FINAL REPORT

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THE ENDANGERED SPECIES PROGRAM

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Endangered and Threatened Species Conservation

Project 70: Status and Long-term Survival Estimates For the Texas Kangaroo Rat

Prepared by: Robert E. Martin

TEXAS PARKS & WILDLIFE

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FINAL REPORT

STATE: Texas **GRANT NO:** E – 1 – 11

PROGRAM TITLE: Endangered and Threatened Species Conservation

PERIOD COVERED: September 1, 1995 – August 31, 2000

PROJECT NUMBER: 70

PROJECT TITLE: Status and Long-term Survival Estimates For the Texas Kangaroo Rat

PROJECT OBJECTIVE:

To determine the current distribution and population status of the Texas kangaroo rat (*Diplodomys elator)* throughout the historic and potential range and make estimates of long-term persistence of this species.

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Date

Section 6 Project 70:

Status and Long Term Survival Estimates for the Texas Kangaroo Rat, *Dipodomys elator*

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INTRODUCTION AND BACKGROUND

Classification and Nomenclature

Scientific Name. *Dipodomys elator* Merriam, 1894: 109-110.

Original Publication. Merriam, C. H. 1894. Preliminary descriptions of eleven new kangaroo rats of the genera Dipodomys and Perodipus. Proceedings Biological Society of Washington, 9: 109-116.

Type Specimen. U.S. National Museum No. 64,802, adult male, from Henrietta, Clay County, Texas.

Synonyms. None

Common Names. Texas kangaroo rat; Loring kangaroo rat.

Family. Heteromyidae

Taxon History. Since the description of this species by C. Hart Merriam (1894), the Texas kangaroo rat has been the subject of numerous studies on anatomy, systematics, and taxonomy (see references in Carter et al., 1985; Jones et al., 1988). *Dipodomys elator* is a monotypic species and not closely related to other species of *Dipodomys*. Dalquest et al. (1992) suggested, from an analysis of living and fossil forms, that *D. elator*, with its distinctive tooth morphology, represents a lineage separate from other kangaroo rat species. They also stated, if further analysis of other species supports the trend, that the distinctive pattern might warrant placing *D. elator* in a different genus.

Current Alternative Taxonomic Treatment. None other than described under Taxon History.

Description

External and Skull Morphology. Described in detail by Carter et al. (1985). Some excellent photos of this species are found in Roberts and Mills (1983). There is also a black and white drawing of *Dipodomys elator* in Caire (1989) although the shape of the body in that drawing looks more like that of *Dipodomys ordii* than of *Dipodomys elator*. Additional color photos are found in the image database accompanying this report.

Local Field Characteristics. The Texas kangaroo rat is one of only two species in Texas that possess a white-plume at the tip of its tail. In the geographic range occupied by this species it is the only species in that area that has a white plume. This characteristic makes it easy for anyone familiar with the species to recognize them from a distance as they cross the road or forage beside a road. The only other species of kangaroo rat in the general area is Ord's kangaroo rat, *Dipodomys ordii*, and it lacks the distinctive white plume at the tip of its tail. It is possible for the Texas kangaroo rat to lose the tip of the tail through injury or encounters with predators. However, in the hand, the Texas kangaroo rat has only four toes on the hind foot whereas the Ord's kangaroo rat has five toes on each hind foot and is also significantly smaller in overall body size.

Significance of Taxon

Genetic, Biogeographic, and Ecological Significance. Many studies indicate that the Texas kangaroo rat is very distinctive genetically (see reviews in Jones et al., 1988) and dentally and not closely related to other species in the genus. Dalquest et al. (1992) even suggested that this species might warrant placement in a genus separate from that of other *Dipodomys* because of its distinctive dental morphology. Behaviorally, individuals of *Dipodomys elator* also exhibit tonic immobility (i.e., "playing possum") on occasion (Martin and Matocha, pers. observ.). They also successfully occupy a harsh landscape that has few other species of small mammals (Dalquest and Collier, 1964).

Significance to Humans. The Texas kangaroo rat has minimal impact on humans because it is so infrequently observed and makes so little economic impact on agricultural fields. Bailey (1905) reported, based on Professor Lantz's observations, that *Dipodomys elator*, may take and store agricultural grains. Chapman (1972) and Dalquest and Horner (1984) stated that most crop seeds taken by this species were likely gleaned on the ground after the fields were harvested with combines. *Dipodomys elator* does not make extensive mounds and thus the burrow entrances made by individuals of this species occupy only a tiny fraction of the ground surface.

Present Legal Status

International. This species is not protected under international law. It is classified as a Vulnerable (Vu) species under the IUCN Red List Category (Martin & Matocha, 1998; Hilton-Taylor, 2000).

Federal. The Texas kangaroo rat is not protected under federal law but is listed as a Category 2 species.

State. The Texas kangaroo rat is a protected nongame species under state regulations.

STUDY AREA & METHODS

AREA.--- All counties in the historic range of the species in both Texas and Oklahoma were visited during the course of the study. Three of the historic grid trapping sites (Long Grid, North Grid, and South Grid) established in 1985 and 1986 were used for live trapping (see

Methods, below). Additional survey trapping was conducted in Hardeman and Childress counties in June 1996, and Hardeman County, in August and November 1998.

Soil samples were collected at each site where *Dipodomys elator* were captured or sighted and then analyzed in the laboratory for particle size. Photographs, if possible, were also made both of animals sighted or captured and of the habitat. Five-meter line transects (sixteen per grid) were used to monitor changes in plant (forbs and grasses) and bare ground on the long-term trapping grids. Photographs were taken at the site of sightings and captures during road surveys to give an indication of the nature of the habitat at that point in time and location. Precipitation data were obtained from the Quanah, Texas station (closest to North Grid and South Grid) and from Copper Breaks State Park (approximately 13 miles south of Quanah and closest to Long Grid).

METHODS.--- *Demographic patterns*.-- were investigated by analysis of existing reproductive and census data from Hardeman County, Texas. Folding Sherman live traps (7.6 x 7.6 x 25 cm), equipped with Tail Savers (K.G. Matocha, personal communication) to prevent damage to tails, were placed in survey lines or in 6 x 6 grids (36 traps)with 20-meter spacing (1.0 ha) or 8 x 8 grids (64 traps) with 20-meter spacing (1.96 ha). On census grids, traps were baited with mixed bird seed (chicken scratch), set in late afternoon, and checked early the next morning, for a total of three days. The site of each capture on the grids was noted and then each animal was marked with a unique toe-clip number, checked for reproductive condition, relative age and condition, and then released at the point of capture. Demographic data were analyzed visually, by use of spreadsheets & by a program written by Dr. Kelly McCoun (McMurry University), to calculate by enumeration the minimum number known alive (MNKA) individuals on the trapping grids. From July 1996 through July 2000, the live-trap grids accumulated 2532 trap nights (Table 1) and 14, 818 trap nights from 1986 to 1995 (Table 2).

Distribution Surveys.–Sherman live traps equipped with Tail Savers and baited with mixed bird seed were also used in survey trapping in Hardeman County during June 1996, August 1997, and November 1998 (See Table 1) for an additional 630 trap nights. Road surveys for current populations of *D. elator* were made throughout the historic range of the species along roads (paved and unpaved) and by walking in potential habitat to look for characteristic "sign" of the species. Determination of presence or absence of the species was made by examination of live-trapped or hand-caught animals, by sighting the distinctive field marks of the species at close distance in road surveys, and by salvage of road-killed specimens. Although the sign of *Dipodomys elator* is distinctive, we did not use "sign" alone as an indicator of the presence of the species in an area since other species may utilize the burrows of *Dipodomys elator* and give a false impression that the species might be present when it is-not. The road surveys were conducted by driving slowly on dark nights during June to August each year from 1996 through 2000 in 12 Texas counties (Table 3)and two Oklahoma counties. These road surveys, covering 2049.8 survey miles and 101.74 of actual survey hours, were useful to detect the presence of the species but were not used for estimates of density. When individuals of *Dipodomys elator* were sighted, an attempt was made to catch them by hand to gather information on sex, reproductive condition, approximate age, and weight. Any captured animals were photographed and then released after marking. The UTM location where animals

Table 1. Number of trap nights for grid and survey trapping, Childress & Hardeman counties, Texas, 1996-2000.

	1996	1997	1998	1999	2000	Totals
CHILDRESS COUNTY						
Grid	140	0	0	0	0	140
Survey	60	0	0	0	0	60
HARDEMAN COUNTY						
Grid						
Long	108	108	180*	108	108	612
North	192	192	192	192	192	960
South	192	192	192	192	192	960
Survey	240	0	190	0	0	430
TOTALS	932	492	754	492	492	3162

* Subtotal includes 72 trap nights on Long Grid, November 21-22, 1998

Table 2. Number of trap nights for grid trapping, Hardeman County, Texas, 1986-1995.

Grid	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Totals
CB01	108										108
HOL03	108										108
HOL04	108										108
HOL05	108	108	108	108	108	108	108	218	108		1082
Long	108	108	108	108	108	108	108	108	108	108	1080
North	960	1088	768	384	320	384	576	384	192	192	5248
South	960	1088	768	384	320	384	576	384	192	192	5248
KingW	108	108	108	108	108	108	108	108			864
KingE	108										864
WilsonN		108		108	108	108	108	108	108		756
WilsonS		108									
TOTALS		2892	2500	1968	1200	1072	1200	1584	1310	600	14,818

Table 3.–Road survey miles and survey hours (in parentheses, to nearest hundreth hour), north-central Texas counties, 1996-2000.

County	1996	1997	1998	1999	2000	Totals
Archer	30.4 (2.30)	0.0 (0.00)	23.6 (2.78)	45.9 (2.15)	42.0 (1.93)	141.9 (9.16)
Baylor	14.0 (0.60)	0.0 (0.00)	20.5 (0.75)	35.2 (2.93)	35.0 (0.92)	104.7 (5.20)
Childress	49.9 (2.90)	55.9 (3.07)	21.8 (1.15)	30.9 (2.00)	12.5 (0.68)	171.0 (9.80)
Clay	77.0 (4.20)	0.0 (0.0)	0.0 (0.00)	32.0 (1.10)	61.8 (2.03)	170.8 (7.33)
Cottle	43.0 (3.00	37.8 (1.22)	39.3 (1.35)	50.6 (2.47)	4.7 (1.19)	204.2 (9.23)
Foard	53.5 (2.50)	27.6 (0.70)	0.0 (0.00)	0.0 (0.00)	37.0 (1.25)	118.1 (4.45)
Hall	21.2 (1.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	21.2 (1.00)
Hardeman	271.9 (14.1)	58.2 (2.48)	37.0 (1.93)	62.7 (2.20)	26.4 (1.12)	456.2 (21.83)
Montague	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	28.1 (1.08)	12.1 (0.72)	40.2 (1.80)
Motley	116.5 (7.50)	35.7 (1.87)	47.2 (2.08)	47.0 (2.80)	33.3 (2.30)	279.7 (16.55)
Wichita	98.8 (4.40)	0.0 (0.00)	10.9 (0.57)	52.8 (2.21)	36.6 (1.40)	199.1 (8.68)
Wilbarger	46.7 (2.80)	0.0 (0.00)	43.6 (2.03)	39.1 (1.50)	13.3 (0.48)	142.7 (6.81)
Totals	**822.9 (45.30)**	**215.2 (9.34)**	**243.9 (12.64)**	**424.3 (20.44)**	**343.5 (14.02)**	**2049.8 (101.74)**

were captured or sighted was noted using either a GPS handheld receiver (Trimble GeoExplorer) or by plotting the location on a 7 1/2 minute topographic map (1:24,000 scale; 1927 North American Datum).

Historic records of occurrence were obtained from museum specimens, and, in some cases, from literature records (See Blair, 1949; Packard and Judd, 1968; Baccus, 1971; Martin and Matocha, 1972, 1991; Cokendolpher, et al., 1979; Jones and Bogan, 1986; Baumgardner, 1987; Jones et al., 1988; and Stangl and Schafer, 1990). Selected information on these specimens and records were then added to an Access database (**lockrmus.mdb**) that is appended to this report. Where possible, UTM coordinates of the historic records of occurrence were determined and then converted to decimal degrees (the X-coordinate or "eastings" as -XXX.XXXXXX and the Y-coordinate or "northings" as YY.YYYYYY) to facilitate entry into the geographic information system (GIS) software. The decimal degree longitude and latitude positions were then used to prepare point-feature shapefiles using the GIS software ArcView (ESRI, Redlands, California). A similar database, for new records of occurrence, was then used to prepare additional shapefiles.

With the historic records, because of variance in the quality of the locality descriptions, we assigned each record a numerical value (the *Coordinate Precision Index* or CPI, see McLaren, 1996). This index allows one to assign a value (ranging from 1 to 9) based on the apparent accuracy of the locality coordinate. For example, a CPI of 1.1 indicates that the coordinate value of the locality has an accuracy of +/- 10 meters; those with 1.2 have an accuracy of +/- 100 meters; and those with 1.3 have an accuracy of +/- 1 kilometer. When the CPI value is a 2, the locality coordinate has an accuracy of +/- 3 miles and one with a value of 3 is used for relative distance data. No locality coordinate was plotted on a map unless the CPI for that coordinate was at least a 2 or lower. Obviously, the smaller the CPI value, the greater confidence one has in the accuracy of the locality coordinate. For all recent records of occurrence, the CPI values were either 1.1 (if GPS coordinates were available) or 1.2 (if coordinates were calculated from a 1:24,000 scale topographic map). All localities that could not be plotted are detailed in Table 4. For the distribution maps, background maps were prepared using existing data in ArcView.

We initially thought that it would be possible to monitor the historic habitat by using historical Landsat imagery. Problems with the software and the availability of the imagery with the appropriate resolution rendered this goal not attainable.

Historic habitat was studied by Dr. Don Frazier (McMurry University) using historical records from the 19th Century in the approximate area where *Dipodomys elator* has been found in the 20th Century.

Table 4.–Unplottable localities in Access *LOCKRMUS.mdb* database. These records (N=15; approximately 2.47% of all records in this database) could not be plotted because of doubt as to the specific reference or a plotted location that ended up in a different county or state from the one on the reference tag. MSWU, Midwestern State Universty; TCWC, Texas Cooperative Wildlife Collection.

Refno	Year	Museum Acronym	Museum Number	Specific Reference	Problem
K0125	1967	MWSU	5848	Wichita Falls, 20 mi. W	Reference point measured from where?
K0130	1967	MWSU	5334	Buffalo Creek Reservoir	
K0150	1968	MWSU	8409	Wichita Falls, 8 mi. NW	Reference point measured from where?
K0151	1968	MWSU	6083	Wichita Falls	No specific locality
K0266	1969 NW?	MWSU	7290	Iowa Park, 20 mi. NE	Illogical locality, could it be
K0305	1969	MWSU	7292	Buffalo Lake, 0.5 mi. E	Measure from what point?
K0308	1969	MWSU	7289	No specific locality	Only county given
K0309	1969	MWSU	7288	Buffalo Lake	
K0323	1969	MWSU	8422	Buffalo Lake	
K0355	1971	MWSU	8406	Buffalo Creek Reservoir	
K0356	1971	MWSU	8417	Buffalo Creek Reservoir	
K0359	1971	MWSU		Wichita Falls, 27 mi. W	Reference point measured from where?
K0423	1972	MWSU	9473	Iowa Park, Buffalo Creek Reservoir, 12 mi. NW	Vague specific reference
K0441	1967	MWSU	5330	Buffalo Creek Reservoir	
K0571	1960	MWSU	1890	Wichita Falls, 15 mi. NE	Illogical locality, could it be NW?

RESULTS AND DISCUSSION

For each topic, results from the study are presented first followed by a discussion section.

DISTRIBUTION

Results. From 1995 to 2000, we were able to confirm the presence of the Texas kangaroo rat in five Texas counties (Table 5) (Archer, Childress, Hardeman, Motley, and Wichita) and none in Oklahoma. In a given year, the Texas kangaroo rat could not always be detected in each of the five counties (Table 5). In most of the years, individuals of the species could be detected near the western end of its known range (in Motley and Childress counties) but they were only detected sporadically in other years in Hardeman, Archer, and Wichita counties. New records of occurrence for the period 1995 to 2000 are shown in Table 6 and those for the period 1986 to 1993 in Table 7. Details of these new records, with coordinates in decimal degrees and in UTM, are in the *Access* database **desurv.mdb**.

Discussion. From the road surveys conducted between 1996 through 2000, it is apparent that the Texas kangaroo rat can be found in some numbers near the western end of its historic range. The western part of the geographic range is more arid and has habitat more suitable to the species. In Motley County and Childress counties there are still areas with considerable amount of open habitat and less land that has been converted into agricultural fields with monoculture. We were not surprised at the lack of occurrence of the species in the eastern part of the range since there have been no sightings or specimens of the Texas kangaroo rat in Clay County, Texas in over 100 years. Interestingly, the current distribution pattern of *Dipodomys elator*, with greatest numbers near the western end of the historic range, is similar to what was noted by Lomolino and Channell (1995) in 23 of 31 ranges of small mammals. They noted, in contrast to what has generally been accepted, that the extant populations of these mammals were located at the periphery of the historic range and not in the center of the range. This suggests that more attention should be given to looking for the Texas kangaroo rat at the periphery of its historic range.

The Texas kangaroo rat has appeared sporadically since its discovery in 1894. For most of the first half of the 20^{th} Century it was known only from Clay County, Texas (Merriam, 1894; Bailey, 1905) and Comanche County, Oklahoma (Bailey, 1905), although it has not been seen in either of those counties since 1900 (Clay County) or 1905 (Comanche County). Blair (1949) extended the known range of the species to Wilbarger County, Texas and reported (Blair, 1954) on an apparent record from Coryell County, Texas that was collected by Hedeen (1953). Subsequent workers, including Martin and Matocha (1972), Jones and Bogan (1986), and Jones et al. (1988) have discounted this Coryell County record although Dalquest and Collier (1964) speculated that an undescribed species or race of *Dipodomys elator* might live in the central Texas area. In subsequent years, additional Texas counties were added to the known range of the species: Archer County (Dalquest and Collier, 1964); Baylor County (Dalquest and Collier, 1964; Baccus, 1971); Foard County (Packard and Judd, 1968); Montague County (Cokendolpher, et al. , 1979); Motley County (Martin and Matocha, 1972; 1991); and Wichita County (Dalquest and Collier, 1964; Jones et al., 1987).

The most recent report (Stangl and Schafer, 1990) on the distributional status of the species documented its

Table 5.–Number of *Dipodomys elator* observed (sight records, live capture, or salvage) in road surveys, north-central Texas counties, 1996-2000. NS = county not surveyed in that year.

County	1996	1997	1998	1999	2000	Totals
Archer	1	NS	0	0	1	2
Baylor	0	NS	0	0	0	0
Childress	1	2	1	2	1	7
Clay	0	NS	NS	0	0	0
Cottle	0	0	0	0	0	0
Foard	0	0	NS	NS	0	0
Hall	0	NS	NS	NS	NS	0
Hardeman*	1	1	0	0	0	2
Montague	NS	NS	NS	0	0	0
Motley	3	0	0	2	5	10
Wichita	0	NS	0	2	0	2
Wilbarger	0	NS	0	0	0	0
Totals	**6**	**3**	**1**	**6**	**7**	**23**

* Two live *Dipodomys elator* were captured in non-grid trapping in 1998; those individuals are not included in the totals of this table. However, those individuals are listed in the *Access* database, *desurv.mdb*.

Table 6.-Records of occurrence of *Dipodomys elator*, counties in north-central Texas, 1996 to 2000, based on road surveys, salvage, and survey trapping. These records do not include animals captured alive on permanent grids and released. Much of the information in this table is also included in the Access database, *DESURV.MDB*. AOR, animal seen or caught alive on road; DOR, animal found dead on road and salvaged; LTRAP, animal caught in live trap in survey trapping. The *Coordinate Precision Index* (CPI) for the coordinates of these records was at least 1.2. The *record#* is a unique identifier for each animal and linked to the GIS database. CRP=Conservation Reserve Program.

DATE	CTY	RECORD#	UTM(X) LONGITUDE(x)	UTM(Y) LATITUDE(y)	STAT	GENERAL HABITAT
19960818	Archer	9608181	509694 -98.895367	3731692 33.72695	AOR	Buffalo grass/mesquite pasture nearby
19960709	Childress	9607091	406034 -100.021833	3802577 34.362050	DOR	Mostly bare field; mesquite pasture nearby
19960710	Hardeman	9607102	411121 -99.967017	3807350 34.405533	AOR	Dense CRP field; cotton field nearby
19960814	Motley	9608142	349267 -100.633105	3768899 34.051728	AOR	Dense grass; cleared mesquite pasture
19960814	Motley	9608143	349289 3769192 -100.632919	34.054369	AOR	Dense mid grasses; cleared mesquite
19960814	Motley	9608144	347640 -100.650482	3767542 34.039259	AOR	Short grass, cleared mesquite, crops
19970805	Childress	9708051	401046 -100.075531	3797897 34.319379	AOR	Bare fields; culvert, CRP land nearby
19970805	Childress	9708052	398542 -100.103523	3804508 34.378751	AOR	Bare field & pasture, large mesquite
19970805	Hardeman	9708053	432554 -99.731298	3774850 34.114072	DOR	Roadside, CRP field; near Copper Breaks State Park
19980621	Childress	9806211	406200 -100.020419	3806090 34.393736	DOR	Rough land, buffalo grass, mesquite
19980806	Hardeman	982102	432120 -99.736129	3776400 34.128015	LTRAP	Buffalo grass/mesquite pasture
19981122	Hardeman	983101	432080 -99.736571	3776500 34.128914	LTRAP	Buffalor grass/mesquite pasture
19990815	Childress	9908151	406188 -100.020611	3806658 34.398857	AOR	Rough land, buffalo grass, mesquite
19990815	Childress	9908152	406260 -100.020134	3808378 34.414375	AOR	Johnson grass; agricultural field; many forbs
19990814	Motley	9908141	336125 -100.773983	3761201 33.980357	AOR	Edge of cotton field; near mesquite
19990814	Motley	9908142	336125 100.773983	3761201 33.980357	AOR	Cotton field;mesquite pasture nearby
19990813	Wichita	9908134	498528 -99.015951	3766637 34.042172	AOR	Near plowed wheat field
19990813	Wichita	9908131	498528 -99.015951	3766637 34.042172	AOR	Near plowed wheat field
20000824	Archer	0008241	510780 -98.883641	3731680 33.726824	AOR	Near cemetery, short grass; mesquite pasture nearby
20000727	Childress	0007271	406200 -100.020419	3806090 34.393736	AOR	Pature, with mesquite & yucca, previously cleared

Table 6, cont.

DATE	CTY	RECORD#	UTM(X) LONGITUDE(x)	UTM(Y) LATITUDE(y)	STAT	GENERAL HABITAT
20000828	Motley	0008281	337080 -100.763644	3761160 33.980129	AOR	Grasses/forbs; next to cotton field
20000828	Motley	0008282	336120 -100.774035	3761180 33.980160	AOR	Johnson grass; mesquite pasture nearby
20000828	Motley	0008283	336120 -100.774095	3761500 33.983044	AOR	Small cleared mesquite; mid grasses
20000828	Motley	0008284	338840 -100.744901	3762800 33.995185	AOR	Russian thistle next to cotton field
20000828	Motley	0008285	339440 -100.738702	3764400 34.009701	AOR	Russian thistle & Johnson grass

Table 7.-- Records of occurrence of *Dipodomys elator*, Hardeman County, Texas, 1986 to 1993, based on road surveys, salvage, and survey trapping. These animals do not include animals captured on permanent grids and released. Much of the information in this table is also included in the *Access* database, DESURV.MDB. AOR, animal seen or caught alive on road; DOR, animal found dead on road and salvaged; LTRAP, animal caught in live trap in survey trapping. The *Coordinate Precision Index* (CPI) for the coordinates of these records was 1.2. The *record#* is a unique identifier for each animal and linked to the GIS database.

DATE	CTY	RECORD#	UTM(X)	UTM(Y)	LONGITUDE(x)	LATITUDE(y)	STAT
19860708	Hardeman	8607061	430473	3775351	-99.753900	34.118450	AOR
19860712	Hardeman	86071214	433746	3795394	-99.719950	34.299417	DOR
19860712	Hardeman	86071215	433744	3795089	-99.719950	34.296667	DOR
19860725	Hardeman	861202	430400	3775200	-99.754684	34.117080	AOR
19860727	Hardeman	861201	430160	3775380	-99.757301	34.118687	AOR
19860727	Hardeman	861203	429958	3774619	-99.759433	34.111817	AOR
19860728	Hardeman	8607281	434292	3795403	-99.714017	34.299533	AOR
19860729	Hardeman	8607291	435957	3795392	-99.695933	34.299533	AOR
19860729	Hardeman	8607292	433766	3795407	-99.719733	34.299533	AOR
19860730	Hardeman	8607301	436610	3795387	-99.688833	34.299533	DOR
19860725	Hardeman	86072526	431631	3793696	-99.742800	34.283967	DOR
19870725	Hardeman	87072521	431811	3785809	-99.740217	34.212850	AOR
19870725	Hardeman	87072522	431811	3785703	-99.740217	34.211900	DOR
19870725	Hardeman	87072523	432478	3776453	-99.732250	34.128517	AOR
19870725	Hardeman	87072524	431877	3787621	-99.739650	34.229200	DOR
19870725	Hardeman	87072525	431908	3787926	-99.739333	34.231950	DOR
19870725	Hardeman	87072520	433685	3793066	-99.720433	34.278417	AOR
19871024	Hardeman	8710241	430245	3774432	-99.756300	34.110150	AOR
19910406	Hardeman	913101	432197	3790753	-99.736417	34.257467	AOR
19930618	Hardeman	932102	432121	3776401	-99.736121	34.128028	LTRAP
19930618	Hardeman	932101	432120	3776400	-99.736129	34.128015	LTRAP
19931112	Hardeman	9311121	430220	3774000	-99.756539	34.106246	AOR

occurrence in only Foard County (sight record), and Hardeman, Wichita, and Wilbarger counties. This pattern of *Dipodomys elator* to be locally abundant followed by decline and disappearance is a notable feature of its history over the last 100 years.

The Oklahoma records of occurence of *Dipodomys elator* include the older records in Comanche County, near Chattanooga (Bailey, 1905) and a specimen collected just north of the Red River, in Cotton County, Oklahoma (Baumgardner, 1987). The Cotton County record dates from 1969 and was from an area with sandy soil, not typically associated with records of *Dipodomys elator*. This more recent record in Oklahoma may represent a dispersal event since the species is known historically from Wichita County, Texas, immediately south of Cotton County (Baumgardner, 1987; Jones et al., 1988). Caire (1989) suggested that individuals of *Dipodomys elator* may occasionally cross the border into Oklahoma although Moss and Melhlhop-Cifelli (1990) were unable to document any other occurrences of *Dipodomys elator* in Oklahoma after extensive habitat surveys, live-trapping, and road surveys. Other than the 1900 report of *Dipodomys elator* in Comanche County, and the 1969 record in Cotton County, there are no other records of occurrence of the species in Oklahoma. If the species is currently present in Oklahoma at all it must be at population levels undetectable by most techniques used to survey for the presence of rodents.

In a comprehensive study, Cameron and Scheel (2001) used GIS, vegetation models, and general circulation models to predict the impact of global climate change (GCC) on the distribution of vegetation in Texas. They found that vegetation would shift both under a warmer, drier climate and under a warmer, wetter climate. In Texas, they found that the impact on rodents in Texas would be greatest under a warmer, drier climate scenario. Under this drier scenario, they predicted that available habitat for *Dipodomys elator* would be reduced to about 52% of the pre-GCC condition. Thus, should this scenario prove true, the available habitat for *Dipodomys elator* would likely decrease significantly under GCC.

HISTORIC HABITAT, NINETEENTH CENTURY

Results. Dr. Don Frazier of McMurry University examined historical records and photographs taken in the mid-19th Century in the general area of the historic range of the Texas kangaroo rat. Dr. Frazier found that three expeditions passed through this general area: 1) the 1841 Texan Santa Fe Expedition; 2) the 1849 Marcy Expedition; and 3) the 1872 Texas Copper and Land Association Expedition. On the 1841 expedition, they were supposed to follow the Red River but instead apparently went west along either the Little Wichita or Wichita River and then moved north to the Pease River. As they approached the Pease River country, the accompanying journalist Kendall commented on the increasingly rugged nature of the country that consisted of hills and gullys. He commented on the "Rough and misshaped hills, formed of rocks and sand, [that] were piled up here and there without system or order, and not a bush or blade of grass could be found upon them to relieve their desolate appearance."

Captain Randolph Marcy passed through the area several times but he was not impressed with the area. He commented that the area "... might prove useful...as a penal colony." He provided little details about the nature of the native habitat.

In 1872, the Texas Copper and Land Association Expedition surveyed possible mineral deposits in the Wichita and Pease River country. They set out from Fort Belknap in Jack

County then traveled northwest into present day Archer County, then south to the Brazos River before turning northwest to Double Mountain and Kiowa Peak. Most of this expedition passed south of the current range of the Texas kangaroo rat although the traverse of the expedition into Archer County is in the historic range of the species. A "naturalist" on the expedition, Miner K. Kellogg, reported "...passing through mesquite trees in plenty–and increasing groups of cacti, the fruit red but unripe." When they reached present day Archer County they encountered increasing numbers of dead mesquite trees. Kellogg also commented on "...cross open prairie ascending, making our road through tufty [*sic*] tall grass." The nature of the grass made travel with the mules and wagons difficult and they saw little wildlife other than some fawns, quail, grasshoppers, and snakes. They also commented on seeing buffalo tracks although they said it was the wrong season to see them. Later, some scouts reported seeing three bull bison. Kellogg reported seeing some fine mesquite grass and various species of cactus. The notes of Kellogg repeatedly complain about the nature of the grass (in tufts) that made travel difficult with the wagons. He commented "Mules go revenously [*sic*] into the fine mesquite grass." He also said "Grasses exhibit a great variety." There were few photos found of the expedition but one showed the dead mesquite trees in Archer County and another the rocky eroded landscape of Copper Gulch and the fairly open habitat of Kiowa Peak.

Discussion. It is apparent from the few photos available that the habitat was somewhat more open than is common in the native habitats of today. The habitat descriptions of these early explorers lack sufficient detail to provide any quantitative data about the nature of the habitat in the 19th Century. Most likely, the area had less extensive mesquite and more grassland and definitely almost no agricultural land in the areas traversed. The explorer's comment on the presence of bison also reinforced that these large mammals, with the grazing effect of large herds and their wallowing activities, might have provided more suitable habitat for the Texas kangaroo rat. Stangl et al. (1992) commented on the probable role of bison in creating conditions that would be favorable to *Dipodomys elator*.

CURRENT HABITAT

Results. The Texas kangaroo rat was found most frequently in habitats that were open and with a considerable amount of short grass or, alternatively, vegetation that was indicative of a disturbed area. We were surprised on several occasions in Motley County to find *Dipodomys elator* at the edges of cotton fields with only small areas of grasses and forbs in the area between the field and the dirt section road. In Childress County, we saw a Texas kangaroo rat in an area that was surrounded on three sides by very large and barren agricultural fields with only a tiny bit of natural vegetation alongside the section road. We also, in marked contrast, saw the Texas kangaroo rat in areas with very dense grass cover (principally Sudan grass in nearby fields and Johnson grass on the roadsides) and very little open ground. The Long Ranch, south of Quanah (Hardeman County), and areas ENE of Childress (Childress County) appeared to have the most suitable native habitat for this species during the years of the surveys although not necessarily the greatest number of sightings. We also, prior to the present study, found the Texas kangaroo rat utilizing open areas created by the activity of oil service crews (margins of well pads, edges of oil field service roads) and using oil field pipes on the ground as places for refuge. Illustrations of habitat are referenced in the **krimages.mdb** database appended to this report. The JPEG images, keyed to the database, are in a directory named **KRATPHOT**.

Table 8.– Soil name associated with sites (exclusive of trapping) where individuals of *Dipodomys elator* were observed, captured and released, or salvaged in Archer, Motley, and Hardeman counties, Texas, from 1996 to 2000. Information on localities for two individuals of *Dipodomys ordii* are included for comparision. Information on Childress and Wichita county records is not yet included. Specific locality information for these records can be found in the *Access* database, *desurv.mdb*.

Record Number	Soil Type	Soil Name	General Texture Class	Per cent Particle Size*		
				250 m	63-250 m	63 m
Dipodomys elator						
Archer County						
9608181	KaB	Kamay Silt Loam	Silt loam	30.42	46.96	22.61
0008241	DsA	Deandale Silt Loam	Silt loam	3.36	93.72	2.92
Hardeman County						
9607102	WeB	Weymouth Clay Loam	Clay loam	33.34	57.68	8.99
9708053	O1A	Olton Loam	Loam	NP**	NP	NP
Motley County						
9608142	AsB	Aspermont Silty Clay Loam	Silty clay loam	29.63	57.50	12.87
9608143	AsB	Aspermont Silty Clay Loam	Silty clay loam	18.59	64.55	16.85
9608144	AsB	Aspermont Silty Clay Loam	Silty clay loam	5.15	73.34	25.92
9908141	AbA	Abilene Clay Loam	Clay loam	46.50	46.66	6.82
9908142	AbA	Abilene Clay Loam	Clay loam	NP	NP	NP
0008281	AbA	Abilene Clay Loam	Clay loam	78.72	18.23	3.05
0008282	AbA	Abilene Clay Loam	Clay loam	67.24	29.98	2.79
0008283	AbA	Abilene Clay Loam	Clay loam	56.17	35.95	7.87
0008284	AbA	Abilene Clay Loam	Clay loam	47.82	41.82	10.36
0008285	AbA	Abilene Clay Loam	Clay loam	61.99	31.31	6.71
Dipodomys ordii						
Cottle County						
9608145	Wu	Woodward & Quinlan Loams	Loam	16.88	72.81	10.30
Motley County						
9608141	MfB	Miles Fine Sandy Loam	Sandy Loam	64.03	32.29	3.69

* Per cent totals may not equal 100.0 because of rounding. ** NP = sample not yet processed

Table 9.–Soil names and particle size distribution associated with selected grid-trapping sites where individuals of *Dipodomys elator* were captured and released in Hardeman County, Texas, from 1986 to 1998.

Site & Sample No.	Soil Type	Soil Name	General Texture Class	Per cent Particle Size*		
				250 m	63-250 m	63 m
Long Grid						
862033	TmB	Tillman Clay Loam	Clay loam	64.02	33.172.80	
862025	TmB	Tillman Clay Loam	Clay loam	35.14	58.466.39	
North Grid						
864122	OcB	Olton Clay Loam	Clay loam	66.04	32.301.66	
864123	OcB	Olton Clay Loam	Clay loam	54.83	41.403.77	
864124	OcB	Olton Clay Loam	Clay loam	62.81	33.713.48	
864132	OcB	Olton Clay Loam	Clay loam	53.46	43.493.05	
864133	OcB	Olton Clay Loam	Clay loam	50.41	36.463.12	
864143	OcB	Olton Clay Loam	Clay loam	55.05	42.732.21	
864152	OcB	Olton Clay Loam	Clay loam	58.81	38.722.47	
864153	OcB	Olton Clay Loam	Clay loam	56.16	40.323.51	
864154	OcB	Olton Clay Loam	Clay loam	51.35	64.352.77	
South Grid						
864022	TmB	Tillman Clay Loam	Clay loam	43.13	53.673.19	
864023	TmB	Tillman Clay Loam	Clay loam	36.44	59.304.26	
864025	TmB	Tillman Clay Loam	Clay loam	34.54	61.503.96	
864045	TmB	Tillman Clay Loam	Clay loam	34.49	57.997.53	
864044	TmB	Tillman Clay Loam	Clay loam	41.31	50.668.03	
864043	TmB	Tillman Clay Loam	Clay loam	41.90	53.554.56	
864042	TmB	Tillman Clay Loam	Clay loam	41.75	52.815.46	
864035	TmB	Tillman Clay Loam	Clay loam	50.44	45.853.71	
864033	TmB	Tillman Clay Loam	Clay loam	49.21	47.563.22	

* Per cent totals may not equal 100.0 because of rounding.

Particle-size analyses of soil samples collected on road surveys revealed that the Texas kangaroo rat occurred in a broad range of soil types that typically are classified by soil scientists as silt loam, silty clay loam, clay loam, loam, and sandy loam (Table 8). We did not find them in areas with the type of soil usually associated with sand dunes or sand drifts. On the long-term grid sites, all captures of *Dipodomys elator* were in soils classified as clay loams (Table 9).

On the live-trapping grids in Hardeman County, the burrows of *Dipodomys elator* were typically found associated with several species of shrubs (*Condalia* sp. and *Ephedra* sp.) and mesquite (*Prosopis glandulosa* var. *glandulosa*), under large to medium-sized rocks, and on the edges of dry washes. Upon release, animals quickly ran to a nearby burrow but at times did not immediately go into the burrow. This behavior may reflect that the closest burrow might not have been the home burrow. On one occasion, we noticed that a kangaroo rat entered a burrow and immediately was chased out by another kangaroo rat already inside the burrow. We also noticed that burrows were sometimes situated in very bare areas with little vegetation of any kind nearby. In other areas, burrows, when found, were often at the edges of ditches along the edges of dirt roads. Rarely did we find burrows in site surveys by day during the period 1995 to 2000, although these burrows were much more evident in the years 1986 to 1990.

During the study, there was considerable variation in the amount of bare ground on the three long-term grids and the amount of precipitation associated with these cover values (Figs. 1-3).

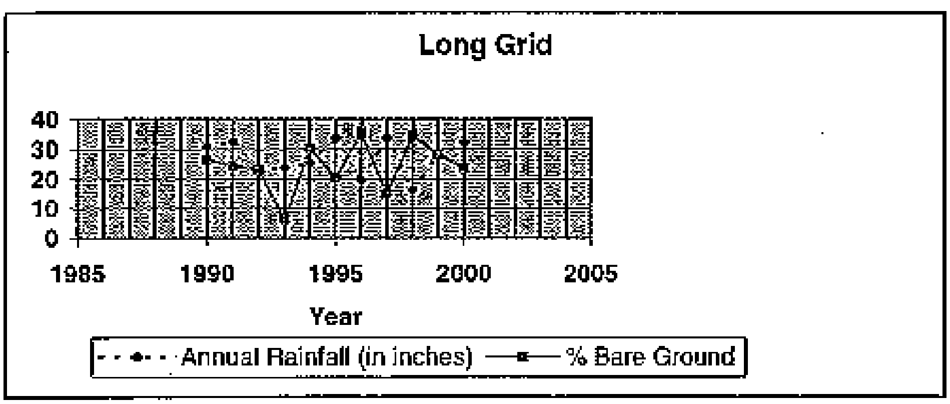

Figure 1. Annual rainfall and bare ground cover on the Long Ranch grid, Hardeman County, Texas.

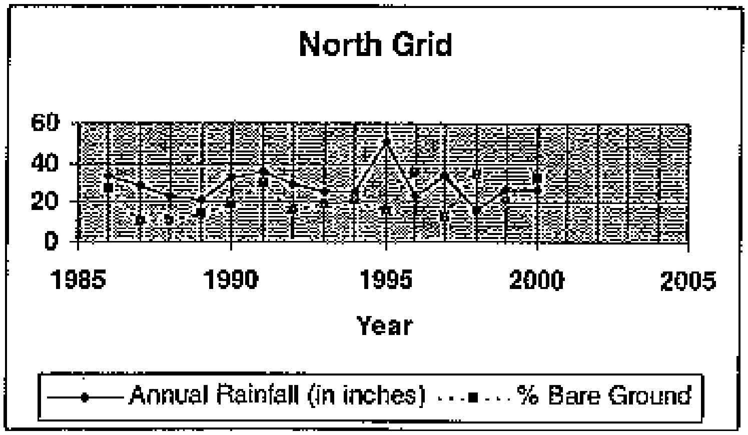

Figure 2. Annual rainfall and bare ground cover on the North Grid, Holcomb Ranch, Hardeman County, Texas.

Cover of grasses and forbs on the grids generally increased during years of high rainfall although the appearance of that vegetative cover in a given year was dependent on when that rainfall occurred. Vegetative cover, and inversely the amount of bare ground, on the North Grid (Table 10; Figure 2) and the South Grid (Table 11; Figure 3) increased extensively during the years of the study although there was considerable variation in this pattern when rainfall was lower than normal. The Long Grid (Table 12; Figure 1) showed a similar pattern but it generally had a higher overall amount of bare ground during the 15 years of the study compared with the North and South grids (Figs. 2 & 3). The mesquite on this grid was removed by root plowing in 1985 but some recovery of the mesquite had occurred by the end of the grid sampling in 2000.

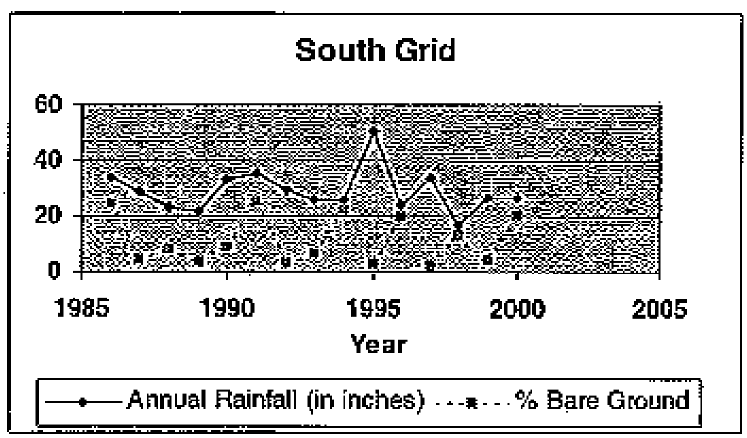

Figure 3. Annual rainfall and bare ground cover on the South Grid, Holcomb Ranch, Hardeman County, Texas.

Table 10.– Changes in plant cover, North Grid, Hardeman County, Texas, 1986-2000. Data represent summary of sixteen 500-cm transects. Percentage values are rounded to the nearest 0.1 cm.; totals may exceed 100.0 because of overlap of forbs and grasses.

Year	Per Cent Grasses	Per Cent Forbs	Per Cent Bare Ground
1986	64.7	12.4	27.6
1987	84.5	14.9	11.1
1988	80.1	18.7	11.5
1989	81.8	11.1	14.4
1990	77.2	8.2	19.7
1991	64.1	8.7	30.4
1992	76.8	24.6	16.3
1993	70.5	25.2	19.3
1994	74.3	8.5	21.7
1995	75.5	20.3	16.1
1996	63.8	2.1	35.2
1997	84.6	9.8	13.2
1998	58.7	8.9	34.8
1999	62.8	36.8	21.3
2000	65.9	3.5	32.6

Table 11.– Changes in plant cover, South Grid, Hardeman County, Texas, 1986-2000. Data represent summary of sixteen 500-cm transects. Percentage values are rounded to the nearest 0.1 cm.; totals may exceed 100.0 because of overlap of forbs and grasses.

Year	Per Cent Grasses	Per Cent Forbs	Per Cent Bare Ground
1986	72.0	4.4	24.0
1987	92.1	30.2	4.2
1988	82.0	22.6	8.1
1989	88.9	21.3	3.9
1990	85.2	14.4	8.6
1991	69.6	11.6	25.3
1992	88.7	62.9	2.9
1993	82.7	28.9	6.3
1994	72.6	11.7	22.5
1995	91.6	50.0	2.7
1996	78.4	4.1	19.9
1997	96.1	19.4	2.5
1998	83.8	8.8	12.5
1999	88.9	32.4	4.6
2000	79.6	2.6	19.8

Table 12.-- Changes in plant cover, North Grid, Hardeman County, Texas, 1986-2000. Data represent summary of sixteen 500-cm transects. Percentage values are rounded to the nearest 0.1 cm.; totals may exceed 100.0 because of overlap of forbs and grasses.

Year	Per Cent Grasses	Per Cent Forbs	Per Cent Bare Ground
1986	66.1	11.1	30.1
1987	73.7	20.2	16.1
1988	80.2	1.5	16.8
1989	67.1	11.4	27.7
1990	72.3	4.2	26.6
1991	74.7	5.0	24.3
1992	69.3	24.9	23.2
1993	82.7	28.9	6.3
1994	65.4	8.0	30.1
1995	76.7	9.3	20.2
1996	63.4	0.9	35.5
1997	81.8	3.8	14.7
1998	61.4	4.2	34.4
1999	47.9	35.4	28.3
2000	75.4	2.5	23.6

There was some anecdotal evidence that the placement of a large liquid feeder by the agricultural leaseholder created openness in the habitat that favored the return appearance of *Dipodomys elator* on the South Grid. Cattle, attracted to the feeder, created a bare area for a radius of 5-6 meters away from the edges of the large tank. Shortly thereafter, a single male *Dipodomys elator* was captured twice near this tank in 1994 despite the overall grass-covered nature of the rest of the grid (that in previous years and subsequently did not support any population of *Dipodomys elator).* Other man-made clearings of the habitat (bulldozing by a pipeline crew) on both the North Grid and the South Grid were not followed by a reappearance of the Texas kangaroo rat on these girds after these populations had previously fallen to zero.

One of the study grids (HOL05) experienced a fire due to apparent trespassers playing with fireworks in July of 1993. Because of the dryness of the habitat the fire was particularly devastating to most of the rodents found on this grid. At the time of the fire, no Texas kangaroo rats were known to be resident on this grid although one individual was caught on the grid in July 1986. When live trapping was ended on this grid in 1994, the wood rat (*Neotoma micropus*) population had not recovered (the fire completely destroyed the dens of these rats), although cotton rats (*Sigmodon hispidus*) and white-footed mice (*Peromyscus leucopus*) had returned to the site. No *Dipodomys elator* were captured on this site in July 1993 or in 1994, despite the low-level of grass cover on the grid following the fire in 1993.

Discussion. Our observations on the apparent habitat preferences of *Dipodomys elator* agree with many previous studies and, in particular, the observations and results obtained by Stangl et al. (1992) in their studies in Wichita County, Texas. Previous researchers commented on the association of *Dipodomys elator* with mesquite as sites for burrows or cover (Bailey, 1905; Chapman, 1972; Martin and Matocha, 1972). Stangl et al. (1992) pointed out that the Texas kangaroo rat is more opportunistic in its habitat requirements and often utilizes man-created structures such as terraces, old homesteads, and the edges of oil service roads as places to put their burrows. We agree with the observations of Stangl et al. that *Dipodomys elator* is capable of taking advantage of clearings provided by man when such cleared areas are adjacent to some areas of native habitat. However, for this effect to work, there must be some resident population of the kangaroo rats in the area since clearings on two of our grids (North and South) when the populations were already depressed to zero levels did not result in any subsequent appearance of the rats in two out of three clearing events (twice with pipeline crews and once with the rancher's placement of a large feeder tank). Should sizeable populations of the Texas kangaroo rat be discovered, we feel it would be useful to do some selective opening and clearing of the habitat much as Price et al. (1994a) conducted as a management strategy for improvement of the habitat of the Stephen's kangaroo rat, *Dipodomys stephensi*.

We also observed , as did Stangl et al.(1992) that root plowed mesquite pastures (such as the site of the Long Grid) still supported small populations of *Dipodomys elator*. Over the years of the study, the root-grubbed mesquite grew to the size of small bushes (generally less than 1 meter). The Texas kangaroo rat was also observed in Childress County and in Motley County living in very close association with extensive agricultural fields that had only a small quantity of native habitat nearby. Thus, as Stangl et al. (1992) astutely pointed out, the Texas kangaroo rat has a broader habitat tolerance than was previously thought by earlier workers.

Likewise, we found the range of soil types utilized by *Dipodomys elator* to be broader than the clay soils or clay loam soils typical of localities where other workers found this species. But Roberts and Packard (1973) and Martin and Matocha (1991) found more flexibility in the types of soil where the Texas kangaroo rat occurred. For example, Martin and Matocha (1991) noted that a Motley County record of the species was found at a site that contained 79.0% sand, 12.1% silt, 8.9% clay, and 2.7% organic matter. In contrast, soils at study sites in Hardeman County had ranges of sand, silt, and clay of 28.0 to 33.8%, 36.7 to 48.0%, and 22.0 to 31.4%, respectively. Earlier, Roberts and Packard (1973) noted that *Dipodomys elator* was not found in the dunes of the Red River where their soil particle analysis showed a sand:silt:clay distribution of 90.57%:6.88%:0.85% ; however, away from the dunes of the Red River, they found the Texas kangaroo rat at a site near Iowa Park Lake where the soil texture analysis revealed a sand:silt:clay distribution of 90.57%:7.88%:1.56%. Roberts and Packard (1973) suggested that the presence of sand does not appear to be as limiting for this species as is the necessity of a minimum of clay for successful burrowing. The results of our soil analyses also suggest that *Dipodomys elator* occurs in a fairly broad range of soil types but always with some soils with fine particle size present (Tables 8 & 9). In contrast, the Ord's kangaroo rat, *Dipodomys ordii*, is well known to occupy habitats with a greater percentage of sand in the soil profile (e.g., Root, et al., 2000). Whether *Dipodomys ordii* and *Dipodomys elator* actively interfere with each other's use of space is unknown and not readily testable given the current depressed population densities of the Texas kangaroo rat.

Simons (1991) and Fitzgerald (2001) found that *Dipodomys merriami* recovered from the effects of fire and actually increased in numbers following a burn. In contrast, Simons (1991) found that populations of the white-throated wood rat (*Neotoma albigula*) were seriously depressed following the fire even though populations of this species increased in a nearby unburned area. These studies suggest that while fire can be an important management tool for control of brush, and may actually enhance numbers of some species of rodents, it can have devastating effects on other species such as wood rats.

POPULATIONS

Results. From 1986 to 2000, the population density of *Dipodomys elator* on the North and South grids dropped to zero (Fig. 4 & 5). We suspect that this precipitous decline was the result of a change in the vegetative cover on these grids from relative openness in 1985 and 1986 to a condition of heavy grass cover by 1989. Overall, the MNKA of the Texas kangaroo rat on the North Grid dropped from ca. 15 individuals on the 1.96 ha grid to zero by 1989. Density wise, the peak numbers reached ca. 7.6 individuals/ha (Fig. 4).

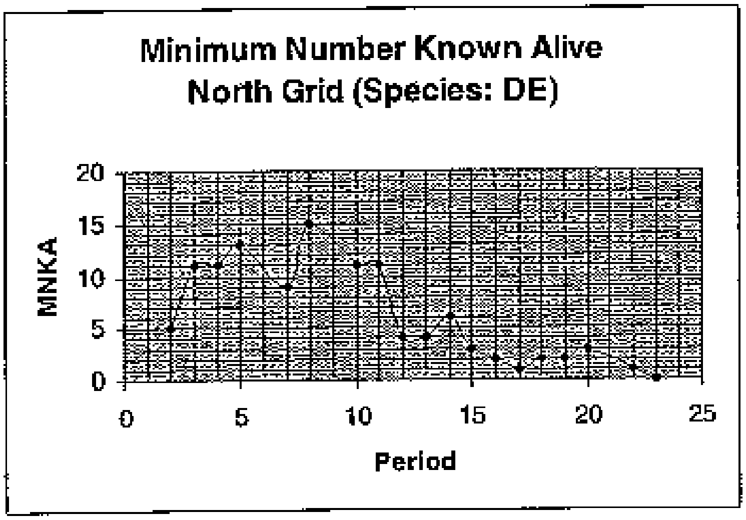

Figure 4. MNKA individuals of *Dipodomys elator* on the North grid, Holcomb Ranch, Hardeman County, Texas, from December 1985 (period 2) to January 1990 (period 23). Divide by values by 1.96 (area of grid) to get density per hectare.

The South grid showed a similar precipitous decline to zero by 1988 (Fig. 5) although one male individual was trapped twice on the South grid during 1994, following the rancher's installation of a cattle feeding tank on the edge of this grid.

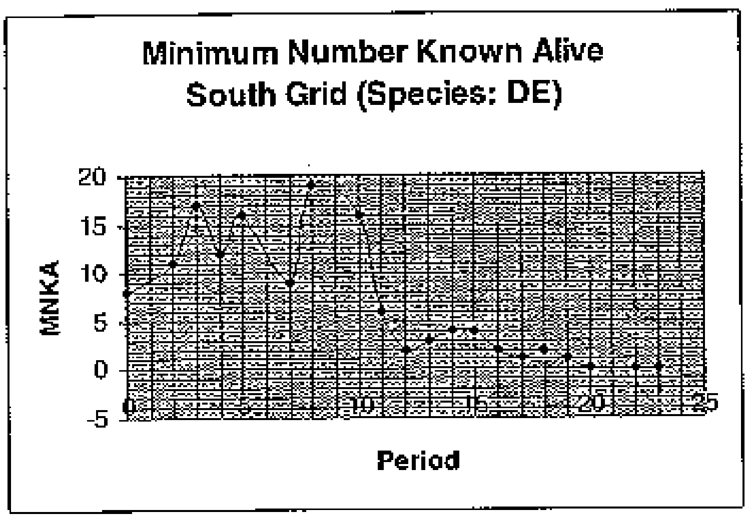

Figure 5. MNKA individuals of *Dipodomys elator* on the South grid, Holcomb Ranch, Hardeman County, Texas, from December 1985 (period 2) to January 1990 (period 23). Divide by values by 1.96 (area of grid) to get density per hectare.

Densities on the Long grid were low and sporadic during the 15 years of sampling (Table 13) but numbers on that grid also declined to zero density by July of 1999 and maintained that number in July 2000.

Table 13.-- Number of trap nights and individuals of *Dipodomys elator* found, live trap grids, Hardeman County, Texas, 1986-1995. NA= not applicable.

Grid	Years Trapped	Number Trap Nights	Individuals*	Years D. *elator* Found on Grids
CB01	1986	108	0	NA
HOL03	1986	108	0	NA
HOL04	1986	108	0	NA
HOL05	1986-1994	1082	1	1986
Long	1986-1995	1080	13	1986, 1989, 1991, 1993, 1994, 1997, 1998
North	1986-1995	5248	38	1986, 1987, 1988, 1989
South	1986-1995	5248	40	1986, 1987, 1988, 1994
KingW	1986-1993	864	2	1986
KingE	1986	864	0	NA
WilsonN	1986-1993	756	6	1986, 1988, 1990, 1991, 1992
WilsonS	1986	108	0	NA
	TOTALS	14,818	100	

* This is the number of all individual *D. elator* live-trapped on the grids for all years of sampling and not the minimum number known alive (MNKA) for a given census.

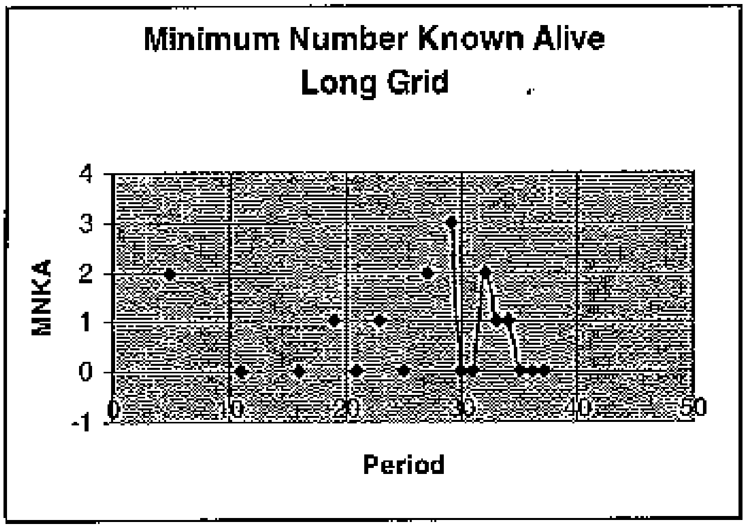

Figure 6. MNKA individuals of *Dipodomys elator* on the Long grid, Long Ranch, Hardeman County, Texas, from July 1986 (period 5) to July 1997 (period 38). MNKA values are equivalent to number per hectare on this 1.0 ha grid.

Discussion

Published reports on population numbers (Roberts, 1969; Roberts and Packard, 1973), reveal densities of 2.0 to 5.7 per hectare based on absolute grid sizes of 0.29 to 0.63 hectares. For grid sizes unadjusted for movements, these density estimates are similar to those noted in the Hardeman County portion of the range during 1986 and 1987 (Martin and Matocha, personal communication), a period of high density during 15 years of sampling at those sites. Perhaps significantly, the peak densities reported in 1986 and 1987 appear to be substantially less than numbers reported for the endangered *Dipodomys stephensi*, a California species (McClenaghan and Taylor, 1993). Cross and Waser (2000) found that three nights of trapping were generally adequate to detect most individuals on their sampling grids. We generally used this number of trapping days in the sampling of all grid sites unless severe cold weather caused an earlier shutdown of the trapping efforts. It is possible that a different type of trap might have produced greater captures on the grids since Kay (1998) found that mesh traps captured more *Dipodomys* than did Sherman traps. However, given the modest size of *Dipodomys elator*, the animals were generally caught in the traps if they were present on the grids. The decline in the number of Texas kangaroo rats caught on the live-trapping grids appeared to be a general decline in their numbers and not related to lack of susceptibility of the animals to enter the traps.

PERSISTENCE

Results. In rodent population studies, it is difficult to separate the effects of mortality from dispersal. Thus, in most live-trapping studies, the length of time that an individual persists on a grid prior to its loss from either mortality or dispersal is called persistence. Consequently, values of persistence are not directly comparable to survivorship because of the possible role of dispersal.

Most individuals of *Dipodomys elator* were captured either as fully grown adults or as subadults (individuals probably about six months of age or younger). Maximum persistence was of the order of 15 to 17 months from time of first capture as adults. This would suggest that longevity (if measurable by persistence data) is at least two years. Of the 100 different individuals of *Dipodomys elator* examined on the grids, no more than 12 to 13 were present at any time on any given grid. Thus, some turnover is occurring on the sites whether it is due to mortality or to dispersal.

Discussion. In the similar-sized Merriam's kangaroo rat (*Dipodomys merriami*), Zeng and Brown (1987) found that persistence curves (presumably death and dispersal) were roughly linear with time for the first 15 months of life and then declined less steeply during months 15 to 42. They found maximum survival in these rats to be from 36 to more than 42 months. Interestingly, all of their long-lived individuals were females. We did not have any individuals of either sex to approach the longevity exhibited by individuals in the population studied by Zeng and Brown (1987).

REPRODUCTION

Results. Fifty per cent or more of males showed scrotal testes in the months of May, July, and December; fewer than 25% had scrotal testes in the months of January & November. Evidence of pregnancy and lactation was present in females in the months of March, May, and July. Previous work indicated that the mean litter size in *Dipodomys elator* averages 2.7 ± 0.8 (mean ± SD) young (Matocha and Martin, *pers. obser.*), reflecting a small to modest reproductive output. Matocha and Martin also found evidence of embryos in the months of January, February, June, July, September, and December. These data suggest that the breeding season is prolonged and probably includes at least two periods when young are produced (spring/summer litters and fall litters).

Discussion

General reproductive trends were analyzed by Webster and Jones (1985) from analysis of specimen tag data. These reproductive trends suggest that the species has a low average litter size. Wahl and Best (1987) also found evidence of embryos in *Dipodomys elator* in the month of March. The apparent prolonged breeding season with seasonality in *Dipodomys elator* is similar to what has been observed in *Dipodomys merriami* (Kenagy and Bartholomew, 1985; Zeng and Brown, 1987).

PREDATION

Results. No direct predation was observed on the Texas kangaroo rat during the course of the study. Potential predators in the area include the coyote (*Canis latrans*), whose scat was observed and collected along a 1700 meter (1.7 km) transect during censuses of the North and South grids. Analysis is pending on these collections of scat (Kenneth G. Matocha, *pers. comm.*). We also observed on occasion in the vicinity, badgers (*Taxidea taxus*) and aerial predators such as Swainson's hawk (*Buteo swainsoni*) and Red-tailed hawk (*Buteo jamaicensis*), although we doubt that these diurnal predators would be effective in capturing the nocturnal *Dipodomys elator*. Barn owls (*Tyto alba*) deposited pellets in a roost approximately 1 mile from the North and South grids; no owl roosts were found near the Long grid. Preliminary analyses of these pellets revealed a small percentage (generally less than 15% of *Dipodomys* (John Chapman, personal obs.). It is possible that some of the skeletal remains of *Dipodomys* in the pellet samples that have been analyzed represent those of Ord's kangaroo rat (*Dipodomys ordii*), since the Red River, with sandy soils, lies less than 5 miles north of the owl roost. We have also observed on the Long, North, and South grids western diamondback rattlesnakes, *Crotalus atrox*, and have seen bull snakes (*Pituophis melanoleucus*) in the vicinity, all of which are capable of capturing individuals of *Dipodomys*. In areas near cities and towns, it is suspected that house cats might pose a threat to *Dipodomys elator*.

Discussion.
Windberg and Mitchell (1990) analyzed the scats of coyotes in South Texas and found that small rodents comprised about 30% of the diet of these predators. Of the small rodents, only 4.3% of the samples contained kangaroo rats (*Dipodomys ordii*). This suggests that coyotes do not rely heavily on these rodents as a food source or else the kangaroo rats are more adept at avoiding capture than some other species of rodents.

Pesaturo, et al. (1989) and Manning and Jones (1990) analyzed Barn owl (*Tyto alba*) pellets collected, respectively, in Lamb and Crosby counties, Texas. Pesaturo, et al. (1989) found that *Dipodomys ordii* made up 15.6% to 19.6% of the prey remains in the pellets, exceeded only by *Perognathus* sp. and *Reithrodontomys* sp. Manning and Jones (1990) found, on three different collection dates, that *Dipodomys ordii* comprised 2.7%, 3.5%, and 20.0% of the pellets analyzed. On these collection dates, they found that the heteromyid *Chaetodipus hispidus* and *Perognathus flavus*, and the cricetines *Reithrodontomys montanus* and *Baiomys taylori* generally accounted for a significantly greater proportion of the prey ingested by the owls compared with the number of *Dipodomys* ingested.

We suspect that domestic cats would pose a threat to populations of the Texas kangaroo rat only near cities and towns. Congdon and Roest (1975) said that some of the reduction in the populations of the Morro Bay kangaroo rat (*Dipodomys heermanni morroensis*) was due to "...increased predation by domestic cats which frequently hunt in the fields near developed areas." Burke et al. (1991) reported that predation by domestic and feral cats posed a threat to populations of the endangered Stephen's kangaroo rat, *Dipodomys stephensi*. However, in most of the areas where individuals of *Dipodomys elator* were observed or live trapped in this project, the threat from domestic cats seemed minimal since these locations were distant from nearby houses or residential areas where these efficient predators might be expected to occur.

Rattlesnakes are capable of taking *Dipodomys* but generally do so in small numbers (Pierce et al., 1992). This may be partly due to their ability to jump and move rapidly when approached in open areas (Munger et al., 1983). We did note on the Long Grid that a marked kangaroo rat disappeared on the grid shortly after we observed a large rattlesnake (*Crotalus atrox*) within 10 meters of the last capture site for the rat. This observation is not proof of predation but it did cause us to wonder if the disappearance of the rat on the grid might have been due to the presence of the rattlesnake in the immediate vicinity.

DISEASE AND PARASITES

Results. No direct evidence was gathered on diseases of *Dipodomys elator*. None of the individuals that we examined appeared to be ill or suffering from any disease condition. Ectoparasites, primarily fleas, were occasionally seen on *Dipodomys elator*. We did not see any evidence of infestations by fly larvae in the several hundred live individuals that were examined. We did not try to determine levels of endoparasites in these animals.

Discussion.
Biggins and Kosoy (2001) and Gage et al (1995) summarized information on the effect of plague, caused by *Yersinia pestis*, in rodents. These authors said that although *Dipodomys* can become infected with this organism, individuals generally seroconvert and few animals become ill and probably only rarely suffer morbidity or mortality during epizootics. Thus, it is not expected that the decline in the population numbers of *Dipodomys elator* is due to any effect of the plague organism. A precipitous decline in a population of *Dipodomys spectabilis* in Arizona was associated with damage to seed stores and possible effects of increased mycotoxins in the stores as the damaged seeds became infected with fungi (Valone et al., 1995). Some of the ectoparasites found on *Dipodomys elator* were noted by Lewis (1970), Dalquest and Horner (1984), and Thomas et al. (1990). Garner et al. (1976) found that individuals of *Dipodomys ordii* infested with cestodes had a reduced amount of axillary and groin fat.

ACTIVITY

Results. We did not test activity levels of kangaroo rats during the study. All road surveys and trapping on the grids and survey trapping was done during periods of the new moon or a few days before or after that lunar event. We did not note much activity of kangaroo rats early in the evening hours until twilight had ended. The Texas kangaroo rat was active most of the dark hours of the night and we frequenty saw them until just slightly before dawn in the morning hours. Extreme cold did not seem to reduce trapping success but rainfall and high wind had a negative effect on trapability since these events sometimes caused the live traps to close prematurely. All road surveys were done in the summer months so we were not able to monitor the effect of temperature on activity levels.

Discussion.
Bailey (1905), commenting on notes by Professor Lantz, suggested that *Dipodomys elator* was attracted by the lights of lanterns. More recent observations suggest that this species is inhibited in its activity by moonlight (Dalquest and Horner, 1988; Jones et al., 1988; Stangl and Schafer, 1990). However, the species is known to show some activity even on nights with considerable moon (Packard and Roberts, 1973). Chew and Butterworth (1964) stated that they did not find moonlight to affect the activity of *Dipodomys merriami*, although their Table 9 showed some decrease in activity on nights with a full moon. However, Kaufman and Kaufman (1982) saw an almost fourfold increase in sightings of *Dipodomys ordii* when there was only starlight and no moonlight. Our experience with the activity of *Dipodomys elator* suggests that they are much more active on dark nights or after the moon has set. We agree with Stangl et al. (1992) that any road surveys for this species must be conducted on dark

nights to maximize the effectiveness of the surveys and increase the efficiency of road surveys.

FOOD HABITS

Results. Our results suggest the the Texas kangaroo rat is an opportunistic seed gatherer. It collects whatever seeds are in abundance at a given time of year. We frequently observed the seeds of grasses and forbs in the cheek pouches of captured animals. Rarely, we would find cut pieces of green vegetation in the cheek pouches.

Discussion.
Bailey (1905), commenting on the notes of Prof. Lantz, reported that *Dipodomys elator* was found foraging in a field of Kafir corn and had seeds of this species along with seeds of *Solanum rostratum* in its cheek pouches. Dalquest and Collier (1964) found seeds of the goathead, *Tribulus terrestris,* in the cheek pouches of the Texas kangaroo rat. Chapman (1972) examined 213 specimens of *Dipodomys elator*, of which 52 contained food items in their cheek pouches. Chapman found the seeds of grasses in 70 per cent of the samples, with cultivated oats (*Avena sativa*) and Johnson grass (*Sorghum halepense*) most common. Cut stems of grasses were also found as were the leaves and immature fruits of stork's bill (*Erodium circutarium*). In April and May, the mature inflorescence and fruits of broomweed (*Xanthocephalum texanum*) and bladder pod (*Lesquerella gracilis*) were also selected. The seeds of buffalo bur, *Solanum rostratum*, were also collected after the spine-covered fruit had ruptured. Many of these species are indicators of overgrazing or disturbance in the habitat. Chapman found little evidence of the use of perennial shrubs by *Dipodomys elator* although these species were common in the study area. Chapman (1972) suggested that mesquite probably is used more for cover than for food.

ASSOCIATED SPECIES

Results. There are two other species of heteromyids that were captured on the long-term trapping grids. The hispid pocket mouse (*Chaetodipus hispidus*) is about half the body mass of the Texas kangaroo rat; the tiny Merriam's pocket mouse, *Perognathus merriami*) has an adult mass of only 8-10 grams. Generally, *Perognathus merriami* was found in greatest numbers and in similar habitat to that of *Dipodomys elator*. The hispid pocket mouse was captured sporadically on the grids and always in much denser vegetation than the sites where the Texas kangaroo rat was captured. As the numbers of Texas kangaroo rats declined on the grids, so did the numbers of Merriam's pocket mice. As *Dipodomys elator* numbers declined in late 1987 on both the North and South grids, the number of *Chaetodipus hispidus* on these girds rose moderately. The increase in numbers of the hispid pocket mouse in late 1987 to 1989 was associated with an increase in the amount of grass cover on the North grid (Table 10) and South grid (Table 11).

The white-footed mouse, *Peromyscus leucopus* reached higher densities in the winter months but the hispid pocket mouse, was at its lowest densities in the colder months as would be expected of a species that goes into torpor at reduced body temperatures. Any possible competitive effect between *Chaetodipus hispidus* and *Dipodomys elator* would most likely be expressed in the summer months when both species are active above ground. However, we have no experimental evidence to suggest that competition plays a role between these species.

Discussion. Communities of rodents that include both heteromyids and murids are exceeding diverse in North American and have been studied by many workers (see, e.g., reviews by Munger et al, 1983; long-term studies by Brown and Zeng, 1989; Heske, et al., 1993, 1994; Valone et al., 1995). Communities of heteromyid rodents typically have species that show little overlap in body mass (Jones, 1985; Brown and Zeng, 1987; Zeng and Brown, 1987; and Schmidly, et al., 1993). This pattern was similar in our study, with the tiny *Perognathus merriami* found along with the medium-sized *Chaetodipus hispidus*, and the much larger *Dipodomys elator*. Bleich and Price (1995) found that the larger *Dipodomys stephensi* was more aggressive than the smaller *Dipodomys agilis* in behavioral encounters. Packard and Roberts (1973) tested aggressive behavior between the Texas kangaroo rat and several species of murids (*Peromyscus* and *Reithrodontomys*) and heteromyids (*Perognathus* and *Chaetodipus* but not another species of *Dipodomys*). They found that *Dipodomys elator* actively avoided the cotton rat, *Sigmodon hispidus*, but only showed passive avoidance of the tested murids and heteromyids.

HOME RANGE AND MOVEMENTS

Results. Analyses of movement data on *Dipodomys elator* from 1985 to 1988 (Sheryl Bateman and Robert Martin, *pers. observ.*) suggests that the home range size (calculated by the minimum convex polygon method) has a *mean area* =0.28 ha for both sexes. Male home ranges were larger (*mean* = 0.30 ha) compared with those of females (*mean* = 0.16 ha). Male home ranges generally encompassed the home ranges of at least two females. There was little movement of individual *Dipodomys elator* between the North and South grids even though these grids were only about 200 meters apart. A single individual was caught both on the North and South grids during grid trapping in the 1980's. We also occasionally found individuals that originally were marked on the live trapping grids on ranch roads in the vicinity of these grids. Overall, however, movement of individuals on the grids was not extensive although they are capable of moving great distances in a short amount of time.

Discussion. Previous studies (Roberts, 1969; Roberts and Packard, 1973) of home range size in *Dipdomys elator* (*mean* of 0.08 hectares) reveal relatively small values for males (maximum home range 0.20 hectares) and females (maximum home range 0.18 hectares), although these estimates were based on relatively small grids (0.29 to 0.65 hectares). Price et al. (1994b) found that males of *Dipodomys stephensi* moved greater distances on average than did females but overall found the species to be relatively sedentary. The situation with *Dipodomys elator* is similar since individuals tended to be recaptured within a 40 to 80 meter radius. Perri and Randall (1999) also found that the home ranges of male *Dipodomys merriami* and *D. ordii* also tended to overlap the home ranges of several females.

ASSESSMENTS AND RECOMMENDATIONS

GENERAL ASSESSMENT

The Texas kangaroo rat has experienced an apparent significant decline in numbers in Hardeman County since 1986. Today, this species is found only in five Texas counties: Archer, Childress, Hardeman, Motley, and Wichita (and possibly in Knox County, based on Stangl and Schafer, 1990). The numbers of this species seem highest in the western portion of historic range and low in the central portions. The far eastern portion of the historic range in Texas and the populations in Oklahoma appear to be extirpated or at such low levels as to be undetectable by the methods used to survey mammal distributions. Jones et al. (1988), Stangl et al. (1992), Jones (1993), and Schmidly (2002) provide the most recent information on the status and habitat requirement of this species.

HABITAT ASSESSMENT

The habitat in the historic range of the Texas kangaroo rat has undergone several significant changes in the fifteen years of the study. For one, there has been an increase in the number of Conservation Reserve Program (CRP) fields and their associated dense grass cover that favors certain species of small rodents but not populations of *Dipodomys elator*. This pattern is particularly evident in Hardeman County, Texas. Further, most crop fields in the historic range of the species cover extensive areas (with some fields covering 320 to 640 acres) that are plowed and planted to monoculture (principally wheat, grain sorghum, and cotton). The edges of these fields do provide food (wheat, grain sorghum) and openness (cotton fields) but the interiors of these fields would be unlikely to support sustainable populations of the Texas kangaroo rat due to periodic deep plowing that would disturb and/or destroy burrow systems and possibly the rats themselves.

THREAT ASSESSMENT

Present and Potential Threats to Populations

At present, most populations of the Texas kangaroo rat are in the western end of its historic range (primarily Motley and Childress counties). These areas have low human population density and agricultural usage is primarily livestock grazing and cultivation of cereals (wheat and grain sorghum) and cotton. Conversion of range land to cultivated land is a potential threat in these areas although most of the cultivated fields have remained stable in these areas due to lack of incentives to convert range land to cultivated fields (commodity prices low; Department of Agriculture rules do not reward producers for converting land from grassland to cropland).

The Texas kangaroo rat may be unable to utilize areas that are low-lying and susceptible to flooding. All of the animals observed or salvaged or caught in live traps were on fairly level to gently sloping (1-3% slope) terrain and away from streams and places where water might collect. Andersen et al.(2000) found that *Dipodomys ordii* showed a marked reluctance to abandon their burrows when the site was flooded. If *Dipodomys elator* show a similar pattern that might pose a risk to their numbers should they occupy low-lying areas. Stock (1972), however, found that *Dipodomys elator* showed good swimming ability in laboratory tests.

Present and Potential Threats to Habitat

The Texas kangaroo rat is capable of utilizing small edges of habitat alongside fence rows and along highway rights of ways. If these small areas are cleared (by plowing or blading) or altered by road construction there could be significant loss of habitat for the Texas kangaroo rat since so little other habitat is suitable for the species in areas where fields are large and devoted to monoculture of wheat, grain sorghum, or cotton. The habitat in much of the historic range of the species is not suitable to maintain viable populations. This is primarily the result of land use patterns on rangeland that promote growth of grasses at the expense of openness of the habitat. Grazing of rangeland needs to be moderate to heavy to create the openness of the habitat that this species appears to favor. As rangeland conservation efforts succeed in increasing the density and coverage of grasses, the numbers of the Texas kangaroo rat appear to decline.

LAND OWNERSHIP AND RESPONSIBILITIES

Most of the land in the historic range of the Texas kangaroo rat is in private ownership. Historically the species is known to occur on state lands at Copper Breaks State Park but it has not been detected there since 1993. Further, the habitat in this park is presently not very suitable for the species due to the dense grass cover on much of the park land. Although periodic burning is conducted on the park land, to reduce the invasion of shrub species such as mesquite, the result of the burning long term is to increase the amount of grass cover and thus render the area less suitable for species of heteromyids such as *Dipodomys elator* and *Perognathus merriami* that favor areas of bare ground in the habitat.

MANAGEMENT POLICIES AND PRACTICES

Existing Regulatory Mechanisms

1. In Texas, the existing regulatory mechanisms seem sufficient to protect this species since it is a protected nongame species. We believe it should be considered a *threatened species* at the federal and international level.

CONSERVATION RECOMMENDATIONS

Maintain and Enhance Present Populations

2. Landowners in areas where the Texas kangaroo rat still occurs should be provided monetary incentives to create the necessary openness of habitat and cleared areas that appear to be favored by this species. This might involve the Landowner's Incentives Program of Texas Parks and Wildlife or other initiatives. Researchers know enough about the habitat requirements of this species to make meaningful recommendations to landowners about how to enhance their property for this species.

3. Rangeland should be moderately to heavily grazed on these lands and open areas created by periodic blading of roads and by creation of earthen mounds (as suggested by Stangl et al., 1992).

4. Institute selective habitat modification in Copper Breaks State Park (Hardeman County), where the Texas kangaroo rat was last observed in 1993 and individuals were found close to the park in 1997. Our recommendation for active management would

be the grassland area next to Texas highway 6, near the entrance to the park, and portions of the equestrian area near Big Lake. This management would involve blading and grading to create open areas and places where the animals could construct burrows. Further, grazing intensity should be increased in these sites to reduce the amount of ground and grass cover. Landowners adjacent to the park should be contacted and encouraged to participate in the Landowner Incentive Program as a way to get added income for enhancing habitat for the Texas kangaroo rat on their lands.

5. In the historic range of the species, all personnel in state parks, wildlife management areas, and fish hatcheries should be made aware of the needs to the species (openness of habitat, suitable areas for burrow construction) so that they do not make management decisions that would negatively affect any populations that may be present in their jurisdictions.

6. The Texas kangaroo rat utilizes the edges of roadsides extensively as sites for burrows and for foraging. Thus, when roads, both paved and unpaved, are reworked or reconstructed, efforts should be made by the engineers of cities, counties, and the Texas Department of Highways and Transportation to provide a minimum of 5 to 6 foot (and preferably 10 to 12 foot) area between the fence line and any construction and dirt excavation and blading related to the construction project. It is important that this narrow strip *not be bladed at any time during this work* since to do so risks destroying burrow systems (and possibly animals contained therein). This simple step of providing narrow, undisturbed strips is inexpensive and can help maintain this species. Further, the nearby clearing efforts for the road construction adds openness to the habitat that is then followed by plant succession that results in an increase in forbs on the disturbed ground. The appearance of the forbs and other species characteristic of disturbed ground can then provide sources of food for this species. These animals are remarkably adaptable if we provide them with some needed "edge" near the fencelines.

7. In areas where there are no fences at property boundaries with public section roads (often observed in Childress and Motley counties) farmers should be discouraged from plowing the edges of their fields to the actual margins of dirt roads. This suggestion should be communicated to field personnel of the Natural Resource Conservation Service (NRCS) and to the Farm Service Agency of the United States Department of Agriculture so that they can advise farmers that are utilizing the public rights-of-way for crop land to stop this practice. The Texas kangaroo rat and other wildlife (game birds, horned lizards, and other species) utilize the edge between the fields and the road surface extensively. This small act can provide benefits to both the Texas kangaroo rat and to these other species as well.

Continue Biological Investigations

8. Biological studies should continue but in a manner that minimizes negative impact on the remaining populations. If sufficient populations can be found, it would be useful to

study the effect of habitat modification (selective removal of shrubs, blading of ground, creation of berms) to see if these treatments can enhance the populations as suggested by observations and research with other species of *Dipodomys*.

9. Removal sampling should be minimized for this species since its presence can be adequately detected by road surveys and, with significantly less success, by surveys using live traps. Road surveys should be conducted at dark times of the night (new moon ± 2 days) to increase the efficiency of the surveys and provide a better opportunity for documenting the presence of this species. At low population densities, these road surveys may be the most cost-efficient means to detect their presence.

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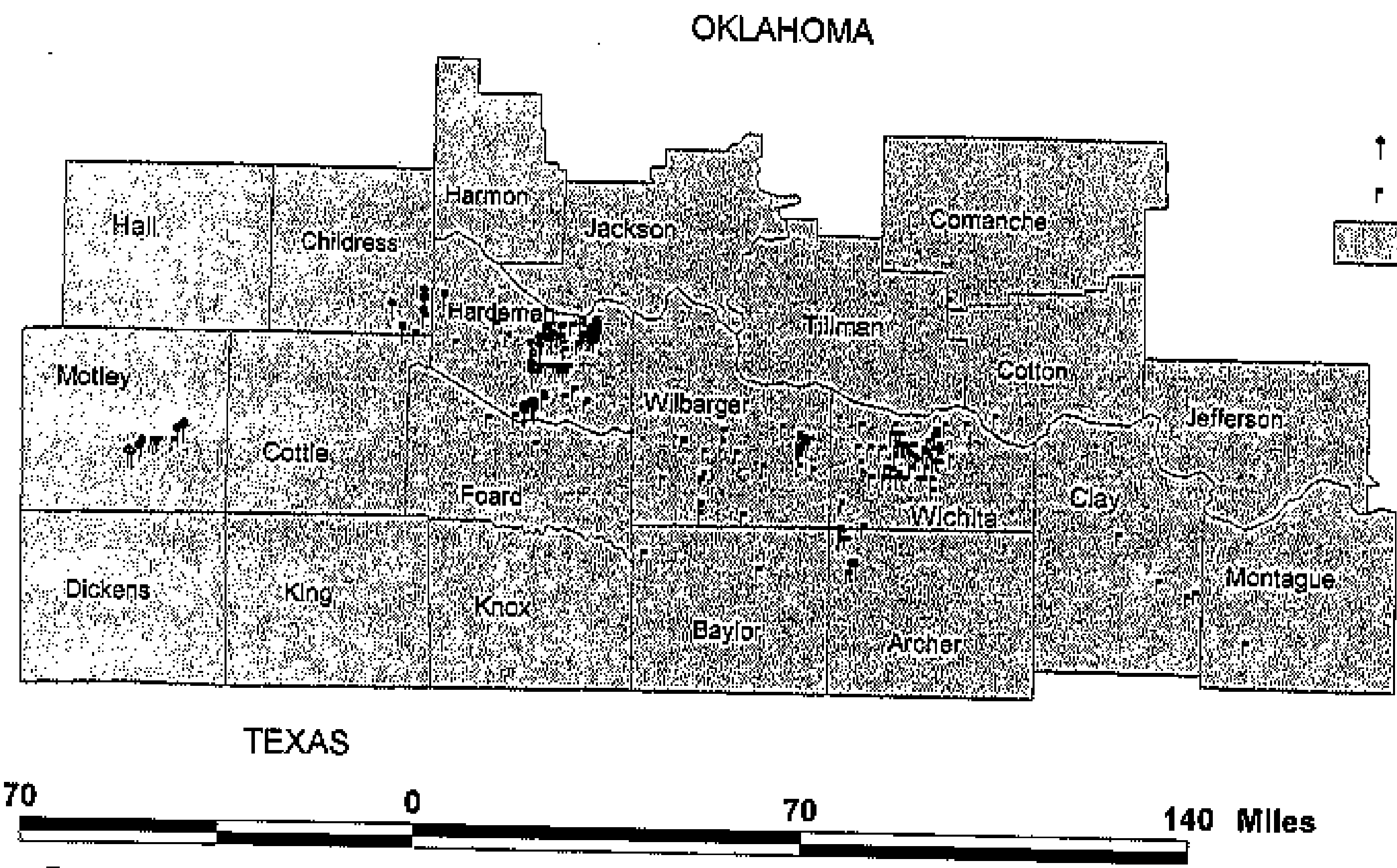
APPENDICES

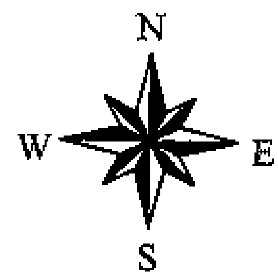
A. Databases of Historic Records of Occurrence (file: **lockrmus.mdb**)
B. Database of Captures, Salvage, and Sightings, This Study (file: **desurv.mdb**)
C. Database of Image Files, This Study (file: **krimages.mdb**)

Geographic Range of the Texas Kangaroo Rat Historic (blue) and Recent (red) Records



New localities
Historic localities
Counties

Points represent unique localities (loccode). Refer to databases for details on all records.



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North American Datum 1927
State Plane, Texas North Central Zone