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

QUARTERLY REPORT

Submitted by:

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Presented to:

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NREL Technical Monitor: Karin Sinclair
NREL Subcontract Administrator:

Quarterly Report
Reporting Period: 2nd Quarter 2007
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EXECUTIVE SUMMARY

Field.— Nearly all of our efforts during this quarter were field-based and focused on conducting lek attendance surveys, capturing and marking greater prairie-chickens at the 3 research units (6 study sites), gathering location and nesting data on transmittered hens, and conducting habitat surveys at nest locations and at random points across the study sites. Two hundred and thirty-five lek surveys were conducted at 50 leks during 19 February – 11 May. The mean ($\pm$SE) number of birds attending leks during this time period was 8.6 $\pm$ 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 that at the northern units (Units 2 and 3). Trapping via walk-in traps and drop nets occurred during 3 March - 16 May, resulting in the 392 captures of 296 prairie-chickens (203 males, 93 females). Radiotransmitters were fitted to 91 females. Median capture dates for males and females was 4 April (range = 3 March - 16 May) and 10 April (range = 14 March – 16 May), respectively.

Radio-marked hens were known to have initiated 61 nests. Average estimated date of first nest initiation was 25 April. Only 3.5% of these nests were successful (hatched $\geq$1 chick). The majority of failed nests were the result of depredation. Eleven hens were known to renest. Data collection is ongoing at the time of this report.

Breeding season (87 day period, 10 March – 5 June) survival of radio-marked male and female greater prairie-chickens across all study areas was 0.733 (95% C.I. = 0.525 – 0.851%). Twenty of 94 radio-marked females have died during the breeding period as of 6 June. Most mortalities were the result of predation. However, the breeding season continues and data collection continues.

Laboratory.— Since November, efforts in this quarter have focused on optimizing amplification and visualization of all 10 microsatellite loci. With the addition of data from newly optimized microsatellite data, mean estimates for heterozygosity (H_Z) and allelic richness (A_R) remain unchanged since last quarter.

Administration and Reporting.—We received new funding from BP Wind Energy which was used to purchase VHF radio collars for prairie-chicken chicks. In addition, our grant proposal for matching funds was accepted by the National Fish and Wildlife Foundation. We hired and trained 14 seasonal research technicians to conduct our spring and summer field seasons.

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. Counts occurred at least 5 days apart to optimize independence of counts. Birds were flushed from untrapped leks between 0600 and 0930. 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 located 50 active leks during the quarter, and 235 lek surveys were conducted at these leks during 19 February – 11 May. The mean ($\pm$SE) number of total prairie-chickens attending leks (lek size) during this time period was 8.6 ± 0.3 but differed among the three research units ($F_{2,212}$ = 7.7, 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. There was no difference in mean lek size between reference and impact areas ($F_{2,143}$ = 0.55, P = 0.46). However, there was an interaction effect between research unit and study site (reference or impact; $F_{2,143}$ = 4.1, P = 0.02). When only females were considered, lek attendance differed among all 3 research units ($F_{2,143}$ = 10.7, P < 0.001, Table 1) with the highest rates of female attendance at lek sites in Unit 2. The presence of traps on leks did not significantly affect lek attendance by prairie-chickens ($F_{1,210}$ = 0.7, P = 0.40); average lek attendance was 8.4 $\pm$ 0.5 and 8.9 $\pm$ 0.4 prairie chickens per lek count on untrapped and trapped leks, respectively.

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

Trapping via walk-in traps and drop nets was conducted during 3 March - 16 May, resulting in 392 captures of 296 prairie-chickens (203 males, 93 females). Radiotransmitters were fitted to 91 females. Unit-specific capture statistics are reported in Table 2.

Wind power facilities have not yet been constructed at impact areas at this time. Effort this quarter was focused on capturing and radio-marking females at all sites and monitoring females to quantify pre-construction habitat selection and space use. 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 are estimated from $\geq$2 triangulation bearings (Millspaugh and Marzluff 2001) using a maximum-likelihood estimator in program LOCATE III (Nams 2006) or flush locations were recorded with a GPS. Aerial searches are conducted using fixed-wing aircraft when birds are unable to be located from the ground for ≥14 days.

As of 6 June, 1,417 locations of radio-marked females have been acquired by triangulation and by approaching radio-marked birds on foot, resulting in an average of 21 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 (Seaman et al. 1999).

Goals For Next Quarter

Pre-construction 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 (UD; Worton 1989) 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) and non-wind-related human structures 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 14 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 (Westerskov 1950). 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 brood hatch, 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 *abandoned* if eggs were cold and unattended for >5 days. Nests were considered *failed* if the eggs were destroyed by flooding, trampling by livestock or by construction equipment. 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 (Sargeant et al. 1998). For successful nests, hatchability was calculated as the percentage of eggs that hatched and produced chicks

As of 6 June 2007, 61 nests have been located (50 first nests, 11 renests). Of first nests, only 1 nest has successfully hatched, 28 failed (23 depredated, 3 abandoned, and 2 trampled by cattle), and 31 were active and information on final fate is not yet available. Mammalian predators were the cause of 21 of 23 (91%) first nest depredations. Snakes were suspected in two depredation events. Eleven renesting attempts have been documented. Two renests have been depredated; the remaining nine nests are still active. Apparent nest success for nests that were due to hatch on or before 5 June was 3.5%. No radio-marked females have initiated a third nesting attempt. Median nest initiation dates for first nests was 25 April. Hatchability of eggs in successful nests is high at 91.7 $\pm$ 8.3% chicks per egg. Mean ($\pm$SE) clutch size for first nests that were known to be complete was 13.1 $\pm$ 0.2 and did not differ among the three research units ($F_{2,33}$ = 1.5, P = 0.23).

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 (Robel et al. 1970). 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 (1959) 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 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. Chicks will be individually marked with numbered Monel metal tags clipped onto the patagium of the leading edge of the wing. 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 (Hubbard et al. 1999). Because broods will not be observed daily, we will use the nest survival model type in Program MARK to evaluate daily brood survival probabilities (Dinsmore et al. 2002, Fields et al. 2006). 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 (Dinsmore et al. 2002). 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 (Cooch and White 2006). 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. Results of this analysis will be presented at the 27th Meeting of the Prairie Grouse Technical Council in Chamberlain, South Dakota on 8 October 2007.

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 $\geq$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 $\geq$2 triangulation bearings (Millspaugh and Marzluff 2001) using a maximum-likelihood estimator in program LOCATE III (Nams 2006) 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.

We recorded vegetation measurements at 44 prairie-chicken nests and their associated paired random points, as well as 53 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 and grass coverage. Mean ($\pm$SE) VOR was significantly greater at nests (3.7 $\pm$ 0.3 dm) than at paired random points (2.5 $\pm$ 0.5 dm) and random points (2.6 $\pm$ 0.4 dm; $F_{2,113} = 8.0$, $P < 0.001$). Mean ($\pm$SE) grass coverage at nest sites was significantly greater (60.8 $\pm$ 3.1%) than at paired random points (52.4 + 3.3%; $F_{2,120} = 3.3$, $P = 0.04$). Forb coverage averaged 15.7 $\pm$ 1.1% did not differ among nests, paired random points, and random points ($F_{2,113} = 2.1$, $P > 0.06$). Data collection was ongoing at the time of this report.

Goals For Next Quarter

A GPS will be used to obtain the spatial location 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.

We will develop logistic regression models to determine if prairie-chicken nest locations can be predicted from vegetative characteristics (i.e., VOR, %forb cover, % grass cover), distance to edge or anthropogenic features, or distance to lek of breeding or nearest lek. 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 (Burnham and Anderson 1998). Selection will be based on minimization of AIC_c, and AIC_c weights (w_i's) to determine models best supported by the data.

Hypothesis V) Impacts on Survival: *Wind-power development does not increase mortality rates of greater prairie-chickens.*

Accomplishments Since Last Quarter

We calculated survival and cause-specific mortality rates for samples pooled across age-classes and study sites using methods of Trent and Rongstad (1974) in the program MICROMORT (Heisey and Fuller 1985) to get an average estimate of greater-prairie-chicken breeding-season survival in the Flint Hills prior to wind power development. This technique assumes that daily survival probability is independent among animals and is constant over time (Pollock et al. 1989).

Ninety-four greater prairie-chickens (91 females, 3 males) were monitored for 1,417 radio days during 3 March – 6 June. Twenty mortalities were documented. Most mortality events (90%) were the result of predation; 16 and 2 by mammalian and avian predators, respectively. The cause of two suspected mortalities was unknown. In these cases, the bird's radio-necklace was found in or near a pile of prairie-chicken feathers but no carcass was recovered. Therefore pooled survival of radio-marked male and female greater prairie-chickens across all study areas was 0.733 (95% C.I. = 0.525 – 0.851%) for the 87 day breeding season (10 March – 5 June).

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 (Burnham and Anderson 1998). Results of this analysis will be presented at the 27th Meeting of the Prairie Grouse Technical Council in Chamberlain, South Dakota on 8 October 2007.

LABORATORY BASED HYPOTHESES

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

Accomplishments Since Last Quarter

We are in the process of increasing the number of loci used for molecular analysis to fourteen. By increasing the number of loci used we hope to increase the statistical rigor of our analysis. Since last quarter we have increased the number of microsatellites used from five to eight. We are also in the process of optimizing six additional markers for use with greater prairie-chicken DNA.

In the past quarter, we have obtained genetic samples for 277 new individuals, bringing our total number of unique individuals included in our genotypic analysis of greater prairie-chickens up to 356 individuals. Blood samples were collected into two types of storage media: Queens lysis buffer and Longmire's solution. Laboratory analyses of the 277 samples collected in 2007 have been started. DNA extractions from all samples have been successfully completed, and DNA has been placed in storage buffer at -20 C^{o} until genotyping via amplification with PCR can be conducted.

Goals for Next Quarter

Obtain genotypic data at 10 microsatellite loci for all individuals sampled from 2006-2007. Conduct preliminary analysis of observed heterozygosities, allelic richness, number of migrants, and N_e. Calculate preliminary measures of gene-flow (F_{ST} and Relatedness) among the three different research units and within each research unit. We will compare DNA yield from the two storage media (Queens lysis buffer and Longmire's solution) and determine which media is best for the goals of our molecular analysis.

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

Major accomplishments during this quarter were the extraction and PCR amplification of greater-prairie-chicken chick DNA collected during the 2006 field season. Chicks collected in 2006 have been typed at 6 loci. Greater prairie-chicken chicks had an observed heterozygosity of 0.61±0.22 and an observed allelic richness of 5.55.

Goals for Next Quarter

Objectives for the upcoming quarter include completing microsatellite fragment analysis, of 14 loci, of greater prairie-chicken chick DNA obtained during the 2006-2007 field seasons. Molecular data from greater prairie-chicken chicks will be used to assess brood parentage, and individual male reproductive success.

Table 1. Mean (SE) lek attendance (birds per day) by female, male and all greater prairie-chickens in the Flint Hills of Kansas, 19 February - 11 May 2007.

Unit[1]	Females[2]	Males	All
1	0.9 (0.2)[a]	5.7 (0.4)[a]	7.3 (0.5)[a]
2	1.5 (0.2)[b]	8.2 (0.5)[b]	9.5 (0.6)[b]
3	0.2 (0.2)[c]	8.9 (0.6)[b]	9.8 (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 α = 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 2007.

	Impact		Reference		Total
Unit*	F	M	F	M	
1	11	18	16	36	81
2	17	19	25	52	113
3	15	48	9	30	102
Total	43	85	50	118	296

* 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

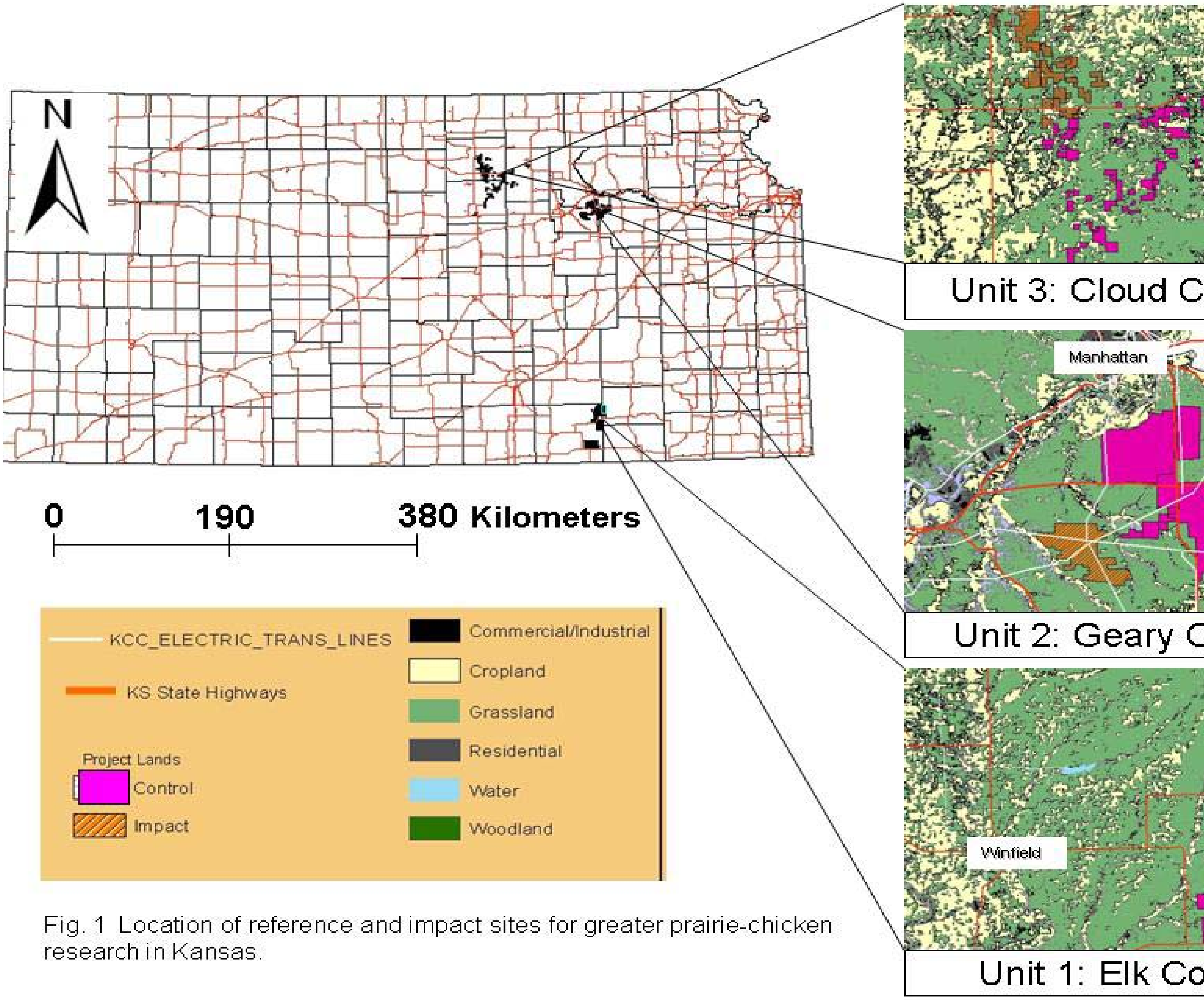

Fig. 1 Location of reference and impact sites for greater prairie-chicken research in Kansas.