

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

**FINAL**



Foote Creek Rim, WY. photo by David Young

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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 of 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 U.S. wind plants. The primary use of the avian baseline data collected at wind developments has been to estimate the overall project impacts (e.g., very low, low, moderate, and high relative mortality) 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 from 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 (e.g., avian use data) required to adequately assess expected impacts of some projects may be reduced. 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 can be one of the most time-consuming aspects of permitting wind power projects.

For baseline data, this study focuses primarily on standardized avian use data usually collected using point count survey methodology and raptor nest survey data. In addition to avian use and raptor nest survey data, other baseline data is usually collected at a proposed project to further quantify potential impacts. These surveys often include vegetation mapping and state or federal sensitive-status wildlife and plant surveys if there is a likelihood of these species occurring in the vicinity of the project area. This report does not address these types of surveys, however, it is assumed in this document that those surveys are conducted when appropriate to help further quantify potential impacts.

The amount and extent of ecological baseline data to collect at a wind project should be determined on a case-by-case basis. The decision should use information gained from this report, recent information from new projects (e.g., Stateline OR/WA), existing project site data from agencies and other knowledgeable groups/individuals, public scoping, and results of vegetation and habitat mapping. Other factors that should also be considered include the likelihood of the presence of sensitive species at the site and expected impacts to those species, project size and project layout.

### **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<sup>1</sup> that extends the Erickson *et al.* (2001) mortality summary to include both baseline data on avian and bat use<sup>2</sup>, raptor nesting<sup>3</sup>, 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 (WRA) 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. Approximately 50% of the turbines currently in operation at Altamont Pass (CA) (approximately 3,000 out of 5,400) are Kenetech 56-100 turbines equipped on 18 m lattice towers, with rotor diameters of 18 m, down-wind blades spinning at approximately 60 revolutions per minute (rpm), with tips within 9 meters of the ground. These turbines are located in a high

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<sup>1</sup> combining or synthesizing information

<sup>2</sup> 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

<sup>3</sup> nest surveys targeting species that are efficiently surveyed from the air

density and clustered arrangement within the 60 mi<sup>2</sup> WRA. Recent studies suggest the 56-100 turbines may cause higher golden eagle mortality than other turbine types (Hunt 2002). The cause of the higher raptor mortality at Altamont is likely a combination of several factors including those listed above (turbine types and configurations), as well as raptor use of the area. 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 golden eagle fatalities per year), coupled with the large number of turbines in one area (approximately 5,400 within a 60 mile<sup>2</sup> tract), have contributed to the concerns over possible population level effects on golden eagles (Orloff and Flannery 1992, Hunt 2002).

**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 (greater than 40 m rotor diameter, with less than 30 blade 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 to 8 average Altamont Pass (CA) turbines<sup>4</sup> to make up the same rotor swept area as a single typical new generation wind turbine (600 kW – 1.5 MW per turbine). The 0.04 raptor fatalities per turbine per year for the 42-44 m rotor diameter turbines at Foote Creek Rim (WY), which is the upper range of raptor fatality rates for new generation wind projects, would equate to 3 raptor fatalities/100,000 m<sup>2</sup> rotor swept area (RSA). This estimate is approximately 3-7 times lower than at Altamont (CA; 9-22 raptor fatalities/100,000 m<sup>2</sup> RSA).

**Raptor Nesting** - There has been low raptor mortality observed at new wind projects, especially for the species that are targeted during the aerial 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 these measures. Raptors nesting closest to turbines are likely to 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

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<sup>4</sup> Assumes an average Altamont turbine is 150 kW; the Kenetech 56-100 turbine is a 100 kW machine.



inadequate to determine the level of these impacts. The golden eagle fatalities at Altamont Pass (CA) have been comprised primarily of non-breeders (subadults<sup>5</sup> and floaters<sup>6</sup>) that tend to have larger home ranges. The population of golden eagles studied by Hunt (2002) appears to be increasing even with the estimated 30 to 70 annual golden eagle fatalities from the Altamont Pass (CA) wind plant, although the population effects from sustained mortality over a longer period of time is not known. Occupancy rates of established and known golden eagle territories have been 100% in most years. 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 fatalities have been observed at this site.

**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 Geronio (CA) and Buffalo Ridge (MN)) have the highest documented waterfowl mortality, with 10 to 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 sites within native landscapes, with the exception of San Geronio, was relatively low. Waterfowl and waterbird use at the sites within agricultural landscapes, with the exception of Buffalo Ridge, was low except during winter, with some sites showing higher use during this season primarily due to occasional observations of large flocks of Canada geese.

**Passerine Mortality** – Protected passerines<sup>7</sup> have been the most common group of birds killed at new wind plants, comprising over 80% of the fatalities reported. 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 been known to occur (the largest single incident reported was 14 migrants found at two turbines during a single search). Many passerine species are represented in the fatality lists, and data do not suggest distinct patterns indicating a particular species or groups of species (e.g., flycatchers)

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<sup>5</sup> 1-3 year-olds (non-breeders)

<sup>6</sup> non-breeding adults

<sup>7</sup> “perching” birds; includes songbirds and a few other species that are protected by the Migratory Bird Treaty Act.

are more susceptible to collision. The level of nocturnal migrant mortality observed appears very low relative to nocturnal passage rates of birds at the wind plants where both mortality and nocturnal radar studies were conducted (San Geronio [CA], Buffalo Ridge [MN], and Stateline [OR/WA]).

**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 suggest 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.

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. This relationship may not exist because many of the migrant species involved may either not be echolocating, or they are flying too high for the bat detectors (Anabat®) to record, but still may be within the zone of collision risk. One of the largest estimates of bat fatalities is from the wind plant at Buffalo Ridge (MN). Preliminary data from this site collected during a five-year study suggest that the numbers of bats susceptible to turbine collisions is large, but the observed mortality is not sufficient to cause population declines of potentially affected bat species based on relatively stable fatality rates over time. However, the effect on migrant populations of sustained collision mortality over several years is not known.

**Seasonal Avian Use** - The relative abundance of raptors and other groups of birds at a site appears to be an important contributing factor to the direct impacts of a wind plant on these species. High correlations between seasonal use by a particular avian group, such as raptors, and use estimates based on four seasons combined would suggest that use 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. These use estimates, in combination with habitat and nesting information, are compared to use estimates (and habitat and nesting information) from other projects where mortality has been estimated. These comparisons have served as the basis for making predictions such as the expected annual number of wind turbine collision fatalities for a proposed wind plant.

In most cases we investigated (e.g., most raptor groups), baseline avian use data collected during one season (usually spring, summer or fall) appear adequate for making overall wind plant direct impact predictions (e.g., low, moderate or high relative mortality). Moderate to high correlations between seasonal use estimates and overall use estimates exist for most of the raptor groups considered, especially all raptors/vultures combined, buteo<sup>8</sup>, golden eagle<sup>9</sup>, northern harrier and large falcons<sup>10</sup>. Sites can be accurately ranked in terms of use by these groups/species reasonably well based on one season of data. Information regarding habitat, raptor nesting, and other factors (e.g., project size and layout) 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 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<sup>11</sup>. Using Buffalo Ridge (MN) as a basis, we estimate only approximately one buteo fatality per year for every 300 turbines.

Estimates of small falcon<sup>12</sup> use tend to vary more among seasons and study areas with weaker correlations between seasonal and overall estimates. Winter small falcon use in most areas tended to be lower than during other seasons. American kestrels have been one of the most commonly observed raptors at most wind projects, and typically are one of the most commonly

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<sup>8</sup> 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

<sup>9</sup> includes both bald and golden eagles, although golden eagles in these data sets comprise 95% of the observations

<sup>10</sup> peregrine falcon, prairie falcon

<sup>11</sup> based on available data through March 31, 2002

<sup>12</sup> American kestrel, merlin

observed raptor fatalities (Erickson *et al.* 2001).

Baseline raptor use has also been used in some cases to guide placement of turbines and facilities (“micro-siting<sup>13</sup>”) 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. Sites with high raptor use, and comprised of large tracts of high quality native habitat with 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 project sites within agricultural landscapes do not typically meet any of these criteria and are therefore not strong candidates for effective micro-siting.

## **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 suggests that the level of raptor mortality observed at Altamont Pass is quite unique (e.g., unique likely because of the number and arrangement of turbines in small area, turbine types, prey availability, raptor use) and can be avoided at other locations.
2. The amount and extent of ecological baseline data to collect at a wind project should be determined on a case-by-case basis. The decision should use information gained from this report, recent information from new projects (e.g., Stateline OR/WA), existing project site data from agencies and other knowledgeable groups/individuals, public scoping, and results of vegetation and habitat mapping. Other factors that should also be considered include the likelihood of the presence of sensitive species at the site and

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<sup>13</sup> Location or placement of turbines within a wind project

expected impacts to those species, project size and project layout.

3. In the majority of the raptor groups we investigated (all raptors combined, buteos, golden eagles, northern harriers, large falcons), 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 relative mortality). This appears to be especially true for sites in agricultural settings. Correlation analyses, in general, suggest overall use predictions for these groups based on one or two seasons of information would be similar to predictions from a four-season study. As a result, sites can be ranked in terms of overall raptor, buteo, golden eagle and large falcon use reasonably well based on one season of data collection (spring, summer or fall), compared to four seasons of data collection.
4. In cases where baseline data or other information (e.g., historic data or habitat) indicate a site has levels of raptor use considered high (regionally high, or in comparison to use at other projects considered high (e.g., Altamont Pass (CA) and Foote Creek Rim (WY) golden eagle use estimates), we recommend collecting more than one season of baseline data to refine predictions and to make micro-siting decisions that might reduce impacts. Sites with high raptor use, and comprised of large tracts of high quality native habitat with 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 project sites within agricultural landscapes do not typically meet any of these criteria and are therefore not strong candidates for effective micro-siting.
5. Raptor use (e.g., golden eagle use) may be a predictor of raptor risk (e.g., likelihood of mortality) when comparing several sites and when comparing different areas within a site. However, low raptor mortality at newer generation wind plants has resulted in low correlation between use and fatality rates at these new projects. It is possible that the new turbine designs and turbine-siting decisions made on avian use patterns have resulted in reduced avian mortality. However, this has not been experimentally tested.
6. Wind plants with year-round waterfowl use have shown the highest waterfowl mortality, although the levels of waterfowl/waterbird mortality appear very low 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 Geronio [CA]). No waterfowl mortality has been documented at the Klondike (OR) wind plant between January 1 and March 31 2002, 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.

7. 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 suggest the mortality appears very low compared to the rates of bird targets passing through the area.
8. Since few raptor species targeted during nest surveys (i.e., those visible from helicopter surveys) have been observed as fatalities at newer wind plants, correlations are very low between fatalities and overall raptor nest density (nest density 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.
9. 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 suggest that wind plants do not currently impact resident breeding bat populations where they have been studied in the U.S.
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. Bat echolocation and collision mortality studies suggest 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. This lack of relationship between activity and mortality is probably because many of the migrant species involved are either not echolocating or are flying too high for the bat detectors (Anabat®) to record but still within the zone of collision risk.

## 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 appeared to reduce 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. We are aware of only one occasion of a raptor perched on a new turbine (tubular, ungued) based on 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 in the newer wind turbines. American kestrels were observed nesting inside the nacelle of older turbines at one project in California, 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. Collisions with wires and electrocutions have been a common source of avian 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 minimize risk of raptor electrocutions 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 are presumably more visible than blades on 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 approximately 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 (often 200+ mph). Studies by Howell (1997) and Hunt (2002) 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) 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 birds that perch on the turbine. 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 2002), 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 of impacts of wind projects on wildlife and habitats, and in some cases, for micro-siting<sup>14</sup> 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.

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<sup>14</sup> Placement of turbines within a wind plant



Erickson *et al.* (2001) recently summarized the operational avian fatality data available through the middle of 2001. This report contains a “meta-analysis<sup>15</sup>” 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. Renewal of this tax credit is somewhat uncertain and financial backing of a project can be affected by this uncertainty.

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

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<sup>15</sup> The combining or synthesis of information

## **METHODS**

We included primarily standardized avian and bat mortality and use data that was collected using approximately the same methods at many proposed and existing wind projects. The avian use data we included consisted of diurnal point count observations that typically targeted large birds such as raptors, waterfowl and corvids (i.e. common raven). At some projects, additional species-specific data may have been collected that targeted a particular sensitive species. For example, mountain plover surveys were conducted on Foote Creek Rim prior to and following construction. Winter bald eagle surveys have been conducted at some projects where this species was present at levels of concern. This meta-analysis does not attempt to synthesize these species/project specific data sets, although we acknowledge that often these targeted surveys are required.

### **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. Most of the fatality data has been collected in the western and midwestern U.S., with some fatality data collected at a few small projects in the east.

### **Avian Use**

A total of 27 different avian use data sets from 13 WRA's were used in this meta-analysis (Tables 1 and 2). Several WRA's had multiple study areas. For example, two reference areas (Morton Pass [WY] and Simpson Ridge [WY]) 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 WRA, 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 into two general landscape scale classes: cultivated agriculture, 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.

Pearson correlations were used to evaluate relationships between:

- spring, summer, fall and winter study area use estimates (i.e., correlations among seasonal use of the study areas);
- 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);

- 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 pattern would suggest 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., hawks, eagles, great horned owl nests in trees) 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**

We summarized the data on bat use and mortality at wind plants, and also provided a literature review of behavior and other characteristics of the bats typically observed as wind turbine fatalities. Some data on bat use and/or mortality have been intentionally collected at nine WRA's 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 fatalities. 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 taken place at the Stateline (OR/WA) wind plant 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 WRA's 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, golden eagles, large falcons, small falcons, northern harriers, accipiters, 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), 12% were owls. (Table 5). Non-protected birds including house sparrows, European starlings, and rock doves comprised 15% of the fatalities. Waterfowl, waterbirds, shorebirds and gamebirds cumulatively comprised less than 5% 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). No other group (e.g., raptors, waterfowl) comprised more than 5% 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 in the U.S. 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. We are also not aware of any raptor fatality incident where several raptors were killed at one time during migration.

To the best of our knowledge, reference or background mortality has been estimated only once during baseline studies of new 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 per year, compared to 0.98, 2.27 and 4.45 fatalities per turbine search plot per year 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 1-15<sup>th</sup>), 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 baseline data that are collected. The ability to micro-site turbines to reduce mortality is improved as more data are collected, although distinct use 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 with 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 project sites within agricultural landscapes 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)<sup>16</sup>, the Stateline Reference Area (OR), Foote Creek Rim (WY) and the Middle Ridge of the Tehachapi Pass (CA) WRA 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 located within 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 (Table 8). 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 use predictions relative to other sites typically would not vary when using less than one year of data.

## **Agricultural Landscapes**

Within agricultural landscapes, average total raptor/vulture seasonal use estimates (averages across the study areas) were highest in the spring (0.598), followed by fall (0.525), summer (0.413), and winter (0.385), suggesting low variability among average seasonal estimates. Average use for individual study areas ranged from 0.258 to 0.602 raptors/20-minute survey, suggesting relatively low variability in four-season use estimates 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

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<sup>16</sup> we used average winter use from the CARES project for Columbia Hills, since no standardized winter use data were collected



assemblages during the winter are typically different from the other seasons. Winter use is often influenced more by northern harriers and rough-legged hawks, whereas use during the other seasons is influenced more by red-tailed hawks, Swainson's hawks, American kestrels, and some other species depending on the 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 fatality was one red-tailed hawk found during a 4-year study at the Buffalo Ridge (MN) wind plant (Johnson *et al.* 2000b) based on studies conducted prior to March 31, 2002.

### **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 Geronio 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 (2000 pers. comm.) providing an estimate of 0.10 fatalities per turbine. Raptor mortality estimates from

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during the study.

Montezuma Hills (CA) also averaged 0.048 fatalities per turbine. These estimates are higher than those reported for Foote Creek Rim (WY), the only new wind plant where more than one raptor fatality has been documented (based on studies conducted prior to March 31, 2002). It would take approximately 3 to 8 average Altamont Pass (CA) turbines<sup>17</sup> to equal the rotor swept area of a single typical new generation wind turbine (600 kW – 1.5 MW per turbine). The 0.04 raptor fatalities per turbine per year for the 42-44 m rotor diameter turbines at Foote Creek Rim (WY), which is the upper range of raptor fatality rates for new generation wind projects, would equate to 3 raptor fatalities/100,000 m<sup>2</sup> rotor swept area (RSA). This estimate is approximately 3-7 times lower than at Altamont (CA; 9-22 raptor fatalities/100,000 m<sup>2</sup> RSA). 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 (WY) wind plant based on searches conducted from May through December 31, 2001 (Garrett 2002, pers. comm.). 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.

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 Geronio (CA) wind plant, and raptor use at this site is very low (Anderson *et al.* 2000).

### **Summary/Impact Prediction**

Projecting overall impacts to raptors as a group such as the estimated number of raptor fatalities per year is typically based on several factors, including habitat, raptor nesting, raptor use, project size and project layout. Based on the correlation analyses provided above for raptor use, and assuming habitat and raptor nesting surveys are conducted, overall impact prediction for all raptors combined would typically be similar after collection of one season of raptor use data

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<sup>17</sup> Assumes an average Altamont turbine is 150 kW; the Kenetech 56-100 turbine is a 100 kW machine.

compared to a full year of data collection. This appears to especially be the case in agricultural landscape settings, where use estimates do not vary much among seasons, micro-siting based on patterns of raptor use is not likely feasible, and mortality data at new wind projects indicate absent to very low raptor mortality. We recommend more than one season of data if a site appears to have relatively high raptor use, especially if micro-siting is practical. Other factors such as project size should also be considered in determining the baseline data requirements.

### **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 use predictions based on one or two seasons of information would be similar to predictions from a four-season study.

### **Agricultural Landscapes**

For study areas within agricultural landscapes, buteo use averaged across all study areas was very similar among seasons (0.2 to 0.3/20-min survey, Table 9, Figure 4), although this pattern was not consistent within study areas. Buteo use was highest in the fall at the Buffalo Ridge (MN) WRA, 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) based on studies through March 31, 2002.

### **Native Landscapes**

Average use across study areas by buteos was also fairly similar among seasons classified primarily as native habitat, where use ranged from 0.107 to 0.167 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<sup>18</sup> (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 (WY), with the 3<sup>rd</sup> 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 larger turbines.

### **Summary/Impact Prediction**

Very little buteo mortality has been documented at new wind plants outside California, even at sites that appear to have moderate to high buteo use compared to Altamont Pass (e.g., Foote Creek Rim [WY]). Based on the correlation analyses provided above for buteo use, and assuming habitat and raptor nesting surveys are conducted, overall impact prediction for buteos would typically be similar after one season of data collection compared to a full year of raptor use data. This appears to especially be the case in agricultural landscape settings, where use estimates do not vary much among seasons, micro-siting based on patterns of raptor use is not likely feasible, and mortality data at new wind projects indicate absent to very low raptor

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<sup>18</sup> there are currently no turbines built at this site

mortality. We recommend more than one season of data if a site appears to have relatively high buteo use, especially if micro-siting is practical.

### **Golden Eagles**

We include 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 golden 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 golden 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 golden eagle use in one season is indicative of golden eagle use in other seasons and for the entire year (Table 12).

### **Agricultural Landscapes**

In general, golden eagle use was low on the sites in the agricultural settings, although all but the Zintel Canyon site (WA) had some documented eagle use during the studies (Table 11, Figure 6). Average golden eagle use was lowest in the summer, likely due to the lack of nesting habitat and prey for golden eagles in these landscapes. Average golden 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 golden 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; 0.333/20-min survey) and Foote Creek Rim (WY; 0.234/20-min survey), followed by the other studies/study areas associated with Foote Creek Rim (WY; Simpson Ridge, Morton Pass Reference Area)<sup>19</sup>. Average use for all of these study areas ranged from 0 to 0.334/20-minute survey.

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<sup>19</sup> it is unclear what the effective viewshed was at Altamont. Points were ½ mile apart to avoid overlap

No bald eagle mortality has been reported at any wind plant in the U.S. (Erickson *et al.* 2001), although none of the projects studied were located near large concentrations of bald eagles. 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 1 to 2 golden eagle fatalities per year for approximately every 100,000 m<sup>2</sup> RSA<sup>20</sup>. The turbines at Foote Creek Rim have a rotor swept area approximately 5 times larger than the average rotor swept area of turbines at Altamont. 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, 0.3 golden eagle fatalities/100,000 m<sup>2</sup> RSA), or approximately 3-7 times lower than at Altamont (CA). The golden eagle fatality rate at Foote Creek Rim is the highest estimate reported for new generation wind projects, and golden eagle use of Foote Creek Rim is apparently similar to golden eagle use at Altamont. This result suggests there may be a difference in risk to eagles based differences in turbine characteristics (size, type, blade rpm's, proximity of blade to ground), which has also been suggested by Hunt (2002), although there are other factors as well that likely contribute to these differences (micro-siting, prey availability, project size). One golden eagle fatality has been reported at both San Geronio (CA) and Tehachapi Pass (CA), where golden eagle use is much lower than Altamont Pass (CA) and Foote Creek Rim (WY). 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 principal prey of many of the raptor species at the site (Hunt 2002). 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), although the population effects from sustained mortality over a longer period of time is not known. Most of the fatalities are sub-adults (1 to 3 year-olds) and

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<sup>20</sup> assumes average size turbine is 200 kW

“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). Occupancy rates of known golden eagle territories have been 100% 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.

### **Summary/Impact Prediction**

Foote Creek Rim (WY) is the only wind plant outside California with any golden eagle mortality, with estimates of 1 golden eagle fatality per year for every 200 turbines, or 0.3 golden eagle fatalities per 100,000 m<sup>2</sup> RSA. Foote Creek Rim (WY) golden eagle use is estimated to be fairly similar to Altamont (CA), and golden eagle use at Altamont (CA) is estimated to be higher than at any other wind plant studied in the U.S.

Based on the correlation analyses provided above for golden eagle use, and assuming habitat and raptor nesting surveys are conducted, overall impact prediction for golden eagles would typically be similar after one season of data collection compared to a full year of data collection. This appears to especially be the case in agricultural landscape settings, where use estimates of golden eagles are very low in all seasons. We recommend more than one season of data if a site appears to have relatively high golden eagle use, and other factors exist on the site that might enhance the ability to effectively micro-site turbines using baseline data (e.g., factors such as high topographic relief, active raptor nests and nest habitat, prey availability). Patterns observed at other projects include flight patterns parallel to the upwind side of ridges (Johnson *et al.* 2001, Erickson *et al.* 1999).

Some observations of bald eagles were included in this grouping, although these observations comprised less than 5% of the total number of observations. If bald eagles winter in concentrations near proposed projects, we would typically recommend specific surveys to document their use of the project during that season.

## **Large Falcons**

This group consists primarily of prairie falcons, with rare observations of peregrine falcons; large falcons comprise a very small proportion of the raptor use of these study areas. The study area with the highest standardized estimated large falcon use is the Morton's Pass Reference (WY; 0.032/20-min survey), followed by Phase II San Gorgonio Water Area (CA; 0.029), Maiden (WA; 0.029) and Foote Creek Rim (WY; 0.024) (Table 13). Correlations between spring, summer and fall seasonal use estimates for large falcons were moderate to high (0.44 to 0.79). Correlations of use estimates in winter compared to the other seasons were low (-0.06 to 0.44). Correlations of any one season to overall large falcon use were moderate to high (0.58 to 0.89).

## **Agricultural Landscapes**

Average large falcon use of the study areas in agricultural settings (0.004/survey) was more than three times lower than average use in native landscapes (0.014/survey) (Table 13, Figure 8). Based on averages within a season but across study areas, mean use was lowest in the summer (0.001/survey) and spring (0.002/survey), and highest in the winter (0.007/survey) and fall (0.005). All 10 study areas had estimated overall large falcon use less than 0.014/survey, which was the average for study areas in native landscapes. No large falcon mortality has been reported at any of the agricultural wind plants (Erickson *et al.* 2001).

## **Native Landscapes**

Based on averages within a season but across study areas, large falcon use was highest in the fall (0.020) and summer (0.016), and lowest in the spring (0.010) and winter (0.009). Mortality of large falcons has been low at U.S. wind plants (Erickson *et al.* 2001), with two prairie falcon fatalities documented at Altamont Pass (CA) and one prairie falcon documented at Tehachapi Pass (CA) and Foote Creek Rim (WY). No peregrine falcon mortality has been documented at any U.S. wind plant (Erickson *et al.* 2001), while some peregrine use has been documented at Altamont Pass (CA), Tehachapi Pass (CA), San Gorgonio (CA) and Foote Creek Rim (WY).

## **Summary/Impact Prediction**

Large falcon use was generally very low on the study areas compared to other raptor groups/species. Foote Creek Rim (WY) is the only windplant outside California with any large



mortality of large falcons, with estimates of approximately 1 prairie falcon fatality per year for every 200 turbines, or 0.3 prairie falcons per 100,000 m<sup>2</sup> RSA. Foote Creek Rim (WY; including the other associated study areas like the Morton Pass Reference [WY]) had high large falcon use relative to the other study areas considered. Overall impact prediction for large falcons would typically be similar after one season of avian use data collection compared to a full year of data collection primarily for the following three reasons: 1) compared to other raptor groups, large falcons comprise a small proportion of the avian use at all the sites considered, 2) the correlation analyses indicate moderate to high correlations of estimates of overall use with estimates of seasonal use, and 3) habitat mapping and raptor nesting surveys should provide information on presence of large falcons in the study area.

### **Small Falcons**

This group consists primarily of American kestrels, with rare observations of merlins. The study area with the highest standardized estimated small falcon use was Columbia Hills (WA; 0.192/survey), followed by Tehachapi Pass (CA; 0.162), Zintel Canyon (WA; 0.140) and Condon (WY; 0.104) (Table 15). Small falcon use between seasons was highly variable. The only significant positive correlation was that between spring and summer use (0.62); the other season correlations ranged from -0.20 to 0.22 (Table 16). These correlations indicate that while spring and summer use data are similar to each other, they cannot be used to predict small 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 (0.48 to 0.69). The low correlations between seasons likely reflect range and behavior of the species in this group. American kestrels, which make up most of the use in this group, often breed locally in spring and summer but then migrate in the fall and are either absent or occur at very low densities during the winter (except for in some CA study areas).

## **Agricultural Landscapes**

The mean small falcon use of the study areas in agricultural settings (0.059/survey) was similar to average use in native landscapes (0.058/survey) (Table 13, Figure 8). Mean falcon use was lowest in the winter (0.030/survey), highest in the fall (0.099/survey) and similar in the spring (0.072) and summer (0.061). Of the 10 study areas in agricultural landscapes, falcon use was highest at Zintel Canyon (WA; 0.140/survey) and Condon (OR; 0.104/survey); use at the other 8 areas was <0.08/survey. No falcon mortality has been reported at any of the agricultural wind plants (Erickson *et al.* 2001).

## **Native Landscapes**

Extensive variability existed in small 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 15, Figure 9). Falcon use was highest at the Columbia Hills<sup>21</sup> (WA; 0.192/survey) followed by the Middle Ridge of Tehachapi Pass (CA; 0.162), CARES<sup>22</sup> (WA; 0.100/survey) and Altamont Pass (CA; 0.089/survey). Average small falcon use calculated across study areas was fairly similar among seasons (0.046 – 0.072). Mortality of small falcons has been high at Altamont Pass (CA), where 49 American kestrel fatalities were documented (Erickson *et al.* 2001). Tehachapi Pass (CA) has the second highest number of falcon fatalities (11 American kestrels) documented. Three American kestrels have been documented at Foote Creek Rim (WY; Young *et al.* 2001, Young *et al.* 2002) based on over three year's of study.

## **Summary/Impact Prediction**

Small falcon use consisted primarily of American kestrels. American kestrels were listed as one of the four raptor species with the highest use at every study area considered except for the Stateline/Vansycle Reference area, where it had the fifth highest raptor use estimate. The American kestrel is also one of the most common raptor species observed as fatalities at U.S. wind plants. American kestrels were the most frequently observed raptor fatality at Altamont Pass (CA), Tehachapi Pass (CA), San Geronio (CA) and Foote Creek Rim (WY), although no

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<sup>21</sup> there are currently no turbines built at this site

American kestrel fatalities have been observed at other new U.S. wind plants. Very high variability existed in seasonal use estimates within certain study areas. Impact predictions for this common raptor species would likely be the most variable compared to impact predictions for other raptor species, due to the high seasonal use variability and likely high year-to-year variability.

### **Northern Harriers**

The study area with the highest estimated use by northern harriers is the Buffalo Ridge (MN) Phase II site where use was 0.163/survey. Other areas with relatively high use by this species were the Buffalo Ridge Reference Area (0.116/survey), Nine Canyon (0.110/survey) the Buffalo Ridge Phase 3 site (0.107 survey) and Stateline/Vansycle (0.110/survey) (Table 17). Rankings of use as the number of seasons was varied were fairly similar for all study areas. Moderately high correlations ( $>0.6$ ) occurred between spring-summer (0.71) and spring-winter (0.65), with lower positive correlations between spring-fall (0.49), summer-winter (0.42) and fall-winter (0.43) use (Table 18). Correlations between use in any one season and overall use were all high ( $>0.75$ ). 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 northern harrier use with one or two seasons of data.

### **Agricultural Landscapes**

Northern harrier use of the study areas in agricultural settings (0.099/survey) was greater than 5 times that of native landscapes (0.019/survey) (Table 17, Figure 10). Mean use averaged across the study areas was much higher in the spring (0.187/survey) than the other 3 seasons, when use ranged from 0.069-0.099/survey. Of the 10 study areas in agricultural landscapes, northern harrier use was highest at the Buffalo Ridge Phase II (MN) site. No mortality of northern harriers has been reported at any of the agricultural wind plants (Erickson *et al.* 2001).

### **Native Landscapes**

Use of native landscapes by northern harriers was very low. The highest use occurred at Maiden site (WA; 0.089), followed by the CARES (WA; 0.084) and Columbia Hills (WA; 0.062) sites (Table 17, Figure 11). Based on averages across study areas, northern harrier use was lowest in

the winter (0.011) and spring (0.013), and highest in the fall (0.036). Northern harrier mortality has been very low at U.S. wind plants, with two reported at Altamont Pass (CA) and one reported at Foote Creek Rim (WY; Erickson *et al.* 2001).

### **Summary/Impact Prediction**

Very little northern harrier mortality has been documented at U.S. wind plants, even at sites that appear to have relatively high northern harrier use (e.g., Buffalo Ridge). Based on the correlation analyses provided above for northern harriers and the low mortality observed of this relatively common species, overall impact prediction for northern harriers would typically be similar after one season of data collection compared to a full year of data collection. Collision risk for northern harriers would appear to be higher at most sites in agricultural landscapes due to a typical pattern of higher use at those sites compared to use in native landscapes.

### **Accipiters**

Accipiter use in general comprised a very small proportion of the raptor use on the study areas considered (Table 19). The Columbia Hills (WA) and CARES (WA) sites had the highest estimated accipiter use (0.060 and 0.041/survey respectively), followed by all four of the Buffalo Ridge (MN) sites. Correlations among spring and summer use estimates was moderate (0.68), with low correlations among the other seasons use estimates (-0.14 to 0.38). Spring, summer and fall use estimates correlated reasonably well with overall use (>0.70), but winter did not (0.21). The low correlation in winter is due to the very low abundance of accipiters during this season. The correlation of overall ranks and ranks based on data from spring only or spring-summer only was moderate (>0.60) and high with spring-fall only (0.94).

### **Agricultural Landscapes**

Accipiter use at study areas in agricultural landscapes was very low, with occasional observations made primarily during fall and spring migration (Table 19, Figure 14). The highest accipiter use occurred at the Buffalo Ridge (MN) sites, although no accipiter mortality has been documented based on five years of monitoring (Erickson *et al.* 2001).

## **Native Landscapes**

Accipiter use at study areas in native landscapes was low, with the highest estimated use occurring within the fall migration period (Table 19, Figure 15). No accipiter mortality has been documented at any of the U.S. wind plants located in native landscapes (Erickson *et al.* 2001).

## **Summary/Impact Prediction**

No accipiter mortality has been documented at U.S. wind plants (Erickson *et al.* 2001). Accipiter use at all these sites comprises a very small proportion of the total raptor use. Overall impacts for accipiters can be expected to be very low at most new wind projects.

## **Waterfowl/Waterbirds**

Waterfowl and waterbird use is highly variable among study sites, primarily due to the larger flock sizes (Table 21). A few large flocks can greatly influence the magnitude of use estimates. The San Geronio (CA) 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 (4.510/20-minute survey) than in native settings (3.123), although this difference would be much larger except for the high waterfowl/waterbird use near the water area at San Geronio (CA; Table 21, Figure 16). Mean

use was highest in the winter (8.611), 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 project area.

### **Native Landscapes**

Waterfowl/waterbird use is low at most sites within this category, except for the areas near the recharge ponds at San Geronio (Table 21, Figure 17). Waterfowl/waterbirds comprise 26% of the total observed mortality at San Geronio (10 of 42 total fatalities); otherwise very few waterfowl/waterbird fatalities have been recorded at existing wind plants (Table 5).

### **Summary/Impact Prediction**

Waterfowl and waterbird mortality has occurred at several wind projects, but apparently in very low numbers relative to the waterfowl/waterbird use of those sites. Correlations of seasonal use to overall use were moderate. At many of the Pacific Northwest sites in agricultural settings, most waterfowl use (especially Canada geese) occurred during the winter. If impacts to waterfowl are considered important at these sites, then surveys should be concentrated during the winter.

## Passerines

The magnitude of passerine<sup>22</sup> and other avian 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 of which are passerines), it is estimated that at the current level of development, wind turbines constitute 0.01 to 0.02% (1 to 2 out of every 10,000) of the avian collision fatalities (Figure 18). Communication tower fatality estimates make up 1 to 2% (1 to 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% of the collision fatalities. The low range estimate of 60 million vehicle collision fatalities comprises 15 to 30% of the total estimated collision fatalities. Powerline collisions are also likely a significant source of collision mortality.

Protected passerines (excludes house sparrows, European starlings and rock doves) have been the most common group of birds killed at wind plants outside California, 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 21 different species were observed at Buffalo Ridge (MN) during the 4-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 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, 2001 documented 10 passerines representing 5 species during standardized carcass searches (Table 5). Horned lark was the most abundant

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<sup>22</sup> “perching” birds; primarily songbirds

casualty found (3), followed by golden-crowned kinglet (2). Horned lark was also the most abundant passerine species based on point count surveys (URS Corporation and WEST 2001).

Nocturnal migrants are estimated to comprise approximately 50% of the fatalities at new wind projects (estimated range 34 to 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 (MN; 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 U.S. wind plant.

Researchers estimated 6,800 birds were killed annually at the San Geronio (CA) 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 (OR/WA) and Vansycle wind plants (OR; Mabee and Cooper 2002) indicate moderate passage rates compared to other studies, with approximately 90% of the radar targets (flocks of birds) estimated flying above the turbine blades. Low passerine mortality was observed at the Vansycle Ridge (OR) wind plant in 1999 (Erickson *et al.* 2000), and at the Stateline wind plant between mid-July 2001 and March 31, 2002 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 very low.

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 currently 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 wind plants.

We are unaware of any studies that directly compare communication tower mortality to wind turbine mortality; although, there is limited information on guyed meteorological (met) tower mortality compared with wind turbine mortality at Foote Creek Rim (WY; Young *et al.* 2001). At this site, searches were conducted 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). Estimates of total bird mortality have ranged between 0 to 3 birds per turbine per year at new wind projects in the U.S. (Figure 19).

### **Other Species/Bird Groups**

We did not present results for certain large bird species/groups due to the relatively low abundance observed at most sites (e.g., shorebirds), or because mortality data indicate the species/group is not very susceptible to collision. For example, common ravens are common at many of the study areas considered, but mortality data included in our analysis suggest these species that primarily forage by scavenging, do not appear very susceptible to collision (Erickson *et al.* 2001, Orloff and Flannery 1992). Bald eagles were combined with golden eagles although they make up very few of the observations, and have very different foraging behaviors than golden eagles. If bald eagles winter in concentrations near projects, we would recommend some site-specific surveys that target this federally threatened species.

### **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 23 and 24. We did not find

comparable data for the other WRA's, especially the older California WRA's. Raptor nest surveys at wind projects 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 one active raptor nest within 2 miles of the project area. There was 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 one-half 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, Young pers. comm. 2002). Hunt (2002) studied the golden eagle population near the Altamont Pass (CA) WRA from 1994-1997. Golden eagle nest density within 2 miles of the WRA is one active nest per 11.3 miles<sup>2</sup>. 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 (TV) 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

( $\leq 5$ ) 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 phases at Buffalo Ridge wind plant combined average 613 per year (Table 25). 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. 2002a) 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 Ruge 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 26). Nearly 90% of all bat fatalities occurred from mid-July through mid-September. Over 50% of the fatalities occurred in August. Most of the fatalities were comprised of migratory tree bats. A total of 616 carcasses were identified to species. The hoary bat was by far the most prominent species, comprising 61.7% of all fatalities (Table 27). 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. Red bats are solitary tree bats (Carter 1950, Izor 1979, Shump and Shump 1982b, Kunz 1982, Barclay *et al.* 1988). Historically, silver-haired bats were believed to roost alone under loose bark, but more recent studies have documented maternal colonies of silver-haired bats (e.g., Betts (1996)). 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 28). 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, which is 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 1 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) Phase III site, however, 42 (48%) of the 87 bat fatalities were found at lighted turbines and 45 (52%) were found at unlit turbines, and approximately half of the turbines sampled were lighted, 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 26). 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 Anabat® 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 Anabat® 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 Anabat® 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 Anabat® 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 Anabat® 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 Anabat® 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 wind power-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 suggests that the level of raptor mortality observed at Altamont Pass is quite unique (e.g., unique likely because of the number and arrangement of turbines in small area, turbine types, prey availability, raptor use) and can be avoided at other locations.
2. The amount and extent of ecological baseline data to collect at a wind project should be determined on a case-by-case basis. The decision should use information gained from this report, recent information from new projects (e.g., Stateline OR/WA), existing project site data from agencies and other knowledgeable groups/individuals, public scoping, and results of vegetation and habitat mapping. Other factors that should also be considered include the likelihood of the presence of sensitive species at the site and

expected impacts to those species, project size and project layout.

3. In the majority of the raptor groups we investigated (all raptors combined, buteos, golden eagles, northern harriers, large falcons), 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 relative mortality). This appears to be especially true for sites in agricultural settings. Correlation analyses, in general, suggest overall use predictions for these groups based on one or two seasons of information would be similar to predictions from a four-season study. As a result, sites can be ranked in terms of overall raptor, buteo, golden eagle and large falcon use reasonably well based on one season of data collection (spring, summer or fall), compared to four seasons of data collection.
4. In cases where baseline data or other information (e.g., historic data or habitat) indicate a site has levels of raptor use considered high (regionally high, or in comparison to use at other projects considered high (e.g., Altamont Pass (CA) and Foote Creek Rim (WY) golden eagle use estimates), we recommend collecting more than one season of baseline data to refine predictions and to make micro-siting decisions that might reduce impacts. Sites with high raptor use, and comprised of large tracts of high quality native habitat with 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 project sites within agricultural landscapes do not typically meet any of these criteria and are therefore not strong candidates for effective micro-siting.
5. Raptor use (e.g., golden eagle use) may be a predictor of raptor risk (e.g., likelihood of mortality) when comparing several sites and when comparing different areas within a site. However, low raptor mortality at newer generation wind plants has resulted in low correlation between use and fatality rates at these new projects. It is possible that the new turbine designs and turbine-siting decisions made on avian use patterns have resulted in reduced avian mortality. However, this has not been experimentally tested.
6. Wind plants with year-round waterfowl use have shown the highest waterfowl mortality, although the levels of waterfowl/waterbird mortality appear very low 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 Geronio [CA]). No waterfowl mortality has been documented at the Klondike (OR) wind plant between January 1 and March 31 2002, 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.

7. 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 suggest the mortality appears very low compared to the rates of bird targets passing through the area.
8. Since few raptor species targeted during nest surveys (i.e., those visible from helicopter surveys) have been observed as fatalities at newer wind plants, correlations are very low between fatalities and overall raptor nest density (nest density 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.
9. 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 suggest that wind plants do not currently impact resident breeding bat populations where they have been studied in the U.S.
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. Bat echolocation and collision mortality studies suggest 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. This lack of relationship between activity and mortality is probably because many of the migrant species involved are either not echolocating or are flying too high for the bat detectors (Anabat®) to record but still within the zone of collision risk.

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

<b>WRA/Study Area</b>	<b>State</b>	<b>Primary Habitat<sup>1</sup></b>	<b>Data<sup>2</sup></b>	<b>References</b>
Buffalo Ridge Phase I	MN	AG, GR	AU, MO, RN, BU	Johnson <i>et al.</i> (2000a), Johnson <i>et al.</i> (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	WEST and Northwest Wildlife Consultants (2002b)
Klondike	OR	AG, GR	AU, RN, MO	WEST and Northwest Wildlife Consultants (2001b)
Condon	OR	AG, GR	AU, RN, BU	URS Corporation <i>et al.</i> (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)

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

<sup>2</sup> 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.**

<b>WRA/Study Area</b>	<b>State</b>	<b>Primary Habitat<sup>1</sup></b>	<b>Data<sup>2</sup></b>	<b>Primary Reference</b>
Cares	WA	GR	AU	Erickson <i>et al.</i> (1999)
Columbia Hills	WA	GR	AU, RN	Jones and Stokes (1995)
Ponnequin	CO	GR	MO, RN	Kerlinger <i>et al.</i> (1999)
				Kerlinger pers. comm. (2000)
Maiden	WA	SS	AU, RN	WEST and Northwest Wildlife Consultants (2001a)
Foot Creek Rim	WY	GR, SS	AU, RN, MO, BU	Johnson <i>et al.</i> (2000a)
				Young <i>et al.</i> (2001)
Simpson Ridge	WY	SS	AU	Johnson <i>et al.</i> (2000a)
Morton Pass Reference	WY	SS, GR	AU	Johnson <i>et al.</i> (2000a)
Tehachapi Pass	CA	SS	AU, MO	Anderson <i>et al.</i> (2000)
San Geronio	CA	DS, SS	AU, MO	Anderson <i>et al.</i> (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)

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

<sup>2</sup> 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.**

<b>WRA/Study Area</b>	<b># aerial surveys<sup>1</sup></b>	<b># ground surveys<sup>2</sup></b>
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

<sup>1</sup> # of annual aerial surveys conducted (max number in any one year)

<sup>2</sup> 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 <sup>1</sup>	# of Raptor Fatalities	Reference
Buffalo Ridge, MN Phase I	Kenetech Model 33-MVS	4/94-12/95	73	50	7 days	12	0	Osborn <i>et al.</i> (2000)
Buffalo Ridge, MN Phase I	Kenetech Model 33-MVS	3/96-11/99	73	21	14 days	13	1	Johnson <i>et al.</i> (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
Footo Creek Rim, WY Phase I	Mitsubishi 600 kW tubular	11/98-12/00	69	69	28 days	95	5	Young <i>et al.</i> (2001)
Footo Creek Rim, WY Phase II&III	3 Mitsubishi 600 kW, 33 NEG 750	7/99-12/00	36	36	28 days	13	2	Young <i>et al.</i> (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 <i>et al.</i> (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 <i>et al.</i> (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)

<sup>1</sup> 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/Study Area	Turbine Types	Dates of Study	# of Turbines Searched	Search Interval	Total # Observed Fatalities <sup>1</sup>	# 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 <i>et al.</i> (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 Geronio, CA	<250 kW turbines	1985	Not available	not available	38	1	McCrary <i>et al.</i> (1986)
San Geronio, 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.)

<sup>1</sup>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.**

WRA	<u>% Composition of Fatalities</u>									# Carcasses
	Waterbirds	Waterfowl	Shorebirds	Diurnal Raptors	Owls	Fowl-like Birds	Protected Passerines	Other Birds	Non-Protected Birds	
<b>California</b>										
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 Geronio	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
<b>Outside California</b>										
Buffalo Ridge, MN	5	9	2	2	0	5	73	0	4	55
Foot 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
<b><u>Outside California</u></b>				
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 <sup>a</sup>	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 <sup>a</sup>	0.000
Subtotal	1,117	589	1.825	0.006
<b><u>California</u></b>				
Altamont Pass, CA	~5,400	~7,340	na <sup>a</sup>	0.048
Montezuma Hills, CA	600	600	na <sup>a</sup>	0.048
San Geronio, CA	~2,900	2,900	2.307	0.010
Grand Total	10,017	11,429	2.19	0.033

<sup>a</sup> not applicable (not calculated or not appropriate).



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

Wind Resource Area	Study Area	<u>Mean Use (#/20-minute survey)<sup>1</sup></u>					<u>Ranks</u>			
		Spr	Sum	Fall	Win	Avg <sup>2</sup>	1 <sup>3</sup>	2 <sup>4</sup>	3 <sup>5</sup>	4 <sup>6</sup>
<b><u>Agricultural Landscapes</u></b>										
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
<b><u>Native Landscapes</u></b>										
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

<sup>1</sup> some biases may exist in comparisons of study areas due to differences in quality of viewsheds out to 800 m and durations of surveys

<sup>2</sup> overall four season average weighted by the length of each season

<sup>3</sup> rank (lower number indicates higher use estimate) of study area using spring data

<sup>4</sup> rank (lower number indicates higher use estimate) of study area using spring and summer data

<sup>5</sup> rank (lower number indicates higher use estimate) of study area using spring, summer and fall data

<sup>6</sup> 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.**

<u>Correlation of Study Area Ranks</u>					<u>Correlation of Seasonal Use Estimates</u>					
	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.**

Wind Resource Area	Study Area	Mean Use (#/20-minute survey) <sup>1</sup>					Ranks			
		Spr	Sum	Fall	Win	Avg <sup>2</sup>	1 <sup>3</sup>	2 <sup>4</sup>	3 <sup>5</sup>	4 <sup>6</sup>
<b><u>Agricultural Landscapes</u></b>										
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
<b><u>Native Landscapes</u></b>										
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

<sup>1</sup> some biases may exist in comparisons of study areas due to differences in quality of viewsheds out to 800 m and durations of surveys

<sup>2</sup> overall four season average weighted by the length of each season

<sup>3</sup> rank (lower number indicates higher use estimate) of study area using spring data

<sup>4</sup> rank (lower number indicates higher use estimate) of study area using spring and summer data

<sup>5</sup> rank (lower number indicates higher use estimate) of study area using spring, summer and fall data

<sup>6</sup> 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.**

<u>Correlation of Study Area Ranks</u>					<u>Correlation of Seasonal Use Estimates</u>					
	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 golden eagle use estimates (estimated #/20-min survey) for several study areas.**

Wind Resource Area	Study Area	Mean Use (#/20-minute survey) <sup>1</sup>					Ranks			
		Spr	Sum	Fall	Win	Avg <sup>2</sup>	1 <sup>3</sup>	2 <sup>4</sup>	3 <sup>5</sup>	4 <sup>6</sup>
<b><u>Agricultural Landscapes</u></b>										
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
<b><u>Native Landscapes</u></b>										
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

<sup>1</sup> some biases may exist in comparisons of study areas due to differences in quality of viewsheds out to 800 m and durations of surveys

<sup>2</sup> overall four season average weighted by the length of each season

<sup>3</sup> rank (lower number indicates higher use estimate) of study area using spring data

<sup>4</sup> rank (lower number indicates higher use estimate) of study area using spring and summer data

<sup>5</sup> rank (lower number indicates higher use estimate) of study area using spring, summer and fall data

<sup>6</sup> rank (lower number indicates higher use estimate) of study area using all four seasons of data

**Table 12. Pearson correlations among golden eagle seasonal use estimates.**

<u>Correlation of Study Area Ranks</u>					<u>Correlation of Seasonal Use Estimates</u>					
	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 large falcon use estimates (estimated #/20-min survey) for several study areas.**

Wind Resource Area	Study Area	Mean Use (#/20-minute survey) <sup>1</sup>					Ranks			
		Spr	Sum	Fall	Win	Avg <sup>2</sup>	1 <sup>3</sup>	2 <sup>4</sup>	3 <sup>5</sup>	4 <sup>6</sup>
<b><u>Agricultural Landscapes</u></b>										
Buffalo Ridge	Phase I	0.000	0.000	0.000	0.000	0.000	9	14	19	22
Buffalo Ridge	Phase II	0.000	0.000	0.000	0.000	0.000	9	14	19	22
Buffalo Ridge	Phase III	0.000	0.000	0.012	0.000	0.002	9	14	16	19
Buffalo Ridge	Reference Area	0.000	0.000	0.000	0.028	0.010	9	14	19	12
Condon	Condon	0.000	0.000	0.014	0.000	0.003	9	14	14	17
Klondike	Klondike	0.000	0.008	0.000	0.018	0.009	9	13	18	14
Nine Canyon	Nine Canyon	0.021	0.000	0.000	0.000	0.003	7	10	13	16
Stateline/Vansycle	Reference Area	0.000	0.000	0.000	0.002	0.001	9	14	19	21
Stateline/Vansycle	Stateline/Vansycle	0.000	0.000	0.000	0.005	0.002	9	14	19	20
Zintel Canyon	Zintel Canyon	0.000	0.000	0.022	0.021	0.012	9	14	11	10
Average		0.002	0.001	0.005	0.007	0.004	8.8	13.5	16.7	17.3
<b><u>Native Landscapes</u></b>										
Altamont	Altamont	0.000	0.020	0.021	0.010	0.013	9	8	9	8
Cares	Cares	0.024	0.014	0.004	0.010	0.012	5	6	10	11
Columbia Hills	Average	0.030	0.037	0.020	0.010	0.022	3	3	4	6
Foote Creek Rim	Foote Creek Rim	0.034	0.029	0.037	0.010	0.024	1	4	3	4
Foote Creek Rim	Foote Creek Rim UV	0.024	0.044	0.034	0.001	0.023	4	2	2	5
Foote Creek Rim	Morton's Pass Reference	0.030	0.061	0.052	0.003	0.032	2	1	1	1
Foote Creek Rim	Simpson's Ridge	0.009	0.016	0.031	0.002	0.013	8	7	7	9
Maiden	Maiden	0.000	0.010	0.038	0.050	0.029	9	11	8	3
San Gorgonio Pass	Phase I High Elevation	0.000	0.000	0.000	0.000	0.000	9	14	19	22
San Gorgonio Pass	Phase I Low Elevation	0.000	0.014	0.000	0.016	0.010	9	9	12	13
San Gorgonio Pass	Phase I Medium Elevation	0.000	0.000	0.000	0.000	0.000	9	14	19	22
San Gorgonio Pass	Phase I Water Area	0.021	0.024	0.032	0.000	0.016	6	5	5	7
San Gorgonio Pass	Phase II Low Elevation	0.000	0.000	0.010	0.006	0.004	9	14	17	15
San Gorgonio Pass	Phase II Water Area	0.000	0.000	0.065	0.042	0.029	9	14	6	2
Tehachapi Pass	East Slope	0.000	0.000	0.000	0.000	0.000	9	14	19	22
Tehachapi Pass	Middle Ridge	0.000	0.000	0.000	0.000	0.000	9	14	19	22
Tehachapi Pass	West Ridge	0.000	0.010	0.000	0.000	0.003	9	12	15	18
Average		0.010	0.016	0.020	0.009	0.014	7.0	8.9	10.3	11.2

**Table 14. Pearson correlations among large falcon seasonal use estimates.**

	<u>Correlation of Study Area Ranks</u>					<u>Correlation of Seasonal Use Estimates</u>				
	Spr	Spr-Sum	Spr-Fall	Overall		Spr	Sum	Fall	Win	Overall
Spr	1.00				Spr	1.00				
Spr-Sum	0.88	1.00			Sum	0.79	1.00			
Spr-Fall	0.76	0.87	1.00		Fall	0.44	0.57	1.00		
					Win	-0.17	-0.06	0.44	1.00	
Overall	0.61	0.72	0.92	1.00	Overall	0.58	0.72	0.89	0.59	1.00



**Table 15. Mean small falcon use estimates (estimated #/20-min survey) for several study areas.**

Wind Resource Area	Study Area	Mean Use (#/20-minute survey) <sup>1</sup>					Ranks			
		Spr	Sum	Fall	Win	Avg <sup>2</sup>	1 <sup>3</sup>	2 <sup>4</sup>	3 <sup>5</sup>	4 <sup>6</sup>
<b><u>Agricultural Landscapes</u></b>										
Buffalo Ridge	Phase I	0.094	0.079	0.072	0.000	0.050	9	6	9	13
Buffalo Ridge	Phase II	0.063	0.023	0.072	0.000	0.031	15	16	14	18
Buffalo Ridge	Phase III	0.088	0.111	0.071	0.024	0.066	10	5	7	11
Buffalo Ridge	Reference Area	0.067	0.033	0.113	0.014	0.048	12	14	12	14
Condon	Condon	0.146	0.135	0.085	0.076	0.104	3	3	5	4
Klondike	Klondike	0.095	0.054	0.143	0.045	0.076	8	8	6	8
Nine Canyon	Nine Canyon	0.035	0.022	0.015	0.009	0.018	18	21	22	23
Stateline/Vansycle	Reference Area	0.066	0.063	0.012	0.009	0.033	14	10	16	16
Stateline/Vansycle	Stateline/Vansycle	0.036	0.028	0.023	0.022	0.026	17	19	20	21
Zintel Canyon	Zintel Canyon	0.028	0.065	0.383	0.104	0.140	19	13	2	3
Average		0.072	0.061	0.099	0.030	0.059	12.5	11.5	11.3	13.1
<b><u>Native Landscapes</u></b>										
Altamont	Altamont	0.125	0.130	0.150	0.013	0.089	5	4	4	6
Cares	Cares	0.107	0.276	0.055	0.004	0.100	7	2	3	5
Columbia Hills	Columbia Hills	0.208	0.507	0.137	0.004	0.192	1	1	1	1
Foote Creek Rim	Foote Creek Rim	0.085	0.079	0.068	0.000	0.048	11	7	11	15
Foote Creek Rim	Foote Creek Rim UV	0.024	0.049	0.024	0.000	0.021	20	17	19	22
Foote Creek Rim	Morton's Pass Reference	0.128	0.021	0.014	0.000	0.030	4	11	15	19
Foote Creek Rim	Simpson's Ridge	0.067	0.055	0.037	0.000	0.033	13	12	13	17
Maiden	Maiden	0.041	0.021	0.213	0.031	0.068	16	20	8	10
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	0.010	0.030	0.170	0.074	22	22	24	9
San Gorgonio Pass	Phase I Medium Elevation	0.000	0.000	0.050	0.000	0.010	23	26	23	24
San Gorgonio Pass	Phase I Water Area	0.168	0.000	0.100	0.073	0.076	2	9	10	7
San Gorgonio Pass	Phase II Low Elevation	0.000	0.011	0.013	0.000	0.005	23	25	25	26
San Gorgonio Pass	Phase II Water Area	0.111	0.000	0.019	0.076	0.051	6	15	17	12
Tehachapi Pass	East Slope	0.021	0.000	0.000	0.011	0.008	21	23	26	25
Tehachapi Pass	Middle Ridge	0.000	0.058	0.038	0.371	0.162	23	18	18	2
Tehachapi Pass	West Ridge	0.000	0.012	0.066	0.026	0.027	23	24	21	20
Average		0.064	0.072	0.060	0.046	0.058	14.3	15.4	15.6	14.5

<sup>1</sup> some biases may exist in comparisons of study areas due to differences in quality of viewsheds out to 800 m and durations of surveys

<sup>2</sup> overall four season average weighted by the length of each season

<sup>3</sup> rank (lower number indicates higher use estimate) of study area using spring data

<sup>4</sup> rank (lower number indicates higher use estimate) of study area using spring and summer data

<sup>5</sup> rank (lower number indicates higher use estimate) of study area using spring, summer and fall data

<sup>6</sup> rank (lower number indicates higher use estimate) of study area using all four seasons of data

**Table 16. Pearson correlations among small falcon seasonal use estimates.**

<u>Correlation of Study Area Ranks</u>					<u>Correlation of Seasonal Use Estimates</u>					
	Spr	Spr-Sum	Spr-Fall	Overall		Spr	Sum	Fall	Win	Overall
Spr	1.00				Spr	1.00				
Spr-Sum	0.87	1.00			Sum	0.62	1.00			
Spr-Fall	0.74	0.87	1.00		Fall	0.18	0.22	1.00		
					Win	-0.20	-0.10	0.10	1.00	
Overall	0.56	0.70	0.80	1.00	Overall	0.48	0.69	0.56	0.54	1.00

**Table 17. Mean northern harrier use estimates (estimated #/20-min survey) for several study areas.**

Wind Resource Area	Study Area	Mean Use (#/20-minute survey) <sup>1</sup>					Ranks			
		Spr	Sum	Fall	Win	Avg <sup>2</sup>	1 <sup>3</sup>	2 <sup>4</sup>	3 <sup>5</sup>	4 <sup>6</sup>
<b><u>Agricultural Landscapes</u></b>										
Buffalo Ridge	Phase I	0.130	0.063	0.025	0.000	0.042	9	9	13	13
Buffalo Ridge	Phase II	0.282	0.301	0.119	0.042	0.163	1	1	1	1
Buffalo Ridge	Phase III	0.188	0.135	0.183	0.010	0.107	6	2	2	4
Buffalo Ridge	Reference Area	0.267	0.074	0.101	0.083	0.116	2	3	3	2
Condon	Condon	0.229	0.030	0.033	0.114	0.095	3	7	10	6
Klondike	Klondike	0.143	0.087	0.043	0.103	0.093	8	8	8	7
Nine Canyon	Nine Canyon	0.215	0.069	0.089	0.102	0.110	4	4	4	3
Stateline/Vansycle	Reference Area	0.174	0.069	0.071	0.051	0.080	7	6	7	10
Stateline/Vansycle	Stateline/Vansycle	0.189	0.076	0.083	0.084	0.099	5	5	6	5
Zintel Canyon	Zintel Canyon	0.056	0.084	0.061	0.097	0.080	11	10	12	11
Average		0.187	0.099	0.081	0.069	0.099	5.6	5.5	6.6	6.2
<b><u>Native Landscapes</u></b>										
Altamont Pass	Altamont Pass	0.031	0.001	0.040	0.001	0.014	12	17	16	16
Cares	Cares	0.030	0.064	0.228	0.042	0.084	13	13	5	9
Columbia Hills	Average	0.069	0.072	0.083	0.042	0.062	10	11	11	12
Foote Creek Rim	Foote Creek Rim	0.022	0.024	0.037	0.001	0.018	16	15	15	15
Foote Creek Rim	Foote Creek Rim UV	0.007	0.014	0.016	0.000	0.008	18	18	18	18
Foote Creek Rim	Morton's Pass Reference	0.012	0.018	0.032	0.000	0.013	17	16	17	17
Foote Creek Rim	Simpson's Ridge	0.029	0.052	0.036	0.001	0.025	14	14	14	14
Maiden	Maiden	0.028	0.092	0.125	0.094	0.089	15	12	9	8
San Gorgonio Pass	Phase I High Elevation	0.000	0.000	0.000	0.000	0.000	19	19	20	21
San Gorgonio Pass	Phase I Low Elevation	0.000	0.000	0.000	0.005	0.002	19	19	20	20
San Gorgonio Pass	Phase I Medium Elevation	0.000	0.000	0.000	0.000	0.000	19	19	20	21
San Gorgonio Pass	Phase I Water Area	0.000	0.000	0.000	0.000	0.000	19	19	20	21
San Gorgonio Pass	Phase II Low Elevation	0.000	0.000	0.000	0.000	0.000	19	19	20	21
San Gorgonio Pass	Phase II Water Area	0.000	0.000	0.000	0.000	0.000	19	19	20	21
Tehachapi Pass	East Slope	0.000	0.000	0.000	0.000	0.000	19	19	20	21
Tehachapi Pass	Middle Ridge	0.000	0.000	0.010	0.005	0.004	19	19	19	19
Tehachapi Pass	West Ridge	0.000	0.000	0.000	0.000	0.000	19	19	20	21
Average		0.013	0.020	0.036	0.011	0.019	16.8	16.9	16.7	17.4

<sup>1</sup> some biases may exist in comparisons of study areas due to differences in quality of viewsheds out to 800 m and durations of surveys

<sup>2</sup> overall four season average weighted by the length of each season

<sup>3</sup> rank (lower number indicates higher use estimate) of study area using spring data

<sup>4</sup> rank (lower number indicates higher use estimate) of study area using spring and summer data

<sup>5</sup> rank (lower number indicates higher use estimate) of study area using spring, summer and fall data

<sup>6</sup> rank (lower number indicates higher use estimate) of study area using all four seasons of data

**Table 18. Pearson correlations among northern harrier seasonal use estimates.**

	<u>Correlation of Study Area Ranks</u>					<u>Correlation of Seasonal Use Estimates</u>				
	Spr	Spr-Sum	Spr-Fall	Overall		Spr	Sum	Fall	Win	Overall
Spr	1.00				Spr	1.00				
Spr-Sum	0.96	1.00			Sum	0.71	1.00			
Spr-Fall	0.90	0.95	1.00		Fall	0.49	0.64	1.00		
					Win	0.65	0.42	0.43	1.00	
Overall	0.94	0.96	0.98	1.00	Overall	0.88	0.85	0.76	0.77	1.00

**Table 19. Mean accipiter use estimates (estimated #/20-min survey) for several study areas.**

wind resource area	subarea	MEAN USE (#/20-minute survey)					Ranks			
		SPR	SUM	FALL	WIN	OVER	1	2	3	4
<b><u>Agricultural Landscapes</u></b>										
Buffalo Ridge	Phase I	0.033	0.000	0.033	0.000	0.013	3	4	4	6
Buffalo Ridge	Phase II	0.059	0.000	0.037	0.000	0.018	2	2	3	4
Buffalo Ridge	Phase III	0.000	0.000	0.036	0.014	0.013	12	12	8	5
Buffalo Ridge	Reference Area	0.007	0.000	0.034	0.028	0.019	8	10	6	3
Condon	Condon	0.000	0.000	0.010	0.000	0.002	12	12	13	14
Klondike	Klondike	0.000	0.000	0.000	0.000	0.000	12	12	17	18
Nine Canyon	Nine Canyon	0.000	0.000	0.000	0.000	0.000	12	12	17	18
Stateline/Vansycle	Reference Area	0.000	0.000	0.017	0.011	0.008	12	12	11	10
Stateline/Vansycle	Stateline/Vansycle	0.000	0.000	0.013	0.022	0.011	12	12	12	7
Zintel Canyon	Zintel Canyon	0.028	0.011	0.000	0.000	0.007	4	3	9	11
Average		0.013	0.001	0.018	0.007	0.009	8.9	9.1	10.0	9.6
<b><u>Native Landscapes</u></b>										
Altamont						0.002				
Cares	Cares	0.013	0.000	0.180	0.003	0.041	5	6	2	2
Columbia Hills	Average	0.068	0.129	0.076	0.003	0.060	1	1	1	1
Foote Creek Rim	Foote Creek Rim	0.009	0.004	0.033	0.000	0.009	7	5	5	8
Foote Creek Rim	Foote Creek Rim UV	0.005	0.000	0.002	0.000	0.001	9	11	16	17
Foote Creek Rim	Morton's Pass Reference	0.005	0.002	0.001	0.000	0.001	10	8	15	16
Foote Creek Rim	Simpson's Ridge	0.004	0.002	0.013	0.003	0.005	11	9	10	13
Maiden	Maiden	0.000	0.000	0.038	0.000	0.008	12	12	7	9
San Gorgonio Pass	Phase I High Elevation	0.000	0.000	0.000	0.000	0.000	12	12	17	18
San Gorgonio Pass	Phase I Low Elevation	0.000	0.000	0.000	0.000	0.000	12	12	17	18
San Gorgonio Pass	Phase I Medium Elevation	0.000	0.000	0.000	0.000	0.000	12	12	17	18
San Gorgonio Pass	Phase I Water Area	0.000	0.000	0.000	0.000	0.000	12	12	17	18
San Gorgonio Pass	Phase II Low Elevation	0.000	0.000	0.000	0.000	0.000	12	12	17	18
San Gorgonio Pass	Phase II Water Area	0.000	0.000	0.000	0.000	0.000	12	12	17	18
Tehachapi Pass	East Slope	0.010	0.000	0.000	0.000	0.002	6	7	14	15
Tehachapi Pass	Middle Ridge	0.000	0.000	0.000	0.000	0.000	12	12	17	18
Tehachapi Pass	West Ridge	0.000	0.000	0.000	0.017	0.006	12	12	17	12
Average		0.007	0.009	0.021	0.002	0.008	9.8	9.7	12.9	13.7

<sup>1</sup> some biases may exist in comparisons of study areas due to differences in quality of viewsheds out to 800 m and durations of surveys

<sup>2</sup> overall four season average weighted by the length of each season

<sup>3</sup> rank (lower number indicates higher use estimate) of study area using spring data

<sup>4</sup> rank (lower number indicates higher use estimate) of study area using spring and summer data

<sup>5</sup> rank (lower number indicates higher use estimate) of study area using spring, summer and fall data

<sup>6</sup> rank (lower number indicates higher use estimate) of study area using all four seasons of data

**Table 20. Pearson correlations among accipiter seasonal use estimates.**

<u>Correlation of Study Area Ranks</u>					<u>Correlation of Seasonal Use Estimates</u>					
	Spr	Spr-Sum	Spr-Fall	Overall		Spr	Sum	Fall	Win	Overall
Spr	1.00				Spr	1.00				
Spr-Sum	0.96	1.00			Sum	0.68	1.00			
Spr-Fall	0.76	0.75	1.00		Fall	0.38	0.29	1.00		
					Win	-0.14	-0.04	0.09	1.00	
Overall	0.65	0.61	0.94	1.00	Overall	0.71	0.76	0.80	0.21	1.00

**Table 21. Mean waterfowl/waterbird use estimates (estimated #/20-min survey) for several study areas.**

Wind Resource Area	Study Area	Mean Use (#/20-minute survey) <sup>1</sup>					Ranks			
		Spr	Sum	Fall	Win	Avg <sup>2</sup>	1 <sup>3</sup>	2 <sup>4</sup>	3 <sup>5</sup>	4 <sup>6</sup>
<b><u>Agricultural Landscapes</u></b>										
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
<b><u>Native Landscapes</u></b>										
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

<sup>1</sup> some biases may exist in comparisons of study areas due to differences in quality of viewsheds out to 800 m and durations of surveys

<sup>2</sup> overall four season average weighted by the length of each season

<sup>3</sup> rank (lower number indicates higher use estimate) of study area using spring data

<sup>4</sup> rank (lower number indicates higher use estimate) of study area using spring and summer data

<sup>5</sup> rank (lower number indicates higher use estimate) of study area using spring, summer and fall data

<sup>6</sup> rank (lower number indicates higher use estimate) of study area using all four seasons of data

**Table 22. Pearson correlations among waterfowl/waterbird seasonal use estimates.**

<u>Correlation of Study Area Ranks</u>					<u>Correlation of Seasonal Use Estimates</u>					
	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 23. Number of active nests and estimated density (excluding inconspicuous ground nesting species) for cultivated agriculture wind projects.**

<b>STATELINE, OR/WA (area = 89 mi<sup>2</sup>) (NW Wildlife Consultants and WEST 2001)</b>		
Species	Number within 2 mi	Density (#/mi <sup>2</sup> )
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
<b>CONDON, OR (area = 50 mi<sup>2</sup>) (URS Corporation <i>et al.</i> 2001)</b>		
Species	Number within 2 mi	Density (#/mi <sup>2</sup> )
Red-tailed Hawk	2	0.040
Unidentified Raptor	1	0.020
TOTAL	3	0.060
<b>KLONDIKE, OR (area = 24 mi<sup>2</sup>) (WEST and NW Wildlife Consultants 2001a)</b>		
Species	Number within 2 mi	Density (#/mi <sup>2</sup> )
Red-tailed Hawk	2	0.083
Swainson's Hawk	1	0.042
Great Horned Owl	1	0.042
TOTAL	4	0.158
<b>NINE CANYON, WA (area = 30 mi<sup>2</sup>) (WEST and NW Wildlife Consultants 2001b)</b>		
Species	Number within 2 mi	Density (#/mi <sup>2</sup> )
Swainson's Hawk	1	0.033
TOTAL	1	0.033
<b>ZINTEL CANYON, WA (area ~50 mi<sup>2</sup>)</b>		
Species	Number within 2 mi	Density (#/mi <sup>2</sup> )
Swainson's Hawk	2	0.040
Red-tailed Hawk	1	0.020
Ferruginous Hawk	1	0.020
TOTAL	4	0.080
<b>BUFFALO RIDGE, MN</b>		
Species	Number within 2 mi	Density (#/mi <sup>2</sup> )
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 24. Nesting information for raptors (excluding inconspicuous ground nesting species) for native wind projects in native landscapes.**

<b>COLUMBIA HILLS, WA (area = 50 mi<sup>2</sup>) (Jones and Stokes 1995)</b>		
Species	Number within 2 mi	Density (#/mi <sup>2</sup> )
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
<b>PONNEQUIN, CO (area =17 mi<sup>2</sup>) (Kerlinger <i>et al.</i> 2000)</b>		
Species	Number within 2 mi	Density (#/mi <sup>2</sup> )
Swainson's Hawk	1	0.059
TOTAL	1	0.059
<b>MAIDEN, WA (area = 96 mi<sup>2</sup>) (WEST and Northwest Wildlife Consultants 2001).</b>		
Species	Number within 2 mi	Density (#/mi <sup>2</sup> )
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
<b>FOOTE CREEK RIM, WY (area = 36 mi<sup>2</sup>) (Johnson <i>et al.</i> 2000b)</b>		
Species	Number within 2 mi	Density (#/mi <sup>2</sup> )
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 25. 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 26. Timing of bat collision mortality at U.S. wind plants**

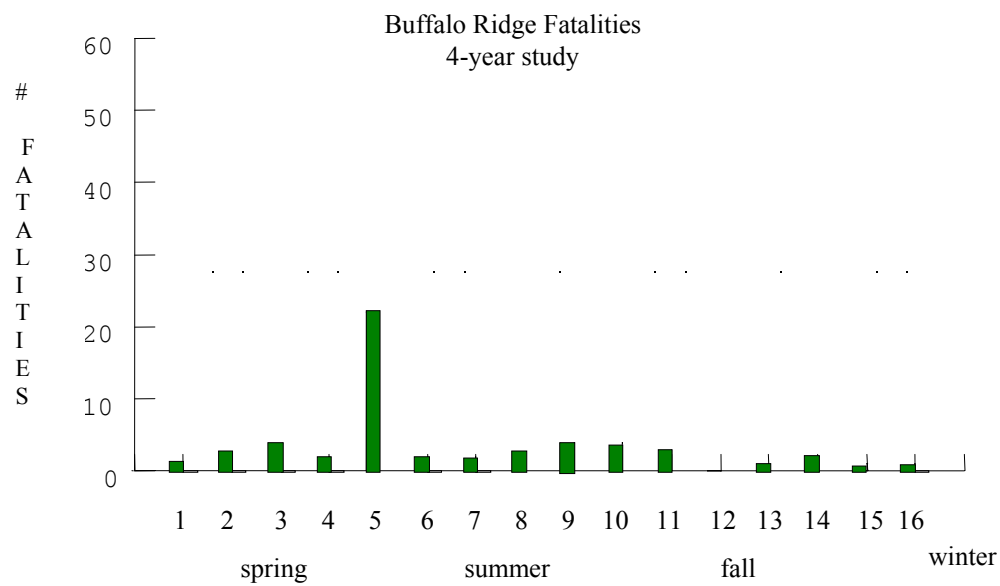
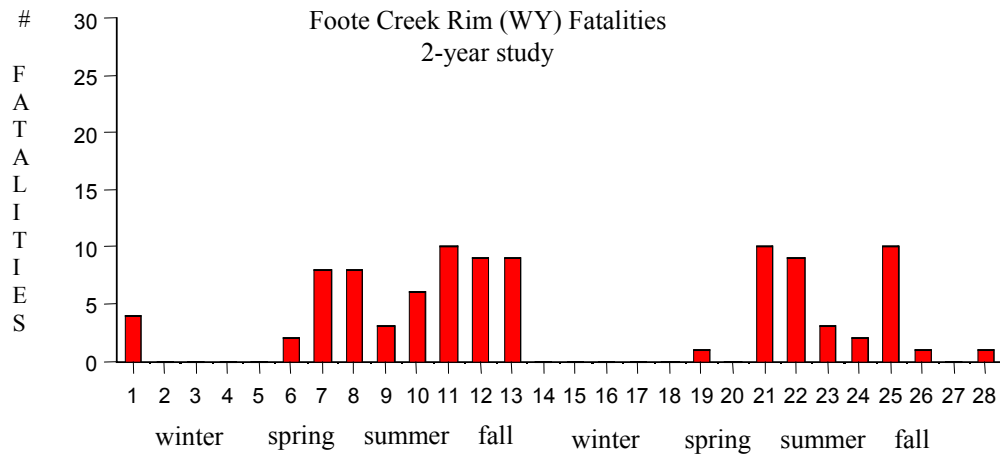
Date	Buffalo Ridge, MN	Vansycle, OR	Buffalo Mtn., TN	Stateline, OR/WA	Foote Creek Rim, WY	TOTAL	Percent
May 1-15	0	0	0	-	0	0	0
May 16-31	1	0	0	-	1	2	0.4
June 1-15	0	0	0	-	1	1	0.2
June 16-30	3	0	0	-	2	5	0.9
July 1-15	9	0	9	0	2	15	2.8
July 16-31	88	0	0	0	26	119	22.2
Aug 1-15	127	0	10	0	19	151	28.2
Aug 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 27. Composition of bat collision fatalities at U.S. wind plants**

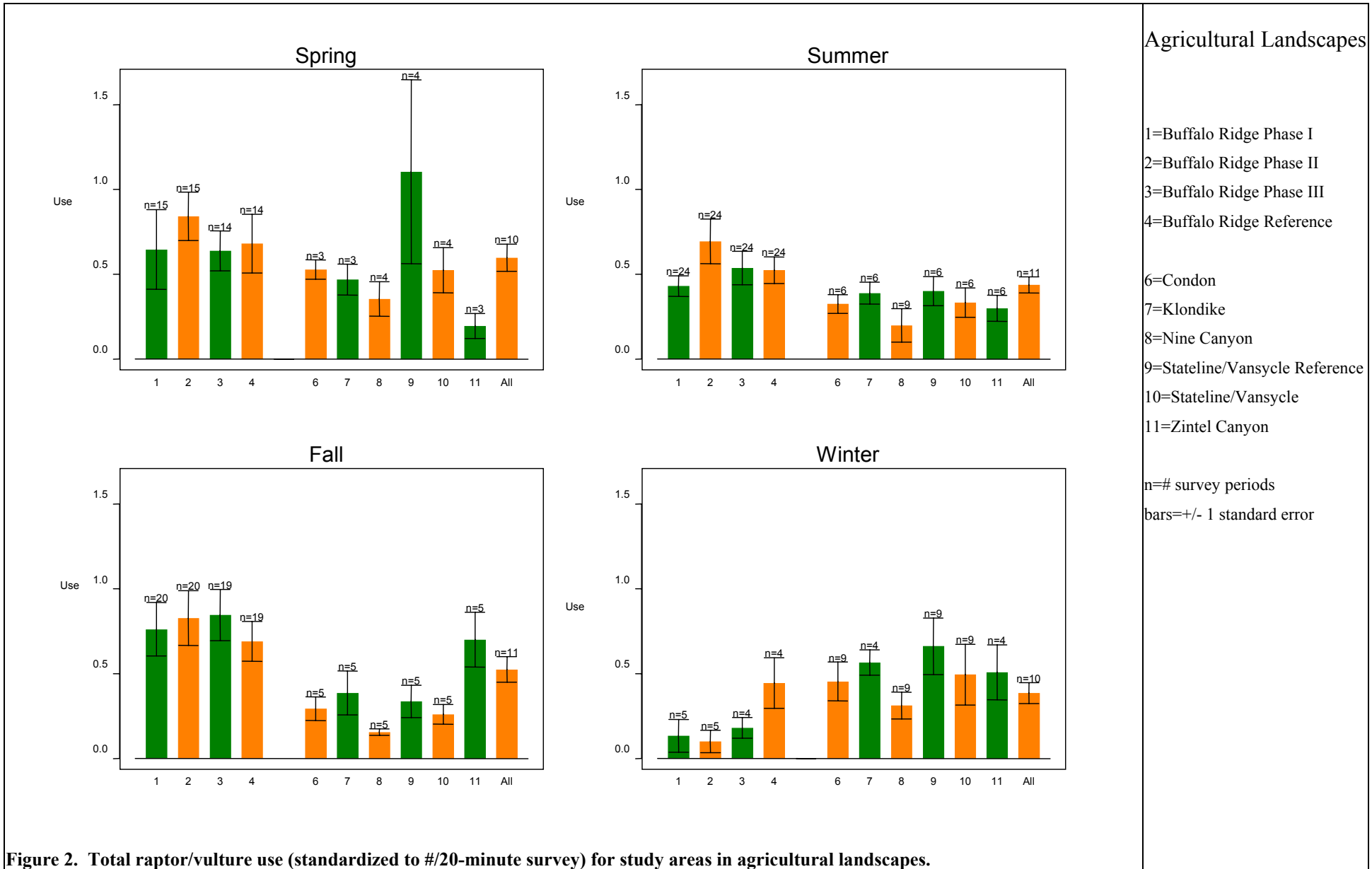
Location	n	HOBA	REBA	SHBA	BBBA	LBBA	EAPI	UNID
Buffalo Ridge, MN	362	229	64	19	12	7	7	24
Buffalo Mtn., TN	32	1	21	1	1	0	8	0
Wisconsin	34	8	20	2	4	0	0	0
Vansycle, OR	10	5	0	3	0	1	0	1
Ponnequin, CO	~18	~14	0	0	0	0	0	~4
Foot Creek Rim, WY	123	107	0	5	2	6	0	3
Stateline, OR/WA	30	14	0	14	0	2	0	0
Green Mtn., 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 28. Habitat at U.S. wind plants with bat mortality.**

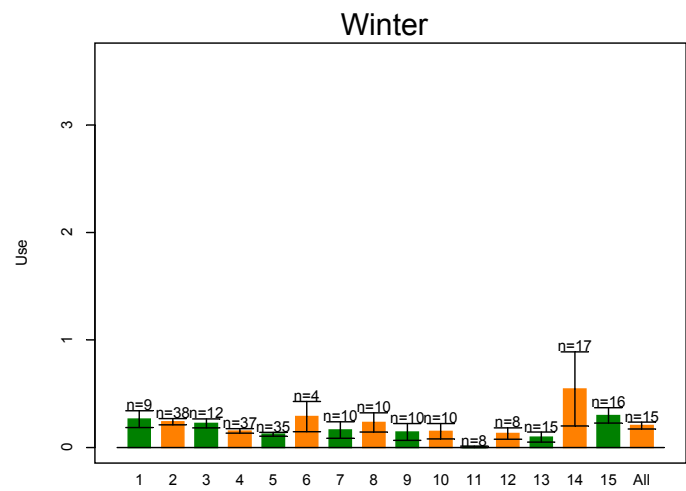
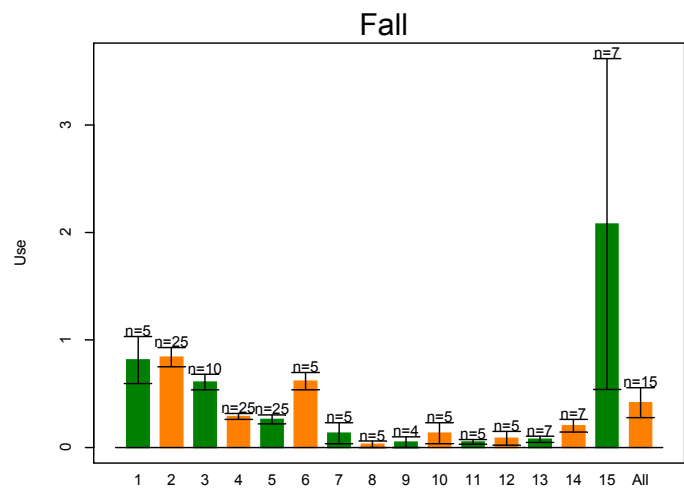
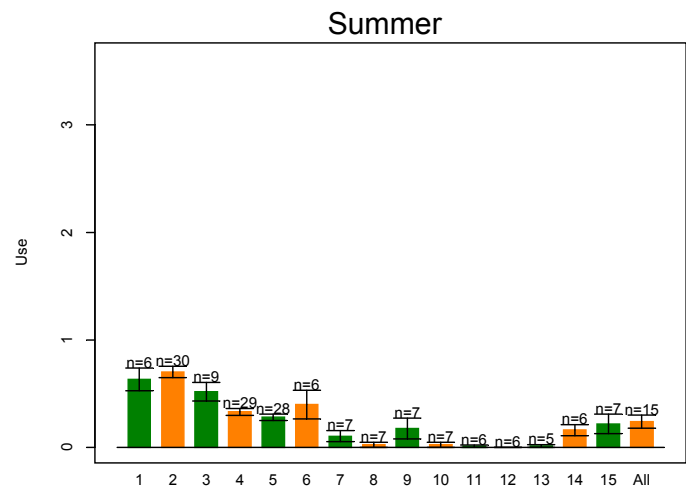
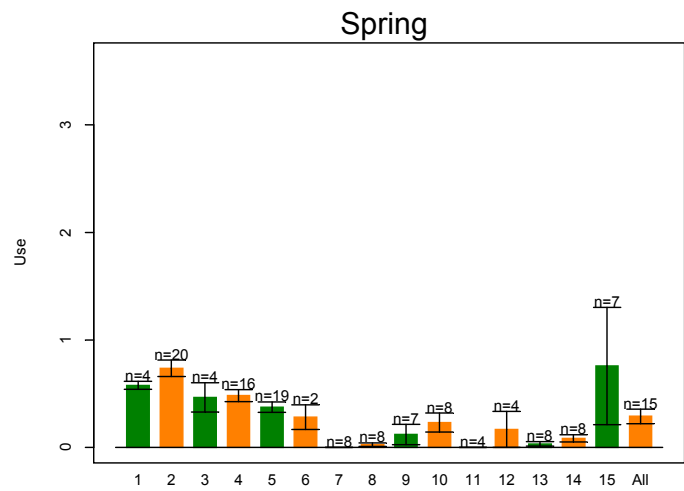
Location	Habitat
Buffalo Ridge, MN	Crop fields, CRP fields, pasture
Buffalo Mtn., TN	Mountain top in deciduous forest
Wisconsin	Crop fields, pasture
Vansycle, OR	Crop fields, grassland
Ponnequin, CO	Short grass prairie on low ridges
Foote Creek Rim, WY	Short grass prairie on prominent rim, aspens along 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 (WY) and Buffalo Ridge (MN) wind projects.**







### 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

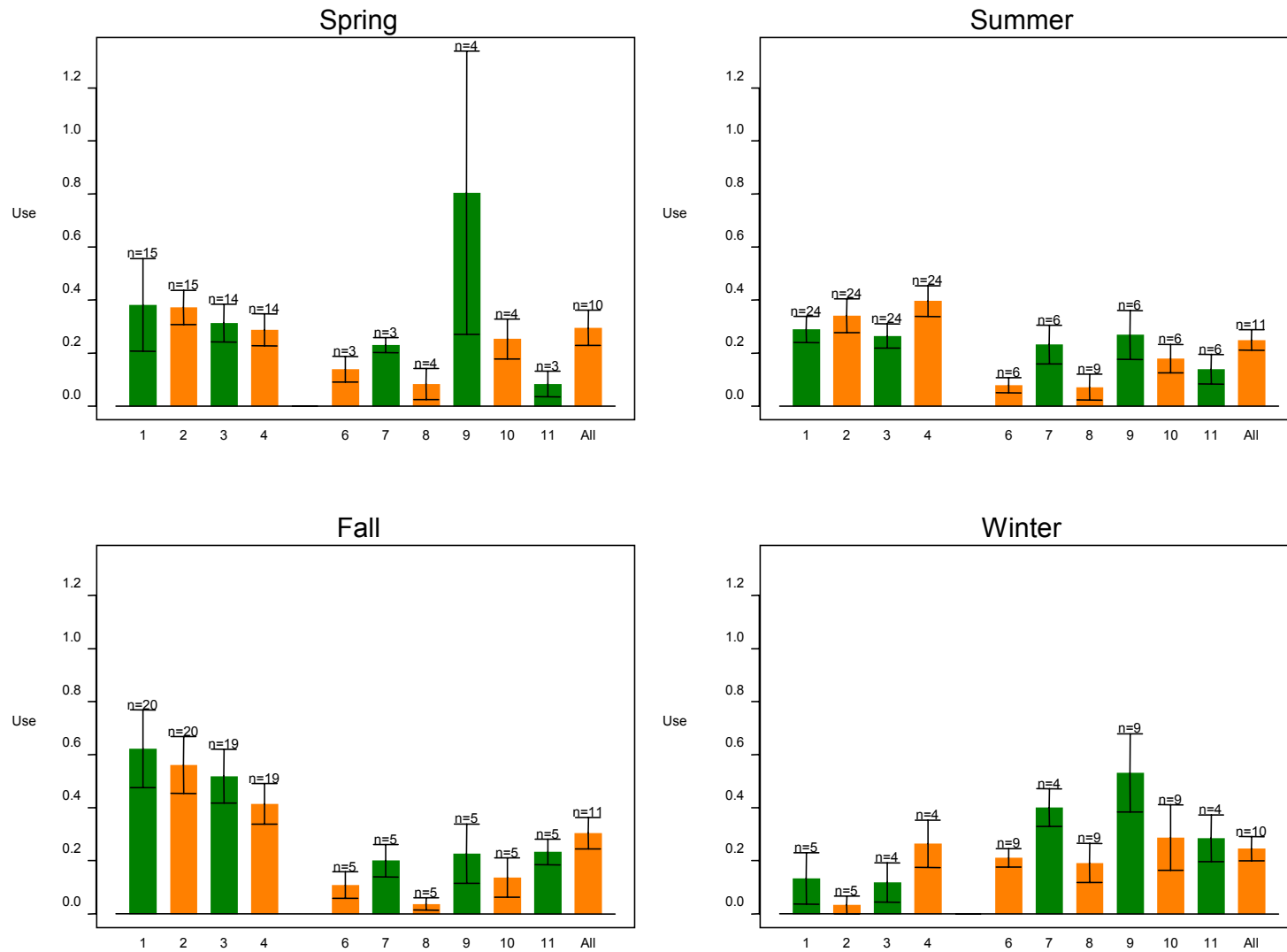
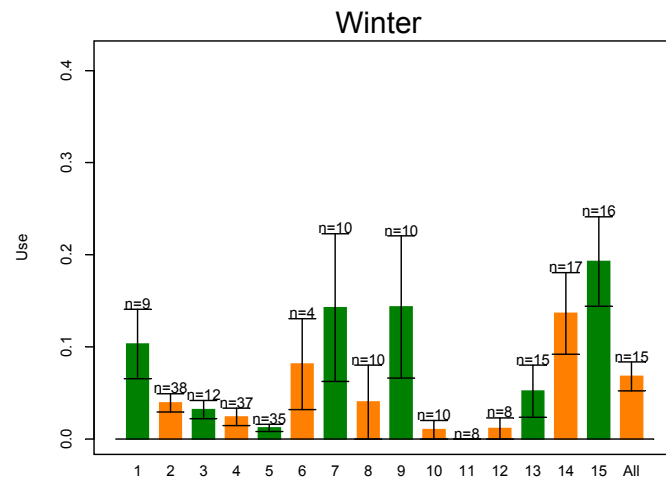
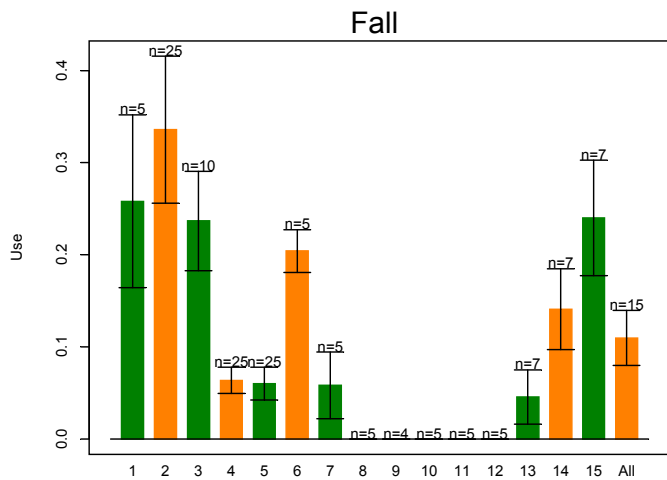
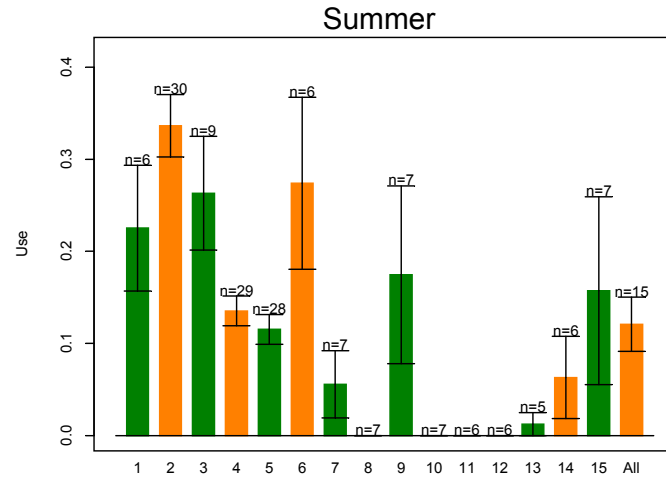
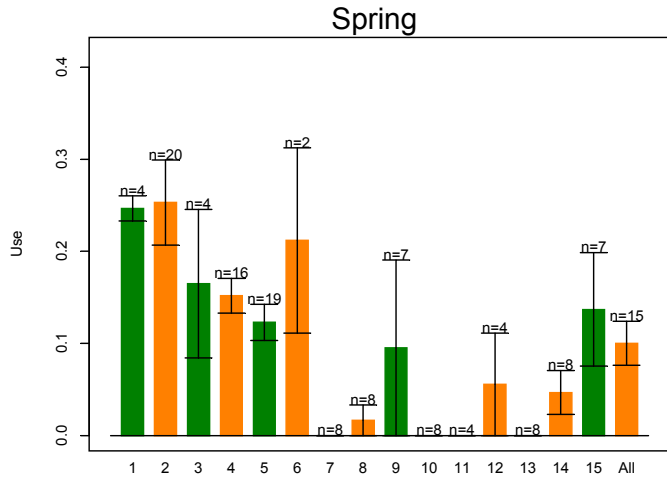


Figure 4. Total buteo use (standardized to #/20-minute survey) for study areas in agricultural landscapes.



### Native Landscapes

- 1=Cares
- 2=Footo Creek Rim
- 3=Footo 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.

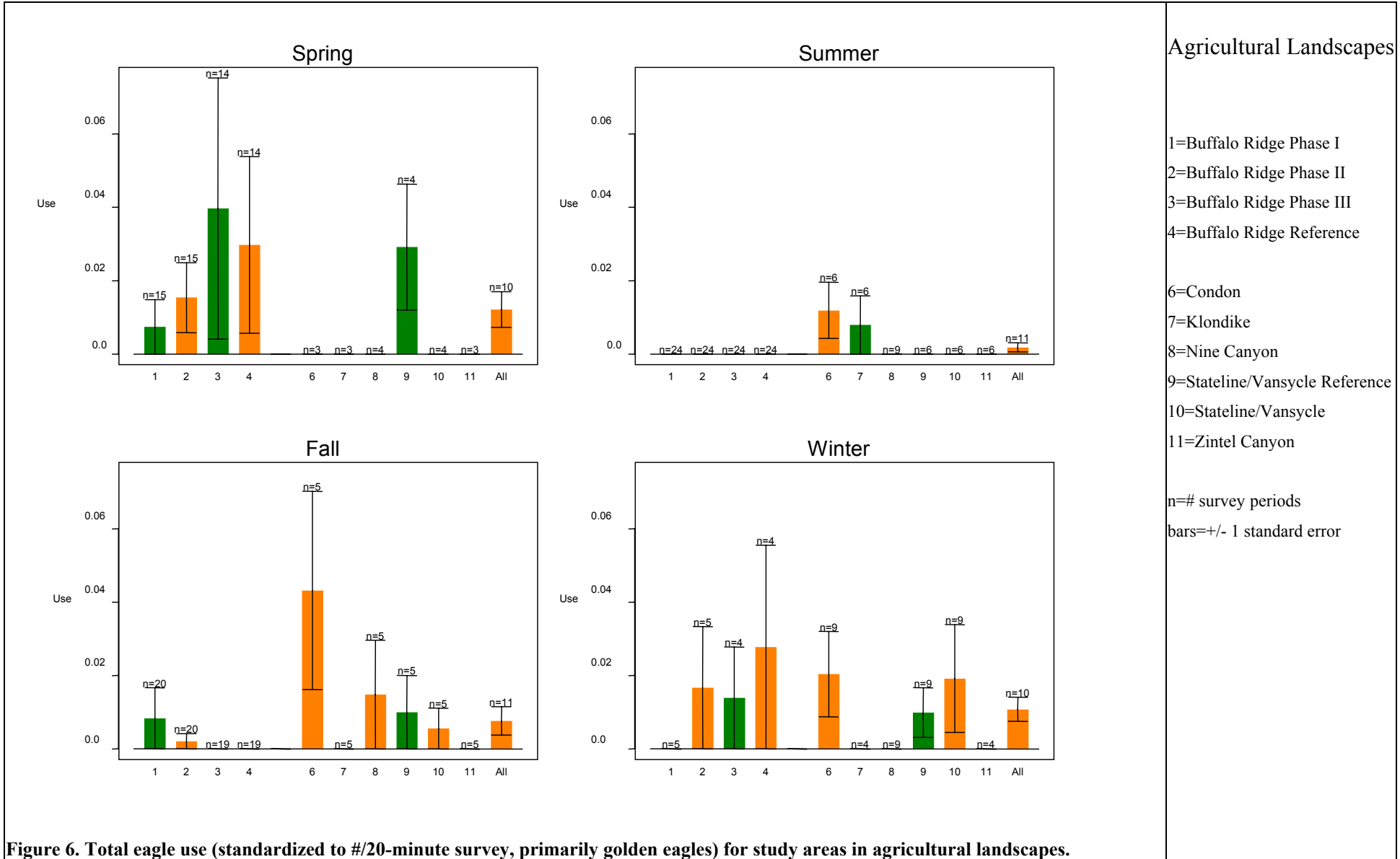
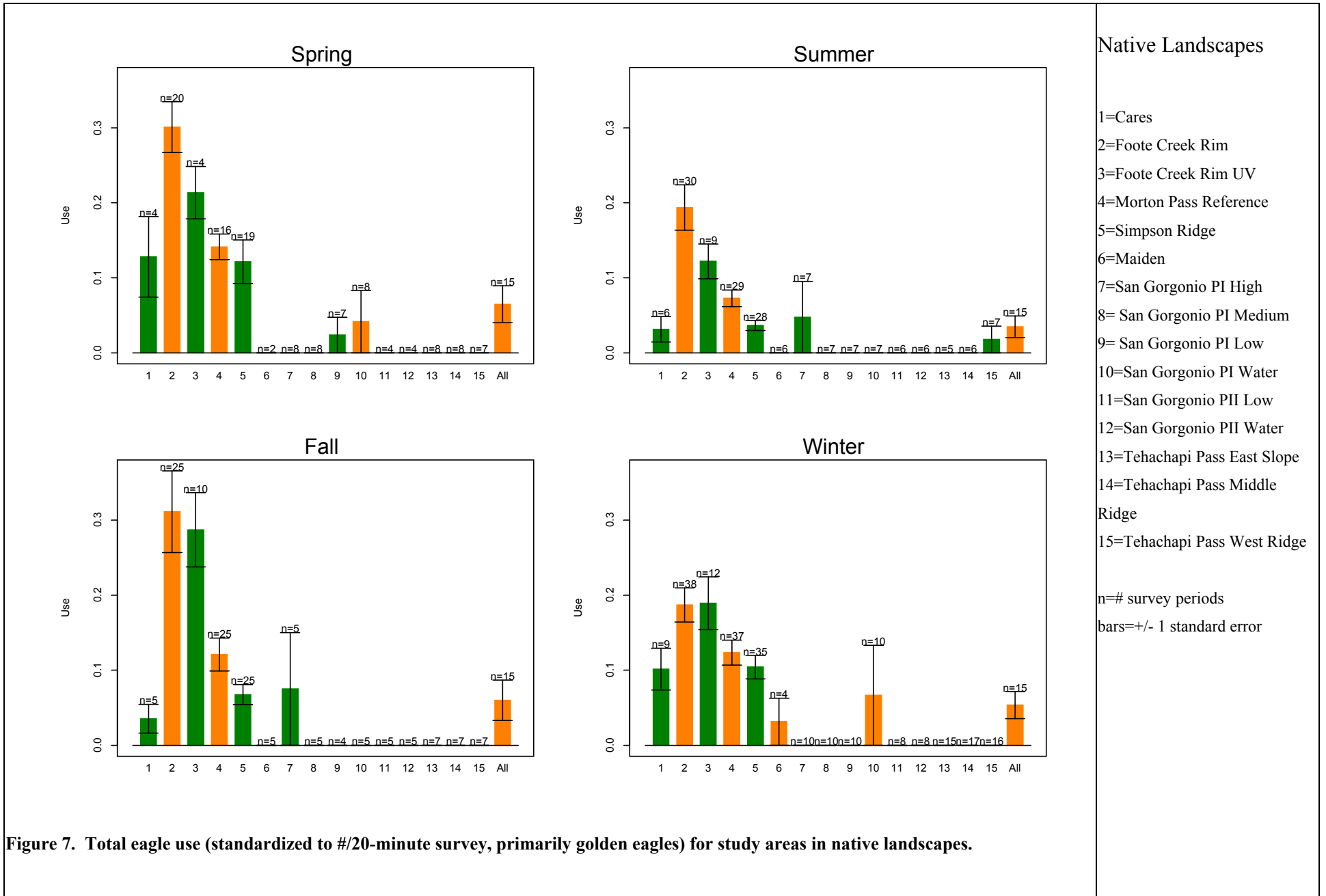
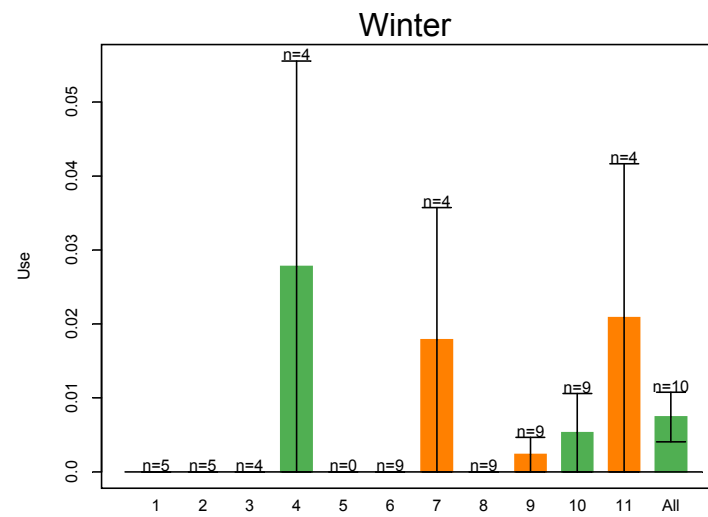
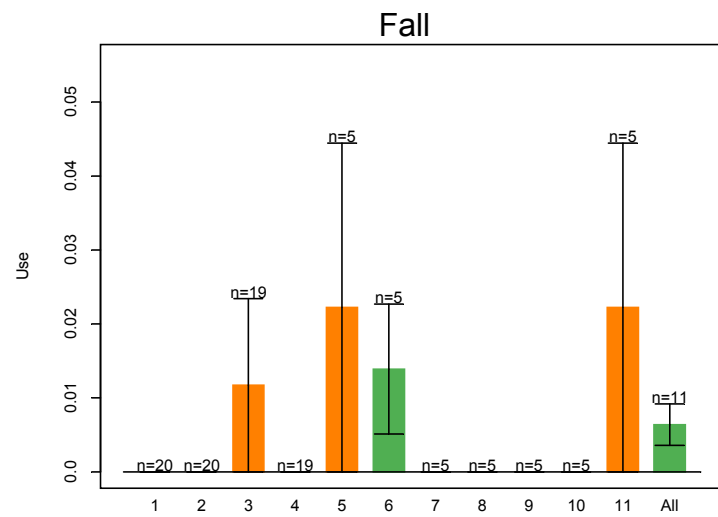
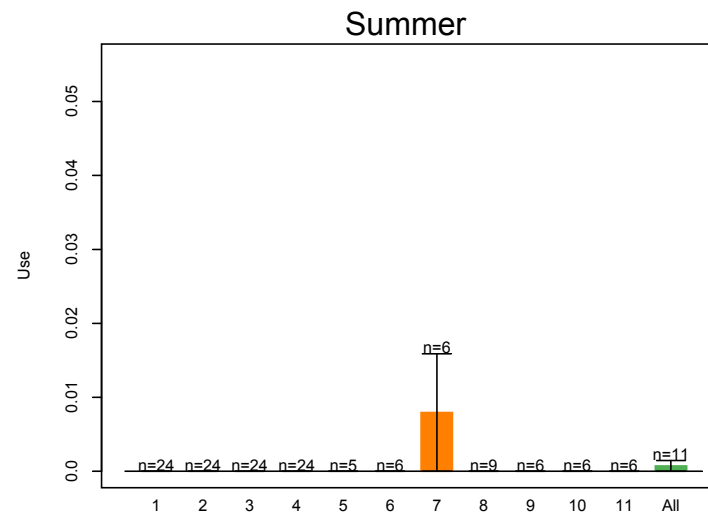
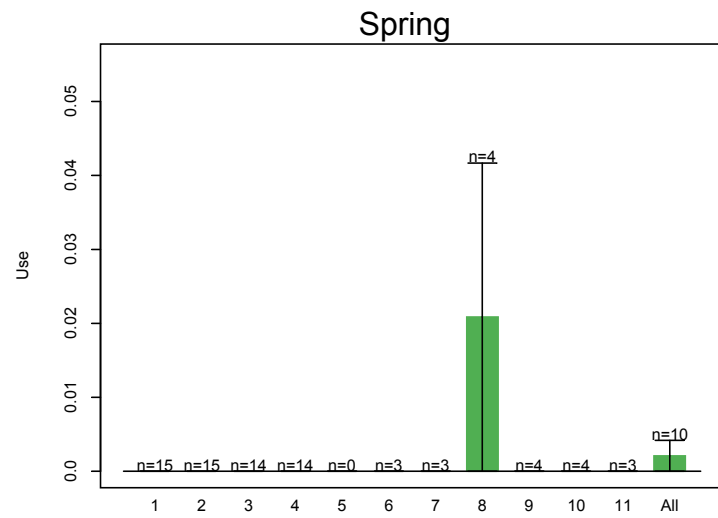


Figure 6. Total eagle use (standardized to #/20-minute survey, primarily golden eagles) for study areas in agricultural landscapes.



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

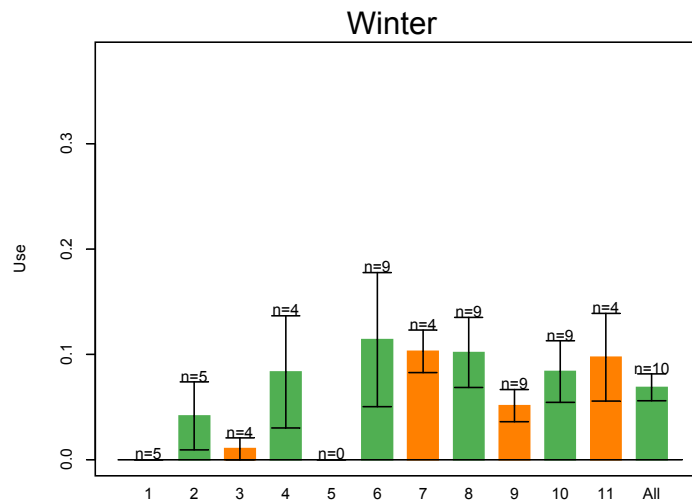
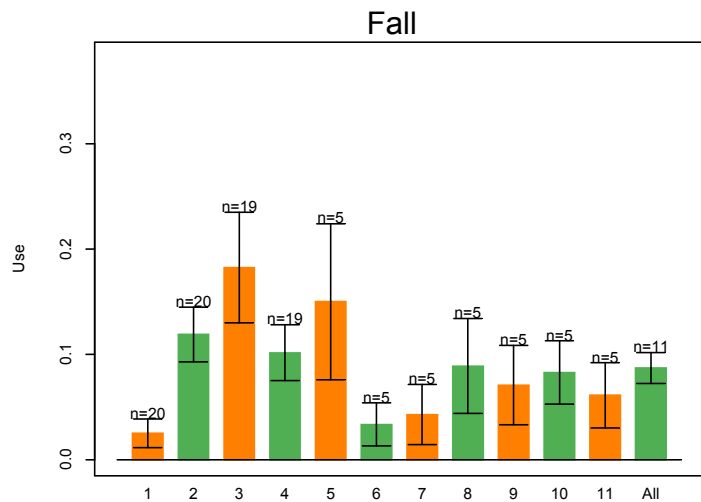
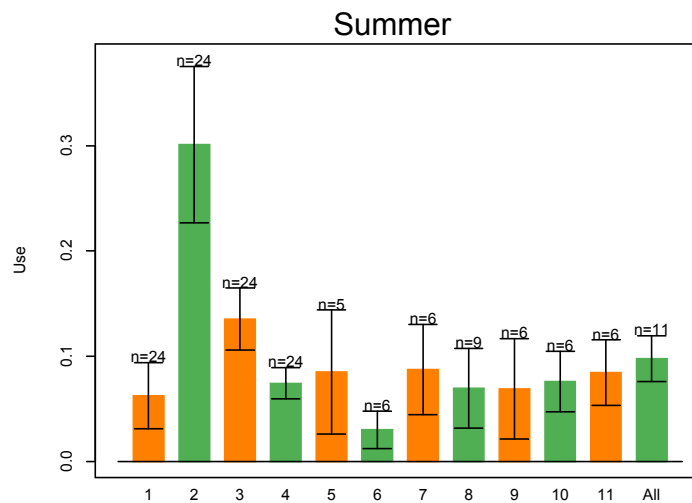
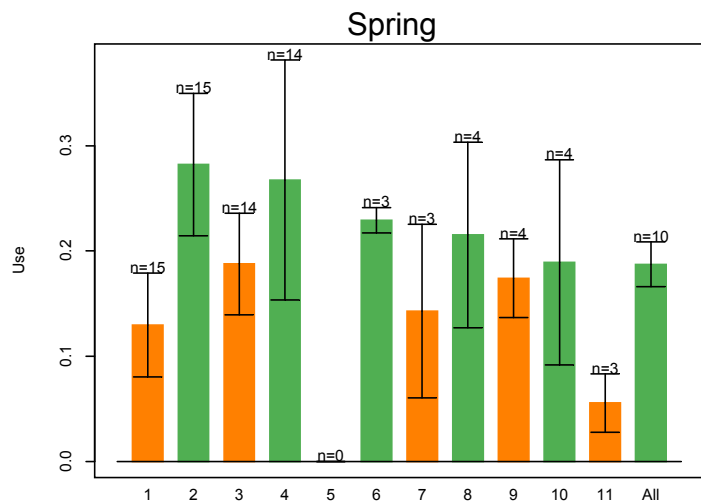


### Agricultural Landscapes

- 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=Statline/Vansycle Reference
- 10=Statline/Vansycle
- 11=Zintel Canyon

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

Figure 8. Total large 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 Geronio PI High
- 8=San Geronio PI Medium
- 9=San Geronio PI Low
- 10=San Geronio PI Water
- 11=San Geronio PII Low
- 12=San Geronio PII Water
- 13=ehachapi Pass East Slope
- 14=Tehachapi Pass Middle Ridge
- 15=Tehachapi Pass West Ridge

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

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

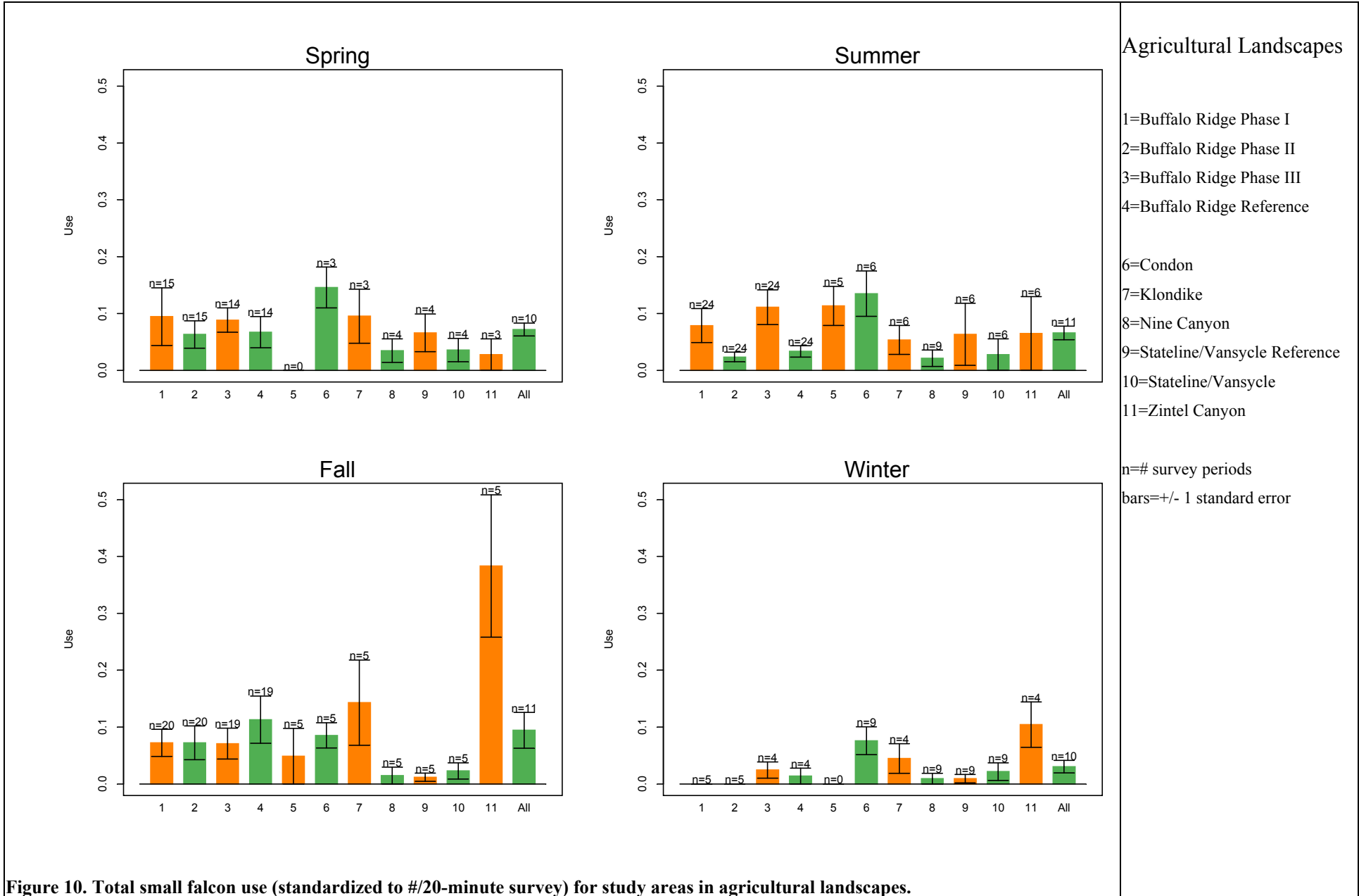
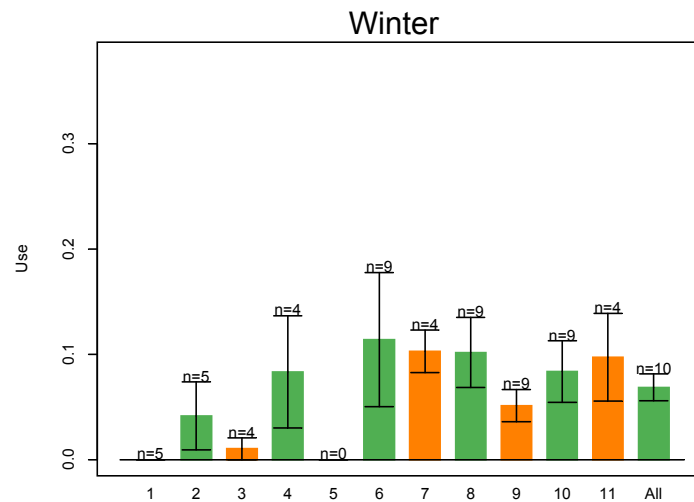
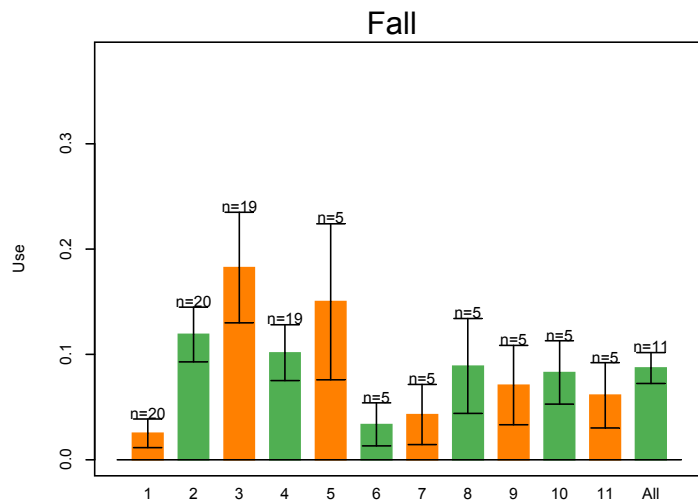
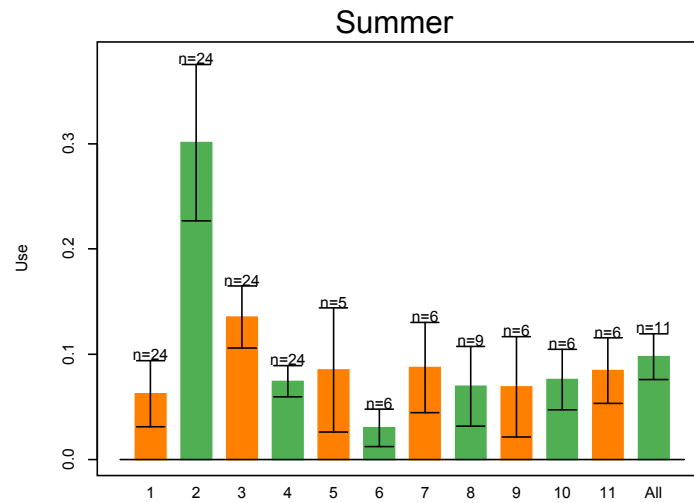
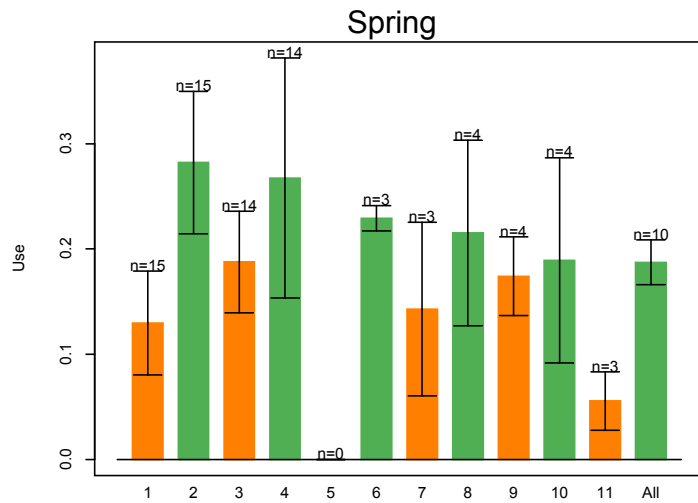


Figure 10. Total small falcon use (standardized to #/20-minute survey) for study areas in agricultural landscapes.





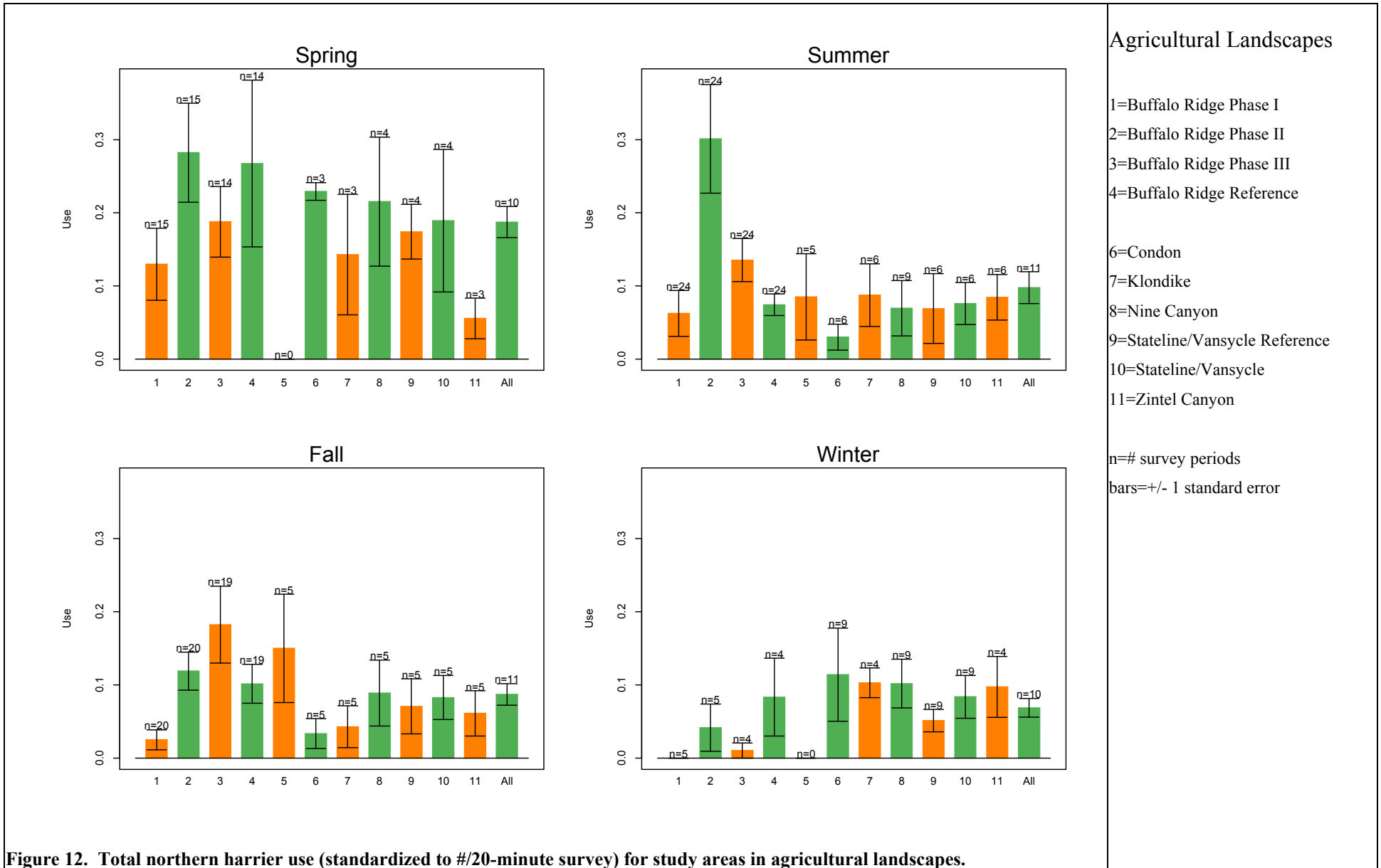
### Native Landscapes

- 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

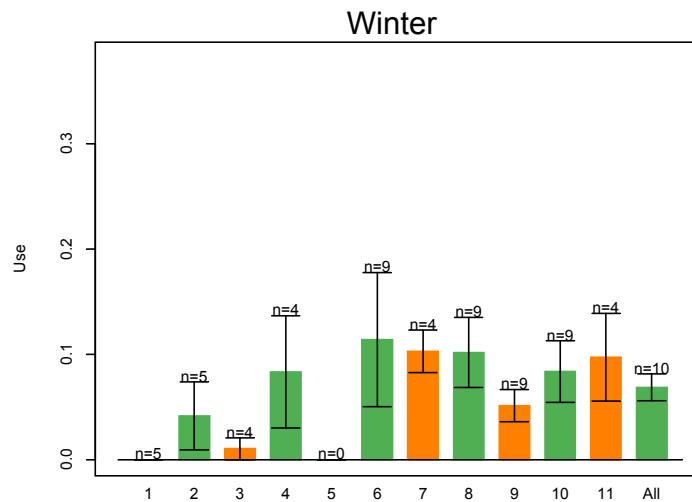
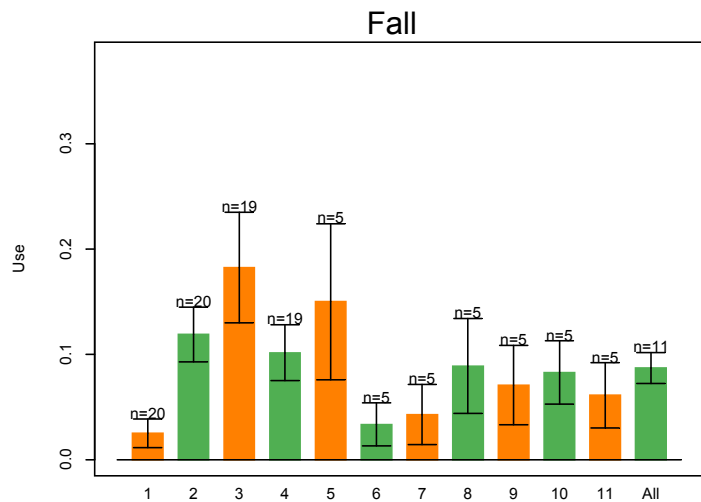
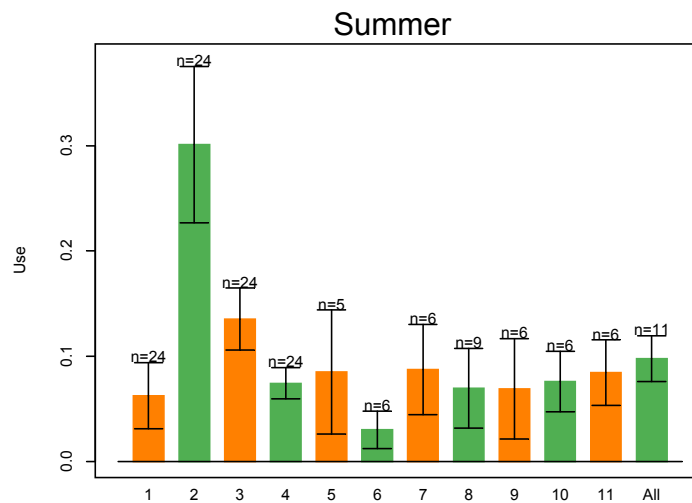
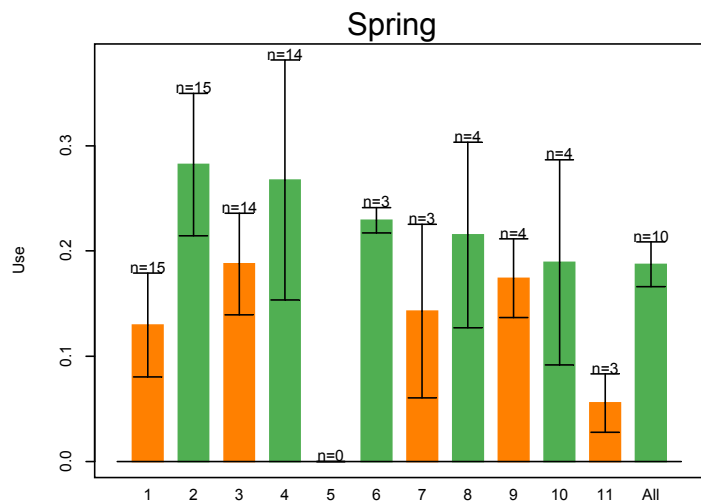
n=# survey periods

bars=+/- 1 standard error

**Figure 11. Total small falcon use (standardized to #/20-minute survey) for study areas in native landscapes.**



**Figure 12. Total 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 Geronio PI High
- 8=San Geronio PI Medium
- 9=San Geronio PI Low
- 10=San Geronio PI Water
- 11=San Geronio PII Low
- 12=San Geronio 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 13. Total northern harrier use (standardized to #/20-minute survey) for study areas in native landscapes.**

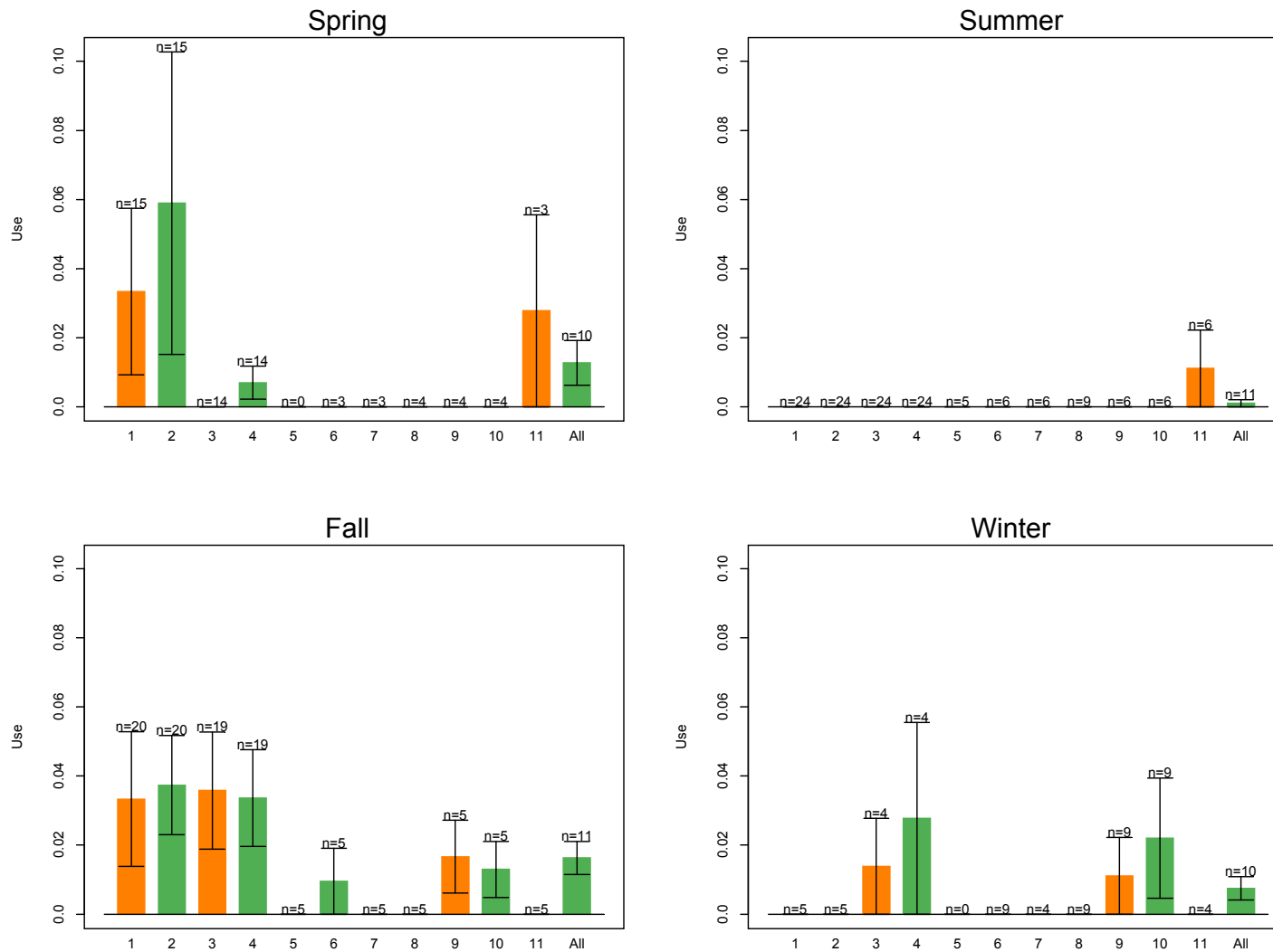
### Agricultural Landscapes

- 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=Statline/Vansycle Reference
- 10=Statline/Vansycle
- 11=Zintel Canyon

n=# survey periods

bars=+/- 1 standard error



**Figure 14. Total accipiter use (standardized to #/20-minute survey) for study areas in agricultural landscapes.**

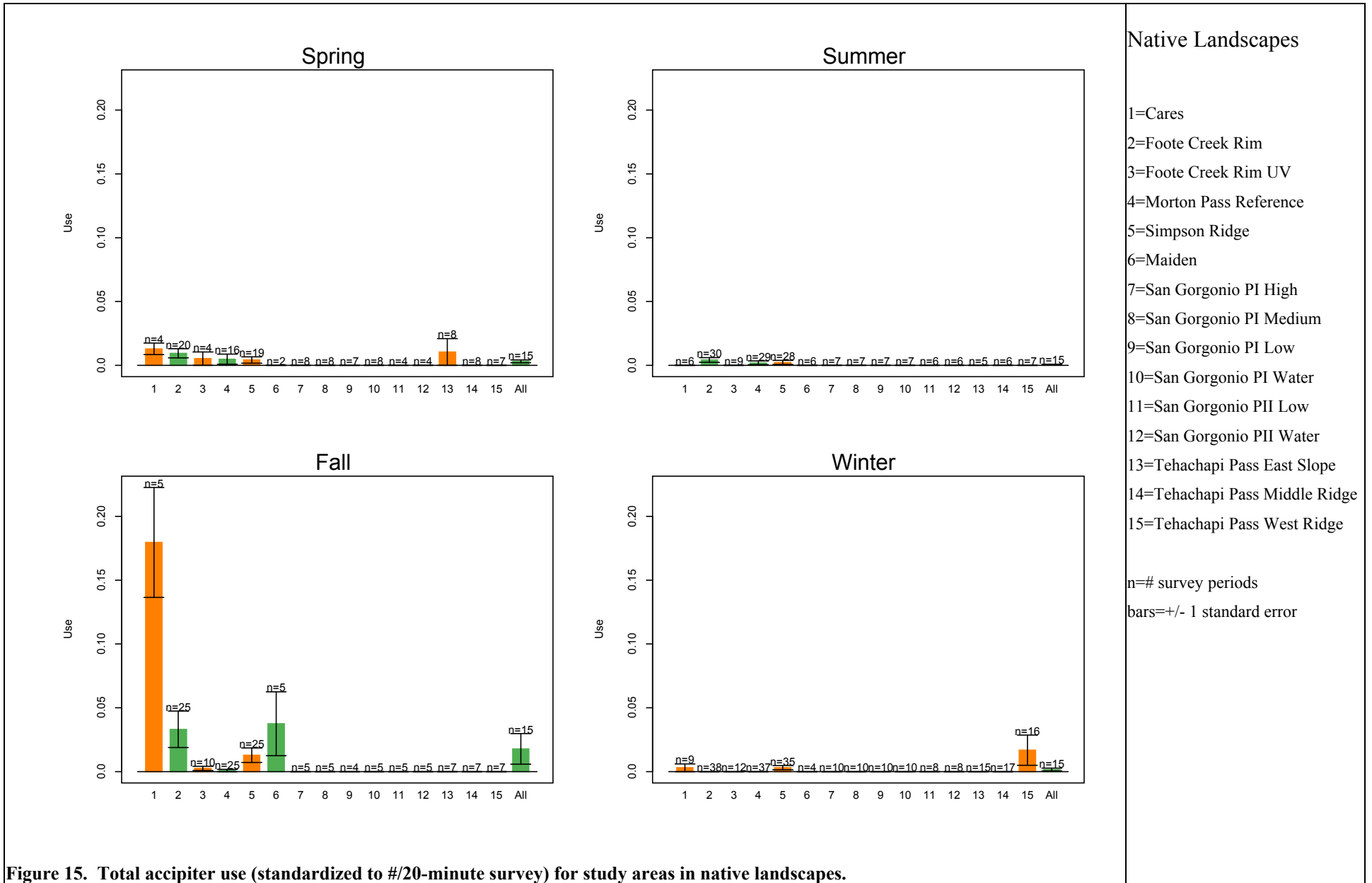


Figure 15. Total accipiter use (standardized to #/20-minute survey) for study areas in native landscapes.

## 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

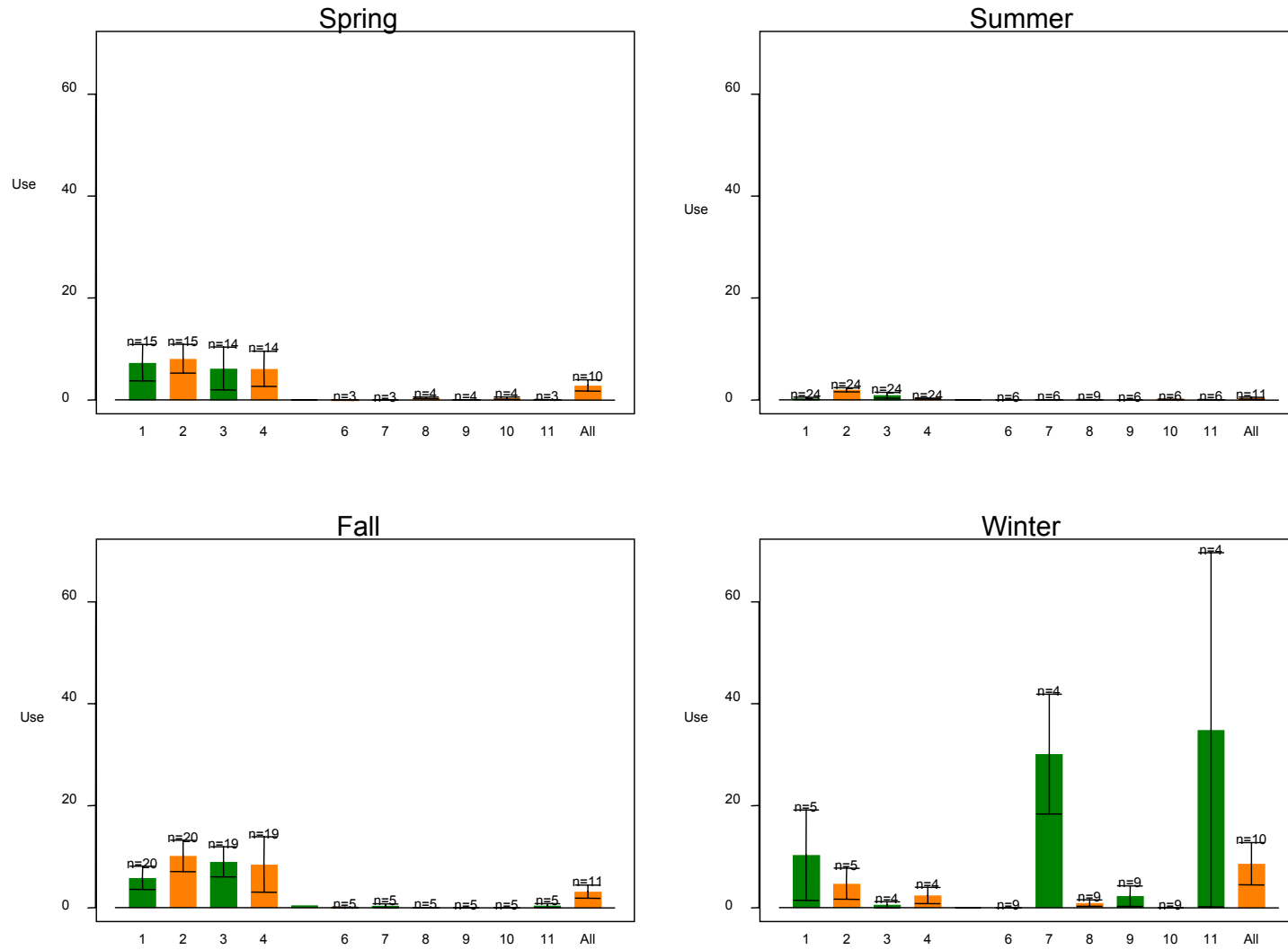
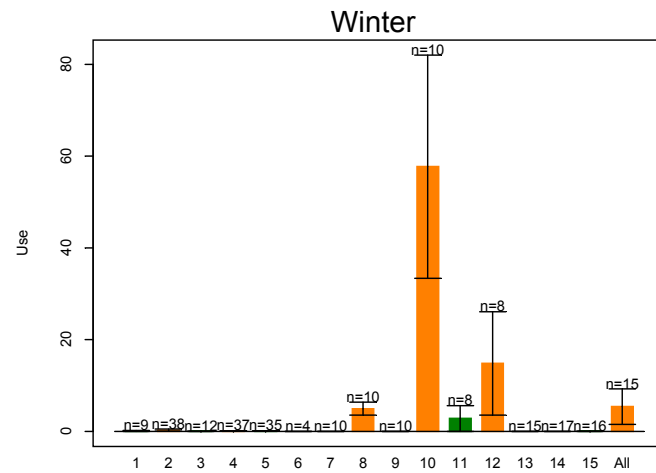
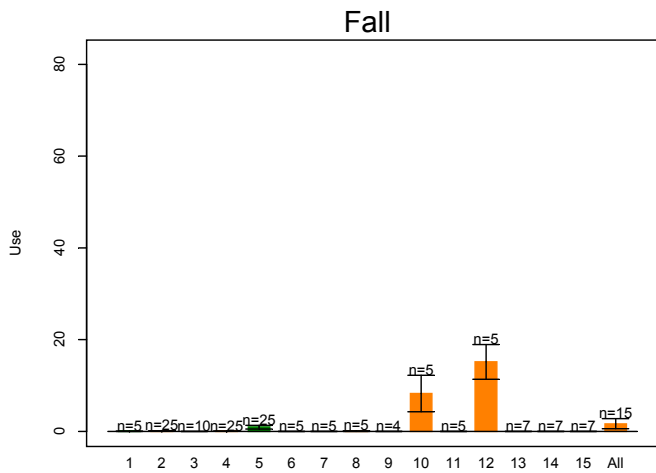
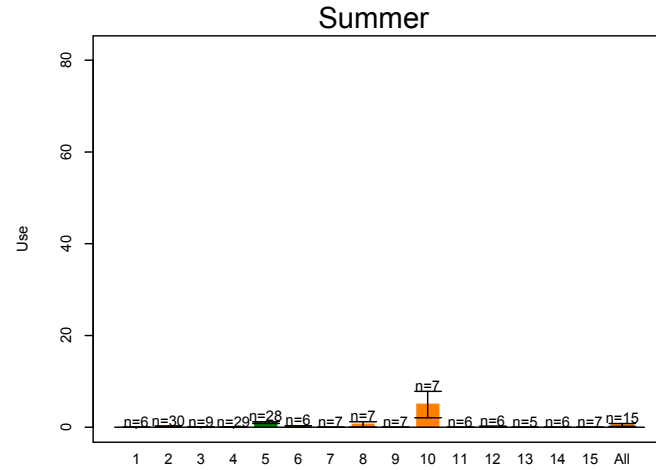
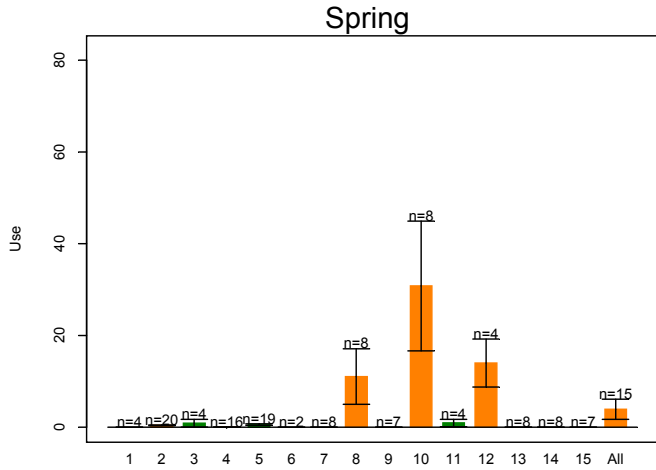


Figure 16. Total waterfowl use (standardized to #/20-minute survey) for study areas in agricultural landscapes.



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

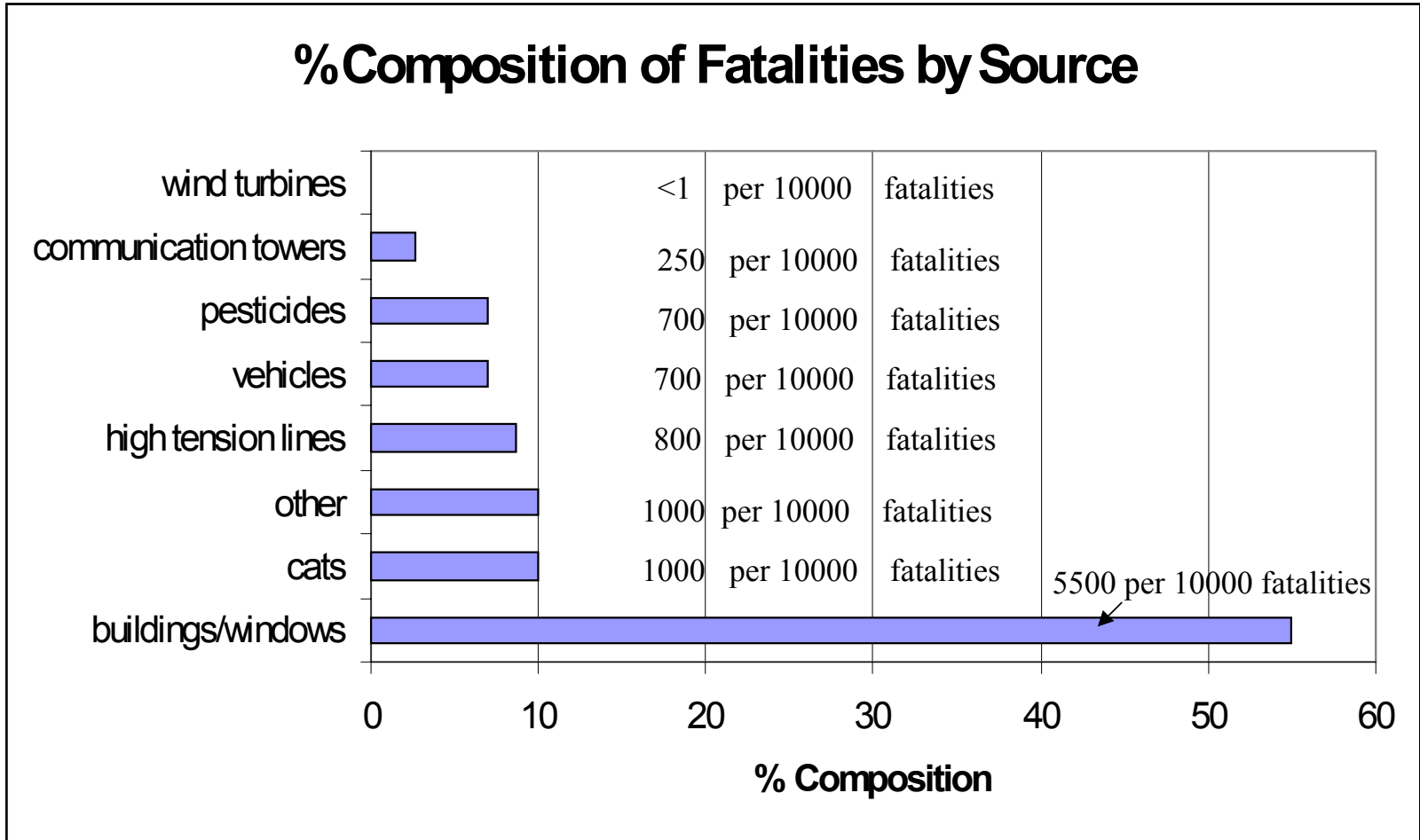
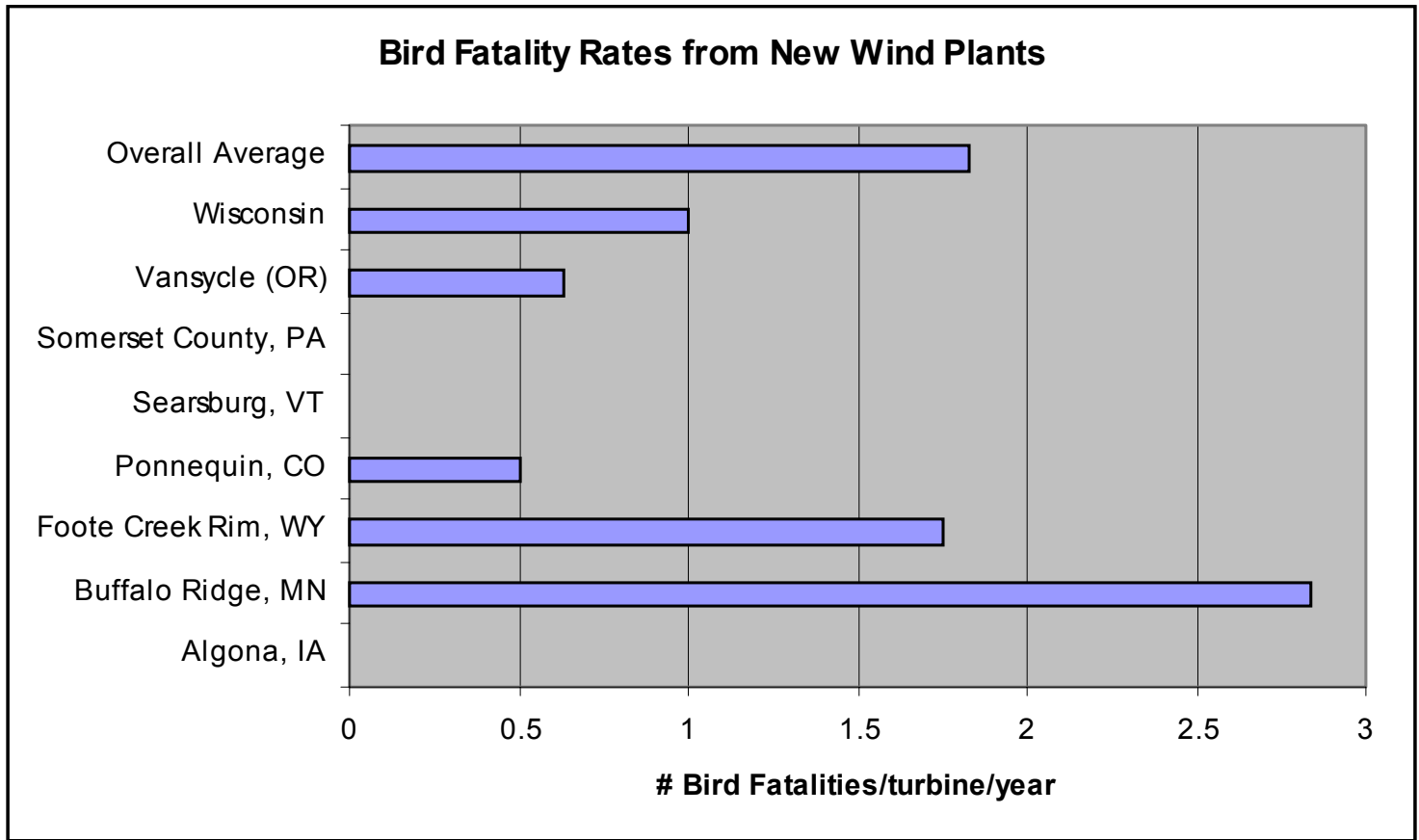


Figure 18. Percent composition of annual bird mortality estimates from various anthropogenic sources (Erickson et al. 2001)





Note: estimates adjusted for scavenging and searcher efficiency in cases when some fatalities were observed.

**Figure 19. Bird fatality rates at wind projects in the U.S. (Erickson *et al.* 2001).**

## **APPENDIX A. REVIEWERS COMMENTS AND RESPONSES.**

Note: In most cases, page number references have been modified to reflect the current draft. It is stated in parentheses if the page number reference is from the original draft.

## **Comments from Dr. Tom Meehan, Biologist, OOE**

Note: comments were received from Tom Meehan over the phone.

**Comment TM-1:** The use of term “indicate”. Recommends that WEST review all places where the term “indicate” is used, and evaluates whether the term “suggest” is more accurate.

***Response TM-1:*** We replaced the term “indicate” with the term “suggest” in most places. We agree that the term “indicate” was too strong in most cases.

**Comment TM-2:** Check use of “native” and “agricultural” before the term site.

***Response TM-2:*** we modified the statements of concern throughout the document. For example, see last two sentences in Executive Summary under waterfowl mortality.

**Comment TM-3:** Throughout the document, use the specific range of dates that data was collected instead of using the term “since” (e.g., since January should say “between January and March, 2002).

***Response TM-3:*** Suggestion made throughout the document.

**Comment TM-4:** Results section. Correlations indicate “use predictions”, not “impact predictions”, would not vary much with one or two seasons worth of data. Impact prediction is based on “use data” and other information such as habitat, raptor nesting, and mortality information.

***Response TM-4:*** See comment TM-5 and response TM-5.

**Comment TM-5:** Results section. Relates to Comment TM-4 above. Add a summary section for each raptor group that includes a discussion of the ability to make impact predictions with less than a year of data for each bird group.

***Response TM-5:*** Suggested summaries added throughout the document.

**Comment TM-6:** Use same # digits of numbers in the text as they are in the tables.

***Response TM-6:*** Suggested changes made throughout the results section.

**Comment TM-7:** Use “[“ instead of “(“ in cases where more than one set of parentheses are found in a sentence.

***Response TM-7:*** Suggested change made.

**Comment TM-8:** Page 5, Executive Summary: Clarify paragraph sentence beginning with “Bat echolocation and collision mortality...” Break up into two sentences.

***Response TM-8:*** Paragraph rewritten below:

“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. This relationship may not exist because many of the migrant species involved may either not be echolocating, or they are flying too high for the bat detectors (Anabat®) to record, but still may be within the zone of collision risk.”

**Comment TM-9:** Page 6, Executive Summary, under **Seasonal Avian Use**, 2<sup>nd</sup> paragraph. Clarify that the cases where one season appears adequate is for “all raptors” as a group, and buteos and golden eagles.

**Response TM-9:** 1<sup>st</sup> two sentences of paragraph now reads:

“In most cases we investigated (e.g., most raptor groups), baseline avian use data collected during one season (usually spring, summer or fall) appear adequate for making overall wind plant direct impact predictions (e.g., low, moderate or high relative mortality). Moderate to high correlations between seasonal use estimates and overall use estimates exist for most of the raptor groups considered, especially all raptors/vultures combined, buteo, golden eagle, northern harrier and large falcons.”

**Comment TM-10 and TM-11:** Page 8, Executive Summary, Overall Conclusions, #3, change term “most” to “many”. Change term “eagles” to “golden eagles”.

**Response TM-10:** Conclusion #3 now reads:

“3. In the majority of the raptor groups we investigated (all raptors combined, buteos, golden eagles, northern harriers, large falcons), 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 relative mortality). This appears to be especially true for sites in agricultural settings. Correlation analyses, in general, suggest overall use predictions for these groups based on one or two seasons of information would be similar to predictions from a four-season study. As a result, sites can be ranked in terms of overall raptor, buteo, golden eagle and large falcon use reasonably well based on one season of data collection (spring, summer or fall), compared to four seasons of data collection.”

**Comment TM-12:** Page 8, Executive summary, Overall Conclusions, #4: Use the term “most” instead of “many”. Get rid of term “between” in parentheses. Add term “baseline” before “data to refine predictions”.

**Response TM-12:** Conclusion #4 has been reworded based on several reviewers suggestions:

“In cases where baseline data or other information (e.g., historic data or habitat) indicate a site has levels of raptor use considered high (regionally high, or in comparison to use at other projects considered high (e.g., Altamont Pass (CA) and Foote Creek Rim (WY) golden eagle use estimates), we recommend collecting more than one season of baseline data to refine predictions and to make micro-siting decisions that might reduce impacts. Sites with high raptor use, and comprised of large tracts of high quality native habitat with 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 project sites within agricultural landscapes do not typically meet any of these criteria and are therefore not strong candidates for effective micro-siting.”

**Comment TM-13:** Reorder the bat conclusions. Move overall conclusion #10 before #9.

**Response TM-13:** Suggestion made.

**Comment TM-14:** Introduction, page 10, 3<sup>rd</sup> paragraph, 1<sup>st</sup> sentence. Add the terms “appear to” before reduced.

**Response TM-14:** Suggestion made.

**Comment TM-15:** Page 16-17, RESULTS AND DISCUSSION, Avian Mortality and Use. Check % composition results against table.

**Response TM-15:** Made corrections to the text.

**Comment TM-16:** Page 19, All Raptors/Vultures, 2<sup>nd</sup> paragraph, add reference to Table 8 at end of first sentence.

***Response TM-16:*** Suggested change made.

**Comment TM-17:** Page 22, Buteos, Agricultural Landscapes. Clarify first sentence.

***Response TM-17:*** Sentence now reads:

“For study areas within agricultural landscapes, buteo use averaged across all study areas was very similar among seasons (0.2 to 0.3/20-min survey, Table 9, Figure 4), although this pattern was not consistent within study areas.”

**Comment TM-18:** Page 26, Falcons, towards bottom of page, give a reference to “(e.g., 0-0.03 American kestrels per turbine per year)”.

***Response TM-18:*** We added a new section for small falcons. The statement was only for illustration. We removed the statement.

**Comment TM-19:** Page 37, 1<sup>st</sup> partial paragraph, Clarify sentence that starts with “Eagle nest density”.

***Response TM-19:*** Sentence now reads:

“Golden eagle nest density within 2 miles of the WRA is one active nest per 11.3 miles<sup>2</sup>.”

## **Comments from Lynn Sharp, Project Manager, URS Corporation**

Note: comments were handwritten on a hard copy of the document.

**Comment LS-1:** Executive Summary, Page 5. Change term “potential” to “potentially”.

***Response LS-1:*** Change made.

**Comment LS-2:** Page 7, Overall Conclusions, #5. Use term “low” instead of “little”.

***Response LS-2:*** Change made.

**Comment LS-3:** Need a disclaimer that none of the other wind plants have been sufficiently studied to indicate whether mortality may be affecting local populations.

***Response LS-3:*** Specified that data from only Buffalo Ridge is the basis for the conclusion.

**Comment LS-4:** Page 18, add “per year” after reference mortality estimates.

***Response LS-4:*** Change made.

**Comment LS-5:** Page 19, clarify first two sentences.

***Response LS-5:*** Sentences now read:

“Within agricultural landscapes, average total raptor/vulture seasonal use estimates (averages across the study areas) were highest in the spring (0.598), followed by followed by fall (0.525), summer (0.413) and winter (0.385), suggesting low variability among average seasonal estimates. Average use for individual study areas ranged from 0.258 to 0.602 raptors/20-minute survey, suggesting relatively low variability in four-season use estimates among study areas as well.”

**Comment LS-6:** Page 22, Buteos, Agricultural Landscapes. Clarify first sentence.

***Response LS-6:*** Sentence now reads:

“For study areas within agricultural landscapes, buteo use averaged across all study areas was very similar among seasons (0.2 to 0.3/20-min survey, Table 9, Figure 4), although this pattern was not consistent within study areas.”

**Comment LS-7:** Page 27, Falcons. Given their different lifestyles, why combine falcons? What happens when you do things separate?

***Response LS-7:*** We have now separated analyses for small falcons from large falcons.

**Comment LS-8:** Page 27, Falcons, first sentence. Tehachapi Pass should be study area with 2<sup>nd</sup> highest falcon use.

***Response LS-8:*** Correction acknowledged. The new sections on small falcons and large falcons contain the correct information.

**Comment LS-9:** Page 28, Falcons: Suggest changes to the following sentence: “At likely all of the wind development areas summarized in this report, the most abundant falcon is the American kestrel, which often breeds locally in spring and summer but then migrates in the fall and is either absent or occurs at very low densities during the winter.”

***Response LS-9:*** Sentence reworked in small falcon section on page 28. One sentence now reads:

“American kestrels, which make up most of the use in this group, often breed locally in spring and summer but then migrate in the fall and are either absent or occur at very low densities during the winter (except for in some CA study areas).”

**Comment LS-10:** Falcon section. Need a better transition beginning with sentence “Impact projections (# fatalities per turbine per year)...”

***Response LS-10:*** Removed those statements.

**Comment LS-11:** Accipiter/Harrier section. Why combine accipiters and harriers?

***Response LS-11:*** These were combined out of convenience. Harriers make up >95% of observations. We have now separated out northern harriers from accipiters and provided results for both.

**Comment LS-12:** Page 34, Passerines. Why don’t you present “Passerine” use like you do “raptors”.

***Response LS-12:*** Surveys and methods used for gathering avian use is most reliable for large birds such as raptors, waterfowl and waterbirds, and observers only recorded large birds at several projects.

**Comment LS-13:** Be consistent with using “%” and “percent”, and number reporting (four-year versus 4-year).

***Response LS-13:*** Changes were made throughout the document for consistency.

**Comments from Gail McEwen, ODFW, Acting Land Resources Program Manager,  
Habitat Division**

Note: comments were included in a letter to WEST.

**Comment GM-1:** The Department agrees that in some cases, particularly for sites in agricultural settings, the level of baseline data needed to adequately assess the expected impacts of a project on certain species may be reduced. However, the wording of Conclusion 2 (Conclusion 3 in this version), which states that baseline avian use data collected during one season appears adequate for making overall wind plant direct impact predictions in “most” cases appears to overstate the data in the Meta-Analysis. Here are some examples:

1. Eagles. Page 23 of the Meta-Analysis states “Relatively high correlations exist between use estimates among seasons (0.66 to 0.98), indicating eagle use in one season is indicative of eagle use in other seasons and for the entire year”.

This statement would not hold true for all species of eagles in all locations in Oregon. The report notes that approximately 95% of the eagle observations in these data sets are of golden eagles (page 23). Because bald eagles forage close to water they may be more concentrated in a given area than golden eagles. In addition, certain areas of Oregon (such as the Klamath Basin) have higher concentrations of bald eagles during winter and spring. In areas with high bald eagle concentrations during winter and spring, surveys conducted during the summer or fall would not be indicative of bald eagle use.

***Response GM-1:*** We have changed the heading from “eagles” to “golden eagles”, so that it is understood the results are relevant to golden eagles and not bald eagles. See response 2 for additional changes to the details.

**Comment GM-2:** Similar concern as in comment 1, but focused on falcons.

2. Falcons Section. Page 25 (draft) of the Meta-Analysis states:

“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 can not be used to predict spring or summer use. Correlations of any one season to overall falcon use were moderate (0.55 to 0.69).”

***Response GM-2:*** We have separated the analysis of falcons into two groups, small falcons (primarily American kestrels) and large falcons (primarily prairie falcons) because of the difference in behavior and abundance of the two groups. The results for small falcons follow the previous results for all falcons (i.e., high variability). The results for large falcons show much less variability, and this group makes up a very small percentage of total falcon use. We have also added the list of groups the results are most relevant to (see below) Conclusion 3 (see response GM-1, originally conclusion 2).



**Comment GM-3:** Similar concern as in comment 1 and 2, but focused on Waterfowl/Waterbirds.

Waterfowl/Waterbirds. Page 32 (28 in draft) of the Meta-Analysis states that “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.” This information suggests that in cases where waterfowl or waterbirds are species of concern (due to the proximity of a project to open water for example), one season of baseline data might not be sufficient to assess a project’s potential impact on waterfowl.”

In addition, if a site contains multiple species of concern one season of baseline data might not adequately predict impacts for all species (for example, winter surveys might be best to predict a project’s impacts on Species A, but spring surveys might be best to predict a project’s impacts on Species B.)

***Response GM-3:*** See response GM-1 and GM-2 above, and we added two paragraphs to emphasize the need for targeted species/group surveys at some projects:

Methods Section:

“At some projects, additional species-specific data may have been collected that targeted a particular sensitive species. For example, mountain plover surveys were conducted on Foote Creek Rim prior to and after construction. Winter bald eagle surveys have been conducted at some projects where this species was of concern. This meta-analysis does not attempt to synthesize these species/project specific data sets, although we acknowledge that often these targeted surveys are required.”

Results Section, Waterfowl/Waterbird Summary/Impact Projections:

“Waterfowl and waterbird mortality has occurred at several wind projects, but apparently in very low numbers relative to the waterfowl/waterbird use of those sites. Correlations of seasonal use to overall use were moderate. At many of the Pacific Northwest sites in agricultural settings, most waterfowl use (especially Canada geese) occurred during the winter. If impacts to waterfowl are considered important at these sites, then surveys should be concentrated during the winter.”

**Comment GM-4:** Page 1 of the Meta-Analysis states, “This report also suggests that the level of baseline data required to adequately assess expected impacts of some projects may be reduced.” We believe this statement is more consistent with the data in the Meta-Analysis than the wording of Conclusion 2. We recommend that Conclusion 2 be amended to be consistent with this statement.

***Response GM-4:*** Conclusion 2 has been reworded (see responses GM-1, GM-2 and GM-3).

**Comment GM-5:** Conclusion 3 (now conclusion 4) reads (in part):

“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.”

The Department agrees that more than one season of data may be needed in some cases to refine predictions and to make micro-siting decisions. We also agree that the amount of raptor use should be one of the factors considered to determine if micro-siting is warranted. Our concern is with using Foote Creek Rim and Altamont Pass estimates as benchmarks for determining whether raptor use at an Oregon project site is “high”. “High” raptor use should be determined by considering raptor use in the locality or state, not by comparison to raptor use in Wyoming and California.

For example, the Klamath Basin has high winter raptor use. Birds have been observed following the ridgelines because of the juxtaposition between the ridges and lakes. If wind projects are proposed along these ridgelines, micro-siting (i.e. guiding placement of turbines within a project boundary) may be appropriate to reduce the potential for impacts on raptors, regardless of whether raptor use of the site reaches the level of use at Foot Creek Rim and Altamont Pass.

We recommend that the reference to Foote Creek Rim and Altamont Pass estimates be deleted from Conclusion 3 (now 4).

***Response GM-5:*** Conclusion 4 (3 in original draft) now reads:

“In cases where baseline data or other information (e.g., historic data or habitat) indicate a site has levels of raptor use considered high (regionally high, or in comparison to use at other projects considered high [e.g., Altamont Pass (CA) and Foote Creek Rim (WY) golden eagle use estimates]), we recommend collecting more than one season of baseline data to refine predictions and to make micro-siting decisions that might reduce impacts....”

We have furthermore added a new conclusion (2) that states:

2. “The amount and extent of ecological baseline data to collect at a wind project should be determined on a case-by-case basis. The decision should use information gained from this report, recent information from new projects (e.g., Stateline OR/WA), existing project site data from agencies and other knowledgeable groups/individuals, public scoping, and results of vegetation and habitat mapping. Other factors that should also be considered include the likelihood of the presence of sensitive species at the site and expected impacts to those species, project size and project layout.”

### **Comments from David Mudd, WDFW, large projects**

Note: comments were received via an email message.

**Comment DM-1:** I would be interested in your thoughts about whether you intended this study to be interpreted as the final definitive word about seasonal vs. a year round survey. My reply has been if the proponents want to shift more uncertainty and risk to the public's wildlife resources, the proponents should be willing to offer up greater contingencies if monitoring results show the impacts are greater than expected.

***Response DM-1:*** We did not intend this report to be the final word regarding seasonal vs. a year round survey. We have synthesized the available data, and made some general recommendations regarding the level of baseline data that is likely sufficient to make relatively accurate impact predictions in a lot of cases. The data that is available now greatly enhances our ability to predict impacts at new projects. We have much less uncertainty because of the baseline and monitoring data collected at several new wind projects. Without this large source of information, we likely would be recommending more than one season worth of baseline data for predicting impacts. We do believe that an adaptive management approach should be used after the project is built and some operational monitoring data is collected. If the predictions of impacts are lower than what is estimated from operational monitoring data, then additional mitigation/monitoring may be appropriate. This adaptive management approach is recommended in cases where a full year of baseline data is collected, or one season is collected. We should also note that projects proposed in Kittitas County, Klickitat County, and Columbia County are collecting more than one season worth of data because of the recommendations made in the meta-analysis document. We have added a new conclusion that reinforces that the need for and the level of baseline data should be evaluated on a case-by-case basis.

**Jeff Bernowitz, WDFW, habitat biologist, Yakima**

Note: comments were received via an email message.

**Comment JB-1:** As stated at the June 4th meeting, in my opinion, a rough analysis of the degree of threat to the species population needs to be incorporated. The number of birds killed doesn't mean much unless you have an idea of the initial population size, survival and reproductive potential, etc. If a wind project is expected to kill 20 buteos, some are likely to say this is a significant impact and the project shouldn't go through. If the 20 buteo's are red-tailed hawks, and the population is 5 million adults producing and estimated 5 million juv's with an 80% survival, I'd be inclined to think the mortality is insignificant or compensatory.

Through such an analysis, we could hopefully get agreement on where to focus survey effort and/or mitigation.

***Response JB-1:*** We agree that the significance of the mortality should be evaluated by taking into account the population in question. In most cases, a "population level" impact can reasonably be excluded as a possibility because of the expected very low mortality and because of what is known regarding the abundance of the species. In most cases, this determination can be made with very little new data. When impacts to a "population" are even remotely possible, some evaluation of the likelihood of such impacts should be made based on the baseline data collected (e.g., raptor nesting) and other existing information.

**Comments from Dr. Burr Betts, Eastern Oregon College**

**Comment BB-1:** Bat Use and Mortality Section. Recent studies of silver-haired bats documented that reproductive females will roost in cavities in colonies.

***Response BB-1:*** Correction made and citation added.

## Comments from Two Ravens Inc., a biological consulting firm in La Grande, Oregon

**Comment TR-1:** The fact that raptor mortality on newer generation wind projects has been substantially lower than that documented at Altamont Pass (Conclusion #1) is heartening. However, we are not inclined to agree that a single season of baseline avian use data will necessarily suffice for impact prediction (Conclusion #2 (now #3)). What season should be selected? The report later states that (at a minimum) summer and winter raptor use varies in degree and species composition, depending on factors such as habitat and prey availability. Waterfowl use at wind sites is best predicted with 2 or 3 seasons of data (page 28). Passerine (and bat) impacts are most likely related to migration. At any given site, are the seasonal avian use patterns and species occurrence predictable prior to conducting seasonal surveys? Not with the accuracy needed for impact assessment, we'd bet.

**Response TR-1:** We demonstrated through defensible statistical analysis that year-round average use for several raptor groups can be predicted reasonably well with one season of data. This avian use data from one season, habitat information, and raptor nesting data, plus the large amount of additional information that is available from other projects (mortality and use), together is likely sufficient in many cases to predict impacts of a wind project of those groups.

**Comment TR-2:** We agree with Conclusion #3 (now #4), which recommends more than one season of data collection in areas where micro-siting of turbines could be important. We also feel that surveys should cover more than one season to adequately address the occurrence of migrant and wintering species at a wind site. We disagree with a second concept brought up in Conclusion #3 (now #4)—that it would be feasible and adequate to use one season of data to prepare a Draft EIS and plug in additional seasons of data for the Final EIS. The DEIS is supposed to be sufficient for public review and comment, addressing all known and potential impacts. Final EIS's are intended to respond to comments, concerns, and deficiencies identified during review of the Draft. In our experience, Finals are generally rubber-stamped by the Decision Document. This suggestion probably arose from the earlier perceived necessity to construct wind projects prior to 31 December 2003. It now appears that this deadline is moot.

**Response TR-2:** The PTC may be extended, but at this time it has not been. We removed most of the discussion, and also removed the discussion regarding the DEIS and FEIS.

**Comment TR-3:** We agree with Conclusion #4 (now #5), that raptor use data may give some prediction of raptor mortality risk; and that such data can be used in turbine siting, which may reduce mortality. The objection that this has not been experimentally tested is valid. However, an adequate "test" might result in undesirable raptor mortality.

**Response TR-3:** Comment noted.

**Comment TR-4:** Conclusion #5 (now #6) would appear to suggest that wind plants be sited away from significant waterfowl use areas. However, the level of waterfowl mortality is apparently not significant. We don't know the reason for emphasis on Canada geese, as many other waterfowl species are less abundant. We know of no area where (low) Canada goose populations are a concern. (Quite the opposite.)

**Response TR-4:** State agencies have brought up concerns over waterfowl, especially as they relate to hunting.

**Comment TR-5:** Proximity of nesting raptors does not appear to be predictive of collision mortality (Conclusion #7). However, we feel that nest surveys should be conducted at wind sites to allow tower siting decisions that minimize raptor nest disturbance.

***Response TR-5:*** Raptor nest surveys are conducted at most new wind projects to identify locations of nests in relationship to location of project facilities. This information is used in siting turbines and in possible construction timing restrictions.

**Comment TR-6:** Regarding bats (Conclusions #8 through 11 in original, now #9-11), we are not convinced that wind generating facilities are not having a substantial impact on bats. Although resident bats do not appear to be affected, mortality of migrants could certainly be affecting populations somewhere. The period of record for bat mortality data (3-4 years?) may not be long enough to register the kind of massive decline that might need to occur to actually decrease the number of migrant bats killed in successive years. As noted in the text, bats have a relatively low reproductive rate. Unlike the case of birds, or larger mammals, there are no solid distribution or abundance data for bats. This leaves bats as a vexing problem. If we don't know how many we have, where they live, or what their habits are, how are we to adequately assess impacts? We have no answer for this concern. As noted in Conclusion #9, most bats being killed are probably high-flying, non-echo-locating migrants. There is currently no way to survey such animals.

***Response TR-6:*** We have qualified the conclusion regarding bat population impacts so that it is clear the statement pertains to Buffalo Ridge and that it is a preliminary result based on 5 years of bat mortality data. Some studies are being conducted to better understand the wind turbine/bat interactions as noted in the text.

**Comment TR-7:** We found the report somewhat repetitive. The 8+ page Executive Summary includes (verbatim) the same two pages of Overall Conclusions that appear at the end of the report.

***Response TR-7:*** We included the conclusions in both the Executive Summary and the main body of the report because some may only read the Executive Summary.

**Comment TR-8:** We appreciate the vast amount of data summarized by the report, but found many instances of overly complex, confusing, or poor wording. This was especially evident in the raptor sections, during discussion of average and overall, seasonal and site-specific, use indices.

***Response TR-8:*** We attempted to clarify some of the text when discussing seasonal raptor use data, although the large amount of data used in the report makes it difficult to present the results in much more of a reduced form. We believe the Executive Summary provides that reduced form.

**Comment TR-9:** The PTC discussion should be revised or removed if recent Congressional action has rendered the 31 December 2003 deadline moot.

***Response TR-9:*** The PTC may be extended, but at this time it has not been. We have removed most of the discussion of the PTC.

**Comment TR-10:** We disagree with the statement that great horned owls are among the species efficiently surveyed from the air. Nests in inconspicuous potholes and abandoned buildings are quite common. Plus nesting chronology frequently puts their fledging date ahead of normal buteo survey timing.

***Response TR-10:*** More than one survey is often conducted to better represent the variations in timing of nesting. We agree with the comment regarding great horned owl nest locations and have changed the wording of the text to:

“We included raptor species that are efficiently surveyed from the air (e.g., buteos, eagles, great horned owl nests in trees)...”

**Comment TR-11:** The attempt to define biologically-based (rather than calendar-based) “seasons” is admirable. Even so, these may not apply equally well in the wide variety of regions covered in this report.

***Response TR-11:*** Comment noted, but we felt the approach was reasonable.

**Comment TR-12:** It would be appropriate to note in Methods that “correlations” of seasonal avian use estimates are Pearson correlation factors. This bit of information must otherwise be discovered in Table 8.

***Response TR-12:*** We added the term “Pearson” correlations in the methods.

**Comment TR-13:** We dispute the assertion that “the typical flight heights of diurnal raptors have been found to be lower than the rotor-sweep height of the new-generation turbine blades...” (later given as 25 meters). In our experience, typical raptor flights (except for northern harriers) often include periods at heights equal to or greater than 25 meters.

***Response TR-13:*** The statement was removed. The intent was to emphasize the stooping and hunting behaviors of golden eagles observed at Altamont, but that was not conveyed by the statement.

**Comment TR-14:** There is an apparent contradiction in falcon discussion. Page 25 (original draft) states that American kestrels migrate out of WRAs in fall, but Page 26 (original draft) states that highest mean falcon use is in fall, and this is attributed to American kestrels.

***Response TR-14:*** Statement clarified:

“American kestrels, which make up most of the use in this group, often breed locally in spring and summer but then migrate in the fall and are either absent or occur at very low densities during the winter (except for some CA study areas).”

**Comment TR-15:** We question the value of combining and averaging the seasonal estimates of raptor use at all sites in all regions. Impacts need to be assessed on a case-by-case or site-by-site basis. When the locations of sites in the analysis range from CA ÷ WA ÷ OR ÷ WY ÷ MN ÷ TN, there will certainly be regional (and probably site-specific) differences in raptor species and use levels. We do not find the average across the various regions terribly meaningful. However, the range of use among the sites gives one an idea of the range in impacts that might be expected.

***Response TR-15:*** Impact assessment is made on a site-by-site or case by case basis using all available information, including data on raptor use and mortality (e.g., for buteos) from other projects. The average use, ranges and variability are discussed throughout the document and all three parameters as well as direct mortality estimates from projects are useful for predicting impacts at a new project.

**Comment TR-16:** Were accipiters and harriers combined (Page 27 original draft) merely because they were raptors of relatively minor occurrence? There are no behavioral or biological reasons to lump these species—flight habits, prey, and habitat use differ greatly.

***Response TR-16:*** We combined accipiters and harriers out of convenience, but these have been separated in the final version.



**Comment TR-17:** A short description of the method of calculating estimated avian and bat mortality would be appropriate. We assume the estimate is based on the number of carcasses found, adjusted for search bias factors (as noted for bats on Table 21). We would also assume some adjustment factor for the probability that scavengers and predators carry off some carcasses. If this latter factor is not included, mortality estimates are probably very conservative.

***Response TR-17:*** The bird mortality estimates include adjustments for searcher efficiency and scavenging. For a discussion of the estimators see (Erickson *et al.* 2000a) and other references in the document. We have included some discussion of the conservative nature of the estimates (over estimate of true fatality rates), because fatalities where cause of death cannot be determined are often included in the estimates.

**Comment TR-18:** The details and history of bat collisions (Page 32 original draft), while interesting, could probably be reduced to a couple of sentences indicating that the phenomenon has been known to exist.

***Response TR-18:*** We are glad you feel the discussions of details and history of bat collisions are interesting. We decided to include this discussion because this information is likely not readily available, and because we were asked to provide detail on the interactions of bats and wind turbines from Oregon Department of Fish and Wildlife.

**Comment TR-19:** We are told in the bat results section that bat mortality at lighted and unlighted turbines at Buffalo Ridge was roughly equal. Were the proportions of lighted and unlighted turbines roughly equal as well? If so, say so.

***Response TR-19:*** We clarified that approximately half of the turbines sampled were lighted, and the other half were not lighted.