Appendix B. Pre-construction Monitoring Studies

Wildlife Baseline Studies for the High Plains Wind Resource Area Carbon and Albany Counties, Wyoming

Final Report
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EXECUTIVE SUMMARY

PacifiCorp has proposed a wind-energy facility in Carbon and Albany Counties, Wyoming, near the towns of Rock River and McFadden. CH2MHILL contracted Western EcoSystems Technology, Inc. to conduct surveys and monitor wildlife resources in the High Plains Wind Resource Area to estimate the impacts of project construction and operations on wildlife. The following document contains results for fixed-point bird use surveys, raptor nest surveys, greater sage-grouse lek surveys, bat acoustic surveys, and incidental wildlife observations.

The principal objectives of the study were to (1) provide site specific bird and bat resource and use data that would be useful in evaluating potential impacts from the proposed wind-energy facility, (2) provide information that could be used in project planning and design of the facility to minimize impacts to birds and bats, and (3) recommend further studies or potential mitigation measures, if warranted.

The objective of the fixed-point bird use surveys was to estimate the seasonal, spatial, and temporal use of the study area by birds, particularly raptors. Fixed-point surveys were conducted from April 6, 2007 to March 14, 2009, and included the spring and fall of 2007, the summer of 2008, and the winter of 2008/2009. Surveys were conducted at 11 points established throughout the High Plains Wind Resource Area. A total of 335 twenty-minute fixed-point surveys were completed and 53 bird species were identified.

Waterbirds/waterfowl were the most abundant bird type observed during the spring (12.00 birds/plot/20-minute survey), summer (9.27), and fall (7.22), while raptors were the most abundant large bird observed in the winter (0.09). High waterbird/waterfowl use was primarily due to large groups of unidentified ducks and Canada geese. Shorebirds had the highest use in spring (2.06 birds/plot/20-minute survey) and were not observed in the winter. Raptor use was highest during the spring (0.84 birds/plot/20-minute survey) and lowest during the winter (0.09). The most common raptors observed in the study area were red-tailed hawk, American kestrel, golden eagle, and ferruginous hawk. Vultures were only recorded during the summer and had a use of 0.03 birds/plot/20-minute survey. Observations of upland gamebirds consisted only of greater sage-grouse; no upland gamebirds were observed in the summer or winter and use by was relatively low in the spring (0.03 birds/plot/20-minute survey) and fall (0.10). Passerine use ranged from 4.02 birds/plot/20-minute survey in the spring to 0.81 in fall.

During the study, 492 single birds or groups totaling 1,481 individuals were observed flying during fixed-point bird use surveys. For all species combined, 96.8% of birds were observed flying below the likely zone of risk, 2.1% were within the zone of risk for collision with turbine blades, and 1.1% were observed flying above the zone of risk for typical turbines that could be used in the High Plains Wind Resource Area. Bird types most often observed flying within the turbine zone of risk were raptors (22.3%) and shorebirds (3.2%). For species with at least 10 separate groups of flying birds, golden eagles were observed most often within the zone of risk. Based on the use (measure of abundance) of the study area by each species and the flight characteristics observed for that species, three species of raptors – ferruginous hawk, golden eagle, and red-tailed hawk, have the highest probability of turbine exposure, with an exposure index of 0.02.

For all bird species combined, use was highest at points three and five (57.0 and 21.7 birds/20-minute survey, respectively). Bird use at other points ranged from 2.03 to 12.1 birds/20-minute survey. The high mean use estimates for points three and five were largely due to waterfowl use at point three (50.8 birds/20-minute survey) and shorebird use at point five (5.35 birds/20-minute survey). Waterfowl use was highest at point three (50.8 birds/20-minute survey) and ranged from zero to 8.58 birds/20-minute survey at other points, while waterbird use was relatively low at all points, with use ranging from zero to 0.45 birds/20-minute survey. With the exception of point five (5.35 birds/20-minute survey), mean shorebird use was fairly uniform between points, ranging from zero to 1.29 birds/20-minute survey at the remaining points. Raptor use was similar across points, ranging from 0.32 to 0.68 birds/20-minute survey. Buteos, eagles, and falcons made up the majority of the raptor use. Vultures were only seen at points four and seven with a mean use of 0.03 birds/20-minute survey at each point. Upland gamebird use was relatively low, with use only observed at points eight and 10 (0.38 and 0.10 birds/20-minute survey, respectively). Passerine use, focused within 100 m (328 ft), was highest at point five (7.16 birds/20-minute survey), and ranged from 1.35 to 4.97 at other points.

No obvious flyways or concentration areas were observed. No strong association with topographic features within the study area was noted for raptors or other large birds. Although some differences in bird use were detected among survey points, the differences are not large enough to suggest that any portions of the High Plains Wind Resource Area should be avoided when siting turbines due to very high bird use.

The objective of the raptor nest surveys was to determine the presence of active raptor nests in and near the study area. The entire study area and a one-mile (1.61 kilometer) buffer around the High Plains Wind Resource Area were systematically searched for active and non-active raptor nests in the spring of 2007 and 2008. No active raptor nests were located within the High Plains Wind Resource Area, but two active raptor nests were within one mile of the High Plains Wind Resource Area, resulting in active raptor nest density of 0.04 nests/square mile (0.03 nests/km^2) for this area. One bald eagle nest was located approximately 0.25 miles (0.4 kilometers) north of the northwest corner of the study area, and one red-tailed hawk nest was found along Rock Creek on the border of the study area. A golden eagle nest was also recorded approximately 1.5 miles (2.4 kilometers) north of the High Plains Wind Resource Area. Three inactive ferruginous hawk nests were located on a powerline approximately one mile (1.61 kilometers) east of the study area, and three additional inactive stick nests were located in or near the study area.

The objective of the greater sage-grouse lek survey was to map sage-grouse leks occurring within two miles of the project area and determine how many birds are using each lek. No greater sage-grouse leks were located on or within two miles (3.2 kilometers) of the High Plains Wind Resource Area.

The objective of the acoustic bat surveys was to estimate the seasonal and spatial use of the study area by bats. Surveys were initiated in July 2008 to assess bat use within the proposed High Plains Wind Resource Area. Acoustic surveys for bats using Anabat™ SD-1 ultrasonic detectors at two fixed stations were conducted from July 14 to October 17, 2008. A total of 721 bat passes were recorded during 192 detector nights. Averaging bat passes per detector-night across locations, a mean of 3.76 mean bat passes per detector-night was recorded.

Approximately 20% of the calls were < 35 kHz in frequency (e.g., big brown bat, hoary bat), and the remaining calls were > 35 kHz (e.g., *Myotis* bat species). Species identification was possible for the hoary bat and eastern red bat, which made up 3.9% and 17.9% of all passes, respectively. Activity levels for all bat passes peaked in late August and activity levels for hoary bats and eastern red bats were also highest in late August, suggesting these species were migrating through the study area at this time of year.

Based on fixed-point bird use data collected for the High Plains Wind Resource Area, mean annual raptor use was 0.45 raptors/plot/20-minute survey. The annual rate was low relative to raptor use at other wind-energy facilities that implemented similar protocols to the present study and had data for three or four different seasons. Similar studies were conducted at 36 other wind-energy facilities. Mean raptor use in the study area was low compared to the other wind resource areas, ranking twenty-second.

A regression analysis of raptor use and raptor collision mortality for 13 new-generation wind-energy facilities where similar methods were used to obtain raptor use estimates showed a significant (R^2 = 69.9%) correlation between raptor use and raptor collision mortality. Using this regression to predict raptor collision mortality the High Plains Wind Resource Area yields an estimated fatality rate of 0.04 fatalities/megawatt/year, or 7.50 raptors per year for a 187.5-megawatt wind-energy development.

Based on species composition of the most common raptor fatalities at other western wind-energy facilities and species composition of raptors observed at the High Plains Wind Resource Area during the surveys, the majority of the fatalities of diurnal raptors will likely consist of red-tailed hawk, ferruginous hawk, golden eagle, and American kestrel. Based on the seasonal use estimates, it is expected that risk to raptors would be unequal across seasons, with the lowest risk in the winter, and highest risk during the spring and summer.

No federally listed threatened or endangered species were observed within the High Plains Wind Resource Area. The greater sage-grouse, which has been petitioned for listing as threatened or endangered under the Endangered Species Act, was recorded during fixed-point surveys. A total of 13 greater sage grouse in two separate groups were recorded within the High Plains Wind Resource Area. Some species considered sensitive by the Wyoming Game and Fish Department were observed within the High Plains Wind Resource Area. During all surveys and incidental observations, 15 sensitive bird species were observed, the most common of which were McCown's longspur (43 observations), ferruginous hawk (18 observations), and mountain plover (13 observations). This is a tally that in some cases represents repeated observations of the same individuals. Some potential exists for turbine collision mortality or for wind turbines to displace these species. Research concerning displacement impacts of wind-energy facilities is limited, but some show the potential for small scale displacement of 180 meters (591 feet) or less, while impacts to densities of birds at larger scales has not been shown.

The mean number of bat passes per detector per night was compared to existing data at five wind-energy facilities where both bat activity and mortality levels have been measured. The level of bat activity documented at the High Plains Wind Resource Area was similar to wind facilities in

Minnesota and Wyoming, where reported bat mortalities are low, and was much lower than at facilities in the eastern US, where reported bat mortality is highest. Assuming that a relationship between bat activity and bat mortality exists, relatively low levels of bat mortality can be expected to occur in the study area, most likely during late August to mid-September.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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REPORT REFERENCE

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INTRODUCTION

PacifiCorp Energy (PacifiCorp) is developing two adjacent wind-energy facilities of 99 megawatts (MW) and 88.5 MW nameplate capacity in Albany and Carbon Counties, Wyoming. The High Plains Wind Resource Area (HPWRA) is located approximately two miles (3.2 kilometers [km]) east of McFadden, Wyoming (Figure 1) in an area composed primarily of grassland. CH2MHILL contracted Western EcoSystems Technology, Inc. (WEST) to conduct surveys and monitor wildlife resources in the HPWRA to estimate the impacts of wind-energy facility construction and operations on wildlife.

The principal objectives of the study were to (1) provide site specific bird and bat resource and use data that would be useful in evaluating potential impacts from the proposed wind-energy facility, (2) provide information that could be used in project planning and design of the facility to minimize impacts to birds and bats, and (3) recommend further studies or potential mitigation measures, if warranted. The protocols for the baseline studies are similar to those used at other wind-energy facilities across the nation, and follow the guidance of the National Wind Coordinating Collaborative (Anderson et al. 1999). The protocols have been developed based on WEST's experience studying wildlife at proposed wind-energy facilities throughout the US, and were designed to help predict potential impacts to bird (particularly raptors) and bat species.

Baseline surveys were conducted from April 6, 2007 to March 14, 2009 at the HPWRA, and included the spring and fall of 2007, the summer of 2008, and the winter of 2008/2009. Surveys conducted at the HPWRA included fixed-point bird use surveys, raptor nest surveys, greater sage-grouse (*Centrocercus urophasianus*) lek surveys, bat acoustic surveys, and incidental wildlife observations. In addition to site-specific data, this report presents existing information and results of studies conducted at other wind-energy facilities. The ability to estimate potential bird mortality at the proposed HPWRA is greatly enhanced by operational monitoring data collected at existing wind-energy facilities. For several wind-energy facilities, standardized data on fixed-point surveys were collected in association with standardized post-construction (operational) monitoring, allowing comparisons of bird use with bird mortality. Where possible, comparisons with regional and local studies were made.

STUDY AREA

The HPWRA is located in Carbon and Albany Counties, in southeastern Wyoming, approximately five miles (eight km) southwest of the town of Rock River and two miles (3.2 km) east of the town of McFadden (Figures 1 and 2). The HPWRA is currently used for ranching and consists of open land with rolling hill topography (Figure 2).

According to National Land Cover Data (USGS NLCD 2001), approximately 96.7% of the nearly 10,557-acre (16.51 square mile [mi^2]; 42.76 square km [km^2]) area is composed of scrub-shrub (Table 1; Figure 3). Although much of the area is classified as scrub-shrub, shrub cover is relatively low on much of the study area and it more closely resembles grassland than scrub-shrub. The next most common habitat is emergent wetland, which comprises only 1.7% of the HPWRA, or 177.11-acres (0.28 mi^2; 0.72 km^2). Areas classified by the NLCD as grasslands cover 0.6% of the proposed wind resource area, and developed open space covers 0.4%. All other habitat types cover 0.3% of the area or less (Table 1; Figure 3).

Using publicly available data from the Wyoming Game and Fish Department (WGFD), the following assessments can be made. The HPWRA is not within an area mapped as a greater sage-grouse core use area (Figure 4). The nearest core use area is located approximately six miles west of the project area. The only big game crucial winter range on the project area occurs in the extreme northeastern portion of the project area, which is classified as pronghorn antelope (*Antilocapra americana*) crucial winter range (Figure 5).

METHODS

The studies at the HPWRA consisted of the following research components: 1) fixed-point bird use surveys; 2) ground-based raptor nest surveys; 3) greater sage-grouse lek surveys; 4) bat acoustic surveys; and 5) incidental wildlife observations.

Fixed-Point Bird Use Surveys

The objective of the fixed-point bird use surveys was to estimate the seasonal, spatial, and temporal use of the study area by birds, particularly raptors, defined here as accipiters, buteos, harriers, eagles, falcons, and owls. Fixed-point surveys (variable circular plots) were conducted using methods described by Reynolds et al. (1980). The points were selected to survey representative habitats and topography of the study area, while also providing relatively even coverage. All birds seen during each 20-minute (min) fixed-point survey were recorded.

Bird Use Survey Plots
Eleven points were selected to achieve relatively even coverage of the study area and survey representative habitats and topography within the study area (Figure 6). Each survey plot was an 800-meter (m; 2,625-foot [ft]) radius circle centered on the point.

Bird Survey Methods
All species of birds observed during fixed-point surveys were recorded. Observations of large birds beyond the 800-m (2,625-ft) radius were recorded, but were not included in the statistical analyses. For small birds (e.g., sparrows), observations beyond a 100-m (328-ft) radius were excluded. A unique observation number was assigned to each observation.

The date, start and end time of the survey period, and weather information such as temperature, wind speed, wind direction, and cloud cover were recorded for each survey. Species or best possible identification, number of individuals, sex and age class (if possible), distance from plot center when first observed, closest distance, altitude above ground, activity (behavior), and habitat(s) were recorded for each observation. The behavior of each bird observed, and the vegetation type in which or over which the bird occurred, were recorded based on the point of first observation. Approximate flight height and flight direction at first observation were recorded to the nearest 5-m (16-ft) interval. Other information recorded about the observation included whether or not the observation was auditory only and the 10-min interval of the 20-min survey in which it was first observed.

Locations of raptors, other large birds, and species of concern seen during fixed-point bird use surveys were recorded on field maps by observation number. Flight paths and perched locations were digitized using ArcGIS 9.3. Any comments or unusual animal observations were recorded in the comments section of the data sheet.

Observation Schedule
Sampling intensity was designed to document bird use and behavior by habitat and season within the study area. Fixed-point bird use surveys were conducted during the period April 6, 2007 through March 14, 2009. Surveys were conducted approximately once a week during spring 2007 (March 15 to May 31) and fall 2007 (September 1 to November 15) and once every two weeks during summer 2008 (June 1 to August 31) and winter 2008/2009 (November 16 to March 14). Surveys were conducted during daylight hours and survey periods were varied to approximately cover all daylight hours during a season. To the extent practical, each point was surveyed about the same number of times; however, the schedule varied in response to adverse weather conditions (e.g., fog, rain, or snow), which may have caused delays and/or missed surveys.

Raptor Nest Surveys

The objective of the raptor nest surveys was to locate and record raptor nests that may be subject to disturbance and/or displacement effects by wind-energy facility construction and/or operation. Surveys were completed by walking and driving along public roads and accessible private roads and looking for raptor nest structures within areas of suitable habitat (trees, rock outcrops, etc). Universal Transverse Mercator (UTM) or Global Positioning System (GPS) coordinates, as well as nesting substrate and current status (inactive, active, incubating, young in nest), were recorded for each nest located.

Greater Sage-Grouse Lek Surveys

The HPWRA is not located within a core greater sage-grouse area, and the WGFD does not have any records of greater sage-grouse leks within two miles (3.2 km) of the study area (Figure 4). To obtain additional information on greater sage-grouse use of the HPWRA, all areas within 2.0 miles of the potential wind-energy facility were searched by vehicle and foot starting at daylight to locate leks. Stops were made every half-mile (0.8 km) along public roads and accessible private roads in the study area to look and listen for lekking greater sage-grouse. Surveys were conducted from March 15 through April 30, 2007. The purpose of this portion of the study was to determine where greater sage-grouse leks are and how many birds are using each lek.

Bat Acoustic Surveys

The objective of the bat use surveys was to estimate the seasonal and spatial use of the HPWRA by bats. Bats were surveyed using Anabat™ SD-1 (Anabat) bat detectors (Titley Scientific™ Pty Ltd., NSW, Australia). Bat detectors are a recommended method to index and compare habitat use by bats. The use of bat detectors for calculating an index to bat impacts has been used at several wind-energy facilities (Kunz et al. 2007a), and is a primary and economically feasible bat risk assessment tool (Arnett 2007). Bat activity was surveyed using two detectors from July 14 to October 17, 2008, a period corresponding to likely fall bat migration at this site. Detectors were placed at two locations (Figure 7).

Anabat detectors record bat echolocation calls with a broadband microphone. The echolocation sounds are then translated into frequencies audible to humans by dividing the frequencies by a predetermined ratio. A division ratio of 16 was used for the study. Bat echolocation detectors also detect other ultrasonic sounds made by insects, raindrops hitting vegetation, and other sources. A sensitivity level of six was used to reduce interference from these other sources of ultrasonic noise. Calls were recorded to a CompactFlash memory card with large storage capacity. The Anabat detectors were placed inside plastic weather-tight containers with a hole cut in the side of the container for the microphone to extend through. Microphones were encased in PVC tubing with drain holes that curved skyward at 45 degrees outside the container to minimize the potential for water damage due to rain. Containers were raised approximately one m (3.3 ft) off the ground to minimize echo interference and lift the unit above vegetation. All units were programmed to turn on each night approximately one half-hour before sunset and to turn off approximately one half-hour after sunrise.

Incidental Wildlife Observations

The objective of incidental wildlife observations was to provide a record of wildlife seen outside of the standardized surveys. All raptors, unusual or unique birds, sensitive species, mammals, reptiles, and amphibians were recorded in a similar fashion to standardized surveys. The observation number, date, time, species, number of individuals, sex/age class, distance from observer, activity, height above ground (for bird species), habitat, and, in the case of sensitive species, the location was recorded by UTM or GPS coordinates.

Statistical Analysis

Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) measures were implemented at all stages of the study, including in the field, during data entry and analysis, and report writing. Following field surveys, observers were responsible for inspecting data forms for completeness, accuracy, and legibility. A sample of records from an electronic database was compared to the raw data forms and any errors detected were corrected. Irregular codes or data suspected as questionable were discussed with the observer and/or project manager. Errors, omissions, or problems identified in later stages of analysis were traced back to the raw data forms, and appropriate changes in all steps were made.

Data Compilation and Storage

A Microsoft® ACCESS database was developed to store, organize, and retrieve survey data. Data were keyed into the electronic database using a pre-defined format to facilitate subsequent QA/QC and data analysis. All data forms, field notebooks, and electronic data files were retained for reference.

Fixed-Point Bird Use Surveys

Bird Diversity and Species Richness

Bird diversity was illustrated by the total number of unique species observed. Species lists, with the number of observations and the number of groups, were generated by season, including all observations of birds detected regardless of their distance from the observer. Species richness was calculated as the mean number of species observed per plot per survey (i.e., number of species/20-min survey). Species diversity and richness were compared between seasons for fixed-point bird use surveys.

Bird Use, Composition, and Frequency of Occurrence

For the standardized fixed-point bird use estimates, only observations of birds detected within the 800-m (2,625-ft) radius plot were used. Estimates of mean bird use (i.e., number of birds/plot/20-min survey) were used to compare differences between bird types, seasons, and other wind-energy facilities.

The frequency of occurrence was calculated as the percent of surveys in which a particular species or bird type was observed. Percent composition was calculated as the proportion of the overall mean use for a particular species or bird type. Frequency of occurrence and percent composition provide relative estimates of species exposure to the proposed wind-energy facility. For example, a species may have high use estimates for the area based on just a few observations of large groups; however, the frequency of occurrence will indicate that the species occurs during very few of the surveys and therefore, the species may be less likely affected by the wind-energy development.

Bird Flight Height and Behavior

To calculate potential risk to bird species, the first flight height recorded was used to estimate the percentages of birds flying within the likely zone of risk (ZOR) for potential collision with turbine blades of 35 to 130 m (114 to 427 ft) above ground level (AGL), which is the blade height of typical turbines that could be used at the HPWRA.

Bird Exposure Index

A relative index of collision exposure (R) was calculated for bird species observed during the fixed-point bird use surveys using the following formula:

$$R = A^*P_f^*P_t$$

Where A equals mean relative use for species i (observations within 800 m [2,625 ft] of the observer) averaged across all surveys, P_f equals the proportion of all observations of species i where activity was recorded as flying (an index to the approximate percentage of time species i spends flying during the daylight period), and P_t equals the proportion of all initial flight height observations of species i within the likely ZOR.

Spatial Use

Data were analyzed by comparing use among plots. Mapped flight paths were qualitatively compared to study area features such as topographic features. The objective of mapping observed bird locations and flight paths was to look for areas of concentrated use by raptors and other large birds and/or consistent flight patterns within the study area. This information can be useful in turbine layout design or adjustments of individual turbines for micro-siting.

Bat Acoustic Surveys
The units of activity were number of bat passes (Hayes 1997). A pass was defined as a continuous series of two or more call notes produced by an individual bat with no pauses between call notes of more than one second (White and Gehrt 2001; Gannon et al. 2003). In this report, the terms bat pass and bat call are used interchangeably. The number of bat passes was determined by downloading the data files to a computer and tallying the number of echolocation passes recorded. Total number of passes was corrected for effort by dividing by the number of detector nights. Bat calls were classified as either high-frequency calls (≥ 35 kHz) that are generally given by small bats (e.g. *Myotis* sp.) or low-frequency calls (< 35 kHz) that are generally given by larger bats (e.g. silver-haired bat [*Lasionycteris noctivagans*], big brown bat [*Eptesicus fuscus*], hoary bat [*Lasiurus cinereus*]). Data determined to be noise (produced by a source other than a bat) or call notes that did not meet the pre-specified criteria to be termed a pass were removed from the analysis. To establish which species may have produced the high- and low-frequency calls recorded, a list of species expected to occur in the study area was compiled from range maps (Table 2; Harvey et al. 1999; BCI website).

Within high- and low-frequency categories, an attempt was made to identify calls made by hoary and eastern red [*Lasiurus borealis*] bats. Calls that had a distinct U-shape and that exhibited variability in the minimum frequency across the call sequence were identified as belonging to the *Lasiurus* genus (C. Corben, pers comm.). Hoary and red bats were distinguished based on minimum frequency: hoary bats typically produce calls with minimum frequencies between 18 and 24 kHz, whereas eastern red bats typically emit calls with minimum frequencies between 30 and 43 kHz (J. Szewczak, pers comm.). These are conservative parameters. Given the high intraspecific variability of lasiurine calls, and the number of call files that were too fragmented for proper identification, it is likely that more hoary and eastern red bat calls were present than were positively identified.

The total number of bat passes per detector night was used as an index of bat use in the HPWRA. Bat pass data represented levels of bat activity rather than the numbers of individuals present because individuals could not be differentiated by their calls. To predict potential for bat mortality (i.e., low, moderate, high), the mean number of bat passes per detector night (averaged across monitoring stations) was compared to existing data from wind-energy facilities where both bat activity and mortality levels have been measured.

RESULTS

Surveys were conducted at the HPWRA during the period April 6, 2007 through March 14, 2009. Fifty-three bird species were identified during all surveys at the HPWRA. Results of the fixed-point bird use surveys, raptor nest surveys, greater sage-grouse lek surveys, bat acoustic surveys, and incidental wildlife observations are discussed in the sections below.

Fixed-Point Bird Use Surveys

Bird Diversity and Species Richness

A total of 335 twenty-minute fixed-point surveys were conducted at the HPWRA (Table 3). Fifty-three unique species were observed over the course of all fixed-point bird use surveys, with a mean number of 1.59 species/survey (Table 3). More unique species were observed during the spring (46 species), followed by summer (36), fall (15), and winter (six). The mean number of species per survey was higher in the summer (2.88 species/survey) and spring (2.67) compared to the fall (0.95) and winter (0.31; Table 3). A total of 4,339 individual bird observations within 815 separate groups were recorded during the fixed-point surveys (Table 4). Cumulatively, two species (3.8% of all species) composed 35.6% of the observations: horned lark (*Eremophila alpestris*) and Canada goose (*Branta canadensis*). Unidentified duck comprised 46.6% of all observations and all other recorded species comprised less than 5% of the observations individually. A total of 163 individual raptors were recorded within the HPWRA, representing 14 species (Table 4).

Bird Use, Composition, and Frequency of Occurrence by Season

Mean bird use, percent composition, and frequency of occurrence for all species and bird types by season were calculated (Table 5). The highest overall bird use occurred in the spring (18.95 birds/plot/20-min survey), followed by summer (14.83), fall (11.29), and winter (0.92). Waterbirds/waterfowl were the most abundant bird type during the spring, summer, and fall, while passerines were the most abundant bird type recorded in winter.

<u>Waterbirds/Waterfowl</u>

Waterbirds/waterfowl had the highest use in spring (12.00 birds/plot/20-min survey), compared to other times of the year (summer 9.27, fall 7.22, and winter 0.02; Table 5). The higher waterbird/waterfowl use in spring was largely due to several large groups of unidentified ducks that made up 56.1% of the overall spring bird use. Waterbirds/waterfowl comprised 64.0% of the overall bird use in the fall, 63.3% in the spring, 62.5% in the summer, and 2.5% in the winter. Waterbirds/waterfowl were observed the least frequently in winter (1.1%) compared to other seasons (spring 36.4%, summer 34.8%, and fall 24.2%). Canada goose, mallard (*Anas platyrhynchos*), and American white pelican (*Pelecanus erythrorhyncos*) were the most abundant waterfowl/waterbird species observed (Table 4).

<u>Shorebirds</u>

Shorebirds had the highest use in spring (2.06 birds/plot/20-min survey) compared to other times of the year (summer 1.23, fall 0.01, and winter 0; Table 5). Shorebirds comprised 10.9% or less of the overall bird use for all four seasons. Shorebirds were observed during 30.7% of the surveys in the spring compared to between 0 and 24.2% at other times of the year. Wilson's phalarope (*Phalaropes tricolor*), American avocet (*Recurvirostra americana*), and killdeer (*Charadrius vociferous*) were the most commonly observed shorebirds (Table 4).

<u>Raptors</u>

Raptor use was highest in the spring (0.84 birds/plot/20-min survey), followed by summer (0.71), fall (0.30) and winter (0.09; Table 5). Higher use in the spring was primarily due to use of the area by red-tailed hawks *(Buteo jamaicensis*; 0.30 birds/plot/20-min survey) and American kestrels (*Falco sparverius*; 0.26 birds/plot/20-min survey). Red-tailed hawks had the highest use of any raptor in the spring (0.30 birds/plot/20-min survey), ferruginous hawks (*Buteo regalis*) had highest use in the summer (0.21), rough-legged hawks (*Buteo lagopus*) and northern harriers (*Circus cyaneus*) had the highest use in fall (0.06 each), and golden eagles (*Aquila chrysaetos*) had the highest use in winter (0.07). Raptors comprised 10.1% of the overall bird use in the winter and less than 5% of the overall bird use during the remaining seasons. Raptors were observed during 51.1% of surveys in the spring and 37.9% in the summer, compared to 25.2% of the surveys in the fall and 7.0% in the winter. The most common raptors observed in the study area were red-tailed hawk (32 observations), American kestrel (31), golden eagle (20), and ferruginous hawk (19; Table 4).

<u>Vultures</u>
Vultures, limited to turkey vulture (*Cathartes aura*), were only recorded using the area in the summer and had a use of 0.03 birds/plot/20-min survey (Table 5). Vultures comprised less than 1% of the overall bird use in this season.

<u>Upland Gamebirds</u>
The only upland gambird observed on the HPWRA was greater sage-grouse. No sage-grouse were observed in the summer or winter and use by sage-grouse was relatively low in the spring (0.03 birds/plot/20-min survey) and fall (0.10; Table 5). Only one group of three greater sage-grouse was documented in the spring and one group of 10 greater sage-grouse was documented in fall (Table 4). Greater sage-grouse comprised less than 1% of overall bird use during these seasons (Table 5) and were observed during 1.1% and 1.0% of surveys in the spring and fall, respectively.

<u>Passerines</u>
A 100-m (328-ft) plot was used for small birds, thus making use values obtained for small birds not directly comparable to use values for large bird types which were recorded out to 800 m. Passerine use was highest in spring (4.02 birds/plot/20-min survey), compared to fall (3.66), summer (3.48), and winter (0.81). Horned larks had the highest use by any one passerine species in all four seasons, with mean use ranging from 3.65 birds/plot/20-min survey in the fall to 0.77 in the winter. Passerines were observed during 87.9% of summer surveys, compared to 64.8% of spring, 39.4% of fall, and 21.6% of winter surveys.

Bird Flight Height and Behavior
Flight height characteristics were estimated for both bird types and bird species (Tables 6 and 7). During the study, 492 single birds or groups totaling 1,481 individuals were observed flying during fixed-point bird use surveys (Table 6). Overall, 2.1% of birds observed flying were recorded within the ZOR for collision with turbine blades of 35 to 130 m (114 to 427 ft) AGL, 96.8% were below the ZOR, and 1.1% were flying above the ZOR (Table 6). Approximately 75% of flying raptors were observed below the ZOR, 22.3% were within the ZOR, and only 2.5% were above the ZOR. Raptors had the highest percentage of flying birds within the ZOR (22.3%), primarily due to 45.0% of eagle observations, 30.2% of buteo observations, and 25.0% of other raptors recorded at this height. Shorebirds ranked second highest, with 3.2% observed within the ZOR. Waterbirds/waterfowl, shorebirds, vultures, upland gamebirds, passerines, and other birds were typically observed flying below the ZOR (Table 6).
Of all large bird types, five species had at least 10 groups observed flying, and only golden eagle was observed flying within the likely ZOR during at least 50% of the observations (50.0%; Table 7). No species were observed flying within the likely ZOR more than 50% of the observations. Of

all passerines, only four species had at least 10 groups observed flying, and only common raven (*Corvus corax*) and horned lark were recorded flying within the ZOR.

Bird Exposure Index
A relative exposure index was calculated for each species (Table 7). This index is only based on initial flight height observations and relative abundance (defined as the use estimate) and does not account for other possible collision risk factors such as foraging or courtship behavior. The exposure index for all species was relatively low, with a maximum exposure index of 0.02 for three raptor species (ferruginous hawk, golden eagle, and red-tailed hawk); all other raptor species had an exposure index of 0.01 or less (Table 7).

Spatial Use
For all bird species combined, use was highest at points three and five (57.0 and 21.7 birds/20-min survey, respectively). Bird use at other points ranged from 2.03 to 12.1 birds/20-min survey (Figure 8). The high mean use estimates for points three and five were largely due to higher use by waterfowl at point three (50.8 birds/20-min survey) and by shorebirds at point five (5.35 birds/20-min survey). Waterbird use was relatively low at all points, with use ranging from zero to 0.45 birds/20-min survey. Waterfowl use was highest at point three (50.8 birds/20-min survey) and ranged from zero to 8.58 birds/20-min survey at other points. With the exception of point five (5.35 birds/20-min survey), mean shorebird use was fairly uniform between points, ranging from zero to 1.29 birds/20-min survey at the remaining points. Raptor use was similar across points, ranging from 0.32 to 0.68 birds/20-min survey; buteos, eagles, and falcons made up the majority of the raptor use. Vultures were only seen at points four and seven with a mean use of 0.03 birds/20-min survey at each point. Upland gamebird use was relatively low, with use only observed at points eight and 10 (0.38 and 0.10 birds/20-min survey, respectively). Passerine use was highest at point five (7.16 birds/20-min survey), and ranged from 1.35 to 4.97 at other points.

Flight paths for waterbirds, waterfowl, shorebirds, raptors, and vultures were digitized and mapped (Figure 9). No obvious flyways or concentration areas were observed for any species. The available data do not indicate that any portions of the study area warrant being excluded from development due to very high bird use.

Raptor Nest Surveys

The entire study area and a one-mile (1.61 km) buffer around the HPWRA were systematically searched for active and non-active raptor nests in the spring of 2007. No active raptor nests were located within the HRWRA, but two active raptor nests were located within one mile of the HPWRA, resulting in active raptor nest density of 0.04 nests/mi^2 (0.03 nests/km^2) for this area (Table 8). One bald eagle (*Haliaeetus leucocephalus*) nest was located approximately 0.25 miles (0.4 km) north of the northwest corner of the study area, and one red-tailed hawk nest was located along Rock Creek on the border of the study area (Figure 10). A golden eagle (*Aquila chrysaetos*) nest was also recorded approximately 1.5 miles (2.4 km) north of the HPWRA (Figure 10). Three inactive ferruginous hawk nests were located on a powerline approximately one mile (1.6 km) east of the study area, and three additional inactive stick nests were located within or near the study area.

Greater Sage-Grouse Lek Surveys

No greater sage-grouse leks were located on or within two miles (3.2 km) of the HPRWA.

Bat Acoustic Surveys

Bat activity was monitored at two sampling locations on a total of 96 nights during the period July 14 to October 17, 2008. Anabat units were operable for 100% of the sampling period (Figure 11), recording 721 bat passes on 192 detector-nights (Table 9). Levels of wind and insect noise were high on some nights (Figure 12), and may have interfered with bat detection. Averaging bat passes per detector-night across locations, a mean of 3.76 bat passes per detector-night were recorded (Table 9).

Spatial Variation

Bat activity was similar between the ground Anabat units HP1 and HP2 (mean of 3.76 bat passes per detector-night; Figures 7 and 13). Patterns of nightly activity were also similar between the two stations; however HP1 recorded more calls throughout August (Figure 14).

Temporal Variation

Bat activity was moderate from July 14 through August 17, and peaking on August 20; however, activity abruptly decreased through September and October (Figures 12 and 14). Peak activity occurred from August 18 through the end of August. Temporal patterns were largely consistent among stations, although station HP1 recorded more calls per night (Figure 14).

Species Composition

Overall, passes by high-frequency bats (HF; 79.9%) outnumbered passes by low-frequency bats (LF; 20.1%; Table 10). However, the proportion of HF and LF bat passes was similar among both stations (Figure 13). Patterns of activity for HF and LF bats were also congruent with the overall trend (Figure 15). HF passes outnumbered LF passes from July 14 through the end of August, but the ratio was more similar during September and October.

Species identification for specific passes was possible for the hoary and eastern red bat; therefore, passes by these species could be separated from passes by other high- and low-frequency bats. Hoary and eastern red bats comprised 3.9% and 17.9%, respectively, of total passes detected within the study area (Table 10). Hoary bat activity was similar among Anabat stations, but eastern red bat activity was more than twice as high at Anabat station HP1 than HP2 (Table 10; Figure 17). Patterns of hoary bat activity were relatively similar with the overall trend (Figure 18 and 19). Patterns of eastern red bat activity were also congruent with the overall trend (Figures 18 and 19), with most passes recorded on August 20.

Incidental Wildlife Observations

Big game observed incidentally at the HPWRA included one group of 25 elk (*Cervus elaphus*) and 79 groups totaling 282 pronghorn antelope (*Antilocrapa americana*). One group of four swift fox (*Vulpes velox*) and one greater short-horned lizard (*Phrynosoma hernandesi*) were also observed incidentally in the project area (Table 11). It is important to note that incidental sightings are recorded ancillary to other survey objectives without systematic sampling methodology. Recording of incidental observations indicates presence of a species on site, but cannot be used in risk assessment. Multiple counts of the same individual may have occurred.

DISCUSSION AND IMPACT ASSESSMENT

Bird Impacts

Direct Effects

The most probable direct impact to birds from wind-energy facilities is direct mortality or injury due to collisions with turbines or guy wires of meteorological (met) towers. Collisions may occur with resident birds foraging and flying within the study area or with migrant birds seasonally moving through the study area. Project construction could affect birds through loss of habitat, potential fatalities from construction equipment, and disturbance/displacement effects from construction activities. Impacts from the decommissioning of the facility are anticipated to be similar to construction in terms of noise, disturbance, and equipment. Potential mortality from construction equipment is expected to be very low. Equipment used in wind-energy facility construction generally moves at slow rates or is stationary for long periods (e.g., cranes). The risk of direct mortality to birds from construction is most likely potential destruction of a nest for ground- and shrub-nesting species during initial site clearing.

Substantial data on bird mortality at wind-energy facilities are available from studies in California and throughout the West and Midwest. Of 841 bird fatalities reported from California studies (more than 70% from the Altamont Pass facility in California), about 39% were diurnal raptors, about 19% were passerines (excluding house sparrows [*Passer domesticus*] and European starlings [*Sturnus vulgaris*]), and about 12% were owls. Non-protected birds including house sparrows, European starlings, and rock doves (*Columba livia*), comprised about 15% of the fatalities. Other bird types generally made up less than 10% of the fatalities (Erickson et al. 2002b). During 12 fatality monitoring studies conducted outside of California, diurnal raptor fatalities comprised approximately 2% of the wind-energy facility-related fatalities and raptor mortality averaged 0.03/turbine/year. Passerines (excluding house sparrows and European starlings) were the most common collision victims, comprising about 82% of the 225 fatalities documented. For all bird species combined, estimates of the number of bird fatalities per turbine per year from individual studies ranged from zero at the Searsburg wind-energy facility in Vermont (Kerlinger 1997) and the Algona facility in Iowa (Demastes and Trainer 2000), to 7.7 at the Buffalo Mountain facility in Tennessee (Nicholson 2003). Using mortality data from the last 10 years from wind-energy facilities throughout the entire United States, the average number of bird collision fatalities is 3.1 per MW per year, or 2.3 per turbine per year (NWCC 2004).

Raptor Use and Exposure Risk

The annual mean raptor use at the HPWRA (0.45 raptors/plot/20-min survey) was compared with other wind-energy facilities that implemented similar protocols and had data for three or four seasons. Similar studies were conducted at 36 other wind resource areas (WRAs). The annual mean raptor use at these WRAs ranged from 0.09 to 2.34 raptors/plot/20-min survey (Figure 20). Based on the results from these WRAs, a ranking of seasonal raptor mean use was developed as: low (0 – 0.5 raptors/plot/20-min survey); low to moderate (0.5 – 1.0); moderate (1.0 – 2.0); high (2.0 – 3.0); and very high (> 3.0). Under this ranking, mean raptor use (number of raptors divided by the number of 800-m [2,625-ft)] plots and the total number of surveys) at the HPWRA is considered to be low, ranking twenty-second highest compared to the other wind-energy facilities (Figure 20).

Although high numbers of raptor fatalities have been documented at some wind-energy facilities (e.g. Altamont Pass), a review of studies at wind-energy facilities across the United States reported that only 3.2% of casualties were raptors (Erickson et al. 2001a). Indeed, although raptors occur in most areas with the potential for wind-energy development, individual species appear to differ from one another in their susceptibility to collision (NRC 2007). Results from Altamont Pass in California suggest that mortality for some species is not necessarily related to abundance (Orloff and Flannery 1992). American kestrels, red-tailed hawks, and golden eagles were killed more often than predicted based on abundance. Thus far, only three northern harrier fatalities at existing wind energy facilities have been reported in publicly available documents, despite the fact they are commonly observed during point counts at these facilities (Erickson et al. 2001a; Whitfield and Madders 2006). Because northern harriers often hunt close to the ground, risk of collision with turbine blades is considered low for this species. Reports from the High Winds wind-energy facility in California document high American kestrel mortality. Relative use by American kestrels at the High Winds facility is almost six times the use of American kestrels at the Altamont Pass facility (Kerlinger 2005). It is likely that many factors, in addition to abundance, are important for predicting raptor mortality.

An exposure index analysis may also provide insight into what species might be the most likely turbine casualties. The index considers relative probability of exposure based on abundance, proportion of daily activity spent flying, and proportion of flight height of each species within the ZOR for turbines likely to be used at the wind-energy facility. For the HPWRA, three raptor species tied for the highest exposure index (0.02), including ferruginous hawk, golden eagle, and red-tailed hawk (Table 7). The exposure index analysis is based on observations of birds during the daylight period and does not take into consideration flight behavior (e.g. during foraging or courtship) or abundance of nocturnal migrants. It also does not take into consideration habitat selection, the ability to detect and avoid turbines, and other factors that may vary among species and influence likelihood of turbine collision. For these reasons, the actual risk for some species may be lower or higher than indicated by this index.

A regression analysis of raptor use and mortality for 13 new-generation wind-energy facilities, where similar methods were used to estimate raptor use and mortality, found that there was a significant correlation between use and mortality (R^2 = 69.9%; Figure 21). Using this regression to predict raptor collision mortality at the HPWRA, based on an adjusted mean raptor use of 0.45 raptors/20-min survey, yields an estimated fatality rate of 0.04 fatalities/MW/year, or 7.50 raptor fatalities per year for a 187.5-MW wind-energy development. A 90% prediction interval around this estimate is zero to 0.30 fatalities/MW/year. Because there is more uncertainty associated with predicting for a single value at a point, rather then estimating a confidence interval around a point, prediction intervals are typically wider than confidence intervals (Devore and Peck 2001).

Based on species composition of the most common raptor fatalities at other western wind-energy facilities and species composition of raptors observed at the High Plains Wind Resource Area during the surveys, there is higher potential for ferruginous hawk, golden eagle, red-tailed hawk and American kestrel fatalities compared to other species. Based on the seasonal use estimates, it is expected that risk to raptors would be unequal across seasons, with the lowest risk in the winter, and highest risk during the spring and summer.

No active raptor nests were found within the HPWRA, and only three active nests were found within 1.5 miles (2.4 km) of the study area, suggesting that there will be limited displacement of nesting raptors at the HPWRA. Active raptor nest density within a 1.0-mile (1.6 km) buffer of the HPWRA was 0.04 nests/mi^2 (0.03 nests/km^2). Maintaining a buffer surrounding known nests when siting turbines will further reduce any impact. Since few raptor species targeted during nest surveys have been observed as fatalities at newer wind-energy facilities, correlations are very low between the number of collision fatalities and raptor nest density within one mile (1.6 km) of project facilities. Raptors nesting closest to turbines likely have higher probabilities of being impacted from collision with turbines, but data on nests very close to turbines (e.g., within a half-mile [0.8 km]) are currently inadequate to determine the level of these impacts. The existing wind-energy facility with the highest reported nest density is Foote Creek Rim, Wyoming. Most of the nests within two miles (3.2 km) of the wind-energy facility are red-tailed hawks (Johnson et al. 2000b), but no red-tailed hawk fatalities have been documented at this facility (Young et al. 2003c).

Non-Raptor Use and Exposure Risk

Most bird species in the US are protected by the Migratory Bird Treaty Act (MBTA 1918), including passerines. Passerines (primarily perching birds) have been the most abundant bird fatality at wind energy facilities outside California (Erickson et al. 2001a, 2002b), often comprising more than 80% of the bird fatalities. Both migrant and resident passerine fatalities have been observed. Given that passerines made up a large proportion of the birds observed during the baseline study, passerines would be expected to make up the largest proportion of fatalities at the HPWRA. Exposure indices indicate that horned lark and common raven are the most likely passerine species to be exposed to collision from wind turbines at the HPWRA (Table 7). Most non-raptors had relatively low exposure indices due to the majority of individuals flying below the likely zone of risk. Due to the low exposure risks at HPWRA, it is unlikely that non-raptor populations will be adversely affected by direct mortality from the operation of the wind-energy facility.

Although substantial concentrations of waterfowl were not observed while conducting bird use surveys, several large groups of ducks and Canada geese were observed during surveys. Wind-energy facilities with year-round use by water dependent species have shown the highest mortality, although the levels of waterfowl/waterbird/shorebird mortality appear insignificant compared to the use of the facilities by these groups. Of 1,033 bird carcasses collected at US wind-energy facilities, waterbirds comprised about 2%, waterfowl comprised about 3%, and shorebirds comprised less than 1% (Erickson et al. 2002b). At the Klondike wind-energy facility in Oregon, only two Canada goose fatalities were documented (Johnson *et al.* 2003) even though 43 groups totaling 4845 individual Canada geese were observed during pre-construction surveys (Johnson et al. 2002a). The recently constructed Top of Iowa wind-energy facility is located in cropland between three Wildlife Management Areas (WMAs) with historically high bird use, including migrant and resident waterfowl. During a recent study, approximately one-million goose-use days and 120,000 duck-use days were recorded in the WMAs during the fall and early winter, and no waterfowl fatalities were documented during concurrent and standardized wind-energy facility fatality studies (Jain 2005). Similar findings were observed at the Buffalo Ridge wind-energy facility in southwestern Minnesota, which is located in an area with relatively high waterfowl/waterbird use and some shorebird use. Snow geese (*Chen caerulescens*), Canada geese, and mallards were the most common waterfowl observed. Three of the 55 fatalities observed during the fatality monitoring studies were waterfowl, including two mallards and one blue-winged teal (*Anas discors*). Two American coots (*Fulica americana*), one grebe, and one shorebird fatality were also found (Johnson et al. 2002b). Based on available evidence, waterfowl do not seem especially vulnerable to turbine collisions and significant impacts are not likely.

<u>Sensitive Species Use and Exposure Risk</u>
No federally listed threatened or endangered species were observed in the HPWRA during fixed-point bird use surveys or incidentally. Two groups totaling 13 individual greater sage-grouse, which has been petitioned for listing as threatened or endangered under the Endangered Species Act, were observed. An additional 14 bird species considered sensitive, or of Native Species Status (NSS) by the WGFD, were observed within the HPWRA (Table 12). Wyoming sensitive species of most concern are those classified as NSS1 or NSS2. No species classified as NSS1 were observed during the study. The only NSS2 bird species observed were greater sage-grouse and bald eagle (four observations of single birds). Due to very low use of the HPWRA by these two species, it is unlikely that collision mortality would occur. In addition, no sage-grouse were observed flying, and the bald eagle had a relatively low exposure index (<0.01).

Of those bird species classified as NSS3 or NSS4, the most frequently observed species were McCown’s longspur (43 observations), ferruginous hawk (18 observations), and mountain plover (13 observations). This is a tally that in some cases represents repeated observations of the same individuals. The ferruginous hawk was one of the more common raptors recorded at the HPWRA and some collision mortality may occur over the life of the wind-energy facility. However, overall raptor collision mortality is expected to be relatively low based on our analysis, and significant population level impacts would not be expected. Mountain plover and McCown’s longspur were never observed flying within the turbine ZOR. Therefore, significant risk of collision mortality is not expected for these species. Mountain plovers were common at the Foote Creek Rim wind-energy facility in Wyoming, yet no fatalities were found during several years of post-construction monitoring (Young et al. 2005a). Use of the HPWRA by the other sensitive species recorded was relatively low and no significant direct impacts are likely to occur.

In addition to sensitive bird species, one group of four swift fox (*Vulpes velox*) and one single greater short-horned lizard (*Phrynosoma hernandesi*)were observed incidentally. Both of these species are classified as NSS4 species. Based on the low numbers observed, however, use of the HPWRA by these two species appears to be relatively low and significant impacts are not expected. However, some individuals could potentially be impacted during construction of the facility.

Indirect Effects
The presence of wind turbines may alter the landscape so that wildlife use patterns are affected, displacing wildlife away from the project facilities and suitable habitat. Some studies from wind-energy facilities in Europe consider displacement effects to have a greater impact on birds than collision mortality (Gill et al. 1996). The greatest concern with displacement impacts for wind-energy facilities in the US has been where these facilities have been constructed in grassland or other native habitats (Leddy et al. 1999; Mabey and Paul 2007), Although Crockford (1992) suggests that disturbance appears to impact feeding, resting, and migrating birds, rather than breeding birds, results from studies in the US suggest that breeding birds are also affected by wind-facility operations.

Raptor Displacement
In addition to possible direct effects on raptors within the study area (discussed above), indirect effects caused by disturbance-type impacts, such as construction activity near an active nest or primary foraging area, also have a potential impact on raptor species. Birds displaced from wind-energy facilities might move to areas with fewer disturbances, but with lower quality habitat, with an overall effect of reducing breeding success. Most studies on raptor displacement at wind-energy facilities, however, indicate effects to be negligible (Howell and Noone 1992; Johnson et al. 2000a, 2003b; Madders and Whitfield 2006). Notable exceptions to this include a study in Scotland that described territorial golden eagles avoiding the entire wind-energy facility area, except when intercepting non-territorial birds (Walker et al. 2005). A study at the Buffalo Ridge wind-energy facility in Minnesota found evidence of northern harriers avoiding turbines on both a small scale (< 328 ft [100 m] from turbines) and a larger scale in the year following construction (Johnson et al. 2000a). Two years following construction, however, no large-scale displacement of northern harriers was detected.

The only published report of avoidance of wind turbines by nesting raptors occurred at the Buffalo Ridge wind energy facility in Minnesota, where raptor nest density on 101 mi^2 (262 km^2) of land surrounding a wind-energy facility was 5.94 nests/39 mi^2 (5.94 nests/101 km^2), yet no nests were present in the 12-mi^2 (31 km^2) facility itself, even though habitat was similar (Usgaard et al. 1997). However, this analysis assumes that raptor nests are uniformly distributed across the landscape, an unlikely event, and even though no nests were found, only two nests would be expected for an area 12 mi^2 in size if the nests were distributed uniformly. At a wind-energy facility in eastern Washington, based on extensive monitoring using helicopter flights and ground observations, raptors still nested in the study area at approximately the same levels after construction, and several nests were located within 0.5 miles (0.8 km) of turbines (Erickson et al. 2004). At the Foote Creek Rim wind-energy facility in southern Wyoming, one pair of red-tailed hawks nested within 0.3 miles (0.5 km) of the turbine strings, and seven red-tailed hawk nests, one great horned owl (*Bubo virginianus*) nest, and one golden eagle nest located within one mile (1.6 km) of the wind-energy facility successfully fledged young (Johnson et al. 2000b). The golden eagle pair successfully nested 0.5 mi from the facility for three different years after it became operational. A Swainson's hawk (*Buteo swainsoni*) also nested within 0.25 miles (0.4 km) of a turbine string at the Klondike I wind-energy facility in Oregon after the facility was operational (Johnson et al. 2003b). These observations suggest that there will be limited nesting displacement of raptors at the HPWRA, although the creation of a buffer surrounding known nests when siting turbines will further reduce any impact.

Displacement of Non-Raptor Bird Species

Studies concerning displacement of non-raptor species have concentrated on grassland passerines and waterfowl/waterbirds (Winkelman 1990; Larsen and Madsen 2000; Mabey and Paul 2007). Wind-energy facility construction appears to cause small-scale local displacement of grassland passerines and is likely due to the birds avoiding turbine noise and maintenance activities. Construction also reduces habitat effectiveness because of the presence of access roads and large gravel pads surrounding turbines (Leddy 1996; Johnson et al. 2000a). Leddy et al. (1999) surveyed bird densities in Conservation Reserve Program (CRP) grasslands at the Buffalo Ridge wind-energy facility in Minnesota, and found mean densities of 10 grassland bird species were four times higher at areas located 180 m (591 ft) from turbines than they were at grasslands nearer turbines. Johnson et al. (2000a) found reduced use of habitat by seven of 22 grassland-breeding birds following construction of the Buffalo Ridge facility in Minnesota. Results from the Stateline wind-energy facility in Oregon and Washington (Erickson et al. 2004), and the Combine Hills facility in Oregon (Young et al. 2005), suggest a relatively small impact of the wind-energy facilities on grassland nesting passerines. Transect surveys conducted prior to and after construction of the wind-energy facilities found that grassland passerine use was significantly reduced within approximately 50 m (164 ft) of turbine strings, but areas further away from turbine strings did not have reduced bird use.

Shaffer and Johnson (2008) examined displacement of grassland birds in the northern Great Plains. Intensive transect surveys were conducted within grid cells that contained turbines as well as reference areas. The study focused on five species at two study sites, one in South Dakota and one in North Dakota. Based on this analysis, killdeer, western meadowlark (*Sturna neglecta*), and chestnut-collared longspur (*Calcarius ornatus*) did not show any avoidance of wind turbines. However, grasshopper sparrow (*Ammodramus savannarum*) and clay-colored sparrow (*Spizella pallida*) showed avoidance out to 200 m (656 ft).

Displacement effects of wind-energy facilities on waterfowl and shorebirds appear to be mixed. Studies from the Netherlands and Denmark suggest that densities of these types of species near turbines were lower compared to densities in similar habitats away from turbines (Winkelman 1990; Pedersen and Poulsen 1991). However, a study from a facility in England found no effect of wind turbines on populations of cormorant (*Phalacrcorax xarbo*), purple sandpipers (*Calidris maritima*), eiders (*Somateria mollissima*), or gulls, although the cormorants were temporarily displaced during construction (Lawrence et al. 2007). At the Buffalo Ridge wind-energy facility in Minnesota, the abundance of several bird types, including shorebirds and waterfowl, were found to be significantly lower at survey plots with turbines than at reference plots without turbines (Johnson et al. 2000a). The report concluded that the area of reduced use was limited primarily to those areas within 100 m (328 ft) of the turbines. Disturbance tends to be greatest for migrating birds while feeding and resting (Crockford 1992; NRC 2007). The majority of waterfowl/waterbird use at the HPWRA included several large groups of unidentified ducks in the spring, summer, and fall, comprising 2,021 observations, and ten groups of Canada geese in the summer and fall comprising a total of 209 individuals. Together, the unidentified ducks and Canada geese comprised 93.7% of all waterfowl/waterbird observations. The presence of similar habitat surrounding the HPWRA means that any displacement of waterfowl is unlikely to impact the population.

A study conducted in England to assess displacement of wintering farmland birds by wind turbines located in an agricultural landscape found that only common (ring-necked) pheasants (*Phasianus colchicus*) apparently avoided turbines. The other species/bird groups examined, including granivores, red-legged partridge (*Alectoris rufa*), Eurasian skylark (*Alauda arvensis*) and corvids, showed no displacement from wind turbines. In fact, Eurasian skylarks and corvids showed increased use of areas close to turbines, possibly due to increased food resources associated with disturbed areas (Devereux et al. 2008).

Much debate has occurred recently regarding the potential impacts of wind-energy projects on prairie grouse, including greater sage-grouse. Under a set of voluntary guidelines, the US Fish and Wildlife Service (USFWS) has taken a precautionary approach and recommends wind turbines be placed at least five miles (eight km) from known prairie grouse lek locations (USFWS 2003). The USFWS argues that because prairie grouse evolved in habitats with little vertical structure, placement of tall man-made structures, such as wind turbines, in occupied prairie grouse habitat may result in a decrease in habitat suitability (USFWS 2004). While the potential exists for wind turbines to displace prairie grouse from occupied habitat, well-designed studies examining the potential impacts of wind turbines on prairie grouse are currently lacking. Ongoing telemetry research being conducted by Kansas State University to examine response of greater prairie-chickens to wind energy development in Kansas and a similar study being conducted by WEST (Johnson et al. 2009) on greater sage-grouse in Wyoming will help to address this lack of knowledge.

Other than these two ongoing telemetry studies, we are aware of only two publicly-available studies that examined response of prairie grouse species to wind energy development. The Nebraska Game and Parks Commission (NGPC 2008) monitored both greater prairie-chicken (*Tympanuchus cupido*) and sharp-tailed grouse (*Tympanuchus phasianellus*) leks following construction of the 36-turbine Ainsworth wind-energy facility in Brown County, Nebraska. Surveys for leks were conducted three years post-construction (2006-2008) within a 1- to 2-mile radius of the facility, an area that covered approximately 25 square miles (65 km^2). Six sharp-tailed grouse and seven greater prairie-chicken leks were recorded during the study, and all 13 leks were present each of the three study years. The total number of greater prairie-chickens and sharp-tailed grouse combined counted on the leks was 136 in 2006, 135 in 2007, and 134 in 2008, indicating no significant decrease in populations within the study area. No pre-construction data were available on prairie grouse leks near the site; however, densities of lekking grouse on the study area at Ainsworth were within the range of expected grouse densities in similar habitats in Brown County and the adjacent Rock County. The 13 leks ranged from approximately 0.30 to 1.59 miles (0.48 to 2.56 km) from the nearest turbine, with an average distance of 0.66 miles (1.06 km).

At a three-turbine wind energy facility in Minnesota, researchers documented six active greater prairie-chicken leks within two miles of the three turbines, with the nearest lek located within one km (0.6 miles) of the nearest turbine. One hen with a brood was also documented immediately adjacent to a turbine (USFWS 2004).

Although the data collected during these two studies indicate that prairie grouse may continue to use habitats near wind-energy facilities, research conducted on greater sage-grouse response to oil and gas development has found population declines due to oil and gas development may not occur until four or five years post-construction (Holloran 2005). Therefore, long-term data may be required to adequately assess impacts of wind-energy development on prairie grouse species. Due to the apparent low density of greater sage-grouse in the HPWRA, and because it is not in a greater sage-grouse core use area, it is unlikely that construction and operation of a wind energy facility in this area will significantly impact greater sage-grouse populations.

Bat Impacts

Assessing the potential impacts of wind-energy development on bats at the HPWRA is complicated by the current lack of understanding of why bats die at wind turbines (Kunz et al. 2007b; Baerwald et al. 2008), combined with the inherent difficulties of monitoring elusive, night-flying animals (O'Shea et al. 2003). To date, monitoring studies of wind-energy facilities suggest that: a) migratory tree-roosting species (eastern red, hoary, and silver-haired bats) comprise almost 75% of reported bats killed; b) the majority of fatalities occur during the post-breeding or fall migration season (roughly August and September); and c) the highest reported fatalities occur at facilities located along forested ridge tops in the eastern US (Gruver 2002; Johnson et al. 2003a; Kunz et al. 2007b; Arnett et al. 2008), although recent studies in agricultural regions of Iowa and Alberta, Canada, report relatively high fatalities as well (Jain 2005; Baerwald 2006).

Some studies of wind-energy facilities have recorded both Anabat detections per night and bat mortality (Table 13). The number of bat calls per night as determined from bat detectors shows a rough correlation with bat mortality, but may be misleading because effort, timing of sampling, species recorded, and detector settings (equipment and locations) varies among studies (Kunz et al. 2007b). Thus, the best available estimate of mortality levels at a proposed facility involves evaluation of the on-site bat acoustic data in terms of activity levels, seasonal variation, species composition, and habitat and topographic features of the study area.

Activity

Bat activity within the HPWRA (mean of 3.8 bat passes per detector-night) was similar when compared to that observed at wind-energy facilities in Minnesota and Wyoming, where bat mortality was low, but activity at the HPWRA was much lower than activity recorded at facilities in West Virginia and Tennessee, where bat mortality rates were high (Table 13). Thus, based on the presumed relationship between pre-construction bat activity and post-construction fatalities, bat mortality rates at HPWRA would be expected to be greater than the 2.2 bat fatalities/turbine/year reported at the Buffalo Ridge facility in Minnesota, but much lower than the 20.8 fatalities/turbine/year reported at the Buffalo Mountain facility in Tennessee.

Spatial Variation

The proposed wind-energy facility is not located near any large, known bat colonies or other features that are likely to attract large numbers of bats. As well, the HPWRA does not contain topographic features that may funnel migrating bats, and is lacking large tracts of forest cover, unlike high-mortality sites in the eastern US. However, the relatively large numbers of bat fatalities recently reported in northern Iowa (Jain 2005) and southwestern Alberta (Baerwald 2006) indicate that an open landscape is no guarantee of low mortality. Based on the lack of forested areas and other bat habitats at the HPWRA, the majority of bat mortalities are expected to be individuals migrating through the area.

Activity was relatively high at Anabat station HP1 compared to station HP2, accounting for the majority of the calls recorded during this study. Station HP1 recorded twice as many eastern red bats than station HP2, however both stations had similar activity by hoary bats.

Temporal Variation

The number of bat calls detected per night at the HPWRA was relatively high during August, with activity peaking on August 21. August activity may represent movement of migrating bats through the area, which may explain the greater number of both low and high-frequency bats at this time. Activity by hoary bats also peaked on August 22, suggesting migration of this species through the area. After August 31, activity was very low, indicating that most bats had left the area for winter hibernacula or warmer climates.

Fatality studies of bats at wind-energy facilities in the US have shown a peak in mortality in August and September and generally lower mortality earlier in the summer (Johnson 2005; Arnett et al. 2008). While the survey effort varies among the different studies, the studies that combine Anabat surveys and fatality surveys show a general association between the timing of increased bat call rates and timing of mortality, with both call rates and mortality peaking during the late summer and early fall (Kunz et al. 2007b). Based on the available data, it is expected that bat mortality at the HPWRA will be highest in late August.

Species Composition

Of the ten species of bat likely to occur in the study area, five are known fatalities at wind-energy facilities (Table 2). Acoustic bat surveys were unable to determine bat species present in the study area (except for hoary and eastern red bats), but were able to distinguish high-frequency from low-frequency species. About 80% of passes were by high-frequency bats, suggesting higher relative abundance of species such as *Myotis* spp. Many of the low-frequency species likely to be present at the HPWRA (e.g., hoary, silver-haired, and big brown bat) tend to forage at higher altitudes than most high-frequency species due to their wing morphology and echolocation call structure (Norberg and Rayner 1987).

Both high-frequency and low-frequency species were most abundant in August. This change in species composition probably reflects movement of both high- and low-frequency species out of the area as they travel to winter hibernacula or warmer climates. Hoary bats made up about 4% of all low-frequency passes, and were most active in late August, suggesting fall migration through the area. Additionally, eastern red bats made up about 18% of all high-frequency passes, and were most abundant throughout August, suggesting fall migration through the area by this species as well.

CONCLUSIONS

Based on data collected during this study, raptor and all bird use of the HPWRA is generally lower than most WRAs evaluated throughout the western and midwestern US using similar methods. Based on the results of the studies to date, bird mortality at the HPWRA would likely be similar or lower than that documented at other wind-energy facilities located in the western and midwestern US where bird collision mortality has been relatively low.

Currently, few published studies are available from the Rocky Mountain West that compare bird use to bird mortality rates. Based on research conducted at wind-energy facilities throughout the US, raptor use at the HPWRA is generally lower than use levels recorded at other wind-energy facilities. Raptor fatality rates are expected to be within the range of fatality rates observed at other facilities where raptor use levels are also relatively low. To date, no relationships have been observed between overall use by other bird types and fatality rates of those bird types at wind-energy facilities. However, the flight characteristics and foraging habits of some species may result in increased exposure for these species at the HPWRA. The surveys conducted for this proposed wind-energy facility also do not address the impacts of the proposed facility to nocturnal migrants, such as passerines. To date, overall fatality rates for birds (including nocturnal migrants) at wind-energy facilities have been relatively low and consistent in the West. As more research is conducted at facilities in the West, more information regarding the potential direct impacts of wind-energy facilities to bird species will be obtained.

The HPWRA is composed primarily of grassland and scrub-shrub. Some potential exists for wind turbines to displace birds within native habitats. Research concerning displacement impacts to songbirds, waterfowl, and waterbirds from wind-energy facilities is limited, but some studies show the potential for small-scale (200 m [656 ft] or less) displacement, while impacts to densities of birds at larger scales have not been shown.

Overall bat activity at the HPWRA (3.76 bat passes/detector-night) was somewhat higher than the mean of 2.2 bat passes/detector-night recorded at the Foote Creek Rim wind-energy facility, which is located approximately five miles (eight km) west of the HPWRA. Actual bat mortality at the Foote Creek Rim facility was estimated at 1.34 bat fatalities/MW/year (Young et al. 2001), which is relatively low compared to most other operational facilities (Johnson 2005; Arnett et al. 2008). Therefore, similar to slightly higher rates of bat mortality are expected at the HPWRA.

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Table 1. The land cover types, coverage, and composition within the High Plains Wind Resource Area.

Habitat	Acres	% Composition
Developed, Open Space	45.59	0.4
Barren	2.78	<0.1
Evergreen Forest	1.56	<0.1
Mixed Forest	1.17	<0.1
Scrub-Shrub	10,222.70	96.7
Grassland	67.17	0.6
Pasture/Hay	26.89	0.3
Woody Wetlands	21.96	0.2
Emergent Wetlands	177.11	1.7
Total	**10,566.93**	**100**

Data from the National Landcover Database (USGS NLCD 2001).

Table 2. Bat species determined from range-maps (Harvey et al. 1999; BCI website) as likely to occur within the High Plains Wind Resource Area, sorted by call frequency.

Common Name	Scientific Name
High-frequency (> 35 kHz)	
western small-footed bat	*Myotis ciliolabrum*
little brown bat†	*Myotis lucifugus*
long-legged bat	*Myotis volans*
eastern red bat*†	*Lasiurus borealis*
Low-frequency (< 35 kHz)	
Townsend's big-eared bat	*Corynorhinus townsendii*
big brown bat†	*Eptesicus fuscus*
silver-haired bat*†	*Lasionycteris noctivagans*
hoary bat*†	*Lasiurus cinereus*
western long-eared bat	*Myotis evotis*
fringed bat	*Myotis thysanodes*

*long-distance migrant; †species known to have been killed at wind-energy facilities.

Table 3. Summary of bird use (number of birds/plot/20-min survey), species richness (species/20-min survey), and sample size by season and overall during the fixed-point bird use surveys at the High Plains Wind Resource Area, March 6, 2007 - March 14, 2009.

Season	Number of Visits	Mean Use	Species Richness	# Species	# Surveys Conducted
Spring	8	18.95	2.67	46	88
Summer	6	14.83	2.88	36	66
Fall	9	11.29	0.95	15	99
Winter	8	0.92	0.31	6	82
Overall	**31**	**10.44**	**1.59**	**53**	**335**

Table 4. Total number of individuals and groups for each bird type and species, by season and overall, during the fixed-point bird use surveys at the High Plains Wind Resource Area, April 6, 2007 - March 14, 2009.

		Spring		Summer		Fall		Winter		Total	
Species/Type	**Scientific Name**	**# grps**	**# obs**	**# grps**	**# obs**	**# grps**	**# obs**	**# grps**	**# obs**	**# grps**	**# obs**
Waterfowl/Waterbirds		**57**	**1,075**	**38**	**612**	**27**	**715**	**1**	**2**	**123**	**2,404**
American white pelican	*Pelecanus erythrorhyncos*	2	27	0	0	0	0	0	0	2	27
American wigeon	*Anas americana*	2	4	1	4	0	0	0	0	3	8
bufflehead	*Bucephala albeola*	1	2	0	0	0	0	0	0	1	2
California gull	*Larus californicus*	0	0	2	2	0	0	0	0	2	2
Canada goose	*Branta canadensis*	7	22	5	107	5	102	0	0	17	231
common merganser	*Mergus merganser*	3	10	0	0	0	0	0	0	3	10
eared grebe	*Podiceps nigricollis*	2	4	2	3	0	0	0	0	4	7
gadwall	*Anas strepera*	1	2	0	0	0	0	0	0	1	2
great blue heron	*Ardea herodias*	0	0	1	1	0	0	0	0	1	1
green-winged teal	*Anas crecca*	3	18	1	1	0	0	0	0	4	19
lesser scaup	*Aythya affinis*	1	9	1	3	0	0	0	0	2	12
mallard	*Anas platyrhynchos*	7	15	5	15	1	1	0	0	13	31
northern pintail	*Anas acuta*	3	14	0	0	0	0	0	0	3	14
northern shoveler	*Anas clypeata*	1	2	0	0	0	0	0	0	1	2
ring-necked duck	*Aythya collaris*	2	4	1	3	0	0	0	0	3	7
sandhill crane	*Grus canadensis*	1	5	0	0	0	0	0	0	1	5
unidentified duck		19	935	18	472	21	612	1	2	59	2,021
unidentified gull		2	2	1	1	0	0	0	0	3	3
Shorebirds		**48**	**181**	**22**	**81**	**1**	**1**	**0**	**0**	**71**	**263**
American avocet	*Recurvirostra americana*	8	29	2	2	0	0	0	0	10	31
common snipe	*Gallinago gallinago*	0	0	1	1	0	0	0	0	1	1
killdeer	*Charadrius vociferus*	15	18	8	9	0	0	0	0	23	27
long-billed curlew	*Numenius americanus*	1	3	0	0	0	0	0	0	1	3
mountain plover	*Charadrius montanus*	9	11	3	3	1	1	0	0	13	15
willet	*Catoptrophorus semipalmatus*	4	6	2	3	0	0	0	0	6	9
Wilson's phalarope	*Phalaropus tricolor*	11	114	6	63	0	0	0	0	17	177

Table 4. Total number of individuals and groups for each bird type and species, by season and overall, during the fixed-point bird use surveys at the High Plains Wind Resource Area, April 6, 2007 - March 14, 2009.

		Spring		Summer		Fall		Winter		Total	
Species/Type	**Scientific Name**	**# grps**	**# obs**	**# grps**	**# obs**	**# grps**	**# obs**	**# grps**	**# obs**	**# grps**	**# obs**
Raptors		**75**	**76**	**43**	**49**	**30**	**30**	**8**	**8**	**156**	**163**
Accipiters		*2*	*2*	*0*	*0*	*1*	*1*	*0*	*0*	*3*	*3*
sharp-shinned hawk	*Accipter striatus*	2	2	0	0	1	1	0	0	3	3
Buteos		*30*	*31*	*29*	*32*	*14*	*14*	*1*	*1*	*74*	*78*
ferruginous hawk	*Buteo regalis*	1	1	13	14	4	4	0	0	18	19
red-tailed hawk	*Buteo jamaicensis*	25	26	5	5	1	1	0	0	31	32
rough-legged hawk	*Buteo lagopus*	1	1	0	0	6	6	1	1	8	8
Swainson's hawk	*Buteo swainsoni*	1	1	5	6	0	0	0	0	6	7
unidentified buteo		2	2	6	7	3	3	0	0	11	12
Northern Harrier		*5*	*5*	*2*	*2*	*6*	*6*	*0*	*0*	*13*	*13*
northern harrier	*Circus cyaneus*	5	5	2	2	6	6	0	0	13	13
Eagles		*11*	*11*	*3*	*3*	*4*	*4*	*6*	*6*	*24*	*24*
bald eagle	*Haliaeetus leucocephalus*	3	3	0	0	1	1	0	0	4	4
golden eagle	*Aquila chrysaetos*	8	8	3	3	3	3	6	6	20	20
Falcons		*26*	*26*	*4*	*5*	*3*	*3*	*1*	*1*	*34*	*35*
American kestrel	*Falco sparverius*	23	23	4	5	3	3	0	0	30	31
merlin	*Falco columbarius*	1	1	0	0	0	0	0	0	1	1
peregrine falcon	*Falco peregrinus*	1	1	0	0	0	0	0	0	1	1
prairie falcon	*Falco mexicanus*	1	1	0	0	0	0	1	1	2	2
Owls		*0*	*0*	*4*	*6*	*0*	*0*	*0*	*0*	*4*	*6*
burrowing owl	*Athene cunicularia*	0	0	4	6	0	0	0	0	4	6
Other Raptors		*1*	*1*	*1*	*1*	*2*	*2*	*0*	*0*	*4*	*4*
osprey	*Pandion haliaetus*	1	1	0	0	0	0	0	0	1	1
unidentified raptor		0	0	1	1	2	2	0	0	3	3
Vultures		**0**	**0**	**2**	**2**	**0**	**0**	**0**	**0**	**2**	**2**
turkey vulture	*Cathartes aura*	0	0	2	2	0	0	0	0	2	2

Table 4. Total number of individuals and groups for each bird type and species, by season and overall, during the fixed-point bird use surveys at the High Plains Wind Resource Area, April 6, 2007 - March 14, 2009.

		Spring		Summer		Fall		Winter		Total	
Species/Type	**Scientific Name**	**# grps**	**# obs**	**# grps**	**# obs**	**# grps**	**# obs**	**# grps**	**# obs**	**# grps**	**# obs**
Upland Gamebirds		**1**	**3**	**0**	**0**	**1**	**10**	**0**	**0**	**2**	**13**
greater sage-grouse	*Centrocercus urophasianus*	1	3	0	0	1	10	0	0	2	13
Passerines		**173**	**521**	**169**	**254**	**61**	**628**	**53**	**84**	**456**	**1,487**
Brewer's blackbird	*Euphagus cyanocephalus*	1	1	2	3	1	1	0	0	4	5
Brewer's sparrow	*Spizella breweri*	5	5	3	3	0	0	0	0	8	8
brown-headed cowbird	*Molothrus ater*	0	0	1	5	0	0	0	0	1	5
cliff swallow	*Petrochelidon pyrrhonota*	4	7	9	11	0	0	0	0	13	18
common raven	*Corvus corax*	4	5	6	6	4	5	10	13	24	29
horned lark	*Eremophila alpestris*	116	445	107	177	56	622	43	71	322	1,315
McCown's longspur	*Calcarius mccownii*	16	22	27	34	0	0	0	0	43	56
red-winged blackbird	*Agelaius phoeniceus*	6	10	1	2	0	0	0	0	7	12
sage thrasher	*Oreoscoptes montanus*	0	0	2	2	0	0	0	0	2	2
tree swallow	*Tachycineta bicolor*	2	2	1	1	0	0	0	0	3	3
unidentified swallow		5	9	1	1	0	0	0	0	6	10
vesper sparrow	*Pooecetes gramineus*	3	4	2	2	0	0	0	0	5	6
violet-green swallow	*Tachycineta thalassina*	1	1	0	0	0	0	0	0	1	1
western meadowlark	*Sturnella neglecta*	10	10	7	7	0	0	0	0	17	17
Other Birds		**0**	**0**	**5**	**7**	**0**	**0**	**0**	**0**	**5**	**7**
common nighthawk	*Chordeiles minor*	0	0	5	7	0	0	0	0	5	7
Overall		**354**	**1,856**	**279**	**1,005**	**120**	**1,384**	**62**	**94**	**815**	**4,339**

Table 5. Mean bird use (number of birds/plot/20-min survey), percent of total composition (%), and frequency of occurrence (%) for each bird type and species by season during the fixed-point bird use surveys at the High Plains Wind Resource Area, April 6, 2007 - March 14, 2009.

	Use				% Composition				% Frequency			
Species/Type	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
Waterbirds/Waterfowl	**12.00**	**9.27**	**7.22**	**0.02**	**63.3**	**62.5**	**64.0**	**2.5**	**36.4**	**34.8**	**24.2**	**1.1**
American white pelican	0.15	0	0	0	0.8	0	0	0	1.1	0	0	0
American wigeon	0.05	0.06	0	0	0.2	0.4	0	0	2.3	1.5	0	0
bufflehead	0.02	0	0	0	0.1	0	0	0	1.1	0	0	0
California gull	0	0.03	0	0	0	0.2	0	0	0	3.0	0	0
Canada goose	0.25	1.62	1.03	0	1.3	10.9	9.1	0	8.0	6.1	5.1	0
common merganser	0.11	0	0	0	0.6	0	0	0	3.4	0	0	0
eared grebe	0.05	0.05	0	0	0.2	0.3	0	0	2.3	3.0	0	0
gadwall	0.02	0	0	0	0.1	0	0	0	1.1	0	0	0
great blue heron	0	0.02	0	0	0	0.1	0	0	0	1.5	0	0
green-winged teal	0.20	0.02	0	0	1.1	0.1	0	0	3.4	1.5	0	0
lesser scaup	0.10	0.05	0	0	0.5	0.3	0	0	1.1	1.5	0	0
mallard	0.17	0.23	0.01	0	0.9	1.5	0.1	0	8.0	7.6	1.0	0
northern pintail	0.16	0	0	0	0.8	0	0	0	3.4	0	0	0
northern shoveler	0.02	0	0	0	0.1	0	0	0	1.1	0	0	0
ring-necked duck	0.05	0.05	0	0	0.2	0.3	0	0	2.3	1.5	0	0
unidentified duck	10.63	7.15	6.18	0.02	56.1	48.2	54.7	2.5	21.6	24.2	21.2	1.1
unidentified gull	0.02	0.02	0	0	0.1	0.1	0	0	2.3	1.5	0	0
Shorebirds	**2.06**	**1.23**	**0.01**	**0**	**10.9**	**8.3**	**0.1**	**0**	**30.7**	**24.2**	**1.0**	**0**
American avocet	0.33	0.03	0	0	1.7	0.2	0	0	9.1	3.0	0	0
common snipe	0	0.02	0	0	0	0.1	0	0	0	1.5	0	0
killdeer	0.20	0.14	0	0	1.1	0.9	0	0	14.8	12.1	0	0
long-billed curlew	0.03	0	0	0	0.2	0	0	0	1.1	0	0	0
mountain plover	0.13	0.05	0.01	0	0.7	0.3	0.1	0	9.1	4.5	1.0	0
willet	0.07	0.05	0	0	0.4	0.3	0	0	4.5	3.0	0	0
Wilson's phalarope	1.30	0.95	0	0	6.8	6.4	0	0	10.2	9.1	0	0

Table 5. Mean bird use (number of birds/plot/20-min survey), percent of total composition (%), and frequency of occurrence (%) for each bird type and species by season during the fixed-point bird use surveys at the High Plains Wind Resource Area, April 6, 2007 - March 14, 2009.

	Use				% Composition				% Frequency			
Species/Type	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**
Raptors	**0.84**	**0.71**	**0.30**	**0.09**	**4.4**	**4.8**	**2.7**	**10.1**	**51.1**	**37.9**	**24.2**	**7.0**
Accipiters	*0.02*	*0*	*0.01*	*0*	*0.1*	*0*	*0.1*	*0*	*2.3*	*0*	*1.0*	*0*
sharp-shinned hawk	0.02	0	0.01	0	0.1	0	0.1	0	2.3	0	1.0	0
Buteos	*0.35*	*0.45*	*0.14*	*0.01*	*1.9*	*3.1*	*1.3*	*1.4*	*26.1*	*28.8*	*13.1*	*1.3*
ferruginous hawk	0.01	0.21	0.04	0	0.1	1.4	0.4	0	1.1	13.6	4.0	0
red-tailed hawk	0.30	0.08	0.01	0	1.6	0.5	0.1	0	21.6	7.6	1.0	0
rough-legged hawk	0.01	0	0.06	0.01	0.1	0	0.5	1.4	1.1	0	5.1	1.3
Swainson's hawk	0.01	0.09	0	0	0.1	0.6	0	0	1.1	7.6	0	0
unidentified buteo	0.02	0.08	0.03	0	0.1	0.5	0.3	0	2.3	4.5	3.0	0
Northern Harrier	*0.06*	*0.03*	*0.06*	*0*	*0.3*	*0.2*	*0.5*	*0*	*4.5*	*3.0*	*4.0*	*0*
northern harrier	0.06	0.03	0.06	0	0.3	0.2	0.5	0	4.5	3.0	4.0	0
Eagles	*0.10*	*0.05*	*0.04*	*0.07*	*0.5*	*0.3*	*0.4*	*7.5*	*10.2*	*3.0*	*4.0*	*4.7*
bald eagle	0.03	0	0.01	0	0.2	0	0.1	0	3.4	0	1.0	0
golden eagle	0.07	0.05	0.03	0.07	0.4	0.3	0.3	7.5	6.8	3.0	3.0	4.7
Falcons	*0.30*	*0.08*	*0.03*	*0.01*	*1.6*	*0.5*	*0.3*	*1.2*	*19.3*	*6.1*	*1.0*	*1.1*
American kestrel	0.26	0.08	0.03	0	1.4	0.5	0.3	0	18.2	6.1	1.0	0
merlin	0.01	0	0	0	0.1	0	0	0	1.1	0	0	0
peregrine falcon	0.01	0	0	0	0.1	0	0	0	1.1	0	0	0
prairie falcon	0.01	0	0	0.01	0.1	0	0	1.2	1.1	0	0	1.1
Owls	*0*	*0.09*	*0*	*0*	*0*	*0.6*	*0*	*0*	*0*	*3.0*	*0*	*0*
burrowing owl	0	0.09	0	0	0	0.6	0	0	0	3.0	0	0
Other Raptors	*0.01*	*0.02*	*0.02*	*0*	*0.1*	*0.1*	*0.2*	*0*	*1.1*	*1.5*	*2.0*	*0*
osprey	0.01	0	0	0	0.1	0	0	0	1.1	0	0	0
unidentified raptor	0	0.02	0.02	0	0	0.1	0.2	0	0	1.5	2.0	0
Vultures	**0**	**0.03**	**0**	**0**	**0**	**0.2**	**0**	**0**	**0**	**3.0**	**0**	**0**
turkey vulture	0	0.03	0	0	0	0.2	0	0	0	3.0	0	0
Upland Gamebirds	**0.03**	**0**	**0.10**	**0**	**0.2**	**0**	**0.9**	**0**	**1.1**	**0**	**1.0**	**0**
greater sage-grouse	0.03	0	0.10	0	0.2	0	0.9	0	1.1	0	1.0	0

Table 5. Mean bird use (number of birds/plot/20-min survey), percent of total composition (%), and frequency of occurrence (%) for each bird type and species by season during the fixed-point bird use surveys at the High Plains Wind Resource Area, April 6, 2007 - March 14, 2009.

	Use				% Composition				% Frequency			
Species/Type	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**
Passerines	**4.02**	**3.48**	**3.66**	**0.81**	**21.2**	**23.5**	**32.4**	**87.4**	**64.8**	**87.9**	**39.4**	**21.6**
Brewer's blackbird	0.01	0.03	0.01	0	0.1	0.2	0.1	0	1.1	1.5	1.0	0
Brewer's sparrow	0.03	0.05	0	0	0.2	0.3	0	0	3.4	4.5	0	0
cliff swallow	0.08	0.17	0	0	0.4	1.1	0	0	4.5	10.6	0	0
common raven	0	0.03	0	0.03	0	0.2	0	3.7	0	3.0	0	2.3
horned lark	3.57	2.56	3.65	0.77	18.8	17.3	32.3	83.7	58.0	78.8	39.4	20.5
McCown's longspur	0.18	0.52	0	0	1.0	3.5	0	0	11.4	31.8	0	0
red-winged blackbird	0	0.03	0	0	0	0.2	0	0	0	1.5	0	0
tree swallow	0.02	0.02	0	0	0.1	0.1	0	0	2.3	1.5	0	0
unidentified swallow	0.07	0.02	0	0	0.4	0.1	0	0	2.3	1.5	0	0
vesper sparrow	0.05	0.03	0	0	0.2	0.2	0	0	3.4	3.0	0	0
violet-green swallow	0.01	0	0	0	0.1	0	0	0	1.1	0	0	0
western meadowlark	0	0.05	0	0	0	0.3	0	0	0	4.5	0	0
Other Birds	**0**	**0.11**	**0**	**0**	**0**	**0.7**	**0**	**0**	**0**	**6.1**	**0**	**0**
common nighthawk	0	0.11	0	0	0	0.7	0	0	0	6.1	0	0
Overall	**18.95**	**14.83**	**11.29**	**0.92**	**4.8**	**3.7**	**2.9**	**0.2**	**93.2**	**95.5**	**63.6**	**27.5**

Table 6. Flight height characteristics by bird type during fixed-point bird use surveys at the High Plains Wind Resource Area, April 6, 2007 - March 14, 2009.

Bird Type	# Groups Flying	# Obs Flying	Mean Flight Height (ft)	% Obs Flying	% within Flight Height Categories 0-35 m	35-135 m	> 135 m
Waterbirds/Waterfowl	19	88	21.95	3.7	84.1	1.1	14.8
Shorebirds	22	31	7.05	11.8	96.8	3.2	0
Raptors	117	121	31.26	76.1	75.2	22.3	2.5
Accipiters	*3*	*3*	*6.00*	*100*	*100*	*0*	*0*
Buteos	*51*	*53*	*44.12*	*69.7*	*66.0*	*30.2*	*3.8*
Northern Harrier	*12*	*12*	*6.42*	*92.3*	*91.7*	*8.3*	*0*
Eagles	*20*	*20*	*53.00*	*90.9*	*50.0*	*45.0*	*5.0*
Falcons	*25*	*25*	*8.36*	*71.4*	*100*	*0*	*0*
Owls	*2*	*4*	*1.00*	*66.7*	*100*	*0*	*0*
Other Raptors	*4*	*4*	*10.50*	*100*	*75.0*	*25.0*	*0*
Vultures	2	2	12.50	100	100	0	0
Upland Gamebirds	0	0	0	0	0	0	0
Passerines	328	1233	3.48	83.0	99.8	0.2	0
Other Birds	4	6	3.00	85.7	100	0	0
Overall	**492**	**1,481**	**10.99**	**34.3**	**96.8**	**2.1**	**1.1**

ZOR: The likely "zone of risk" for potential collision with a turbine blade, or 35-130 m (114-427 ft) above ground level (AGL).

Table 7. Relative exposure index and flight characteristics by species during the fixed-point bird use surveys at the High Plains Wind Resource Area, April 6, 2007 - March 14, 2009.

Species	# Groups Flying	Overall Mean Use	% Flying	% Flying within ZOR based on initial obs	Exposure Index	% Within ZOR at anytime
golden eagle	16	0.05	88.9	50.0	0.02	62.5
ferruginous hawk	14	0.06	78.9	33.3	0.02	53.3
red-tailed hawk	19	0.08	62.5	30.0	0.02	40.0
unidentified buteo	9	0.03	90.0	22.2	0.01	22.2
rough-legged hawk	7	0.02	87.5	28.6	<0.01	85.7
Swainson's hawk	2	0.03	28.6	50.0	<0.01	50.0
mallard	3	0.10	22.6	14.3	<0.01	14.3
killdeer	8	0.08	33.3	11.1	<0.01	11.1
unidentified raptor	3	0.01	100	33.3	<0.01	33.3
northern harrier	12	0.03	92.3	8.3	<0.01	8.3
bald eagle	4	0.01	100	25.0	<0.01	25.0
horned lark	237	2.42	84.4	0.1	<0.01	0.2
common raven	17	0.02	67.9	5.3	<0.01	10.5
American avocet	1	0.08	3.2	0	0	0
American kestrel	21	0.08	67.7	0	0	0
American white pelican	1	0.03	100	0	0	0
Brewer's blackbird	4	0.01	100	0	0	0
McCown's longspur	39	0.17	92.9	0	0	0
Wilson's phalarope	3	0.52	4.0	0	0	0
burrowing owl	2	0.02	66.7	0	0	0
California gull	2	0.01	100	0	0	0
Canada goose	4	0.68	10.4	0	0	0
cliff swallow	13	0.06	100	0	0	0
common merganser	1	0.02	20.0	0	0	0
common nighthawk	4	0.03	85.7	0	0	0
great blue heron	1	<0.01	100	0	0	0
long-billed curlew	1	0.01	100	0	0	0
merlin	1	<0.01	100	0	0	0

Table 7. Relative exposure index and flight characteristics by species during the fixed-point bird use surveys at the High Plains Wind Resource Area, April 6, 2007 - March 14, 2009.

Species	# Groups Flying	Overall Mean Use	% Flying	% Flying within ZOR based on initial obs	Exposure Index	% Within ZOR at anytime
mountain plover	5	0.04	33.3	0	0	0
osprey	1	<0.01	100	0	0	0
peregrine falcon	1	<0.01	100	0	0	0
prairie falcon	2	0.01	100	0	0	0
red-winged blackbird	5	0.01	66.7	0	0	0
sharp-shinned hawk	3	0.01	100	0	0	0
tree swallow	3	0.01	100	0	0	0
turkey vulture	2	0.01	100	0	0	50.0
unidentified duck	4	5.37	1.8	0	0	36.1
unidentified gull	3	0.01	100	0	0	0
unidentified swallow	6	0.02	100	0	0	0
violet-green swallow	1	<0.01	100	0	0	0
western meadowlark	2	0.01	11.8	0	0	0
willet	4	0.03	66.7	0	0	0
American wigeon	0	0.02	0	0	0	0
Brewer's sparrow	0	0.02	0	0	0	0
bufflehead	0	<0.01	0	0	0	0
common snipe	0	<0.01	0	0	0	0
eared grebe	0	0.02	0	0	0	0
gadwall	0	0.00	0	0	0	0
greater sage grouse	0	0.03	0	0	0	0
green-winged teal	0	0.05	0	0	0	0
lesser scaup	0	0.03	0	0	0	0
northern pintail	0	0.03	0	0	0	0
northern shoveler	0	0.00	0	0	0	0
ring-necked duck	0	0.02	0	0	0	0
vesper sparrow	0	0.02	0	0	0	0

ZOR: The likely "zone of risk" for potential collision with a turbine blade, or 35-130 m (114-427 ft) above ground level (AGL).

Table 8. Nesting raptor species and nest density for the High Plains Wind Resource Area and the study area, based on raptor nest surveys.

Species	# of nests within the HPWRA	# of nests within 1-mi buffer of HPWRA	Density: HPWRA (# of nests/mi^2)	Density: 1-mi buffer of HPWRA (#nests/mi^2)
red-tailed hawk	0	1	0	0.02
bald eagle	0	1	0	0.02
ferruginous hawk	0	3 (inactive)	0	0.06
inactive	2	1	0.12	0.06
Total	**2**	**6**	**0.12**	**0.16**

Table 9. Results of bat acoustic surveys conducted at High Plains Wind Resource Area, July 14, 2008 - October 17, 2008

AnaBat Location	# of HF Bat Passes	# of LF Bat Passes	Total Bat Passes	Detector-Nights	Bat Passes/ Night
HP1	319	86	405	96	4.22
HP2	257	59	316	96	3.29
Total	**576**	**145**	**721**	**192**	**3.76**

Table 10. Results of bat acoustic surveys for high-frequency and low frequency species conducted at the High Plains Wind Resource Area, July 14, 2008 - October 17, 2008

Anabat Location	# of HF Bat Passes	# of LF Bat Passes	# of Hoary Bat Passes*	# of Eastern Red Bat Passes**	Total Bat Passes	Detector-Nights	Bat Passes/ Night
HP1	319	86	13	94	405	96	4.22
HP2	257	59	15	35	316	96	3.29
Total	**576**	**145**	**28**	**129**	**721**	**192**	**3.76**

*Data for hoary bat passes is included in LF bat passes
**Data for eastern red bat passes is included in HF bat passes

Table 11. Incidental wildlife observed while conducting all surveys at the High Plains Wind Resource Area, April 6, 2007 - March 14, 2009.

Species	Scientific Name	#grps	# obs
elk	*Cervus elephus*	1	25
pronghorn antelope	*Antilocapra americana*	79	282
swift fox	*Vulpes velox*	1	4
Mammal Subtotal	***3 species***	**81**	**311**
greater short-horned lizard	*Phrynosoma hernandesi*	1	1
Reptile Subtotal	***1 species***	**1**	**1**

Table 12. Summary of sensitive species observed at the High Plains Wind Resource Area during fixed-point bird use surveys and as incidental observations, April 6, 2007 – March 14, 2009.

Species	Scientific Name	Federal Status	State Status	# grps	# obs
Birds					
McCown's longspur	*Calcarius mccownii*		NSS4	43	56
ferruginous hawk	*Buteo regalis*		NSS3	18	19
mountain plover	*Charadrius montanus*		NSS4	13	15
northern pintail	*Anas acuta*		NSS3	3	14
greater sage-grouse	*Centrocercus urophasianus*	P	NSS2	2	13
lesser scaup	*Aythya affinis*		NSS3	2	12
Brewer's sparrow	*Spizella breweri*		NSS4	8	8
Swainson's hawk	*Buteo swainsoni*		NSS4	6	7
burrowing owl	*Athene cunicularia*		NSS4	4	6
bald eagle	*Haliaeetus leucocephalus*		NSS2	4	4
long-billed curlew	*Numenius americanus*		NSS3	1	3
sage thrasher	*Oreoscoptes montanus*		NSS4	2	2
great blue heron	*Ardea herodias*		NSS4	1	1
merlin	*Falco columbarius*		NSS3	1	1
peregrine falcon	*Falco peregrinus*		NSS3	1	1
Mammals					
Swift fox	*Vulpes velox*		NSS4	1	4
Reptiles					
greater short-horned lizard	*Phrynosoma hernandesi*		NSS4	1	1
Total	**17 species**			**111**	**167**

P – Petitioned for listing under the Endangered Species Act (ESA 1973) as threatened or endangered.

NSS2 - Populations declining, extirpation possible; habitat restricted or vulnerable but no recent or ongoing significant loss; species likely sensitive to human disturbance OR populations declining or restricted in numbers or distribution, extirpation not imminent; ongoing significant loss of habitat.

NSS3 - Populations greatly restricted or declining, extirpation possible; habitat not restricted, vulnerable but no loss; species not sensitive to human disturbance OR populations declining or restricted in numbers or distribution, extirpation not imminent; habitat restricted or vulnerable but no recent or ongoing significant loss; species likely sensitive to human disturbance OR species widely distributed; population status or trends unknown but suspected to be stable; on-going significant loss of habitat.

NSS4 - Populations greatly restricted or declining, extirpation possible; habitat stable and not restricted OR populations declining or restricted in numbers or distribution, extirpation not imminent; habitat not restricted, vulnerable but no loss; species not sensitive to human disturbance OR species widely distributed, population status or trends unknown but suspected to be stable; habitat restricted or vulnerable but no recent or on-going significant loss; species likely sensitive to human disturbance OR populations stable or increasing and not restricted in numbers or distribution; on-going significant loss of habitat.

Definitions from USFWS (2007), WGFD (2005), and Wyoming's Natural Diversity Database (WYNDD 2009).

Table 13. Wind-energy facilities in the US with both pre-construction Anabat sampling data and post-construction mortality data for bat species (adapted from Kunz et al. 2007b).

Wind-Energy Facility	Activity (#/detector night)	Mortality (bats/turbine/year)	Reference
High Plains, WY	3.8	?	This study
Foote Creek Rim, WY	2.2	1.3	Gruver 2002
Buffalo Ridge, MN	2.1	2.2	Johnson et al. 2004
Buffalo Mountain, TN	23.7	20.8	Fiedler 2004
Top of Iowa, IA	34.9	10.2	Jain 2005
Mountaineer, WV	38.3	38	Arnett et al. 2005

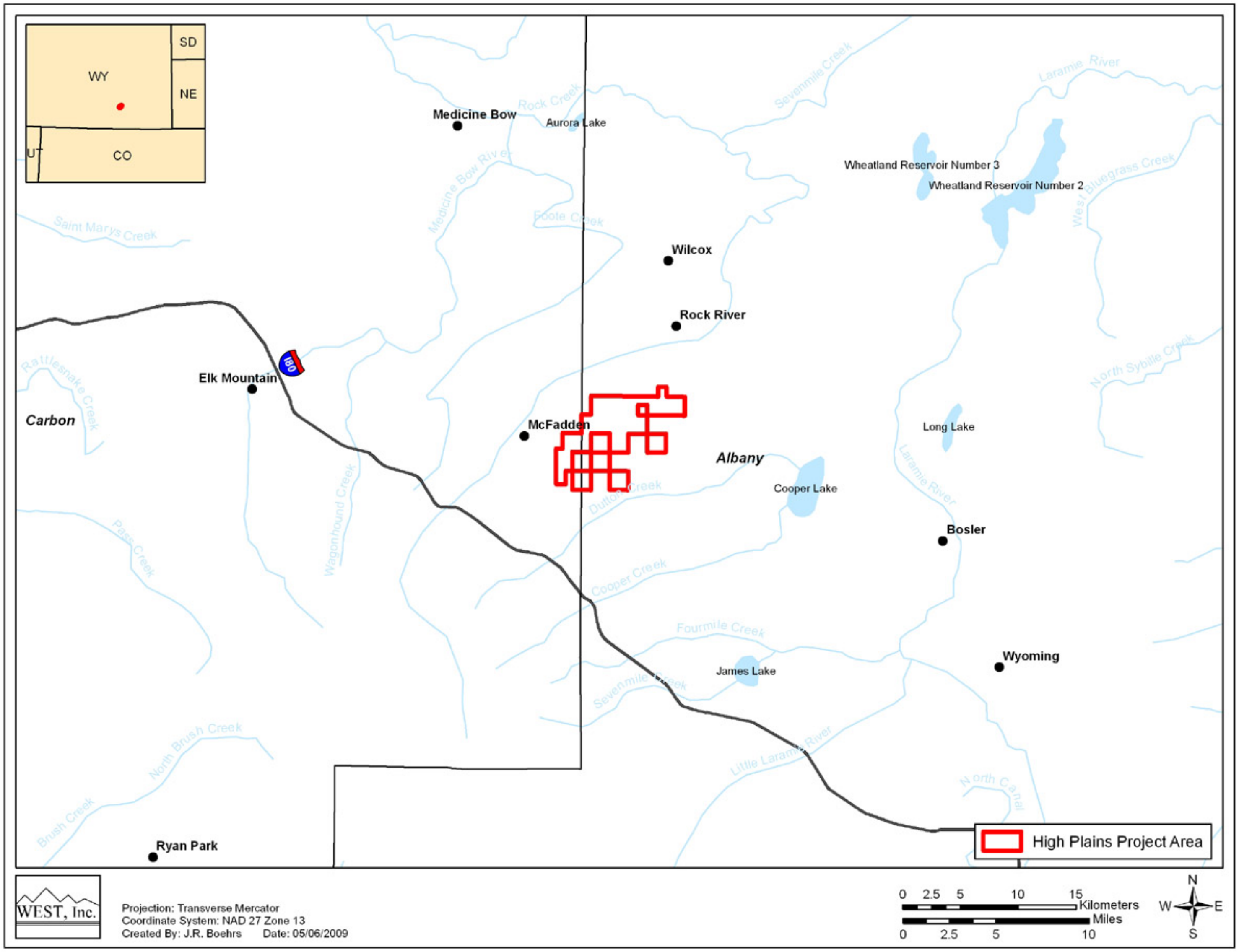


Figure 1. Location of the High Plains Wind Resource Area.

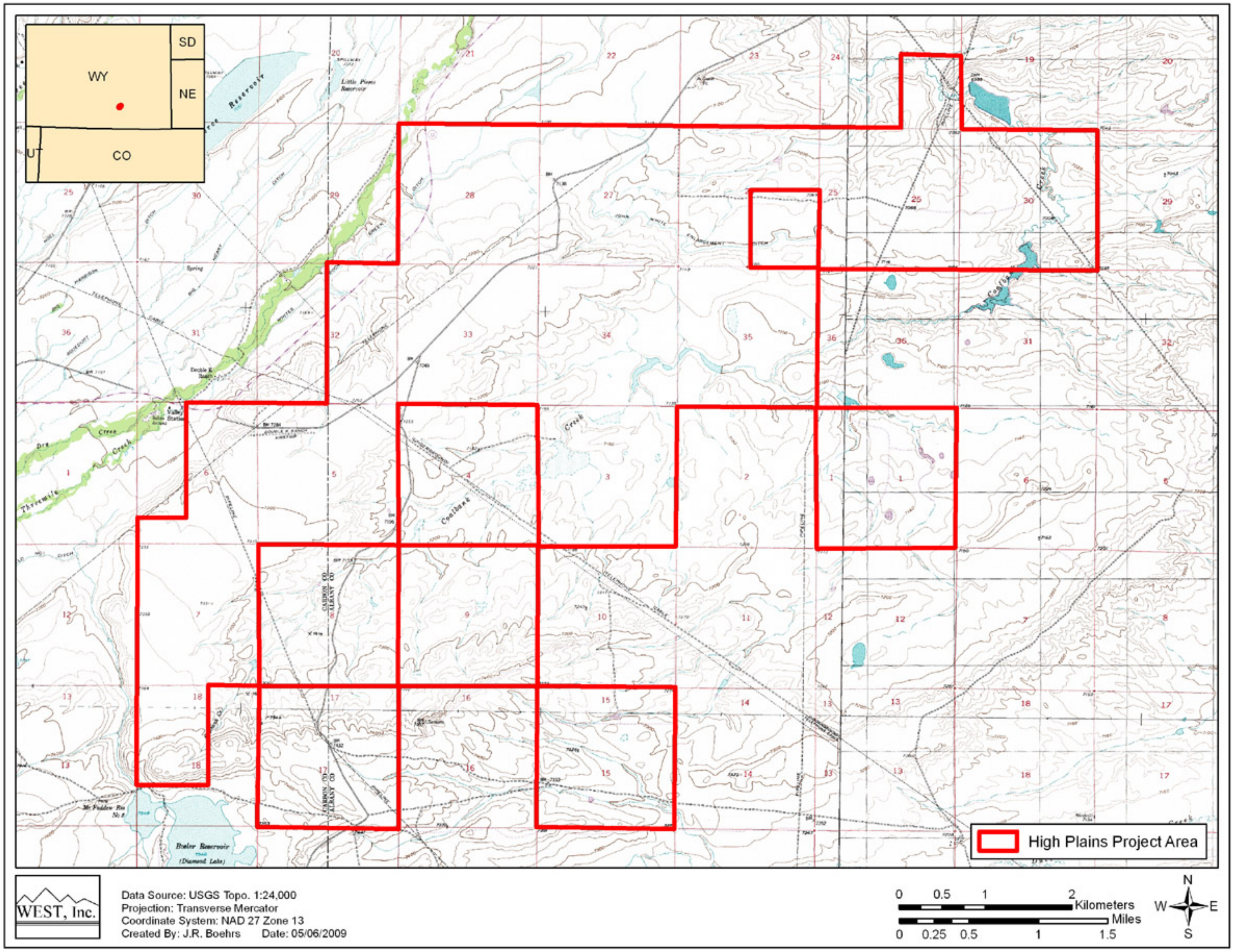


Figure 2. Elevation and topography of the High Plains Wind Resource Area.

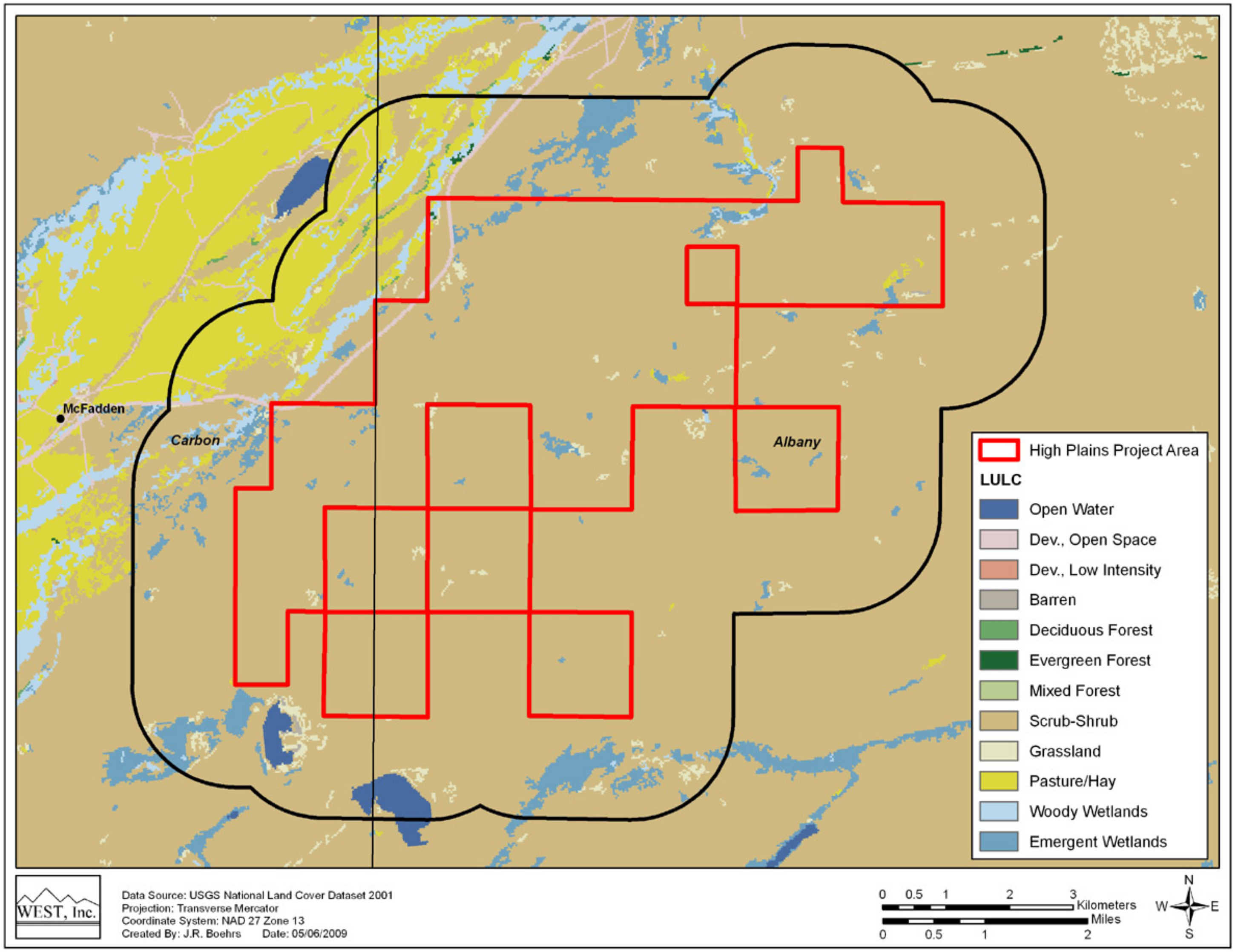


Figure 3. The land cover types and coverage within the High Plains Wind Resource Area (USGS NLCD 2001).

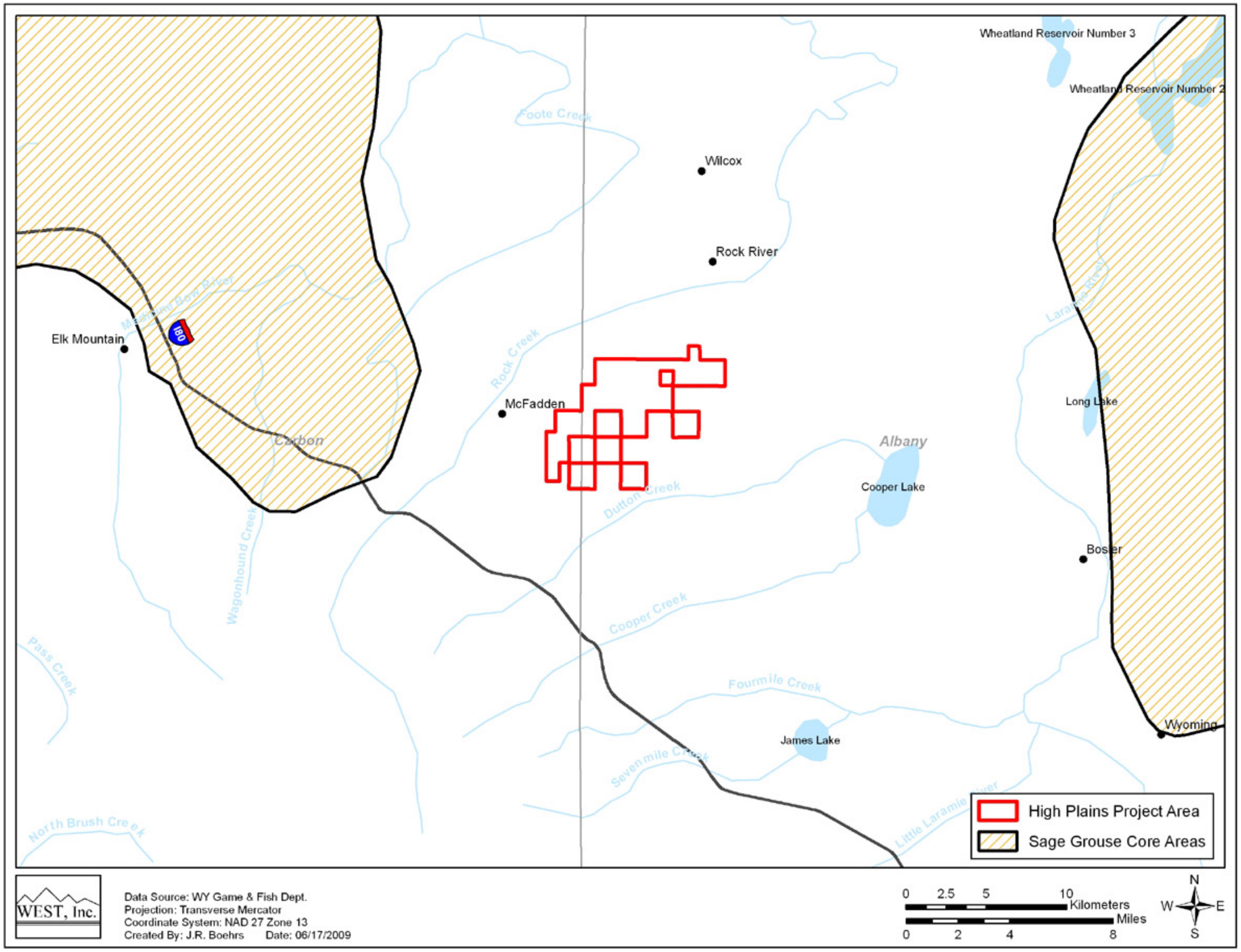


Figure 4. Location of core greater sage-grouse habitats in relation to the High Plains Wind Resource Area.

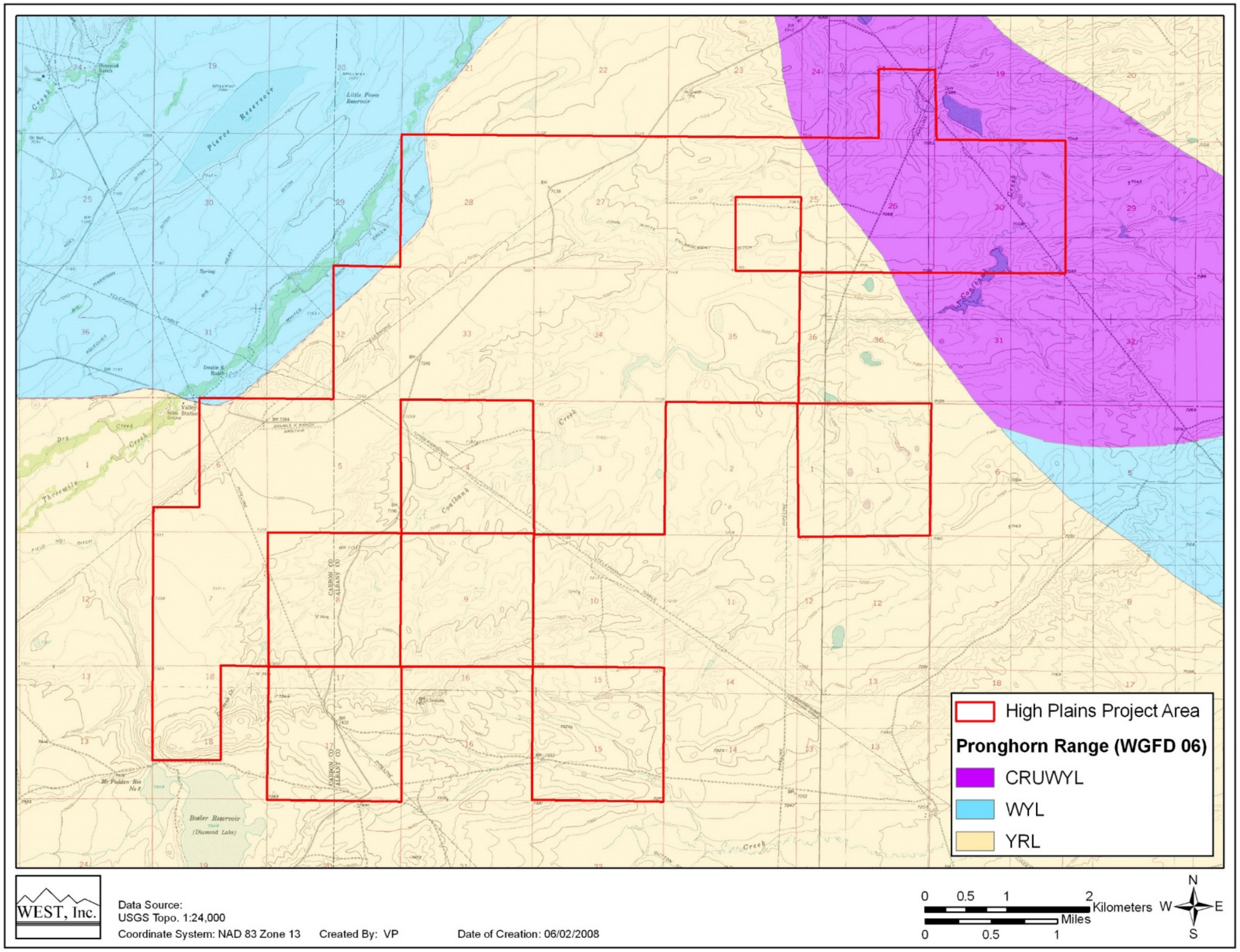


Figure 5. Location of pronghorn antelope seasonal ranges in relation to the High Plains Wind Resource Area.

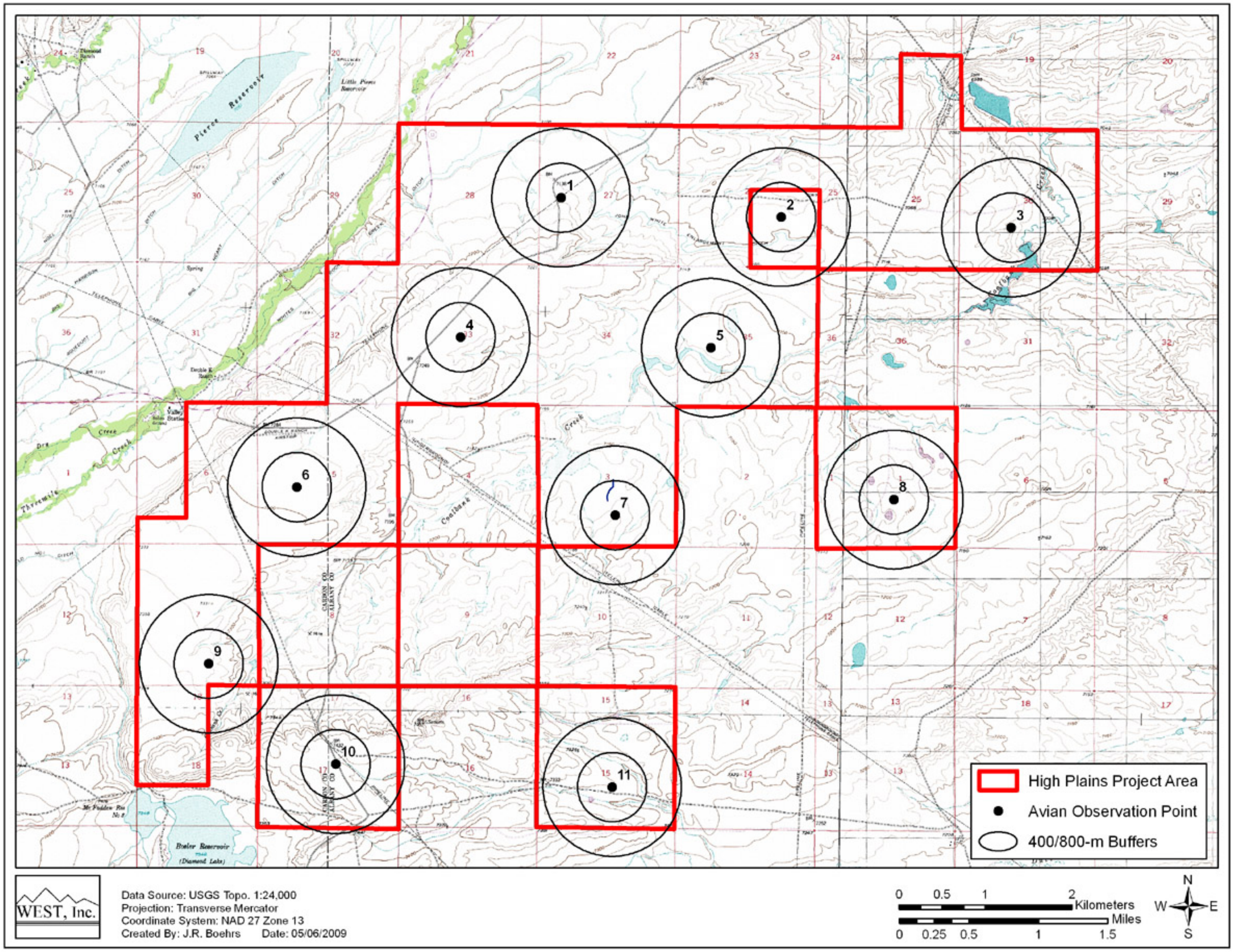


Figure 6. Fixed-point bird use survey points at the High Plains Wind Resource Area.

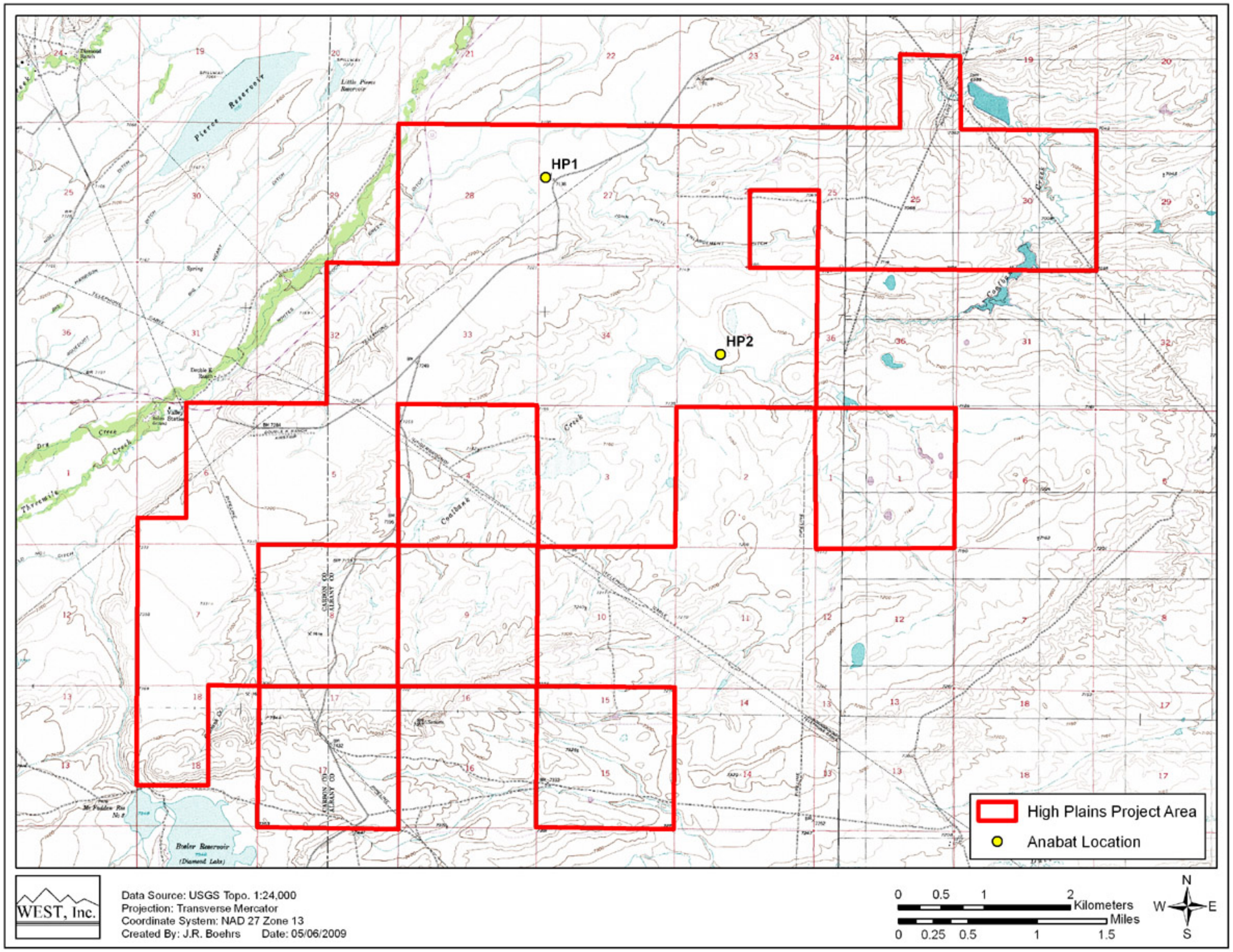
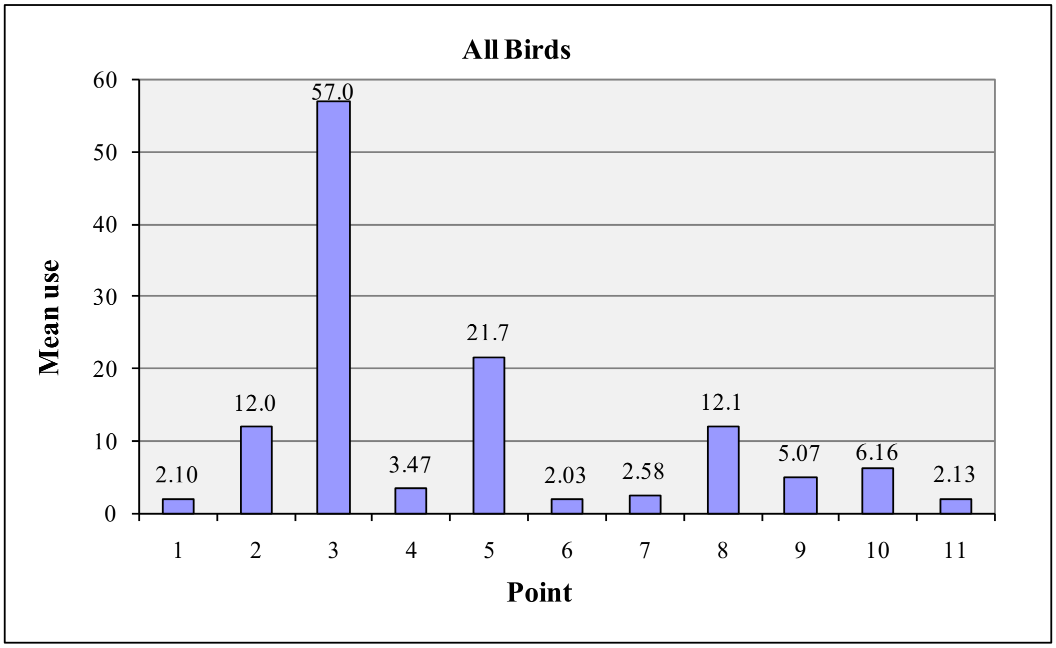


Figure 7. Study area map and Anabat sampling locations at the High Plains Wind Resource Area.



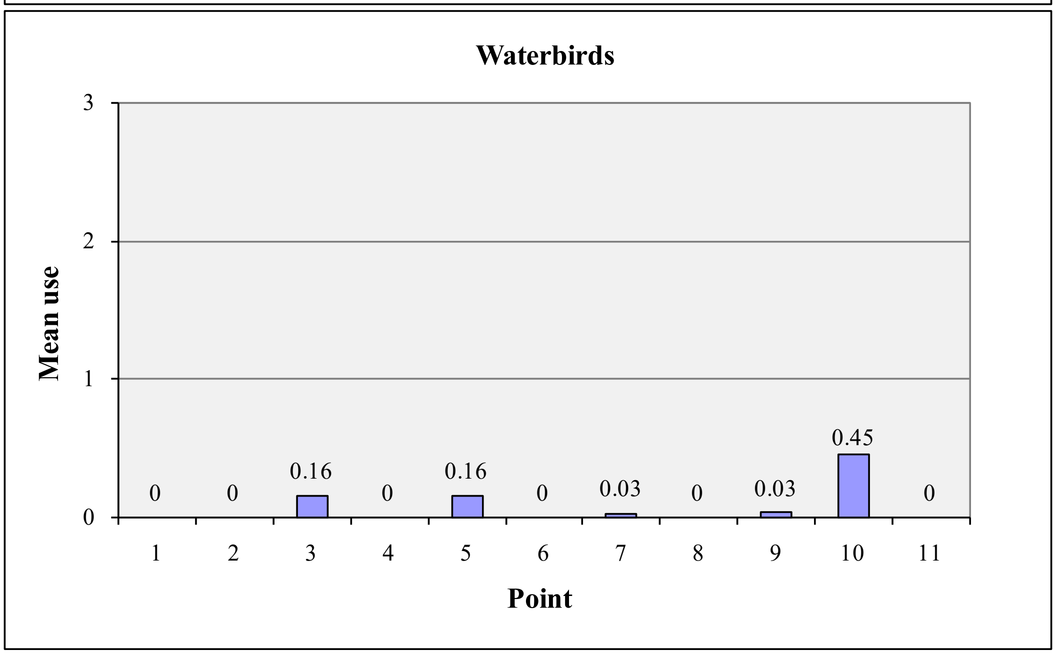
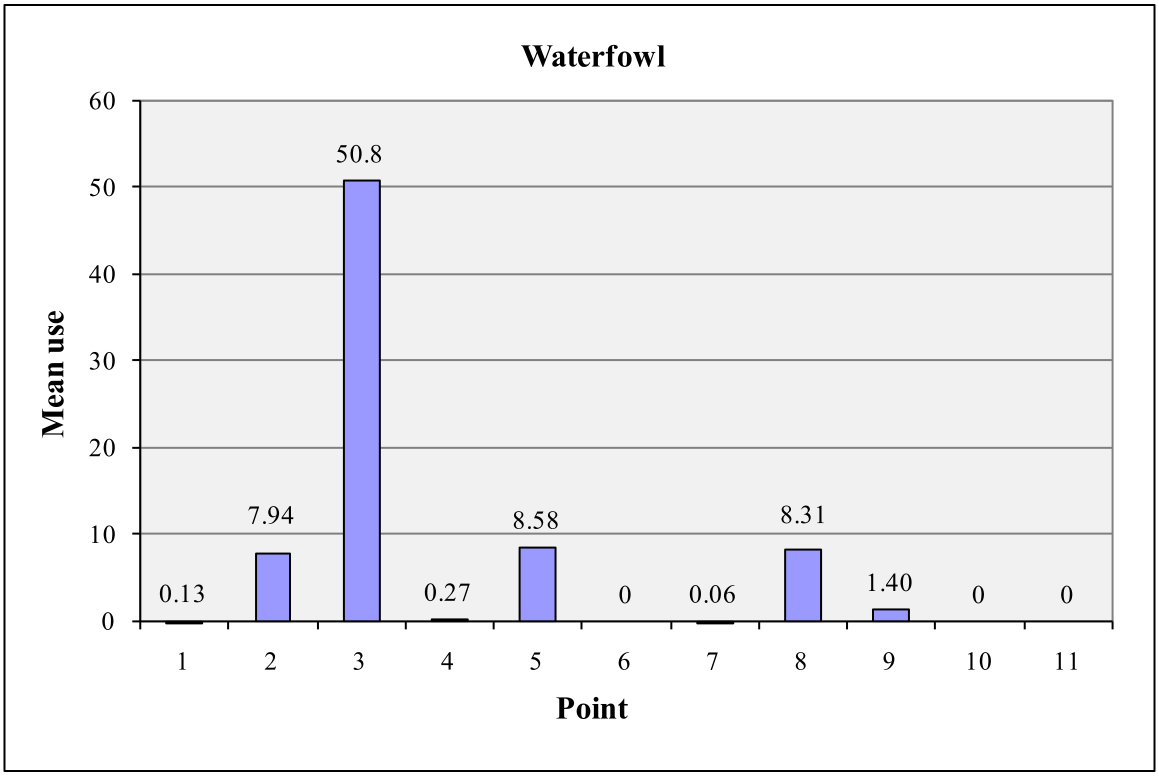


Figure 8. Mean use (number of birds/20-min survey) at each fixed-point bird use survey point for all birds, major bird types, and raptor subtypes at the High Plains Wind Resource Area.



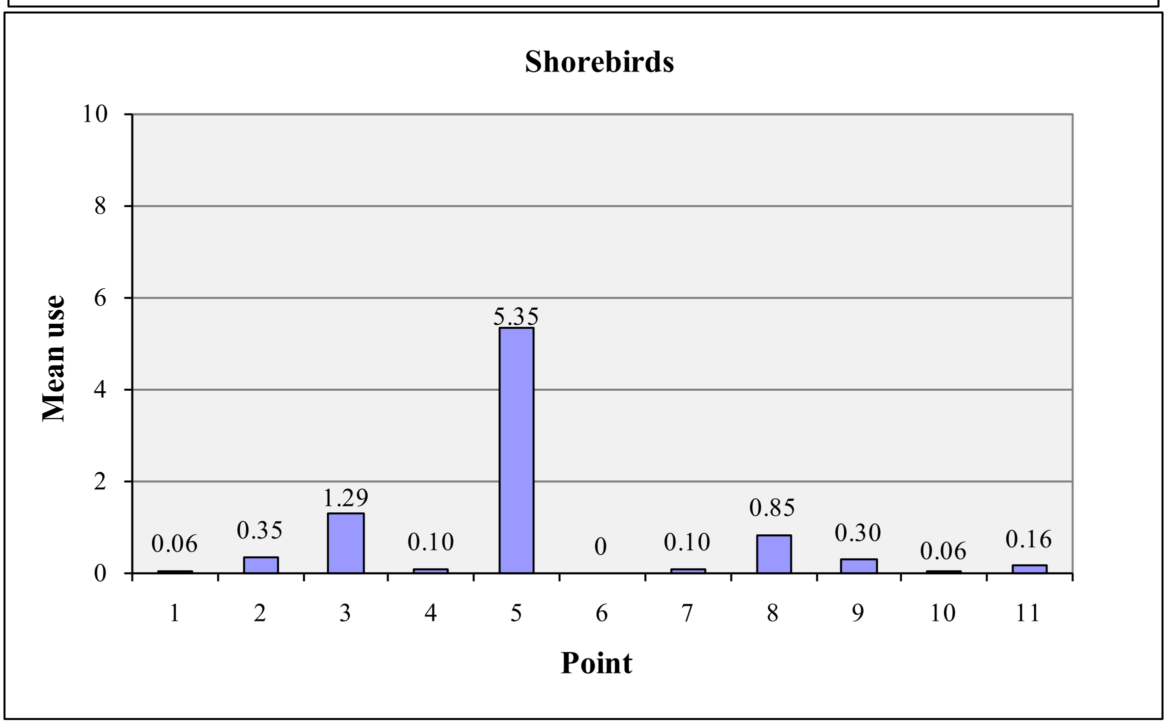
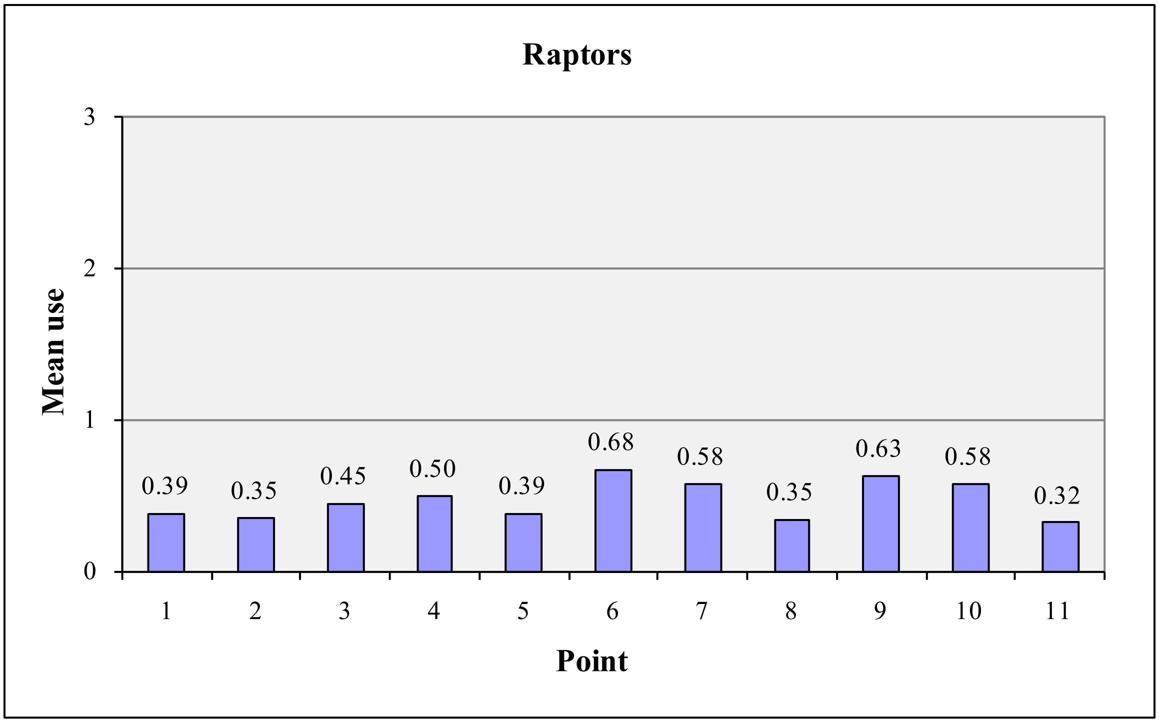


Figure 8 (*continued*). Mean use (number of birds/20-min survey) at each fixed-point bird use survey point for all birds, major bird types, and raptor subtypes at the High Plains Wind Resource Area.



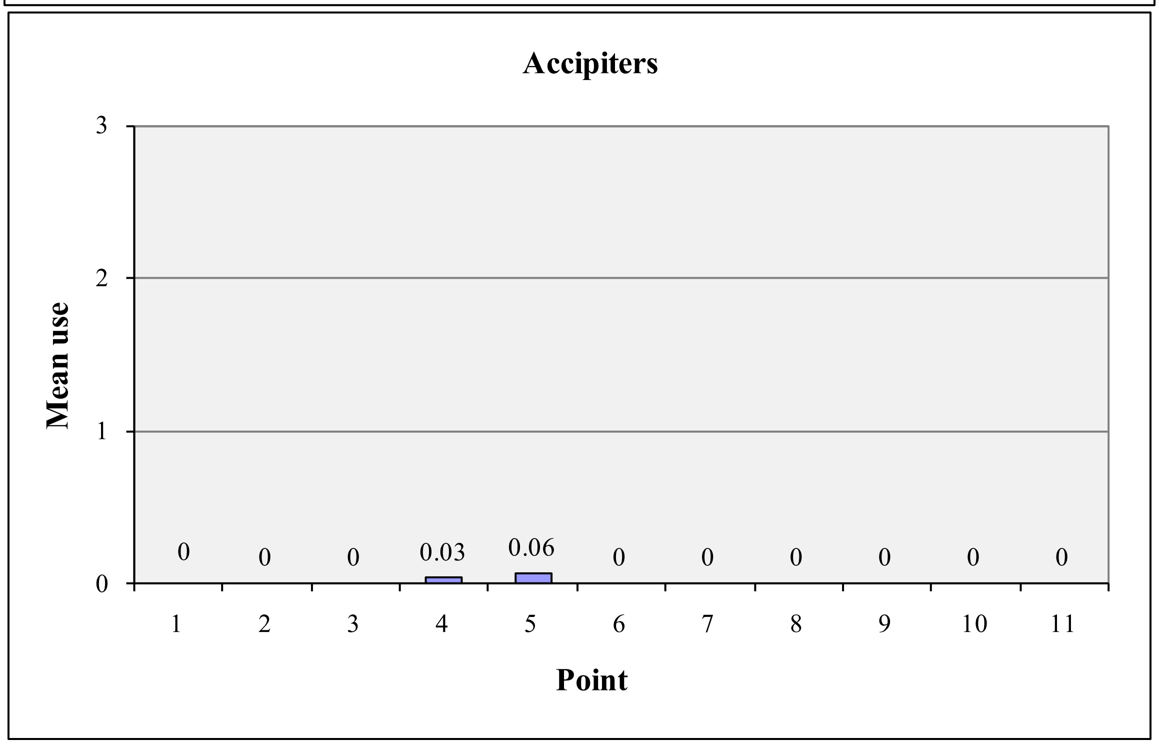
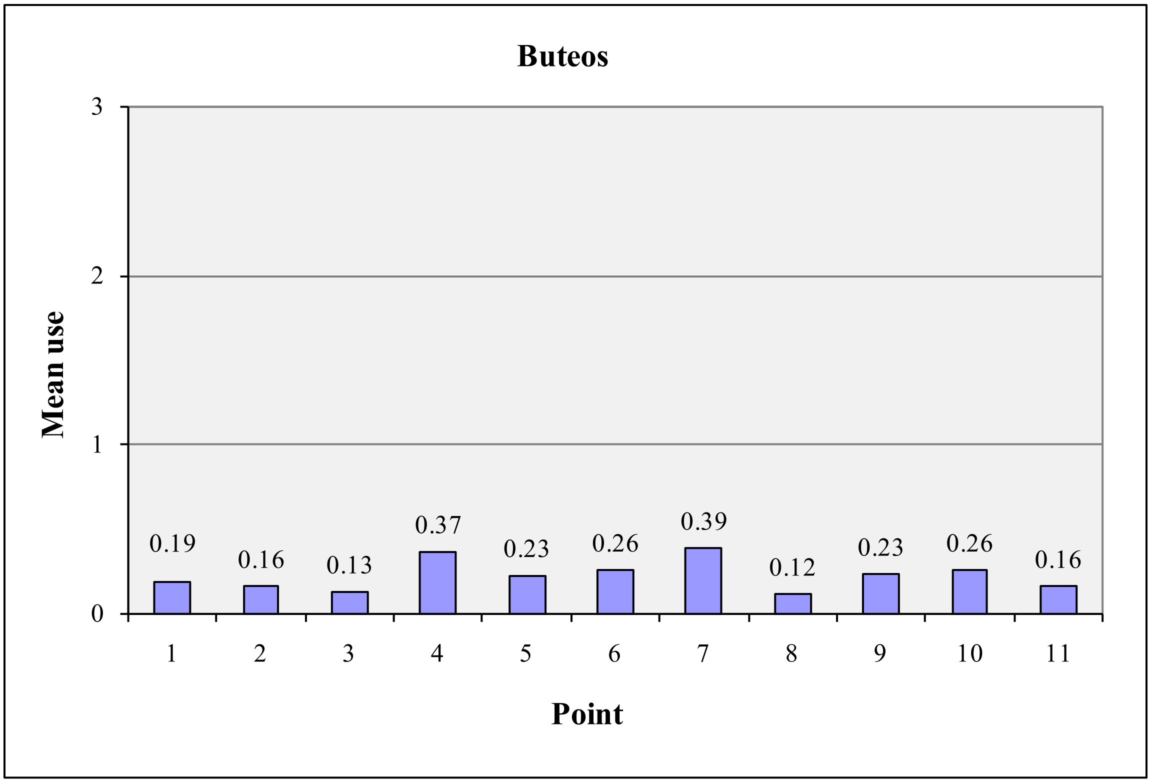


Figure 8 (*continued*). Mean use (number of birds/20-min survey) at each fixed-point bird use survey point for all birds, major bird types, and raptor subtypes at the High Plains Wind Resource Area.



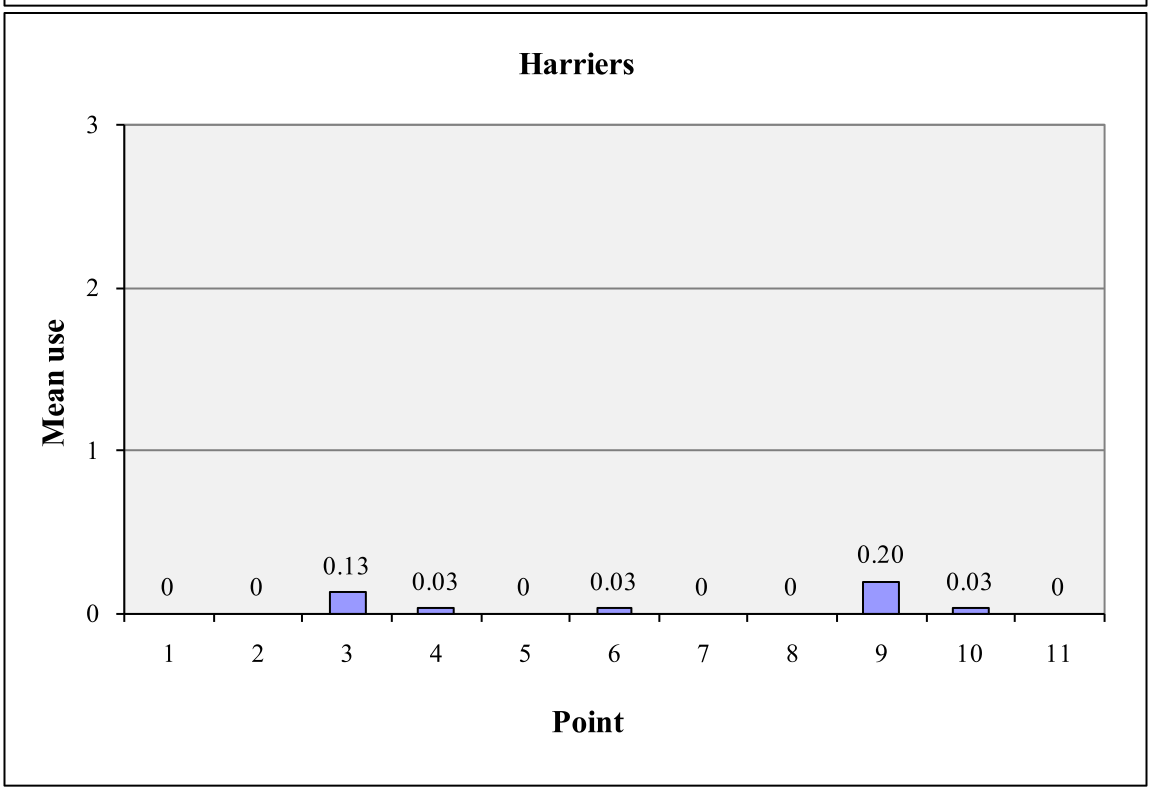
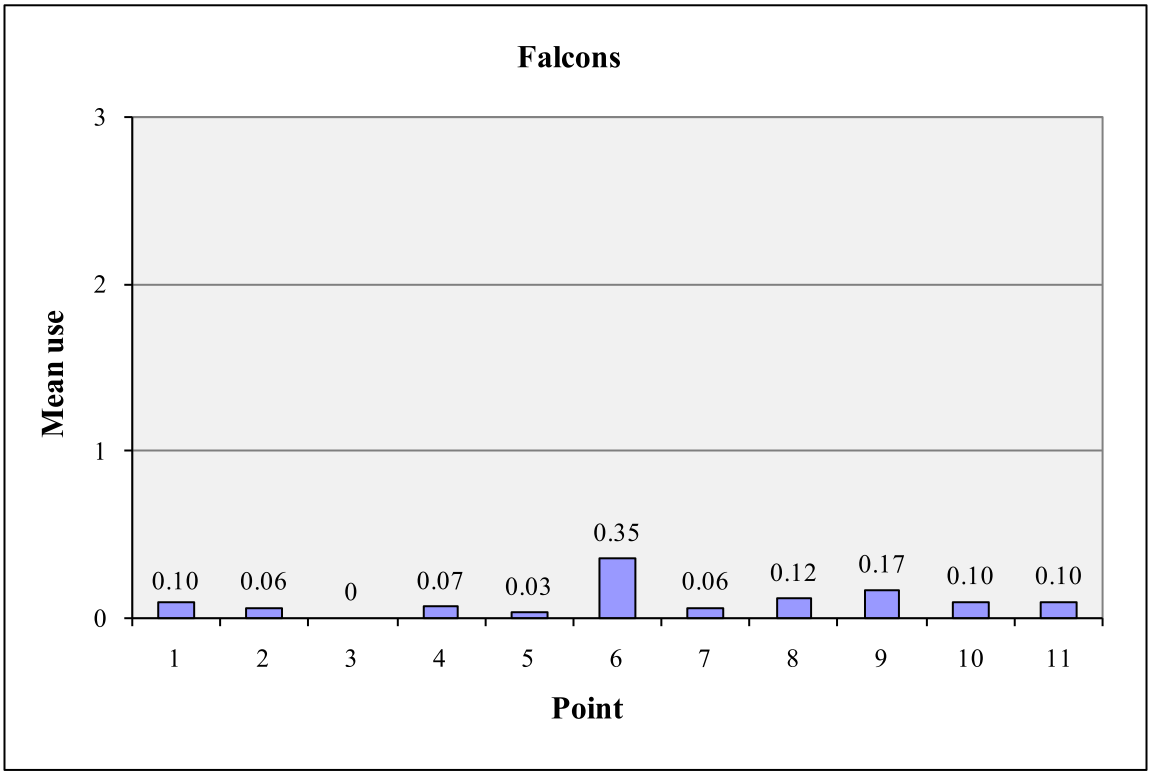


Figure 8 (*continued*). Mean use (number of birds/20-min survey) at each fixed-point bird use survey point for all birds, major bird types, and raptor subtypes at the High Plains Wind Resource Area.



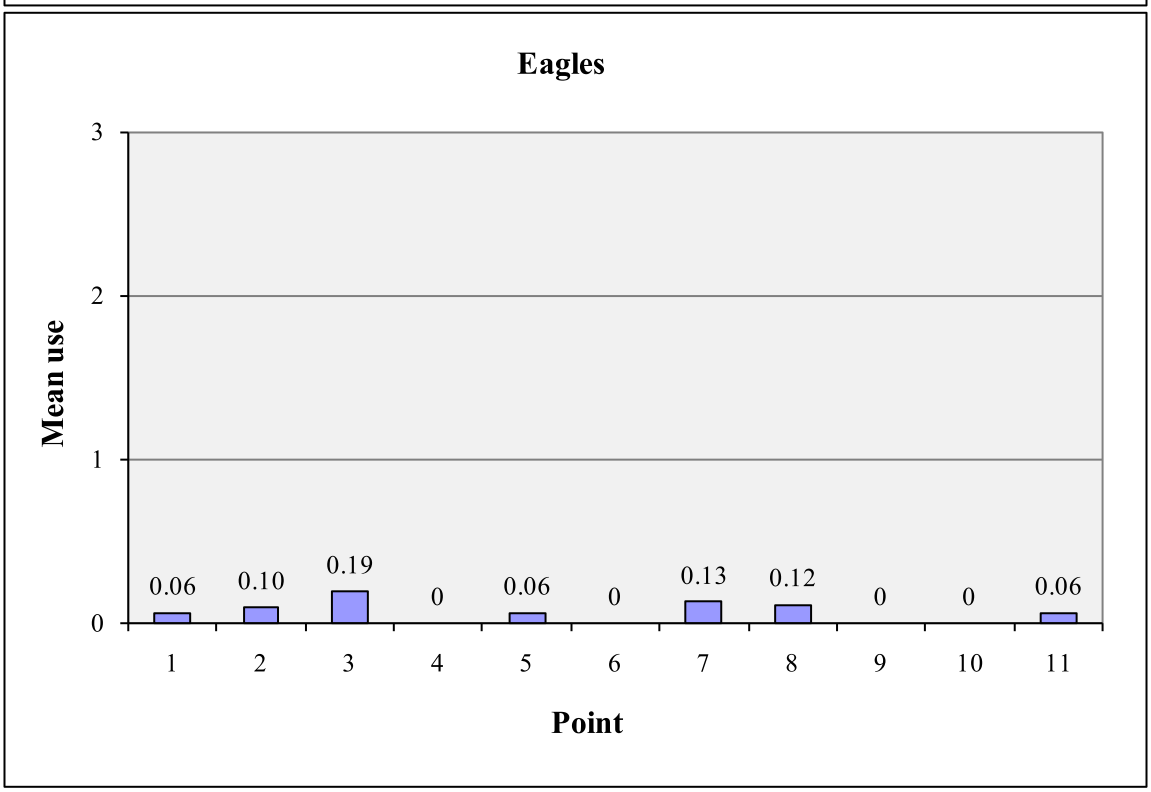
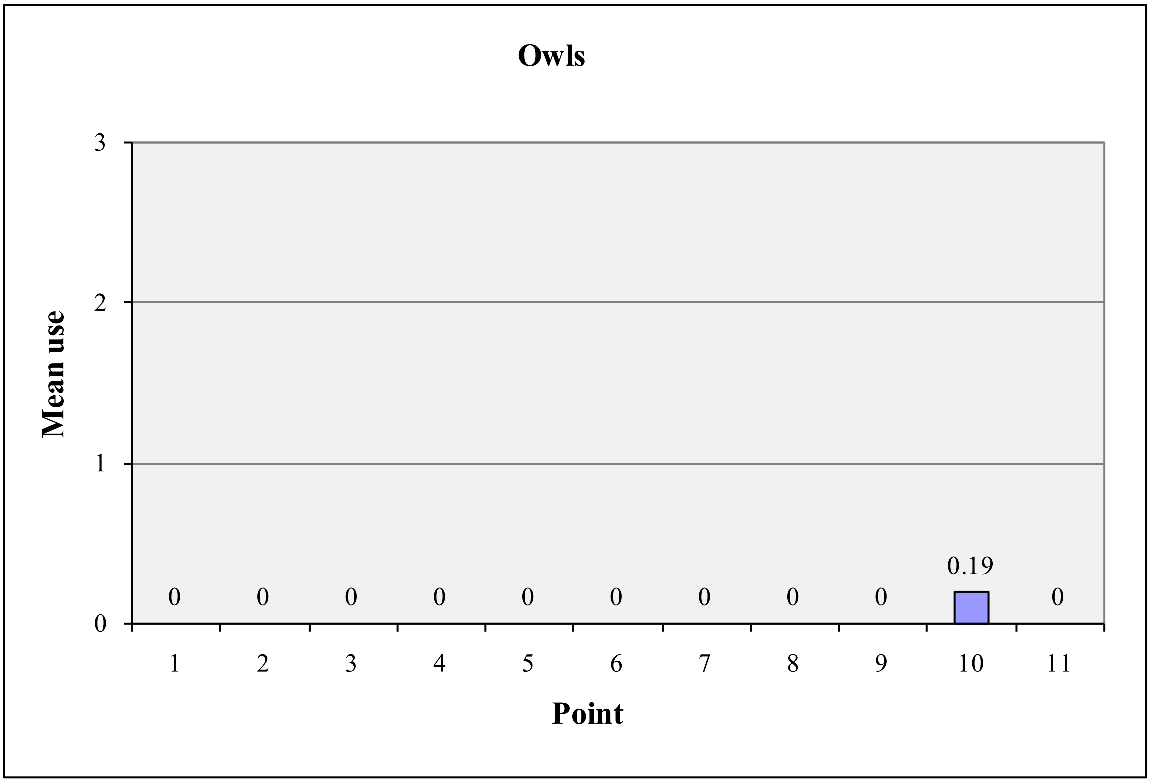


Figure 8 (*continued*). Mean use (number of birds/20-min survey) at each fixed-point bird use survey point for all birds, major bird types, and raptor subtypes at the High Plains Wind Resource Area.



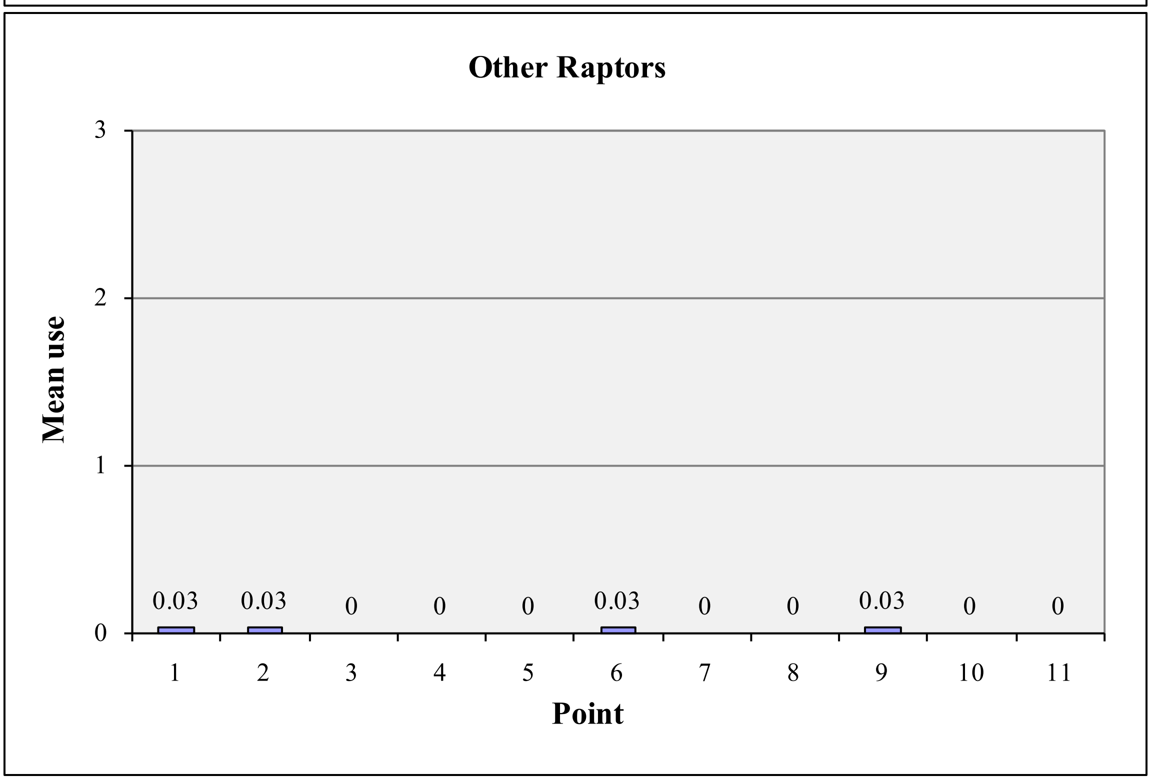
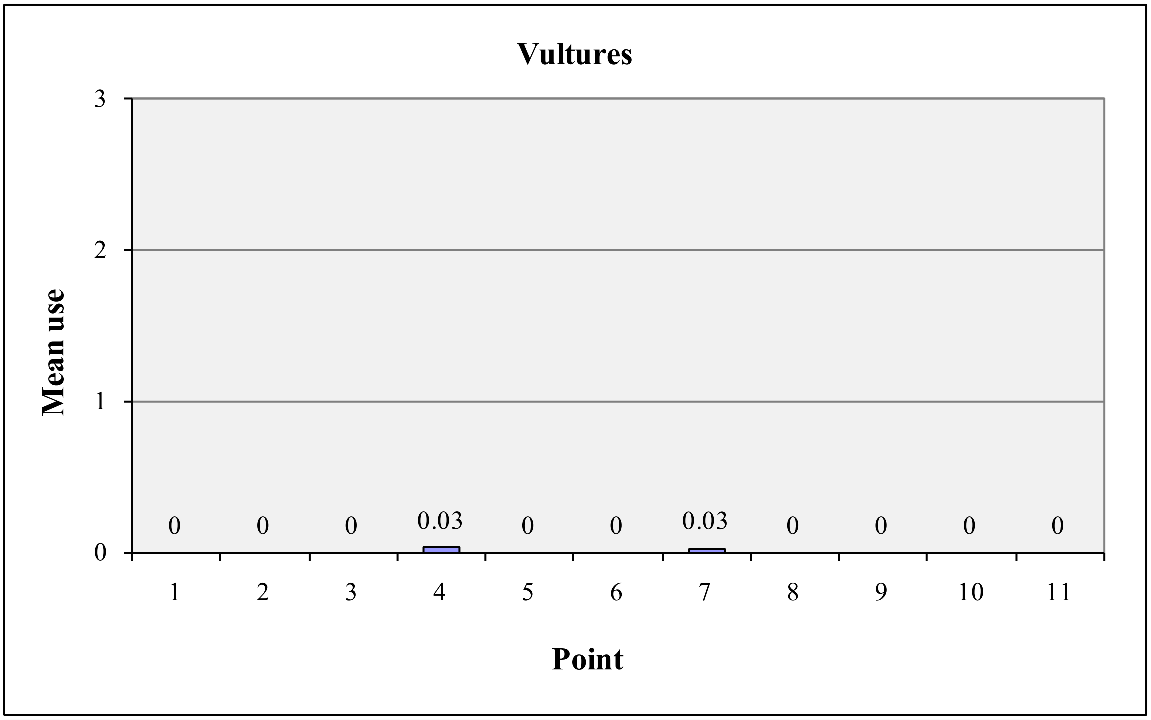


Figure 8 (*continued*). Mean use (number of birds/20-min survey) at each fixed-point bird use survey point for all birds, major bird types, and raptor subtypes at the High Plains Wind Resource Area.



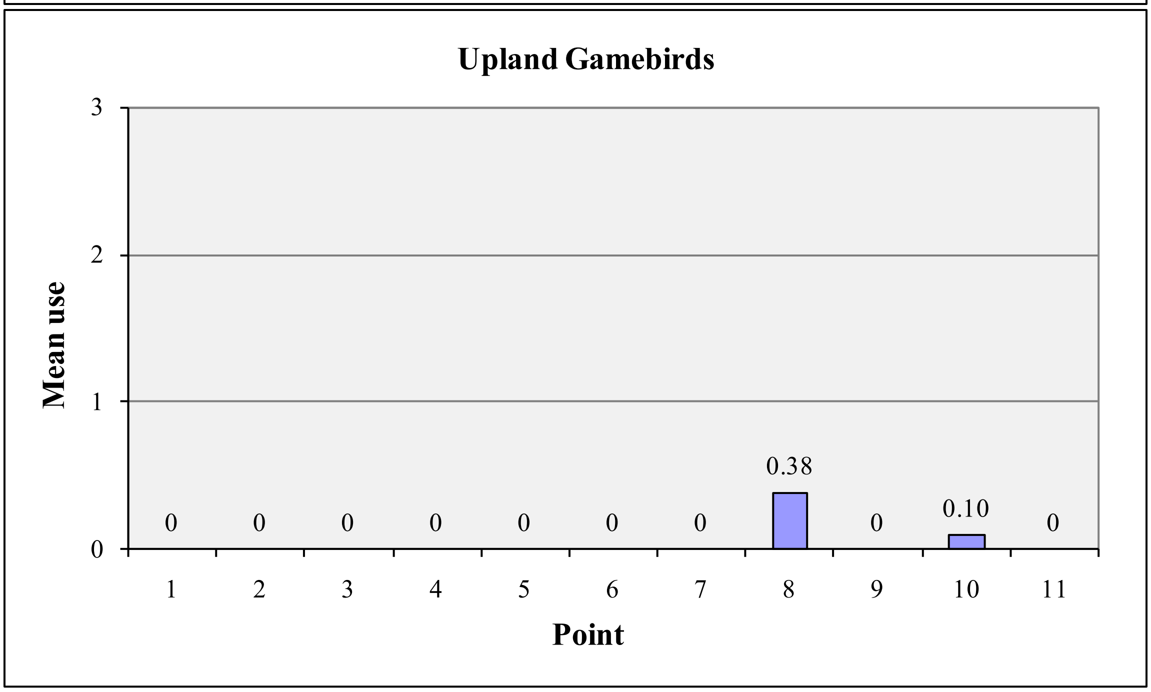
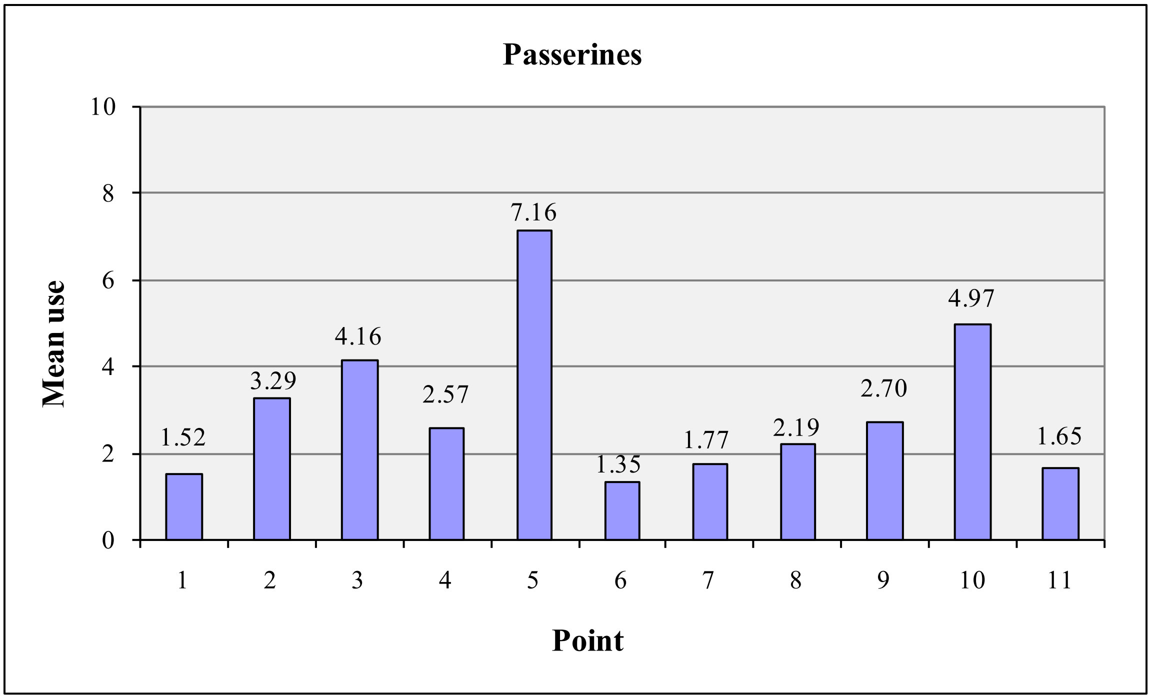


Figure 8 (*continued*). Mean use (number of birds/20-min survey) at each fixed-point bird use survey point for all birds, major bird types, and raptor subtypes at the High Plains Wind Resource Area.



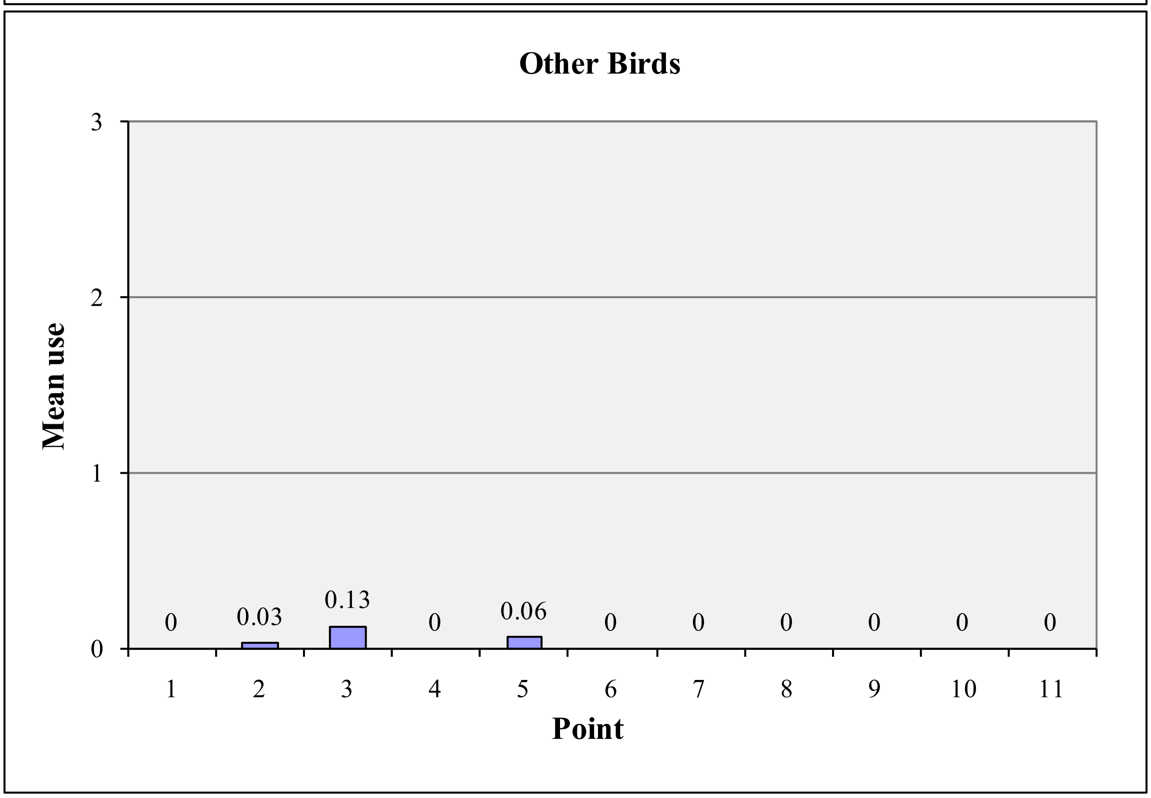


Figure 8 (continued). Mean use (number of birds/20-min survey) at each fixed-point bird use survey point for all birds, major bird types, and raptor subtypes at the High Plains Wind Resource Area.

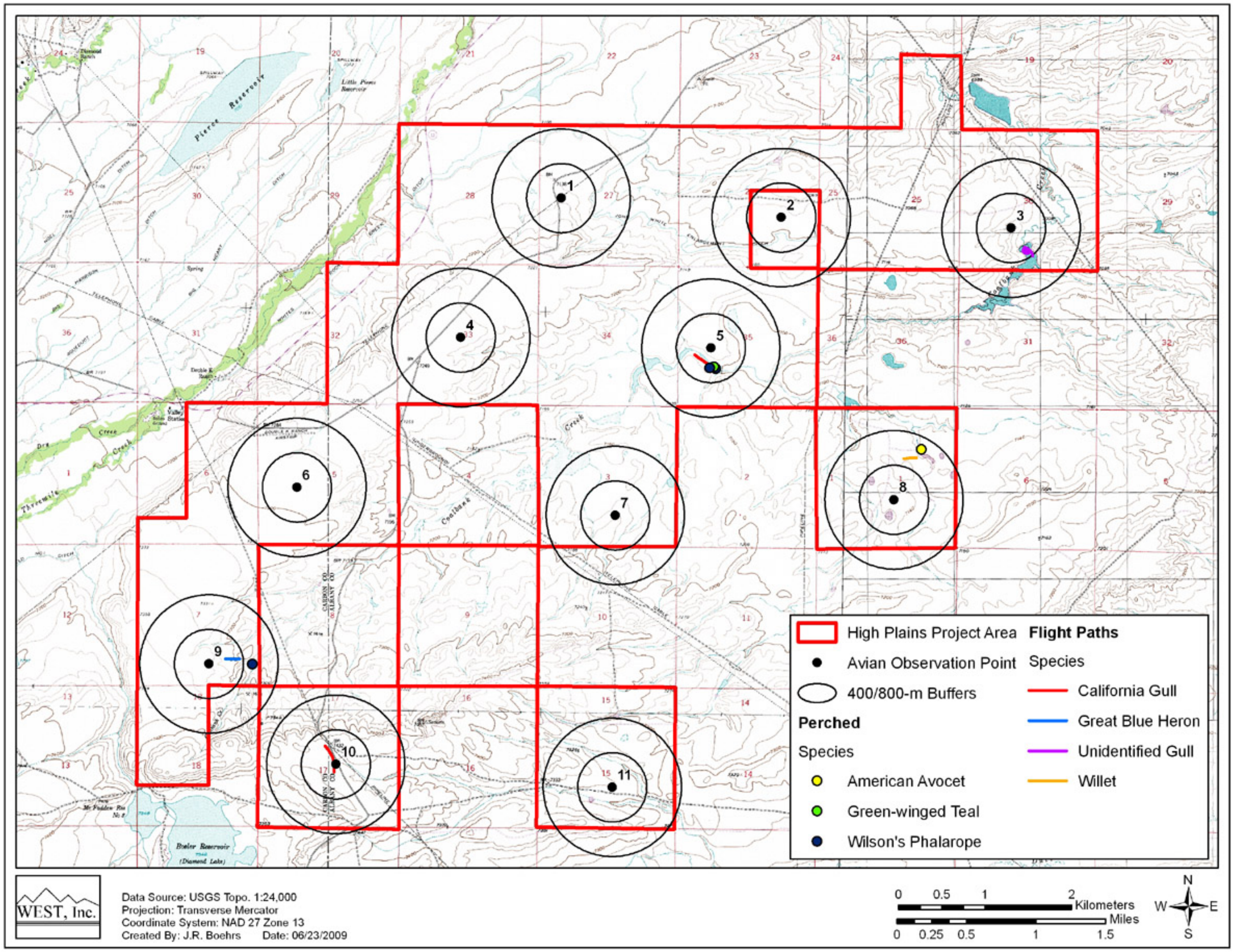


Figure 9. Flight paths of waterbirds and shorebirds at the High Plains Wind Resource Area.

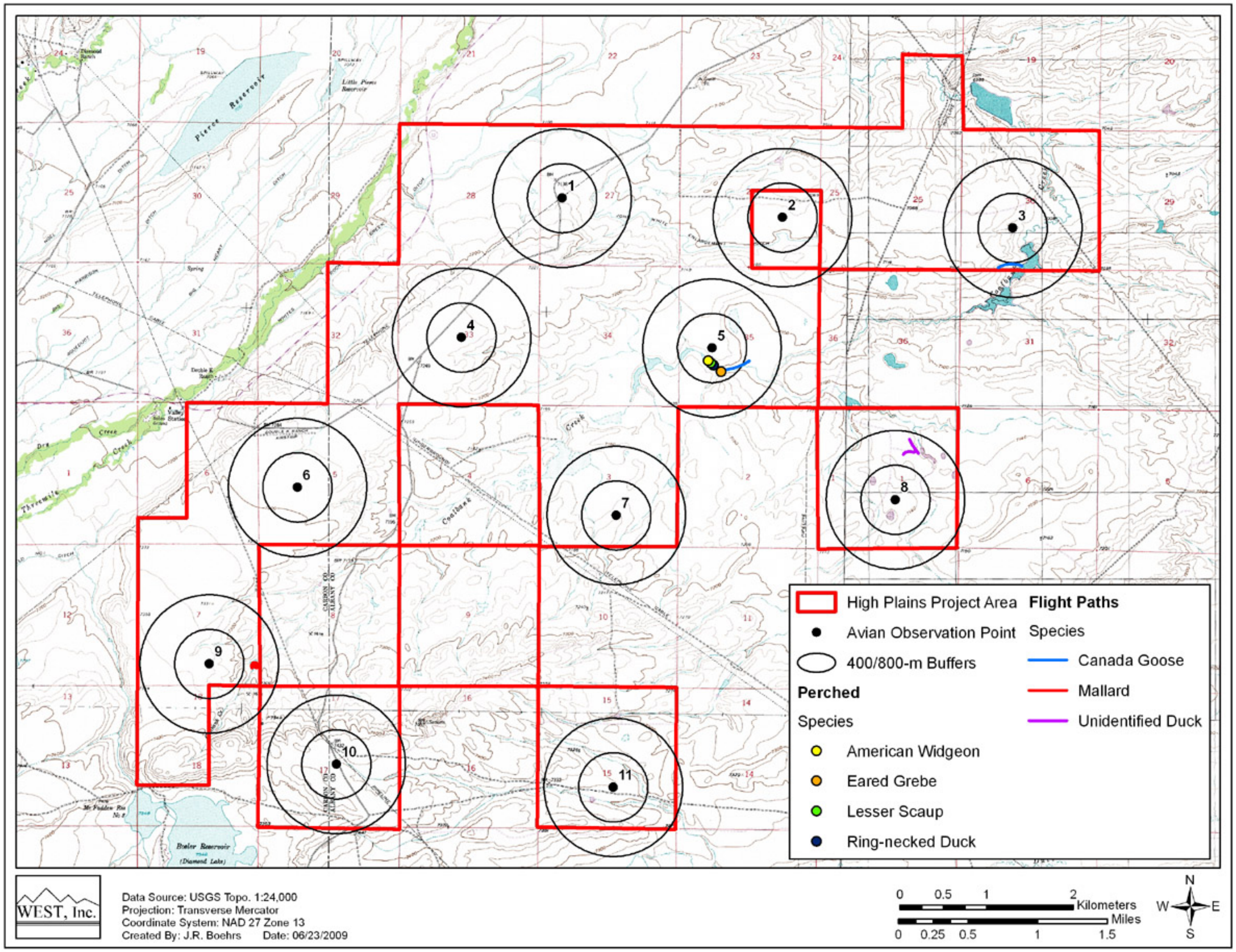


Figure 9 (*continued*). Flight paths of waterfowl at the High Plains Wind Resource Area.

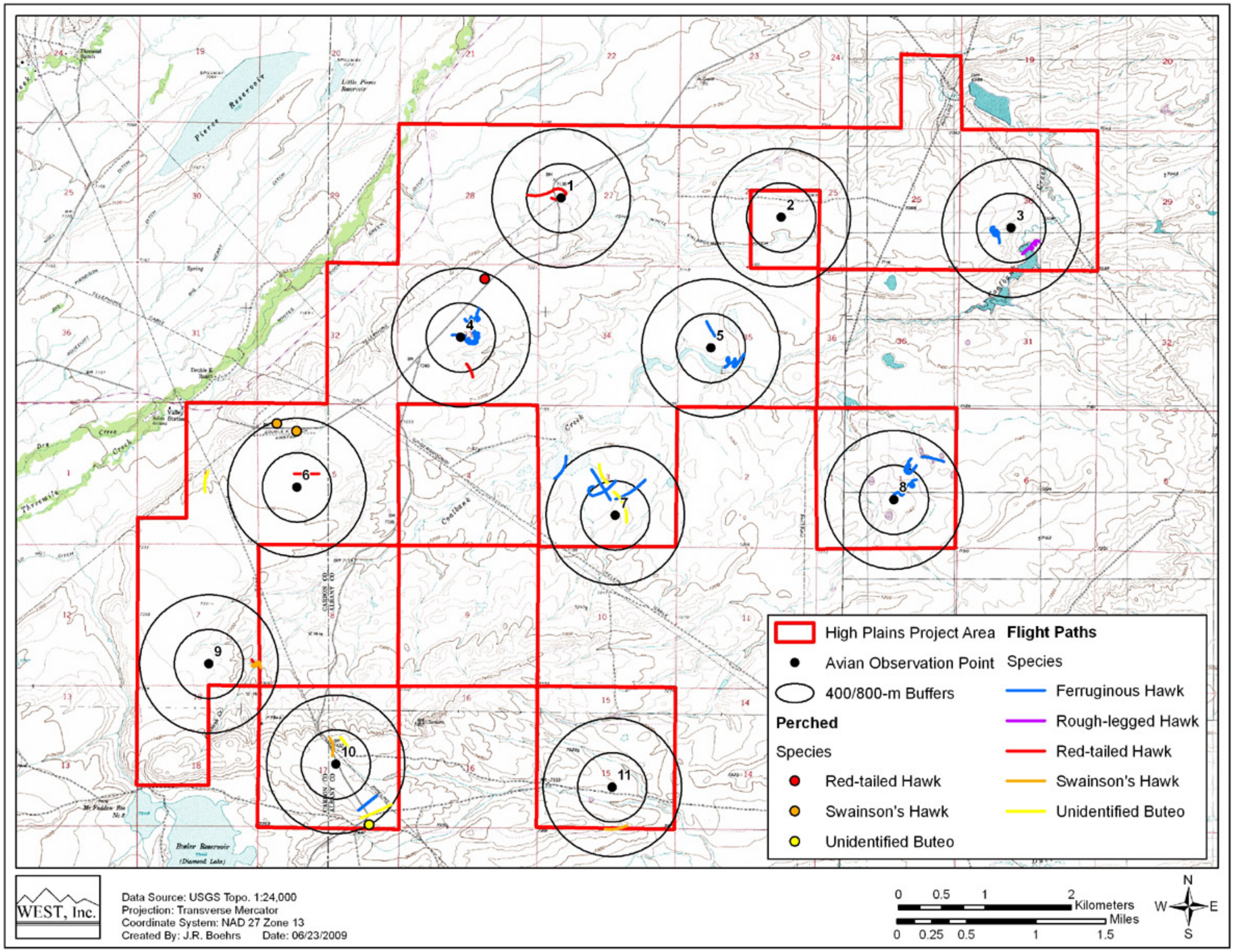


Figure 9 (*continued*). Flight paths of buteos at the High Plains Wind Resource Area.

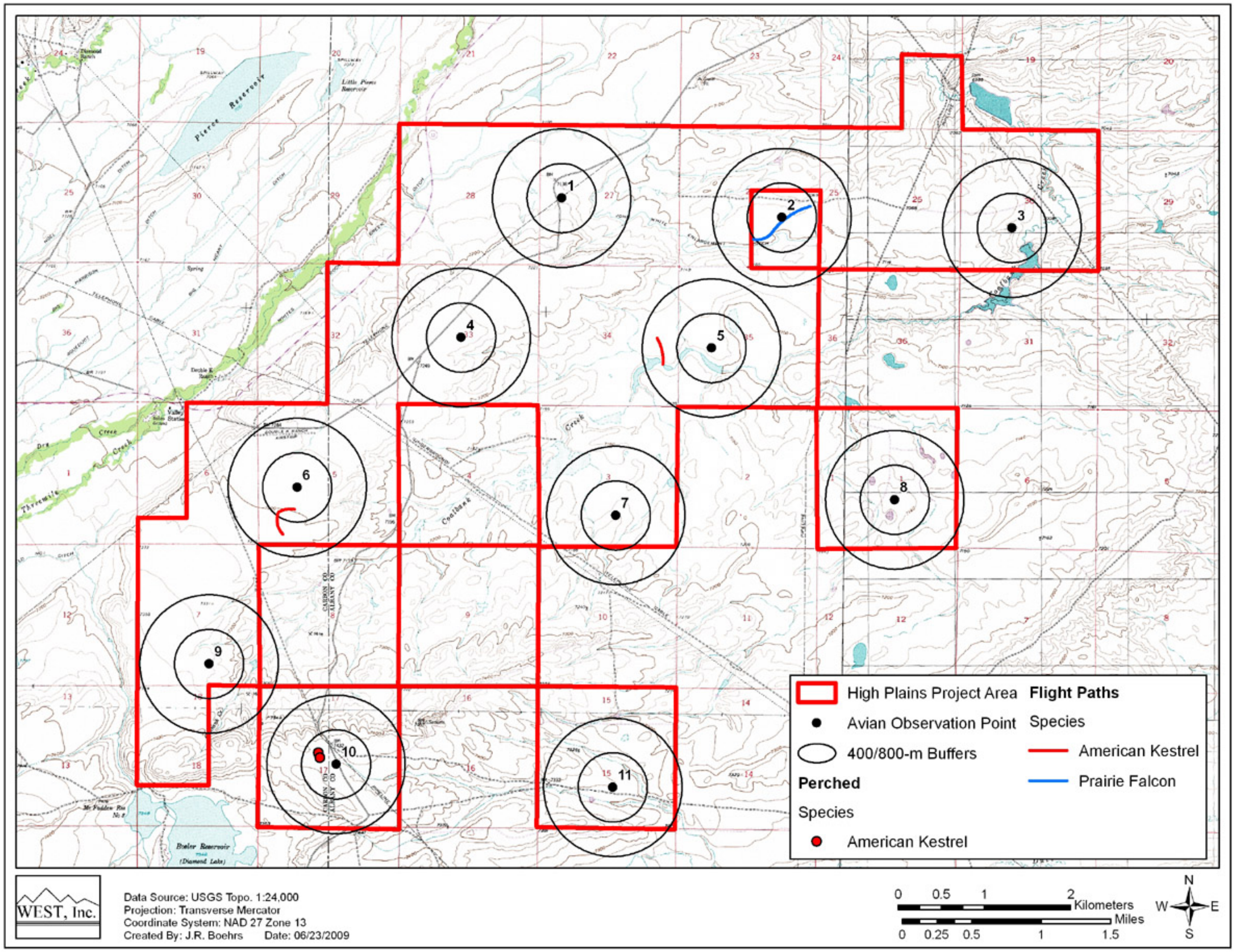


Figure 9 (*continued*). Flight paths of falcons at the High Plains Wind Resource Area.

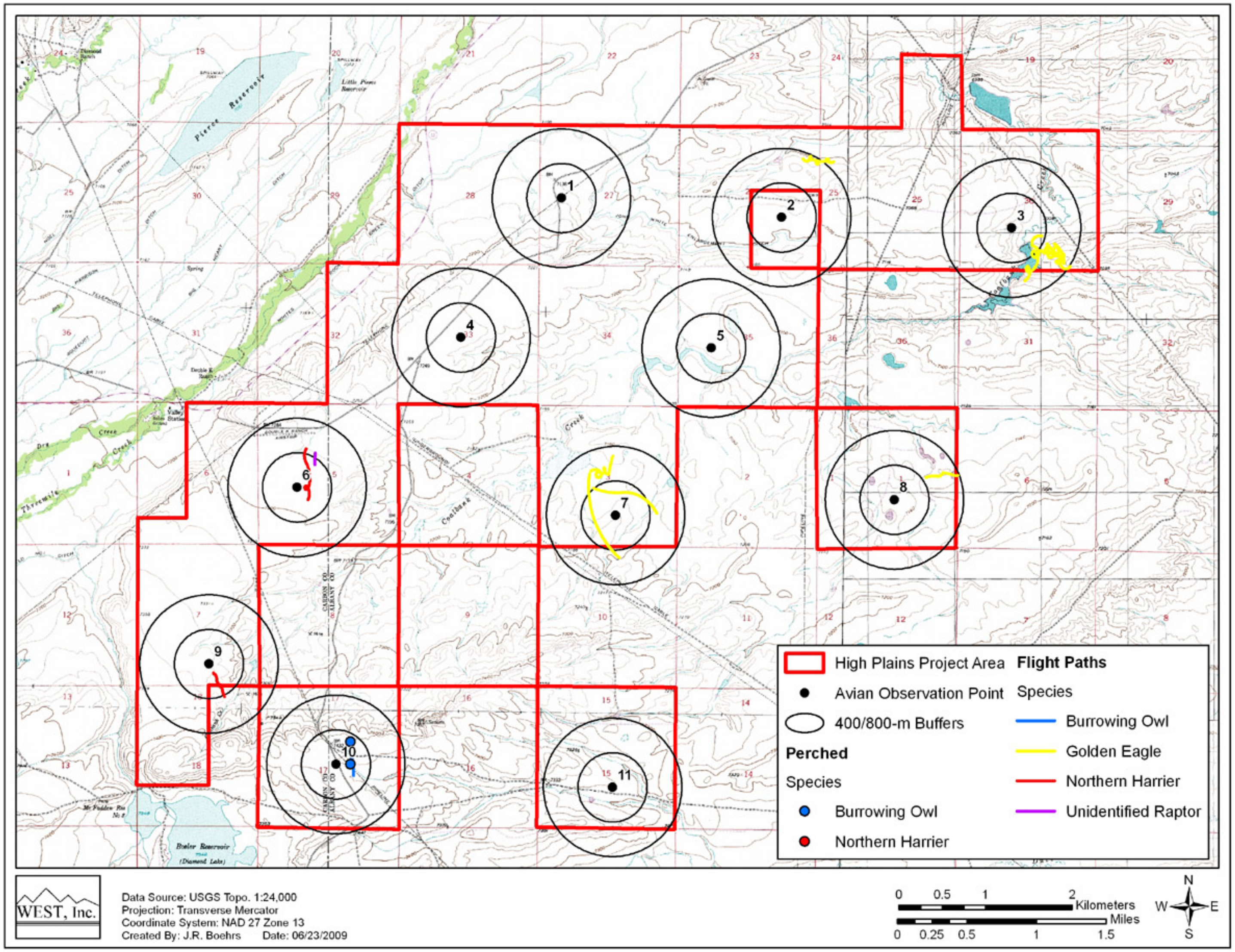


Figure 9 (*continued*). Flight paths of northern harriers, eagles, owls, and other raptors at the High Plains Wind Resource Area.

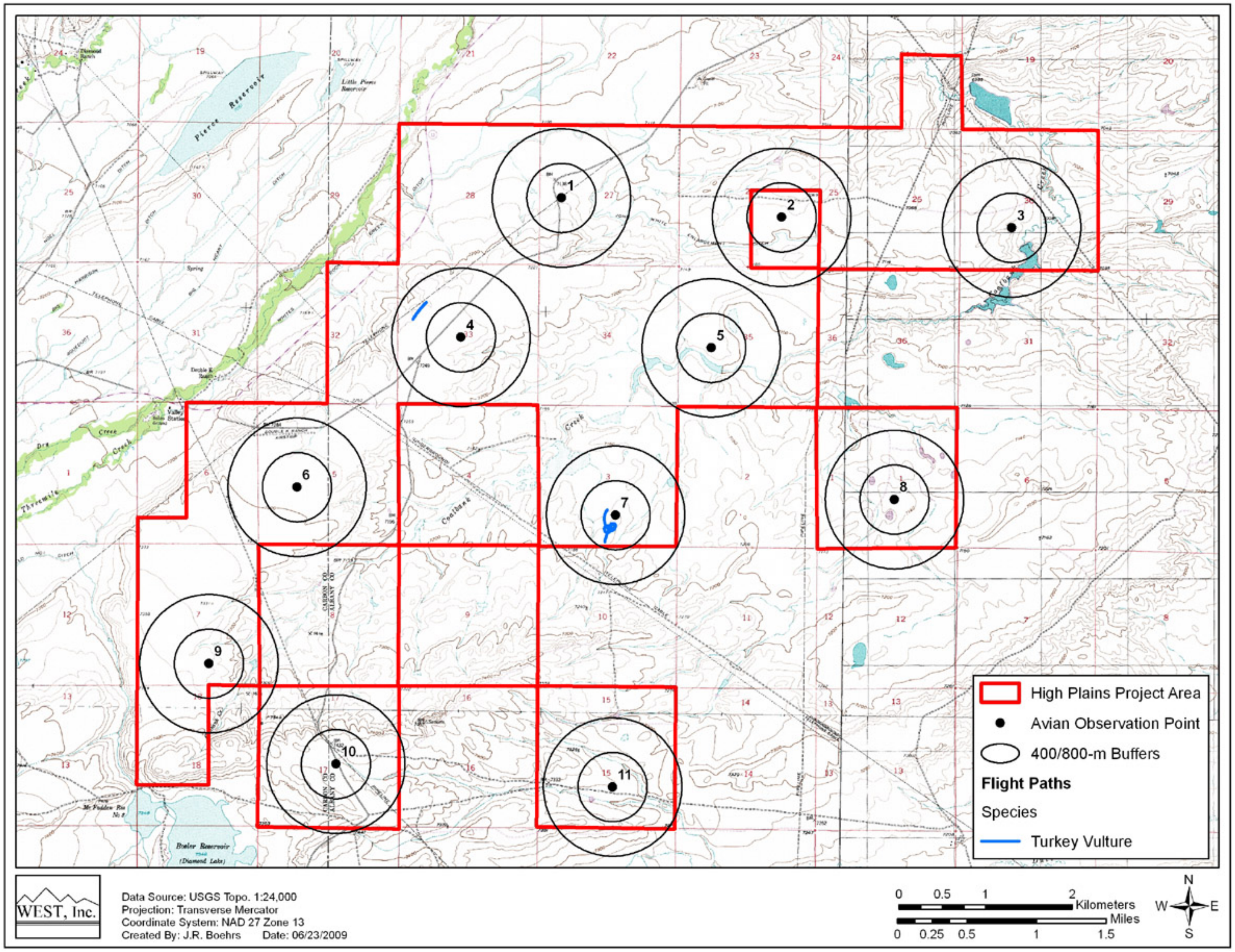


Figure 9 (*continued*). Flight paths of vultures at the High Plains Wind Resource Area.

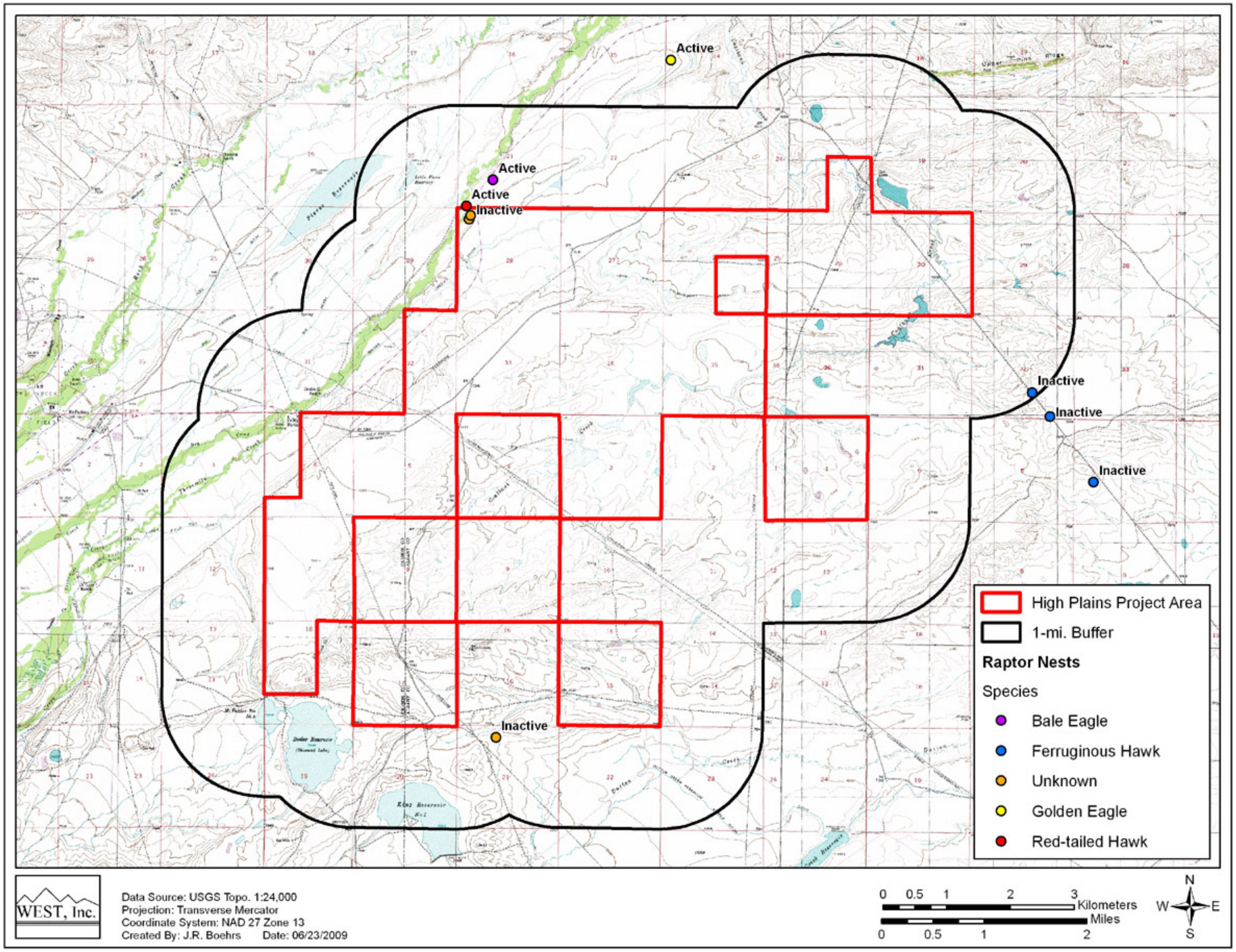


Figure 10. Location of raptor nests at the High Plains Wind Resource Area.

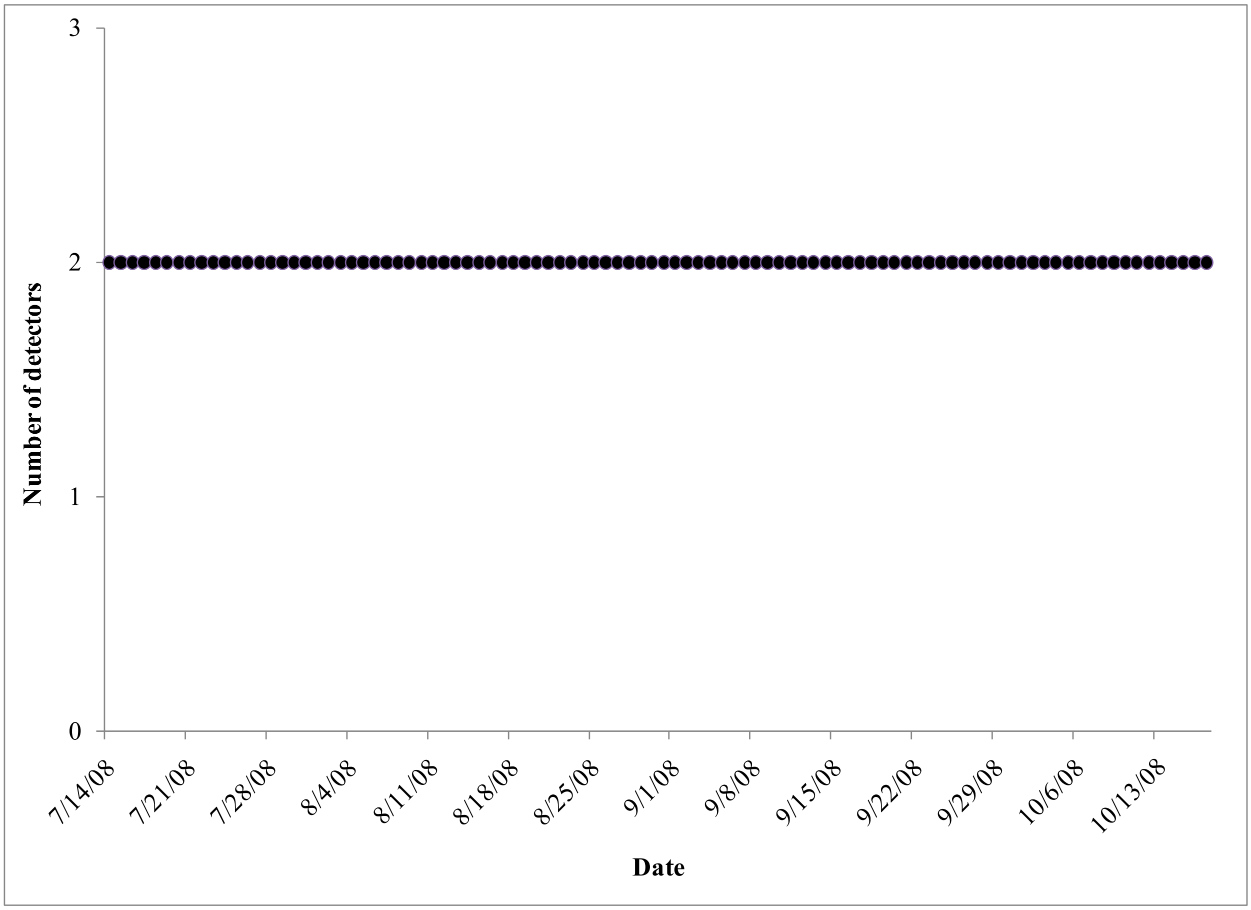


Figure 11. Number of Anabat detectors (n = 2) at the High Plains Wind Resource Area operating during each night of the study period July 14 – October 17, 2008.

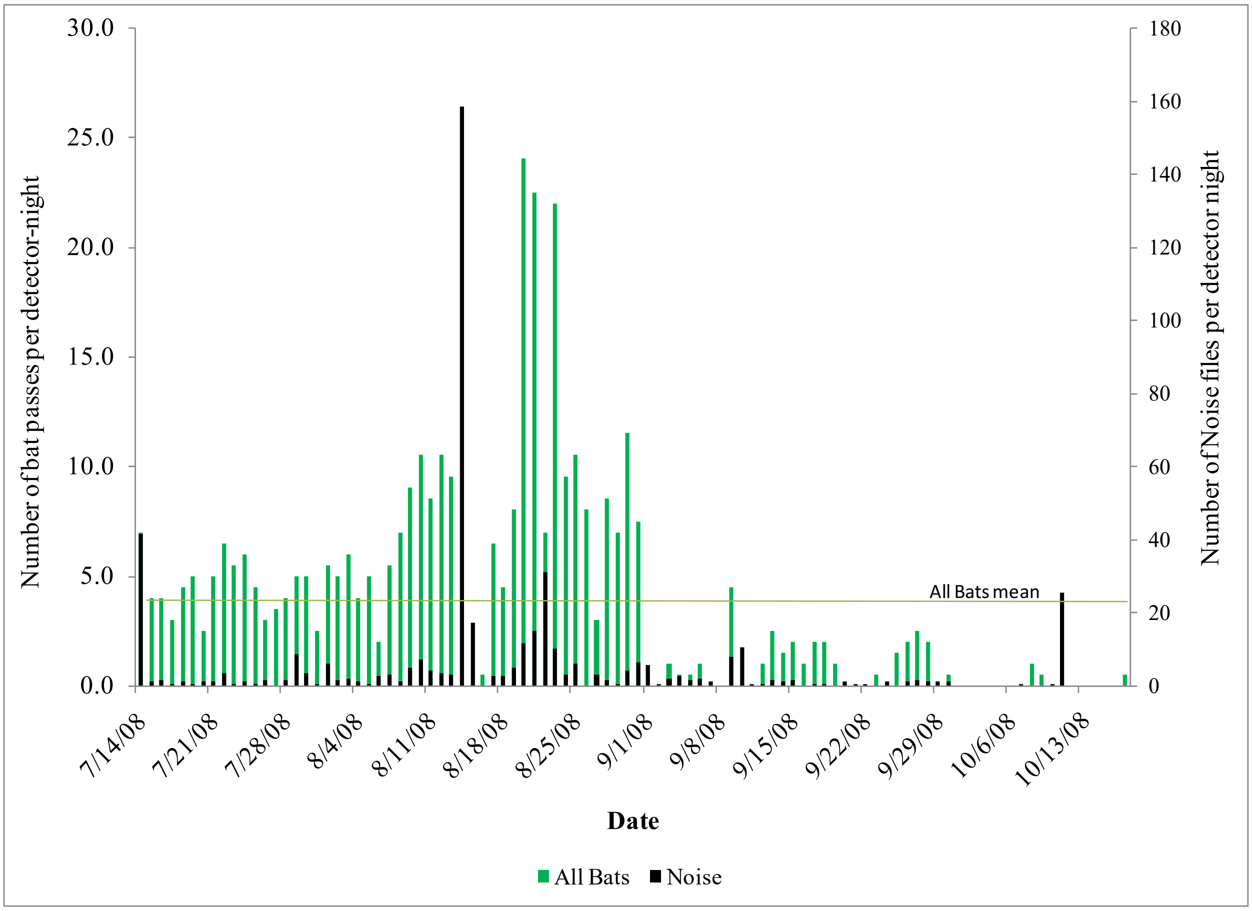


Figure 12. Number of bat passes and noise files detected per detector-night at the High Plains Wind Resource Area for the study period July 14 – October 17, 2008, presented nightly. Noise files are indicated on the second axis.

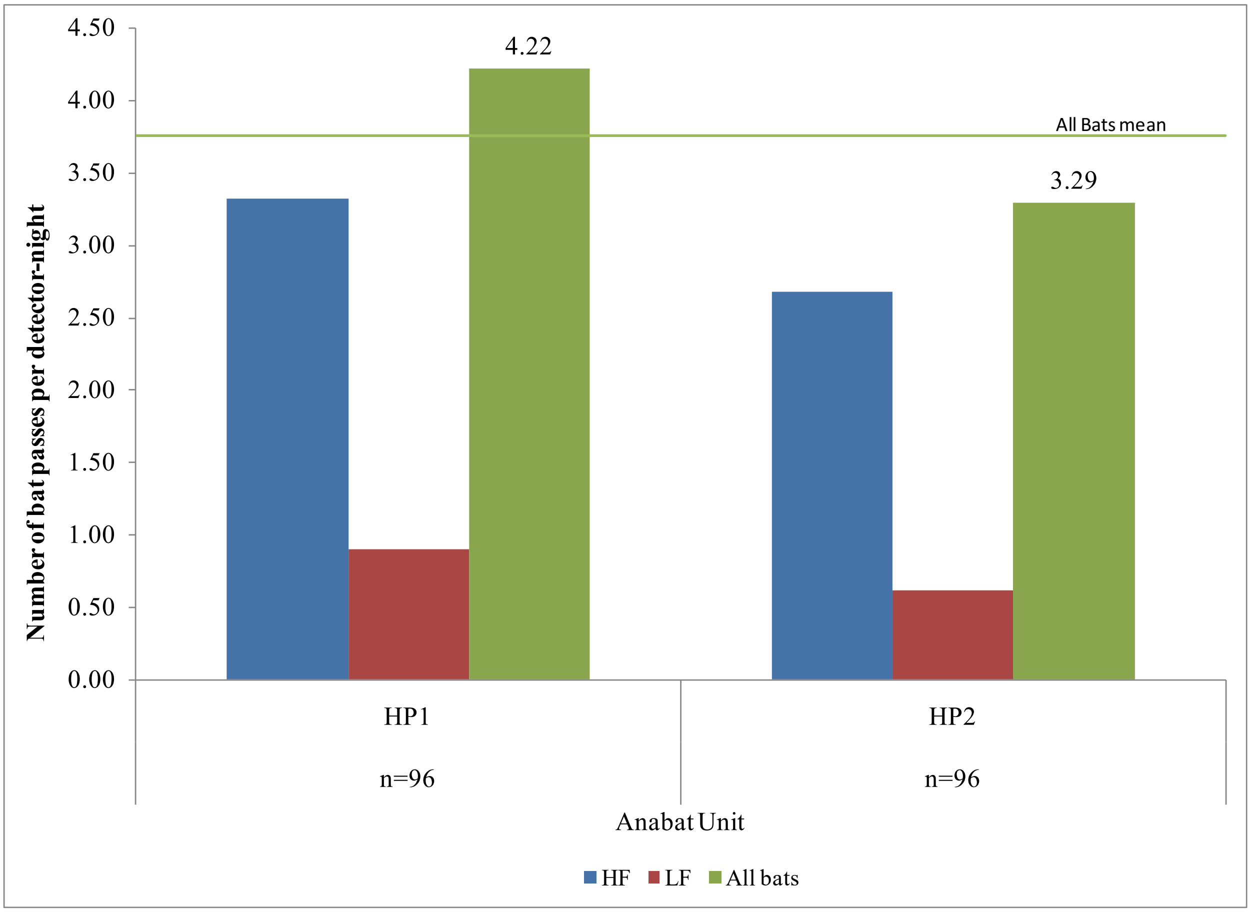


Figure 13. Number of bat passes per detector-night by Anabat location at the High Winds Wind Resource Area for the study period July 14 – October 17, 2008.

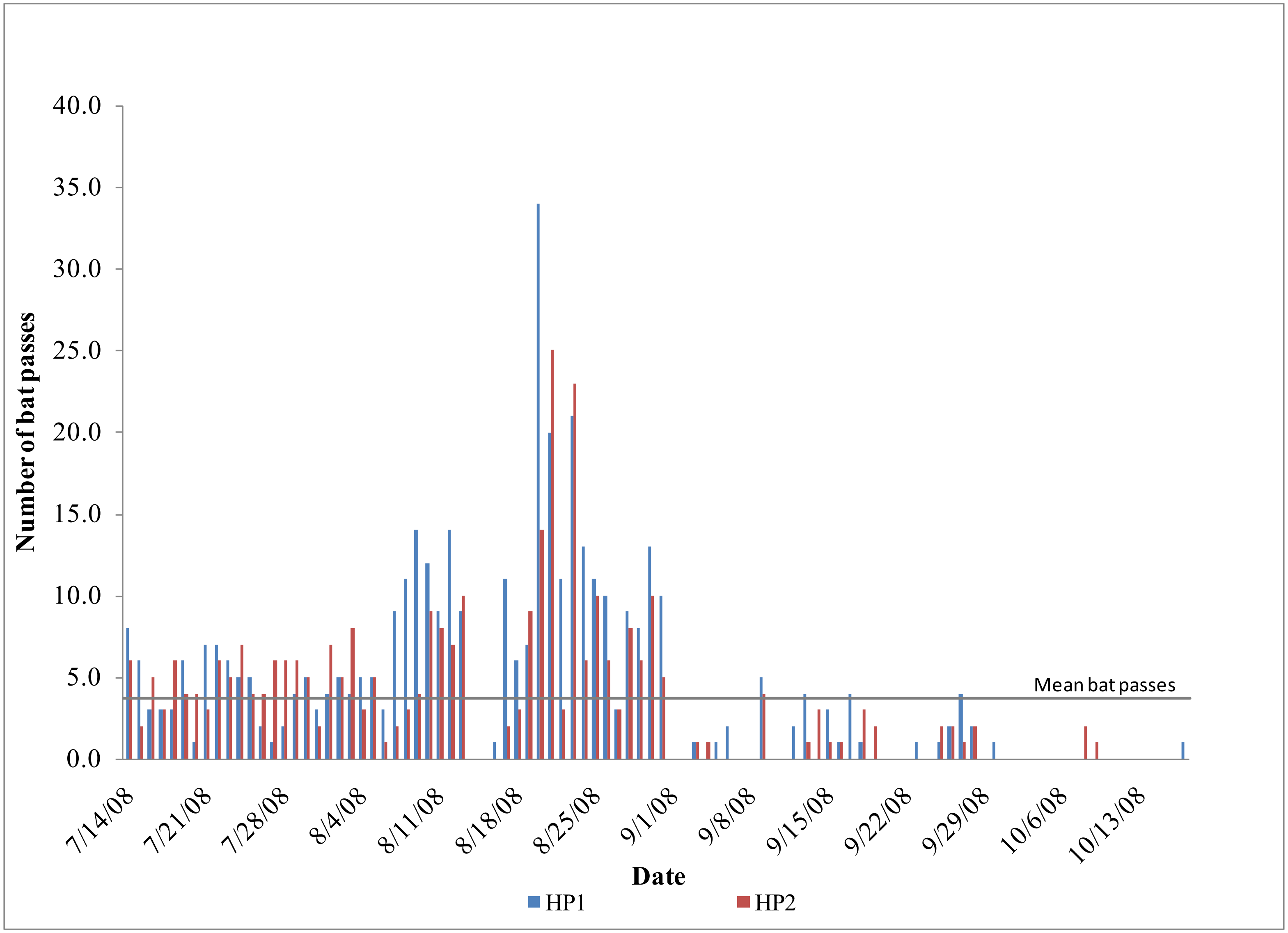


Figure 14. Number of nightly bat passes, grouped by Anabat location at the High Plains Wind Resource Area for the for the study period July 14 – October 17, 2008.

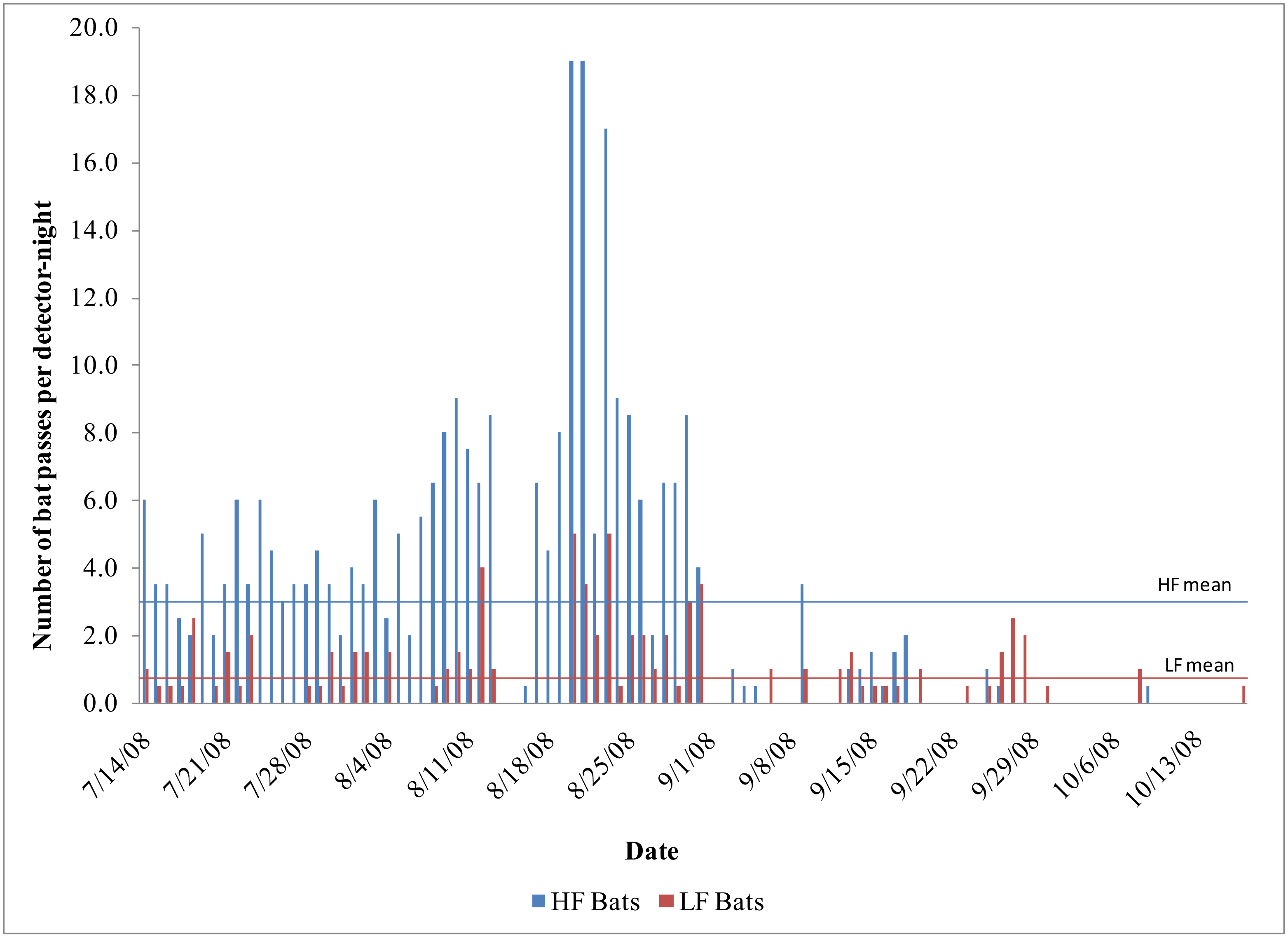


Figure 15. Nightly activity by high-frequency (HF) and low-frequency (LF) bats at the High Plains Wind Resource Area for the study period July 14 – October 18, 2008.

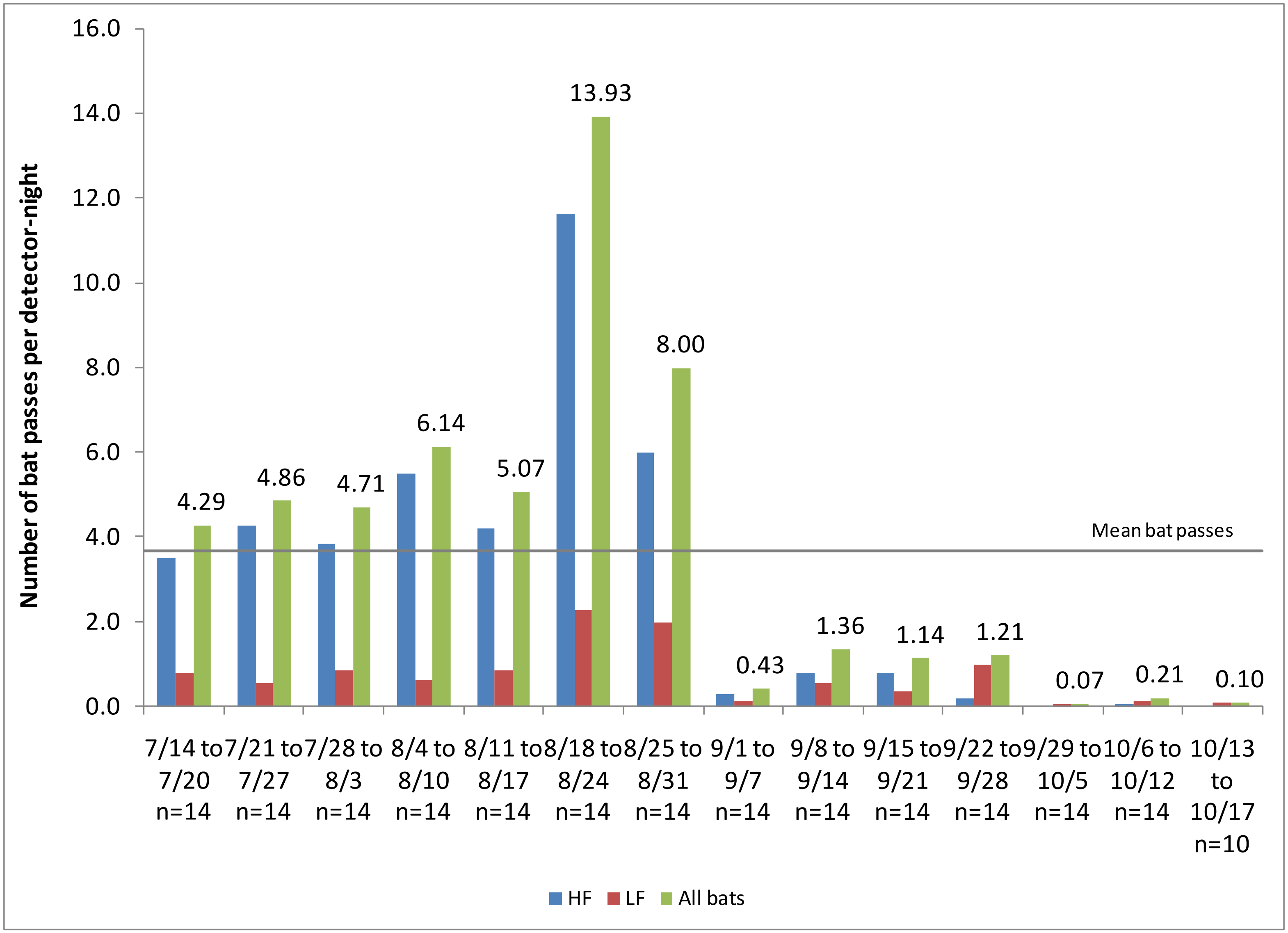


Figure 16. Weekly activity by high-frequency (HF) and low-frequency (LF) bats at the High Plains Wind Resource Area for the study period July 14 – October 17, 2008.

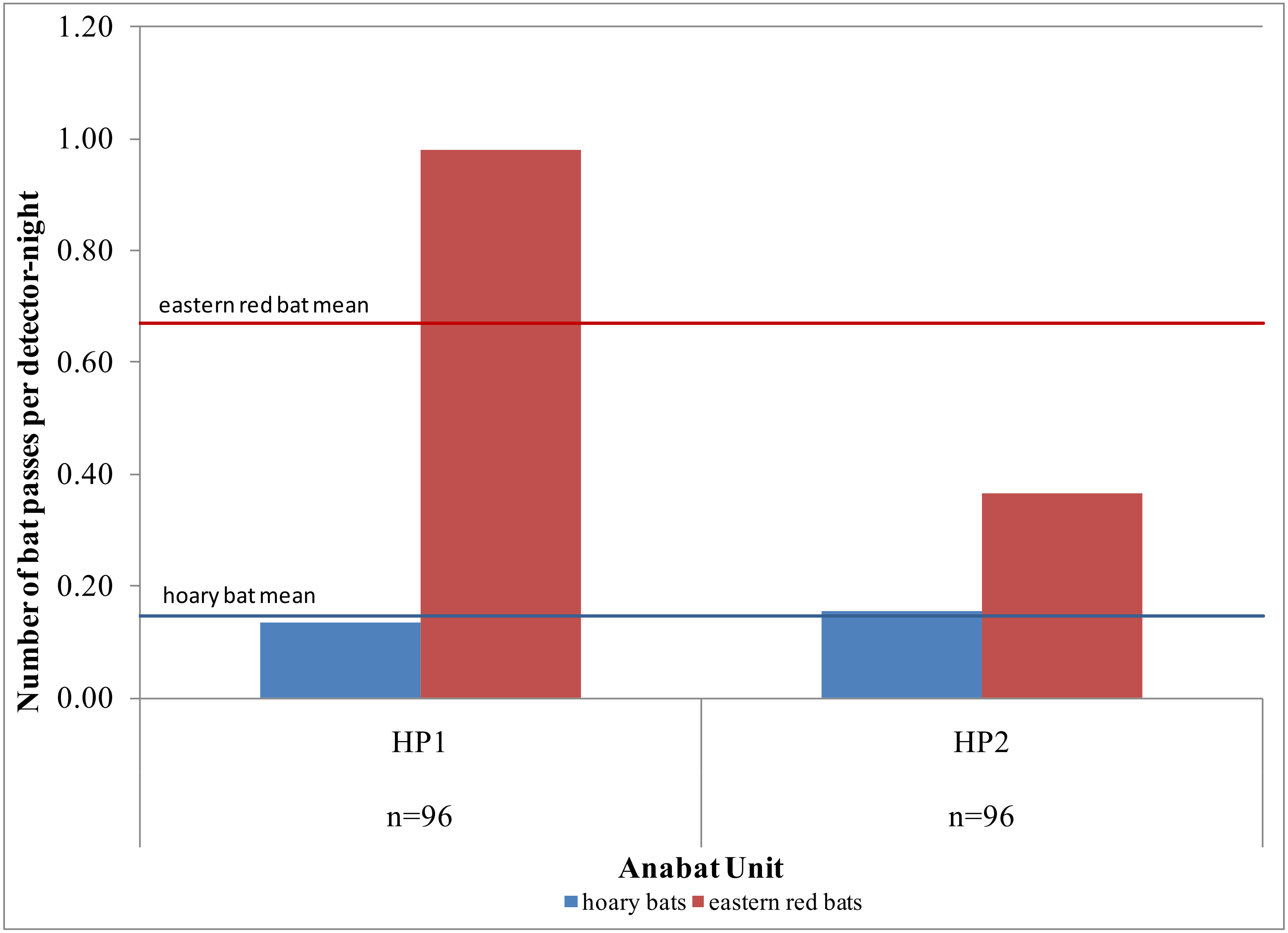


Figure 17. Number of passes by hoary bats and eastern red bats per detector-night by Anabat location at the High Plains Wind Resource Area for the study period July 14 – October 17, 2008.

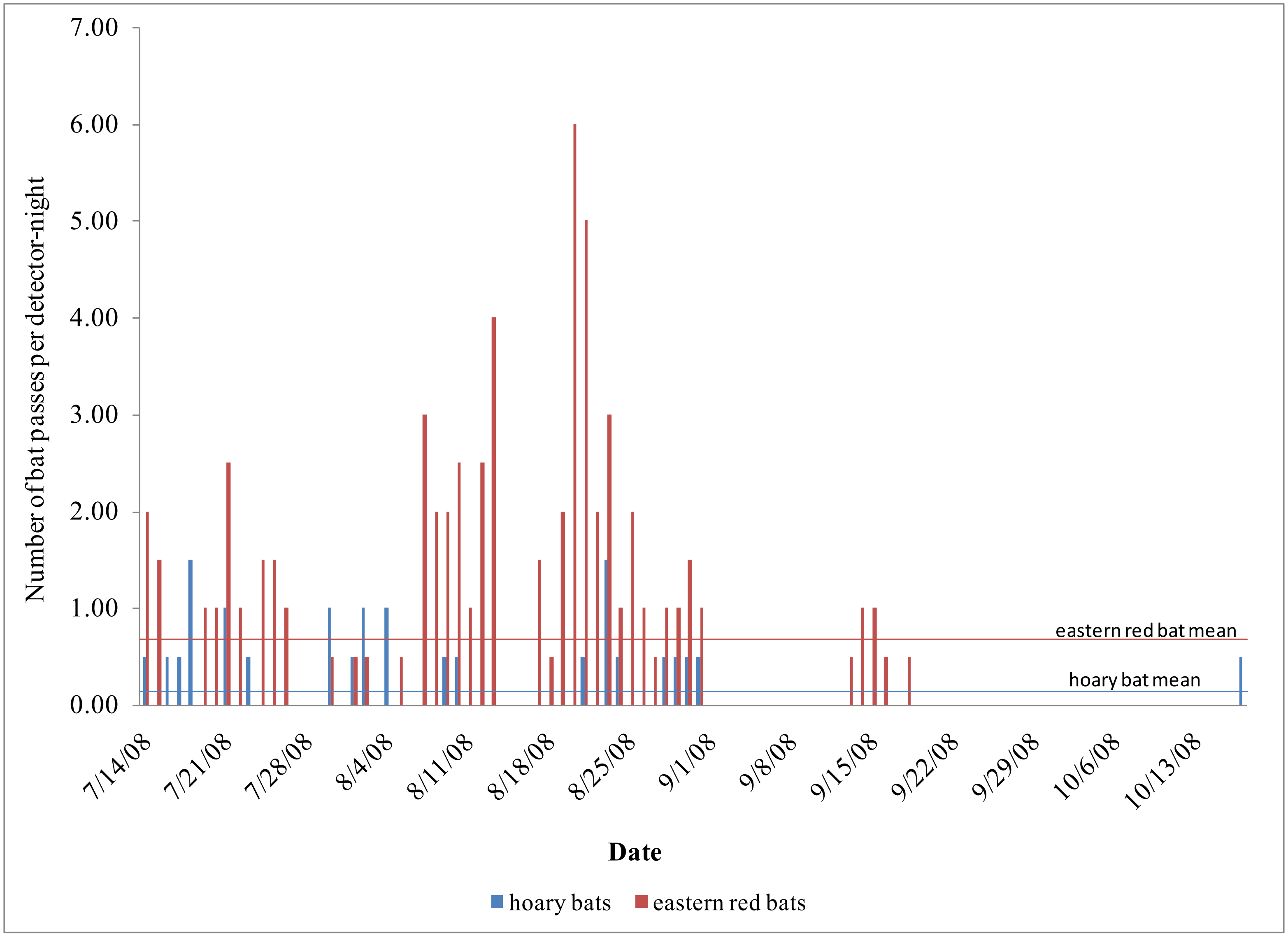


Figure 18. Nightly activity by hoary bats and eastern red bats at the High Plains Wind Resource Area for the study period July 14 – October 18, 2008.

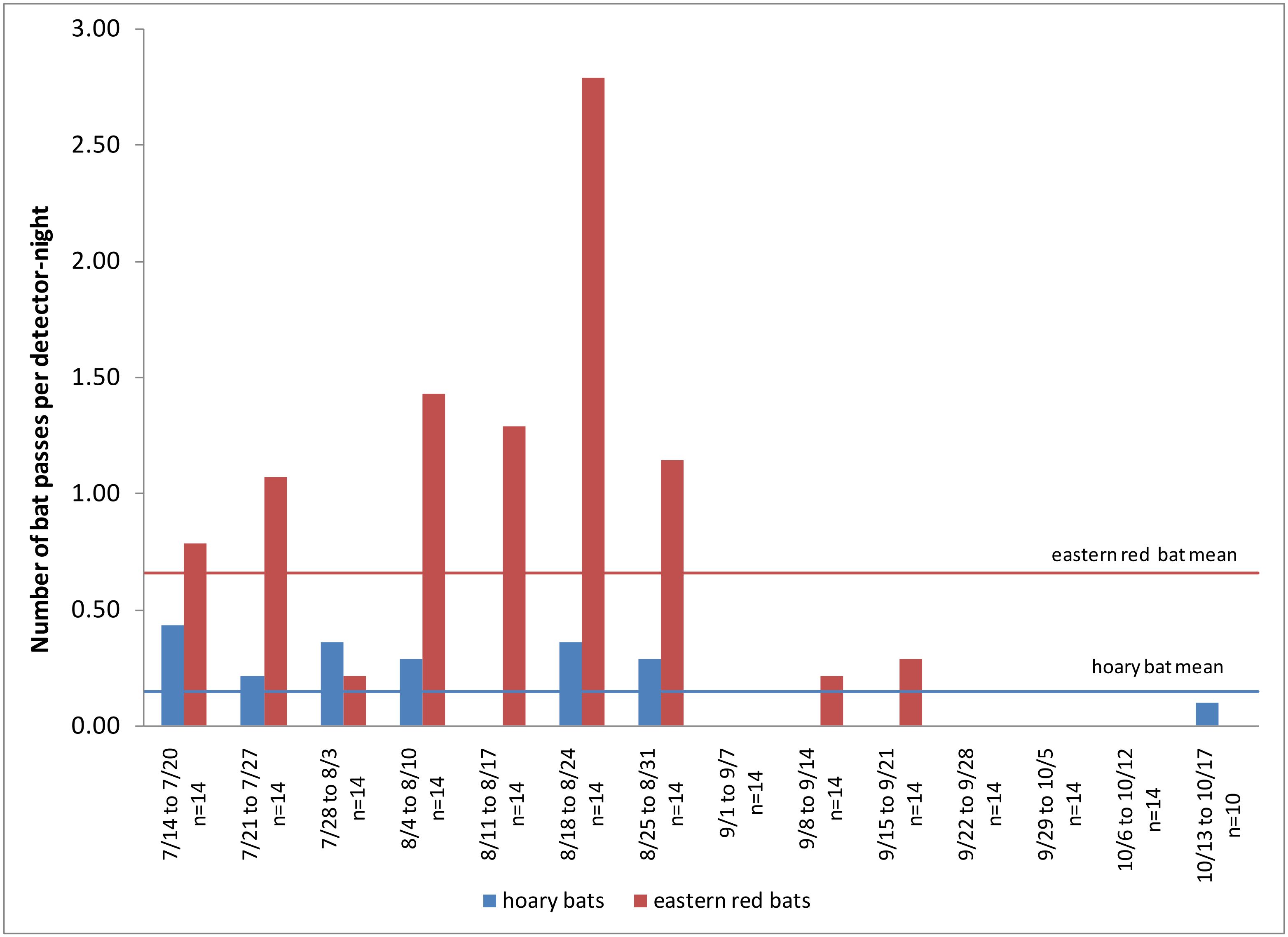


Figure 19. Weekly activity by hoary bats and eastern red bats at the High Plains Wind Resource Area for the study period July 14 – October 17, 2008.

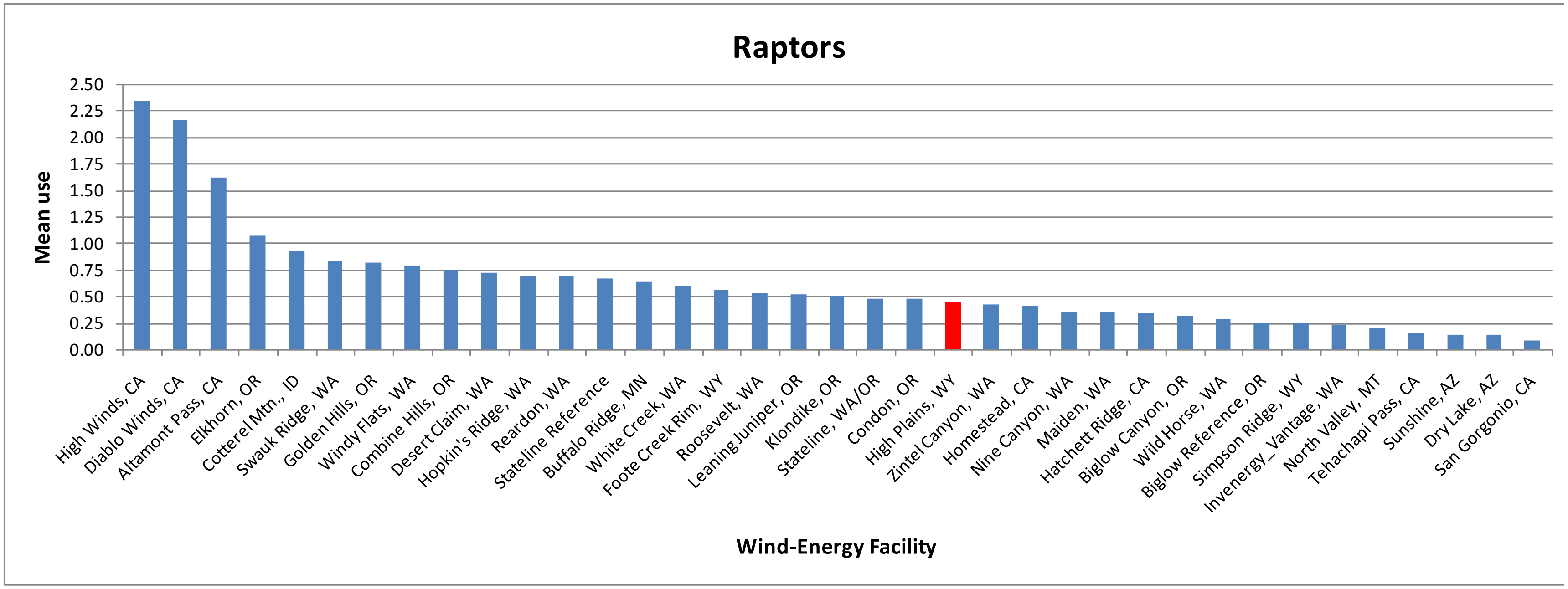
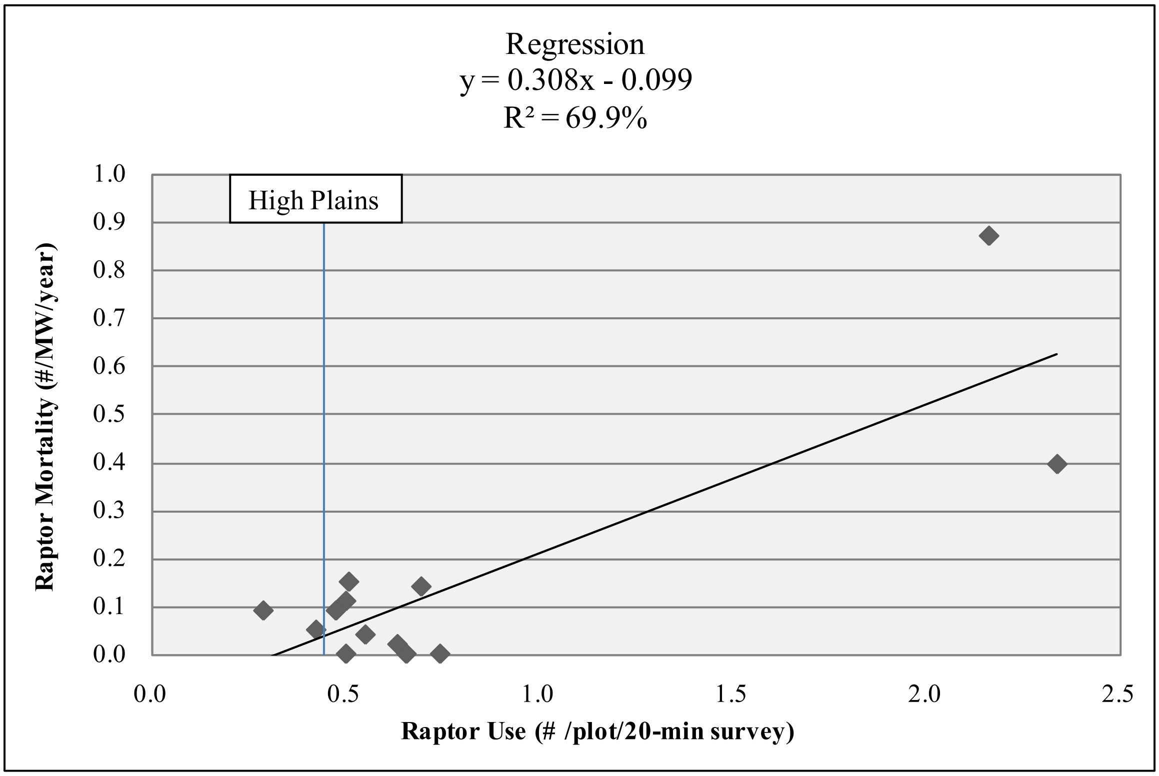


Figure 20. Comparison of annual raptor use between the High Plains Wind Resource Area and other US wind-energy facilities.

Data from the following sources:

High Plains, WY	This study.				
High Winds, CA	Kerlinger et al. 2005	Stateline Reference	URS et al. 2001	Maiden, WA	Erickson et al. 2002b
Diablo Winds, CA	WEST 2006a	Buffalo Ridge, MN	Erickson et al. 2002b	Hatchet Ridge, CA	Young et al. 2007b
Altamont Pass, CA	Erickson et al. 2002b	White Creek, WA	NWC and WEST 2005a	Biglow Canyon, OR	WEST 2005c
Elkhorn, OR	WEST 2005a	Foote Creek Rim, WY	Erickson et al. 2002b	Wild Horse, WA	Erickson et al. 2003a
Cotterel Mtn., ID	Cooper et al. 2004	Roosevelt, WA	NWC and WEST 2004	Biglow Reference, OR	WEST 2005c
Swauk Ridge, WA	Erickson et al. 2003b	Leaning Juniper, OR	NWC and WEST 2005b	Simpson Ridge, WY	Johnson et al. 2000b
Golden Hills, OR	Jeffrey et al. 2008	Klondike, OR	Johnson et al. 2002a	Invenergy_Vantage, WA	WEST 2007
Windy Flats, WA	Johnson et al. 2007	Stateline, WA/OR	Erickson et al. 2002b	North Valley, MT	WEST 2006b
Combine Hills, OR	Young et al. 2003d	Condon, OR	Erickson et al. 2002b	Tehachapi Pass, CA	Erickson et al. 2002b
Desert Claim, WA	Young et al. 2003b	Zintel Canyon, WA	Erickson et al. 2002a	Sunshine, AZ	WEST and the CPRS 2006
Hopkin's Ridge, WA	Young et al. 2003a	Homestead, CA	WEST et al. 2007	Dry Lake, AZ	Young et al. 2007c
Reardon, WA	WEST 2005b	Nine Canyon, WA	Erickson et al. 2001b	San Gorgonio, CA	Erickson et al. 2002b



Overall Raptor Use 0.45
Predicted Fatality Rate 0.04 fatalities/MW/year
90.0% Prediction Interval (0, 0.30 fatalities/MW/year)

Figure 21. Regression analysis comparing raptor use estimates versus estimated raptor mortality.

Data from the following sources:

Study and Location	Raptor Use (birds/plot/20-min survey)	Source	Raptor Mortality (fatalities/MW/yr)	Source
Buffalo Ridge, MN	0.64	Erickson et al. 2002b	0.02	Erickson et al. 2002b
Combine Hills, OR	0.75	Young et al. 2003d	0.00	Young et al. 2005
Diablo Winds, CA	2.161	WEST 2006a	0.87	WEST 2006a
Foote Creek Rim, WY	0.55	Erickson et al. 2002b	0.04	Erickson et al. 2002b
High Winds, CA	2.34	Kerlinger et al. 2005	0.39	Kerlinger et al. 2006
Hopkins Ridge	0.70	Young et al. 2003a	0.14	Young et al. 2007a
Klondike II, OR	0.50	Johnson 2004	0.11	NWC and WEST 2007
Klondike, OR	0.50	Johnson et al. 2002a	0.00	Johnson et al. 2003b
Stateline, WA/OR	0.48	Erickson et al. 2002b	0.09	Erickson et al. 2002b
Vansycle, OR	0.66	WCIA and WEST 1997	0.00	Erickson et al. 2002b
Wild Horse, WA	0.29	Erickson et al. 2003a	0.09	Erickson et al. 2008
Zintel, WA	0.43	Erickson et al. 2002a	0.05	Erickson et al. 2002b
Bighorn, WA	0.51	Johnson and Erickson 2004	0.15	Kronner et al. 2008

Pronghorn and Greater Sage-grouse Pellet Count Study
High Plains Wind Energy Project
Carbon and Albany County, Wyoming

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION AND BACKGROUND

PacifiCorp Energy (PacifiCorp) is developing two adjacent wind-energy facilities of 99 megawatts (MW) and 88.5 MW nameplate capacity in Albany and Carbon Counties, Wyoming, in an area referred to as the High Plains Wind Resource Area (HPWRA). A portion of the project area is on land designated as crucial winter range for pronghorn antelope (*Antilocapra americana*; Figure 1). Crucial winter range is defined by the Wyoming Game and Fish Department (WGFD) as the determining factor in the animal population's ability to maintain itself on a long-term basis. Animals on crucial range may be at risk due to disturbance and habitat loss. Therefore, the WGFD requested that a pellet study be conducted to determine to what extent, if any, pronghorn antelope avoid wind turbines. The project area is also occupied by greater sage-grouse (*Centrocercus urophasianus*), a species that has been petitioned for listing as threatened or endangered under the Endangered Species Act (ESA 1973). No research has been conducted to determine how greater sage-grouse respond to wind-energy development. Therefore, the WGFD requested that a pellet study be conducted to determine to what extent, if any, sage-grouse avoid wind turbines.

There is little information regarding wind-energy facility operation effects on big game. At the nearby Foote Creek Rim wind-energy facility in Wyoming, pronghorn antelope observed during raptor use surveys were recorded year round (Johnson et al. 2000). The mean number of pronghorn antelope observed at the six survey points was 1.07 animals/survey prior to construction of the wind-energy facility and 1.59 and 1.14 animals/survey, respectfully, for the two years immediately following construction, indicating no reduction in use of the immediate area. A study of interactions of elk (*Cervus elaphus*) with operating wind-energy facilities was recently conducted in Oklahoma (Walter et al. 2004). The study found no evidence that operating wind turbines have a measurable impact on elk use of the surrounding area.

Much debate has occurred recently regarding the potential impacts of wind-energy facilities on prairie grouse, including greater sage-grouse. Under a set of voluntary guidelines, the US Fish and Wildlife Service (USFWS) has taken a precautionary approach and recommends wind turbines be placed at least five miles (mi; eight kilometers [km]) from known prairie grouse lek locations. The USFWS argues that because prairie grouse evolved in habitats with little vertical structure, placement of tall man-made structures such as wind turbines in occupied prairie grouse habitat may result in a decrease in habitat suitability (USFWS 2004). Some initial research has shown avoidance of a large power plant and associated powerlines by breeding lesser prairie-chickens (*Tympanuchus pallidicinctus)* in Kansas (Hagen 2003). The USFWS (2004) describes an unpublished study in which three greater prairie-chicken (*Tympanuchus cupido*) leks were active after the construction of three wind turbines in Minnesota. Two of the leks were located within two miles of the turbines and one lek was located 0.6 mi (1.0 km) from the turbines. The report describes one hen and a brood using an area immediately adjacent to a turbine. The study took place in an isolated patch of suitable grassland surrounded by unsuitable cropland. The USFWS concluded that the amount of habitat, rather than the presence of wind turbines, was limiting the population. The USFWS describes the results as potentially implying that "if other factors are not limiting to Greater Prairie Chickens, turbines might not be avoided elsewhere. However, while birds may persist near turbines, survival of those individuals may be compromised, resulting in a population decline." While the potential exists for wind turbines to displace greater sage-grouse from occupied habitat, it is clear that well designed studies examining the potential impacts of wind turbines on prairie grouse are lacking. Currently, a large-scale study of wind-energy effects on greater prairie-chickens is being conducted at several wind-energy facilities in Kansas. The results of this research will help better define the impacts of wind-energy facilities on prairie grouse.

According to the WGFD, there are no documented greater sage-grouse leks within one mi (1.6 km) of the HPWRA boundary, and no leks were found during surveys of the study area. Therefore, it is unlikely that significant numbers of greater sage-grouse use the area for wintering or as nesting or brood-rearing habitat.

The purpose of this study was to obtain pre-construction data on use of the study area by pronghorn antelope and greater sage-grouse through estimating pellet density. Similar data collected after construction will allow us to determine if construction of the wind-energy facility results in avoidance of the project area. To ensure any measured changes in use of the study area following construction are not due to other factors such as weather, pronghorn antelope and greater sage-grouse pellet densities were also determined on a reference area located over one mi (1.6 km) from the nearest proposed turbine location.

STUDY AREA

The proposed HPWRA is located on private land in Carbon and Albany Counties of southeastern Wyoming, five mi (eight km) southwest of the town of Rock River. The HPWRA is currently used for ranching and consists of open grassland with rolling hill topography. Habitat is composed nearly entirely of grasslands with some areas of sagebrush. Several ponds are present in the area. Elevations range from approximately 7,000 to 7,200 feet (ft; 2,134 to 2,164 meters [m]).

METHODS

Six plots were established at 24 proposed turbine locations (Figure 2), resulting in a total of 144 plots for pellet counts. The six plots were established at random distances from 49 to 328 ft (15 to 100 m) away from each proposed turbine, perpendicular to the access road. Each plot was marked with a 12-inch (0.31-m) piece of rebar, and the Global Positioning System (GPS) location was recorded. All pellet groups within a 6.6-ft (2-m) radius of each point were enumerated and then removed from the plot. Surveys were conducted in the spring (June 20 and 23, 2008) and again in the fall (October 28, 31, and November 2, 2008) to gather baseline data for future comparisons. The survey in early June was conducted strictly to clear the plots of all pellets, while the survey in October/November documented the previous summer's use of the site. Even through the spring surveys were conducted to clear plots only, the number of pronghorn antelope and sage-grouse pellets within each plot estimated to be less than six months old were recorded to gain some insight into the previous winter's use. Pellets were also removed from each plot following the fall survey. Only pellet groups with over half of the pellet group by horizontal surface within the plot were counted. For those pellet groups that were half in and half out, every other one was counted (Neff 1968).

For reference data, six plots were established at 25 random points located in an area of similar topography and vegetation as the turbines, for a total of 150 survey plots. Reference survey plots were at least one mi (1.6 km) from the nearest turbine (Figure 2). Methods for the reference plots were identical to those at the turbine plots.

RESULTS

Only 14 pronghorn antelope and no greater sage-grouse pellet groups were found at the 144 turbine plots in the spring of 2008, resulting in a density of 31.3 pronghorn antelope pellet groups/acre (Table 1). At the 150 reference plots, 20 pronghorn antelope (32.2 pellet groups/acre) and one greater sage-grouse pellet groups (2.1 pellet groups/acre) were found. In the fall of 2008, 41 pronghorn antelope (91.8 pellet groups/acre) and no greater sage-grouse pellets were found at the 144 turbine plots, while 51 pronghorn antelope (109.6 pellet groups/acre) and 15 greater sage-grouse pellet groups (32.2 pellet groups/acre) were found at the 150 reference plots.

Data collected during the 2008 survey events are all pre-construction data. These data will be compared to post-construction data once the wind-energy facility has been completed. The initial data indicate relatively low use of the proposed turbine development site by pronghorn antelope, and no use by greater sage-grouse.

Table 1. Density (#/acre) of pronghorn antelope and greater sage-grouse pellet groups observed in plots during pre-construction surveys, High Plains Wind Resource Area, Carbon and Albany County, Wyoming.

	Turbine plots		Reference Plots	
Season	Pronghorn Antelope	Greater Sage-Grouse	Pronghorn Antelope	Greater Sage-Grouse
Spring 2008	31.3	0	32.2	2.1
Fall 2008	91.8	0	109.6	32.2

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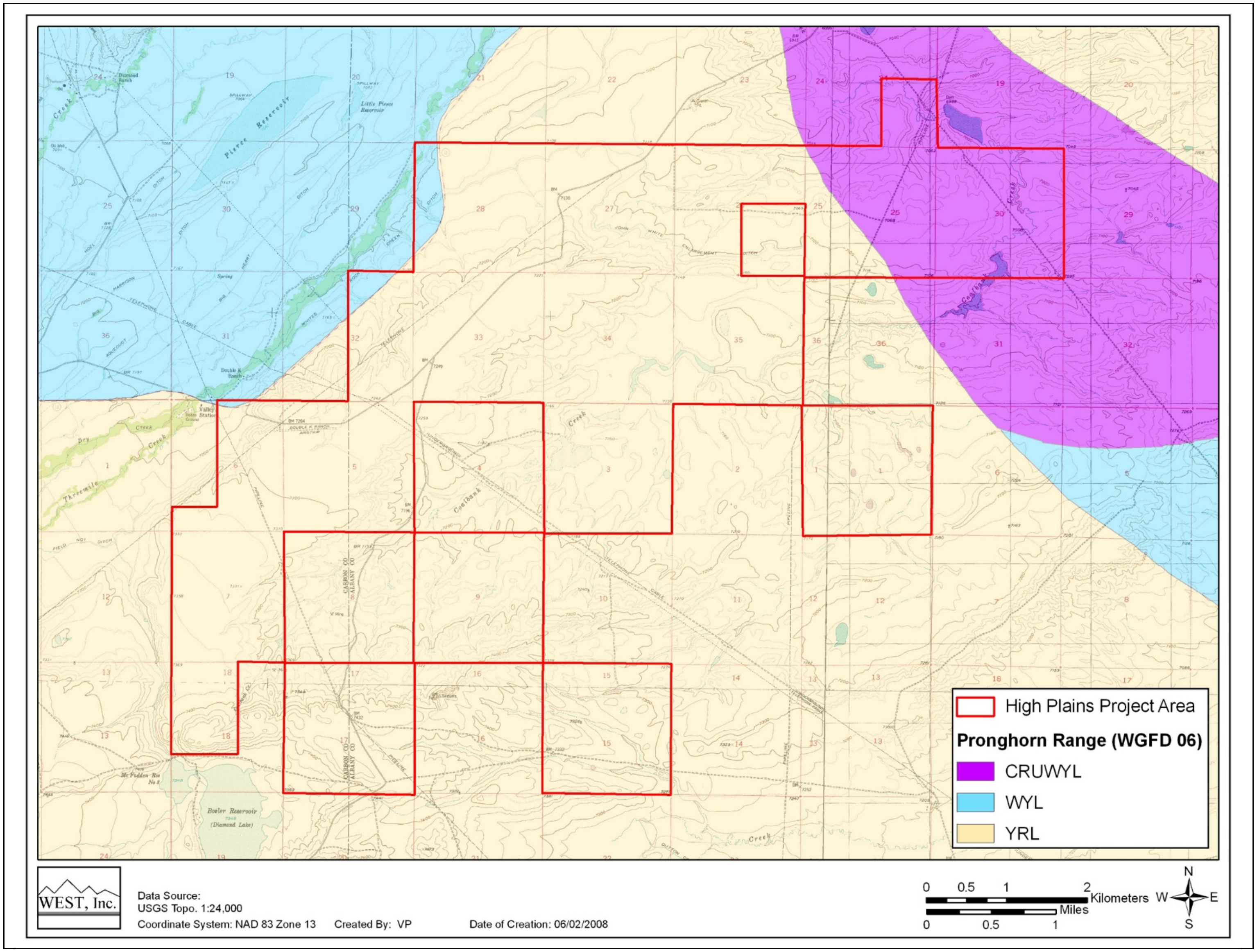

Figure 1. Location of pronghorn antelope crucial winter range on the High Plains Wind Resource Area.

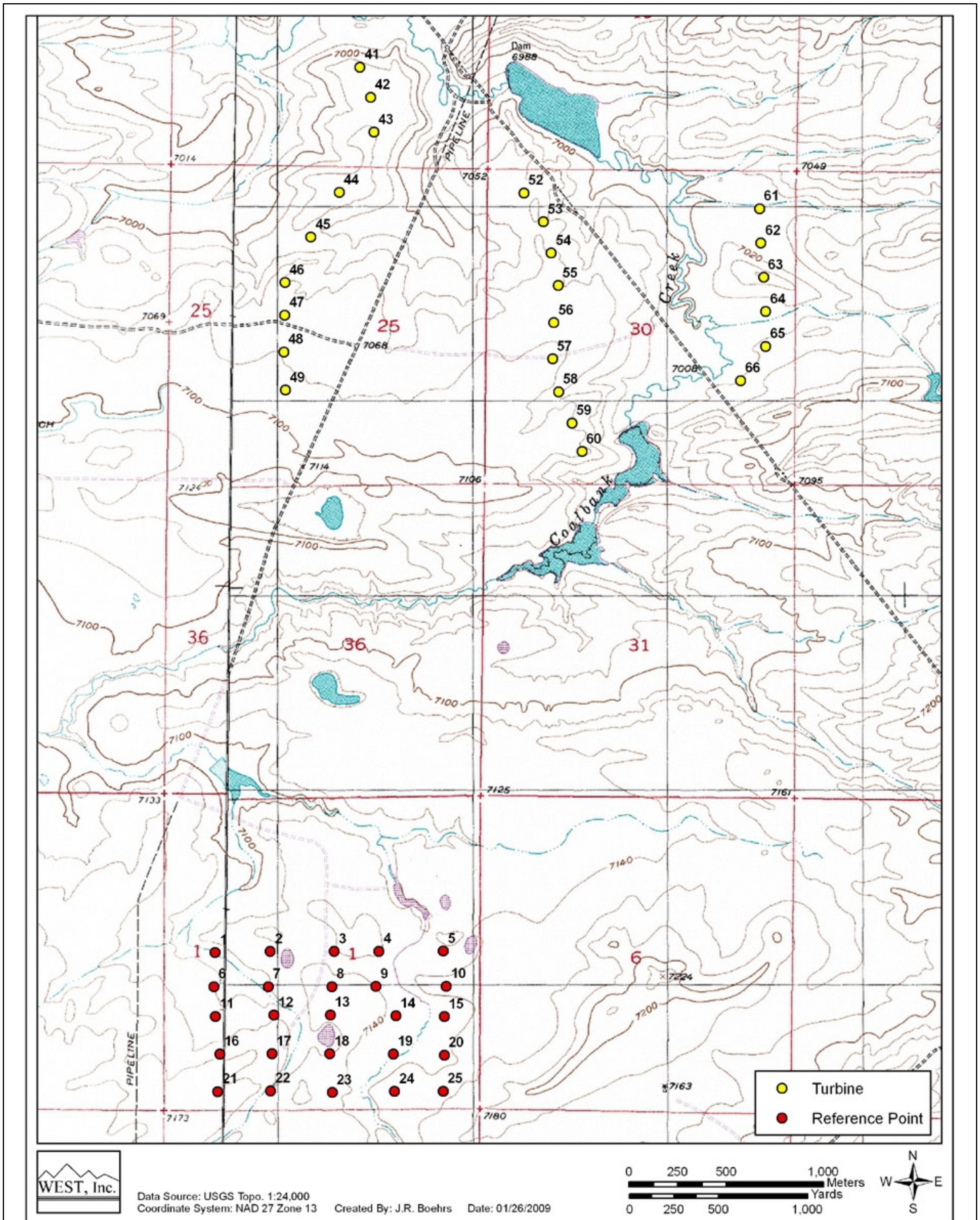

Figure 2. Location of proposed turbines and reference plots used to estimate pronghorn antelope and greater sage-grouse use through pellet group surveys at the High Plains Wind Resource Area.