ASSOCIATION OF BLACK-TAILED PRAIRIE DOGS (*CYNOMYS LUDOVICIANUS*) WITH PLAYA LAKES AND A NEW APPROACH TO ESTIMATING SIZE OF POPULATIONS

ALISON L. PRUETT, CLINT W. BOAL,* MARK C. WALLACE, HEATHER A. WHITLAW, AND JAMES D. RAY

Department of Natural Resources Management, Texas Tech University, Lubbock, TX 79409 (ALP, CWB, MCW)
United States Geological Survey, Texas Cooperative Fish and Wildlife Research Unit,
Department of Natural Resources Management, Texas Tech University, Lubbock, TX 79409 (CWB)
Texas Parks and Wildlife Department, Lubbock, TX 79409 (HAW)
B&W Pantex, LLC, Pantex Plant, Building T-9061, Amarillo, TX 79120 (JDR)
**Correspondent: clint.boal@ttu.edu*

ABSTRACT—We studied 403 colonies of black-tailed prairie dogs (*Cynomys ludovicianus*) in a 28,927-km^2, 12-county area of the southern High Plains, and we examined the distribution, area of colonies, size of populations, and association of these colonies with playa lakes. We used visual counts and estimated size of populations based on modeling of the proportion of a population of prairie dogs above ground at the times of surveys. Colonies in the southern High Plains were small (median = 8.8 ha), with generally small populations (median = 68), and average densities of 14 ± 22 prairie dogs/ha. Colonies were closer to playa lakes than would be expected by chance ($P < 0.001$), with 40% of colonies built in the basin, slopes, or both, of playa lakes compared to only 3% of 1,000 random points. The association of prairie dogs with playa lakes in the heavily cultivated area of the southern High Plains suggests that playas are a major portion of the habitat of black-tailed prairie dogs in the region.

RESUMEN—Estudiamos 403 colonias de perros de la pradera cola negra (*Cynomys ludovicianus*) en una área de 28,927 km^2 en 12 condados en las Altas Planicies meridionales, y examinamos la distribución, el área de las colonias, el tamaño de las poblaciones, y la asociación de las colonias con los lagos efímeros. Contamos visualmente y estimamos el tamaño de las poblaciones basados en modelos de la proporción de una población de perros de la pradera sobre el suelo durante la hora de los muestreos. Las colonias de perros de la pradera fueron pequeñas (promedio = 8.8 ha), con poblaciones generalmente pequeñas (promedio = 68) y una densidad promedio de 14 ± 22 perros de la paradera por ha. Las colonias se encontraron significativamente cerca de los lagos efímeros ($P < 0.001$), con 40% de las colonias construidas en la cuenca o en las pendientes de los lagos efímeros, o en ambas, comparadas con solamente 3% de 1,000 puntos aleatorios. La asociación de los perros de la pradera con los lagos efímeros en la región con mucha agricultura en las Altas Planicies meridionales sugiere que los lagos efímeros son una parte importante del hábitat de los perros de la pradera en la región.

The conservation and management of black-tailed prairie dogs (*Cynomys ludovicianus*) has been, and continues to be, a contentious conservation issue. The species was found to warrant federal protection under the Endangered Species Act, but was precluded due to higher-priority species (United States Department of the Interior, 2000). More recently, it was removed as a candidate species (United States Department of the Interior, 2004), but continues to be an object of litigation (e.g., L. McCain et al., in litt.). The legal focus on prairie dogs has led state, federal, and tribal wildlife agencies to assess the status of black-tailed prairie dogs, and develop conservation and management plans (Luce, 2003).

The historical distribution of prairie dogs in Texas is primarily the southern Great Plains region, including the southern High Plains, which, prior to agricultural development, was dominated by prairie grasslands. Dispersed across the southern High Plains are >20,000 playa lakes; shallow, circular depressions that serve as natural drainage systems in the region (Smith, 2003). With rare exception, playas are ephemeral and fill with water through precipitation and through runoff from agricultural irrigation (Smith, 2003). Playas become completely dry during periods of little rainfall, but can rapidly flood during wet periods. Thus, agricultural interests often view playas as a management challenge (Schwiesow, 1965; Smith, 2003). Often, playa basins are considered unsuitable for production of agricultural crops and are left uncultivated. As a result, many playa basins and their grassland slopes function as oases of wildlife habitat in an otherwise inhospitable mosaic of agricultural lands (Haukos and Smith, 1992; Fish et al., 1995; Smith, 2003).

Because playas provide some of the last areas not converted to agricultural production in the southern High Plains, we suspected they served as important habitat for prairie dogs. However, associations of black-tailed prairie dogs with playa lakes have not been investigated. We assessed distribution, area of colonies, size of populations, and association of black-tailed prairie dogs in the southern High Plains of Texas with playa lakes. We attempted to develop an efficient method for estimating size of populations of prairie dogs that would be applicable at regional scales, reduce land-ownership and access issues, and take into account temporal patterns of above ground activity. Our goal was to develop a better understanding of the status of prairie dogs in the southern High Plains and to provide information relevant for conservation, management, and monitoring of the species.

Materials and Methods—*Study Area*—We searched for prairie dogs in 12 counties within the southern High Plains of Texas: Armstrong, Briscoe, Carson, Castro, Crosby, Floyd, Hale, Hockley, Lamb, Lubbock, Randall, and Swisher. Counties within this primarily privately owned landscape have a well-developed road system with county roads about every 1.6 km. The study area generally was level with elevations ranging from 1,002 m in the south to 1,099 m in the north. There were ca. 11,213 playa lakes (Fish et al., 1995) within this 28,927-km^2, 12-county study area. Along the extreme eastern side of the study area was the Caprock Escarpment, an abrupt elevational change of 30 to >300 m, which separates the southern High Plains from the lower-elevation Rolling Plains ecoregion. Average precipitation and temperatures fluctuate widely, ranging from 22.1 to 102.9 cm and −4 to >50°C, respectively (Blackstock, 1979).

Historically the southern High Plains was composed of short-grass and mid-grass prairies, especially buffalograss (*Buchloë dactyloides*), blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), little bluestem (*Schizachyrium scoparium*), and sand dropseed (*Sporobolus cryptandrus*), with some low shrubs, especially honey mesquite (*Prosopis glandulosa*), and cholla and prickly pear cacti (*Opuntia*; Brook and Emel, 1995; Savage, 2004). During our study, the area was dominated by agricultural production, especially cotton (*Gossypium hirsutum*), grain sorghum (*Sorghum bicolor*), and cattle grazing. Allotments in the Conservation Reserve Program were common, with allotments seeded in mixed-native grasses and older allotments in monocultures of introduced weeping lovegrass (*Eragrostis curvula*) and cultivars of Old World bluestem (*Bothriochloa*).

Collection and Analysis of Data—The grid of roadways and the generally level topography allowed for a reasonably complete ground survey of the entire study area. We drove every public road within the 12-county study area in search of colonies of prairie dogs during May–September 2002 and 2003. We did not have permission to access most private properties, so we mapped perimeters of colonies from viewpoints on the closest public roads. We used ArcView 3.2 and a laptop computer to digitize the visually estimated perimeter of each colony onto an appropriate Digital Orthoimagery Quarter Quadrangle. Due to level terrain, we were able to view the entire area for almost all colonies. After colonies were mapped, we estimated area of each with the calculate-area function within ArcView.

Estimates of size and densities of populations of prairie dogs are difficult because the species spends a large amount of time under ground (Hoogland, 1995). An improbable assumption of visual counts (Fagerstone and Biggins, 1986; Menkens and Anderson, 1993; Severson and Plumb, 1998) is that the entire population is above ground during a count. Efficiency of the method also is hampered by surveying only in the morning to avoid hotter temperatures when prairie dogs are likely to retreat to burrows (Tileston and Lechleitner, 1966).

To develop a predictive model of size of populations, we conducted 9 all-day counts, ca. 2 weeks apart, at a single 15-ha colony (hereafter Primary Colony) in Lubbock County, Texas, during each summer (May–September 2002 and 2003). We counted prairie dogs at 0.5-h intervals from dawn to dark and measured temperature after each count with a Kestrel® 4000 (Nielsen-Kellerman, Boothwyn, Pennsylvania) hand-held weather unit. We considered the highest count of the day to be the population of the Primary Colony on that day (Fagerstone and Biggins, 1986). This inevitably biased estimations low, but was as close to a total count of the population as possible using visual counts. We converted other counts from that same day into a percentage of the total population, and transformed proportion data with the arcsine-square-root transformation (Kleinbaum and Kupper, 1978; Zar, 1999). To account for variability in length of day during the study, we calculated time as a percentage of length of day. We pooled percentages of length of day for each count into time categories of 10%-daylight intervals. We obtained times of sunrise and sunset from an almanac website (www.almanac.com).

Because temperature is related to time of day, we generated a unique model for each time category using simple regression with proportion of prairie dogs seen as the dependent variable. We tested models at five colonies (hereafter Test Colonies). We collected and processed data exactly as with the Primary Colony, then randomly selected one, two, three, four, and five

Table 1—Mean and standard errors for size of colonies (ha), size of populations, and densities (individuals/ha) at 403 of 425 colonies of black-tailed prairie dogs (*Cynomys ludovicianus*) within a 12-county area of the southern High Plains, Texas, 2002–2003.

County	*n*	Size of colony	Size of population	Density
Armstrong	3	4.9 ± 2.9	65.3 ± 61.4	9.8 ± 4.9
Briscoe	7	22.4 ± 12.7	244.7 ± 155.3	8.3 ± 2.0
Carson	24	15.8 ± 5.3	108.5 ± 28.3	8.2 ± 1.4
Castro	55	24.1 ± 4.6	225.2 ± 37.0	19.1 ± 5.4
Crosby	10	7.9 ± 2.3	59.1 ± 19.5	9.1 ± 2.2
Floyd	58	13.0 ± 2.2	137.5 ± 21.6	11.8 ± 1.2
Hale	17	21.7 ± 4.6	103.9 ± 18.8	6.4 ± 0.9
Hockley	50	32.2 ± 13.5	153.2 ± 38.3	17.6 ± 3.6
Lamb	58	14.6 ± 2.4	114.0 ± 20.5	15.1 ± 2.2
Lubbock	42	12.6 ± 2.3	72.2 ± 24.0	12.3 ± 2.7
Randall	43	50.0 ± 14.7	240.1 ± 44.6	13.4 ± 4.6
Swisher	36	20.5 ± 6.4	239.3 ± 77.5	16.3 ± 2.8
Total	403	22.2 ± 2.6	157.5 ± 12.6	14.0 ± 1.1

counts from each Test Colony to construct test trials. The only restriction on randomness was that no count be within 2 h of any other count to reduce the possibility of violating independence of counts. We ran 20 test trials for each set of counts for a total of 100 trials for each Test Colony. Mean of outputs of individual-count models was then calculated as output for the trial. For example, a count trial occurring in time-interval 8 would have a regression formula of 1.31—(0.0144 times temperature; Pruett, 2004). The result was then transformed using the reverse of the arcsin-square-root transformation, which resulted in an estimation of the proportion of prairie dogs above ground at that time and temperature. Standard error for this estimate was calculated by using the standard error for the corresponding time category. This was derived from the square root of the residual mean square for the model (Ott and Longnecker, 2001) and multiplying it by estimated size of population. An estimated size of population based on multiple counts was generated by the sum of counts divided by number of counts. Similarly, the *SE* for the estimation was derived by the sum of the *SE* for each count divided by number of counts. Further details, examples, and time-category, regression formulas for this modeling approach are available in Pruett (2004).

To assess number of counts required for accurate estimation of size of population, we tested results of trials using Tukey's honestly significant difference (HSD) tests (Zar, 1999). Our model-testing efforts indicated trials with three, four, and five counts were not statistically different. Therefore, to estimate size of populations in colonies, we conducted three counts separated by ≥2 h at each colony.

We used a digital layer of all playa lakes within Texas (E. Fish, unpublished data) to assess distribution of colonies in relation to playas. We used the measuring tool in ArcView to measure distance between edge of each active colony and edge of the nearest playa lake. We then generated 1,000 random points across the study area and measured distance between points and the edge of the nearest playa. We used a Student's *t*-test (Zar, 1999) to compare distribution of colonies and random points in relation to playa lakes.

Results—We located 425 active colonies in the 12-county study area, with total area occupied by prairie dogs of ca. 9,113 ha. We estimated area of colony and size of population for 403 of the colonies (Table 1). Colonies generally were small (median = 8.8 ha), but varied widely, ranging from <1 to 599 ha (mean = 22.2 ± 2.6 ha). The estimated average size of populations was 157 ± 13 prairie dogs (median = 68; range = 1–2,587), with a mean, but highly variable, density of 14 ± 1.1 prairie dogs/ha (median = 9 prairie dogs/ha; Table 1). Based on size of populations at the 403 colonies in our study area, we estimated 60,000–65,000 black-tailed prairie dogs were present. Distances between colonies was <1.0–14.0 km (mean = 2.8 ± 2.2 km).

We located 53 colonies in the Rolling Plains ecoregion, which was within our study area but at a lower elevation below the Caprock Escarpment and did not contain playa lakes. To assess associations of prairie dogs with playa lakes, we only included the 372 colonies located in the southern High Plains and restricted our 1,000 random points to the southern High Plains. Colonies of prairie dogs were significantly closer to playa lakes (mean = 277 ± 23 m; median = 63 m) than random points (mean = 580 ± 14 m; median = 513 m; $t_{1370} = -11.318$; $P < 0.001$). Indeed, 40% of colonies were in the basin, slopes, or both, of playa lakes compared to only 3% of random points.

Discussion—Colonies of black-tailed prairie dogs once occupied ca. 15,000,000 ha in the United States, with single colonies occupying up to several thousand hectares and consisting of thousands of individuals (Luce, 2003). In contrast, colonies in the southern High Plains were small and consisted of few individuals. Small populations may put individual colonies at increased risk of extirpation through persecution, habitat conversion, flooding, disease, or other events. Average distance between colonies was 2.8 km, which is similar to the estimated 2.4-km dispersal distance for the species (Garrett and Franklin, 1988). Although clusters of colonies in our study area may be within estimated dispersal distances, recolonization of extirpated colonies may be hampered by relatively low numbers of individuals and inhospitable landscapes of agricultural production between colonies. Thus, small sizes and segregation of colonies may put them at risk for long-term persistence (e.g., Luce, 2003; United States Department of the Interior, 2004).

A partial explanation for patterns of distribution and size of colonies is the clear association of prairie dogs with playa lakes in our study area. There is no direct evidence that slopes of playa lakes were selected preferentially by prairie dogs. Rather, we suspect infrequent use of playas for cultivation allows them to be inhabited by prairie dogs with little direct or indirect persecution by landowners. Additionally, small size of colonies probably was due to association with playa lakes. Size of playa and adjacent slope likely influences the size to which a colony can grow before it is limited by persecution or encountering land-uses that do not allow expansion (e.g., cultivation).

Individual visual counts cannot be used to estimate size of population in a colony with reliability. Trials consisting of 1–2 counts lacked accuracy, whereas trials with 3–5 counts did not differ statistically. Our estimates of size of population derived from this modeling approach are likely biased low, but we believe our method provides a more accurate, and logistically and financially feasible, approach to estimation of size of population than others that are used currently. However, we have tested our method in our study area only. While this approach should be applicable elsewhere, models likely will need to be refined to local conditions, such as latitudinal differences in length of day and range of temperature.

Land-use practices and efforts to reduce populations of prairie dogs appear to be the most relevant factors in current location of colonies in the southern High Plains. Prairie dogs here are closely associated with playa lakes because they are the few areas that have not undergone substantive alteration to crop or livestock production. This presents an excellent opportunity for conservation efforts through landowner-incentive programs; many landowners already are disinclined to alter playa lakes due to periodic flooding. Although playa lakes already are important for conservation of prairie dogs in the southern High Plains of Texas, if land conversion to agriculture continues throughout the region, playas may become the only areas available to prairie dogs regardless of management decisions.

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Literature Cited

Blackstock, D. A. 1979. Soil survey: Lubbock County, Texas. United States Department of Agriculture Soil Conservation Service, Washington, D.C.

Brook, E., and J. Emel. 1995. The Llano Estacado of the American southern High Plains. Pages 255–303 in Regions at risk: comparisons of threatened environments (J. X. Kasperson, R. E. Kasperson, and B. L. Turner, editors). United Nations University Press, New York.

Fagerstone, K. A., and D. E. Biggins. 1986. Comparison of capture-recapture and visual count indices of prairie dog densities in black-footed ferret habitat. Great Basin Naturalist Memoirs 8:94–98.

Garrett, M. G., and W. L. Franklin. 1988. Behavioral ecology of dispersal in the black-tailed prairie dog. Journal of Mammalogy 69:236–250.

HOOGLAND, J. L. 1995. The black-tailed prairie dog: social life of a burrowing mammal. University of Chicago Press, Chicago, Illinois.

KLEINBAUM, D. G., AND L. L. KUPPER. 1978. Applied regression analysis and other multivariate methods. Duxbury Press, North Scituate, Massachusetts.

LUCE, R. J. 2003. A multi-state conservation plan for the black-tailed prairie dog, *Cynomys ludovicianus*, in the United States—an addendum to the black-tailed prairie dog conservation assessment and strategy, November 3, 1999. Prairie Dog Conservation Team, Sierra Vista, Arizona.

MENKENS, G. E., JR., AND S. H. ANDERSON. 1993. Mark-recapture and visual counts for estimating population size of white-tailed prairie dogs. Biological Report 13:67–72.

OTT, R. L., AND M. LONGNECKER. 2001. An introduction to statistical methods and data analysis. Fifth edition. Duxbury Press, Pacific Grove, California.

PRUETT, A. L. 2004. Black-tailed prairie dog association with playa lakes in the southern High Plains and a new approach to estimating colony population sizes. M.S. thesis, Texas Tech University, Lubbock.

SAVAGE, C. 2004. Prairie: a natural history. Greystone Books, Vancouver, British Columbia, Canada.

SCHWIESOW, W. F. 1965. Playa lake use and modification in the High Plains. Studies of Playa Lakes in the High Plains, Texas Water Development Board, Austin 10:1–9.

SEVERSON, K. E., AND G. E. PLUMB. 1998. Comparison of methods to estimate population densities of black-tailed prairie dogs. Wildlife Society Bulletin 26: 859–866.

SMITH, L. M. 2003. Playas of the Great Plains. University of Texas Press, Austin.

TILESTON, J. V., AND R. R. LECHLEITNER. 1966. Some comparisons of the black-tailed and white-tailed prairie dogs in north-central Colorado. American Midland Naturalist 75:292–316.

UNITED STATES DEPARTMENT OF THE INTERIOR. 2000. Endangered and threatened wildlife and plants: 12-month finding for a petition to list the black-tailed prairie dog as threatened. Federal Register 65:5476–5488.

UNITED STATES DEPARTMENT OF THE INTERIOR. 2004. Endangered and threatened wildlife and plants; finding for the resubmitted petition to list the black-tailed prairie dog as threatened. Federal Register 69:51217–51226.

ZAR, J. H. 1999. Biostatistical analysis. Fourth edition. Prentice Hall, Upper Saddle River, New Jersey.

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