Wind Energy and Wildlife Pre- and Post-Construction Project at Pantex Plant

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Executive Summary:

From 2009-2017, we conducted pre- and post-construction monitoring of wildlife at the Pantex Plant before and after construction of five wind turbines on the plant in 2014-2015. Pre-construction sampling consisted of:

- Acoustic monitoring for bats
- Point count surveys for nesting birds
- Raptor/eagle surveys
- Swainson's hawk home range and habitat study (transferred to Texas Tech University)

Post-construction sampling began in late 2015/2016 and consisted of:

- Acoustic monitoring for bats
- Point count surveys for nesting birds
- Birds of prey/eagle surveys
- Mortality surveys (under turbines)
- Carcass removal/carnivore study
- Ancillary discovery/survey of mortalities in transformer basins (manuscript submitted concurrently with this report)

Summary of results:

Acoustic monitoring for bats:

Pre-construction acoustic monitoring for bats was conducted at five sites on Pantex. Acoustic (here after Anabat) files were downloaded 30 times with Anabat files recorded from 6/21/2010 through 1/17/2014. The resulting data include over 3,000,000 files and we hope to analyze them in the future.

We were never successful recording acoustic data after 2014 (post-construction). This is despite numerous attempts to trouble shoot our acoustic monitors. Wind damage to cables going from the body of the monitor to their microphones could not be repaired or replaced while towers were standing.

Point counts for nesting birds:

Sampling of breeding birds was accomplished through point counts conducted at sites selected for turbine construction and others selected as control sites. Precipitation varied greatly over the

course of the study, from a low of 17.81 cm (7.01 inches) during 2011 to a high of 87.96 cm (34.63 inches) during 2015.

The pre-construction portion of the project was characterized by fairly extreme drought starting in 2011. Total precipitation for 2011 and 2012 was just 49.12 cm (19.34 inches), less than 50% of the average for a two-year period. The impact of this drought on nesting grassland birds manifest as low nesting species richness and abundance. In 2011 and 2012, 20 and 17 species were documented during point counts, respectively. Post-construction sampling followed the wet year of 2015 (87.96 cm, 34.63 inches). Species richness of nesting birds in 2016 and 2017 was considerably higher than during the drought, 40 and 37 species, respectively.

We suspect changes in resource availability associated with relief from drought starting after 2015 was responsible for the recovery/increase in species detected during the breeding season; less importantly any changes from installation of turbines or changes in surface management (e.g., row-crop type). In a small mammal-fire study conducted nearby (Crossbar Cooperative Management Area, Amarillo, TX), we found precipitation explained 94-97% of variation in small mammal biomass during a 6 year sampling effort (Priesmeyer et al., 2014). The dominant impact of precipitation on resource availability in the arid Panhandle obscured any effects of fire on small mammals in a way similar to what we suggest here for birds.

It is clear from our results, however, that the presence of turbines alone is insufficient to prevent use of these sites by grassland-agricultural nesting birds on Pantex. Horned larks and western meadowlarks are common wintering and nesting species and were represented in both point count surveys and as carcasses in mortality surveys under turbines. Horned larks were the second most common species detected in 82 mortality surveys (n=7) while only 1 western meadowlark was found. Horned lark carcasses were found in all seasons, consistent with year-round use of the site.

The siting of all Pantex turbines in intensive row crop agriculture likely reduces the impact of turbines to wildlife by reducing the quality of the habitat under the turbines for nesting birds. This would likely reduce the abundance of small mammals too, that serve as prey and could attract raptors to the turbines.

Birds of prey/eagle surveys:

Birds of prey/eagle surveys (diurnal species surveys) were conducted in fall, winter and spring to accommodate the timing of use of the area by eagles and by abundant wintering raptors. Despite their abundance locally, raptors made little use of the area around the turbines during our surveys and no eagles were observed in the turbine fields during the entirety of all our pre- and post-construction field efforts during 2009-2017. This result is borne out in the results of our mortality surveys. For birds of prey (hawks, vultures, and falcons), a single American kestrel was found during 82 carcass surveys during 2015-2017. In our removal study using camera traps we did find that carcasses attracted turkey vultures. However, turkey vultures only visited carcasses on control sites and not turbine sites. This is preliminary given the small number of turbines and short duration of the carcass removal study but suggests turkey vultures might not be attracted to carcasses of birds/bats that fall near turbines.

Eagles were present in our study area only during winter. No eagles were detected during summers from 2010-2017 while conducting full time research activity (June-August; approximately 400 hours per season) including intensive point count surveys for birds and other activities by research crews. Bald and, less frequently, golden eagles were detected during winter raptor surveys (~0.25 bald eagles/survey, pre- and post-construction) at prairie dog colonies and playa wetlands but never on the site selected for turbine placement. Eagles were not among carcasses found during 82 carcass surveys in 2015 (14 surveys), 2016 (39 surveys) and 2017 (29 surveys).

Under current land management, row-crop agriculture, there are few resources to attract substantial use by birds of prey and especially eagles. Under this scenario it is expected that use of turbine sites by birds of prey including bald and golden eagles will continue to be light. Eagles in particular, while present locally and regionally common during winter, would likely only transit through the Pantex turbine field during irregular trips and therefore not become common victims of collision with Pantex turbines.

Mortality surveys:

Pre-construction sampling is designed to both provide baseline information for comparing post-construction findings and also to inform the client (Pantex Plant) of the potential impacts to wildlife of construction of turbines at the proposed location. The siting of the five turbines at Pantex Plant represents a best-case scenario for reducing potential impacts to wildlife. Many turbines in the panhandle of Texas are sited on the edge of escarpments. The topography increases wind speeds and performance of turbines but places turbines in locations where resources for bats (e.g., crevices and caves for roosting, trees) would likely lead to increased bat activity and mortality. Further, migrating and soaring birds congregate along these topographic features likely increasing their risk of collision with the blades of turbines. Pantex turbines are on an open plain and the land use where the turbines are sited is row-crop agriculture.

Consistent with our assessment, only one bird of prey, and American kestrel, was discovered during 82 mortality surveys from 2015-2017. The majority of bird mortalities were common nesting or wintering or migratory species that defy easy description (most species n=1 for 82 searches). The exotic house sparrow was the most common species encountered in mortality searches (n=10). Horned larks were the only other species found with any consistency (n=7). House sparrows may view the turbine structures as habitat, increasing their time and risk around turbines. Horned larks are common open habitat species and were present in the study area year-round.

Bats made up approximately 25% of mortalities with most of these being the tree-roosting Hoary bat ((*Lasiurus cinereus*); n=14). Hoary bats are likely encountering Pantex turbines during migration and most mortalities were discovered in August and September. Brazilian free-tailed bats (n=3) were the only other species of bat identified from the 82 mortality surveys.

Technical issues impacted greatly our acoustic monitoring study and plagued our night filming using thermal cameras. It was hoped that thermal cameras could capture birds and bats that flew

through the turbine's rotor sweep zone. Doing so over the course of several years would provide timing of risk providing insight into migration and other movements (e.g., feeding, roosting) that brought birds and bats into risk of collision with turbine blades. Frequency and intensity prevent generalization, however, birds and bats were recorded in the rotor sweep zone on numerous occasions indicating risk of collision exists throughout the year for birds and from at least March through November for bats (most bat mortalities occurred in August or September). From other research on bats we conducted in the area, we know that bats are actively flying during all months of the year (Riedle and Matlack, 2013).

Numbers of carcasses discovered during fatality searches might have been influenced by scavenging by predators. Using camera traps, we documented avian and mammalian predators scavenging carcasses. Larger bird carcasses tended to be scavenged faster than smaller birds. Bat carcasses were tracked after they were found and tended to not be scavenged. As a result, the number of bats found is likely a reasonable estimate of mortality of bats. Bird carcasses, however, especially larger ones, are likely underrepresented in our fatality searches due to scavenging by predators before discovery.

Significance of results:

Wind energy development in a number of locations have been found to impact wildlife due to collision with the turning blades of turbines. In Texas, wind energy facilities monitor fatalities but do not report these findings publicly. As a result, there is a paucity of data from this region on the impacts of turbines on wildlife. Given that Texas leads the nation in wind energy development and much of that development is within a few hundred miles Pantex Plant, these findings, while tentative, are very important and will be of interest to scientists and the public.

We anticipate a number of publications resulting from these findings in peer-reviewed publications. A manuscript on mortalities caused by turbine basins is more than 90% complete and is submitted for review in addition to this report. Additionally, Matlack will present the findings of the fatality and removal studies at the South Western Association of Naturalists next April in San Marcos, TX. Matlack will continue to finalize publications with Ray and submit these to appropriate peer-reviewed publications. The importance of completing these publications is such that West Texas A&M University supports PI Matlack by covering his publication costs and travel costs to present at scientific meetings.

INTRODUCTION--

The Pantex Plant resides in the central Texas Panhandle, Carson County. The Pantex Plant is the main disassembly and assembly site for nuclear weapons and materials in the United States. The plant totals a ~18,000-acre site consisting of agricultural cropland, mixed short and tall grass prairie, grazing land for cattle and playa wetlands throughout. The plant is operated by the United States Department of Energy/National Nuclear Security Administration. The five 400-foot tall turbines sit on a 1,500-acre agricultural plot adjacent to the main plant and is the largest federally-owned wind farm in the country. These became operational in the spring of 2015.

MATERIALS AND METHODS--

Acoustic Monitoring--

Beginning June of 2010 echolocation calls of bats were recorded by AnaBat SD1 Bat Detectors at each of five towers. Towers were located near the Cockrell Homestead, at the south meteorological tower near the Pantex turbines, at the north meteorological tower, in the northeast pasture of the Pantex Lake Playa Management Unit, and north of Playa 2 in the Playa 2 Playa Management Unit (ref. Maps 1 and 2). In order to determine the vertical distribution of bat activity within the typical rotor-sweep area of wind turbines, we affixed these detectors at ground level, 30m, and 60m aboveground on two meteorological towers and ground level and 23m above ground on three temporary towers. Multiple towers were included to ensure sufficient spatial sampling and because of the possibility of additional turbine rows being erected elsewhere on the property. We programmed acoustic monitoring to occur nightly throughout all seasons, with each device storing echolocation calls to a compact flash card for later analysis using the Zero-Crossings method. A small solar panel and 12v battery jointly powered each acoustic array.

Map 1

Playa 1/Red Lake
TLAP/ North of the Lighthouse
NMT
Zone 8 Area
P2BT
Playa 2
Pantex "East Property"
Zone 10 Area
SMT
CBT
Texas Tech/Range 3 - PE 3 Gate
Google earth

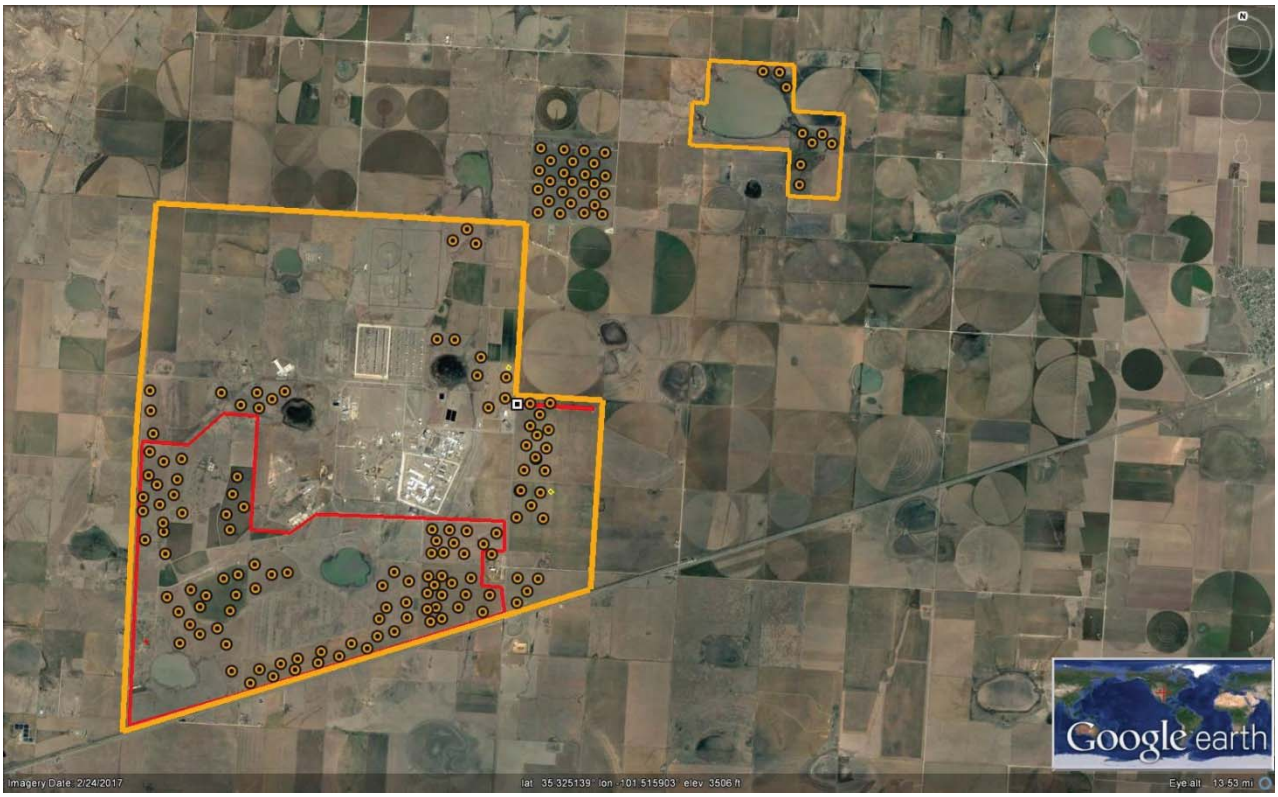
Map 2

Pantex Lake
Pantex Lake
PLBT
County Rd. H
Playa 1/Red Lake
TLAP/ North of the Lighthouse
NMT
P2BT
Playa 2
Google earth

Point Count Sampling--

During the summers of 2010, 2011, 2012, 2013, 2014, 2016 and 2017 (designated May - August), we conducted bird point counts across 20 agricultural and grassland plots on the Pantex Plant and Texas Tech Research Farm (Tech Farm) properties. These fields were further organized into five groups according to proximity: Playa Two (PD2, PD3), Pantex Lake (PD1, N1, CNT1), East Property (CT1, CT2, CT3), Playa 1 (CNT2, N2, N3, CNT5), and the Tech Farm (GNT2, GNT3, GNT4, N4, CNT3, CNT4, GT1, GT3). Within each plot, randomized observation points were selected and stored using a combination of Geographic Information System (GIS) techniques and Global Positioning System (GPS) units, respectively (Map 3; points on map are approximate).

Map 3



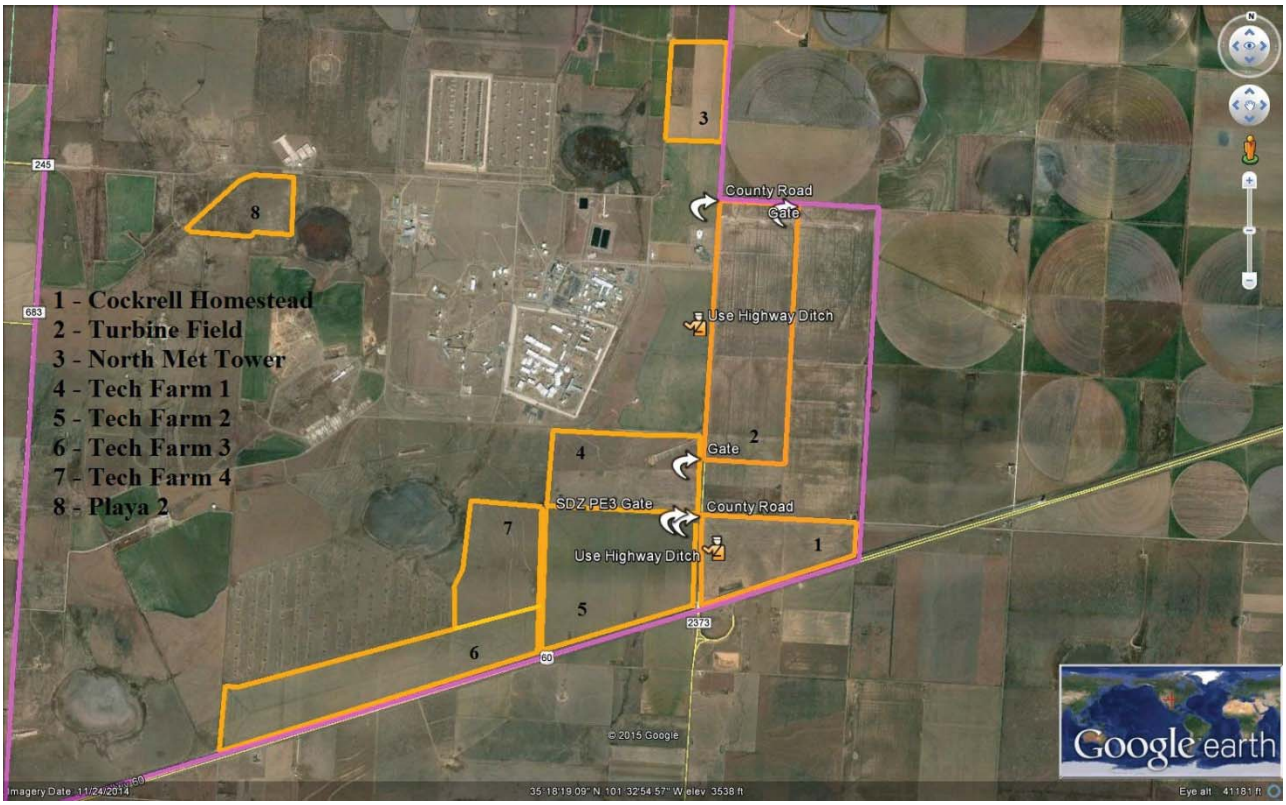
Weather-permitting, we surveyed each field weekly, targeting early morning periods of high songbird activity. Moving on foot in order to minimize disturbances, our teams surveyed at every GPS point for a duration of five minutes to catalogue sightings and calls, employing binoculars and spotting scopes as necessary. For each bird observed, we recorded location, time, distance from observer, type of identification (visual or audio), species, and dominant vegetation. When possible, we also documented sex, number of individuals, and behavioral notes, including nesting and courtship displays. Throughout both seasons, only birds observed inside the designated field borders and within 200m of a given point were recorded.

Raptor Surveys--

Between October 2010 and February 2017, our teams conducted winter raptor surveys across seven routes both on and adjacent to Pantex property. Specifically, these routes included the Cockerel Homestead Field and the Turbine Field east of the plant along Farm Road 2373; Tech Two, Tech Three, and Tech Four within Tech Farm and the Surface-Danger Zone (SDZ); and the North Met Tower Field and Playa Two (ref. Map 4).

Weather-permitting, we performed roadside diurnal raptor surveys twice weekly, targeting mid-afternoon periods with high visibility. Teams surveyed each field at least once per week, and all accessible fields were searched at least twice per month. During every trip, drivers maintained a speed of 10 to 25 miles per hour, occasionally halting to scan field borders and fence lines with binoculars or spotting scopes. For each raptor observed, we recorded the GPS coordinates, time, distance and direction from observer, and species. When possible, we also documented age (juvenile or adult), morph, sex, and behavioral notes, including descriptions of specific flight patterns. Only raptors observed within the designated field borders were recorded.

Map 4



Nocturnal Filming—We began our nocturnal filming trials in June 2016. Filming sessions were designed to capture birds and bats flying near or possibly striking the blades and center hub or "Rotor Zone". Filming was conducted using two FLIR cameras connected to 12 volt automotive batteries and laptops using the Cyberlink Power Director Program. We setup two filming stations, marking a center point 50 meters from the base of the turbine and placing each camera station 50 meters in opposing directions from that center point (ref. Diagram 1). We positioned

each camera at 45 degree angles using Wixely Digital Angle Gauge (ref. Diagram 2).

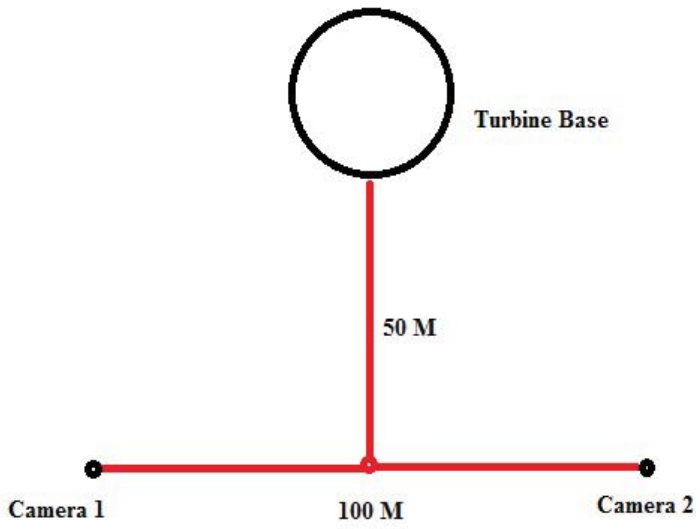


Diagram 1

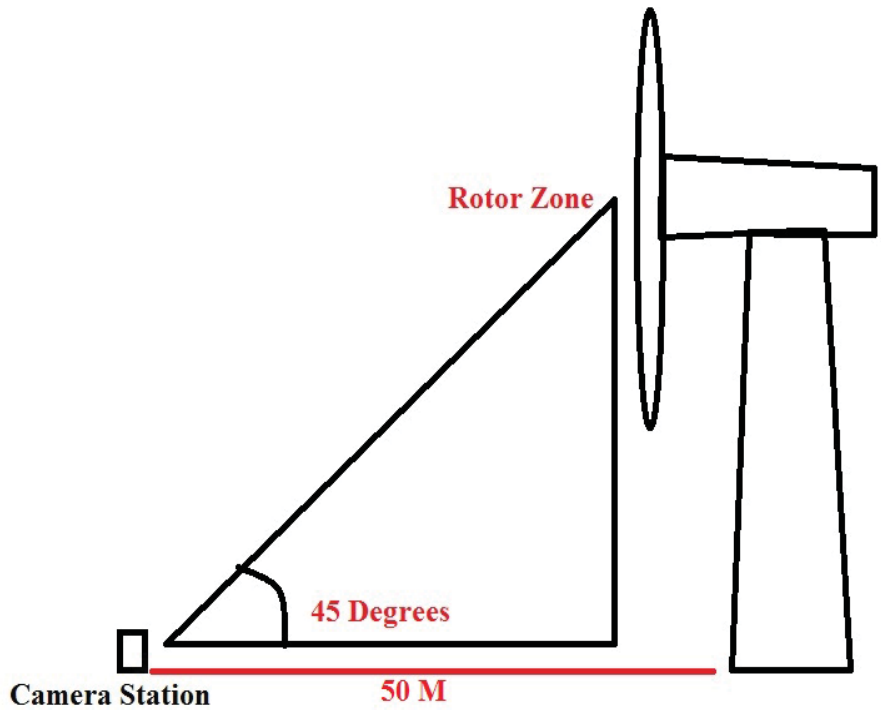


Diagram 2

Filming sessions lasted approximately 3 hours due to laptop and battery converter constraints. Film footage for each camera was closely reviewed simultaneously, once a bird or bat enters into the Rotor Zone field of view both laptops video feed is paused and observers mark the time of the object entering field of view and attempt to locate the object on both camera feeds. If object in question is identified in both camera feeds, observers differentiate between bird or bat by flight pattern as well as size and shape. Only objects that appear in both cameras Rotor Zone or actual strikes with the blades were recorded.

Fatality Searches--

Beginning August 2015, we conducted fatality searches weekly October-June and twice weekly July-September during peak migrations. The five Pantex Turbines (PTs) are 2.5 MW turbines, 124.7 m tall (maximum blade tip), and have a rotor length (rotor diameter) of 76.8 m.

Originally, our teams performed searches on both the Pantex wind farm and a private installation to the north (Burrell); however, we were unexpectedly barred from this second property by the wind energy company shortly after the project began. These turbines were smaller, with a generating capacity of 1.5MW, 116.7 m tall, with a rotor length of 74.9 m. Turbines on Burrell property were 8 m shorter than those on Pantex and had turbine blades 1.9 m shorter than Pantex turbines. While serious comparison would be inappropriate, no mortalities were discovered on the Burrell property before surveys were halted.

For each of the five Pantex turbines, teams of five observers performed carcass searches utilizing a 50m rope pulled taut from the base of the tower. In order to preserve this radius, the main length was linked by carabiner to a second rope encircling each tower, allowing for free rotation as observers walked. Spacing ourselves ten meters apart, we moved in unison, searching the field for bird and bat fatalities. Upon discovery of a carcass, we recorded turbine number (PT1, PT2, PT3, PT4, PT5), distance and bearing from turbine, GPS location, species, and condition (fresh, decayed, or consumed). In order to assess the average survival time of turbine fatalities, "captured" carcasses were designated by zip ties attached at the leg or wing and counted as "recaptures" in subsequent searches; additionally, we conducted a removal study using camera traps (detailed below) in 2016.

Removal Study--

In March of 2016, remote camera traps were placed 25 meters from each turbine, with corresponding control plots located at 500 meters; further, each stand was separated by a distance of at least 100 meters to ensure independence. Utilizing commercially available quail carcasses to represent avian fatalities, a total of ten camera traps were set and baited per season.

Throughout 2016, removal trials took place once per season: spring (March – May), summer (June – August), and fall (September – November). In order to prevent habituation, also referred to as scavenger swamping, each of these four trials lasted no longer than two weeks. Every time a camera recorded a scavenging event, the captured species were considered a present and active member of the scavenger community on Pantex. Unidentifiable carcasses that persisted without evidence of scavenging activity (fourteen cases) throughout the trials were omitted from results of these trials.

RESULTS—

Acoustic Monitoring--

Between 21 June 2010 and 17 January 2014 (pre-construction) we recorded >3,250,000 acoustic files (>170Gb) from Pantex. These filed were not analyzed. The majority of these files (I estimate several million) contain ultrasound from wind and other sources and not bat calls. We were never successful recording acoustic data after 2014 (post-construction). This is despite numerous attempts to trouble shoot our acoustic monitors. Wind damage to cables going from the body of the monitor to their microphones could not be repaired or replaced while towers were standing.

Point Count Sampling—

Summer 2016-- During 2016, our teams positively identified a total of 40 species, 36 of which receive protection under the Migratory Bird Treaty Act. Two game birds, Northern bobwhite (*Colinus virginianus*) and ring-necked pheasant (*Phasianus colchicus*), and two unprotected species, Eurasian collared dove (*Streptopelia decaocto*) and rock pigeon (*Columba livia*), accounted for the remainder.

The Texas Tech Research Farm (hereafter Tech Farm) yielded the greatest number of individual sightings with 30 species, followed by the East Property and Playa 1 with 24 and 23 species respectively, Pantex Lake with 20 species, and Playa Two with fourteen species. Species richness was highest at Pantex Lake, averaging ten species per plot, followed closely by the East Property and Playa Two; the Tech Farm exhibited the lowest species richness with an average of four species observed per plot. Fields nearest playa lakes supported mixed-grass prairie communities, while vegetation on agricultural lands was dominated by oat, wheat, and sorghum monocultures, as well as Old World bluestem in most pastures.

Visual and audio identifications decreased throughout the summer, reaching their nadir in early August, after which surveys were concluded for the year. Western meadowlarks (*Sturnella neglecta*) accounted for 25% of sightings in 2016, followed by 16% horned larks (*Eremophila alpestris*), 14% mourning doves (*Zenaida macroura*), 13% grasshopper sparrows (*Ammodramus savannarum*), and 9% great-tailed grackles (*Quiscalus mexicanus*).

Summer 2017-- During 2017, our teams positively identified a total of 37 species, 32 of which receive protection under the Migratory Bird Treaty Act. Scaled quail (*Callipepla squamata*), Northern bobwhite, ring-necked pheasant, and two unprotected species, Eurasian collared dove and rock dove, accounted for the remainder.

Playa 1 yielded the greatest number of individual sightings with 32 recorded species, followed by the East Property and Playa Two with 21 and 20 species respectively, Pantex Lake with 20 species, and the Tech Farm with eight species. Species richness was again highest at Playa Two and Pantex Lake. Playa 1 exhibited a slight increase in species richness during 2017, averaging eight observations per plot, while sightings on the Tech Farm decreased to an average of only one species per plot. Fields nearest playa lakes continued to support mixed-grass prairie

communities, while vegetation on agricultural land remained restricted to monocultures of wheat, sorghum, cotton, and Old World bluestem.

Visual and audio identifications again decreased throughout the summer, leveling off as surveys concluded for the year in early August. Western meadowlarks accounted for 31% of sightings in 2017, followed by 19% horned larks, 14% grasshopper sparrows, 7% red-winged blackbirds (*Agelaius phoeniceus*), and 6% mourning doves.

Raptor Surveys--

October 2016--The project area was surveyed three days in October, during which we recorded 19 individual raptors. The Tech Farm remained inaccessible at this time, limiting our observations to the Cockerel Homestead, Turbine Field, North Met Tower Field, and Playa Two. Northern harriers (*Circus cyaneus*) accounted for approximately 30 percent of sightings, followed by American kestrels (*Falco sparverius*) and ferruginous hawks (*Buteo regalis*), but red-tailed hawks (*Buteo jamaicensis*) and prairie falcons (*Falco mexicanus*) were also noted. Three of these five species - northern harriers, ferruginous hawks, and prairie falcons - are migrant, wintering in Texas before returning north.

November 2016--Due to adverse weather and road conditions, the project area was surveyed two days in November, during which we recorded 19 individual raptors. At this time, Tech Three and Tech Four became accessible and were added to our regular routes, which may explain an increase in sightings per day. Nevertheless, species distribution remained relatively unchanged, with northern harriers and American kestrels together comprising nearly 70 percent of observations. Red-tailed hawks, ferruginous hawks, and prairie falcons again accounted for the remainder.

December 2016--The project area was surveyed five days in December, during which we recorded 63 individual raptors and incorporated Tech Two into our regular survey routes. During this period, species counts doubled in proportion to previous months. Northern harriers - typically male-female pairs - and American kestrels again proved to be the most abundant species, collectively comprising 65 percent of all observations; other recurring species included ferruginous hawks (both light and dark morphs), red-tailed hawks, and prairie falcons. Most importantly, we recorded two bald eagles (*Haliaeetus leucocephalus*) - likely a breeding pair - and one golden eagle (*Aquila chrysaetos*) at Playa Two.

January 2017--The project area was surveyed seven days in January, throughout which we recorded 62 individual raptors across our seven regular routes. During this observation period, northern harriers and American kestrels collectively accounted for nearly 80 percent of all sightings; by comparison, species counts for red-tailed and ferruginous hawks decreased by half in proportion to their December numbers. In addition to recurring prairie falcons and one observation of a bald eagle at Playa Two, we also documented two new raptors during January: one migrant rough-legged hawk (*Buteo lagopus*) and one dark-morph Harlan's hawk (*Buteo jamaicensis harlani*). Although the name "Harlan's hawk" now technically describes a red-tailed hawk subspecies, the individual was noted separately due to its relative rarity and unique morph. No golden eagles were observed this month.

February 2017--The project area was surveyed seven days in February, during which we recorded 60 individual raptors across our seven regular routes. In keeping with data from previous months, northern harriers and American kestrels collectively comprised 75 percent of all sightings, followed by red-tailed and ferruginous hawks. One rough-legged hawk and two bald eagles - likely the same pair initially observed in December - were again noted at Playa

Two. We observed no prairie falcons, Harlan's hawks, or golden eagles throughout the end of February, at which point raptor surveys were concluded for the year.

Nocturnal Filming --

2015 -- Due to laptop hardware and software upgrades, we were unable to collect any film footage during the proposed filming schedule.

2016-2017 – Due to high winds and above average inclement weather, filming opportunities were reduced from what was outlined in our proposal. In 2016, we were able to successfully film 7 nights from August to October totaling 23 hours and 30 minutes. 11 birds and 2 bats were captured on film inside the rotor zone. October produced the most bat activity of 2016, 2 bats were captured in the rotor zone on October 7th and 1 bat was captured in the rotor zone on October 14th. Observers recorded birds or bats at separate times during the night in several occasions. No visible strikes were recorded in 2016. In 2017, we filmed only 6 nights from March to June totaling 14 hours and 30 minutes. We attribute decrease in film hours to inclement weather and system malfunctions. 10 birds and 1 bat were captured on film inside the rotor zone. Our earliest bat was recorded in March 25 of 2017, the bat entered the field of view 10 minutes into filming and remained in view for 29 seconds. The largest activity count occurred on May 26 of 2017, a total of 8 birds were captured inside the rotor zone throughout the 3 hour and 30 minute film duration. Again, there was common separate captures of birds on film. No visible strikes were recorded in 2017.

Fatality Searches--

2015-2016-- Our teams documented 36 carcasses representing 15 species between August 2015 and July 2016. Of these, four individuals were too decayed or consumed to

positively identify, and three were recognizable only as doves. Six hoary bats accounted for the largest number of fatalities, followed by house sparrows (*Passer domesticus*) and horned larks. Two birds of prey - a short-eared owl (*Asio flammeus*) and an American kestrel - one shorebird - an upland sandpiper (*Bartramia longicauda*) - and a male mallard (*Anas platyrhynchos*) were also recorded. Although the short-eared owl was discovered outside our 50m search radius, evidence of blunt trauma suggested that it was, in fact, struck by a turbine blade and simply drifted farther than most other birds due to its greater size and wingspan.

Fatalities were concentrated at turbines two (33%) and four (25%). The short-eared owl, upland sandpiper, and mallard were documented at PT2, and the American kestrel at PT4. Of the six hoary bats, two were discovered at PT2, one at PT3, and three at PT4. Seasonally, peak mortality occurred during summer (June-August) and winter (December-February). Hoary bat fatalities in particular were highest during August, with five of the six total individuals found in that period. Both birds of prey were struck during winter (December-February) months, and all instances of scavenging fell between fall (September-November) and winter, as well. One hoary bat, two doves, and three unidentifiable birds accounted for these consumed carcasses.

2016-2017-- Our teams documented a total of 24 carcasses representing seven species between August 2016 and July 2017 (Table 1.). Of these, only one bat was too decayed to positively identify. As in the previous year, eight hoary bats accounted for the largest number of fatalities, followed by house sparrows and horned larks. One barn owl (*Tyto alba*) and three Brazilian free-tailed bats (*Tadarida brasiliensis*) were also recorded. The barn owl was discovered 53m east of PT5 in a similar manner to the short-eared owl.

Table 1. Date of discover and species for carcasses discovered during fatality searches on Pantex Plant during 2015-2017.

SUMMER		FALL		WINTER		SPRING	
Date	Species	Date	Species	Date	Species	Date	Species
8/13/2015	Hoary Bat	9/4/2015	Horned Lark	12/18/2015	American Kestrel	3/25/2016	Rock Dove
8/13/2015	Hoary Bat	9/18/2015	Unable to ID	12/18/2015	Dove Species	3/25/2016	House Sparrow
8/13/2015	Hoary Bat	9/18/2015	Mourning Dove	12/18/2015	Dove Species	3/25/2016	House Sparrow
8/13/2015	Hoary Bat	9/18/2015	Unable to ID	12/18/2015	Dove Species	3/25/2016	House Sparrow
8/13/2015	Barn Swallow	11/7/2015	Hoary Bat	1/15/2016	Horned Lark	4/22/2016	Mallard
8/17/2015	Barn Swallow	9/9/2016	Hoary Bat	1/15/2016	Unable to ID	5/23/2016	Rock Dove
8/18/2015	Hoary Bat	9/9/2016	Hoary Bat	1/15/2016	Unable to ID	4/13/2017	Horned Lark
6/13/2016	Eurasian Collared Dove			2/5/2016	Western Meadowlark	5/25/2017	Bat Species
6/28/2016	Cassin's Sparrow			2/27/2016	House Sparrow	5/25/2017	Horned Lark
6/28/2016	Great-tailed Grackle			2/27/2016	Short-eared Owl	5/25/2017	Barn Owl
7/6/2016	House Sparrow					5/25/2017	White-winged Dove
7/14/2016	Cassin's Sparrow					5/31/2017	Hoary Bat
7/14/2016	Grasshopper Sparrow						
7/15/2016	Horned Lark						
7/26/2016	Upland Sandpiper						
8/4/2016	Hoary Bat						
8/6/2016	Hoary Bat						
8/6/2016	Hoary Bat						
8/6/2016	Hoary Bat						
8/8/2016	Hoary Bat						
8/8/2016	Brazilian Free-tailed Bat						
6/5/2017	House Sparrow						
6/9/2017	House Sparrow						
6/12/2017	Horned Lark						
6/12/2017	House Sparrow						
6/21/2017	House Sparrow						
6/21/2017	Horned Lark						
6/22/2017	House Sparrow						
7/10/2017	Kingbird						
7/18/2017	Brazilian Free-tailed Bat						
7/21/2017	Brazilian Free-tailed Bat						

Fatalities were highest at PT1 (29%), but relatively evenly distributed overall. Brazilian free-tailed bats were documented at PT1, PT2, and PT3, while hoary bats were found mainly at PT1 and PT3. Peak mortality occurred in the summer months (67%); by contrast, we recorded only two carcasses during the fall season and none in winter. Hoary bat fatalities were again highest during August and early September, with seven of the eight individuals found in that period, and Brazilian free-tailed bats were documented mainly during July and early August. We observed two instances of consumption on a white-winged dove (*Zenaida asiatica*) and house sparrow in late May and early July, respectively.

Removal Study--

Spring Trial--During the spring season, camera traps photographed one raccoon, one striped skunk, and three coyotes. The raccoon was detected on an experimental plot nearest the wind turbines (25m), the striped skunk at a more distant control plot (500m), and the coyotes across both. However, carcass-persistence time varied drastically between the experimental and control plots, averaging nearly fourteen days at 25 meters and only six days at 500 meters. All five scavenging events occurred at night or during crepuscular hours (dusk and dawn).

Summer Trial--During the summer season, cameras photographed two striped skunks, four coyotes, and two turkey vultures. The carnivores scavenged at both control and experimental camera traps, but turkey vultures were recorded exclusively at distant control plots. Consistent with spring data, carcass-persistence time averaged eleven days at 25 meters versus six days at 500 meters. Roughly 70% of scavenging events occurred nocturnally, perpetrated by striped skunks and coyotes; the remaining 30% were carried out diurnally by turkey vultures.

Fall Trial--During the fall season, cameras photographed two coyotes, two striped skunks, and one American badger. The coyotes scavenged only at experimental plots, while the skunks and badger scavenged only at control plots. In keeping with spring and summer trends, carcass-persistence time averaged eight days at 25 meters versus only four days at 500 meters. Each scavenging event occurred at night or during crepuscular hours.

Although the winter trial was ultimately excluded, it is worth noting that a domestic dog was observed removing quail during that period.

DISCUSSION--

Acoustic Monitoring--

Due to persistent equipment failure, we were unable to collect any meaningful acoustic data in 2016. We believe that exposure to the elements, severed cables (wind and rodents), or a

combination of both severely degraded the AnaBat arrays, which had been utilized by previous studies, before our project began. In order to successfully implement this portion of the research, we recommend professional repairs to each tower and increased protection around any loose cables.

Point Count Sampling--

Throughout 2016 and 2017, species richness remained highest at plots featuring natural or artificial water sources, especially Pantex Lake and Playa Two. Although this might be partly due to differences in total area, several trends are still worth investigating. First, both fields contain natural playa lakes surrounded by mixed-grass prairie and Old World bluestem pasture, respectively. Water attraction in particular may explain the disproportionate number of species recorded on the cultivated East Property and more specifically CT3, which was planted with wheat (2016) and cotton (2017) during our study. A deep, artificial catchment exists on the southern border of this plot, and following rainfall events our teams occasionally observed killdeer (*Charadrius vociferous*) and American avocets (*Recurvirostra americana*) foraging nearby, in addition to the more usual songbird and raptor species.

Our evidence further suggests that human activity might be another factor encouraging higher species richness near playa lakes. As mentioned earlier, crop and bluestem monocultures on the East Property and Tech Farm yielded generally homogenous observations, with horned larks, Western meadowlarks, barn swallows (*Hirundo rustica*), and cliff swallows (*Petrochelidon pyrrhonota*) comprising the majority of sightings. Northern harriers and American kestrels exhibited hunting and courtship behaviors in farmed fields, but most other individuals were observed flying north toward Playa 1 or Playa Two. Meanwhile, frequent herbicide and pesticide applications probably reduced available food items to unsustainable

levels. Exacerbated by summer heat, these trends reduced sightings in cultivated plots to few or none by early August.

We also suspect that the sharp decline in species richness on the Tech Farm between 2016 and 2017 was due to construction of a new administration building in GT1. Pre-construction, GT1 provided valuable food and grass cover for ground-nesting species such as grasshopper sparrows and common nighthawks (*Chordeiles minor*). Post-construction, observations on the Tech Farm dropped from an average of four species per plot to only one; we believe that mechanical disturbance and noise deterred many species from returning to the area.

Combined with raptor survey results, point count sampling implies that most species resist spending extended periods of time on developed land unless a reliable water source is present. We expect individuals to largely avoid the turbines in CT1 due to heavy agricultural use of that field, and GT1 populations will likely remain low for the duration of construction of the new building. Carnivores that are attracted by small mammal communities (owls, northern harriers, and American kestrels) and generalist prairie songbirds (western meadowlarks, horned larks) frequent these areas and thus run a greater risk of collision.

However, wind farms to the north, especially those located on mixed-grass prairie near Pantex Lake, pose a more significant threat, most notably to migratory shorebird populations. We suggest that future studies direct monitoring efforts here with permission from local landowners. Similarly, farmers and land developers should strive to preserve these habitats by creating buffer zones around playa lakes. Persistent negative effects have been found to occur in several bird species up to 600m from wind turbines (Langston and Pullan 2003). We suggest consideration be given to movement and travel that occurs at a farther distance from favored

habitats (e.g., playa wetlands and prairie dog colonies in our study area) and the associated increased activity and likelihood for collision that is likely to occur.

Raptor Surveys--

Across the five-month study period, our teams documented a total of 223 individual raptors representing eight species. Both species diversity and individual counts were lowest throughout the fall months, designated October to November; by contrast, individual sightings tripled during the winter months, designated December to February. Species diversity was also highest in December and January at seven species recorded per month.

Of the four fields made available from the start, Playa Two supported the largest and most diverse raptor community, while the Turbine Field yielded the smallest and most homogeneous observations. The reasons for this discrepancy are likely twofold: firstly, Playa Two provides the most varied habitat in terms of vegetation type, elevation, and prey communities. The field consists of mixed grass pasture that descends into a large playa lake on its eastern edge; black-tailed prairie dog (*Cynomys ludovicianus*) burrows pepper the elevated grasslands, while waterfowl and other migratory birds blanket the wetlands throughout fall and winter. In addition, utility poles of various heights lining the field borders provide excellent perches for foraging raptors. Large species appeared to hunt preferentially in this area: the greatest number of ferruginous hawks and the only bald and golden eagles observed during our surveys were recorded at Playa Two.

By contrast, the Turbine Field underwent frequent plowing and herbicide applications prior to the start of raptor surveys in October, at which point it was allowed to fallow. Although prey communities of small mammals and birds remained, topographical homogeny and an absence of vegetation seemed to deter many species from frequenting this route. Though its

precise effects remain unclear, the wind facility located at the northern fence line may play an additional role in discouraging raptor visitation. Northern harriers and prairie falcons were by far the most abundant species observed hunting in this area.

Northern harriers were also the most abundant and seemingly adaptable raptors overall, appearing uniformly in cropland, pasture, and grassland habitats throughout a variety of weather conditions. During January we documented one pair exhibiting courtship flights and ground nesting behavior near the Turbine Field and Cockerel Homestead area, respectively.

The bald eagles initially observed in December remained at Playa Two through the conclusion of regular surveys in February, and we suspect they constitute a breeding pair. In accordance with the Bald and Golden Eagle Protection Act, these wintering individuals should receive focused management aimed at minimizing anthropogenic disturbances and preventing illegal take. A long-running Pantex-sponsored study of Swainson's Hawk nesting ecology has not found any eagle nests on the Pantex Plant or in the surrounding area. Although records of breeding golden eagles exist for the Panhandle region, we observed only one individual throughout the duration of this project.

Nocturnal Filming—Due to equipment failure and difficulties with inclement weather we were unable to gain the proposed amount of field data in our filming trials. With the film data we were able to review we did observe activity in and around the Rotor Zone to be a common occurrence. Both bat and bird species were recorded in close proximity to turbine blades, possibly to forage the abundant flying insects at ground level and at Rotor Zone height. Advances in deterrent systems such as UV lighting or blades that are colored to be less attractive to insects foraged by both bird and bat species could help reduce mortalities and studies should be implemented in future wind farms and if possible to current wind farm sites.

Fatality Searches-- Peak mortality coincides with peak bat fatalities/migrations in late summer (July-August). Hoary bats consistently suffer the greatest losses per species, even above common prairie songbirds such as Western meadowlarks and horned larks.

Turbine-specific mortality appears random. At the very least, it reflects no obvious aversion among migratory species to turbines nearer busy developments such as FM 2373 and the Pantex Plant. Scavengers, on the other hand, seem to avoid the wind facility in general as observed in additional through the removal study.

2015-2017 --

Mortalities of birds of prey, to include owl species, seem to coincided with high scavenging activity during the fall and winter months. It is possible these predatory species are more inclined to scavenge near turbines as prey availability decreases. This trend was also observed with results from the 2016 removal study.

Of the species that were identifiable, doves seem to be consumed preferentially from other more abundant but smaller carcasses such as sparrows. By contrast, only one Hoary Bat was ever found partially consumed. The one waterfowl of our study, a mallard was not scavenged, along with our only raptor, and American kestrel.

Both owls were discovered over 50m from turbines, probably due to greater size and wingspan than usual songbirds and bats. These larger species may be better able to absorb the hit, even if it eventually proves fatal. Larger raptors, such as eagles, might even be able to glide or walk out of observers' sight.

Again, based on results from raptor surveys, songbird fatalities would probably be much higher if the turbines were located in a mixed-grass prairie habitat. If a playa lake were nearby, protected shorebirds and their predators, including bald and golden eagles, would also be at

much greater risk. Playas are integral habitat in the western Great Plains region for a wide variety of taxa, especially wetland birds. Where playas are the only source of nearby surface water, they can attract many species of wildlife, often in high concentrations. This danger likely extends to bats, as well, assuming that insect prey populations are higher in such areas (water source for breeding, fewer pesticides, etc.). Bats are known to feed on emerging insects at wet playas (Smith 2003).

Removal Study--

In total, five scavenger species were detected: four carnivores – raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), coyote (*Canis latrans*), and American badger (*Taxidea taxus*) – and one bird – turkey vulture (*Cathartes aura*). Positive identifications reveal that coyotes were by far the most common scavengers (eight cases), followed by striped skunks (five cases). However, striped skunks tended to scavenge and remove carcasses much more quickly than coyotes, despite greater occurrence of the latter throughout the duration of study. Although the winter trial was ultimately excluded, it is worth noting that a domestic dog was observed removing quail during that period, as well; future studies may consider including an analysis of the impacts of domestic scavengers, such as dogs and feral cats.

Members of the carnivore guild were distributed relatively evenly across experimental and control plots. However, of the species recorded, coyotes appeared to be less daunted by the presence of wind turbines than other guild members. Due to their opportunistic and generalized diets, these canids often associate closely with human activities, which may explain this behavior. Turkey vultures, by comparison, only scavenged far afield, suggesting a possible aversion to turbines and the unique risk they present to avian species.

Behavioral differences between guilds may also explain the disproportionate number of nocturnal sightings. Turkey vultures, for example, generally limit any scavenging activities to daylight hours, during which their vision can best complement a strong sense of smell. Most carnivores, on the other hand, are highly attuned to odor cues and hunt preferentially at night or on a crepuscular schedule. Since carnivores have been responsible for the majority of scavenging events in this study, nocturnal trends are to be expected.

Common to both guilds, however, was an increase in scavenging activity according to distance from the wind facility. In each trial, more events occurred on the control plots at 500 meters than on the experimental plots at 25 meters. Additionally, carcass-persistence time for control plots was nearly half that of the experimental plots across all three seasons, suggesting that wind turbines may displace the natural foraging activities of these animal communities. Overall persistence time also decreased as the year progressed. We suspect that dwindling food sources may have encouraged animals to scavenge more frequently approaching the winter months. Declining rainfall may also have played a part in preserving scent cues, making carcasses easier to locate during the relatively dry fall months.

Based on these results, we suggest that fatality searches in the Texas Panhandle take place at least once every two weeks during the spring months when food and rainfall occur in relative abundance. During summer and fall, weekly or bi-weekly carcass searches are necessary in order to preclude the possibility of scavenging or removal.

Conclusion –

The renewable wind energy farms is one of the fast growing industries of the modern era and is growing faster than biologists can fully understand the effects that it is having on the

ecosystem around them. Our team attempted to not only observe and record mortalities of turbines by strikes, but what happened next in the cycle? Apart from the searches for bird and bat carcasses, we learned early on that these turbines were having devastating effects on the local small mammal and amphibian populations, killing dozens of individuals monthly after being trapped in the turbines transformer basin. Nearly every level of the ecosystem is altered by the presence of these turbines and more research is required if we wish to step ahead of the change with tools and knowledge to correct and prevent further damage. The Pantex Wind Farm was a unique opportunity in a unique setting to observe these machines' threat to birds and bat species. We successfully observed multiple federally protected species such as birds of prey and game birds; scavenger and carnivore activity near the turbines, raptor activity and how it altered through a season, as well as concentrations of bird populations in relation to the turbine field. We believe that site selection of future turbines needs to include factors like proximity to large bodies of water, habitat type (exotic monocultures versus native plant species), as well as knowledge of the local wildlife populations with due consideration to migrating populations.

Literature Cited

Priesmeyer, W, R. S. Matlack, and R. T. Kazmaier. 2014. Precipitation and fire impacts on small mammals in shortgrass prairie. The Prairie Naturalist 46:11-20.

Riedle, T. D. H., and R. S. Matlack. 2013. Bats of Palo Duro Canyon State Park, Texas: community composition, abundance, and seasonal activity. Western North American Naturalist 73:89-97.

Birds observed (including all research activities and incidental observations) and discovered as mortalities under turbines on Pantex during 2009-2017.

Species observed	**Mortalities**
American kestrel	American kestrel
American robin	Barn swallow
Bald eagle	Barn owl
Barn swallow	Cassin's sparrow
Black-crowned night heron	Eurasian collared dove
Black-necked stilt	Grasshopper sparrow
Burrowing owl	Great-tailed grackle
Cassin's sparrow	Horned lark
Cattle egret	House sparrow
Cliff swallow	Western kingbird
Common grackle	Mallard
Common nighthawk	Mourning dove
Common raven	Rock dove
Dickcissel	Short-eared owl
Eurasian collared dove	Upland sandpiper
Ferruginious hawk	Western meadowlark
Golden eagle	White-winged dove
Grasshopper sparrow	
Great egret	
Great horned owl	
Great-tailed grackle	
Horned lark	
Killdeer	
Lark bunting	
Lark sparrow	
Mallard	
Merlin	
Mourning dove	
Northern Bobwhite quail	
Northern harrier	
Prairie falcon	
Red-tailed hawk	
Red-winged blackbird	
Ring-necked pheasant	
Rock dove	
Rough-legged hawk	
Scaled quail	
Scissor-tailed flycatcher	
Swainson's hawk	
Turkey vulture	

Upland sandpiper
Vesper sparrow
Western kingbird
Western meadowlark
White-faced ibis
White-winged dove
Wilson's phalarope
Yellow-headed blackbird