EXPECTED IMPACTS ON GREATER PRAIRIE-CHICKENS OF ESTABLISHING A WIND TURBINE FACILITY NEAR ROSALIA, KANSAS

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There are 10 species of grouse native to North America. Prairie chickens are grouse and they generally are considered birds of the grasslands. Prairie chickens consist of two taxonomic species, the lesser prairie-chicken (*Tympanuchus pallidicinctus*) and the greater prairie-chicken (*Tympanuchus cupido*) (American Ornithologists' Union 1998).

The lesser prairie-chicken has the most restricted distribution of the two grassland grouse species (Aldrich 1963, Johnsgard 1983). It is found in rangeland dominated primarily by sand sagebrush (*Artemisia filifolia*) or shinnery oak (*Quercus havardii*) and bluestem grasses (*Andropogan* spp.) in eastern New Mexico, southeastern Colorado, western Oklahoma, the Texas panhandle, and southwestern Kansas. Even though this area of the Southern Great Plains is populated sparsely by humans, their activities have had a severe impact on lesser prairie-chicken populations. Intensive livestock grazing and conversion of native rangelands to cropland coupled with recurrent droughts have reduced lesser prairie-chicken habitat by 92% and populations by approximately 97% range-wide since the 1800s (Crawford 1980). Lesser prairie-chicken populations are now fragmented and isolated over much of their original range (Geisen 1998), and the species was petitioned in 1995 for listing under provisions of the Endangered Species Act (Mote et al. 1999). The U.S. Fish and Wildlife Service determined that listing the species as threatened was warranted, but precluded (Clark 1999). The primary range of the lesser prairie-chicken in Kansas is the southwestern part of the state, far removed from the proposed site of the wind farm near Rosalia, Kansas.

Three subspecies of the greater prairie-chicken are recognized (Aldrich 1963, Johnsgard

1983). The heath hen (*Tympanuchus cupido cupido*), formerly found along the east coast of the United States, became extinct in 1932. The Attwater's prairie-chicken (*T. c. attwateri*) is endangered (U.S. Fish and Wildlife Service 1983) and restricted to isolated areas along the Texas coast. The wild population of Attwater's prairie-chicken now numbers less than 100 birds (Morrow 1999), and efforts are being made to maintain the population through releases of captivity-reared birds. The greater prairie-chicken (*T. c. pinnatus*) had, and still has, a wider distribution than either the heath hen or the Attwater's prairie-chicken. Historically, the greater prairie-chicken ranged across the tallgrass prairies of North America from eastern Texas north westward to Alberta and north eastward to Michigan and southern Ontario (Figure 1). It has been extirpated or very much reduced in numbers over much of its range, and was numerous enough in only four states (Kansas, Colorado, Nebraska, and South Dakota) to be hunted legally during 2001.

Conversion of the tallgrass prairie habitat to intensive agriculture is the primary cause of declines in the greater prairie-chicken population across its original range (Schroeder and Robb 1993). This conversion over much of the midwestern portion of North America greatly reduced or degraded the nesting habitat of greater prairie-chickens and negatively impacted their populations (Christisen 1969, 1985). Predator populations also reduce nesting success of greater prairie-chicken (Lawrence 1982). Other factors reported to negatively affect the numbers of greater prairie-chickens include hunting isolated populations (Hamerstrom and Hamerstrom 1973); reduced insect availability for broods because of pesticide use (Flickinger and Swineford 1983); and interspecific competition with ring-necked pheasants (*Phasianus colchicus)* (Vance and Westemeier 1979, Westemeier 1986, Westemeier et al. 1998).

Greater prairie-chicken population trends in North America

Few estimates exist for greater prairie-chicken population numbers in North America prior to the 1960s. However, the numbers of these birds were sufficient to support subsistence and market hunting in several of the Great Plains states in the late 1800s and early 1900s (Hier 1999). Most state wildlife agencies began to monitor greater prairie-chicken populations by the mid 1960s. Generally this monitoring consists of counting males displaying on breeding grounds (leks) in the spring, adjusting the survey numbers to account for the female portion of the population, and extrapolating those numbers across the known habitat of the greater prairie-chicken. The validity of such a practice is questionable (Applegate 2000) and the accuracy of the estimates is dubious at best. Even so, those data, if collected in a consistent manner each year, probably reflect trends in greater prairie-chicken populations over time. Svedarsky et al. (2000) summarized the recent population estimates of state wildlife agencies across the range of the greater prairie-chicken and reported the following for states which permitted hunting those birds and for states in which hunting did not occur.

Year	Estimated numbers of greater prairie-chickens	
	Hunting permitted (4 states)	Hunting not permitted (7 states)
1968	760,000	18,860
1979	1,200,000	17,672
1985	740,000*	16,054
1989	742,000*	14,268*
1997	371,484	14,758

* incomplete data set

The above estimates disclose a 60 to 70% decline in the greater prairie-chicken population of North America between 1968-79 and the late 1990s. This population decline has raised concerns over the future viability of greater prairie-chicken populations in the Great Plains states.

Greater prairie-chicken population trends in Kansas

The most recent review of the status of the greater prairie-chicken in Kansas was conducted in the late 1990s (Applegate and Horak 1999). That review documented the early legislative actions that established prairie chicken hunting seasons in Kansas. Those hunting regulations probably reflected prairie chicken populations, i.e., being liberal when birds were abundant and restrictive when populations were low. Generally in the 1860s, the hunting seasons were long, state-wide, and had few restrictions. Farming activities of the early settlers in the 1870s benefitted prairie chicken populations to the point that the hunting seasons were very liberal, essentially prairie chickens could be killed by anyone, anyplace, by any means, any time of the year. The combination of an increased food source provided by small-grain agriculture and expansive tallgrass prairie habitat resulted in an abundance of greater prairie-chickens in the late 1800s. As agricultural activity expanded at the expense of the tallgrass prairie habitat, prairie chicken populations declined.

The decrease in prairie chicken numbers was reflected by the closing of prairie chicken hunting seasons and reductions of daily bag limits in the early 1900s (Wood 1964). In 1905, Butler County closed the prairie chicken hunting season for 3 years. The prairie chicken hunting season was closed in all of Kansas from 1913 through 1916. Between the 1920s and 1957, there was a mix of closed and open prairie chicken hunting seasons, variable bag limits, season

lengths, and legal shooting hours. These changes coincided with the establishment of the Kansas Forestry, Fish and Game Commission in 1921 (now Kansas Department of Wildlife and Parks), severe drought conditions of the 1930s and 1950s, changes in agricultural activity and overgrazing by livestock, and natural fluctuations of prairie chicken numbers (Applegate and Horak 1999). Since 1957, Kansas has permitted the hunting of greater prairie-chickens each year. From 1957 to the early 1970s, the hunting seasons were 2 to 11 days in length whereas in the 1970s and early 1980s they generally ranged from 30 to 90 days. In 1989, an "early season" was established which added 31 days to the 86- to 91-day hunting season from 1989 through 2001. The daily bag limit for greater prairie-chickens has remained at 2 since 1957.

Kansas began monitoring greater prairie-chicken populations in 1963. The annual surveys consist of lek counts of greater prairie-chickens during March and April. From these data, indices to greater prairie-chicken populations are generated for four physiographic regions in Kansas, and pooled for a state-wide index. A Rural Mail Carrier Survey of greater prairie-chickens is also conducted four times per year, but is considered less reliable than the survey of displaying males on booming grounds or leks.

The lek survey index is based on the number of birds counted on leks along 10-mile long routes (commonly a county road) in typical greater prairie-chicken habitat. It is assumed that all leks within one mile on both sides of the road can be detected during the survey, and the number of birds on those leks represents all of the males in the 20 square mile survey area. The count data are converted to birds per square mile and used as the index to the greater prairie-chicken population for each route. The lek surveys of greater prairie-chickens began with 11 routes in 1963 but now consists of 28 routes. Generally no more than one survey route is located in any single county.

Over the years, the stronghold of the North American greater prairie-chicken population has been the tallgrass prairies of Kansas, primarily the Flint Hills region of eastern Kansas (Applegate and Horak 1999, Svedarsky et al. 2000). The lek surveys conducted in Kansas since the early 1960s reflect a state-wide decline in the greater prairie-chicken population. The average multi-year state-wide greater prairie-chicken population index fluctuated between 7.6 and 8.2 birds per square mile between 1963 and 1989, but decreased to 5.5 for the 1990-99 period, and was 4.8 for 2000-02. The index to greater prairie-chicken populations in the Flint Hills region of Kansas has fluctuated over the years, but has not reflected as great a decline as the state-wide index. Below is a summary of the 1963-2002 state-wide and Flint Hills region indices to greater prairie-chicken populations obtained from various Kansas Department of Wildlife and Parks reports. The figures represent annual averages, but each is not necessarily based on data from the same number of routes each year.

Time period	Lek survey index (birds per square mile)	
	State-wide data	Flint Hills region
1963-69	8.0	9.1
1970-79	7.6	7.4
1980-89	8.2	10.5
1990-99	5.5	7.4
2000-02	4.8	6.7

Even though the above indices are widely accepted as reflecting long-term trends in greater prairie-chicken populations (Applegate 2000), no controlled research has been conducted to determine if they accurately reflect the number of birds present along the survey routes, and

more importantly, in the region or the state as a whole. The lek surveys from which the trend indices are developed are conducted in March and April, therefore represent indices to the spring greater prairie-chicken population.

Greater prairie-chicken population trends in Butler County

For survey purposes, the greater prairie-chicken range in Kansas is divided into four physiographic regions (Figure 2). The Flint Hills region extends from Riley County on the north, southward through the Flint Hills to the Oklahoma border. The Flint Hills region includes Butler County plus eight other counties, and is bordered on the east by the Eastern Cropland region, on the southeast by the Blackjack region, and on the west by the Western Cropland region. Since 1980, with few exceptions, the lek survey indices of greater prairie-chicken populations have been higher in the Flint Hills region than in the other survey regions in Kansas. The Butler County lek survey route is located approximately 20 miles northwest of Rosalia, adjacent to Chase County. Lek surveys have been conducted on the Butler County route since 1963 and the greater prairie-chicken population indices determined from that route have been the highest or second highest of the indices each year in the Flint Hills region since the survey's inception (Kansas Department of Wildlife and Parks, unpubl. reports). Below is a comparison between the greater prairie-chicken population indices for Butler County and those for all of the Flint Hills region over the last 22 years.

Time period	Lek survey index (birds per square mile)	
	Flint Hills region	Butler County
1980-84	11.0	19.1
1985-89	9.9	14.2
1990-94	8.4	14.5
1995-99	6.0	11.6
2000-02	6.7	15.2

If the lek count survey indices reflect gross population numbers, the preceding data indicate that the area along the Butler County lek survey route has a greater prairie-chicken population exceeded by few other locations in the Flint Hills region.

Factors associated with greater prairie-chicken population trends

Greater prairie-chickens are birds of the open grassland prairies and are intolerant of human intrusions into their environment. The conversion of grasslands to intensive row crop agriculture has had the most detrimental impact on greater prairie-chicken populations across their historical range (Schroeder and Robb 1993, Svedarsky et al. 2000).

When row crop agriculture began in Kansas, it had a positive influence on greater prairie-chicken populations because the small grains supplemented the natural food sources of the birds, especially during sever winter months (Applegate and Horak 1999). The long-term decline in the greater prairie-chicken population of Kansas began in the late 1800s and was coincidental with more grassland being converted to intensive agriculture. The loss of grassland habitat plus the drought years of the 1930s and 1950s drastically reduced the numbers and range of the

greater prairie-chicken in Kansas. Since the 1950s, the loss of grasslands slowed in Kansas and the greater prairie-chicken gradually increased its range and numbers (Applegate and Horak 1999). The soils of the Flint Hills of Kansas are shallow and underlain by layers of limestone. Thus, the tallgrass prairies of the Flint Hills were not readily converted to row crop agriculture and became the stronghold of the greater prairie-chicken population in Kansas.

During the 1960s and 1970s, the population of greater prairie-chickens in Kansas fluctuated with annual changes in weather conditions, primarily weather conditions during the nesting and brood-rearing seasons. The Kansas indices to greater prairie-chicken populations reflected relatively stable populations through the 1980s, but since have indicated a declining population. The trend is quite obvious for the state-wide index, but appears in the index to the greater prairie-chicken population in the Flint Hills region as well. There has not been an obvious increase in conversion of grassland to row crop agriculture in eastern Kansas during the 1990s (Cartwright 2000). If the lek survey indices truly reflect greater prairie-chicken population trends, the cause for the declining population since the 1980s must be associated with something besides loss of native grassland to agricultural activity. Several Kansas Department of Wildlife and Parks' biologists (Rodgers, personal comm., Applegate and Horak 1999) have speculated that changes in the management of the grasslands by livestock producers have been implicated in the decline of the greater prairie-chicken population in Kansas.

Grasslands in Kansas commonly are grazed by livestock and therefore the grasslands generally are referred to as rangelands by their owners. The management of rangelands in eastern Kansas is accomplished primarily by a combination of grazing and burning, with some brush control done with chemical applications. Range management is a complex discipline combining science with common sense. A successful range manager must interact continuously

with a constantly changing rangeland ecosystem, while responding to current and future economic constraints and opportunities (Robel 2001).

Range managers strive to manipulate rangeland vegetation in such a way that it maximizes the sustained yield of grazing animals. Because domestic animals generally are the grazers with the highest economic value, range managers concentrate on maximizing the production of cattle, sheep, goats, and other commercial livestock. Wildlife populations on most managed rangelands, including greater prairie-chickens of Kansas, are incidental byproducts of livestock management.

Extensive research has been conducted by range scientists to determine the "proper utilization" of most rangeland forage species. Proper utilization is the maximum point of defoliation that continues to maintain desirable range productivity (Heady and Child 1994). Proper utilization of most rangeland vegetation results in average stubble grass heights ranging from 1 to 4 inches (for *Buchloe dactyloide* and *Agropyron smithii*, respectively). Heavy stocking rates reduce the average stubble height and light stocking rates result in taller stubble heights. Generally, these stubble heights are shorter than optimal for greater prairie-chickens.

Vegetation heights of good nesting habitat for greater prairie-chickens range from 8 to 11 inches in Kansas (Horak 1985) and 10 to 28 inches in Oklahoma (Jones 1963). Similar heights of vegetation cover are needed for good brood range, day and night roosting, and winter cover.

Many progressive ranchers in Kansas attempt to graze their rangelands at "proper utilization" levels which often results in standing vegetation shorter than is optimal for greater prairie-chicken nest success and brood survival. Different livestock grazing systems (intensive-early, season-long, late-season, plus others) produce vegetative stands of different plant composition and structure. Increases in the proportions of ranchers adopting proper utilization

stocking rates and shifting from season-long to intensive-early grazing systems appear to be associated with declines of greater prairie-chickens in the Flint Hills of Kansas. However, no research has been conducted to determine if a cause-effect relationship exists between stocking rates and grazing systems and the population trends of the greater prairie-chicken in Kansas.

In eastern Kansas, periodic fire is necessary to maintain tallgrass prairie (Hulbert 1988). Without fire, these grasslands are invaded by woody species (Owensby 1994). Prescribed burns in the spring every 3 to 5 years following 2 or 3 years of successive burning are sufficient to control the invasion by woody species. These burns also increase the nutrient quality of rangeland vegetation for livestock (Owensby 1994), thereby elevating livestock gain rates by 10 to 15%. This increased livestock production has encouraged annual burning of the Flint Hills, and more frequent burning has detrimental impacts on nesting by grassland birds (Robel et al. 1998). Costs of burning decreases with increasing size (at least up to 1250 acres), therefore burning large tracts of land has become a common range management strategy in the Flint Hills. The increased frequency and expanse of spring burning of rangelands in eastern Kansas are thought to be involved in declines of greater prairie-chicken populations in Kansas (Rodgers, personal comm., Applegate and Horak 1999). Again, however, no large-scale controlled research has been conducted to determine if a cause-effect relationship exists between burning frequency and expanse on the declines of greater prairie-chicken populations in the Flint Hills of Kansas.

Although herbicides are sometimes used to reduce woody species, poisonous plants, cropland weeds, and herbaceous plants competing with grasses in the grasslands of Kansas, their use is very limited. Other management methods (e.g., grazing and burning) are better suited than herbicides for modifying vegetation composition and structure of tallgrass prairie habitats. There

are no research data showing a relationship between herbicide use and greater prairie-chicken population trends in Kansas.

In summary, there are no research data associating any specific factor with the decline of greater prairie-chicken populations in Kansas. Speculation and circumstantial evidence points to changes in grazing systems and frequency of rangeland burning as possible causes of the recent declines, but no large-scale research has been done to document such. Other possible explanations include changes in predator populations, increased human activities, encroachment of woody vegetation into the grasslands, climatic changes, and hunting pressure. Although each possibility is intriguing, there are few experimental data to relate these latter possible explanations to the state-wide decline of the lesser prairie-chicken in Kansas.

Landscape and land use changes in Butler County

Cartwright (2000) conducted a survey of landscape and land use changes along lek survey routes in seven counties of Kansas, and examined the relationship of those changes with trends in greater prairie-chicken lek survey indices for the 1960s to 1999 period. The bulk of this section relies on the Cartwright (2000) data for Butler County.

Landscape changes

Low altitude aerial photographs and color transparencies of selected years were examined in the Butler County USDA Service Center to determine landscape type coverage and changes thereof. Areas of coverage were calculated using a digital planimeter. The primary landscape cover classes were rangeland, cropland, trees, and shrubs. Other cover categories included roads, surface water, residential, oil production, and other minor cover types; none of which exceeded

0.5% of the lek survey area. Below are listed the proportions of the four major landscape cover types along the Butler County lek survey route for selected years.

Proportion of the 20-square mile lek survey route area

Year	Rangeland	Cropland	Tree cover	Shrub cover
1970	.815	.158	.002	.006
1980	.806	.158	.006	.007
1986	.797	.159	.007	.008
1992	.766	.177	.008	.008
1996	.732	.216	.008	.014

Along the Butler County lek survey route between 1970 and 1996, the amount of rangeland decreased whereas the land devoted to crop production and covered by trees and shrubs increased. The landscape cover type proportions along the lek survey route in Butler County were very similar to the county-wide landscape cover proportions detected by the USDA-NRCS Kansas Broad Cover/Use surveys (Cartwright 2000).

Cartwright (2000) determined that state-wide the amount of rangeland was positively correlated with lek survey indices whereas the amount of cropland, tree cover, and shrub cover was negatively correlated with lek survey indices. Cartwright (2000) also determined that the amount of land occupied by homes in the lek survey area was negatively associated with greater prairie-chicken lek count data.

Land use changes

To determine land use changes along the Butler County lek survey route, records in the

USDA Service Center were examined and interviews were conducted with current and past employees of the Agricultural Stabilization and Conservation Service, Farm Service Agency, Natural Resources Conservation Service, and the Soil Conservation Service. Only people with in-depth and long-term knowledge of the Butler County lek survey route were interviewed. Additionally, individuals who conducted the lek surveys were mailed questionnaires to obtain information on land use along the Butler County survey route over time. Data gathered through the above approaches were combined to determine land use changes in the area 1 mile either side of the 10-mile Butler County lek survey route.

The land uses examined included: burn frequencies, grazing intensity/system, and traffic on the survey road. These land use factors were quantified and analyzed in detail (Cartwright 2000). The land use changes for the Butler County survey route area are summarized below for the 1965 to 1996 period.

BURNING	Frequency increased from burning every 2 years (1965-1985) to burning twice every 3 years (1985-1996), timing was early season from 1965 to 1980 and late early season from 1980 to 1996.
GRAZING	Intensity was medium from 1965 to 1980 and medium high from 1980 to 1996, type of grazing went from cow/calf (1965-1975) to mixed (1975-1985) to intensive early stocking (1985-1996).
ROADS	An increase in traffic occurred between 1980 and 1996.

Few significant relationships were found between the above land use variables and lek survey indices to greater prairie-chicken populations for the Butler County survey route, or for

state-wide pooled data (Cartwright 2000). Analysis of the data disclosed that the combined effect of grazing and burning was not significantly related state-wide (r = -0.19, P = 0.29) to the lek survey indices to greater prairie-chicken populations.

Quality of Prairie Habitat for Greater Prairie-Chickens

The proposed site of the wind generating facility near Rosalia was visited twice to evaluate its quality relative to nesting and brood rearing habitat for greater prairie-chickens. Our research and the studies of Peterson et al.(1998) and Wisdom and Mills (1997) document that nesting and brood-rearing are the two most critical elements in the population dynamics equation of prairie grouse. In conjunction with three lesser prairie-chicken researchers (Christian Hagen, James Pitman, and Curran Salter), I developed 10 criteria to quantitatively evaluate the habitat of the proposed site relative to prairie chicken nesting and brood-rearing needs. These criteria assume that the behavior of greater prairie-chickens in tallgrass prairies near Rosalia, Kansas is very similar to the behavior of the lesser prairie-chicken in the sand sagebrush habitats of southwestern Kansas and that the behavior of greater prairie-chickens in Butler County, Kansas is similar to that of those birds in Geary County, Kansas.

The evaluation criteria included are based on six years of telemetry studies of lesser prairie-chickens in southwestern Kansas (over 45,000 individual locations of 350+ lesser prairie-chickens, 200+ nests, and tracking of 40+ broods), and an 8-year study of greater prairie-chickens in the Flint Hills of Geary County, Kansas (Robel 1966a, Robel 1966b, Robel et al. 1970, Robel 1970, Ballard and Robel 1974, Robel and Ballard 1974, Bowen et al. 1976, Bowman and Robel 1977). The evaluation criteria and their parameters are detailed in Exhibit 1. A value of 10 for a criterion is excellent and values less than that indicate poorer quality nesting

Quantitative evaluations of characteristics of tallgrass prairie important as nesting and brood rearing habitat for greater prairie-chickens.

Habitat continuity

Patch site contiguous with adjoining tallgrass prairie habitat

Perimeter:	0 - 25% contiguous	1
	25 - 50% contiguous	4
	50 - 75% contiguous	7
	> 75% contiguous	10

Proportion of patch site composed of native tallgrass prairie

0 - 25%	1
25 - 50%	4
50 - 75%	7
> 75%	10

Proportion of woodland cover in patch site

0 - 15%	10
15 - 30%	7
30 - 50%	4
> 50%	1

Proportion of row crop land in patch site

0 - 25%	10
25 - 50%	7
50 - 75%	4
> 75%	1

Proportion of patch site consisting of road and transmission line edges

(Edges = 200 yards either side of roads or transmission lines)

0 - 5%	10
5 - 10%	7
10 - 15%	4
> 15%	1

Proportion of human intrusion area in patch site

(Area = ½ mile radius around inhabited structures, compressor stations, and other foci of human activity)

0 - 10%	10
10 - 20%	7
20 - 30%	4
> 30%	1

Greater prairie-chicken presence on patch site	
Leks or flocks present and bird numbers stable or increasing	10
Leks or flocks present but bird numbers declining	7
Leks or flocks present historically, but none active now	4
No historical record of leks or flocks presence	1
Spring burning practices on patch site	
No burning	10
Burn frequency commonly 4 to 5 years	7
Burn frequency commonly 2 to 3 years	4
Annual burning common	1
Invasion of rangeland by woody vegetation on patch site	
No woody plant seedlings (<3 ft tall) present	10
Scattered woody plant saplings (3 to 6 ft tall) present	7
Woody plant seedlings and saplings common	4
Woody plants >6 ft tall common	1
Relative human activity on patch site	
(Oil/gas development/production, hiking trails, camping, fishing, or general recreational activity)	
Little (no wells, pasture trails, or access roads)	10
Low moderate (<1 well, trail, or road/section)	7
Moderate (1 to 4 wells, trails, or access roads/section)	5
High moderate (5 to 8 wells, trails, or access roads/section)	3
High (>8 wells, trails, or access roads/ section)	1

and brood rearing habitat for greater prairie-chickens. A value of 1 is the lowest score possible for any habitat criteria. The evaluation system includes 10 criteria, therefore the highest score possible is 100 (extremely good nesting and brood-rearing habitat) and the lowest is 10 which would reflect very poor nesting and brood-rearing habitat for greater prairie-chickens. Our data document that prairie-chickens seldom nest or raise their broods within 1 mile of an operating electric generating station, and we assume the same disturbance distance will apply to operating wind turbines. Data from California documented adverse impacts on lekking sage grouse 1 to 4 miles from wind turbines (Frank Hall, personal communication). Based on our field data for lesser prairie-chickens, I predict the minimal impacted area of the proposed wind turbine facility will extend 1 mile beyond the actual construction site and will include approximately 19,000 acres of habitat.

Greater prairie-chickens require expansive areas of grassland and are highly mobile, especially hens in the spring and early summer. Therefore Criterion A of the evaluation provides continuous grassland habitat a higher value than fragmented habitat. Greater prairie-chickens are grassland birds therefore sites composed entirely of grass are of higher quality than patches of grass (Criterion B), and sites with woodlands generally are avoided by prairie chickens (Criterion C). Greater prairie-chickens generally do not nest successfully in tilled crop fields, thus the value of sites decreases as the amount of row cropland increases (Criterion D). Sharp changes in habitat type constitutes an edge, and edges serve as predator lanes which are avoided by nesting prairie grouse. Nesting and brood-rearing grouse avoid heavily traveled roads. Commonly 200 yards either side of roads or edges are avoided by nesting and brood-rearing prairie chickens, thus the inclusion of Criterion E in the evaluation scheme. Prairie chickens are very sensitive to human activity and seldom nest within a ½ mile of inhabited homes, therefore the increased

human presence decreases the quality of prairie chicken habitat (Criterion F). The presence of greater prairie-chickens reflects the suitability of habitat (Criterion G). Greater prairie-chickens nest in the previous year's dead vegetation, therefore burning that vegetation before the nesting season reduces the habitat's suitability as a nesting area (Criterion H), however, more open areas may provide good brood-rearing habitat (Jamison et al. 2002). Woody vegetation in rangelands serves as raptor perches and decreases the area readily observable for greater prairie-chickens, therefore increased woody vegetation reduces the quality of prairie chicken habitat (Criterion I). Because human activity generally is inversely proportional to the quality of greater prairie-chicken nesting and brood-rearing habitat, Criterion J is included in the 10 criteria used to evaluate the quality of the proposed site as greater prairie-chicken habitat.

The proposed site is surrounded by tallgrass prairie which allows unrestricted movements of prairie chickens to and from the proposed site (value of 10 for Criterion A). Over 95% of the site is composed of tallgrass prairie resulting in a value of 10 for Criterion B. Woodlands cover approximately 4% of the proposed site, therefore resulting in a value of 10 for Criterion C. There is no active row-crop farming on the site, thus Criterion D obtains a value of 10. The abandoned railway and Kansas Highway 54 transect the site and 200 yards either side of both would be considered edge that is avoided by nesting and brood-rearing greater prairie-chickens. This amounts to less than 3% of the proposed site, and results in a value of 10 for Criterion E. Only one human residence is within the impacted area. The area impacted by the house (½ mile radius around the house) is less than 3% of the area of the site, therefore Criterion F gets a value of 10. Active greater prairie-chicken display areas (leks) are known to be on the area but no population surveys have been conducted on the site to document trends in population numbers. The lek survey route data for Butler County reflect a stable to declining population, so to be

conservative, I gave Criterion G a value of 7, but a value of 10 might be just as appropriate. Annual burning eliminates the standing dead vegetation needed by ground nesting birds (including greater prairie-chickens), therefore a value of 1 was recorded for Criterion H. No woody vegetation was invading the tallgrass prairie, thus Criterion I received a score of 10. Two small oil fields were on the eastern edge of the proposed site, but their impact on greater prairie-chicken nesting and brood-rearing habitat was considered low moderate producing a value of 7 for Criterion J.

Combining the values for each of the 10 site factors and characteristics results in a total score of 85 for the 19,000-acre site (highest = 100, lowest = 10). This assumes each criterion measured is of equal importance and mutually exclusive. No doubt this assumption is not valid, but no data are available to weight the criteria differently. Based on the 10 criteria used to evaluate the proposed construction site, I would consider the area to be very good to excellent greater prairie-chicken habitat.

Site-specific impacts of the facility on greater prairie-chickens

Prairie grouse are area-sensitive birds with a low tolerance for human disturbance. Our research has determined that greater prairie-chickens in the Flint Hills exhibit extensive movements (Robel et al. 1970) similar to lesser prairie-chickens in the sandsage rangelands of southwestern Kansas. Other life characteristics of greater prairie-chickens (lek fidelity, nesting habits, elements of population dynamics, etc.) are similar enough to those of lesser prairie-chickens that lesser prairie-chickens can be used as surrogates of greater prairie-chickens. Therefore, results from our lesser prairie-chicken research in southwestern Kansas are being used to predict the impacts of the wind generation facility on greater prairie-chickens because the

required data are not available for greater prairie-chickens. Our data have documented that nest establishment by females, the hatching success of those nests, and the survival of the chicks produced by those nests are the most critical factors in the maintenance of prairie chicken populations. Sensitivity analyses of 6-years of these data from our lesser prairie-chicken research determined that negative impacts on any of these vital factors will adversely impact the long-term viability of prairie-chicken populations.

The 45,000+ radio locations of lesser prairie-chickens on our two 10,000-acre study areas disclose that birds avoid suitable habitat within ½ mile around human residences, well traveled roads, and compressor stations. Birds were never located within 1 mile of a coal-fired generating station, even though the habitat within that 1-mile radius had vegetation structure similar to that frequented by lesser prairie-chickens more than 1 mile from the power plant. None of our 200+ radio-equipped lesser prairie-chicken hens nested within ½ mile of a human residence, well travel road, or compressor station, nor did they nest within 1 mile of the power plant. Radio-equipped hens with broods likewise avoided these areas. Wind turbines are large structures known to have adverse impacts on sage grouse up to 4 miles away (Frank Hall, personal communication). Although hard data are not available to document the distance wind turbines might adversely impact greater prairie-chickens, I firmly believe such impacts be will as great as those of the coal-fired generating station on lesser prairie-chickens in southwestern Kansas, i.e., the habitat within a minimum of 1 mile will become unsuitable for greater prairie-chickens.

Based on the above, I predict that the entire proposed wind-turbine site and the tallgrass prairie habitat within 1 mile of the site, will become unusable for nesting and brood-rearing by greater prairie-chickens once the wind turbines are erected and operational. Thus, the establishment of the wind generating facility near Rosalia, Kansas will eliminate approximately 19,000 acres of very good to excellent greater prairie-chicken habitat even though the tallgrass

prairie itself is not destroyed in the process.

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