

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

QUARTERLY REPORT

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Presented to:

**National Wind Coordinating Collaborative
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Quarterly Report
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EXECUTIVE SUMMARY

Field.— Field efforts focused on conducting lek attendance surveys, capturing and marking Greater Prairie-Chickens at the 3 research units, gathering location and nesting data on radio-marked hens, and conducting habitat surveys at nest locations and at random points across the study sites. Four hundred thirty-three (433) surveys were conducted at 49 leks during 25 February – 26 May. The mean (\pm SE) number of birds attending leks during this time period was 9.9 ± 0.3 and differed among the three research units. The mean number of prairie-chickens attending leks at the southern research unit (Unit 1) was significantly less than the northern units (Units 2 and 3). Trapping via walk-in traps and drop nets was conducted during 3 March - 16 May, resulting in the 310 captures of 255 prairie-chickens (152 males, 103 females). Radiotransmitters were fitted to 101 females. Including prairie-chickens fitted with radio-transmitters in 2007, 136 females were monitored. Median capture dates for males and females were 26 March (range = 4 March - 9 May) and 9 April (range = 3 March – 10 May), respectively.

We collected >3,100 locations on 136 radio-marked hens. As of 6 June, radio-marked hens have initiated 94 nests. Two additional nests of unmarked hens were found opportunistically. Average estimated date of first nest initiation was 23 April. Eleven (14.1%) of these nests were successful (hatched \geq 1 chick). The majority of failed nests were the result of depredation. Twelve hens were known to renest, and one hen initiated a third nest. Data collection is ongoing at the time of this report. Twenty-four radio-marked females have died since 1 January. Most (83.3%) mortalities were the result of predation.

Laboratory.— We have completed DNA extraction from all samples obtained during the 2008 trapping season (n =255). We have extracted DNA from 235

individuals, and PCR-based genotyping has been completed for 192 of the samples obtained in 2008. We also began conducting molecular sexing of chicks captured during the 2007 and 2008 trapping/nesting season.

Administration and Reporting.— During the Spring 2008 trapping season one of our field trucks (2001 Dodge Ram 1500; donated by KDWP) had a transmission failure. This truck was replaced by a vehicle from the Kansas Cooperative Fish and Wildlife Unit housed at Kansas State University.

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 all 3 study units. 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. To assess whether the presence of traps affected lek attendance, an analysis of variance (ANOVA) was used to compare the number of prairie-chickens observed between trapped and untrapped lek counts. An ANOVA was used to test whether the mean number of prairie-chickens on leks differed among research units and between reference and impact areas (pre-construction). A Tukey-Kramer HSD was used to compare lek counts between research units at the $\alpha = 0.05$ level.

We conducted 433 lek surveys at 49 leks during 25 February – 26 May. The mean (\pm SE) number of total prairie-chickens attending leks (lek size) during this time period was 9.9 ± 0.3 but differed among the three research units ($F_{2,429} = 36.7, P < 0.001$; Table 1). The number of male prairie-chickens attending leks at the southern research unit (Unit 1) was significantly lower than that at the two northern units; lek size did not differ between Units 2 and 3. Lek attendance was significantly less at Unit 1 when

compared to last year (Fig. 1). At Unit 3, where development is scheduled to occur, mean lek attendance was less at impact areas than at reference areas ($F_{2,173} = 14.4$, $P < 0.001$). The presence of traps on leks did not significantly affect lek attendance by prairie-chickens. In fact average lek attendance was greater on trapped leks (11.6 ± 0.4) than at untrapped leks (6.3 ± 0.5); most likely due to greater visibility of chickens when leks were trapped.

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 ≥ 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 ≥ 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 ≥ 14 days.

Trapping via walk-in traps and drop nets was conducted during 3 March - 16 May, resulting in 310 captures of 255 prairie-chickens (152 males, 103 females). Radiotransmitters were fitted to 101 females. Unit-specific capture statistics are reported in Table 2. During 1 January – 6 June, $>3,100$ locations of 136 radio-marked females were acquired by triangulation and by approaching radio-marked birds on foot, resulting in an average of 23 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

Breeding season space use by females will be evaluated on all study sites by incorporating the estimated locations into ArcMap 9.1. Home ranges of hens will be estimated for the breeding period by calculating 95% fixed-kernel utilization distribution for each radio-marked animal using the Animal Movements extension in ArcMap 9.1. In addition, we will begin documenting the locations of wind power structures (turbines, roads, transmission lines, and buildings) at Unit 3 with a handheld GPS unit.

Anthropogenic features and lek locations will be spatially mapped over geo-referenced ortho-quadrat digital photos on impact areas using ArcMap 9.0 (ESRI, Redlands, CA, USA). Direction (bearing from lek) and distance between a lek and the closest of each type of wind-related feature will be calculated.

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 8 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 – 16 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 luke-warm 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 11 June 2008, 96 nests have been located (83 first nests, 12 renests, 1 third nest). Eleven nests have successfully hatched; 72 have failed (62 depredated, 8 destroyed by hail, 1 abandoned, and 1 trampled by cattle). Thirteen nests were active and information on final fate is not yet available. Apparent nest success for nests that were due to hatch on or before 11 June was 14.1%, and was greatest at Unit 3. Median nest initiation dates for first nests was 23 April. Hatchability of eggs in successful nests is high at $85.8 \pm 8.6\%$ chicks per egg. Mean (\pm 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 will be quantified at each nest site within 3 days of hatching or failure. We will 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 will create 3 subsampling plots at 2-m intervals from the nest bowl in each cardinal direction for a total of 12 sub-sampling plots and estimate non-overlapping vegetation cover (% grass, forbs, and shrub) at each subsampling location using a 20 x 50-cm Daubenmire frame. We will measure the heights of the tallest grass and forb plant within 5 cm of the nest and the height of the nearest shrub within 100 m of the nest.

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 re-nest), 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

Radio-marked prairie-chickens were located ≥ 3 times/week from project trucks, an ATV, or on foot using portable radio receivers and handheld 3-element yagi antennas. Bird locations are estimated from ≥ 2 triangulation bearings using a maximum-likelihood estimator in program LOCATE III or flush locations were recorded with a GPS. Vegetation structure was quantified at each nest site within 3 days of hatching or failure. We recorded visual obstruction readings (VOR in dm) and non-overlapping vegetation cover (% grass, forbs, and shrub) at nests, paired random points within 200 m of the nest, and random points across the study sites as described above to assess pre-construction habitat availability at two spatial scales. We used analysis of variance (ANOVA) to compare mean VOR and log-transformed vegetation cover at nests, paired random points and random points.

During 1 January - 6 June, we collected >3,100 locations on radio-marked hens to assess breeding season home ranges. We recorded vegetation measurements at 61 prairie-chicken nests and their associated paired random points, as well as 109 random points across the study sites. Due to small sample sizes at the time of this report, samples were pooled across research units and sites for preliminary analyses. Our initial results indicate that females may be selecting for areas with greater VOR. Mean (\pm SE) VOR was significantly greater at nests (2.3 ± 0.1 dm) than at paired random points (1.3 ± 0.1 dm) and random points (0.8 ± 0.1 dm; $F_{2,226} = 36.4$, $P < 0.001$). Data collection was ongoing at the time of this report.

Goals For Next Quarter

A GPS will be used to map spatial locations of all anthropogenic features (roads, meteorological towers, power lines, wind towers, etc.) and habitat edges across the study areas. 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 nearest distance (m) to lek (both nearest and lek of capture), anthropogenic feature, and habitat edge will be calculated for each nest.

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 – 6 June, 2008, 136 female Greater Prairie-Chickens were monitored. Twenty-four mortalities were documented. Most mortality events (83.3%) were the result of predation; 14 and 6 by mammalian and avian predators, respectively. Two mortalities were due to collisions; 1 with a fence, 1 with a power line. One hen was killed by hail. The cause of death of another hen was unknown. More females died during the quarter at Unit 3 (14) than at the other two research units (3 and 7 for Units 1 and 2, respectively).

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 .

LABORATORY BASED HYPOTHESES

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

Accomplishments Since Last Quarter

We have collected blood or tissue samples from 286 prairie-chickens. In addition to samples collected on the 3 study units, we collected blood samples from 31 birds on Ft. Riley Military Reservation. Thus far DNA has been extracted from 235 blood samples, and PCR-based genotyping at all 11 microsatellite loci has been conducted on 198 individuals. Data quality control, re-PCR of all homozygotes and a randomly drawn

subset of heterozygotes, is currently underway. Prior to completion of genotyping and genetics data quality control measures it would be inappropriate to include these data in our estimates of genetic diversity and effective population size. Consequently these estimates remain unchanged since the 2007 annual report.

Goals for Next Quarter

PCR based genotyping and data quality control for all 2008 samples will be completed by fall. Estimates of genetic diversity and effective population size will be updated to include the 2008 samples. Temporal variation in allele frequencies between 2007 and 2008 will be quantified as measure of immigration to the Flint Hills. Landscape genetic analysis of the Flint Hills is ongoing as remotely sensed habitat data is incorporated into our model of population connectivity.

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

At the time of this report, we have extracted DNA from all chicks captured in 2008, and have begun PCR based genotyping and molecular based sexing. We estimated a low probability of two individuals sharing the same multi-locus genotype ($5 * 10^{-16}$); therefore, we will be able to uniquely identify all individuals in our population with high accuracy. One way in which this method will be useful is identifying survival to adulthood. We will be able to identify adults captured as chicks in prior years. This change, from patagial tagging of chicks to genetically fingerprinting all individuals, circumvents uncertainties in the data created by lost tags. Finally, we have collected and frozen >80% of all eggs found at depredated nest sites. No molecular data has been extracted from these samples at this time.

Goals for Next Quarter

We will complete molecular based sexing of all 2007 and 2008 chick samples to calculate a pre fledge sex ratio for Greater Prairie-Chickens. We will begin extraction of embryonic chicken DNA from depredated eggs collected in 2008.

Table 1. Mean (\pm SE) lek attendance (birds per day) by female, male and all Greater Prairie-Chickens in the Flint Hills of Kansas, 25 February - 26 May 2008.

Unit ¹	Females ²	Males	All
1	0.7 (0.1) ^a	6.0 (0.6) ^a	6.1 (0.5) ^a
2	1.3 (0.1) ^b	10.6 (0.5) ^b	11.9 (0.5) ^b
3	1.2 (0.1) ^b	10.8 (0.5) ^b	11.2 (0.5) ^b

¹ Unit refers to research unit: Unit 1 = Elk and Cowley counties, Unit 2 = Geary, Morris, Riley, Wabaunsee counties, Unit 3 = Clay, Cloud, and Ottawa counties

² Letters (a,b,c) indicate significant differences in means at the $\alpha = 0.05$ level

Table 2. Numbers of individual Greater Prairie-Chickens captured at impact and reference sites in the Flint Hills of Kansas, 3 March - 16 May 2008.

Unit*	Impact		Reference		Total
	F	M	F	M	
1	0	0	12	10	22
2	6	2	30	54	92
3	24	40	31	46	141
Total	30	42	73	110	255

* Unit refers to research units: Unit 1 = Elk and Cowley counties, Unit 2 = Geary, Morris, Riley, Wabaunsee counties, Unit 3 = Clay, Cloud, and Ottawa counties

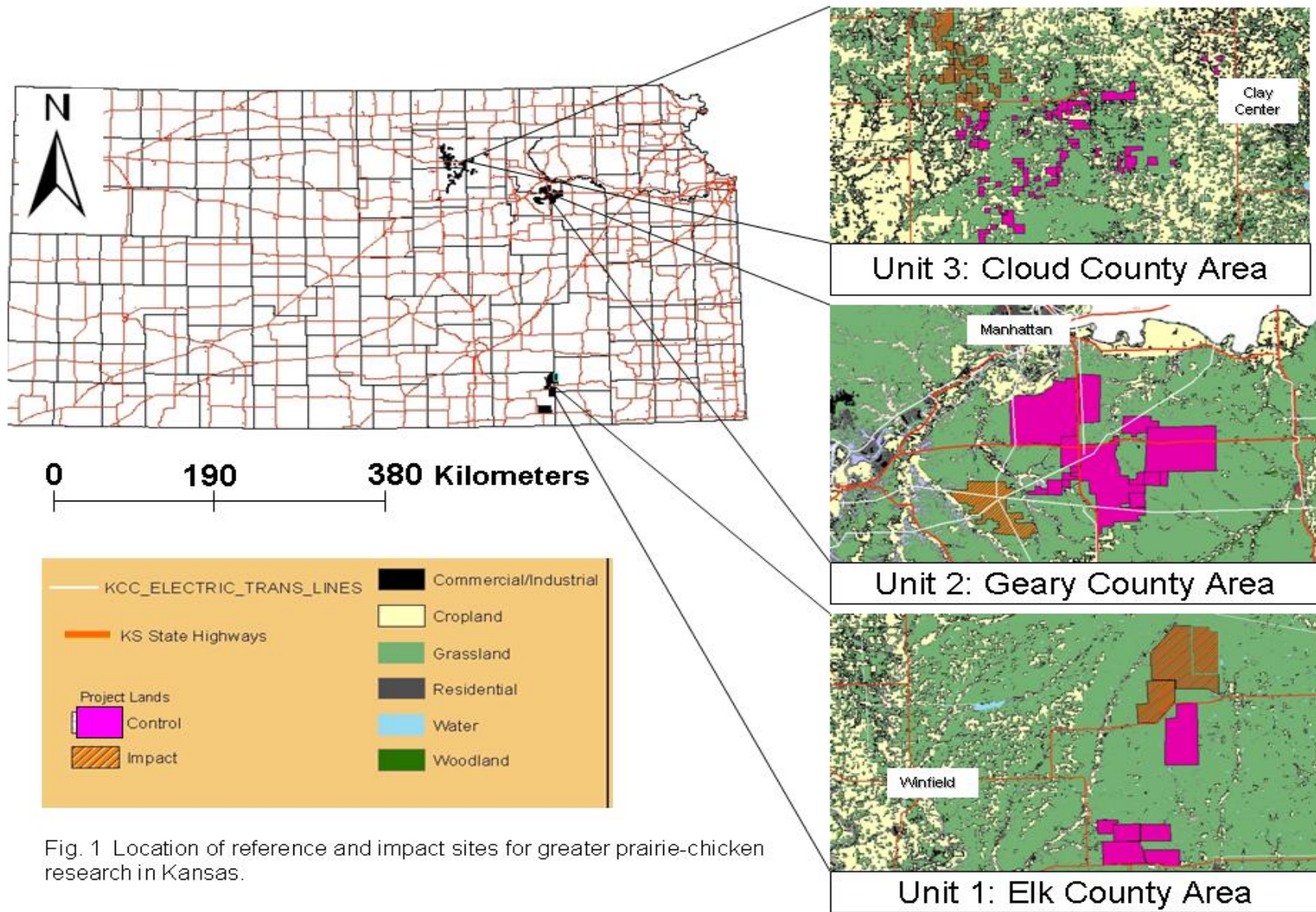


Fig. 1 Location of reference and impact sites for greater prairie-chicken research in Kansas.

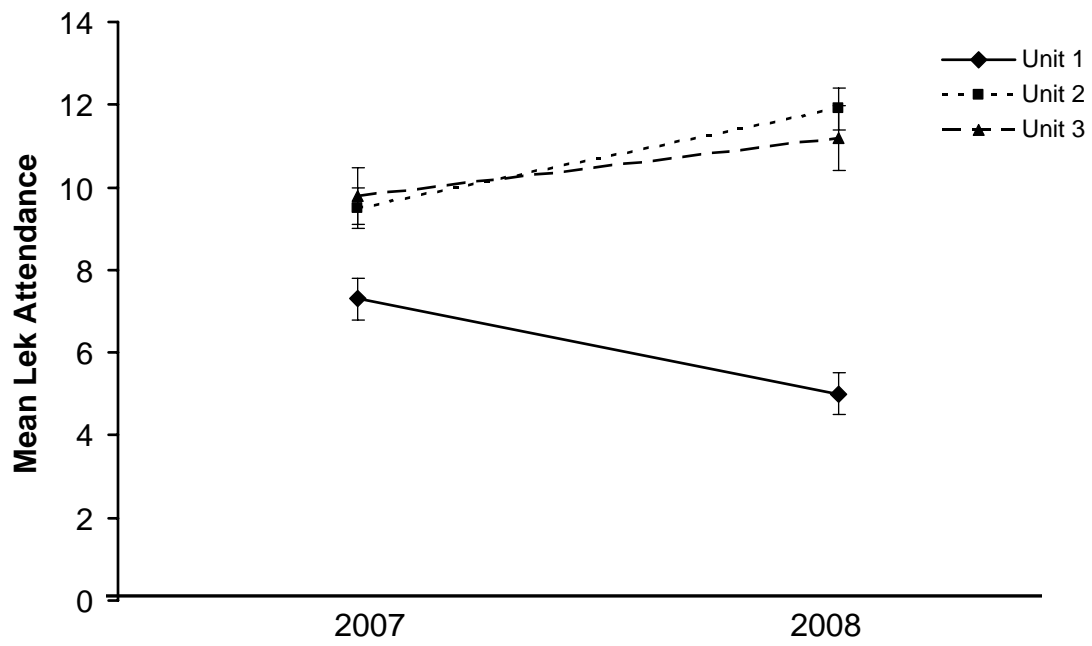


Figure 2. Mean lek attendance (birds per count \pm SE) of Greater Prairie-Chickens during 2007-08 at three research units in Kansas.