EFFECTS OF WIND POWER ON THE DEMOGRAPHY AND POPULATION GENETICS OF THE GREATER PRAIRIE-CHICKEN

QUARTERLY REPORT

Submitted by:

Avian Ecology Laboratory
Conservation Genetics and Molecular Ecology Laboratory
Division of Biology
Kansas State University

Presented to:

National Wind Coordinating Council
Kansas Department of Wildlife and Parks

NREL Technical Monitor: Karin Sinclair

<u>Principal Investigators</u>

Brett Sandercock
Samantha Wisely

<u>Graduate Research Assistants</u>

Andrew Gregory
Lance McNew

<u>Field/Lab Technicians</u>

Samantha Caldwell, Logan Gill, Nathan Libal, Deborah Martell, Thomas Prebyl, Ryan Voetsch, William White

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NREL Subcontract Administrator:

Quarterly Report
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EXECUTIVE SUMMARY

Field.— Field efforts focused on conducting lek attendance surveys, capturing and marking Greater Prairie-Chickens at impact and reference areas of the Meridian Way wind power facility, gathering location and nesting data on radio-marked hens, and conducting habitat surveys at nest locations and at random points across the study sites. Two hundred thirty (230) surveys were conducted at 25 leks during 14 February – 5 May. The mean ($\pm$SE) number of birds attending leks during this time period was 13.0 $\pm$ 0.5 and did not differ between the impact and reference areas. Mean differences between pre- and post-construction lek attendance was related to distance from wind turbines. Trapping via walk-in traps and drop nets was conducted during 3 March - 10 May, resulting in 183 captures (134 males, 49 females). Radio-transmitters were fitted to 48 females. Including prairie-chickens fitted with radio-transmitters in previous years, 68 females were monitored in the breeding season of 2009. Median capture dates for males and females were 26 March (range = 4 March - 5 May) and 9 April (range = 3 March – 6 May), respectively.

We collected >2,200 locations on 68 radio-marked hens. As of 29 June, radio-marked hens have initiated 68 nests. Average estimated date of first nest initiation was 23 April. Apparent success of nests on both impact and reference areas was 29.5%. The majority of failed nests were the result of depredation. Sixteen hens were known to renest, and one hen initiated a third nest. Data collection is ongoing at the time of this report. Twelve radio-marked females have died since 1 January. Most mortalities (91.7%) were the result of predation.

Laboratory.— Laboratory activities during the second quarter of 2009 have focused on tracking radio monitored female prairie-chickens to locate broods and collect blood samples for molecular analysis from all chicks. In addition, we have completed extraction of all adult prairie-chickens captured in 2009 and are in the process of PCR amplification of all extracted DNA. Extraction and PCR amplification of chick samples is also underway. In an effort to better understand local effects of wind development on breeding behavior and natal dispersal we have elected to increase the number of molecular markers being used in our analysis at Unit 3. Currently we have selected 16 new markers to be used, bringing the total number of markers being used at Unit 3 from 11 to 27 (Table 1). To date, we have completed amplification of Unit 3 prairie-chicken samples with only two of the additional primers.

Administration and Reporting.— New funding secured for the project by co-PI's Wisely and Sandercock includes: a $300K grant from the Department of Energy that is in the process of being finalized with K-State, and a $145K grant from the State Wildlife Grants program of the Kansas Department of Wildlife and Parks that has been recommended for funding to the U.S. Fish and Wildlife Service. Sandercock and colleagues have also been awarded a 3-year $0.75M grant from the Department of Education that will provide financial support for training of graduate students. For 2009, Gregory was awarded a competitive fellowship that will provide graduate support through the new GK-12 program at K-State funded by the National Science Foundation. We have prepared three manuscripts for submission to a special issue of *Studies in Avian Biology* focusing on grouse ecology. These manuscripts include data collected during the pre-construction phase of this study. Drafts of all manuscripts are attached.

Gregory, A. J., L. B. McNew, T. J. Prebyl, B. K. Sandercock, and S. M. Wisely. *In review*. A multi-scale hierarchical modeling approach to mapping lek habitats of Greater Prairie-chickens in eastern Kansas. Studies in Avian Biology.

McNew, L. B., A. J. Gregory, S.M. Wisely, and B. K. Sandercock. *In review*. Reproductive chronology of Greater Prairie-chickens in Kansas. Studies in Avian Biology.

McNew, L.B., A.J. Gregory, S.M. Wisely, and B. K. Sandercock. *In review*. Evidence of human-mediated life-history evolution in Greater Prairie-chickens. Studies in Avian Biology.

FIELD BASED HYPOTHESES

Hypothesis I) Lek Attendance: ***Lek attendance on impact sites is not affected by wind-power development.***

Accomplishments Since Last Quarter

Leks were identified by field surveys at both the reference and impact areas at the Meridian Way wind park. The total number of males, females, and prairie-chickens of unknown sex was recorded, as well as the weather conditions (e.g., estimated temperature, visibility) and time and date of observation. Birds were flushed from untrapped leks between 0600 and 0930 hrs. Alternately, the maximum number of prairie-chickens observed on the lek was recorded on trapped leks. The maximum number of males attending each lek will be used to calculate an average maximum number of males at reference and impact areas. The locations of leks and all wind turbines were collected in the field using a GPS unit and uploaded to ArcMap 9.3. The nearest neighbor tool was used to measure the distance from each lek to the nearest turbine.

To test whether the construction of the wind power facility negatively impacted lek attendance, we calculated mean lek attendance for each lek during 2007, 2008, and 2009; with 2007 and 2008 representing the pre-construction period. Lek attendance did not differ between 2007 and 2008 and data collected during these years were pooled into a single pre-construction sample. As per BACI design, differences in mean lek attendance before and after development were calculated for each lek. The mean difference in lek attendance for observations occurring before and after development was then compared between reference and impact sites using an analysis of variance (ANOVA). Alternately, we assessed the relationship between the difference in mean lek attendance before and after development and the distance from leks to the nearest turbine using linear regression. Distances to nearest turbine was square root-transformed for normality. All statistical tests were conducted using program JMP IN (Ver. 4.0.4, SAS Institute, 2001).

We conducted 230 lek surveys at 25 leks during 14 February – 5 May. The mean ($\pm$SE) number of total prairie-chickens observed attending all surveyed leks during this time period was 13.0 $\pm$ 0.5. Mean lek attendance was similar to previous years of study for 13 previously monitored leks (10.5 $\pm$ 1.2 and 11.1 $\pm$ 1.7 for 2007-08 and 2009). There was no difference in mean lek attendance between the reference and impact areas in 2009 ($F_{1,26}$ = 0.06, P = 0.81). Differences in mean lek attendance before and after construction did not differ between impact and reference areas ($F_{1,11}$ = 0.61, P = 0.45; Table 2). However, there was marginal support that proximity to wind turbines explained some of the difference in pre- and post- construction lek attendance (r^2 = 0.32, df = 1, P = 0.04); mean lek attendance declined for 80% of leks within 2,200 m of a wind turbine and increased for 63% of leks >2,200 m from a turbine (Fig. 1). Notably, two new leks were discovered within 300 m of wind turbines during spring surveys in 2009; each with average attendances $\geq$12 birds. Because survey data prior to development were lacking, we excluded these leks from our BACI analysis.

Goals For Next Quarter

The lekking season occurs from March – May; no efforts will be made to address this hypothesis in the upcoming quarter.

Hypothesis II) Avoidance of anthropogenic structures: *Prairie-chickens do not avoid wind-towers and/or other anthropogenic features on impact sites.*

Accomplishments Since Last Quarter

Wind power development has not occurred at Unit 1 and 2 impact areas, and will not occur during this study. Development at Unit 3 began this spring. Effort this quarter was focused on capturing and radio-marking females at all sites and monitoring females to quantify space use and survival. Prairie-chickens were captured and females fitted with radio-transmitters (see 2007 annual report). Radio-marked prairie-chickens were located $\geq$3 times/week from project trucks, an ATV, or on foot using portable radio receivers and handheld 3-element Yagi antennas. Bird locations were estimated from $\geq$2 triangulation bearings using a maximum-likelihood estimator in program LOCATE III or flush locations were recorded with a GPS. Aerial searches were conducted using fixed-wing aircraft when birds are unable to be located from the ground for $\geq$14 days.

Trapping via walk-in traps and drop nets was conducted during 3 March - 10 May at Unit 3, resulting in 183 captures (134 males, 49 females; Table 2). Radio-transmitters were fitted to 48 newly captured females; we replaced the transmitter of a recaptured female. The transmitters of 19 females captured last year were active. During 1 January – 25 June, 2,257 locations of 68 radio-marked females were acquired by triangulation and by approaching radio-marked birds on foot, resulting in an average of 33 locations per bird. Evaluation of home range size and space use has not been conducted, but we are on track to collect the 30-50 locations per individual that are required for estimation of home range size using kernel methods.

Goals For Next Quarter

A preliminary analysis of nest site selection in relation to wind power structures (i.e., turbines, roads, substations, and transmission lines) will be conducted in the next quarter. The spatial locations of nests are being recorded in the field. Vegetation structure, including visual obstruction at 2 m, average canopy coverage, and distances of nearest shrub is quantified at each nest site within 3 days of hatching or failure. Parallel sampling is conducted at a paired random point within and distance of 200 m from the nest, as well as a random point on the entire study site. Spatial locations of newly constructed wind power structures and infrastructure were collected with a handheld GPS. These locations will be uploaded to a geographic information system (GIS) and overlaid onto a land-cover map of the study areas obtained from the Kansas Applied Remote Sensing Program at Kansas University (http://www.kars.ku.edu/products/ksid/index.shtml). An additional layer containing all nest locations will be constructed and the distance to the nearest wind power feature will be calculated for each nest as well as for random points.

We will develop logistic regression models to determine if prairie-chicken nest locations can be predicted from linear and non-linear vegetative characteristics (i.e., VOR, %forb cover, %grass cover, etc), landscape characteristics (e.g., patch size, contagion) or proximity to each of the nearest wind power features. We will use SAS 9.1 (SAS Institute 2005) to develop a set of candidate models and use Akaike's Information Criterion to assess the models that best fit the data. Selection will be based on minimization of AIC_c, and AIC_c weights (w_i's) to determine models best supported by the data.

To illustrate the degree to which hens avoid anthropogenic features when selecting nest sites, we will conduct Monte Carlo simulations of nest locations. We will select a set of random points on the study areas using ArcMap 9.1 (Environmental Systems Research Institute; Redlands, CA). We will create 1,000 simulated data sets for each study area. Each data set will consist of a number of random points equal to the number of nests located on the study area. I will use the nearest neighbor feature in ArcMap to measure the distance between each point and the closest anthropogenic feature. The median random distance to each type of anthropogenic feature will be selected from each of the 1,000 data sets and these distances will be used to create distributions of distances from each type of feature to the nearest random point. We will compare the nearest distance from a nest location to a feature with the Monte Carlo distribution. A *P*-value will be calculated as the proportion of nearest random points that are at least as far away from the feature as the observed nest. We will conclude that hens avoid an anthropogenic features if $P \geq 0.80$.

Hypothesis III) Impacts on Fecundity Rates: ***Wind development will not reduce nest success or chick survival.***

Accomplishments Since Last Quarter

Efforts this quarter focused on 1) hiring and training 6 research technicians, 2) capturing and radio-marking female prairie-chickens at all sites, and 3) intensive monitoring of radio-marked prairie-chickens to locate nests and broods. Capture and handling of prairie-chickens occurred as described in our research proposal during 3 March – 6 May. Captured females were fitted with necklace-style radio-transmitters. Radio-marked hens were located by triangulation or homing ≥3 times/week from project trucks, an ATV, or on foot. When females localize in an area and their estimated location does not change for 3 successive days, we used portable radio receivers and handheld Yagi antennas to locate and flush the bird so that the eggs could be counted and nest location recorded with a GPS unit. Nest locations were marked with natural landmarks at a distance ≥25 m from the nest bowl to aid in relocation. If the nest was found during laying, nest sites were visited again in <2 weeks to assess clutch size and nest status. During this time eggs were removed and carried >200 m from the nest and floated in a small container of lukewarm water to assess stage of incubation, estimate hatch date, and estimate the date of clutch initiation by backdating. Nest sites were not visited again until it was determined that the female had departed (i.e., was located away from the nest for ≥2 consecutive days); due to successful hatching of the clutch or failure due to depredation, or abandonment. Thus, nest sites were disturbed by the presence of an observer only 1-2 times during the entire laying and incubation period, all nests were monitored by triangulation of the radio signal from a distances >30 m.

Once the female departed, we classified nest fate as successful (≥1 chick produced), failed, depredated, or abandoned. Nests were considered *failed* if the eggs were destroyed or abandoned. Nests were considered *abandoned* if eggs were cold and unattended for >5 days. Nests were considered *depredated* if the entire clutch disappeared before the expected date of hatching, or if eggshell and nest remains indicate that the eggs were destroyed by a predator. When a depredation occurred, the egg remains were evaluated and the area searched for predator signs in an attempt to determine the predator's identity. For successful nests, hatchability was calculated as the percentage of eggs that hatched and produced chicks

As of 25 June 2009, 68 nests have been located at Unit 3 (52 first nests, 16 renests, 1 third nest). Eighteen nests have successfully hatched; 43 have failed (39 depredated, 2 abandoned, and 2 destroyed by hay cutting equipment). Seven nests were active and information on final fate is not yet available. Apparent nest success for nests at Unit 3 that were due to hatch on or before 29 June was 29.5%. Apparent nest success was 17.6% and 44.4% for the impact and reference sites, respectively. Median nest initiation dates for first nests was 23 April. Hatch rate of eggs in successful nests was high at 83.8 ± 3.1% chicks per egg. Mean (±SE) clutch sizes for first and renests that were known to be complete were 12.9 ± 0.2 and 10.2 ± 0.7, respectively.

Goals For Next Quarter

Vegetation structure is currently being quantified at each nest site within 3 days of hatching or failure. We record visual obstruction readings (VOR) at the nest from a distance of 2 m and a height of 0.5 m using a Robel pole. We estimate non-overlapping vegetation cover (% grass, forbs, and shrub) at 12 subsampling locations within 6 m of the nest using a 20 x 50-cm Daubenmire frame. The heights and distances of the nearest grass, forb, and shrub are measured.

We will use the nest survival model in Program MARK to generate maximum likelihood estimates of daily nest survival. Multiple model selection and inference will be used to evaluate the importance of multiple sources of variation on daily nest survival prior to wind power development. Variables will include: nest age, nest attempt (first or renest), hen age, VOR (dm), COVER, and distances to anthropogenic features. In addition, the underlying morphological factors of nest hens will be determined by conducting a factor analysis on hen morphometric variables collected at capture, and the newly generated factor scores for these new underlying factors will be used as covariates in nest survival modeling. We will then calculate the overall nest survival probability by raising the daily nest survival estimate to an exponent equal to the mean incubation interval for prairie-chickens on the study site. The duration of laying and incubation periods will be determined from observations of successful nests discovered during laying, or from published values in the literature if necessary.

Brood Survival.— Chicks will be captured by hand within 3 days of hatch by homing in and flushing the brood hen. Captured chicks will be placed in a cloth sack, and held inside a researcher's jacket to maintain chick body temperature and carried to a field truck for processing. If captured, the hen will be placed in a separate cloth sack. The location of capture will be recorded with a GPS. Standard morphometrics will be collected from the chicks. This year, chicks will not individually marked with numbered metal patagial tags. Instead, DNA genotyping with microsatellite markers will be used to identify surviving chicks captured on leks next spring. Processed chicks will be placed in a second cloth sack. If a hen is captured with the brood, a soft-release will be attempted at the location of capture using a bisected release pen. If the hen is not captured with the brood, the chicks will be hard released together at the location of capture. The hen will be monitored via radiotelemetry to confirm that she returns to the brood.

Initial brood size will be considered the number of chicks that were known to hatch based on nest observations. Systematic flush counts will be used to estimate pre-fledge (0-14 days) and post-fledge (14-60 days) survival. Because broods will not be observed daily, we will use the nest survival model type in Program MARK to evaluate daily brood survival probabilities. Covariates will include hen age, a forb:grass cover index, VOR, and average home range distance to closest anthropogenic feature. Daily brood survival probabilities will be calculated using maximum likelihood estimates. The daily brood survival rate will be raised to the power of 14 to estimate the pre-fledge juvenile survival rate.

Broods will be considered *successful* if >1 chick survives until fledging. Fledging success will be calculated as the percentage of chicks that survive until fledging, among successful broods. Dipnets and spotlights will be used to capture >25 day old chicks by relocating radio-marked females at night. We will mark juveniles with numbered metal leg bands, record morphometrics and equip them with radio transmitters attached with glue or sutures. Survival rates of juvenile prairie-chickens from 30-days old to first breeding (post-brood survival; PBS) will be estimated using known-fate modeling in MARK 4.1. Models will be developed with design matrices and the logit link function, and selection will be based on minimization of Akaike's Information Criterion (AIC). AIC weights will be used to select the model best supported by the data. Post-brood survival will be estimated for individual cohorts if sample sizes are sufficient, but pooled across cohorts for small sample sizes.

Hypothesis IV) Impacts on Breeding Habitat: ***Placement of wind-towers and related structures does not impact the habitat use of breeding Greater Prairie-Chickens.***

Accomplishments Since Last Quarter

We conducted an extensive analysis to evaluate the relationship between leks and habitat characteristics at multiple spatial scales in areas without wind power development. The following manuscript describes this statistical analysis in detail:

Gregory, A. J., L. B. McNew, T. J. Prebyl, B. K. Sandercock, and S. M. Wisely. *In review*. A multi-scale hierarchical modeling approach to mapping lek habitats of Greater Prairie-chickens in eastern Kansas. Studies in Avian Biology.

Goals For Next Quarter

The lekking season occurs during March-June. Therefore no activity is scheduled for this task.

Hypothesis V) Impacts on Survival: ***Wind-power development does not increase mortality rates of Greater Prairie-Chickens.***

Accomplishments Since Last Quarter

We monitored Greater Prairie-Chickens remotely via radio-telemetry to assess survival at the three research units. During 1 January – 29 June, 2009, 68 female Greater Prairie-Chickens were monitored at Unit 3. Twelve mortalities were confirmed. Eleven mortality events were the result of predation; 7 and 4 by mammalian and avian predators, respectively. One mortality was capture related. No radio-marked females have died as a result of collisions with human structures. An additional nine females were censored from the study when their radio-transmitters were found with no sign of death.

In an effort to increase our understanding of the potential for wind power development to impact the survival of Greater Prairie-Chickens, we have initiated predator surveys across unit 3, Cloud County, Kansas. We established 200 scent track stations. Scent track stations were set at intervals of 200 m along 10 randomly chosen 1.6-km transects in both impact and reference areas of the unit 3 research site. Scent stations consisted of a 1-square meter plot of sifted sand baited with a fatty acid plaster disk (Wildlife Services Supply Depot, Pocatello, Idaho). Each station is checked daily for three consecutive days and number of visits by various potential Greater Prairie-Chicken predators is recorded as an index of relative predator density, both within the research unit and between impact and reference portions of the unit.

Goals For Next Quarter

A complete breeding season survival analysis will be conducted in the next quarter. We will model female survival using known-fate procedures in Program MARK (Cooch and White 2006). We will develop candidate models using the design matrix and logit link function, and model selection will be based on minimization of AIC_c, and AIC_c weights (w_i) to determine models best supported by the data. We will include hen age (yearling, adult), body condition at capture and study site as covariates in the survival analyses. Survival ($\hat{S}$) estimates will be calculated using the model averaging procedure if the difference in AIC_c values (ΔAIC_c) between competing models is < 2.

Predator surveys via scent stations commenced with the onset of Greater Prairie-chicken nesting season on 22 April, 2009, which was the day that the first nest was located. To date we have set 158 scent stations, 142 in Unit 3 and 16 in Unit 2. In Unit 3 two types of scent stations have been set, road surveys (110 stations), which survey randomly chosen 1-mile sections of roads and random points (32 stations, 16 on impact and 16 on reference areas). In Unit 2 only random points have been placed and only on reference areas. Thus far we have detected 221 total predators, 174 at Unit 3 and 47 at Unit 2. The modal predator in both sites thus far has been coyote. Scent stations will continue to be set until the end of the nesting and brood rearing season.

LABORATORY BASED HYPOTHESES

Hypothesis I) Affects on breeding behavior: ***There will be no change detected in the Ne/N.***

Current estimates of N_e and genetic diversity including data from the two additional markers for which molecular data analysis is complete are displayed in Table 4. Paternity analysis was conducted using the 11 microsatellites for which we have data collected for all adult and juvenile prairie-chicken samples. Using a combination of exclusionary and probability methods we were able to assign paternity to 274 of 363 (75%) of the chicks captured from 2006-2008. Of the 274 chicks that were assignable, only 214 (78% assignable, 59% of total), from 39 broods, were assignable with $\geq$ 95% confidence. In the quarterly report for quarter 1, 2009 we identified one possible reason for the low assignment success may have been because putative fathers were closely related and therefore shared a set of common alleles, which would make it difficult to definitively assign paternity of a chick to one male over another. In an attempt to further explore this possibility, analyses of pairwise relatedness between all putative fathers were conducted. Pairwise relatedness (± standard deviation) analysis between all males indicated that both across and within all three research units males were unrelated (across units $r = -0.005 \pm 0.149$, unit 1 $r = 0.003 \pm 0.138$, unit 2 $r = -0.002 \pm 0.144$, and unit 3 $r = -0.001 \pm 0.141$). Because the standard deviations are large (~0.14), which is the level of relatedness expected between half siblings or cousins, it is still possible that within research units, putative father relatedness may confound paternity assignments. However, inclusionary methods of paternity analysis will identify multiple males as a potential father for a given chick mother combination. As the male population as whole within each research unit is unrelated, we can be fairly certain that one of the identified males is most likely the true father of the chick in question. Using information on nesting chronology, location, and female movements since banding it may be possible to eliminate one or more of the putative fathers identified as a likely father and thereby increase the confidence in our paternity assignments.

Goals for Next Quarter

During the next quarter we hope to complete the extraction and amplification of all adult Greater Prairie-chicken samples collected in 2009. Data from these samples will then be incorporated into data from previous years to recalculate N_e for each research unit independently, across all three research units, and within years within each research unit. Calculating N_e within years will allow us to look for changes to the N_e of the prairie-chicken populations inhabiting our three research units. Changes in N_e may reflect changes in the underlying population demography, which may be occurring as a result of changes to the landscape. We will also conduct preliminary paternity analysis of all chick samples collected from 2006-2008, and begin extraction and PCR amplification of 2009 prairie-chicken, chick data.

Hypothesis II) Influence on Natal Dispersal: ***There will be no differences detected in the dispersal patterns of prairie chickens pre and post wind-power development.***

Accomplishments Since Last Quarter

We have completed the mapping of all anthropogenic structures associated with wind-power development and continue to document the location of all anthropogenic structures in Unit 3. Furthermore, all chicks captured in 2008 and 2009 have had a molecular sample taken and we have selected additional microsatellite primers to enhance our ability to unambiguously identify individuals captured at leks in subsequent years. This will enable us to identify individuals that were captured as chicks and successfully survived to recruitment and entered the potential breeding population.

Goals for Next Quarter

Continue to map anthropogenic structures across Unit 3. Complete PCR based analysis of all Unit 3 samples including the addition of all new markers.

Literature Cited:

Caizergues, A, S Dubois, A Loiseau, G Mondor, and J Rasplus. 2001. Isolation and characterization of microsatellite loci in black grouse (*Tetrao tetri*x). Molecular Ecology Notes 1:36-38.

Cheng HH, Levin I, Vallejo RL, Khatib H, Dodgson JB, Crittenden LB, Hillel J. 1995. Development of a genetic map of the chicken with markers of high utility. Poultry Science 74:1855-1874.

Piertney SB, Dallas JF. 1997. Isolation and characterization of hypervariable microsatellites in the red grouse (*Lagopus lagopus scoticus*). Molecular Ecology 6:93-95.

Piertney SB, Hoglund J. 2001. Polymorphic microsatellite DNA markers in black Grouse *(Tetrao tetrix*). Molecular Ecology Notes 1:303-304.

Taylor SE, Oyler-McCance SJ, Quinn TW. 2003. Isolation and characterization of microsatellite loci in greater sage-grouse (*Centrocercus urophasianus*). Molecular Ecology Notes 3:262-264.

Table 1. Microsatellite markers selected for use in population genetic analysis of Greater Prairie-chicken populations across Kansas.

Marker	NA	AR	HO	HWE	Species originally described from	Citation for microsatellite primer
ADL-146	7	5	0.57	0.051	A	Cheng et al. 1995
ADL-230	9	4	0.56	0.932	A	
ADL-123**					A	
ADL-142**					A	
ADL-144**					A	
BG-12	8	3	0.41	0.80	B	Peirtney and Hoglund 2001
BG-16	12	5	0.55	0.673	B	
BG-18	23	17	0.90	0.789	B	
BG-10**					B	
BG-14**					B	
BG-19**					B	
BG-20**					B	
LLSD-3	11	9	0.92	0.049	C	Piertney and Dallas 1997
LLSD-4	29	19	0.89	0.123	C	
LLSD-7	33	25	0.72	0.104	C	
LLST-1	8	5	0.73	0.229	C	
LLSD-2**					C	
SGCA-6	12	7	0.85	0.061	D	Taylor et al. 2003
SGCA-9	26	18	0.93	0.834	D	
SGTAT**					D	
SGCA-11**					D	
TTD-1**					B	Caizeguess et al. 2001
TTD-2**					B	
TTD-3**					B	
TTD-4**					B	
TTD-5**					B	
TTD-6**					B	

*indicates new primers recently added to the analysis. ** indicates primers recently added to the analysis for which no data currently exists. Species letter codes are as follows: A = Domestic Chicken (*Gallus gallus*), B = Black Grouse (*Tetrao tetrix*), C = Red Grouse (*Lagopus lagopus scoticus*), D = Sage Grouse (*Centrocercus urophasianus*).

Table 2. Mean (±SE) lek attendance (birds per day) by female and all Greater Prairie-Chickens at impact (I) and reference (R) areas at the Meridian Way study site, 2007-09.

Year		Females	All
2007	I	0.3 (0.1)	10.6 (1.0)
	R	0.1 (0.1)	8.8 (0.8)
2008	I	1.1 (0.1)	9.5 (0.6)
	R	1.2 (0.2)	14.5 (1.0)
2009	I	1.2 (0.2)	13.2 (0.6)
	R	1.6 (0.3)	12.5 (0.7)

Table 3. Numbers of individual greater prairie-chickens captured at impact and reference sites at the Meridian Way study site, 2006-09.

Year	Impact		Reference		Total
	F	M	F	M	
2006	0	0	0	0	0
2007	15	48	9	30	102
2008	24	40	31	46	141
2009	29	95	20	39	183
Total	68	183	60	115	426

Table 4. Population genetic parameters for adult Greater Prairie-chickens in Kansas based on analysis with 11 microsatellite markers.

Deme	N	H_O	H_E	AR	N_e ± 95% CI	F_{IS}	Observed Pairwise F_{ST}	Observed Pairwise D
Unit 1	138	0.69	0.77	7.0	150.6 ± 32.3	0.10		
Unit 2*	259	0.72	0.79	8.4	275 ± 90.3	0.11		
Unit 3*	394	0.72	0.79	7.9	192 ± 24.6	0.10		
Unit 1 – Unit 2							0.01	0.06
Unit 2 – Unit 3							0.01	0.04
Unit 1 – Unit 3							0.01	0.07
Flint Hills Population*	791	0.70	0.78	7.27	669.4 ± 114	0.10		

* indicates estimates that were derived using data from newly added primers. All other estimates were calculated using data from the original 11 microsatellites.

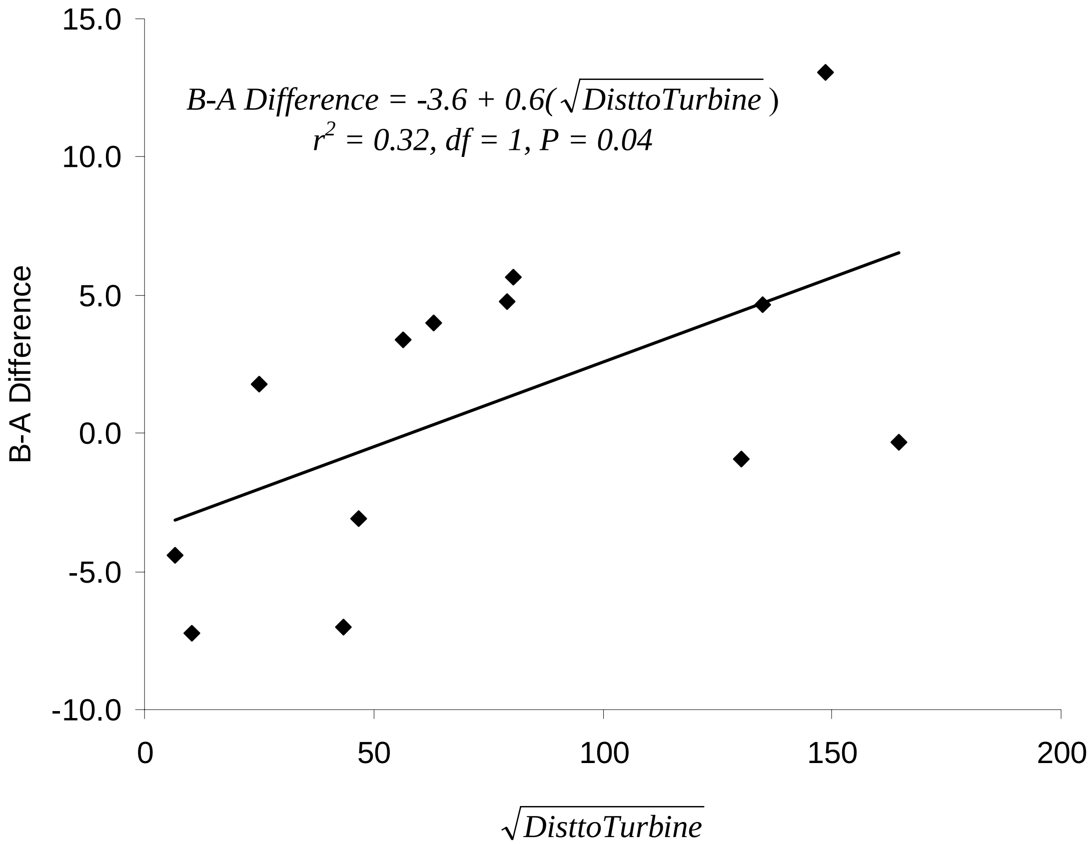

Figure 1. Relationship between the average difference between pre- and post-construction lek attendance and the square-root-transformed distance (m) between leks and the nearest wind turbine for 13 leks in Cloud and Ottawa Counties, Kansas.