study areas),
2) seasonal study area use (spring, summer, fall or winter) estimates and overall (four season) study area use estimates, (i.e., correlations between seasonal use and four season use estimates of the study areas)
3) ranks of sites based on spring only, spring-summer, or spring-fall and ranks based on four seasons combined. (i.e., correlations between ranks (based on use) of study areas using less than 4 seasons of data and ranks using 4 seasons of data).

Different patterns in the data can lead to high correlations for any of these categories. One season (e.g., spring) or a combination of two seasons (e.g., spring and summer) might show consistently higher use among the study areas, and also show high correlations with overall use. That would indicate use estimates in that season (or combination of seasons) are typically higher than other seasons, but that the relative ordering of sites based on use (or ranks of use) for a four season study would be similar to orderings using only one season. Other indicators of predictability of overall use across habitats or by habitat from less than a full year of data would be a pattern of low variability in seasonal use estimates among study areas considered.

Seasons for this meta-analysis were defined by the following dates:

Spring	March 16 – May 15
Summer	May 16 – August 15
Fall	August 16 – October 31
Winter	November 1 – March 15

Raptor Nesting

Active raptor nest density was estimated based on summary data typically provided in reports in the form of maps and tables for 10 study areas (Table 3). We included raptor species that are efficiently surveyed from the air (e.g., buteos, eagles, great horned owls) and eliminated those that are inconspicuous ground nesting species (e.g., Northern harriers, short-eared owls, burrowing owls). We did not account for differences in survey effort, although effort varied by study area as well (Table 3). Some surveys were only conducted once, but in other cases, surveys were conducted twice, supplemented by ground visits. Survey timing (e.g., April versus May) could also affect results due to variations in nest timing for different species, or differences in amount of foliage on trees.

Bat Use and Mortality

This section includes a discussion of the bat results from studies conducted at wind plants and also provides a literature review of behavior and other characteristics of the bats typically observed as wind turbine fatalities. Some data on bat use or mortality have been intentionally collected at nine Wind Resource Areas in the U.S. A small amount of anecdotal information on bat mortality is also available for some California wind plants. All available data were used in this meta-analysis (Tables 1 and 2). Most of the available data on timing and species composition of bat fatalities have come from bat carcasses picked up while searching turbines for avian mortalities. Major studies conducted specifically to examine bat collision issues have been conducted at Buffalo Ridge (MN), Foote Creek Rim (WY); the WPSC site (WI) (only the mortality data from 1999 field season are currently available); and Buffalo Mountain (TN). These studies have combined mortality surveys for bats with collection of bat use data using bat echolocation detectors and mist nets. Minor efforts (1-2 nights) to examine bat use have occurred at the Stateline wind plant (OR/WA) and the Condon (OR) wind plant.

RESULTS AND DISCUSSION

Tables 1 and 2 list study areas and data types used in the meta-analysis. Over 30 study areas from 15 Wind Resource Areas were used in the analyses in at least one of the following five categories: avian use, avian mortality, raptor nesting, bat use and bat mortality. Each of these categories is discussed below. We discuss avian use and mortality in general and then specific to several taxonomic groups (all raptors/vultures, buteos, eagles, falcons, accipiters and Northern harriers, waterfowl and waterbirds).

Avian Mortality and Use

We present some tables from the publication Erickson *et al.* (2001), updated to include recent results for the Buffalo Mountain (TN), the Stateline (OR/WA), and the Klondike (OR) wind plants. Table 4 contains descriptions of wind projects with mortality data available, and summarizes all birds and raptor casualties observed. Of 841 avian fatalities reported from the California studies (>70% from Altamont Pass (CA)), 39% were diurnal raptors, 19% were passerines (excluding house sparrows and European starlings), and 12% were owls (Table 5). Non-protected birds including house sparrows, European starlings, and rock doves comprised 15% of the fatalities. Other avian groups generally made up <10% of the fatalities. Outside of California, diurnal raptor fatalities comprised only 2% of the wind plant-related fatalities. Passerines (excluding house sparrows and European starlings) were the most common collision victims, comprising 82% of the 225 fatalities documented (Table 5). Other groups combined comprised <10% of the fatalities.

For all avian species combined, estimates of the number of bird fatalities per turbine per year from individual studies have ranged from 0 at the Searsburg, Vermont (Kerlinger 1997) and Algona, Iowa sites (Demastes and Trainer 2000) to 4.45 on the Buffalo Ridge (MN) Phase III site (Johnson *et al.* 2000b). The Phase III Buffalo Ridge (MN) site estimate was based on one field season (1999) and was greatly influenced by a fatality event involving 14 migrants, comprised of warblers, vireos and flycatchers, observed during a May 17 carcass search of two turbines (Johnson *et al.* 2000b). Avian fatality rates were much lower at the Buffalo Ridge (MN) Phase I and II sites, where several years of data were collected (Osborn *et al.* 2000, Johnson *et al.* 2000b). Throughout the entire U.S., the average number of avian collision fatalities per turbine is 2.19 per year (Table 6). We are unaware of any other fatality incident like the one recorded at Buffalo Ridge (MN; 14 migrants at 2 turbines during a single search). Typical casualty searches usually yield no fatalities, and when fatalities are discovered on a plot, usually only one fatality is found.

Reference or background mortality has been estimated only once during baseline studies of wind plants. During a four-year study at Buffalo Ridge (MN), 2,482 fatality searches were conducted on study plots without turbines to estimate reference mortality in the study area, and 31 avian fatalities comprised of 15 species were found. Reference mortality consisted of eight upland gamebirds, seven doves, five sparrows, three waterfowl, three raptors, two blackbirds, one waterbird, one shorebird, and one unidentified bird. The exact cause of death of many birds found in reference plots could not be determined; however, most birds appeared to have been killed by predators or vehicles. Reference mortality was estimated to average 1.1 per plot, compared to 0.98, 2.27 and 4.45 fatalities per turbine search plot in the Phase 1, 2 and 3 wind plants, respectively (Johnson *et al.* 2000a). These numbers indicate that estimates of turbine mortality likely include some fatalities not related to turbine collision, and therefore the estimates should be considered conservative (over-estimates) of true avian collision mortality at wind plants.

Figure 1 contains timing of avian fatalities discoveries from the multi-year studies conducted at Buffalo Ridge (MN) and Foote Creek Rim (WY) wind plants. Except for the one spike related to the 14 migrants found at two turbines during one search in spring migration, a relatively consistent number of birds were found at Buffalo Ridge (MN) during the spring, summer and fall. Very little winter data were collected (November 1-15th), due to the expected very low bird use and bird mortality during this period and the difficult winter conditions for accessing the site and conducting surveys. Foote Creek Rim (WY) also shows fairly consistent all bird fatality rates in the spring, summer, and fall, with a significant drop-off in fatalities during the winter months (Figure 1).

Baseline bird use (especially raptor use) has been used in some cases to guide placement of turbines within a wind project. For example, some proposed turbine locations were voluntarily moved or dropped by developers based on patterns in raptor use at the Foote Creek Rim (WY), Condon (OR), and Stateline (OR/WA) wind plants. The ability to identify concentration areas or patterns in utilization on a site is related to several factors, including topography of a site, habitat types, levels of bird use, and amount of data that are collected. The ability to micro-site turbines to reduce mortality is improved as more data are collected, although distinct patterns are not always apparent, even with multiple years of information. The strongest candidates for effective micro-siting are sites with high raptor use, and are comprised of large tracts of high quality native habitat, high topographic relief (e.g., distinct ridges) and/or containing other features (e.g., significant water sources, high prey base) that may lead to distinct patterns in raptor use. Many of the agricultural sites do not typically meet any of these criteria and are therefore not strong candidates for effective micro-siting.

All Raptors/Vultures

Estimated and standardized total raptor/vulture use varied by study area and season. The study area with by far the highest standardized and estimated raptor/vulture use is Altamont Pass (CA) (Table 7). Columbia Hills (WA)[17], the Stateline Reference Area (OR), Foote Creek Rim (WY) and the Middle Ridge of the Tehachapi Pass (CA) Wind Resource Area have the next highest estimates. The relatively high raptor use of the Stateline Reference Area (OR) was greatly influenced by a kettle of 40 Swainson's hawks observed in the spring of 1995. The Stateline Reference Area (OR) is located within an agricultural setting and the other four plants are within primarily native landscapes.

Using the data reported in Table 7, high correlations (>0.7) exist between seasonal use estimates for each site relative to other sites. Furthermore, total raptor use in any one season is highly correlated with overall use estimates for the entire year for each site relative to other sites, indicating total raptor use in any one season is indicative of overall raptor use for all seasons (Table 8). We investigated how the rank of sites based on use estimates varied if only spring data were collected, if only spring/summer data were collected, if only spring/summer/fall data were collected, and if data were collected all four seasons. Study area ranks based on mean raptor use from only one or two seasons varied only slightly (Table 7) and were highly correlated with ranks using all four seasons (Table 8), indicating overall raptor impact predictions relative to other sites typically would not vary when using less than one year of data.

Agricultural Landscapes

For study areas within agricultural landscapes, average total raptor/vulture use estimates were highest in the spring, although average estimates for all seasons were between 0.38 and 0.59 raptors/20-minute survey (Table 7, Figure 2), indicating low variability among seasonal estimates. Average use for all of these study areas ranged from 0.26 to 0.60 raptors/20-minute survey, indicating relatively low variability in use among study areas as well. For the Pacific Northwest sites in agricultural landscapes, seasonal estimates tend to vary less, with winter estimates similar to other seasons, especially spring. However, raptor assemblages during the

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[17] we used average winter use from the CARES project for Columbia Hills, since no standardized winter use data were collected

winter are typically different from the other seasons. Winter use is often dominated by Northern harriers and rough-legged hawks, whereas use during the other seasons is dominated by red-tailed hawks, Swainson's hawks, American kestrels, and some other species depending on location.

Raptor mortality has been very low for all new generation wind plants located in agricultural settings (Tables 4, 5 and 6). The only reported raptor mortality was one red-tailed hawk found during a 4-year study at the Buffalo Ridge (MN) wind plant (Johnson *et al.* 2000b).

Native Landscapes

More variability exists in raptor use among study areas comprised primarily of native habitat, likely due to the high variability in habitats within this category (Table 7, Figure 3). Raptor use is estimated to be very high at Altamont Pass (CA) and very low at San Gorgonio Pass (CA). Estimates of raptor use at Montezuma Hills (CA) are likely higher than at Altamont Pass (CA), although data for Montezuma Hills were unavailable at a level of detail comparable to the other studies (Howell and Noone 1992). Average raptor/vulture use estimates were highest in the fall for all sites, although average estimates for all seasons were between 0.3 and 0.6 raptors/20-minute survey. Average four-season raptor use estimates for all of these study areas ranged from 0.02 to 2.4/20-minute survey.

Raptor and other bird mortality estimates for wind projects where standardized data have been collected are summarized in Tables 4, 5 and 6. Comparison of mortality on a per turbine basis between older and newer wind plants is difficult due to differences in turbine sizes and study methodologies. For example, most of the older generation wind plants in California are composed of small turbines (average size typically less than 200 kW machines), whereas newer turbines are typically much larger. Estimates of annual raptor mortality at Altamont Pass (CA) averages 0.048 per turbine, with the most recent study conducted by Thelander (2002 pers. comm.) providing an estimate of 0.10 fatalities per turbine. Raptor mortality estimates from Montezuma Hills (CA) also averaged 0.048 fatalities per turbine. These estimates are higher

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during the study.

than those reported for Foote Creek Rim (WY), the only new wind plant that has documented more than one raptor fatality. Furthermore, the average turbine size at Altamont Pass (CA) and Montezuma Hills (CA) is approximately 1/3 – 1/4 the size in terms of electricity output and rotor diameter. If estimates were standardized to a per MW basis, or a per rotor swept area equivalent basis, the estimates at Altamont Pass (CA) and Montezuma Hills (CA) would be approximately 5 times higher than Foote Creek Rim (WY). In addition, recent information collected in 2001 at Foote Creek Rim (WY) will reduce the average annual raptor mortality estimate.   No raptor fatalities were observed on Phase I of the Foote Creek Rim wind plant based on searches conducted from May through December 31, 2001 (Garrett 2002, pers. comm.).

Although not directly comparable to other wind projects because of the 3-month interval between searches, the West Ridge of Tehachapi Pass (CA), which has the highest raptor use compared to the other areas within Tehachapi Pass (CA), also had much higher raptor mortality than the other two areas (Anderson *et al.* 2000). Very few raptor mortalities have been documented at the San Gorgonio (CA) wind plant, and raptor use at this site is very low (Anderson *et al.* 2000).

Buteos

Buteos were typically the most abundant raptor group observed in the studies included in the meta-analysis, especially for sites within agricultural settings. The study area with the highest standardized estimated buteo use is Altamont Pass (CA) (Table 9), followed by several agricultural sites. The relatively high buteo use for the Stateline Reference Area (OR) was greatly influenced by a kettle of 40 Swainson's hawks observed in the spring of 1995. Using the data reported in Table 9, moderate to high correlations exist between use estimates among seasons (0.4 to 0.8, Table 10), with the lowest correlation occurring between summer and winter estimates. Correlations between a single season use estimate and overall use for a site are high (0.8 – 0.9), indicating that estimates from any one season are relatively strong predictors of overall annual buteo use (Table 10). Study area ranks based on mean buteo use from only one or two seasons were highly correlated with ranks using all four seasons (Table 10). These correlations indicate, in general, overall buteo impact predictions based on avian use information alone from one or two seasons of information would be similar to predictions from a four-season study.

Agricultural Landscapes

For study areas within agricultural landscapes, average buteo use was very similar among seasons (0.2 to 0.3/20-min survey, Table 9, Figure 4), although this pattern was not consistent among study areas. Buteo use was highest in the fall at the Buffalo Ridge (MN) wind resource area, and typically highest in the winter for the Pacific Northwest sites, with the exception of the Stateline Reference Area (OR; spring Swainson's hawk observations). The winter buteo use in these agricultural settings is typically dominated by rough-legged hawks. Eight of the nine study areas (Altamont Pass (CA) is the one exception) with the highest buteo use occurred in agricultural landscapes.

Buteo mortality has been very low for all wind projects considered in this category, which are all "new generation" wind plants, even though high buteo use at many of the study areas (e.g., Buffalo Ridge (MN)) would indicate greater potential for buteo collision mortality. One red-tailed hawk fatality was observed during the course of a 4-year study at the Buffalo Ridge (MN) wind plant. Otherwise, no other raptor mortality has been reported at wind plants located in agricultural settings (Tables 4 and 5). Given the low buteo fatality rates at these sites, and the relatively similar buteo use estimates compared to Altamont Pass (CA) and Tehachapi Pass (CA), these data provide some empirical evidence that buteo collision risk at newer generation turbines is lower than buteo collision risk at older turbines. Lower risk associated with the taller turbines may occur because the typical flight heights of diurnal raptors have been found to be lower than the rotor-swept height of the new-generation turbine blades (e.g., Johnson *et al.* 2000a), the blades are more visible due to lower rpm's, and the turbines are spaced further apart. Other factors not related to turbine design such as prey availability could also influence these comparisons.

Native Landscapes

Mean use by buteos was also fairly similar among seasons at study areas classified primarily as native habitat, where it ranged from 0.11 to 0.27 per 20-minute period (Table 9; Figure 5). For all 4 seasons combined, buteo use was over twice as high at Altamont Pass (CA; 0.64/20-minute survey), than the area with the next highest use (Columbia Hills (WA; 0.24/20-minute survey). The third highest buteo use occurred at Foote Creek Rim (WY; 0.22). The highest level of buteo mortality has also occurred at Altamont Pass (CA), where at least 193 buteo fatalities have been documented (Erickson *et al.* 2001). In contrast, Foote Creek Rim (CA), with the 3rd highest buteo use of wind plants in native landscapes, has no documented buteo fatalities. The turbines at Foote Creek Rim (WY) are the newer-generation turbines, and the lack of mortality there compared to Altamont Pass (CA) provides additional evidence that suggests lower buteo collision risk associated with the newer generation turbines.

Eagles

Eagle use consists of both bald and golden eagle observations, although approximately 95% of the eagle observations in these data sets are of golden eagles. The study area with the highest standardized estimated eagle use is Altamont Pass (CA; Table 11), followed by several of the study areas associated with the Foote Creek Rim (WY) wind plant. Site ranks based on eagle use showed the least variability as the number of seasons used was varied. Relatively high correlations exist between use estimates among seasons (0.66 to 0.98), and between seasonal and overall estimates (0.76 to 0.98), indicating eagle use in one season is indicative of eagle use in other seasons and for the entire year (Table 12).

Agricultural Landscapes

In general, eagle use was low on the sites in the agricultural settings, although all but the Zintel Canyon Site (Washington) had some documented eagle use (Table 11, Figure 6). Average eagle use was lowest in the summer, likely due to the lack of nesting habitat and prey for golden eagles in these landscapes. Average eagle use was similar in the spring, fall and winter. No eagle mortality (bald or golden) has been reported at any of the wind plants located in the agricultural landscapes (Erickson *et al.* 2001).

Native Landscapes

More variability exists in eagle use among study areas located within native landscapes, likely due to the high variability in golden eagle nesting and foraging habitat at sites within this category (Table 11, Figure 7). Very high golden eagle use is estimated for Altamont Pass (CA; 0.33/20-min survey) and Foote Creek Rim (WY; 0.23/20-min survey), followed by the other studies/study areas associated with Foote Creek Rim (WY; Simpson Ridge, Morton Pass Reference Area)[18]. Average use for all of these study areas ranged from 0 to 0.33/20-minute survey.

No bald eagle mortality has been reported at any wind plant in the U.S. (Erickson *et al.* 2001). Golden eagle mortality at Altamont(CA) has been well publicized, with estimates made in the early 1990's of 30 to 70 golden eagle fatalities per year. That is approximately equivalent to 1 golden eagle fatality per year for every 100 to 200 turbines at Altamont Pass (CA), or 2 to 5 golden eagles for approximately every 100 MW of electricity[19]. Based on the one golden eagle fatality reported for Foote Creek Rim (WY; Young et al. 2002), we estimate approximately 1 golden eagle fatality for every 200 turbines at that site, or 0.75 for every 100 MW of electricity[20]. One golden eagle fatality has been reported at both San Gorgonio and Tehachapi Pass (CA), where golden eagle use is much lower than Altamont Pass (CA) and Foote Creek Rim (WY).

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[18] it is unclear what the effective viewshed was at Altamont. Points were ½ mile apart to avoid overlap

[19] assumes average size turbine is 200 kW

[20] assumes average turbine size is 600 kW

Standardized estimates are not easily obtained for those California projects, due to the 3-month interval between fatality searches. No golden eagle (or bald eagle) mortality has been reported at any other wind plant in the U.S. (Erickson *et al.* 2001).

One factor likely related to the high mortality of golden eagles (and other raptors) at Altamont Pass (CA) is the high density and year-round activity of California ground squirrels, the principle prey of many of the raptor species at the site (Hunt 2002, in press). The population of golden eagles near the Altamont Pass (CA) is apparently increasing, even with the 30-70 wind plant-related fatalities each year (Hunt 2002, in press). Most of the fatalities are sub-adults (1 to 3 year-olds) and "floaters" (non-breeding adults) that have larger home ranges than breeders. Very few juvenile fatalities have been reported, likely because juveniles do not typically hunt live prey (Hunt 2002, in press). Occupancy rates of golden eagle territories have been 100 percent in almost every year of the study. There are also several prairie dog towns near the Foote Creek Rim (WY) wind project, likely contributing to the high use of golden eagles at that site.

Falcons

The study area with the highest standardized estimated falcon use is Columbia Hills (WA; 0.217/20-min survey), followed by Zintel Canyon (WA; 0.152) and Altamont Pass (CA; 0.141) (Table 13). Falcons had the greatest variability in rankings of use as the number of seasons used in the calculations was varied. The only significant correlation was that between spring and summer use (0.70); the other season correlations ranged from –0.18 to 0.23 (Table 14). These correlations indicate that while spring and summer use data are similar to each other, they cannot be used to indicate falcon use at other times of the year. Similarly, data collected in the fall and winter cannot be used to predict spring or summer use. Correlations of any one season to overall falcon use were moderate (0.55 to 0.69). The low correlations between seasons likely reflect range and behavior of the species in this group. In many areas, the most abundant falcon is the American kestrel, which often breeds in the WRA's in spring and summer but then migrates out of the WRA's in the fall and is either absent or occurs at very low densities during the winter. Impact projections (# fatalities per turbine per year) for American kestrels may be wide ranging with less than one full year of baseline data (e.g., 0 – 0.03 kestrels per turbine per year), but impact projections for prairie falcons would likely be much less variable due to the expected lower and less variable use and mortality estimates.

Agricultural Landscapes

Falcon use of the study areas in agricultural settings (0.064/survey) was similar to average use in native landscapes (0.075/survey) (Table 13, Figure 8). Mean falcon use was lowest in the winter (0.038/survey), highest in the fall (0.104/survey) and similar in the spring (0.074) and summer (0.063). These data again reflect the significant contribution of American kestrel data in the falcon grouping. Of the 10 study areas in agricultural landscapes, falcon use was highest at Zintel Canyon (WA; 0.152/survey) and Condon (OR; 0.107/survey); use at the other 8 areas was <0.08/survey. Well over 90% of the falcon use was from American kestrels, a very common raptor species. No falcon mortality has been reported at any of the agricultural wind plants (Erickson *et al.* 2001).

Native Landscapes

Extensive variability exists in falcon use among study areas comprised primarily of native habitats likely due to the high variability in suitability of habitats for falcon nesting and foraging within this category (Table 13, Figure 9). Falcon use was highest at the Columbia Hills (WA; 0.217/survey) followed by Altamont Pass (CA; 0.141/survey). For all study areas in this habitat category, average total falcon use was fairly similar among seasons (range=0.062 – 0.089). Falcon mortality has been high at Altamont Pass (CA), where 51 mortalities (49 American kestrels, 2 prairie falcons) have been documented. Tehachapi Pass (CA) has the second highest number of falcon fatalities (11 kestrels, 1 prairie falcon), yet falcon use of this area (0.035/survey) is quite low compared to Altamont Pass. Four falcon fatalities (three American kestrels and one prairie falcon) have been documented at Foote Creek Rim (WY; Young *et al.* 2001, Young *et al*. 2002) based on over three year's of standardized monitoring at that site.

Accipiters/Harriers

The study area with the highest estimated use by accipiters/harriers is the Buffalo Ridge (MN) WRA where use was 0.180/survey at the Phase 2 site, 0.134/survey at the reference area, and 0.120/survey at the Phase 3 area. Other areas with relatively high use by this group were Stateline/Vansycle (OR/WA; 0.110/survey) and Nine Canyon (OR; 0.110/survey) (Table 15). Most of the use at these sites is from Northern harriers. Rankings of use as the number of seasons was varied were fairly similar for all study areas except the Condon (OR) site, where rankings varied from #3 in spring to #8 using all four seasons. Moderately high correlations (>0.6) occurred between spring-summer (0.75) and spring-winter (0.66), with lower positive correlations between spring-fall (0.38), summer-winter (0.42) and fall-winter (0.36) use (Table 16). Correlations between use in any one season and overall use were all high (>0.7). The correlation of overall ranks and ranks based on data from spring only, spring-summer only, and spring-fall only were all greater than 0.90, indicating good predictability of accipiter/harrier use with one or two seasons of data.

Agricultural Landscapes

Accipiter/harrier use of the study areas in agricultural settings (0.107/survey) was greater than 4 times that of native landscapes (0.025/survey) (Table 15, Figure 10). Mean use was much higher in the spring (0.200/survey) than the other 3 seasons, when use ranged from 0.076-0.100/survey. Of the 10 study areas in agricultural landscapes, accipiter/harrier use was highest at the Buffalo Ridge (MN) site. No mortality of Northern harriers or accipiters has been reported at any of the agricultural wind plants (Erickson *et al.* 2001).

Native Landscapes

Use of native landscapes by accipiters/harriers was very low. The highest use occurred at Cares (0.125), followed by the Columbia Hills (0.099), and Maiden (0.097) sites in Washington (Table 15, Figure 11). For all study areas in this habitat category, average total accipiter/harrier use was lowest in the winter (0.013), and highest in the fall (0.056). No accipiter mortalities have been documented at U.S. wind plants (Erickson *et al.* 2001). Northern harrier mortality has been very low, with two reported at Altamont Pass (CA) and one reported at Foote Creek Rim (WY;

Erickson *et al.* 2001).

Waterfowl/Waterbirds

Waterfowl and waterbird use is highly variable among study sites, primarily due to the larger flock sizes (Table 17). A few large flocks can greatly influence the magnitude of use estimates. The San Gorgonio and the Buffalo Ridge (MN) study areas tend to have the highest year round waterfowl/waterbird use, primarily due to proximity to open water. Two other agricultural study areas (Zintel Canyon (WA) and Klondike (OR)) have higher use than most other study areas due to a few large flocks of Canada geese observed during winter, typically flying above the expected heights of the turbine blades. Correlations between seasonal use estimates were highly variable from a low of 0.32 between fall and winter, to a high of 0.86 between spring and summer (Table 18). Correlations between seasonal use estimates and overall use estimates were highest for winter (0.97), and lowest for fall (0.52). The correlation of overall ranks and ranks based on data from spring only and spring-summer only was approximately 0.7, but increased to 0.98 by including fall data, indicating moderate predictability of waterfowl use based on two seasons of data, and good predictability of overall use with 3 seasons of data.

Agricultural Landscapes

All sites within agricultural landscapes had some waterfowl/waterbird use. Overall waterfowl/waterbird use was slightly higher in agricultural settings (4.5/20-minute survey) than in native settings (3.12), although this difference would be much larger except for the high waterfowl/waterbird use near the water area of the San Gorgonio project (Table 17, Figure 12). Mean use was highest in the winter (8.6), and lowest in the summer (0.369). Occasional waterfowl/waterbird mortality has been documented at some of the agricultural wind plants (Table 5), including the Wisconsin site (3 fatalities, 15% of total), and Buffalo Ridge (MN; 5 fatalities, 14% of total). One Canada goose wind turbine collision fatality was documented this past winter at the Stateline (OR/WA) wind plant by maintenance personnel. That is the only Canada goose mortality reported based on the studies we reviewed. No goose mortality has been observed at the 16 Klondike turbines since January (January – April 15, 2002), although several observations of Canada geese have been made in the vicinity of the turbines.

Native Landscapes

Waterfowl/waterbird use is low at most sites within this category, except for the areas near the recharge ponds at San Gorgonio (Table 17, Figure 13). Waterfowl/waterbirds comprise 26 percent of the total observed mortality at San Gorgonio (10 of 42 total fatalities); otherwise very few waterfowl/waterbird fatalities have been recorded at existing wind plants (Table 5).

Passerines

The magnitude of passerine[21] and other mortality due to collisions with human-made structures such as buildings and windows, vehicles, powerlines, communication towers and wind turbines has received quite a bit of attention recently (Erickson et al. 2001, Kerlinger 2000). Using the annual avian collision mortality estimate of 200-500 million (a very large portion are passerines), it is estimated that at the current level of development, wind turbines constitute 0.01 percent to 0.02 percent (1 out of every 10,000 to 2 out of every 10,000) of the avian collision fatalities. Communication tower fatality estimates make up 1-2 percent (1 out of every 100 or 2 out of every 100) using the conservative estimates of 4 million annual avian fatalities due to collisions with these structures. The low range estimate from buildings/windows of 98 million (Klem 1991) would comprise approximately 25 to 50 percent of the collision fatalities. The low range estimate of 60 million vehicle collision fatalities comprises 15-30% of the total estimated collision fatalities. Powerline collisions are also likely a significant source of collision mortality. Most of the fatalities from these sources are passerines.

Protected passerines (excludes house sparrows and European starlings) have been the most common group of birds killed at new wind plants, comprising over 80% of the fatalities reported (Table 5) and involves both resident and migrant species (Erickson *et al.* 2001). Forty-two passerine fatalities representing twenty-one different species were observed at Buffalo Ridge (MN) during the four-year study. The largest number of fatalities of any one species was seven (common yellowthroat). Seven out of the 10 fatalities at Vansycle (OR) were passerines, including four white-crowned sparrows. Eighty-seven passerine fatalities representing 26 different species were observed at Foote Creek Rim (WY), with horned lark by far the most

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[21] "perching" birds; primarily songbirds

commonly observed fatality (32%) and most commonly observed bird during point count surveys (Johnson et al. 2000a). Horned lark was also the most common observed fatality at Ponnequin (CO; 5 out of 8 passerine fatalities). Only three species were observed more than once as fatalities at the Wisconsin wind plant (2 golden-crowned kinglets, 2 savannah sparrows, 2 tree swallows), based on 14 passerine fatalities (Howe 2001, pers. comm.). Recent studies at Stateline (OR/WA) between July and December 31, 2002 documented 10 passerines representing 5 species during standardized carcass searches (Table 5). Horned lark was the most abundant casualty found (3), followed by golden-crowned kinglet (2). Horned lark is also the most abundant passerine species based on point count survey (URS Corporation and WEST 2001).

Nocturnal migrants are estimated to comprise approximately 50% of the fatalities at new wind projects (estimated range 34 - 59%) based on timing and species (Erickson *et al.* 2001). Some nighttime surveys using radar equipment have been conducted at wind plants and results have been compared to fatalities. Radar studies at Buffalo Ridge (Hawrot and Hanowski 1997) indicate that as many as 3.5 million birds per year may migrate over the wind development area (Johnson *et al.* 2000b). The largest single mortality event reported at a U.S. wind plant was 14 nocturnal migrating passerines at two turbines at Buffalo Ridge (MN) during spring migration. We are not aware of any other mortality events greater than a few birds at single or adjacent turbines found during a single search at any wind plant.

Researchers estimated 6,800 birds were killed annually at the San Gorgonio wind facility based on 38 dead birds found while monitoring nocturnal migrants. The 38 avian fatalities included 15 passerine species. McCrary *et al.* (1983,1984) estimated that 69 million birds pass through the Coachella Valley annually during migration; 32 million in the spring and 37 million in the fall. Considering the high number of passerines migrating through the area relative to the number of passerine fatalities, the authors concluded that this level of mortality was biologically insignificant (McCrary *et al.* 1986). Three seasons of nocturnal radar surveys at the Stateline and Vansycle wind plants (Mabee and Cooper 2002) indicate moderate passage rates compared to other studies, with approximately 90% of the radar targets (flocks of birds) flying above the turbine blades. Low passerine mortality was observed at the Vansycle Ridge Windplant in 1999 (Erickson et al. 2000), and at the Stateline wind plant since July 2001, with a few likely nocturnal migrant fatalities observed. The last season of radar data was gathered concurrently with the recent Stateline mortality data, providing some evidence that mortality relative to passage rates is insignificant.

The low avian mortality due to wind turbines compared with communication towers (Erickson et al. 2001) can probably be attributed to the fact that the majority of wind turbines range from 200-400 feet (60-133 m) in height, whereas television and radio communication towers are generally much taller. Many of the existing communication towers are guyed structures, whereas nearly all of the newer generation wind turbines are unguyed structures. There are relatively few reports of single mortality events (greater than a few birds) at communication structures less than 500 feet (150 m) in height (Kerlinger 2000) or at windplants.

We are unaware of any studies that directly compare communication tower mortality to wind turbine mortality; although, we do have limited information on guyed meteorological (met) tower mortality compared with wind turbine mortality at Foote Creek Rim (WY). At this site we searched both wind turbines (600-kW, approximately 200-ft (60-m) towers) and guyed met towers (200 ft (60 m) in height) once a month during the study. During this period of study, the met towers had estimates of 7.5 bird fatalities per tower per year, whereas the turbines had estimates of 1.8 bird fatalities per turbine per year (Young *et al.* 2001).

RAPTOR NESTING

The number of active raptor nests observed and estimated raptor nest density within 2 miles of the wind projects in agricultural (Condon (OR), Buffalo Ridge (MN), Klondike (OR), Zintel Canyon (WA), Stateline (OR/WA)) and native (Columbia Hills (WA), Foote Creek Rim (WY), Maiden (WA), Ponnequin (CO)) landscapes are reported in Tables 19 and 20. We did not find comparable data for the other wind resource areas, especially the older California Wind Resource Areas. Raptor nest surveys at these sites have been used to aid in understanding potential impacts such as collision, disturbance and displacement to breeding raptors, especially sensitive species. The methods for surveying may also have differed among studies (e.g., one aerial survey versus two). The lowest estimated raptor nest density occurred at Nine Canyon (WA), with no active raptor nests within two miles of the project area. There is a historically active Swainson's hawk nest just over two-miles from the Nine Canyon (WA) wind turbine locations. Columbia Hills (WA) and Foote Creek Rim (WY) have the highest estimated raptor nest densities (0.320 and 0.270 per square mile, respectively). A large majority of the nests within 2 miles of the Foote Creek Rim (WY) turbines are red-tailed hawks, although no red-tailed hawk fatalities have been reported to date. One golden eagle nest within approximately ½ mile of the wind turbines was active and successfully fledged two young the first year of wind plant operation in 1999. The nest site was inactive in 2000, but active again in 2001 (Johnson *et al.* 2000c). Hunt (2002, in press) studied the golden eagle population near the Altamont Pass (CA) Wind Resource Area from 1994-1997. Eagle nest density within 2 miles of the wind resource area is one pair per 11.3 sq. miles. The most recent models indicate an increasing population, even with the wind plant related golden eagle fatalities. Raptors nesting closest to turbines likely have higher probabilities of being impacted from disturbance (construction and operation) or from collision with turbines, but data on nests very close to turbines (e.g., within ½ mile) is currently inadequate to determine the level of these impacts.

BAT MORTALITY AND USE AT WIND PLANTS

The primary source of information in this section comes from recent research conducted by Johnson *et al.* (2002). Bat collision mortality is not unique to wind plants. Previous studies have documented bats colliding with other man-made structures. The first report was that by Saunders (1930), who reported that five bats comprised of three species (red, hoary, and silver-haired) were killed at a lighthouse in Ontario, Canada. Five eastern red bats were reported killed by colliding with a television tower in Kansas (Van Gelder 1956). During 25 years of monitoring a television tower in Florida, Crawford and Baker (1981) found 54 bat collision victims representing seven species. Twelve dead hoary bats were picked up underneath another TV tower in Florida over an 18-year period (Zinn and Baker 1979). Similarly, small numbers (≤ 5) of bats have been killed by colliding with communication towers in Missouri (Anonymous 1961), North Dakota (Avery and Clement 1972), Tennessee (Ganier 1962), Saskatchewan, Canada (Gollop 1965), and Florida (Taylor and Anderson 1973). Over an 8-year period, 50 eastern red, 27 silver-haired, 1 hoary, and 1 little brown bat collision victims were found underneath large windows at a convention center in Chicago, Illinois (Timm 1989). Four eastern red bats were killed by colliding with the Empire State Building in New York City (Terres 1956) and other studies have documented eastern red bat fatalities at tall buildings (Mumford and Whitaker 1982). Bats have also been documented to collide with powerlines (Dedon *et al*. 1989) and fences (Iwen 1958, Denys 1972, Wisely 1978, Fenton 2001).

Wind plant-related bat mortality was first documented in Australia, where 22 white-striped mastiff-bats (*Tadarida australis*) were found at the base of turbines over a 4-year period (Hall and Richards 1972). At Buffalo Ridge (MN), 362 dead bats were collected at turbines from 1994 through 2001 (Osborn *et al.* 1996, Krenz and McMillan 2000, Johnson *et al.* 2000a, 2002). Mortality estimates for the three wind plants combined average 613 per year (Table 21). From 1999 to 2001, 123 dead bats were found at the Foote Creek Rim (WY) wind plant, resulting in a mean annual mortality estimate of 138 (Young *et al.* 2001). Ten dead bats were found in 1999 at the Vansycle Ridge (OR) wind plant, resulting in a mortality estimate of 28 (Erickson *et al*. 2000a). Thirty-four dead bats were found within the 31-turbine Wisconsin wind plant (Keeley *et al*. 2001). In 2001, 30 dead bats were found at the Stateline wind plant (OR/WA) (WEST and Northwest Wildlife Consultants Inc. 2002) and several dead bats were found over a 3-year period at the Ponnequin (CO) wind plant (Curry and Kerlinger 2002, unpublished data). The highest mortality reported yet on a per turbine basis was at a 3-turbine wind plant on top of Buffalo Mountain (TN), where 32 bats were found over a 15-month period (Tennessee Valley Authority 2002). Small numbers of dead bats have also been found at several wind plants in California (Howell and Didonato 1991, Orloff and Flannery 1992, Howell 1997, Anderson *et al*. 2000, Thelander and Rugge 2000) and a small wind plant in Pennsylvania (Curry and Kerlinger, unpublished data).

Most bat mortality documented at wind plants occurred in late summer and early fall. We found data for 536 bat collision fatalities in the U.S. where the approximate date of the collision was reported (Table 22). Nearly 90% of all the fatalities occurred from mid-July through mid-September. Over 50% of the fatalities occurred in August. Most of the fatalities are comprised of migratory tree bats. A total of 616 carcasses were identified to species. Hoary bat was by far the most prominent species, comprising 61.7% of all fatalities (Table 23). Eastern red bats comprised 17.2% and silver-haired bats comprised 7.1% of the fatalities. The remaining fatalities were comprised of small numbers of big brown bat, little brown bat, and eastern pipistrelle.

The hoary bat is a migratory species with the widest distribution of any bat in North America, ranging from just below the Canadian tree line to South America (Shump and Shump 1982a). Hoary's are solitary bats that roost primarily in deciduous trees (Barbour and Davis 1969, Nordquist 1997). Red and silver-haired bats are similar to the hoary bat in that they also migrate and are solitary tree bats (Carter 1950, Izor 1979, Shump and Shump 1982b, Kunz 1982, Barclay *et al.* 1988). The other species (little brown bat, big brown bat, eastern pipistrelle) are colonial species that roost in buildings, hollow trees, wood piles, and other structures (Fenton and Barclay 1980, Kurta and Baker 1990).

It is unlikely that resident bats comprise the bulk of the collision mortality. If residents were involved, then the collisions should have occurred while bats were commuting from roosting to foraging areas or were foraging within the wind plant. In most cases, there is no pattern in the distribution of fatalities among turbines (Johnson *et al.* 2000a, Young *et al*. 2001). If the bulk of the collision victims were local bats commuting from roosting to foraging areas, defined flight corridors between these areas would be expected, and a widespread random distribution of fatalities would seem unlikely. It also seems unlikely that bats would spend significant time foraging at turbine rotor-swept heights within habitats where most wind plants occur. Most turbines in the U.S. are situated within crop fields, pastures, grasslands, short-grass prairie, and shrublands (Table 19). Although hoary bats have been known to occasionally forage in agricultural areas when insect abundance at preferred feeding areas was low (Hickey and Fenton 1996), most bats prefer to forage near trees or water (*e.g.*, Carter *et al*. 1999, Everette *et al*. 2001). Both hoary and eastern red bats prefer to forage over sites with woody plant cover and are positively associated with edge situations (Furlonger *et al*. 1987), neither of which are present in most areas where turbines are located; therefore, they would not be expected to frequently forage in habitats where the turbines are placed. At Buffalo Ridge (MN), bat activity recorded at turbines (*i.e.*, 2.2 passes per night), was very low compared to more suitable habitats such as woodlands and wetlands, where bat activity was 15 times higher (*i.e.*, 33.1 passes per night) (Johnson *et al.* 2002).

Resident bats sometimes do fly at heights making them susceptible to turbine collision. Clark and Stromberg (1987) reported that hoary bats observed feeding over hayfields in Wyoming occasionally circled to high altitudes while feeding, and the eastern red bat is known for erratic flight behavior upon first flight in the evening, when it will often fly at altitudes of 100 to 200 m (LaVal and LaVal 1979). In Missouri, both hoary and eastern red bats were observed "foraging high above trees and pastures" (LaVal *et al*. 1977), and in Florida, hoary bats were observed foraging from 5 to 30 m above rivers and swamps (Zinn and Baker 1979). In general, however, bats forage at heights well below the space occupied by turbine blades. Hoary and eastern red bats typically forage from treetop level to within a meter of the ground, silver-haired bats spend most of their time foraging at heights less than 6 m, and big brown bats forage from 7 m to 10 m above ground (Barclay 1984, Fitzgerald *et al*. 1994). Little brown bats forage almost exclusively less than 5 m above the ground; much of their foraging is done from 1 m to 2 m above ground (Fenton and Bell 1979). It seems unlikely that foraging bats would routinely forage above 25 m, the lowest height of the blade on most new generation turbines.

Foraging bats locate their prey primarily through echolocation (Simmons *et al*. 1979). Bats have the ability to navigate through constructed clutter zones made of staggered vertical strands of twine 3 mm in diameter spaced 1 m apart (Mackey and Barclay 1989, Brigham *et al*. 1997). Bats are also able to detect large landscape and background features by echolocation out to 100 m (Griffin 1970, Suthers 1970). Surprisingly, studies with captive bats have shown that they can avoid colliding with moving objects more successfully than stationary ones, presumably because their foraging habits program them to detect moving objects (Jen and McCarty 1978). It seems unlikely that foraging bats using echolocation to locate prey would be unable to detect the turbines, especially given the hoary bat's ability to detect prey at long distances (Simmons and Stein 1980, Belwood and Fullard 1984, Barclay 1985, Barclay 1986). As evidence that foraging bats can detect turbines, bats were observed foraging within one meter of an operating wind turbine in Europe, yet no mortality was documented (Bach *et al.* 1999). Similarly, during a study of bat use at the National Wind Technology Center in Golden, Colorado, several bats were observed foraging around research wind turbines, many of which were at heights similar to those occupied by turbine blades, but no mortality was documented during routine carcass searches (U.S. Department of Energy 2002).

At one study area in Ontario, Canada, both hoary and eastern red bats spent most of their foraging time near street lights (Hickey and Fenton 1990, Hickey 1992), where moth abundance is much higher than areas away from the lights (Hickey and Fenton 1990). Other studies have also shown high foraging activity around lights by hoary, red and big brown bats (Wilson 1965, Hamilton and Whitaker 1979, Fenton *et al*. 1983, Belwood and Fullard 1984, Geggie and Fenton 1985, Barclay 1985, Furlonger *et al*. 1987, Fullard 1989); therefore, lights on turbines may increase the probability of bat collisions, assuming that the Federal Aviation Administration lighting attracts nocturnal insects. At Buffalo Ridge (MN), however, 42 (48%) of the 87 bat fatalities were found at lighted turbines and 45 (52%) were found at unlit turbines, suggesting that presence of lighting had no bearing on numbers of collision fatalities at that site.

Adults of some species of bats have been shown to change foraging patterns and locations once juveniles are capable of flying, presumably due to the increased competition for food (Adams 1996; Adams 1997). However, this was documented only for colonial bats that occur in high densities and has not been shown to occur in solitary species such as the hoary, red or silver-haired bat. Therefore, the late summer increase in mortality is not likely explained by a concurrent shift in diet or habitat use of resident adult bats. Recently fledged juvenile bats have been reported to have reduced abilities to echolocate and fly compared to adults (Gould 1955; Buchler 1980; Timm 1989; Rolseth *et al*. 1994); thus they may be more susceptible to colliding with turbines or other objects (Manville 1963). Juvenile bats also change diets and increase home range size over the first several weeks post fledging (Rolseth *et al*. 1994), thereby possibly making them more susceptible to turbine collision during post fledging. However, the increase in mortality during late summer cannot be explained by a shift in habitat use by juveniles or an increase in the number of young, inexperienced bats that had recently begun flying. In Minnesota, 68% of all bat collision victims were adults (Johnson *et al.* 2000a, 2002) and at the Foote Creek Rim (WY), all 21 bat collision victims aged in 2000 were adults (Young *et al.* 2001).

Based on all available evidence, it does not appear that bat mortality involves resident bats foraging within the wind plant or commuting between foraging and roosting areas. In virtually all cases of bat collision mortality documented at other structures, the timing suggested that migrant bats were involved (*e.g.*, Van Gelder 1956, Zinn and Baker 1979, Crawford and Baker 1981, Timm 1989). Data collected at wind plants in the U.S. also suggest that fall migrants comprise most of the bat collision mortality (Keeley *et al.* 2001). Findley and Jones (1964) reported that fall migration of hoary bats begins in August, and that migratory concentrations of hoary bats in August have been observed throughout North America, including Nevada, Massachusetts, and New York. At Delta Marsh along the southern end of Lake Manitoba, Canada, hoary bats started migrating south in mid July (Koehler and Barclay 2000, Koehler 2002, pers. comm.), and the latest date for hoary bat captures was 3 September (Barclay 1984). Hoary bats are thought to migrate through Badlands National Park in southern South Dakota in mid-August (Bogan *et al.* 1996). Migrant hoary bats reach Florida as early as late September (Hallman 1968). Similar timing of migration has been documented on the west coast, where migrant hoary bats were found on the Farallon Islands, California from 30 August to 6 September (Tenaza 1966), and museum records indicated a fall migration period of August and September (Dalquest 1943).

LaVal and LaVal (1979) reported that eastern red bats migrate south from September through November. Silver-haired bats are thought to migrate through Wyoming (Clark and Stromberg 1987) and Illinois (Izor 1979) in August and September. At Delta Marsh, Manitoba, both red and silver-haired bats began migrating through the area in mid July (Koehler 2002, pers. comm.), and the last capture date at Delta Marsh was 10 September for silver-haired bat and 19 September for both red and little brown bats (Barclay 1984). The big brown bat, little brown bat and eastern pipistrelle spend the winter in hibernacula, but the little brown and eastern pipistrelle may migrate several hundred kilometers to hibernate (Davis and Hitchcock 1965, Griffin 1970, Humphrey and Cope 1976), and the big brown bat may migrate up to 80 km to hibernate (Mills *et al*. 1975). Autumn migration of little brown bats in Indiana and north-central Kentucky occurred from the last week of July to mid-October (Humphrey and Cope 1976), and little brown bats departed from central Iowa to areas near hibernacula after late August (Kunz 1971). Dispersal of summer colonies of eastern pipistrelles and big brown bats also occurs as early as August (Barbour and Davis 1969). The timing of migratory or dispersal movements by species other than hoary bat also corresponds to the timing of collision mortality that has occurred at most wind plants.

Based on the timing of spring migration (e.g., Koehler and Barclay 2000), hoary, red and silver-haired bats are assumed to be migrating north through North America in mid to late May. However, very few collision fatalities have been found in the spring at U.S. wind plants. Of 536 bat collision mortalities at wind plants across the U.S., only 2 were killed in May (Table 17). Spring migrants have also rarely been found at other structures; of 50 dead eastern red bats collected at a building in Chicago, 48 were found in the fall and 2 in the spring (Timm 1989). Why spring migrants are not as susceptible to colliding with turbines as fall migrants is not clear. Several species of birds are known to follow different migration routes in the spring and fall (*e.g.*, Cooke 1915, Lincoln 1950, Richardson 1974, 1976), and perhaps some bat populations may follow similar patterns. Behavioral differences between migrating hoary bats in the spring and fall may be related to mortality patterns. Such differences have been reported; in Florida, autumn migration occurred in waves whereas the spatial distribution of bats during spring migration appeared to be far more scattered (Zinn and Baker 1979).

At the Foote Creek Rim (WY) wind plant, data from Anabats® bat detectors indicated 2.6 bat passes per turbine per night during the summer and fall (Gruver, 2002, pers. comm.). At Buffalo Ridge (MN), the number of bat passes recorded with an Anabats® detector averaged 2.2 per turbine per night. The number of passes decreased as distance to woodland increased (p=0.017), and the number of passes increased with increases in the proportion of residential woodlots within 100 m of the turbine (p=0.012). Based on Anabats® and mortality data, the authors estimated that one collision fatality occurred for every 70 bat passes recorded (Johnson *et al.* 2002), with an unknown number of passes not detected. There was no statistical relationship between bat activity at turbines and the number of bat fatalities, as the mean number of bat passes at turbines with no mortality (2.29) was not significantly different from the mean number of passes at turbines with mortality (1.60) (t=0.33, p=0.7412, df=133). At the Buffalo Mountain (TN) wind plant, bat activity as measured with Anabats® was also not correlated with collision mortality (Nicholson 2001). The migrant species observed as fatalities may not be echolocating or are flying too high for the bat detectors to pick up.

Although there are at least 39 species of bats in the U.S., only 6 species comprise all known bat fatalities at U.S. wind plants. In Minnesota, sampling with Anabats® and mist nets indicated that there are relatively large breeding populations of big brown and little brown bats in close proximity to the wind plant that experience little to no wind plant related collision mortality. At the Foote Creek Rim (WY) wind plant, mist net studies indicated the presence of large numbers of long-eared myotis, little brown bat, and long-legged myotis near the wind plant, yet none of these populations appeared susceptible to collision mortality (Gruver 2002, pers. comm.). Similarly, at Buffalo Mountain (TN), two species of bats (little brown and eastern big-eared bat) were detected near the wind plant with Anabats® and mist nets, yet neither species was among the 32 bat fatalities documented the first year of operation (Nicholson 2001). The factors that account for the differential susceptibility to turbine collisions are unknown. Because they have high wing loading and aspect ratio (Norberg and Rayner 1987) hoary bats fly rapidly but are not very maneuverable (Farney and Fleharty 1969, Barclay 1985) compared to other bat species in the U.S. These characteristics may make hoary bats more susceptible to turbine collision than other species. There is little information available on flight heights of migrating bats, however, Altringham (1996) reported that at least some groups of bats are known to migrate much higher than 100 m in altitude, and bats migrating during the day over Washington, D.C. were reported flying from 46 to 140 m (Allen 1939). Many species of bats make extensive use of linear features in the landscape while commuting (Limpens and Kapteyn 1991) and migrating (Humphrey and Cope 1976; Timm 1989), and perhaps linear features such as ridges or rivers are followed by migrating bats.

The cause of bat collisions with wind turbines or other man-made structures is not well understood (Osborn *et al.*1996, Johnson *et al.* 2000a). According to Van Gelder (1956), most bat collisions at other man-made structures occur during migration and are normally associated with inclement weather and avian collision mortalities. Based on this, he hypothesized that inclement weather forced migrating birds to fly lower, and the birds somehow confused the migrating bats. However, at a communication tower in Florida, bat fatalities were found largely in the absence of associated avian mortalities (Crawford and Baker 1981), and there appeared to be no relationship in the number of bat and bird fatalities found during previous studies of wind plants in the U.S. (Osborn *et al*. 1996, Erickson *et al*. 2000, Johnson *et al*. 2000a, 2000b, Young *et al.* 2001).

Even though echolocation in flying bats does not require additional energy expenditures (Speakman and Racey 1991), evidence suggests that migrating bats may navigate without use of echolocation (Van Gelder 1956, Griffin 1970, Crawford and Baker 1981, Timm 1989). Despite the common phrase “blind as a bat”, bats have good visual acuity (Suthers 1966, 1970) and evidence indicates that bats depend on vision, rather than echolocation, for long-distance orientation (Mueller 1968, Williams and Williams 1970, Fenton 2001). If bats are flying through wind farms by sight only, then causes of bat mortality could be similar to causes of avian collision mortality at wind plants.

Potential population effects of windpower-related mortality cannot be quantified with available data. At Buffalo Ridge (MN), circumstantial evidence suggests that the mortality may not be great enough to cause population declines of bat populations migrating over the study area. Most bats have very slow population growth rates for a small mammal (Fitzgerald *et al*. 1994). As a result, high mortality rates should result in population declines (Humphrey and Cope 1976, Keeley *et al*. 2001). If bat mortality associated with wind power development at Buffalo Ridge (MN) has significantly impacted the affected bat “population”, then one might expect lower mortality each subsequent year simply because there would be fewer bats present to collide with turbines. However, based on data collected from 1998 through 2001 (Johnson *et al*. 2000a, Krenz and McMillan 2000, Johnson *et al.* 2002), mortality has not decreased for at least 4 consecutive years at one wind plant and 3 successive years at another. Potential effects on populations of sustained collision mortality at these levels over several years are not known, but preliminary data suggest that the number of bats migrating through the Buffalo Ridge (MN) area may be substantial (Johnson et al. 2002), and that wind plant-related mortality is apparently not large enough to cause measurable population declines.

Few studies have attempted to examine bat use of WRA’s prior to development. Efforts were made to estimate bat use of the Stateline (OR/WA) wind plant (Hayes and Waldien 2000a) and the Condon (OR) wind development area (Hayes and Waldien 2000b). Potential roost structures (trees, rock outcrops, buildings) were scarce throughout both areas. Few water sites were also available in the study areas, especially during late summer when bats are migrating through the study areas. Very limited surveying with mist nets and bat echolocation detectors did not detect any bat activity at the Stateline (OR/WA) project area. At the Condon (OR) site, bat activity was low at upland sites; 9 bat passes were recorded during 10 detector nights in September. There was considerable activity recorded at the stream and pond sites. For most of these sites, bat activity was nearly continual for portions of the night when bat activity was monitored. All bats recorded at stream and pond sites were *Myotis* bats. Based on results of the surveys, the authors concluded that the impacts of the proposed development on resident bats would likely be low but that completion of the proposed project would likely result in increased mortality of migratory bats.

OVERALL CONCLUSIONS

1. Raptor mortality has been absent to very low at all newer generation wind plants studied in the U.S. This and other information regarding wind turbine design and wind plant/wind turbine siting strongly indicates that the level of raptor mortality observed at Altamont Pass is quite unique (e.g., number and arrangement of turbines in small area, turbine types, prey availability, raptor use) and can be avoided at other locations.
2. In most cases, baseline avian use data collected during one season (spring, summer or fall) appear adequate for making overall wind plant direct impact predictions (e.g., low, moderate or high mortality). Sites can be accurately ranked in terms of overall raptor, buteo and eagle use reasonably well based on one season of data. This appears to be especially true for sites in agricultural settings.
3. In many cases where baseline data or other information (e.g., historic data or habitat) indicate a site has levels of raptor use considered high (e.g., between Foote Creek Rim and Altamont Pass estimates), we recommend collecting more than one season of data to refine predictions and to make micro-siting decisions that might reduce impacts. Impact predictions collected after one season for these situations are likely adequate for draft permitting documents (e.g., a draft Environmental Impact Statement (EIS)), with refinements to these predictions and decisions regarding micro-siting strengthened from additional data (e.g., a final EIS). Sites with high

raptor use, and comprised of large tracts of high quality native habitat, high topographic relief (e.g., distinct ridges) and/or containing other features (e.g., significant water sources) that may lead to distinct patterns in raptor use are likely candidates for effective micro-siting. Many of the agricultural sites do not typically meet any of these criteria and are therefore typically not strong candidates for effective micro-siting.

4. Raptor use (e.g., eagle use) may be a predictor of raptor risk (e.g., likelihood of mortality) when comparing several sites and when comparing different areas with a site. However, low raptor mortality at newer generation wind plants has lead to little correlation between use and fatality rates at these new projects. It is possible that the new turbine designs and turbine-siting decisions within new plants based on avian use have resulted in reduced avian mortality. However, this has not been experimentally tested.
5. Wind plants with year-round waterfowl use have shown the highest waterfowl mortality, although the levels of waterfowl/waterbird mortality appear insignificant compared to the waterfowl/waterbird use of the sites. Sites within native landscapes have shown very low waterfowl use, except when significant water sources are available (e.g., San Gorgonio). No waterfowl mortality has been documented at the Klondike (OR) wind plant since January, although several Canada goose flocks have been observed during surveys, and only one Canada goose fatality has been reported at any U.S. wind plant.
6. Passerines comprise a large proportion of the fatalities at new wind plants, and involve both residents and migrant species. Studies of nocturnal migration at several wind plants indicate the mortality compared to the rates of bird targets passing through the area is insignificant.
7. Since few raptor species targeted during nest surveys have been observed as fatalities at newer wind plants, correlations are very low between fatalities and overall raptor nest density (e.g., within 2 miles of project facilities). Raptors nesting closest to turbines likely have higher probabilities of being impacted from disturbance (construction and operation) or from collision with turbines, but data on nests very close to turbines (e.g., within ½ mile) are currently inadequate to determine the level

of these impacts. The existing wind plant with the highest reported nest density is Foote Creek Rim (WY). Most of the nests within 2 miles of the wind plant are red-tailed hawks, but no red-tailed hawk fatalities have been documented at this site.

8. Bat collision mortality during the breeding season is virtually non-existent, despite the fact that relatively large numbers of some bat species have been documented in close proximity to wind plants. These data indicate that wind plants do not currently impact resident breeding bat populations where they have been studied in the U.S.
9. Bat echolocation and collision mortality studies indicate that only a small fraction of detected bat passes near turbines result in collisions, and that there appears to be little relationship between documented bat activity at turbines and subsequent collision mortality likely because many of the migrant species involved are either not echolocating or flying too high for the bat detectors to pick up.
10. All available evidence indicates that most of the bat mortality at U.S. wind plants involves migrant or dispersing bats in the late summer and fall.
11. Preliminary data (Buffalo Ridge (MN)) indicate that the numbers of bats susceptible to turbine collisions is large but that the observed mortality is not sufficient to cause declines in numbers of potential affected bats. The effect on migrant bat populations of sustained collision mortality over several years is not known, however.

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LITERATURE CITED

Adams, R.A. 1996. Size specific resource use in juvenile little brown bats, *Myotis lucifugus* (Chiroptera: Vespertilionidae): Is there an ontogenetic shift? Canadian Journal of Zoology 74:1204-1210.

Adams, R.A. 1997. Onset of volancy and foraging patterns of juvenile little brown bats, *Myotis lucifugus*. Journal of Mammalogy 78:239-246.

Allen, G.M. 1939. Bats. Dover Publications, Inc., New York, New York. 358pp.

Altringham, J.D. 1996. Bats: Biology and Behaviour. Oxford University Press, Inc., New York. 262 pp.

Anderson, R. 2000a. Personal communication. Composition data collected during phase I studies at San Gorgonio (1996-1998).

Anderson, R. 2000b. Personal communication. Composition data collected during pilot and phase I studies at Tehachapi Pass (1995-1998).

Anderson, R., M. Morrison, K. Sinclair and D. Strickland. 1999. Studying wind energy/bird interactions: A guidance document. National Wind Coordinating Committee/RESOLVE, Washington, D.C. 87pp.

Anderson, R.L., D. Strickland, J. Tom, N. Neumann, W. Erickson, J. Cleckler, G. Mayorga, G. Nuhn, A. Leuders, J. Schneider, L. Backus, P. Becker and N. Flagg. 2000. Avian monitoring and risk assessment at Tehachapi Pass and San Gorgonio Pass wind resource areas, California: Phase 1 preliminary results. Proceedings of the National Avian-Wind Power Planning Meeting 3:31-46. National Wind Coordinating Committee, Washington, D.C.

Anonymous. 1961. Large bird kills at TV towers. Bluebird 28:9.

Avery, M. and T. Clement. 1972. Bird mortality at four towers in eastern North Dakota: Fall 1972. Prairie Naturalist 4:87-95.

American Wind Energy Association (AWEA). 1995. Avian interactions with wind energy facilities: a summary. Prepared by Colson & Associates for AWEA, Washington, D.C.

Bach, L., R. Brinkman, H.J.G.A. Limpens, U. Rahmel, M. Reichenbach, and A. Roschen. 1999. Bewertung und planerische Umsetzung von Fledermausdaten im Rahmen der Windkraftplanung. - Bremer Beitraege fuer Naturkunde und Naturschutz, Band 4. Themenheft "Voegel und Windkraft":163-170.

Barbour, R.A. and W.H. Davis. 1969. Bats of America. Univ. of Kentucky, Lexington.

Barclay, R.M.R. 1984. Observations on the migration, ecology and behaviour of bats at Delta Marsh, Manitoba. Canadian Field-Naturalist 98:331-336.

Barclay, R.M.R. 1985. Long- versus short-range foraging strategies of hoary (*Lasiurus cinereus*) and silver-haired (*Lasionycteris noctivagans*) bats and the consequences for prey selection. Canadian Journal of Zoology 63:2507-2515.

Barclay, R.M.R. 1986. The echolocation calls of hoary (*Lasiurus cinereus*) and silver-haired (*Lasionycteris noctivagans*) bats as adaptations for long- versus short-range foraging strategies and the consequences for prey selection. Canadian Journal of Zoology 64:2700-2705.

Barclay, R.M.R., P.A. Faure, and D.R. Farr. 1988. Roosting behavior and roost selection by migrating silver-haired bats (*Lasionycteris noctivagans*). Journal of Mammalogy 69:821-825.

Belwood, J.J. and J.H. Fullard. 1984. Echolocation and foraging behaviour in the Hawaiian hoary bat, *Lasiurus cinereus semotus*. Canadian Journal of Zoology 62:2113-2120.

Bogan, M.A., J.G. Osborne, and J.A. Clarke. 1996. Observations on bats at Badlands National Park, South Dakota. Prairie Naturalist 28:115-123.

Brigham, R.M., S.D. Grindal, M.C. Firman, and J.L. Morissette. 1997. The influence of structural clutter on activity patterns of insectivorous bats. Canadian Journal of Zoology 75:131-136.

Buchler, E.R. 1980. The development of flight, foraging, and echolocation in the little brown bat (*Myotis lucifugus*). Behavioral Ecology and Sociobiology 6:211-218.

California Energy Commission (CEC). 1989. Avian mortality at large wind energy facilities in California: identification of a problem. California Energy Commission staff report P700-89-001.

Carter, T.D. 1950. On the migration of the red bat, *Lasiurus borealis borealis*. Journal of Mammalogy 31:349-350.

Carter, T.C., M.A. Menzel, B.R. Chapman, K.V. Miller, and J.R. Lee. 1999. A new method to study bat activity patterns. Wildlife Society Bulletin 27:598-602.

Clark, T.W. and M.R. Stromberg. 1987. Mammals in Wyoming. Univ. of Kansas Museum of Natural History. 314pp.

Cooke, W.W. 1915. Bird migration. U.S. Department of Agriculture Bulletin 185:1-47.

Crawford, R.L. and W.W. Baker. 1981. Bats killed at a north Florida television tower: a 25-year record. Journal of Mammalogy 62:651-652.

Dalquist, 1943. . Seasonal distribution of the hoary bat along the Pacific coast. Murrelet 24:21-24.

Davis, W.H. and H.B. Hitchcock. 1965. Biology and migration of the bat, *Myotis lucifugus*, in New England. Journal of Mammalogy 46:296-313.

Dedon, M., S. Byrne, J. Aycrigg, and P. Hartman. 1989. Bird mortality in relation to the Mare Island 115-kV transmission line: progress report 1988/1989. Department of the Navy, Western Division, Naval Facilities Engineering Command, Office of Environmental Management, San Bruno, California. Report 443-89.3. 150pp.

Demastes, J. W. and J. M. Trainer. 2000. Avian risk, fatality, and disturbance at the IDWGP Wind Farm, Algona, Iowa. Final report submitted by University of Northern Iowa, Cedar Falls, IA. 21pp.

Denys, G.A. 1972. Hoary bat impaled on barbed wire. Jack-Pine Warbler 50:63.

Erickson, W.P., G. D. Johnson, M. D. Strickland, D. P. Young, Jr., K.J. Sernka and R.E. Good. 2001. Avian collisions with wind turbines:A summary of existing studies and comparisons to other sources of avian collision mortality in the United States. National Wind Coordinating Committee Publication. http://www.nationalwind.org/pubs/default.htm

Erickson, W.P., M.D. Strickland, G.D. Johnson, and J.W. Kern. 2000a. Examples of statistical methods to assess risk of impacts to birds from wind plants. Proceedings of the National Avian-Wind Power Planning Meeting III. National Wind Coordinating Committee, c/o RESOLVE, Inc., Washington, D.C.

Erickson, W.P., G.D. Johnson, M.D. Strickland, and K. Kronner. 2000b. Avian and bat mortality associated with the Vansycle Wind Project, Umatilla County, Oregon: 1999 study year. Technical Report prepared by WEST, Inc. for Umatilla County Department of Resource Services and Development, Pendleton, Oregon. 21pp.

Erickson W.P., G. D. Johnson, M. D. Strickland, and K. Kronner. 1999. Avian baseline study at the proposed CARES Wind plant, Goldendale WA. NREL/SR-500-259.

Everette, A.L., T.J. O'Shea, L.E. Ellison, L.A. Stone, and J.L. McCance. 2001. Bat use of a high-plains urban wildlife refuge. Wildlife Society Bulletin 29:967-973.

Farney, J. and E.D. Fleharty. 1969. Aspect ratio, loading, wing span, and membrane areas of bats. Journal of Mammalogy 50:362-367.

Fenton, M.B. 2001. Bats, Revised Edition. Checkmark Books, New York, NY. 224 pp.

Fenton, M.B. and R.M.R. Barclay. 1980. *Myotis lucifugus*. Mammalian Species 142:1-8.

Fenton, M.B. and G.P. Bell. 1979. Echolocation and feeding behaviour in four species of *Myotis* (Chiroptera). Canadian Journal of Zoology 57:1271-1277.

Fenton, M.B., H.G. Merriam, and G.L. Holryod. 1983. Bats of Kootenay, Glacier, and Mount Revelstoke national parks in Canada: identification by echolocation calls, distribution, and biology. Canadian Journal of Zoology 61:2503-2508.

Findley, J.S. and C. Jones. 1964. Seasonal distribution of the hoary bat. Journal of Mammalogy45:461-470.

Fitzgerald, J.P., C.A. Meaney, and D.M. Armstrong. 1994. Mammals of Colorado. University Press of Colorado, Niwot, CO. 467pp.

Fullard, J.H. 1989. Echolocation survey of the distribution of the Hawaiian hoary bat (*Lasiurus cinereus semotus*) on the island of Kaua'i. Journal of Mammalogy 70:424-426.

Furlonger, C.L., H.J. Dewar, and M.B. Fenton. 1987. Habitat use by foraging insectivorous bats. Canadian Journal of Zoology 65:284-288.

Ganier, A.F. 1962. Bird casualties at a Nashville TV tower. Migrant 33:58-60.

Garrett, M. 2002. Personal communication regarding bird fatalities on Foote Creek Rim in 2001.

Geggie, J.F. and M.B. Fenton. 1985. A comparison of foraging by *Eptesicus fuscus* (Chiroptera: Vespertilionidae) in urban and rural environments. Canadian Journal of Zoology 63:263-267.

Gollop, M.A. 1965. Bird migration collision casualties at Saskatoon. Blue Jay 23:15-17.

Gould, E. 1955. The feeding efficiency of insectivorous bats. Ibid 36:399-407.

Griffin, D.R. 1970. Migrations and homing of bats. Pages 233-264 *in* W.A. Wimsatt, ed. Biology of bats. Vol. 1. Academic Press, New York. 406pp.

Gruver, J. 2002. University of Wyoming. Personal communication regarding his bat research progress at the Foote Creek Rim wind plant.

Hall, L.S. and G.C. Richards. 1972. Notes on *Tadarida australis* (Chiroptera:molossidae). Australian Mammalogy 1:46.

Hallman, R.C. 1968. Hoary bat (*Lasiurus cinereus*) in Bay County, Florida. Florida Naturalist 41:36.

Hamilton, W.J., Jr. and J.O. Whitaker, Jr. 1979. Mammals of the eastern United States. Cornell Univ. Press, Ithaca, NY. 346pp.

Hawrot, R. Y. and J. M. Hanowski. 1997. Avian assessment document: avian population analysis for wind power generation regions--012. NRRI Technical Report No. NRRI/TR-97-23, Center for Water and the Environment, Natural Resources Research Institute, Duluth, MN. 14pp.

Hayes, J.P. and D.L. Waldien. 2000a. Potential influences of the Stateline wind project on bats. Unpublished report prepared for CH2MHILL, Portland, Oregon.

Hayes, J.P. and D.L. Waldien. 2000b. Potential influences of the proposed Condon wind project on bats. Unpublished report prepared for CH2MHILL, Portland, Oregon.

Hickey, M.B.C. 1992. Effect of radiotransmitters on the attack success of hoary bats, *Lasiurus cinereus*. Journal of Mammalogy 73:344-346.

Hickey, M.B.C. and M.B. Fenton. 1996. Behavioural and thermoregulatory responses of female hoary bats, *Lasiurus cinereus* (Chiroptera: Vespertilionidae), to variations in prey availability. Ecoscience 3:414-422.

Hickey, M.B.C. and M.B. Fenton. 1990. Foraging by red bats (*Lasiurus borealis*): do intraspecific chases mean territoriality? Canadian Journal of Zoology 68:2477-2482.

Howe, R. 2001. Personal communication on avian fatalities observed at two Wisconsin wind plants.

Howell, J.A. 1997. Bird mortality at rotor swept area equivalents, Altamont Pass and Montezuma Hills, California. Transactions of the Western Section of the Wildlife Society 33:24-29.

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 submitted to U.S. Windpower, Inc.

Howell, J. A. and J. Noone. 1992. Examination of avian use and mortality at a U.S. Windpower wind energy development site, Solano County, California. Final Report to Solano County Department of Environmental Management, Fairfield, CA. 41pp.

Howell, J. A., J. Noone and C. Wardner. 1991a. Avian use and mortality study, U.S. Windpower, wind energy site development, Montezuma Hills, Solano County, California, post construction, spring, 1990 to spring, 1991. Prepared for Solano County Department of Environmental Management, Fairfield, California.

Howell, J. A., J. Noone and C. Wardner. 1991b. Visual experiment to reduce avian mortality related to wind turbine operations, Altamont Pass, Alameda and Contra Costa counties, California, April 1990 through March 1991. Final report prepared for Kenetech Windpower.

Hunt, W.G., 2002 (in press). Golden eagles in a perilous landscape: predicting the effects of mitigation for energy-related mortality. Report to the California Energy Commission, PIER Grant No. 500-97-4033 to the University of California, Santa Cruz, CA.

Humphrey, S.R. and J.B. Cope. 1976. Population ecology of the little brown bat, *Myotis lucifugus*, in Indiana and north-central Kentucky. American Society of Mammalogists Special Publication No. 4. 81pp.

Iwen, F.A. 1958. Hoary bat the victim of a barbed wire fence. Journal of Mammalogy 39:438.

Izor, R.J. 1979. Winter range of the silver-haired bat. Journal of Mammalogy 69:641-643.

Jeffrey, J. 2002. Personal communication regarding bird behaviors at the Stateline Wind Plant.

Jen, P.H.S. and J.K. McCarty. 1978. Bats avoid moving objects more successfully than stationary ones. Nature 275:743-744.

Johnson, G.D. 2002. Personal communication regarding Klondike wind project monitoring.

Johnson, G.D., W.P. Erickson, D.A. Shepherd, M. Perlik, M.D. Strickland, and C. Nations. 2002. Bat interactions with wind turbines at the Buffalo Ridge, Minnesota wind resource area: 2001 field season. Electric Power Research Institute, Palo Alto, California.

Johnson, G. D., D. P. Young, Jr., W. P. Erickson, C. E. Derby, M. D. Strickland, and R. E. Good. 2000a. Wildlife Monitoring Studies: SeaWest Windpower Project, Carbon County, Wyoming: 1995-1999. Tech. Report prepared by WEST, Inc. for SeaWest Energy Corporation and Bureau of Land Management. 195pp.

Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd and D.A. Shepherd. 2000b. Avian Monitoring Studies at the Buffalo Ridge Wind Resource Area, Minnesota: Results of a 4-year study. Technical report prepared for Northern States Power Co., Minneapolis, MN. 212pp.

Johnson, G.D., D.P. Young, Jr., W.P. Erickson, M.D. Strickland, R.E. Good and P. Becker. 2000c. Avian and bat mortality associated with the initial phase of the Foote Creek Rim Windpower Project, Carbon County, Wyoming: November 3, 1998 - October 31, 1999. Tech. Rept. prepared for SeaWest Energy Corporation and Bureau of Land Management. 32pp.

Jones & Stokes Associates, Inc. 1995. Technical report: Avian use of proposed Kenetech and Cares Wind Farm Sites in Klickitat County, Washington.

Keeley, B., S. Ugoretz, and D. Strickland. 2001. Bat ecology and wind turbine considerations.

Proceedings of the National Avian-Wind Power Planning Meeting, 4:135-146. National Wind Coordinating Committee, Washington, D.C.

Kerlinger, P. 2000. Avian mortality at communication towers: a review of recent literature, research, and methodology. Unpublished report prepared for the U.S. Fish and Wildlife Service, Office of Migratory Bird Management. http://migratorybirds.fws.gov/issues/towers/review.pdf

Kerlinger, P. 1997. A study of avian fatalities at the Green Mountain Power Corporation's Searsburg, Vermont, windpower facility – 1997. Prepared for Vermont Department of Public Service, Green Mountain Power Corporation, National Renewable Energy Laboratory and Vermont Environmental Research Associates. 12pp.

Kerlinger, P., R. Curry, and R. Ryder. 2000. Ponnequin wind energy project: reference site avian study, January 1, 1998 – December 31, 1998. NREL/SR-500-27546.

Kerlinger, P. 2000. Curry and Kerlinger, Inc. Personal communication regarding avian mortality data from Ponnequin, Colorado, Somerset Pennsylvania and Searsburg, Vermont.

Koehler, C.E. and R.M.R. Barclay. 2000. Post-natal growth and breeding biology of the hoary bat (*Lasiurus cinereus*). Journal of Mammalogy 81:234-244.

Koehler, C.E. 2002. Personal communication regarding bat research [NEED AFFILIATION].

Krenz, J.D., and B.R. McMillan. 2000. Final Report: Wind-turbine related bat mortality in southwestern Minnesota. Minnesota Department of Natural Resources, St. Paul.

Kunz, T.H. 1971. Reproduction of some Vespertilionid bats in central Iowa. American Midland Naturalist 86:477-486.

Kunz, T.H. 1982. *Lasionycteris noctivagans*. Mammalian Species 172:1-5.

Kurta, A. and R.H. Baker. 1990. *Eptesicus fuscus*. Mammalian Species 356:1-10.

LaVal, R.K. and M.L. LaVal. 1979. Notes on reproduction, behavior, and abundance of the red bat, *Lasiurus borealis*. Journal of Mammalogy 60:209-212.

LaVal, R.K., R.L. Clawson, M.L. LaVal, and W. Caire. 1977. Foraging behavior and nocturnal activity patterns of Missouri bats, with emphasis on the endangered species *Myotis grisescens* and *Myotis sodalis*. Journal of Mammalogy 58:592-599.

Limpens, H.J.G.A. and K. Kapteyn. 1991. Bats, their behaviour and linear landscape elements. Myotis 29:39-47.

Lincoln, F.C. 1950. Migration of birds. U.S. Fish and Wildlife Service, Circular No. 16, Washington, D.C.

Mabee, T. J. and B. A. Cooper. 2002. Nocturnal bird migration at the Stateline and Vansycle wind energy projects, 2000-2001. Final report prepared for CH2MHILL and FPL Energy Vansycle, LLC, by ABR Inc., Forest Grove, OR.

Mackey, R.L. and R.M.R. Barclay. 1989. The influence of physical clutter and noise on the activity of bats over water. Canadian Journal of Zoology 67:1167-1170.

Manville, R.H. 1963. Accidental mortality in bats. Mammalia 27:361-366.

McCrary, M. D., R. L. McKernan, R. E. Landry, W. D. Wagner and R. W. Schreiber. 1983. Nocturnal avian migration assessment of the San Gorgonio wind resource study area, spring 1982. Report prepared for Research and Development, Southern California Edison Company. 121pp.

McCrary, M. D., R. L. McKernan and R. W. Schreiber. 1986. San Gorgonio wind resource area: Impacts of commercial wind turbine generators on birds, 1985 data report. Prepared for Southern California Edison Company. 33pp.

McCrary, M. D., R. L. McKernan, W. D. Wagner and R. E. Landry. 1984. Nocturnal avian migration assessment of the San Gorgonio wind resource study area, fall 1982. Report prepared for Research and Development, Southern California Edison Company; report #84-RD-11. 87pp.

Mills, R.S., G.W. Barrett, and M.P. Farrell. 1975. Population dynamics of the big brown bat (*Eptesicus fuscus*) in southwestern Ohio. Journal of Mammalogy 56:591-604.

Mueller, H.C. 1968. The role of vision in vespertilionid bats. American Midland Naturalist 79:524-525.

Mumford, R.E. and J.O. Whitaker, Jr. 1982. Mammals of Indiana. Indian Univ. Press, Bloomington, IN. 537pp.

National Wind Coordinating Committee (NWCC). 1999. Permitting of wind energy facilities: A handbook. NWCC c/o RESOLVE, Washington, D.C.

Nicholson, C.P. 2001. Buffalo Mountain Windfarm bird and bat mortality monitoring report: October 2000 - September 2001. Tennessee Valley Authority, Knoxville.

Norberg, U.M. and J.M.V. Rayner. 1987. Ecological, morphology and flight in bats (Mammalia: Chiroptera): wing adaptations, flight performance, foraging strategy and echolocation. Philosophical Transactions Royal Society London 316:335-427.

Nordquist, G.E. 1997. Bats in Minnesota. James Ford Bell Museum of Natural History Natural

History Leaflet. Univ. of Minnesota.

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 by Biosystems Analysis, Inc., Tiburon, CA.

Orloff, S. and A. Flannery. 1996. A continued examination of avian mortality in the Altamont Pass Wind Resource Area. Final Report to the California Energy Commission by Biosystems Analysis, Inc., Tiburon, CA.

Osborn, R. G., K. F. Higgins, R. E. Usgaard, C. D. Dieter and R. G. Neiger. 2000. Bird mortality associated with wind turbines at the Buffalo Ridge Wind Resource Area, Minnesota. Am. Midl. Nat. 143:41-52.

Osborn, R.G., K.F. Higgins, C.D. Dieter, and R.E. Usgaard. 1996. Bat collisions with wind turbines in southwestern Minnesota. Bat Research News 37:105-108.

Richardson, W.J. 1974. Spring migration over Puerto Rico and the western Atlantic: a radar study. Ibis 116:172-193.

Richardson, W.J. 1976. Autumn migration over Puerto Rico and the western Atlantic: a radar study. Ibis 118:309-332.

Rolseth, S.L., C.E. Koehler, and R.M.R. Barclay. 1994. Differences in the diets of juvenile and adult hoary bats, *Lasiurus cinereus*. Journal of Mammalogy 75:394-398.

Saunders, W.E. 1930. Bats in migration. Journal of Mammalogy 11:225.

Shump, K.A., Jr. and A.U. Shump. 1982a. *Lasiurus cinereus*. Mammalian Species 185:1-5.

Shump, K.A., Jr. and A.U. Shump. 1982b. *Lasiurus borealis*. Mammalian Species 183:1-6.

Simmons, J.A., M.B. Fenton, and M.J. O'Farrell. 1979. Echolocation and the pursuit of prey by bats. Science 203:16-21.

Simmons, J.A. and R.A. Stein. 1980. Acoustic imaging in bat sonar: echolocation signals and the evolution of echolocation. Journal of Comparative Physiology 135:61-84.

Speakman, J.R. and P.A. Racey. 1991. No cost of echolocation for bats in flight. Nature 350:421-423.

Suthers, R.A. 1970. Vision, olfaction, and taste. Pages 265-309 *in* W.A. Wimsatt, ed. Biology of bats. Vol. 2. Academic Press, New York. 477pp.

Suthers, R.A. 1966. Optomotor responses by echolocating bats. Science 152:1102-1104.

Taylor, W.K. and B.H. Anderson. 1973. Nocturnal migrants killed at a central Florida TV tower: autumns 1969-1971. Wilson Bulletin 85:42-51.

Tenaza, R.H. 1966. Migration of hoary bats on South Farallon Island, California. Journal of Mammalogy 47:533-535.

Tennessee Valley Authority. 2002. Draft Environmental Assessment - 20-MW Windfarm and Associated Energy Storage Facility. Tennessee Valley Authority, Knoxville, Tennessee.

Terres, J.K. 1956. Migration records of the red bat, *Lasiurus borealis*. Journal of Mammalogy 37:442.

Thelander, C. G. 2000. Bioresource Consultants Inc. Personal communication. Species composition data from National Renewable Energy Laboratory funded Altamont Studies (1999-2000).

Thelander, C.G. and L. Rugge. 2000. Bird risk behaviors and fatalities at the Altamont Wind Resource Area. Pp. 5-14 *in* Proceedings of the National Avian-Wind Power Planning Meeting III. National Wind Coordinating Committee/RESOLVE. Washington, D.C.

Timm, R.M. 1989. Migration and molt patterns of red bats. Illinois Bull. Chicago Academy of Science.

URS Corporation, WEST, Inc. and Northwest Wildlife Consultants. 2001. Final Report: Ecological Baseline Study for the Condon Wind Project.

URS Corporation and WEST Inc. 2001. Avian baseline study for the Stateline Project, Vansycle Ridge, Oregon and Washington. Technical report prepared for ESI Vansycle Partners, L.P.

U.S. Department of Energy. 2002. Draft Site-Wide Environmental Assessment of National Renewable Energy Laboratory's National Wind Technology Center. U.S. Department of Energy, Golden, Colorado.

Van Gelder, R.G. 1956. Echo-location failure in migratory bats. Transactions of the Kansas Academy of Science 59:220-222.

Walla Walla County Regional Planning Department. 2000. Final Environmental Impact Statement on FPL Energy's Proposal for the Stateline Wind Project.

WEST, Inc. and Northwest Wildlife Consultants, Inc. 2002. Technical report on progress of the Stateline Wind plant. July-December 31, 2001. Technical report prepared by Western EcoSystems Technology, Inc., Cheyenne, Wyoming and Northwest Wildlife Consultants Inc., Pendleton, OR.

WEST, Inc. and Northwest Wildlife Consultants, Inc. 2001a. Interim Report, Avian Baseline Study for the Maiden Wind Power Project, Yakima and Benton Counties, Washington. April-October 2001. Technical report prepared by Western EcoSystems Technology, Inc., Cheyenne, Wyoming.

WEST, Inc. and Northwest Wildlife Consultants, Inc. 2001b. Baseline ecological studies for the proposed Klondike wind project, Sherman County, Oregon.

WEST, Inc. and Northwest Wildlife Consultants, Inc. 2001c. Wildlife baseline study for the Nine Canyon Wind Project.

Williams, T.C. and J.M. Williams. 1970. Radio tracking of homing and feeding flights of a neotropical bat. Animal Behavior 18:302-309.

Wilson, N. 1965. Red bats attracted to insect light traps. Journal of Mammalogy 46:704-705.

Wisely, A.N. 1978. Bat dies on barbed wire fence. Blue Jay 36:53.

Young, D.P. Jr., Johnson, G. D., W. P. Erickson, M. D. Strickland, R. E. Good and P. Becker. 2001. Avian and bat mortality associated with the initial phase of the Foote Creek Rim Windpower Project, Carbon County, Wyoming: November 3, 1998 - October 31, 2000. Tech. Report prepared by WEST, Inc. for SeaWest Energy Corporation and Bureau of Land Management. 32pp.

Young, D.P. Jr., W.P. Erickson, M.D. Strickland, and R.E. Good. 2002 in review. Comparison of avian effects from UV light reflective paint applied to wind turbines. Foote Creek Rim Wind Plant, Carbon County, Wyoming.

Zinn, T.L. and W.W. Baker. 1979. Seasonal migration of the hoary bat, *Lasiurus cinereus*, through Florida. J. Mamm. 60:634-635.

Table 1. List of studies/study areas and data components used in this report for sites categorized as within agricultural landscapes.

WRA/Study Area	State	Primary Habitat[1]	Data[2]	References
Buffalo Ridge Phase I	MN	AG, GR	AU, MO, RN, BU	Johnson *et al.* (2000a), Johnson *et al.* (2002)
Buffalo Ridge Phase II	MN	AG, GR	AU, MO, BU	Same as above
Buffalo Ridge Phase III	MN	AG, GR	AU, MO, BU	Same as above
Buffalo Ridge Reference	SD	AG, GR	AU, MO, BU	Same as above
Nine Canyon	WA	AG, GR	AU, RN	WEST and Northwest Wildlife Consultants (2001c)
Zintel Canyon	WA	AG, GR	AU, RN, MO	
Klondike	OR	AG, GR	AU, RN, MO	WEST and Northwest Wildlife Consultants (2001b)
Condon	OR	AG, GR	AU, RN, BU	URS Corporation *et al.* (2001)
Stateline/Vansycle	OR/WA	AG, GR	AU, MO, RN, BU	URS Corporation and WEST (2001)
Stateline/Vansycle Reference	OR	AG,GR	AU	Same as above
MG&E & WPSC	WI	AG, GR	MO	Howe (2001, pers. comm.)
Algona	IA	AG	MO	Demastes and Trainer (2000)

[1] AG=cultivated agriculture, GR=native and/or CRP grasslands, SS=shrub steppe, DS=desert scrub, UN=unknown at this time

[2] list of data types used in this report. AU=diurnal avian use surveys, RN=aerial raptor nest surveys, BU=bat use surveys, MO=mortality surveys

Table 2. List of studies/study areas and data components used in this report for sites categorized as within predominantly native landscapes.

WRA/Study Area	State	Primary Habitat[1]	Data[2]	Primary Reference
Cares	WA	GR	AU	Erickson *et al.* (1999)
Columbia Hills	WA	GR	AU, RN	Jones and Stokes (1995)
Ponnequin	CO	GR	MO, RN	Kerlinger et al. (1999) Kerlinger pers. comm. (2000)
Maiden	WA	SS	AU, RN	WEST and Northwest Wildlife Consultants (2001a)
Foote Creek Rim	WY	GR, SS	AU, RN, MO, BU	Johnson *et al.* (2000a) Young *et al.* (2001)
Simpson Ridge	WY	SS	AU	Johnson *et al.* (2000a)
Morton Pass	WY	SS, GR	AU	Johnson *et al.* (2000a)
Tehachapi Pass	CA	SS	AU, MO	Anderson *et al.* (2000)
San Gorgonio	CA	DS, SS	AU, MO	Anderson *et al.* (2000)
Altamont Pass	CA	GR	AU, MO	Orloff and Flannery (1992) Orloff and Flannery (1996)
Somerset County	PA	UN	MO	Kerlinger pers. comm. (2000)
Searsburg	VT	UN	MO	Kerlinger (1997)
Montezuma Hills	CA	GR, AG	AU, MO	Howell (1997) Howell and Noone (1992)
Buffalo Mountain	TN	FO	MO	Nicholson (2001)

[1] AG=cultivated agriculture, GR=native and/or CRP grasslands, SS=shrub steppe, DS=desert scrub, UN=unknown at this time

[2] list of data types used in this report. AU=diurnal avian use surveys, RN=aerial raptor nest surveys, BU=bat use surveys, MO=mortality surveys

Table 3. Description of raptor nest survey methods for relevant study areas.

WRA/Study Area	# aerial surveys[1]	# ground surveys[2]
Foote Creek Rim	1	at least 1
Condon	1	0
Nine Canyon	2	0
Zintel Canyon	2	0
Columbia Hills	?	0
Maiden	2	0
Stateline	2	0
Klondike	2	0
Buffalo Ridge	0	at least 1
Ponnequin	1	0

[1] # of annual aerial surveys conducted (max number in any one year)

[2] typical # ground visits

Table 4. Description of study areas of avian mortality used for species composition or fatality estimates.

WRA/Study Area	Turbine Types	Dates of Study	# of Turbines In WRA	# of Turbines Searched	Search Interval	Total # Observed Fatalities[1]	# of Raptor Fatalities	Reference
Buffalo Ridge, MN Phase I	Kenetech Model 33-MVS	4/94-12/95	73	50	7 days	12	0	Osborn *et al.* (2000)
Buffalo Ridge, MN Phase I	Kenetech Model 33-MVS	3/96-11/99	73	21	14 days	13	1	Johnson *et al.* (2000b)
Buffalo Ridge, MN Phase II	Zond Z-750	3/98-11/99	143	40	14 days	22	0	Same as above
Buffalo Ridge, MN Phase III	Zond Z-750	3/99-11/99	138	30	14 days	20	0	Same as above
Foote Creek Rim, WY Phase I	Mitsubishi 600 kW tubular	11/98-12/00	69	69	28 days	95	5	Young *et al.* (2001)
Foote Creek Rim, WY Phase II&III	3 Mitsubishi 600 kW, 33 NEG 750	7/99-12/00	36	36	28 days	13	2	Young et al. (2002, in review)
Green Mountain Searsburg, VT	Zond Z-40	6/97-10/97	11	11	Weekly-monthly	0	0	Kerlinger (1997)
IDWGP Algona, IA	Zond Z-50	10/99-7/00	3	3	14 days	0	0	Demastes and Trainer (2000)
Ponnequin, CO	NEG/MICON7 50 kW	11/98-11/00	29	29	3 days-1.5 mo.	9	0	Kerlinger *et al.* (2000)
Somerset County, PA		6/00-1/00	8	8	Weekly-monthly	0	0	Kerlinger (2000, pers. comm...)
Vansycle Ridge, OR	660 kW Vestes	1/99-12/99	38	38	28 days	12	0	Erickson *et al.* (2000b).
Stateline, OR/WA	660 kW Vestes	7/01-present	399	125	14-28 days	20	0	WEST and Northwest Wildlife Consultants (2002)
Klondike, OR	1.5 MW	01/02-present	16	16	28 days	1	0	Johnson (2002, pers. comm.)
Buffalo Mtn., TN	~660 kW	10/00-9/01	3	3	2/week-weekly	12	0	Nicholson (2001)
Wisconsin	Vestes 660 kW	Spring 98-12/00	31	31	Daily-weekly	21	0	Howe pers. comm. (2001)

[1] types of fatalities often varied by study. For example, in some studies, feather spots were included or electrocutions were included. In other studies only fresh carcasses that were likely turbine kills were included. Sometimes incidental discoveries were included, other times they were not.

Table 4 (*cont.*). Description of studies of avian mortality used for species composition or fatality estimates.

WRA	Turbine Types	Dates of Study	# of Turbines Searched	Search Interval	Total # Observed Fatalities[1]	# of Raptor Fatalities	Reference
Altamont Pass, CA and Tehachapi	<250 kW turbines	1984-1988	Incidental discoveries	Incidental discoveries	Raptor reports	63 (Alt) 9 (Teh)	California Energy Commission (1989)
Altamont Pass, CA	<250 kW turbines	9/88-8/89	359	2/week	42	18	Howell and DiDonato (1991)
Altamont Pass, CA	<250 kW turbines	4/90-3/91	150	2/week	10	1	Howell *et al.* (1991b)
Altamont Pass, CA	<250 kW turbines	1989-1991	1169	1-2/week	182	74	Orloff and Flannery (1992)
Altamont Pass, CA	<250 kW turbines	1/1994	1169	one time search	20	15	Orloff and Flannery (1996)
Altamont Pass, CA	KVS –33 & 56-100	12/93-8/95	165	2/week	72	44	Howell (1997)
Altamont Pass, CA	Mostly <250 kW turbines	4/98-3/00	785	1/5 weeks	256	117	Thelander pers. comm. (2000)
Montezuma Hills, CA	<250 kW turbines	4/90-5/92	237	Weekly	22	14	Howell and Noone (1992)
Montezuma Hills, CA	KVS –33 & 56-100	11/94-9/95	76	2/Week	13	10	Howell (1997)
San Gorgonio, CA	<250 kW turbines	1985	Not available	not available	38	1	McCrary *et al.* (1986)
San Gorgonio, CA	Mostly <250 kW turbines	3/97-5/98	~360	Quarterly	42	7	Anderson (2000a, pers. comm.)
Tehachapi Pass, CA	mostly < 250 kW turbines	5/95-5/98	640-760	Quarterly	147	46	Anderson (2000b, pers. comm.)

[1] types of fatalities often varied by study. For example, in some studies, feather spots were included or electrocutions were included. In other studies only fresh carcasses that were likely turbine kills were included. Sometimes incidental discoveries were included, other times they were not.

Table 5. Composition of fatalities from U.S. wind projects.

	% Composition of Fatalities									
WRA	Waterbirds	Waterfowl	Shorebirds	Diurnal Raptors	Owls	Fowl-like Birds	Protected Passerines	Other Birds	Non-Protected Birds	# Carcasses
California										
Altamont Pass	2	1	0	48	11	0	19	2	18	613
Montezuma Hills	0	5	0	62	7	0	12	7	7	42
San Gorgonio	5	21	2	5	12	0	10	17	29	42
Tehachapi Pass	0	0	0	20	3	11	32	22	11	144
Subtotal	1	2	0	39	12	1	19	11	15	841
Outside California										
Buffalo Ridge, MN	5	9	2	2	0	5	73	0	4	55
Foote Creek Rim, WY	1	0	0	4	1	0	91	3	0	95
Ponnequin, CO	0	11	0	0	0	0	89	0	0	9
Vansycle, OR	0	0	0	0	0	25	67	8	0	12
Wisconsin	5	10	0	0	0	0	67	5	14	21
Buffalo Mtn, TN	0	0	0	0	0	0	92	8	0	12
Stateline, OR/WA	5	0	0	0	0	5	85	5	0	20
Klondike, OR	0	0	0	0	0	0	0	0	100	1
Subtotal	3	4	<1	2	<1	3	82	3	3	225
Grand total	2	3	0	32	9	1	33	9	13	1033

Table 6. Estimates of avian collision mortality by wind resource areas

Wind Resource Area	Turbines in WRA end of 2001	Turbines in WRA during study	# bird fatalities/ turbine/year	# raptor fatalities /turbine/year
Mean Fatalities/Turbine/Year				
Outside California				
Buffalo Ridge, MN	~450	~400	2.834	0.002
Foote Creek Rim, WY	133	69	1.750	0.036
Green Mountain, Searsburg, VT	11	11	0.000	0.000
IDWGP, Algona, IA	3	3	0.000	0.000
Ponnequin, CO	44	29	na[b]	0.000
Somerset County, PA	8	8	0.000	0.000
Vansycle/Stateline,OR/WA	437	38	0.630	0.000
Wisconsin (MG&E and PSC)	31	31	na[b]	0.000
Subtotal	1,117	589	1.825	0.006
California				
Altamont Pass, CA	~5,400	~7,340	na[b]	0.048
Montezuma Hills,CA	600	600	na[b]	0.048
San Gorgonio, CA	~2,900	2,900	2.307	0.010
Grand Total	10,017	11,429	**2.19**	**0.033**

Table 7. Mean raptor/vultures use estimates (estimated #/20-min survey) by study areas.

		Mean Use (#/20-minute survey)[1]					Ranks			
Wind Resource Area	Study Area	Spr	Sum	Fall	Win	Avg[2]	1[3]	2[4]	3[5]	4[6]
Agricultural Landscapes										
Buffalo Ridge	Phase I	0.646	0.431	0.761	0.133	0.424	8	9	10	12
Buffalo Ridge	Phase II	0.841	0.694	0.827	0.100	0.523	4	3	7	7
Buffalo Ridge	Phase III	0.638	0.537	0.845	0.181	0.484	9	8	8	9
Buffalo Ridge	Reference	0.681	0.524	0.690	0.444	0.555	7	7	6	6
Condon	Condon	0.528	0.325	0.293	0.453	0.400	11	14	15	15
Klondike	Klondike	0.468	0.389	0.386	0.566	0.468	14	12	12	10
Nine Canyon	Nine Canyon	0.354	0.199	0.156	0.312	0.258	17	18	19	19
Stateline/Vansycle	Reference	1.104	0.401	0.336	0.662	0.602	2	5	3	4
Stateline/Vansycle	Stateline/Vansycle	0.524	0.333	0.260	0.494	0.410	12	13	16	14
Zintel Canyon	Zintel Canyon	0.194	0.299	0.700	0.507	0.443	20	19	11	11
Average		0.598	0.413	0.525	0.385	0.457	10.4	10.8	10.7	10.7
Native Landscapes										
Altamont Pass	Altamont Pass	2.125	2.375	3.375	2.063	2.424	1	1	1	1
Cares	Cares	0.577	0.632	0.813	0.263	0.522	10	6	9	8
Columbia Hills	Columbia Hills	0.935	1.335	0.775	0.263	0.750	3	2	4	2
Foote Creek Rim	Foote Creek Rim	0.735	0.702	0.839	0.239	0.562	6	4	5	5
Foote Creek Rim	Foote Creek Rim UV	0.464	0.518	0.608	0.224	0.417	15	10	13	13
Foote Creek Rim	Morton's Pass Reference	0.480	0.329	0.287	0.153	0.279	13	15	17	18
Foote Creek Rim	Simpson's Ridge	0.373	0.280	0.261	0.123	0.233	16	17	20	20
Maiden	Maiden	0.280	0.398	0.617	0.288	0.382	18	16	14	16
San Gorgonio Pass	Phase I High Elevation	0.000	0.103	0.133	0.162	0.114	26	24	23	23
San Gorgonio Pass	Phase I Low Elevation	0.024	0.024	0.030	0.232	0.103	25	25	25	24
San Gorgonio Pass	Phase I Medium Elevation	0.119	0.175	0.050	0.143	0.128	22	20	24	22
San Gorgonio Pass	Phase I Water Area	0.231	0.024	0.132	0.150	0.128	19	22	21	21
San Gorgonio Pass	Phase II Low Elevation	0.000	0.011	0.052	0.006	0.016	26	27	27	27
San Gorgonio Pass	Phase II Water Area	0.167	0.000	0.084	0.130	0.094	21	23	22	25
Tehachapi Pass	East Slope	0.031	0.013	0.075	0.096	0.060	24	26	26	26
Tehachapi Pass	Middle Ridge	0.084	0.160	0.203	0.545	0.301	23	21	18	17
Tehachapi Pass	West Ridge	0.756	0.218	2.080	0.297	0.725	5	11	2	3
Average		0.434	0.429	0.613	0.316	0.426	16.1	15.9	15.9	15.9

[1] some biases may exist in comparisons of study areas due to differences in quality of viewsheds out to 800 m and durations of surveys

[2] overall four season average weighted by the length of each season

[3] rank (lower number indicates higher use estimate) of study area using spring data

[4] rank (lower number indicates higher use estimate) of study area using spring and summer data

[5] rank (lower number indicates higher use estimate) of study area using spring, summer and fall data

[6] rank (lower number indicates higher use estimate) of study area using all four seasons of data

Table 8. Pearson correlations among all raptor/vulture seasonal use estimates.

Correlation of Study Area Ranks					**Correlation of Seasonal Use Estimates**					
	Spr	Spr-Sum	Spr-Fall	Overall		Spr	Sum	Fall	Win	Overall
Spr	1.00				Spr	1.00				
Spr-Sum	0.95	1.00			Sum	0.89	1.00			
Spr-Fall	0.92	0.92	1.00		Fall	0.83	0.81	1.00		
					Win	0.75	0.76	0.73	1.00	
Overall	0.91	0.93	0.99	1.00	Overall	0.93	0.93	0.92	0.90	1.00

Table 9. Mean buteo use estimates (estimated #/20-min survey) for several study areas.

		Mean Use (#/20-minute survey)[1]					Ranks			
Wind Resource Area	Study Area	Spr	Sum	Fall	Win	Avg[2]	1[3]	2[4]	3[5]	4[6]
Agricultural Landscapes										
Buffalo Ridge	Phase I	0.381	0.289	0.622	0.133	0.316	3	6	3	4
Buffalo Ridge	Phase II	0.372	0.341	0.561	0.033	0.277	4	3	4	6
Buffalo Ridge	Phase III	0.313	0.264	0.519	0.118	0.271	6	8	5	7
Buffalo Ridge	Reference	0.287	0.396	0.414	0.264	0.332	7	4	6	3
Condon	Condon	0.139	0.079	0.108	0.211	0.144	15	19	15	16
Klondike	Klondike	0.230	0.232	0.200	0.401	0.288	11	11	7	5
Nine Canyon	Nine Canyon	0.083	0.071	0.037	0.191	0.111	20	20	18	18
Stateline/Vansycle	Reference	0.805	0.268	0.227	0.531	0.447	1	1	2	2
Stateline/Vansycle	Stateline/Vansycle	0.253	0.179	0.136	0.287	0.223	8	13	9	9
Zintel Canyon	Zintel Canyon	0.083	0.139	0.233	0.285	0.204	19	18	11	11
Average		0.295	0.226	0.306	0.245	0.261	9.4	10.3	8.0	8.1
Native Landscapes										
Altamont Pass	Altamont Pass	0.636	0.375	0.876	0.699	0.644	2	2	1	1
Cares	Cares	0.247	0.225	0.258	0.103	0.190	10	10	12	12
Columbia Hills	Columbia Hills	0.370	0.327	0.319	0.103	0.248	5	5	8	8
Foote Creek Rim	Foote Creek Rim	0.253	0.336	0.336	0.039	0.211	9	7	10	10
Foote Creek Rim	Foote Creek Rim UV	0.165	0.263	0.237	0.032	0.155	13	12	16	15
Foote Creek Rim	Morton's Pass Reference	0.152	0.135	0.064	0.024	0.081	14	16	19	20
Foote Creek Rim	Simpson's Ridge	0.123	0.115	0.060	0.012	0.066	17	17	22	22
Maiden	Maiden	0.212	0.274	0.204	0.081	0.177	12	9	14	14
San Gorgonio Pass	Phase I High Elevation	0.000	0.056	0.058	0.143	0.079	24	22	21	21
San Gorgonio Pass	Phase I Low Elevation	0.017	0.000	0.000	0.040	0.018	23	25	25	24
San Gorgonio Pass	Phase I Medium Elevation	0.095	0.175	0.000	0.143	0.113	18	15	20	17
San Gorgonio Pass	Phase I Water Area	0.000	0.000	0.000	0.010	0.004	24	26	26	26
San Gorgonio Pass	Phase II Low Elevation	0.000	0.000	0.000	0.000	0.000	24	26	27	27
San Gorgonio Pass	Phase II Water Area	0.056	0.000	0.000	0.011	0.014	21	23	24	25
Tehachapi Pass	East Slope	0.000	0.013	0.046	0.052	0.032	24	24	23	23
Tehachapi Pass	Middle Ridge	0.047	0.063	0.141	0.136	0.104	22	21	17	19
Tehachapi Pass	West Ridge	0.137	0.157	0.240	0.193	0.184	16	14	13	13
Average		0.148	0.148	0.167	0.107	0.137	16.4	16.1	17.5	17.5

[1] some biases may exist in comparisons of study areas due to differences in quality of viewsheds out to 800 m and durations of surveys

[2] overall four season average weighted by the length of each season

[3] rank (lower number indicates higher use estimate) of study area using spring data

[4] rank (lower number indicates higher use estimate) of study area using spring and summer data

[5] rank (lower number indicates higher use estimate) of study area using spring, summer and fall data

[6] rank (lower number indicates higher use estimate) of study area using all four seasons of data

Table 10. Pearson correlations among buteo seasonal use estimates.

	Correlation of Study Area Ranks					Correlation of Seasonal Use Estimates				
	Spr	Spr-Sum	Spr-Fall	Overall		Spr	Sum	Fall	Win	Overall
Spr	1.00				Spr	1.00				
Spr-Sum	0.96	1.00			Sum	0.77	1.00			
Spr-Fall	0.92	0.92	1.00		Fall	0.72	0.81	1.00		
					Win	0.67	0.41	0.48	1.00	
Overall	0.91	0.92	0.99	1.00	Overall	0.90	0.82	0.86	0.82	1.00

Table 11. Mean eagle use estimates (estimated #/20-min survey) for several study areas.

		Mean Use (#/20-minute survey)[1]					Ranks			
Wind Resource Area	Study Area	Spr	Sum	Fall	Win	Avg[2]	1[3]	2[4]	3[5]	4[6]
Agricultural Landscapes										
Buffalo Ridge	Phase I	0.007	0.000	0.008	0.000	0.003	14	18	19	20
Buffalo Ridge	Phase II	0.015	0.000	0.002	0.017	0.009	13	16	14	15
Buffalo Ridge	Phase III	0.040	0.000	0.000	0.014	0.012	9	10	12	12
Buffalo Ridge	Reference	0.030	0.000	0.000	0.028	0.015	10	11	11	11
Condon	Condon	0.000	0.012	0.043	0.020	0.020	15	15	10	10
Klondike	Klondike	0.000	0.008	0.000	0.000	0.002	15	17	20	21
Nine Canyon	Nine Canyon	0.000	0.000	0.015	0.000	0.003	15	19	18	19
Stateline/Vansycle	Reference	0.029	0.000	0.010	0.010	0.011	11	12	13	14
Stateline/Vansycle	Stateline/Vansycle	0.000	0.000	0.006	0.019	0.008	15	19	16	16
Zintel Canyon	Zintel Canyon	0.000	0.000	0.000	0.000	0.000	15	19	20	22
Average		0.012	0.002	0.008	0.011	0.008	13.2	15.6	15.3	16.0
Native Landscapes										
Altamont Pass	Altamont Pass	0.438	0.063	0.500	0.375	0.333	1	2	1	1
Cares	Cares	0.128	0.031	0.035	0.101	0.075	5	7	6	7
Columbia Hills	Columbia Hills	0.040	0.142	0.050	0.101	0.091	8	4	7	5
Foote Creek Rim	Foote Creek Rim	0.301	0.194	0.311	0.187	0.234	2	1	2	2
Foote Creek Rim	Foote Creek Rim UV	0.214	0.122	0.287	0.189	0.197	3	3	3	3
Foote Creek Rim	Morton's Pass Reference	0.141	0.073	0.121	0.123	0.113	4	5	4	4
Foote Creek Rim	Simpson's Ridge	0.122	0.036	0.067	0.104	0.082	6	6	5	6
Maiden	Maiden	0.000	0.000	0.000	0.031	0.012	15	19	15	13
San Gorgonio Pass	Phase I High Elevation	0.000	0.048	0.075	0.000	0.028	15	8	9	9
San Gorgonio Pass	Phase I Low Elevation	0.000	0.000	0.000	0.000	0.000	15	19	20	22
San Gorgonio Pass	Phase I Medium Elevation	0.024	0.000	0.000	0.000	0.004	12	14	17	18
San Gorgonio Pass	Phase I Water Area	0.042	0.000	0.000	0.067	0.032	7	9	8	8
San Gorgonio Pass	Phase II Low Elevation	0.000	0.000	0.000	0.000	0.000	15	19	20	22
San Gorgonio Pass	Phase II Water Area	0.000	0.000	0.000	0.000	0.000	15	19	20	22
Tehachapi Pass	East Slope	0.000	0.000	0.000	0.000	0.000	15	19	20	22
Tehachapi Pass	Middle Ridge	0.000	0.000	0.000	0.000	0.000	15	19	20	22
Tehachapi Pass	West Ridge	0.000	0.018	0.000	0.000	0.004	15	13	20	17
Average		0.085	0.043	0.085	0.075	0.071	9.9	10.9	11.6	11.9

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[1] some biases may exist in comparisons of study areas due to differences in quality of viewsheds out to 800 m and durations of surveys

[2] overall four season average weighted by the length of each season

[3] rank (lower number indicates higher use estimate) of study area using spring data

[4] rank (lower number indicates higher use estimate) of study area using spring and summer data

[5] rank (lower number indicates higher use estimate) of study area using spring, summer and fall data

[6] rank (lower number indicates higher use estimate) of study area using all four seasons of data

Table 12. Pearson correlations among eagle seasonal use estimates.

Correlation of Study Area Ranks					**Correlation of Seasonal Use Estimates**					
	Spr	Spr-Sum	Spr-Fall	Overall		Spr	Sum	Fall	Win	Overall
Spr	1.00				Spr	1.00				
Spr-Sum	0.91	1.00			Sum	0.66	1.00			
Spr-Fall	0.90	0.93	1.00		Fall	0.96	0.69	1.00		
					Winter	0.97	0.66	0.94	1.00	
Overall	0.87	0.93	0.99	1.00	Overall	0.98	0.76	0.98	0.98	1.00

Table 13. Mean falcon use estimates (estimated #/20-min survey) for several study areas.

		Mean Use (#/20-minute survey)[1]					Ranks			
Wind Resource Area	Study Area	Spr	Sum	Fall	Win	Avg[2]	1[3]	2[4]	3[5]	4[6]
Agricultural Landscapes										
Buffalo Ridge	Phase I	0.094	0.079	0.072	0.000	0.050	10	9	16	16
Buffalo Ridge	Phase II	0.063	0.023	0.072	0.000	0.031	15	17	18	21
Buffalo Ridge	Phase III	0.088	0.111	0.082	0.024	0.069	11	7	14	13
Buffalo Ridge	Reference	0.067	0.033	0.113	0.042	0.059	13	15	11	15
Condon	Condon	0.146	0.135	0.099	0.076	0.107	4	4	7	6
Klondike	Klondike	0.095	0.062	0.143	0.062	0.084	9	12	8	9
Nine Canyon	Nine Canyon	0.056	0.022	0.015	0.009	0.021	16	19	23	23
Stateline/Vansycle	Reference	0.066	0.063	0.012	0.012	0.034	14	13	22	19
Stateline/Vansycle	Stateline/Vansycle	0.036	0.036	0.023	0.027	0.030	19	18	21	22
Zintel Canyon	Zintel Canyon	0.028	0.065	0.406	0.125	0.152	20	14	1	3
Average		0.074	0.063	0.104	0.038	0.064	13.1	12.8	14.1	14.7
Native Landscapes										
Altamont Pass	Altamont Pass	0.125	0.156	0.161	0.126	0.141	6	3	2	4
Cares	Cares	0.131	0.290	0.059	0.014	0.112	5	2	15	5
Columbia Hills	Columbia Hills	0.254	0.537	0.168	0.014	0.217	1	1	3	1
Foote Creek Rim	Foote Creek Rim	0.124	0.109	0.107	0.010	0.074	7	5	10	12
Foote Creek Rim	Foote Creek Rim UV	0.054	0.093	0.059	0.003	0.046	17	10	20	18
Foote Creek Rim	Morton's Pass Reference	0.163	0.082	0.066	0.003	0.062	3	6	13	14
Foote Creek Rim	Simpson's Ridge	0.084	0.071	0.068	0.003	0.047	12	11	17	17
Maiden	Maiden	0.041	0.031	0.250	0.081	0.097	18	20	5	7
San Gorgonio Pass	Phase I High Elevation	0.000	0.000	0.000	0.000	0.000	23	26	27	27
San Gorgonio Pass	Phase I Low Elevation	0.007	0.024	0.030	0.187	0.083	22	22	12	10
San Gorgonio Pass	Phase I Medium Elevation	0.000	0.000	0.050	0.000	0.010	23	26	24	24
San Gorgonio Pass	Phase I Water Area	0.189	0.024	0.132	0.073	0.092	2	8	6	8
San Gorgonio Pass	Phase II Low Elevation	0.000	0.011	0.023	0.006	0.010	23	25	25	25
San Gorgonio Pass	Phase II Water Area	0.111	0.000	0.084	0.118	0.080	8	16	9	11
Tehachapi Pass	East Slope	0.021	0.000	0.000	0.011	0.008	21	24	26	26
Tehachapi Pass	Middle Ridge	0.000	0.058	0.038	0.371	0.162	23	21	4	2
Tehachapi Pass	West Ridge	0.000	0.022	0.081	0.026	0.032	23	23	19	20
Average		0.077	0.089	0.081	0.062	0.075	13.9	14.6	13.9	13.6

[1] some biases may exist in comparisons of study areas due to differences in quality of viewsheds out to 800 m and durations of surveys
[2] overall four season average weighted by the length of each season
[3] rank (lower number indicates higher use estimate) of study area using spring data
[4] rank (lower number indicates higher use estimate) of study area using spring and summer data
[5] rank (lower number indicates higher use estimate) of study area using spring, summer and fall data
[6] rank (lower number indicates higher use estimate) of study area using all four seasons of data

Table 14. Pearson correlations among falcon seasonal use estimates.

Correlation of Study Area Ranks

	Spr	Spr-Sum	Spr-Fall	Overall
Spr	1.00			
Spr-Sum	0.90	1.00		
Spr-Fall	0.51	0.54	1.00	
Overall	0.53	0.62	0.95	1.00

Correlation of Seasonal Use Estimates

	Spr	Sum	Fall	Win	Overall
Spr	1.00				
Sum	0.70	1.00			
Fall	0.23	0.23	1.00		
Winter	-0.18	-0.09	0.19	1.00	
Overall	0.55	0.69	0.61	0.55	1.00

Table 15. Mean accipiter/harrier use estimates (estimated #/20-min survey) for several study areas.

		Mean Use (#/20-minute survey)[1]					Ranks			
Wind Resource Area	Study Area	Spr	Sum	Fall	Win	Avg[2]	1[3]	2[4]	3[5]	4[6]
Agricultural Landscapes										
Buffalo Ridge	Phase I	0.163	0.063	0.058	0.000	0.055	8	10	13	13
Buffalo Ridge	Phase II	0.341	0.301	0.156	0.042	0.180	1	1	2	1
Buffalo Ridge	Phase III	0.188	0.135	0.218	0.024	0.120	6	2	4	4
Buffalo Ridge	Reference	0.274	0.074	0.135	0.111	0.134	2	3	3	2
Condon	Condon	0.229	0.030	0.043	0.114	0.097	3	8	7	8
Klondike	Klondike	0.143	0.087	0.043	0.103	0.093	9	9	11	10
Nine Canyon	Nine Canyon	0.215	0.069	0.089	0.102	0.110	4	4	5	6
Stateline/Vansycle	Reference	0.174	0.069	0.087	0.062	0.088	7	7	10	11
Stateline/Vansycle	Stateline/Vansycle	0.189	0.076	0.096	0.106	0.110	5	5	6	5
Zintel Canyon	Zintel Canyon	0.083	0.096	0.061	0.097	0.087	11	11	12	12
Average		0.200	0.100	0.099	0.076	0.107	5.6	6.0	7.3	7.2
Native Landscapes										
Altamont Pass	Altamont Pass	0.031	0.001	0.040	0.001	0.014	14	18	16	17
Cares	Cares	0.042	0.064	0.407	0.045	0.125	12	13	1	3
Columbia Hills	Columbia Hills	0.100	0.129	0.160	0.045	0.099	10	6	8	7
Foote Creek Rim	Foote Creek Rim	0.031	0.028	0.070	0.001	0.027	15	15	14	15
Foote Creek Rim	Foote Creek Rim UV	0.012	0.014	0.018	0.000	0.009	18	17	18	18
Foote Creek Rim	Morton's Pass Reference	0.017	0.020	0.033	0.000	0.015	17	16	17	16
Foote Creek Rim	Simpson's Ridge	0.033	0.054	0.048	0.004	0.030	13	14	15	14
Maiden	Maiden	0.028	0.092	0.163	0.094	0.097	16	12	9	9
San Gorgonio Pass	Phase I High Elevation	0.000	0.000	0.000	0.000	0.000	20	20	23	23
San Gorgonio Pass	Phase I Low Elevation	0.000	0.000	0.000	0.005	0.002	20	20	22	21
San Gorgonio Pass	Phase I Medium Elevation	0.000	0.000	0.000	0.000	0.000	20	20	23	23
San Gorgonio Pass	Phase I Water Area	0.000	0.000	0.000	0.000	0.000	20	20	23	23
San Gorgonio Pass	Phase II Low Elevation	0.000	0.000	0.000	0.000	0.000	20	20	23	23
San Gorgonio Pass	Phase II Water Area	0.000	0.000	0.000	0.000	0.000	20	20	23	23
Tehachapi Pass	East Slope	0.010	0.000	0.000	0.000	0.002	19	19	21	22
Tehachapi Pass	Middle Ridge	0.000	0.000	0.010	0.005	0.004	20	20	19	20
Tehachapi Pass	West Ridge	0.000	0.000	0.000	0.017	0.006	20	20	20	19
Average		0.018	0.024	0.056	0.013	0.025	17.3	17.1	17.4	17.4

[1] some biases may exist in comparisons of study areas due to differences in quality of viewsheds out to 800 m and durations of surveys

[2] overall four season average weighted by the length of each season

[3] rank (lower number indicates higher use estimate) of study area using spring data

[4] rank (lower number indicates higher use estimate) of study area using spring and summer data

[5] rank (lower number indicates higher use estimate) of study area using spring, summer and fall data

[6] rank (lower number indicates higher use estimate) of study area using all four seasons of data

Table 16. Pearson correlations among accipiter/harrier seasonal use estimates.

Correlation of Study Area Ranks					Correlation of Seasonal Use Estimates					
	Spr	Spr-Sum	Spr-Fall	Overall		Spr	Sum	Fall	Win	Overall
Spr	1.00				Spr	1.00				
Spr-Sum	0.96	1.00			Sum	0.75	1.00			
Spr-Fall	0.89	0.91	1.00		Fall	0.39	0.56	1.00		
					Win	0.66	0.42	0.36	1.00	
Overall	0.90	0.93	0.99	1.00	Overall	0.86	0.85	0.74	0.75	1.00

Table 17. Mean waterfowl/waterbird use estimates (estimated #/20-min survey) for several study areas.

		Mean Use (#/20-minute survey)[1]					Ranks			
Wind Resource Area	Study Area	Spr	Sum	Fall	Win	Avg[2]	1[3]	2[4]	3[5]	4[6]
Agricultural Landscapes										
Buffalo Ridge	Phase I	7.298	0.303	5.839	10.300	6.371	5	5	6	5
Buffalo Ridge	Phase II	8.086	1.997	10.129	4.681	5.713	4	4	5	6
Buffalo Ridge	Phase III	6.165	0.942	8.979	0.583	3.352	6	6	8	9
Buffalo Ridge	Reference	6.112	0.264	8.460	2.375	3.738	7	7	7	8
Condon	Condon	0.014	0.000	0.029	0.000	0.008	17	19	19	20
Klondike	Klondike	0.000	0.019	0.357	30.125	11.376	18	18	4	3
Nine Canyon	Nine Canyon	0.417	0.043	0.017	0.907	0.424	11	12	13	13
Stateline/Vansycle	Reference	0.028	0.000	0.000	2.258	0.852	16	17	11	11
Stateline/Vansycle	Stateline/Vansycle	0.350	0.083	0.000	0.000	0.079	13	13	16	16
Zintel Canyon	Zintel Canyon	0.056	0.042	0.422	34.875	13.186	14	15	3	2
Average		2.853	0.369	3.423	8.611	4.510	11.1	11.6	9.2	9.3
Native Landscapes										
Cares	Cares	0.000	0.007	0.017	0.077	0.034	18	20	17	19
Foote Creek Rim	Foote Creek Rim	0.416	0.224	0.056	0.224	0.221	12	11	15	14
Foote Creek Rim	Foote Creek Rim UV	0.858	0.032	0.000	0.002	0.151	9	9	14	15
Foote Creek Rim	Morton's Pass Reference	0.036	0.049	0.007	0.041	0.035	15	16	18	18
Foote Creek Rim	Simpson's Ridge	0.600	0.978	0.901	0.043	0.549	10	8	12	12
Maiden	Maiden	0.000	0.156	0.000	0.000	0.039	18	14	21	17
San Gorgonio Pass	Phase I High Elevation	0.000	0.000	0.000	0.000	0.000	18	21	21	22
San Gorgonio Pass	Phase I Low Elevation	11.001	0.600	0.060	4.917	3.840	3	3	9	7
San Gorgonio Pass	Phase I Medium Elevation	0.000	0.000	0.000	0.000	0.000	18	21	21	22
San Gorgonio Pass	Phase I Water Area	30.771	4.942	8.221	57.693	29.712	1	1	1	1
San Gorgonio Pass	Phase II Low Elevation	0.904	0.000	0.000	2.804	1.202	8	10	10	10
San Gorgonio Pass	Phase II Water Area	13.973	0.122	15.129	14.779	11.053	2	2	2	4
Tehachapi Pass	East Slope	0.000	0.000	0.000	0.000	0.000	18	21	21	22
Tehachapi Pass	Middle Ridge	0.000	0.000	0.000	0.000	0.000	18	21	21	22
Tehachapi Pass	West Ridge	0.000	0.000	0.000	0.007	0.003	18	21	20	21
Average		3.904	0.474	1.626	5.372	3.123	12.4	13.3	14.9	15.1

[1] some biases may exist in comparisons of study areas due to differences in quality of viewsheds out to 800 m and durations of surveys
[2] overall four season average weighted by the length of each season
[3] rank (lower number indicates higher use estimate) of study area using spring data
[4] rank (lower number indicates higher use estimate) of study area using spring and summer data
[5] rank (lower number indicates higher use estimate) of study area using spring, summer and fall data
[6] rank (lower number indicates higher use estimate) of study area using all four seasons of data

Table 18. Pearson correlations among waterfowl/waterbird seasonal use estimates.

Correlation of Study Area Ranks					Correlation of Seasonal Use Estimates					
	Spr	Spr-Sum	Spr-Fall	Overall		Spr	Sum	Fall	Win	Overall
Spr	1.00				Spr	1.00				
Spr-Sum	0.97	1.00			Sum	0.86	1.00			
Spr-Fall	0.76	0.75	1.00		Fall	0.68	0.47	1.00		
					Win	0.68	0.66	0.32	1.00	
Overall	0.73	0.76	0.98	1.00	Overall	0.83	0.77	0.52	0.97	1.00

Table 19. Number of active nests and estimated density (excluding inconspicuous ground nesting species) for cultivated agriculture wind projects.

STATELINE, OR/WA (area = 89 mi^2) (NW Wildlife Consultants and WEST 2001)

Species	Number within 2 mi	Density (#/mi2)
Ferruginous Hawk	3	0.034
Swainson's Hawk	3	0.034
Red-tailed Hawk	7	0.079
Great Horned Owl	6	0.067
TOTAL	19	0.213

CONDON, OR (area = 50 mi^2) (URS Corporation *et al.* 2001)

Species	Number within 2 mi	Density (#/mi2)
Red-tailed Hawk	2	0.040
Unidentified Raptor	1	0.020
TOTAL	3	0.060

KLONDIKE, OR (area = 24 mi^2) (WEST and NW Wildlife Consultants 2001a)

Species	Number within 2 mi	Density (#/mi^2)
Red-tailed Hawk	2	0.083
Swainson's Hawk	1	0.042
Great Horned Owl	1	0.042
TOTAL	4	0.158

NINE CANYON, WA (area = 30 mi^2) (WEST and NW Wildlife Consultants 2001b)

Species	Number within 2 mi	Density (#/mi^2)
Swainson's Hawk	1	0.033
TOTAL	1	0.033

ZINTEL CANYON, WA (area=~50 mi^2)

Species	Number within 2 mi	Density (#/mi^2)
Swainson's Hawk	2	0.040
Red-tailed Hawk	1	0.020
Ferruginous Hawk	1	0.020
TOTAL	4	0.080

BUFFALO RIDGE, MN

Species	Number within 2 mi	Density (#/mi^2)
Swainson's Hawk	Unk	0.074
Red-tailed Hawk	Unk	0.059
Ferruginous Hawk	Unk	0.005
Great Horned Owl	Unk	0.015
TOTAL	Unk	0.153

Table 20. Nesting Information for raptors (excluding inconspicuous ground nesting species) for native wind projects in native landscapes.

Species	Number within 2 mi	Density (#/mi^2)
COLUMBIA HILLS, WA (area = 50 mi^2) (Jones and Stokes 1995)		
Species	Number within 2 mi	Density (#/mi^2)
Red-tailed Hawk	9	0.180
Golden Eagle	1	0.020
Swainson's Hawk	2	0.040
Prairie Falcon	1	0.020
Sharp-shinned Hawk	1	0.020
Great Horned Owl	1	0.020
TOTAL	15	0.300
PONNEQUIN, CO (area =17 mi^2) (Kerlinger *et al.* 2000)		
Species	Number within 2 mi	Density (#/mi^2)
Swainson's Hawk	1	0.059
TOTAL	1	0.059
MAIDEN, WA (area = 96 mi^2) (WEST and Northwest Wildlife Consultants 2001).		
Species	Number within 2 mi	Density (#/mi^2)
Red-tailed Hawk	4	0.042
Swainson's Hawk	5	0.052
Ferruginous Hawk	3	0.031
Prairie Falcon	3	0.031
Great Horned Owl	2	0.021
TOTAL	17	0.178
FOOTE CREEK RIM, WY (area = 36 mi^2) (Johnson *et al.* 2000b)		
Species	Number within 2 mi	Density (#/mi^2)
Red-tailed Hawk	8.0	0.022
Golden Eagle	1.25	0.035
Great Horned Owl	0.5	0.014
TOTAL	10	0.271

Table 21. Bat mortality estimates at U.S. wind plants

Location	Year	Mean annual mortality	Bat mortalities per turbine	Notes
Buffalo Ridge, MN P1	1999	5	0.07	Adjusted for search biases
Buffalo Ridge, MN .P2	1998-2001	289	2.02	Adjusted for search biases
Buffalo Ridge, MN P3	1999-2001	319	2.32	Adjusted for search biases
Wisconsin	1999	34	1.10	Not adjusted for search biases
Foote Creek Rim, WY	1998-2001	138	1.04	Adjusted for search biases
Buffalo Mtn., TN	2001	30	10.0	Not adjusted for search biases
Vansycle, OR	1999	28	0.74	Adjusted for search biases

Table 22. Timing of bat collision mortality at U.S. wind plants

Date	Buffalo Ridge, MN	Vansycle, OR	Buffalo Mtn., TN	Stateline, OR/WA	Foote Creek Rim, WY	TOTAL	Percent
May 1-15	0	0	0	-	0	0	0
May 16-31	1	0	0	-	1	2	0.4
June 1-15	0	0	0	-	1	1	0.2
June 16-30	3	0	0	-	2	5	0.9
July 1-15	9	0	9	0	2	15	2.8
July 16-31	88	0	0	0	26	119	22.2
Aug 1-15	127	0	10	0	19	151	28.2
Aug 16-31	75	4	0	11	33	128	23.9
Sep 1-15	52	4	8	0	21	81	15.1
Sep 16-30	4	2		10	0	20	3.7
Oct 1-15	1	0	0	8	2	11	2.1
Oct 16-31	2	0	0	0	0	2	0.4
Nov 1-15	0	0	0	1	0	1	0.2

Table 23. Composition of bat collision fatalities at U.S. wind plants

Location	n	HOBA	REBA	SHBA	BBBA	LBBA	EAPI	UNID
Buffalo Ridge, MN	362	229	64	19	12	7	7	24
Buffao Mtn., TN	32	1	21	1	1	0	8	0
Wisconsin	34	8	20	2	4	0	0	0
Vansycle, OR	10	5	0	3	0	1	0	1
Ponnequin, CO	~18	~14	0	0	0	0	0	~4
Foote Creek Rim, WY	123	107	0	5	2	6	0	3
Stateline, OR/WA	30	14	0	14	0	2	0	0
Green Mtn., PA	1	0	0	0	0	1	0	0
California	6	2	1	0	0	0	0	3
Total	616	380	106	44	19	17	15	35
Percent(%)		61.7%	17.2%	7.1%	3.1%	2.8%	2.4%	5.7%

Table 24. Habitat at U.S. wind plants with bat mortality.

Location	Habitat
Buffalo Ridge, MN	Crop fields, CRP fields, pasture
Buffalo Mtn., TN	Mountain top in deciduous forest
Wisconsin	Crop fields, pasture
Vansycle, OR	Crop fields, grassland
Ponnequin, CO	Short grass prairie on low ridges
Foote Creek Rim, WY	Short grass prairie on prominent rim, aspens along east edge, shrubs along west edge
Stateline, OR/WA	Crop fields, grassland
Green Mtn, PA	Deciduous woodland
California	Desert shrub on hills

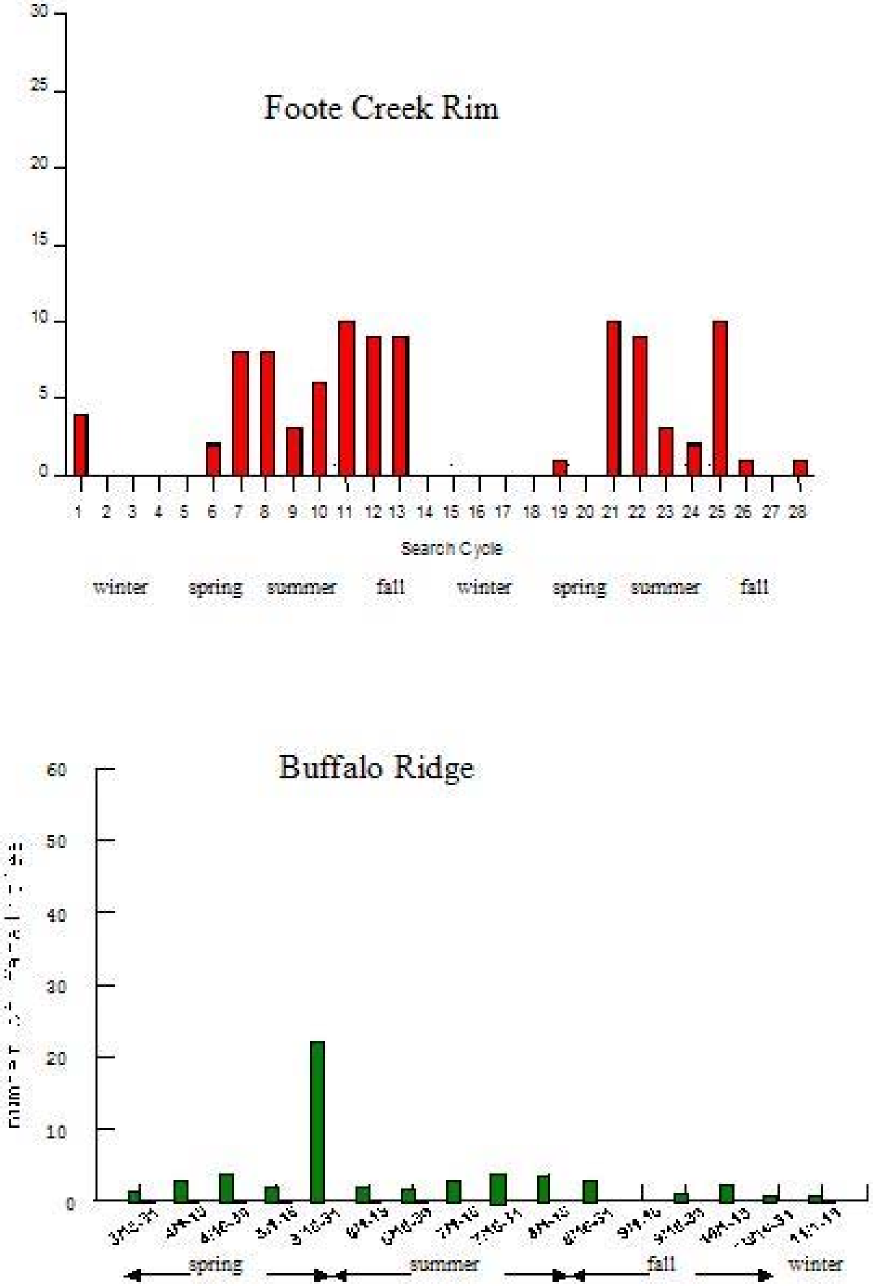
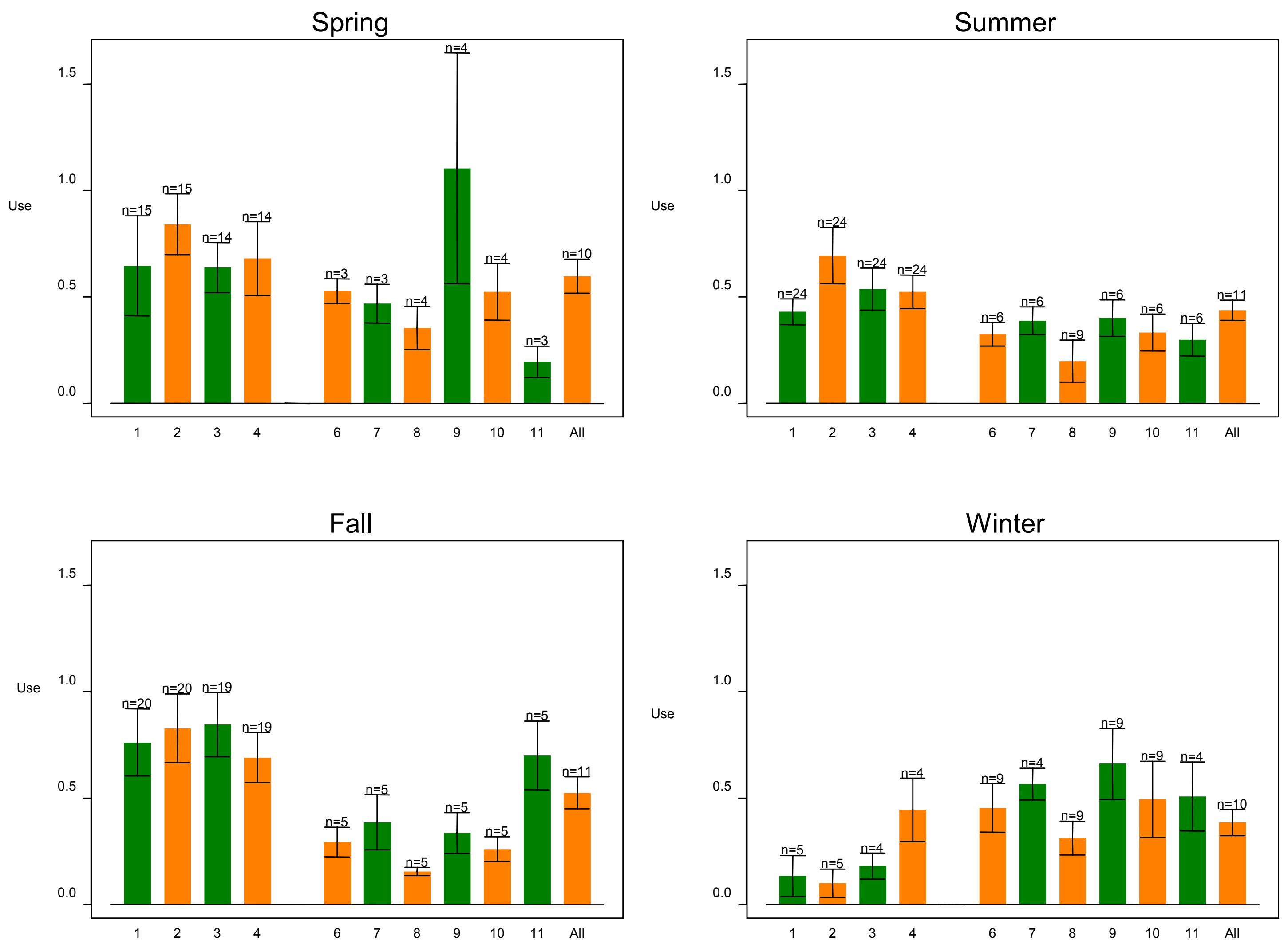


Figure 1. Timing of avian fatality discoveries for the Foote Creek Rim and Buffalo Ridge Wind Projects.



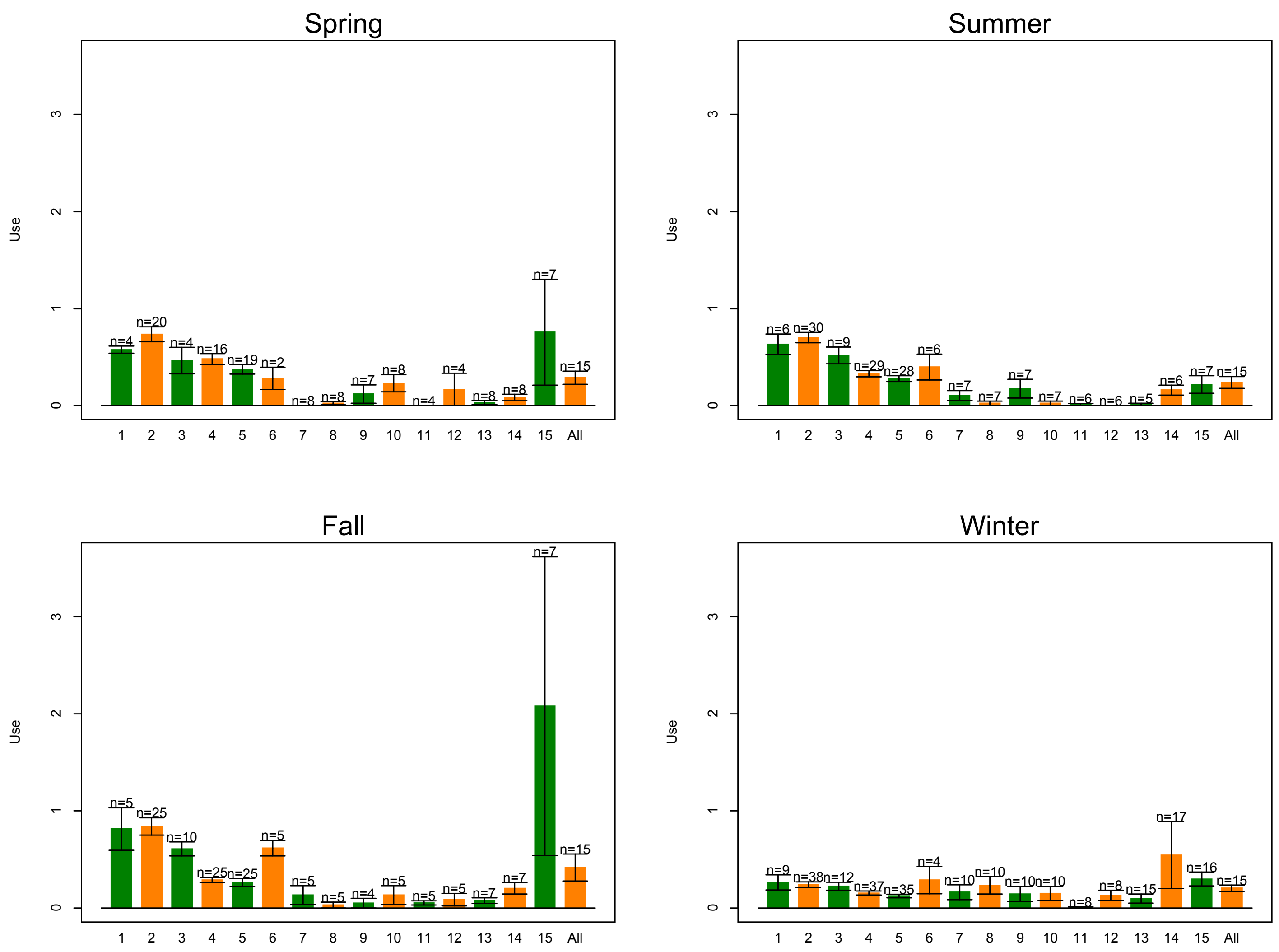
Agricultural Landscapes

1=Buffalo Ridge Phase I
2=Buffalo Ridge Phase II
3=Buffalo Ridge Phase III
4=Buffalo Ridge Reference

6=Condon
7=Klondike
8=Nine Canyon
9=Stateline/Vansycle Reference
10=Stateline/Vansycle
11=Zintel Canyon

n=# survey periods
bars=+/- 1 standard error

Figure 2. Total raptor/vulture use (standardized to #/20-minute survey) for study areas in agricultural landscapes.

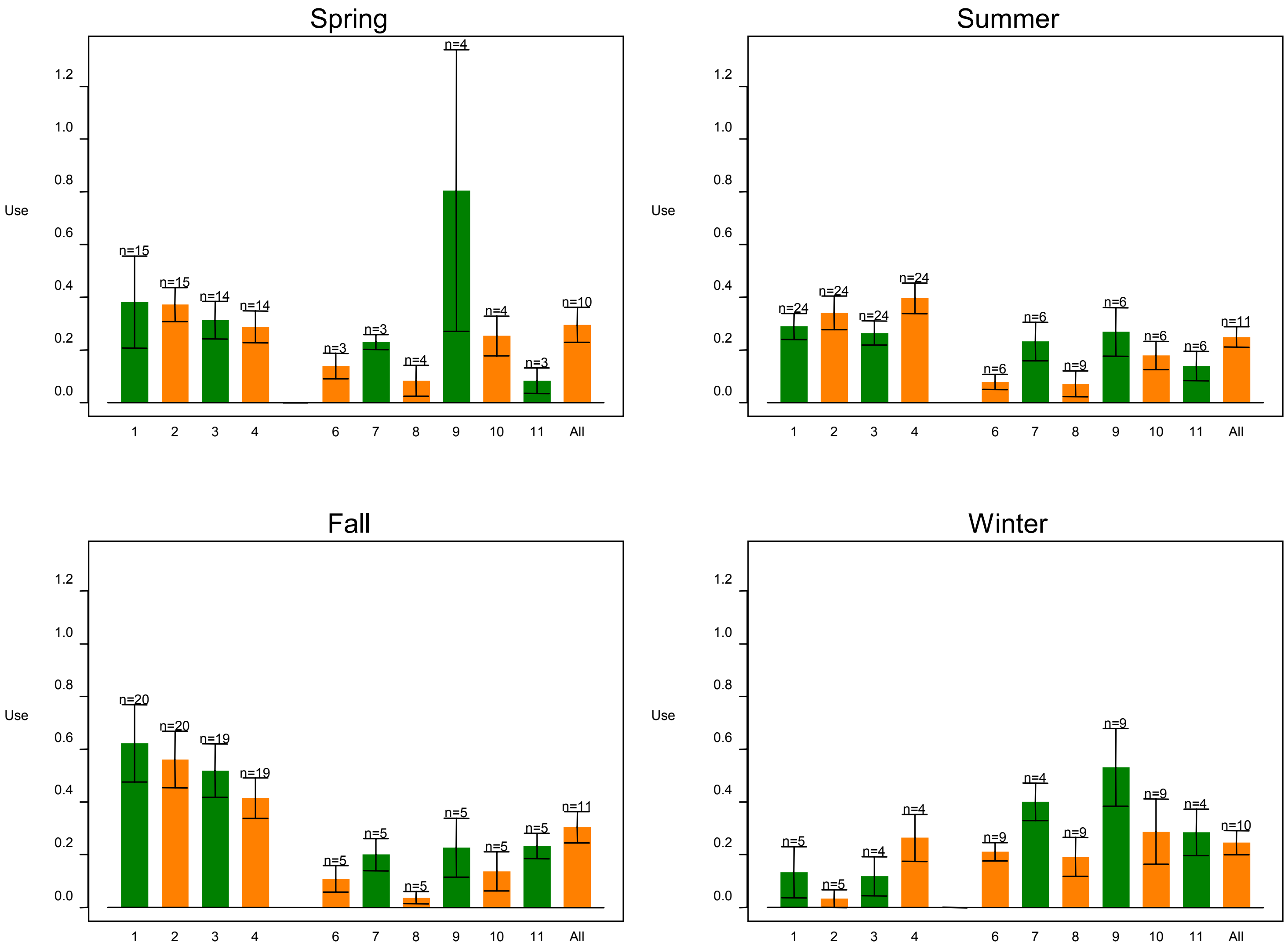


Native Landscapes

1=Cares
2=Foote Creek Rim
3=Foote Creek Rim UV
4=Morton Pass Reference
5=Simpson Ridge
6=Maiden
7=San Gorgonio PI High
8= San Gorgonio PI Medium
9= San Gorgonio PI Low
10= San Gorgonio PI Water
11= San Gorgonio PII Low
12= San Gorgonio PII Water
13=Tehachapi Pass East Slope
14= Tehachapi Pass Middle Ridge
15= Tehachapi Pass West Ridge

n=# survey periods
bars=+/- 1 standard error

Figure 3. Total raptor/vulture use (standardized to #/20-minute survey) for study areas in native landscapes.



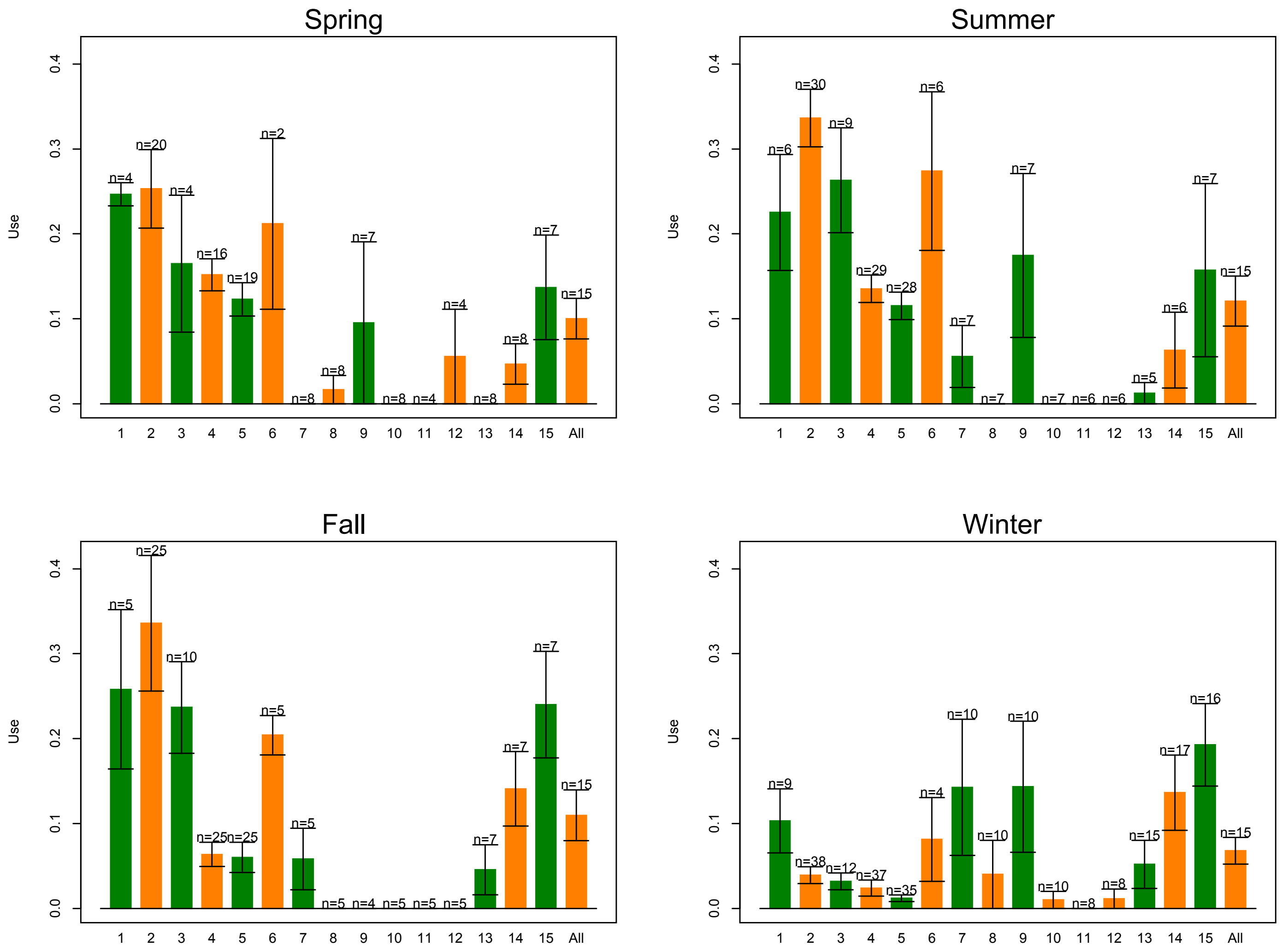
Agricultural Landscapes

1=Buffalo Ridge Phase I
2=Buffalo Ridge Phase II
3=Buffalo Ridge Phase III
4=Buffalo Ridge Reference

6=Condon
7=Klondike
8=Nine Canyon
9=Stateline/Vansycle Reference
10=Stateline/Vansycle
11=Zintel Canyon

n=# survey periods
bars=+/- 1 standard error

Figure 4. Total buteo use (standardized to #/20-minute survey) for study areas in agricultural landscapes.

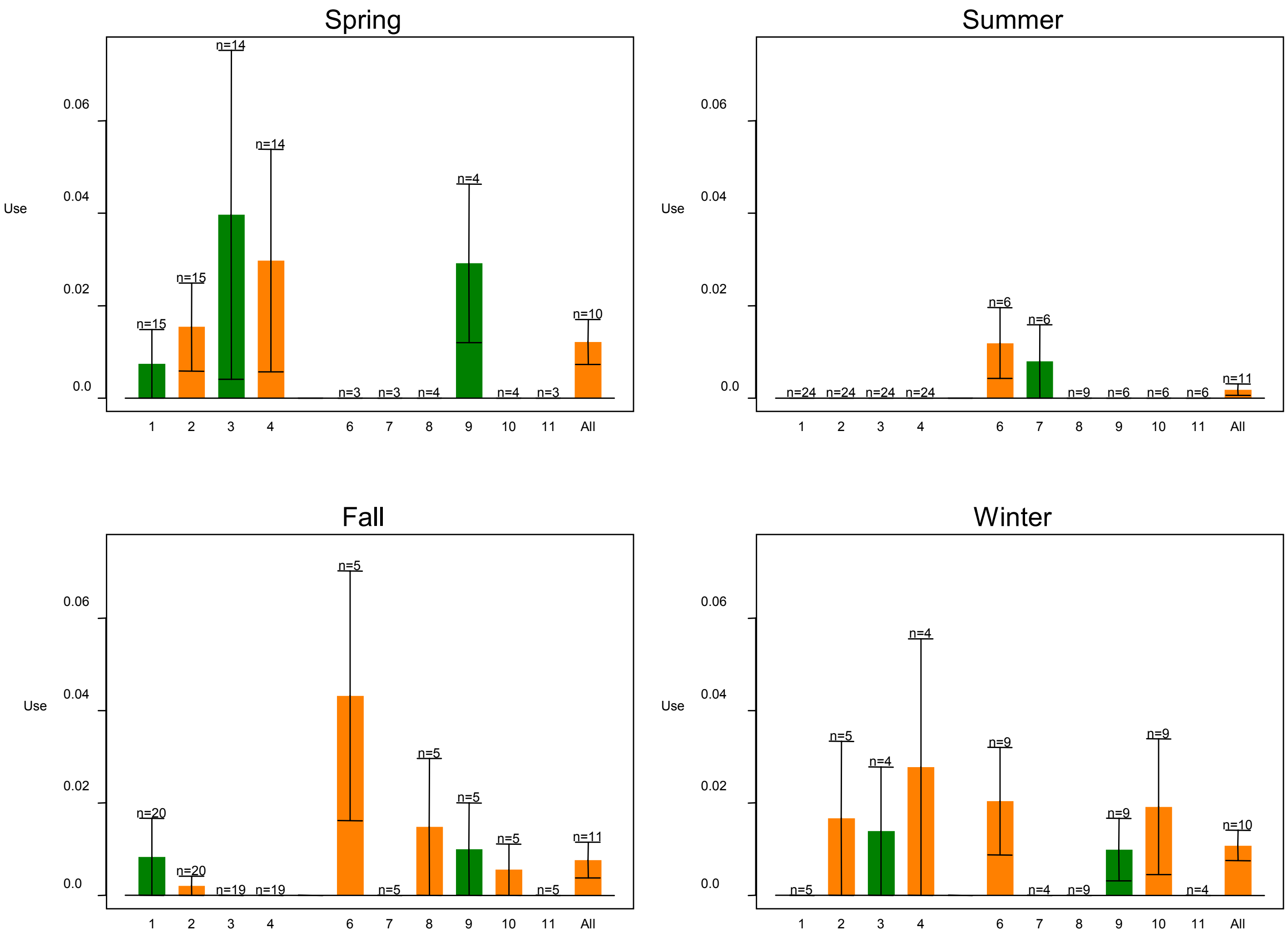


Native Landscapes

1=Cares
2=Foote Creek Rim
3=Foote Creek Rim UV
4=Morton Pass Reference
5=Simpson Ridge
6=Maiden
7=San Gorgonio PI High
8= San Gorgonio PI Medium
9= San Gorgonio PI Low
10= San Gorgonio PI Water
11= San Gorgonio PII Low
12= San Gorgonio PII Water
13=Tehachapi Pass East Slope
14= Tehachapi Pass Middle Ridge
15= Tehachapi Pass West Ridge

n=# survey periods
bars=+/- 1 standard error

Figure 5. Total buteo use (standardized to #/20-minute survey) for study areas in native landscapes.



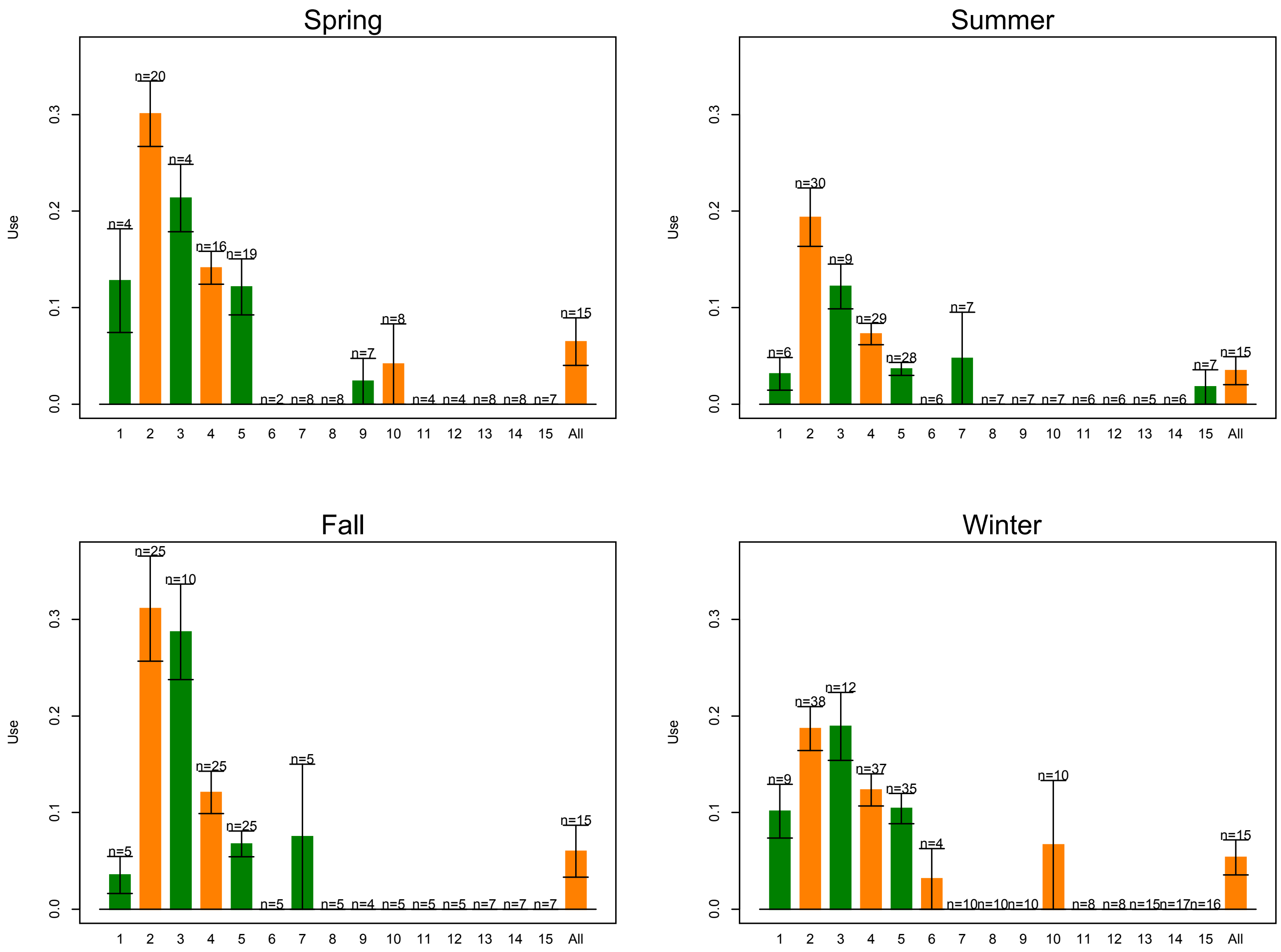
Agricultural Landscapes

1=Buffalo Ridge Phase I
2=Buffalo Ridge Phase II
3=Buffalo Ridge Phase III
4=Buffalo Ridge Reference

6=Condon
7=Klondike
8=Nine Canyon
9=Stateline/Vansycle Reference
10=Stateline/Vansycle
11=Zintel Canyon

n=# survey periods
bars=+/- 1 standard error

Figure 6. Total eagle use (standardized to #/20-minute survey) for study areas in agricultural landscapes.

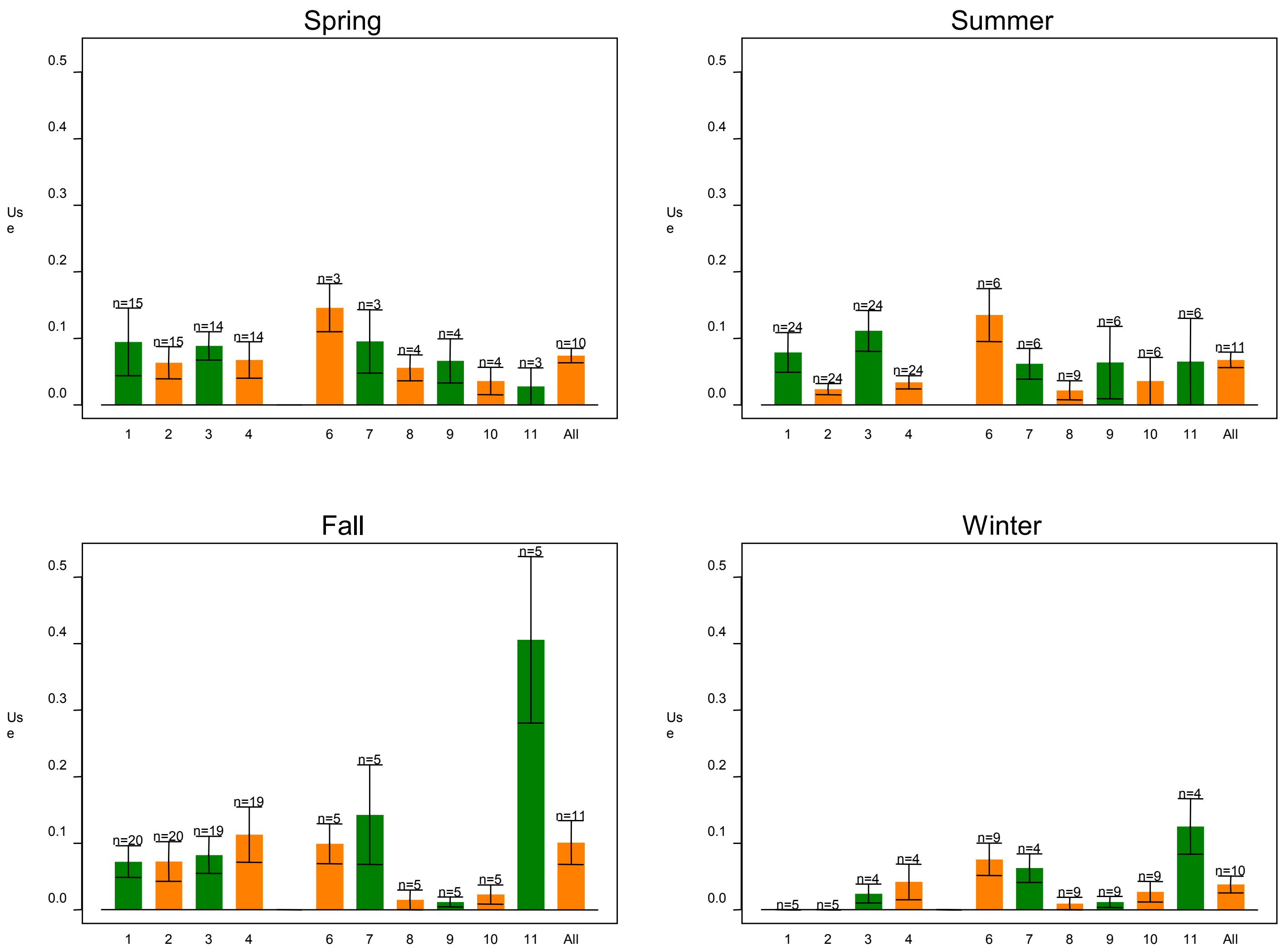


Native Landscapes

1=Cares
2=Foote Creek Rim
3=Foote Creek Rim UV
4=Morton Pass Reference
5=Simpson Ridge
6=Maiden
7=San Gorgonio PI High
8= San Gorgonio PI Medium
9= San Gorgonio PI Low
10= San Gorgonio PI Water
11= San Gorgonio PII Low
12= San Gorgonio PII Water
13=Tehachapi Pass East Slope
14= Tehachapi Pass Middle Ridge
15= Tehachapi Pass West Ridge

n=# survey periods
bars=+/- 1 standard error

Figure 7. Total eagle use (standardized to #/20-minute survey) for study areas in native landscapes.



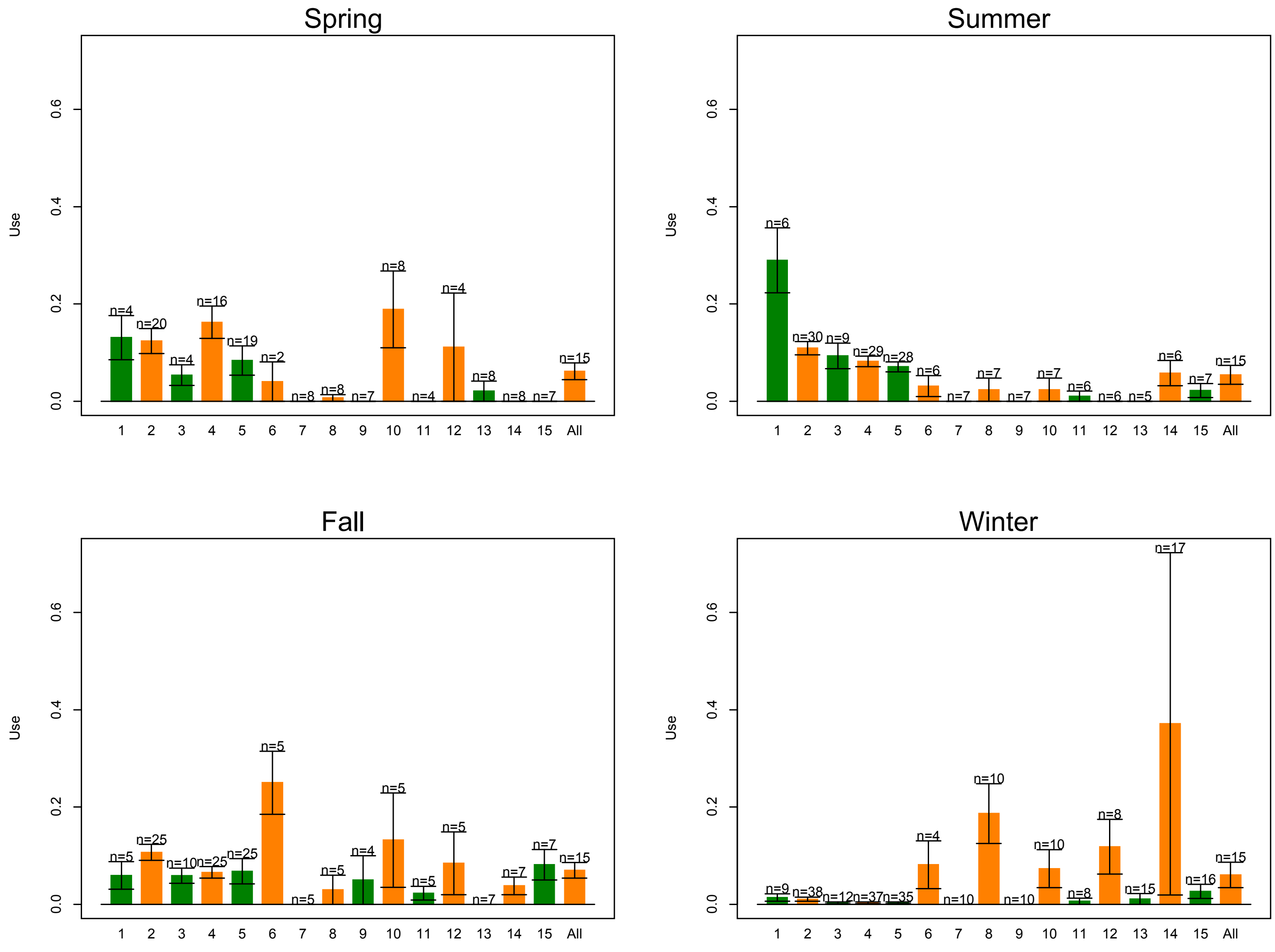
Agricultural Landscapes

1=Buffalo Ridge Phase I
2=Buffalo Ridge Phase II
3=Buffalo Ridge Phase III
4=Buffalo Ridge Reference

6=Condon
7=Klondike
8=Nine Canyon
9=Stateline/Vansycle Reference
10=Stateline/Vansycle
11=Zintel Canyon

n=# survey periods
bars=+/- 1 standard error

Figure 8. Total falcon use (standardized to #/20-minute survey) for study areas in agricultural landscapes.

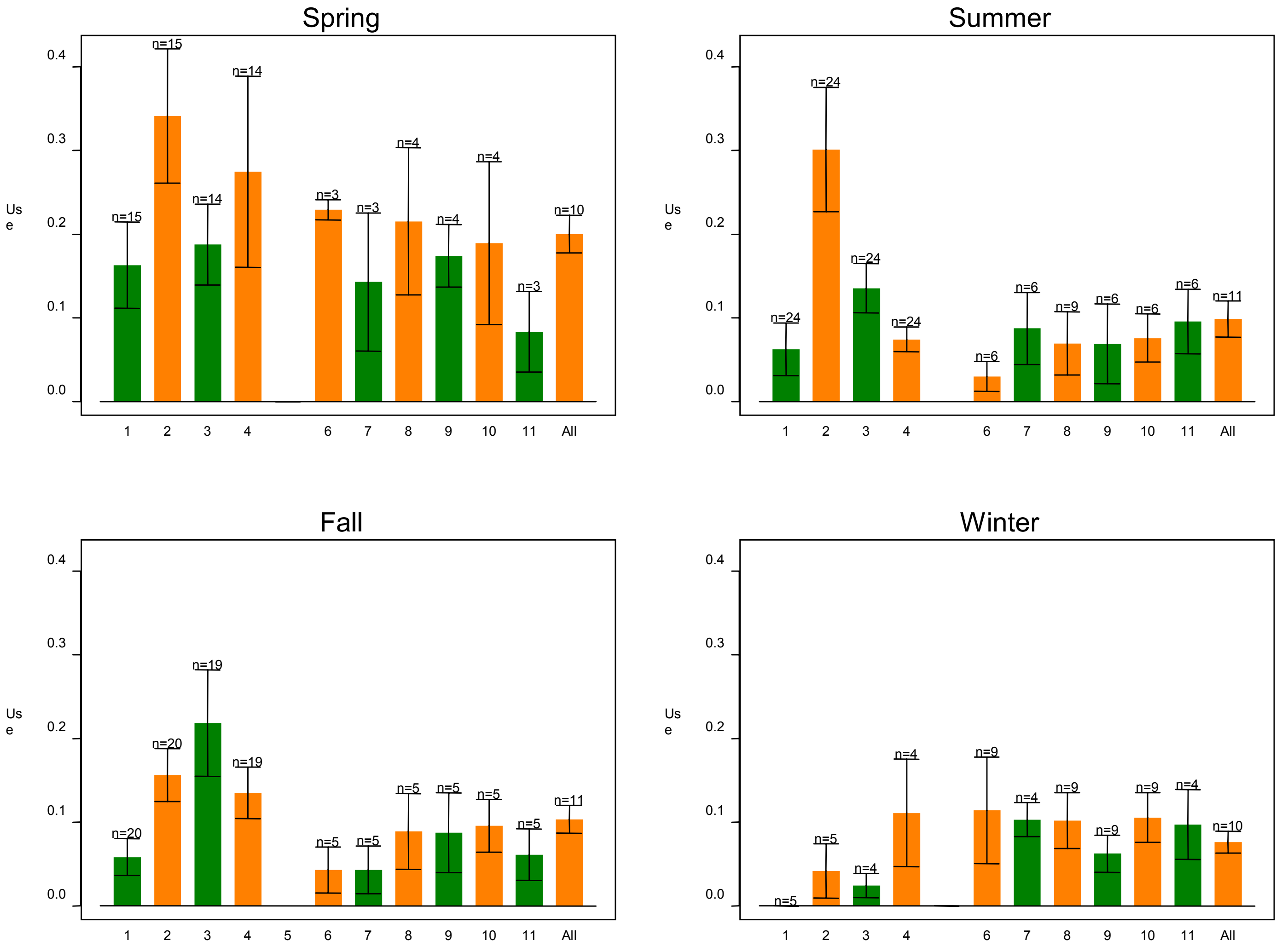


Native Landscapes

1=Cares
2=Foote Creek Rim
3=Foote Creek Rim UV
4=Morton Pass Reference
5=Simpson Ridge
6=Maiden
7=San Gorgonio PI High
8= San Gorgonio PI Medium
9= San Gorgonio PI Low
10= San Gorgonio PI Water
11= San Gorgonio PII Low
12= San Gorgonio PII Water
13=Tehachapi Pass East Slope
14= Tehachapi Pass Middle Ridge
15= Tehachapi Pass West Ridge

n=# survey periods
bars=+/- 1 standard error

Figure 9. Total falcon use (standardized to #/20-minute survey) for study areas in native landscapes.



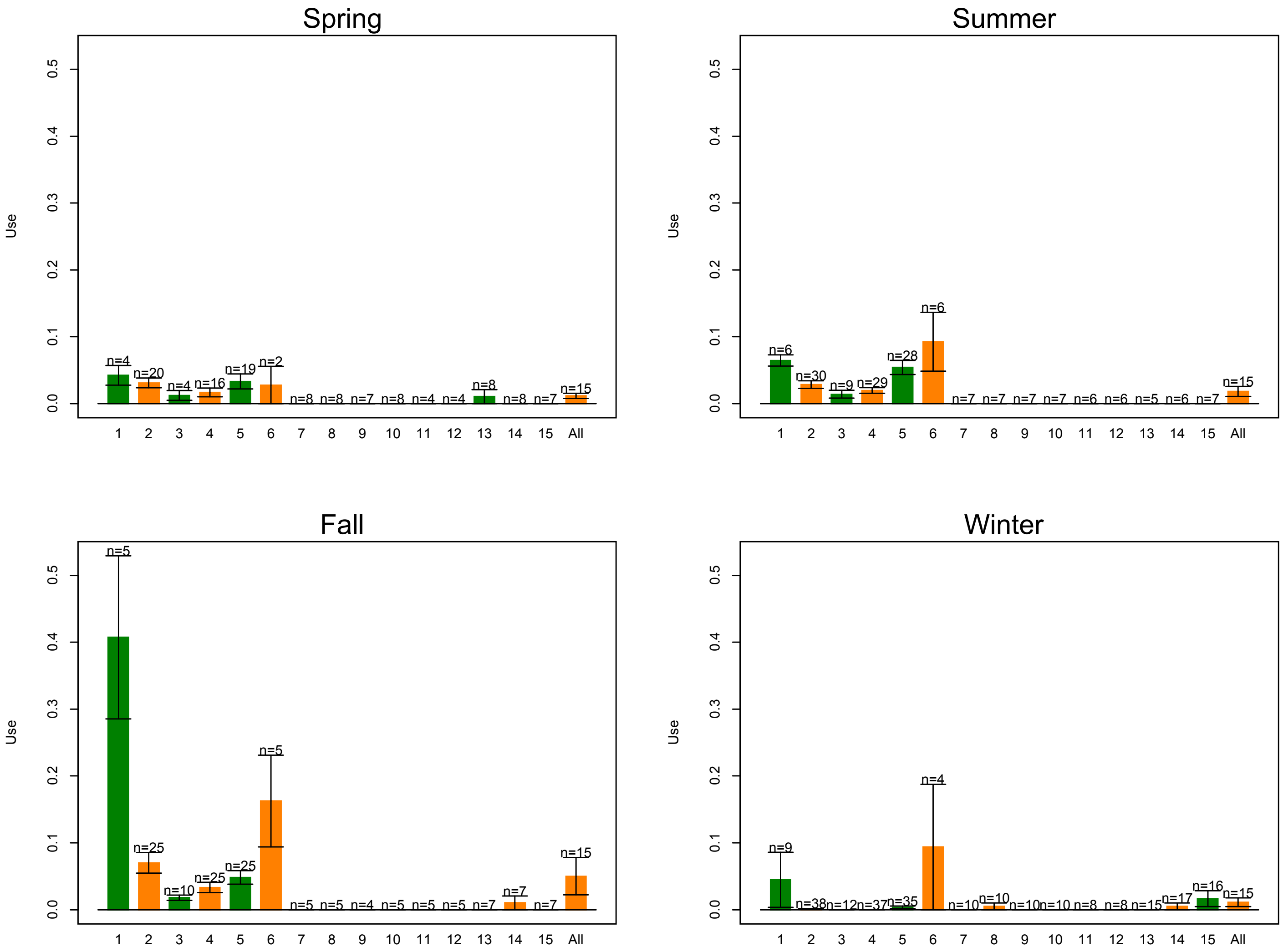
Agricultural Landscapes

1=Buffalo Ridge Phase I
2=Buffalo Ridge Phase II
3=Buffalo Ridge Phase III
4=Buffalo Ridge Reference

6=Condon
7=Klondike
8=Nine Canyon
9=Stateline/Vansycle Reference
10=Stateline/Vansycle
11=Zintel Canyon

n=# survey periods
bars=+/- 1 standard error

Figure 10. Total accipiter/northern harrier use (standardized to #/20-minute survey) for study areas in agricultural landscapes.

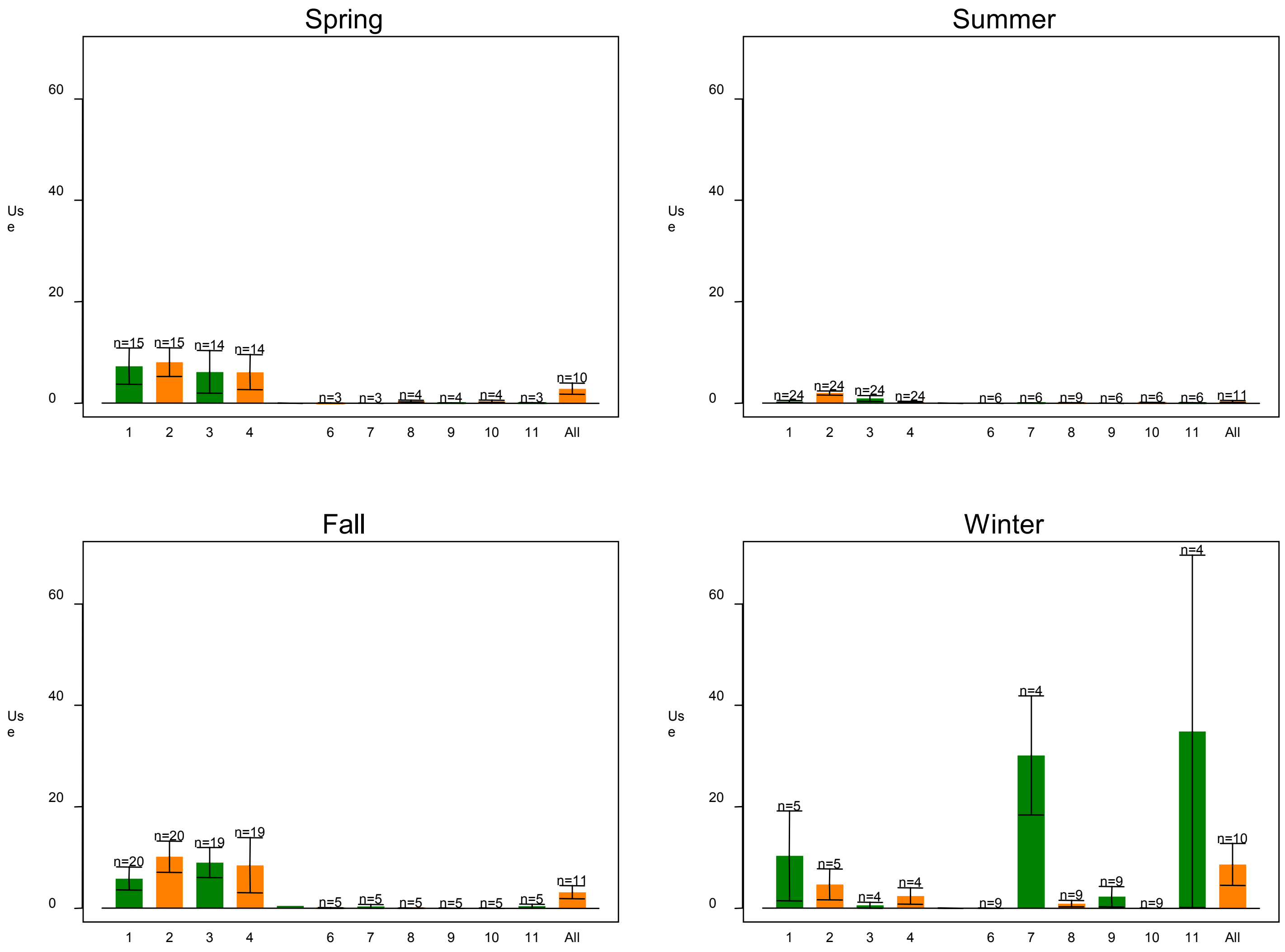


Native Landscapes

1=Cares
2=Foote Creek Rim
3=Foote Creek Rim UV
4=Morton Pass Reference
5=Simpson Ridge
6=Maiden
7=San Gorgonio PI High
8= San Gorgonio PI Medium
9= San Gorgonio PI Low
10= San Gorgonio PI Water
11= San Gorgonio PII Low
12= San Gorgonio PII Water
13=Tehachapi Pass East Slope
14= Tehachapi Pass Middle Ridge
15= Tehachapi Pass West Ridge

n=# survey periods
bars=+/- 1 standard error

Figure 11. Total accipiter/northern harrier use (standardized to #/20-minute survey) for study areas in native landscapes.



Agricultural Landscapes

1=Buffalo Ridge Phase I
2=Buffalo Ridge Phase II
3=Buffalo Ridge Phase III
4=Buffalo Ridge Reference

6=Condon
7=Klondike
8=Nine Canyon
9=Stateline/Vansycle Reference
10=Stateline/Vansycle
11=Zintel Canyon

n=# survey periods
bars=+/- 1 standard error

Figure 12. Total waterfowl use (standardized to #/20-minute survey) for study areas in agricultural landscapes.

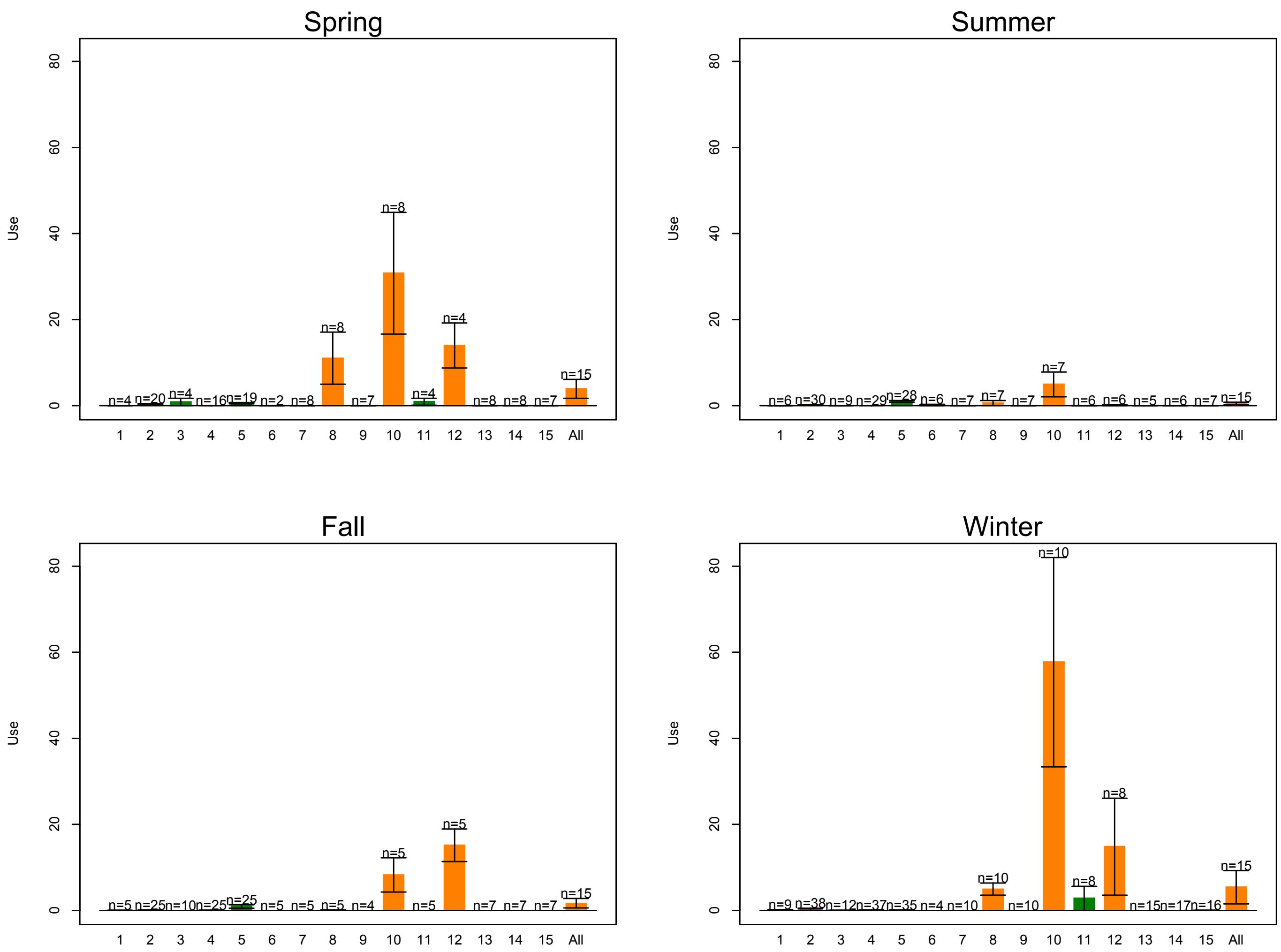


Figure 13. Total waterfowl/waterbird use (standardized to #/20-minute survey) for study areas in native landscapes.

Native Landscapes

1=Cares
2=Foote Creek Rim
3=Foote Creek Rim UV
4=Morton Pass Reference
5=Simpson Ridge
6=Maiden
7=San Gorgonio PI High
8= San Gorgonio PI Medium
9= San Gorgonio PI Low
10= San Gorgonio PI Water
11= San Gorgonio PII Low
12= San Gorgonio PII Water
13=Tehachapi Pass East Slope
14= Tehachapi Pass Middle Ridge
15= Tehachapi Pass West Ridge

n=# survey periods
bars=+/- 1 standard error