U.S. Fish & Wildlife Service

2017 Black-Tailed Prairie Dog Inventory at the Rocky Mountain Arsenal National Wildlife Refuge

October 2017

The mission of the U.S. Fish and Wildlife Service is working with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people.

The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and, where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations.

CITATION

U.S. Fish and Wildlife Service. 2017. 2017 Black-Tailed Prairie Dog Inventory at the Rocky Mountain Arsenal National Wildlife Refuge. Commerce City, CO: U.S. Department of the Interior, Fish and Wildlife Service. 19 p.

(Cover Photo) Ray Fetherman, 2017

Introduction:

The black-tailed prairie dog (*Cynomys ludovicianus* or prairie dog) is an integral member of the short- and mixed-grass prairie ecosystem found on the Rocky Mountain Arsenal National Wildlife Refuge (Refuge). Prairie dogs alter their environment by excavating soil for elaborate underground tunnels and removing vegetation for forage and improved visibility. Their communal lifestyle forming large colonies creates habitat that can support other short-grass prairie species, such as burrowing owls and black-footed ferrets. Prairie dogs are essential to the health of the prairie ecosystem as they provide a prey base for many raptors and carnivores while improving the prairie nutrient value for other herbivores.

The Refuge is located on a site that was substantially disturbed by human activity. Restoration of short- and mixed-grass prairie is of primary importance at the Refuge (FWS 2013a). The historical disturbance resulted in an ecosystem with an abundant population of prairie dogs. This high number of vegetative consumers is in conflict with the larger goal of grassland restoration. Furthermore, high densities of prairie dogs are unhealthy for the colonies themselves. An epizootic event such as sylvatic plague spreading through the colony can be catastrophic, resulting in high rates of death. To achieve an ecological balance between a healthy prairie dog population and grassland restoration the Refuge has designated 2,995 acres as prairie dog habitat. For management purposes the prairie dog habitat has been divided into geographical zones (FWS 2013a, FWS 2013b). The Southwest Zone (SWZ) is comprised of parts of Sections 2 and 3. The Eastern Zone (EZ) contains parts of Sections 5,8,19,20,29,30, and 32. The Northwest Zone (NWZ) is comprised of parts of Sections 22, 27, and 28. A target density of 6-10 prairie dogs per acre in these zones is desired to prevent the overutilization of vegetation and promote the health of the prairie dog population (FWS 2013b). To determine prairie dog densities in the management zones, an inventory of black-tailed prairie dogs was initiated in 2014. The objectives of the inventory were to establish baseline densities of prairie dogs on the Refuge and to ensure sufficient prairie dog densities to support the reintroduction of black-footed ferrets (*Mustela nigripes*). A major factor of ensuring a sustainable ferret population at the Refuge is a reliable food source consisting, predominately, of black-tailed prairie dogs. The prairie dogs inventories will help to ensure a sufficient density of prairie dogs to support a population of black-footed ferrets on the Refuge.

Inventories will be conducted yearly or as needed to understand prairie dog densities, spatial distribution of the prairie dog complex, and the health of the prairie dog population on the Refuge. The data collected will be used to track changes or find trends in the prairie dog population that may lead to future management actions.

Purpose:

The purpose of this inventory is to determine black-tailed prairie dog distribution, densities, and population size within the management zones at the Rocky Mountain Arsenal National Wildlife Refuge as adopted in the Refuge's Habitat Management Plan (HMP) 2010 (FWS 2013a). The results of the inventory will guide future management decisions for the prairie dog populations in support of habitat restoration and black-footed ferret recovery.

Methods:

Survey methods and data analysis were based on protocol established by Biggins et al. (1993, 2006) but altered from prior surveys at the Refuge to increase efficiency and accuracy (FWS 2014, 2015 and 2016). In keeping with the 2016 study, 2.5% of the prairie dog management zones were surveyed and data was extrapolated to estimate prairie dog densities with a confidence interval of ≥95% (Orien Richmond, personal communication, Spring 2016).

Three-meter wide transects spaced 120 meters apart with a north-south orientation were surveyed within the boundaries of the management zones. If a management zone contained multiple sections, each section was surveyed individually. Transects start approximately 10 feet from the section boundary and end either at the boundary of the management zone or within 10 feet of the next section boundary. Transects were created as a GPX file and transferred to a Garmin GPSMAP unit. To visualize the 3-meter width of each transect, an aluminum pipe was attached at the midpoint to the front of a Honda ATV and chains were hung perpendicular to the ground by bolts 3-meters apart on the pipe (Figure 1). A Garmin GPS unit with the preloaded transects was fixed to the steering bar of the ATV.

Transects were surveyed by an individual riding on the ATV. The individual would use the fixed GPS ("Inactive GPS") to navigate the transect as well as mark inactive holes. The Inactive GPS also tracked the movement of the ATV to ensure that the surveyor stayed on the transect. The surveyor would hold a second GPS ("Active GPS") to mark active holes that fell within the 3-meter width of the chains (Figure 2). If greater than 50% of a burrow was within 3-meters as gaged by the hanging chains, the burrow was marked as either Inactive or Active as determined by the surveyor. The surveyor started on one side of the management zone and surveyed along the north/south transects progressing toward the other side of the management zone. If there are two surveyors, management sections would be divided so that transects would not be counted twice.

The GPS points taken in the field were downloaded once the surveyor returned from the field, taking special care to label the points from the Inactive GPS as inactive burrows and the points from the Active GPS as active burrows. The GPX files downloaded from the GPS unit were converted into shapefiles to be used in ArcGIS 10.2 software in order to map the location of active and inactive burrows and calculate prairie dog densities.

Figure 1. Three meter pole attached at midpoint to ATV

Figure 2. ATV configuration for inactive & active GPS

The following criteria were used to identify a burrow as active or inactive:

- Burrows were considered active if the opening was at least 7 cm and the end was not visible (Figure 3). Active burrows also included those with fresh scat or vegetation clippings within 0.5 m of the burrow. Burrows with spider webs or fresh debris in the entrance would not be disregarded as active as long as there was fresh scat within 0.5 m. Fresh scat is described as green, black, or dark brown in color and not desiccated. Large, badger-reamed burrows are counted because prairie dogs are known to use these burrows once vacated by the badger (Biggins et al 1993).

- Burrows were considered inactive if they were covered with vegetation, debris, spider webs, or were noticeably unused (Figure 4).

- Digging on the surface that did not result in a hole was disregarded.

Figure 3. Active burrow

Figure 4. Inactive burrow

The following formula derived by Dean Biggins and colleagues (1993) was used to determine the densities of prairie dogs (PD) per hectare for each transect.

*Prairie Dog Density (PD/ha) = [(# of active burrows*0.179/0.566)/(transect length*3)]*10,000*

In this equation, *0.179* is the regression coefficient between the number of active burrows counted and the number of prairie dogs; and *0.566* is the observability index for black-tailed prairie dogs.

The densities were then converted from prairie dogs/ hectare to prairie dogs/acre and the mean densities were derived for each management zone (Table 1) then broken down into individual sections within the management zones (Table 2).

A 120m X 120m grid was created along each transect in the Eastern and Northwest management zones, a 60m X 60m grid was created in the Southwest zone. Within each grid unit the density was calculated along that portion of the transect and then extrapolated to the area covered by the grid. This allows the prairie dog density to been seen on a smaller scale and represents a more accurate map of the location and density of prairie dogs within the management areas (Map 1, 2, 3).

Results:

Black-tailed prairie dog densities

Approximately 100 kilometers of 3-meter wide transects were surveyed over 9 days beginning August 17 and ending October 11, 2017. The area of the transects surveyed totaled 73.5 acres, approximating 2.5% of the 2,995 acres managed as prairie dog habitat on the Refuge.

The mean prairie dog density across all management zones was 20.25 PD/acre. Densities broken down by management zone are as follows: 19.40 PD/acre in the Eastern Zone; 23.27 PD/acre in the Northwest Zone; 23.33 PD/acre in the Southwest Zone. Each of the management zones exceeded the desired population density of 6-10 PD/acre (Table 2).

Among all management zones Section 20 had the lowest density with 14.40 PD/acre and Section 2 had the highest with 31.29 PD/acre. Each of the sections exceeded the desired population density of 6-10 PD/acre. Within the Southwest Zone, Section 2 had the highest density with 31.29 PD/acre while Section 3 had a density of 19.70 PD/acre. The lowest density within the Eastern Zone was 14.40 PD/acre in Section 20 and the highest was 26.47 PD/acre in Section 32. The lowest density within the Northwest Zone was 21.90 PD/acre in Section 28 while the highest density was in Section 22 at 24.56 PD/acre.

Prairie dog densities derived from surveys over the 4-year period were compared across management zones (Graph 1) and sections (Table 3, Graph 2). Densities were lowest in the Southwest Zone in 2014 and 2015, but lowest in the Eastern Zone in 2016 and 2017. Densities were highest in the Northwest Zone in 2014 and 2015, but highest in the Southwest Zone in 2016 and 2017. Section 5 had the lowest densities in 2014 and 2015, while Section 20 had the lowest density in 2016 and 2017. Section 8 had the highest densities per acre each of the first 3 years surveyed; in 2017 Section 2 had the highest density. Densities were seemingly more consistent over the 4 year period in the Northwest and Eastern Zones. There was a lot of variability in densities of the sections that make up the Southwest management zone. The overall mean prairie dog densities for each management zone from 2014-2017 are 18.72 PD/acre (SWZ), 20.51 PD/acre (EZ), 20.96 PD/acre (NWZ).

Prairie dog densities to support Black-footed ferret families

The average number of prairie dogs needed to sustain a black-footed ferret family for a year is 763. A ferret family consists of 1 female, 3.3 kits, and 0.5 males (Biggins et al. 1993). A good habitat for the release of black-footed ferrets is one with more than 12 PD/ha (4.85 PD/ac) (Biggins et al. 1993). In order to determine if the prairie dog habitat management zones are suitable habitat for a population of the black-footed ferrets, we incorporated the transect data into a spreadsheet provided by Dr. Dean Biggins of the U.S. Geological Society. Originally there was an energetic model with a linear conversion from the number of prairie dogs to the number of black-footed ferret families (PD/763), which is to say 763 prairie dogs can support one ferret family per year and a rating is assigned (Biggins et al. 1993). This was edited in later years to incorporate the territoriality of the ferrets once a density of 18 PD/ha is achieved and suggest that once prairie dog populations exceed 42 PD/ha, ferret populations do not increase (Biggins et al. 2006). The Southwest Zone at the Refuge has a rating of 1.04, the Eastern Zone has a rating of 38.04 and the Northwest Zone has a rating of 9.90 (Table 4). In total the Refuge can support 49 ferret families inside the prairie dog management zones at current prairie dog population densities.

Discussion:

Reoccurring inventories of the black-tailed prairie dogs on the Refuge are essential to the Comprehensive Conservation Plan/HMP objectives to maintain a healthy prairie dog population, allow for habitat restoration to occur, and a successful reintroduction of black-footed ferrets.

Acreage on the Refuge managed for prairie dog habitat as well as acreage within the management zones has shifted over time. Total acreage managed for prairie dog habitat on the Refuge in 2015 totaled 2,580.4 acres. In 2016 the total acreage managed for prairie dog habitat increased to 2,995.0 acres. This acreage has stayed consistent in 2017.

Results from the 2017 inventory indicate that prairie dog densities on the refuge are more than adequate to support existing populations of black-footed ferrets and any future offspring. A population survey in September and October 2017 found 60 black-footed ferrets in the Eastern Zone, including 34 wild-born ferrets and one captive-bred ferret released in fall 2017 (data yet to be published). The prairie dog population has not been dramatically affected by the ferret releases and has even increased in density, showing that the stable population of prairie dogs can sustain the ferrets currently inhabiting the Eastern Zone. The Northwest Zone also shows promise in supporting a black-footed ferret population, with 23.27 PD/acre. This factored into the decision to release 13 black-footed ferrets captured from the EZ into the NWZ in October of 2017. The Eastern Zone covers an area of 2,364 acres while the Northwest Zone includes 589 acres. The smaller area may prove to limit the ferret population in this management zone, but that is yet to be known.

The density of prairie dogs in the management zones on the Refuge is much larger than the 6-10 PD/acre which is optimal for native vegetation to reestablish. Over time the black-footed ferrets released onto the Refuge could prove to naturally balance the prairie dog population. However, given the time it may take for this to occur, some management of the prairie dog population by refuge staff may be necessary. From 2014 to 2017 refuge staff, with the help of a contractor, protected prairie dogs within the zones from sylvatic plague by dusting prairie dog burrows with Deltamethrin as a flea control and removing prairie dogs from all outlying colonies. In 2016, approximately 1,100 acres of prairie dog colonies in the Eastern Zone were treated with experimental sylvatic plague vaccine (SPV) baits to further protect the population from a plague event. In 2017 the same 1,100 acres were treated with SPV bait again. In the future the use of Deltamethrin will be completely replaced with the dispersal of SPV baits across the management zones. These manipulations could potentially augment the population densities inside the zones by increasing survivorship and reproduction inside the zone and by increasing recruitment of prairie dogs into the protected colonies. This could affect both habitat restoration projects as well as the range of the black-footed ferrets on the refuge.

The 2014 and 2015 prairie dog inventories will be used as a baseline for the prairie dog population on the Refuge, while subsequent inventories will be used to understand trends in the population. This will also allow for the evaluation of different management techniques. The inventory can be used to monitor for an outbreak of plague or other major population fluctuations as well. Comparing the number of active to inactive burrows can be an indication of a plague event if more than 50% of the total burrows are inactive (Biggins et al. 1993).

Initial trend analyses show there is a pattern of increased densities across the management zones over the 4 year period. The Eastern and Northwest Zones appear to have less variability in density from year to year than the Southwest Zone, represented by the stronger positive trend in the SWZ (Graph 1). The mean density variability within the management zones shows similar results in that there is less variability in densities in the Eastern and Northwest Zones than in the Southwest Zone.

Several study design changes occurred in 2017. The most significant change was the implementation of ATVs to conduct the surveys. This reduced the time and number of people needed to survey the management zones. This allowed for the incorporation of GPS units to mark active and inactive holes providing the basis a better visual representation of prairie dog densities. There have been adaptations to the study design over the four year period the prairie dog inventory has been conducted culminating in the methodology used in the 2017 inventory. Staff are in agreement that these changes have led to an acceptable study design and at this time no foreseeable changes are warranted in the near future.

Acknowledgements:

A majority of this project was funded by the Service's Cooperative Recovery Initiative, with analytical support from the Regional Inventory and Monitoring Program. We look forward to continued collaboration with these programs.

List of Preparers

Author's Name	Position	Work Unit
Scott Quigley	Biological Science Technician	Rocky Mountain Arsenal NWR (Commerce City, CO)
Susan Horton	Biological Science Technician	Rocky Mountain Arsenal NWR (Commerce City, CO)
Nick Kaczor	Assistant Refuge Manager	Rocky Mountain Arsenal NWR (Commerce City, CO)

References:

Biggins D.E., Brian J. Miller, Louis R. Hanebury, Bob Oakleaf, Adrian H. Farmer, Ron Crete, Arnold Dood. 1993. A Technique for Evaluating Black-footed Ferret Habitat. U.S. Fish and Wildlife Service, National Ecology Research Center, Fort Collins, Colorado. July 1993. Biological Report 13: 73-88.

Biggins, D.E., J.M. Lockhart, and J.L. Godbey. 2006c. Evaluating habitat for black-footed ferrets: revision of an existing model. Pp. 143–152 in J.E. Rolle, B.J. Miller, J.L. Godbey, and D.E. Biggins, eds., Recovery of the black-footed ferret — progress and continuing challenges. U.S. Geological Survey Scientific Investigations Report 2005-5293, U.S. Geological Survey, Reston, Va.

[FWS] U.S. Fish and Wildlife Service. 2013a. Habitat management plan: Rocky Mountain Arsenal National Wildlife Refuge. Commerce City, Colorado: U.S. Department of the Interior, Fish and Wildlife Service, Rocky Mountain Arsenal National Wildlife Refuge.

[FWS] U.S. Fish and Wildlife Service. 2013b. Management of black-tailed prairie dog (Cynomys ludovicianus) populations on the Rocky Mountain Arsenal National Wildlife Refuge. Commerce City, Colorado: U.S. Department of the Interior, Fish and Wildlife Service, Rocky Mountain Arsenal National Wildlife Refuge.

[FWS] U.S. Fish and Wildlife Service. 2013c. Mountain-Prairie Region FY14 Regional Priorities. U.S. Department of the Interior, Fish and Wildlife Service, Mountain-Prairie Region, Lakewood, Colorado. Available online < http://www.fws.gov/mountain-prairie/20131031_2014_RegionalPriorities.pdf>.

[FWS] U.S. Fish and Wildlife Service. 2014a. I&M RFP Submission for 2014, 2015. Commerce City, Colorado: U.S. Department of the Interior, Fish and Wildlife Service, Rocky Mountain Arsenal National Wildlife Refuge.

[FWS] U.S. Fish and Wildlife Service. 2014b. Mountain-Prairie Region FY15 Regional Priorities. U.S. Department of the Interior, Fish and Wildlife Service, Mountain-Prairie Region, Lakewood, Colorado.

[FWS] U.S. Fish and Wildlife Service. 2014c. Preparing the Rocky Mountain Arsenal National Wildlife Refuge for a Black-footed Ferret Reintroduction. Commerce City, Colorado: U.S. Department of the Interior, Fish and Wildlife Service, Rocky Mountain Arsenal National Wildlife Refuge.

[FWS] U.S. Fish and Wildlife Service. 2015. 2014 Black-tailed Prairie Dog Inventory: U.S. Department of the Interior, Fish and Wildlife Service, Rocky Mountain Arsenal National Wildlife Refuge. iv., 29p.

[FWS] U.S. Fish and Wildlife Service. 2015. 2015 Black-Tailed Prairie Dog Inventory: U.S. Department of the Interior, Fish and Wildlife Service, Rocky Mountain Arsenal National Wildlife Refuge. iv., 36 p.

[FWS] U.S. Fish and Wildlife Service. 2017. 2016 Black-Tailed Prairie Dog Inventory at the Rocky Mountain Arsenal National Wildlife Refuge. Commerce City, CO: U.S. Department of the Interior, Fish and Wildlife Service. 22 p.

[FWS] U.S. Fish and Wildlife Service. 2016. 2015 Black-footed Ferret Post-reintroduction Survival at the Rocky Mountain Arsenal National Wildlife Refuge. U.S. Department of the Interior, Fish and Wildlife Service, Rocky Mountain Arsenal National Wildlife Refuge. iv., 12p.

Richmond, Orien, and Steve Kettler. Spring 2016. Personal Communication.

Tables and Graphs:

Table 1. Black-tailed Prairie Dog (PD) Densities by Management Zones at Rocky Mountain Arsenal National Wildlife Refuge in 2017.

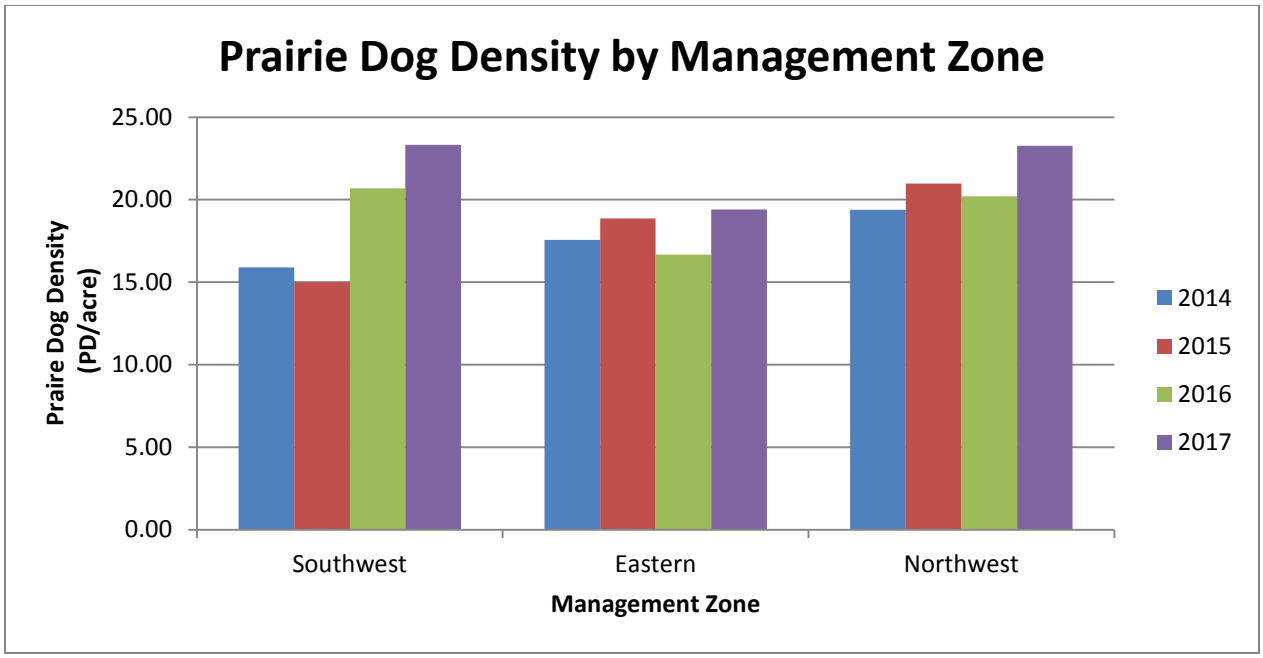
Management Zone	Area of Transects (m^2)	PD Count	PD/hectare	PD/acre
Southwest (SWZ)	8,231	47	57.63	23.33
Eastern (EZ)	232,155	1,113	47.92	19.40
Northwest (NWZ)	56,956	327	57.47	23.27
Total (or mean)	297,343	1,487	**(50.02)**	**(20.25)**

Table 2. Black-tailed Prairie Dog (PD) Densities by Public Land Survey System Sections at Rocky Mountain Arsenal National Wildlife Refuge in 2017.

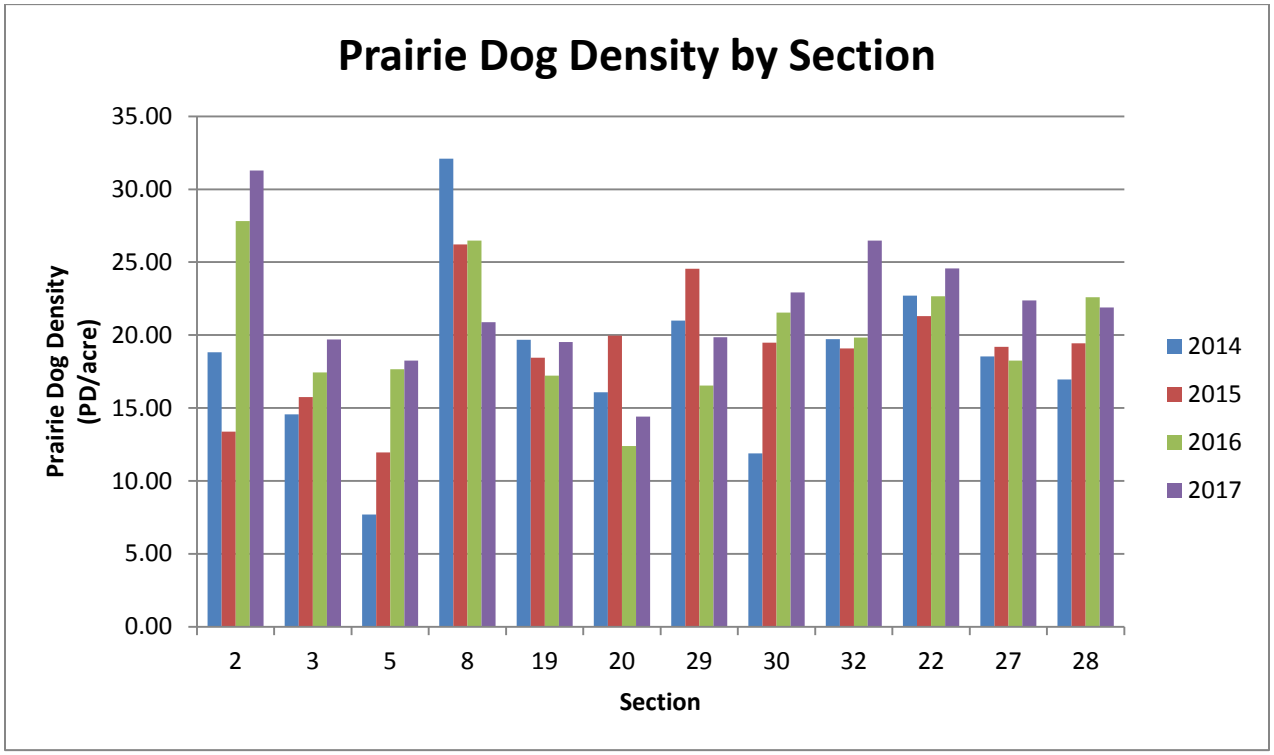
Section	Area of Transects (m^2)	PD Count	PD/hectare	PD/acre
2 (SWZ)	2,578	20	77.29	31.29
3 (SWZ)	5,653	28	48.67	19.70
5 (EZ)	26,100	118	45.07	18.25
8 (EZ)	2,515	13	51.56	20.88
19 (EZ)	32,730	158	48.22	19.52
20 (EZ)	58,245	207	35.56	14.40
29 (EZ)	62,374	306	49.03	19.85
30 (EZ)	19,384	110	56.62	22.92
32 (EZ)	30,807	201	65.39	26.47
22 (NWZ)	23,513	143	60.66	24.56
27 (NWZ)	31,631	175	55.29	22.38
28 (NWZ)	1,813	10	54.08	21.90
Total (or mean)	297,343	1,487	**(50.02)**	**(20.25)**

Table 3. Comparison of Black-tailed Prairie Dog Densities at Rocky Mountain Arsenal National Wildlife Refuge from 2014 to 2017 arranged by Public Land Survey System Sections.

Section	2014 PD/acre	2015 PD/acre	2016 PD/acre	2017 PD/acre
2 (SWZ)	18.83	13.38	27.81	31.29
3 (SWZ)	14.56	15.75	17.44	19.70
5 (EZ)	7.70	11.95	17.66	18.25
8 (EZ)	32.10	26.21	26.48	20.88
19 (EZ)	19.67	18.44	17.21	19.52
20 (EZ)	16.08	19.96	12.40	14.40
29 (EZ)	21.00	24.55	16.55	19.85
30 (EZ)	11.89	19.47	21.53	22.92
32 (EZ)	19.73	19.09	19.82	26.47
22 (NWZ)	22.70	21.3	22.65	24.56
27 (NWZ)	18.54	19.2	18.26	22.38
28 (NWZ)	16.95	19.44	22.60	21.90



Graph 1. Comparison of Black-tailed Prairie Dog Densities by Year and Management Zone at Rocky Mountain Arsenal National Wildlife Refuge.



Graph 2. Comparison of Black-tailed Prairie Dog Densities by Year and Public Land Survey System Section at Rocky Mountain Arsenal National Wildlife Refuge.

Table 4. Number of Black-footed Ferret Families (1 female, 3.3 young, and 0.5 male (Biggins et al. 1993)) the Rocky Mountain Arsenal National Wildlife Refuge Can Support as of Summer 2017 arranged by Management Zones.

Management Zone	**Rating 1993 PD/763**	**>18 PDs**	**>=42 PDs**	**Rating 2006 If 1993 rating <2**
Southwest	1.04	0.47	0.55	1.04
Eastern	60.27	36.71	37.75	38.04
Northwest	17.96	8.95	9.54	9.90
Total	79.27	46.13	47.84	48.99

Table 5. The Number of Black-footed Ferret Families (1 female, 3.3 young, and 0.5 male (Biggins et al. 1993)) the Rocky Mountain Arsenal National Wildlife Refuge Can Support as of Summer 2017 arranged by Public Land Survey System Sections.

Section	**N**	**PROP GOOD**	**HA**	**HA GOOD**	**BUR/HA**	**PD/HA**	**PD EST**	**Rating 1993 PD/763**	>18 PDs	≥42 PDs	**Rating 2006 If 1993 rating <2**
2	6	0.833	5.3	4.4	244.4	77.3	341.3	0.45	0.09	0.18	0.45
3	10	0.800	11.7	9.4	153.9	48.7	455.6	0.60	0.38	0.37	0.60
5	9	1.000	107.4	107.4	142.5	45.1	4841.1	6.34	4.32	4.30	4.30
8	2	1.000	10.4	10.4	163.0	51.6	536.2	0.70	0.41	0.42	0.70
19	11	1.000	128.8	128.8	152.5	48.2	6210.2	8.14	5.18	5.15	5.15
20	13	1.000	240.4	240.4	112.5	35.6	8550.1	11.21	9.09	9.09	9.09
29	13	1.000	256.8	256.8	155.0	49.0	12590.6	16.50	10.31	10.27	10.27
30	12	1.000	77.4	77.4	179.0	56.6	4382.1	5.74	2.95	3.10	3.10
32	13	1.000	135.7	135.7	206.8	65.4	8873.7	11.63	4.45	5.43	5.43
22	11	1.000	100.1	100.1	191.8	60.7	6072.1	7.96	3.61	4.00	4.00
27	14	1.000	126.5	126.5	174.8	55.3	6994.3	9.17	4.89	5.06	5.06
28	3	1.000	11.8	11.8	171.0	54.1	638.2	0.84	0.46	0.47	0.84
Total (or mean)	117	0.969	1212.3	1209.1	170.6	54.0	60485.6	79.27	46.13	47.84	48.99

Sec=Section number
N=Number of transects
PROP GOOD =Proportion of good habitat (transects with > 12 prairie dogs per hectare)
HA=Hectares of prairie dog habitat within the management zone for each section
HA GOOD=Hectares of good prairie dog habitat in each section (PROP GOOD * HA)
BUR/HA=Active burrows per hectare of good prairie dog habitat
PD/HA= Prairie dogs per hectare (=BUR/HA*0.179/0.566)
PD EST=Estimated prairie dogs in each section (PD/HA * HA GOOD)
PD/763=Linear conversion of PDs to BFFs (PD EST/763, Biggins et al. 1993)
>18 PDs=This conversion of PDs to BFFs incorporates an increasing effect of BFF territoriality when PD density > 18/ha (Biggins et al. 2006)
≥42 PDs=This conversion shows no increase in BFFs if PD density≥42 PDs/ha
2006=This conversion presumes lack of competition if the potential for the Section is to support less than 2 BFF families. It defaults to the PD/763 value (Biggins et al. 2006)

Appendix A- Raw Data Tables:

Section 20 (240.4 ha)

Name	Shape_Length (m)	Number_Active	PD Count	PD / transect	PD / ha	PD / acre
1_20_12	1527.7	47	14.86	0.003243147	32.43	13.13
1_20_13	1527.1	47	14.86	0.003244421	32.44	13.14
1_20_14	1528.0	60	18.98	0.004139402	41.39	16.76
1_20_15	1527.7	66	20.87	0.004554355	45.54	18.44
1_20_16	1527.7	54	17.08	0.003726291	37.26	15.09
1_20_17	1532.8	61	19.29	0.004195405	41.95	16.99
1_20_18	1535.7	51	16.13	0.003500827	35.01	14.17
1_20_19	1534.2	41	12.97	0.00281727	28.17	11.41
1_20_20	1533.6	40	12.65	0.002749489	27.49	11.13
1_20_21	1528.3	29	9.17	0.002000357	20.00	8.10
1_20_22	1507.6	49	15.50	0.00342639	34.26	13.87
1_20_23	1358.3	60	18.98	0.004656792	46.57	18.85
1_20_24	1246.5	50	15.81	0.004228633	42.29	17.12
Total:	19415.10	655	207.15	0.003556453	35.56	14.40

Section 19 (128.8 ha)

Name	Shape_Length (m)	Number_Active	PD Count	PD / transect	PD / ha	PD / acre
1_19_01	153.2	8	2.53	0.005506661	55.07	22.29
1_19_02	342.3	19	6.01	0.005850918	58.51	23.69
1_19_03	1036.6	54	17.08	0.005491852	54.92	22.23
1_19_04	1081.4	33	10.44	0.00321694	32.17	13.02
1_19_05	1146.2	57	18.03	0.005242258	52.42	21.22
1_19_06	1153.1	39	12.33	0.003565562	35.66	14.44
1_19_07	1172.6	46	14.55	0.004135384	41.35	16.74
1_19_08	1182.6	54	17.08	0.004813817	48.14	19.49
1_19_09	1227.5	66	20.87	0.005668196	56.68	22.95
1_19_10	1208.9	62	19.61	0.005406371	54.06	21.89
1_19_11	1205.9	61	19.29	0.005332758	53.33	21.59
Total:	10910.15	499	157.81	0.004821533	48.22	19.52

Section 30 (77.4 ha)

Name	Shape_Length (m)	Number_Active	PD Count	PD / transect	PD / ha	PD / acre
1_30_38	630.2	45	14.23	0.007527477	75.27	30.48
1_30_39	628.3	20	6.33	0.003355609	33.56	13.59
1_30_40	629.4	36	11.39	0.006030115	60.30	24.41
1_30_41	629.4	27	8.54	0.004522586	45.23	18.31
1_30_42	628.1	28	8.86	0.004699573	47.00	19.03
1_30_43	628.4	40	12.65	0.006710257	67.10	27.17
1_30_44	624.1	39	12.33	0.006587367	65.87	26.67
1_30_45	628.4	29	9.17	0.004865246	48.65	19.70
1_30_46	628.8	33	10.44	0.00553288	55.33	22.40
1_30_47	521.7	35	11.07	0.007072331	70.72	28.63
1_30_48	207.6	6	1.90	0.00304618	30.46	12.33
1_30_49	76.9	9	2.85	0.012332812	123.33	49.93
Total:	6461.19	347	109.74	0.00566151	56.62	22.92

Section 29 (256.8 ha)

Name	Shape_Length (m)	Number_Active	PD Count	PD / transect	PD / ha	PD / acre
1_29_25	1601.6	69	21.82	0.004541559	45.42	18.39
1_29_26	1600.2	55	17.39	0.003623341	36.23	14.67
1_29_27	1600.9	46	14.55	0.003029162	30.29	12.26
1_29_28	1601.3	33	10.44	0.002172511	21.73	8.80
1_29_29	1598.5	102	32.26	0.006726923	67.27	27.23
1_29_30	1603.3	73	23.09	0.004799803	48.00	19.43
1_29_31	1601.4	108	34.16	0.007109415	71.09	28.78
1_29_32	1598.2	75	23.72	0.004946979	49.47	20.03
1_29_33	1598.4	91	28.78	0.006001546	60.02	24.30
1_29_34	1594.9	76	24.04	0.005023311	50.23	20.34
1_29_35	1601.0	84	26.57	0.005530961	55.31	22.39
1_29_36	1595.0	76	24.04	0.00502309	50.23	20.34
1_29_37	1596.7	79	24.98	0.00521568	52.16	21.12
Total:	20791.40	967	305.82	0.004902957	49.03	19.85

Section 32 (135.7 ha)

Name	Shape_Length (m)	Number_Active	PD Count	PD / transect	PD / ha	PD / acre
1_32_50	100.0	4	1.27	0.004215461	42.15	17.07
1_32_51	100.2	3	0.95	0.003156862	31.57	12.78
1_32_52	99.5	7	2.21	0.007418588	74.19	30.03
1_32_53	99.0	10	3.16	0.010646146	106.46	43.10
1_32_54	97.5	5	1.58	0.005406058	54.06	21.89
1_32_55	97.7	6	1.90	0.006475316	64.75	26.22
1_32_56	99.1	2	0.63	0.002126867	21.27	8.61
1_32_57	1597.9	88	27.83	0.005805763	58.06	23.51
1_32_58	1595.7	114	36.05	0.007531094	75.31	30.49
1_32_59	1596.2	102	32.26	0.006736405	67.36	27.27
1_32_60	1596.1	97	30.68	0.006406711	64.07	25.94
1_32_61	1595.3	111	35.10	0.007335022	73.35	29.70
1_32_62	1594.8	88	27.83	0.005816939	58.17	23.55
Total	10268.95	637.00	201.45	0.006539262	65.39	26.47

Section 5 (107.4 ha)

Name	Shape_Length (m)	Number_Active	PD Count	PD / transect	PD / ha	PD / acre
1_05_63	1537.2	74	23.40	0.005074774	50.75	20.55
1_05_64	1588.8	61	19.29	0.004047398	40.47	16.39
1_05_65	1348.8	70	22.14	0.005470989	54.71	22.15
1_05_66	1011.6	50	15.81	0.005210466	52.10	21.10
1_05_67	843.7	32	10.12	0.003998317	39.98	16.19
1_05_68	783.9	30	9.49	0.004034372	40.34	16.33
1_05_69	792.1	33	10.44	0.004391868	43.92	17.78
1_05_70	630.7	18	5.69	0.003008604	30.09	12.18
1_05_71	163.3	4	1.27	0.002582196	25.82	10.45
Total	8700.10	372.00	117.65	0.004507482	45.07	18.25

Section 8 (10.4 ha)

Name	Shape_Length (m)	Number_Active	PD Count	PD / transect	PD / ha	PD / acre
1_08_72	403.4	15	4.74	0.003919861	39.20	15.87
1_08_73	434.8	26	8.22	0.006303463	63.03	25.52
Total	838.22	41.00	12.97	0.005156336	51.56	20.88

Section 3 (11.7 ha)

Name	Shape_Length (m)	Number_Active	PD Count	PD / transect	PD / ha	PD / acre
3_3_102	68.9	9	2.85	0.013778148	137.78	55.78
3_3_103	195.4	10	3.16	0.005394164	53.94	21.84
3_3_104	294.3	9	2.85	0.003223687	32.24	13.05
3_3_105	242.5	15	4.74	0.006521247	65.21	26.40
3_3_106	86.0	4	1.27	0.004903169	49.03	19.85
5_3_113	45.8	17	5.38	0.03909486	390.95	158.28
5_3_114	72.4	18	5.69	0.02620893	262.09	106.11
5_3_115	224.0	5	1.58	0.002352768	23.53	9.53
5_3_116	374.5	0	0.00	0	0.00	0.00
5_3_117	280.5	0	0.00	0	0.00	0.00
Total	1884.36	87.00	27.51	0.004867105	48.67	19.70

Section 2 (5.3 ha)

Name	Shape_Length (m)	Number_Active	PD Count	PD / transect	PD / ha	PD / acre
4_2_107	88.0	0	0.00	0	0.00	0.00
4_2_108	170.1	18	5.69	0.011158639	111.59	45.18
4_2_109	181.4	17	5.38	0.009879318	98.79	40.00
4_2_110	141.3	8	2.53	0.00596974	59.70	24.17
4_2_111	144.3	7	2.21	0.00511313	51.13	20.70
4_2_112	134.3	13	4.11	0.010202768	102.03	41.31
Total	859.31	63.00	19.92	0.007728693	77.29	31.29

Section 28 (11.8 ha)

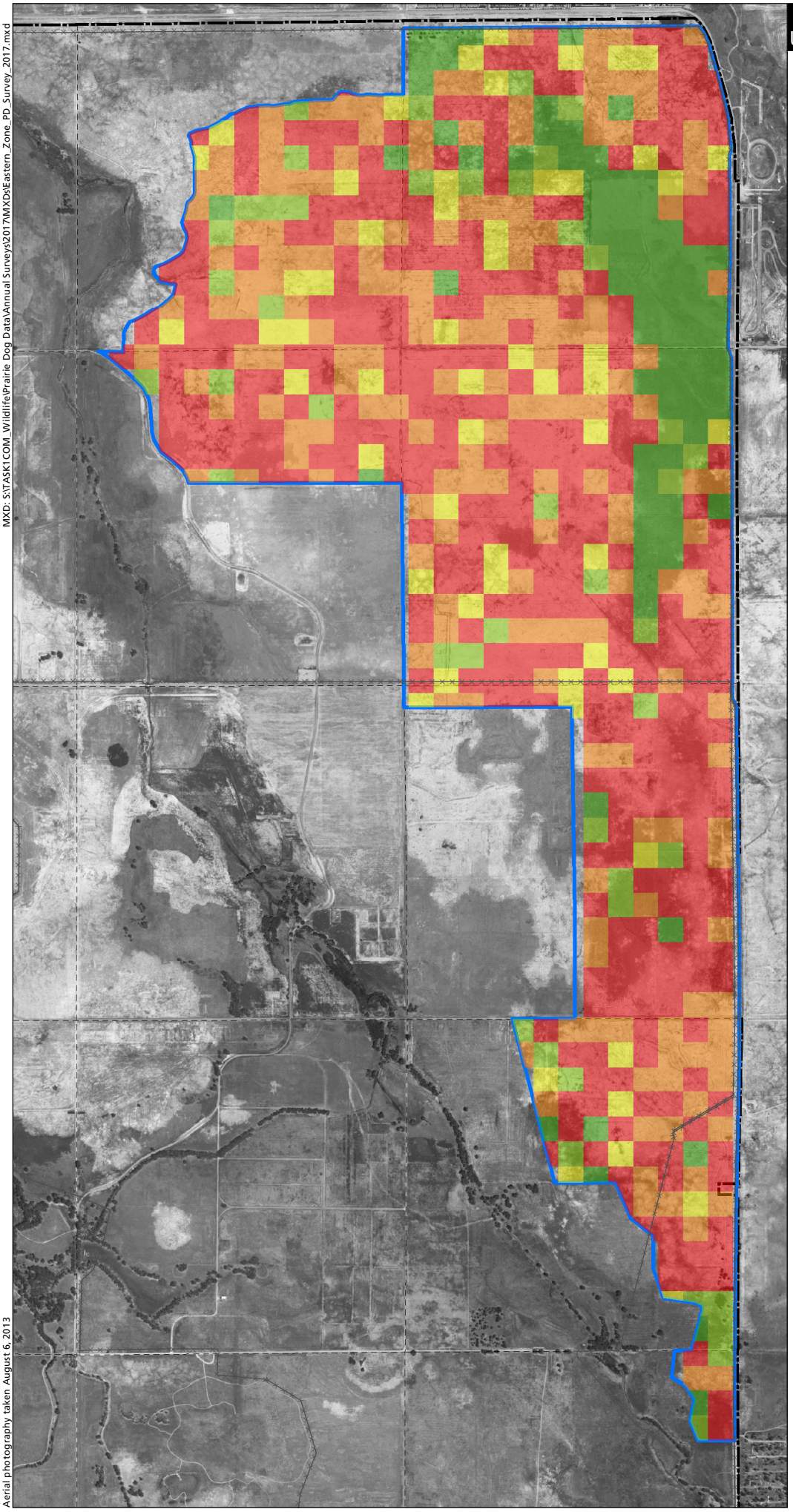
Name	Shape_Length (m)	Number_Active	PD Count	PD / transect	PD / ha	PD / acre
2_28_85	61.9	3	0.95	0.005108293	51.08	20.68
2_28_86	200.1	15	4.74	0.007901619	79.02	31.99
2_28_87	342.2	13	4.11	0.004004663	40.05	16.21
Total	604.24	31.00	9.80	0.005408385	54.08	21.90

Section 27 (126.5 ha)

Name	Shape_Length (m)	Number_Active	PD Count	PD / transect	PD / ha	PD / acre
2_27_88	456.5	18	5.69	0.004156502	41.57	16.83
2_27_89	574.5	41	12.97	0.007523445	75.23	30.46
2_27_90	654.8	38	12.02	0.006117449	61.17	24.77
2_27_91	803.9	40	12.65	0.005245271	52.45	21.24
2_27_92	805.9	39	12.33	0.005101764	51.02	20.65
2_27_93	803.7	37	11.70	0.004853022	48.53	19.65
2_27_94	807.4	30	9.49	0.0039169	39.17	15.86
2_27_95	804.5	37	11.70	0.004848498	48.48	19.63
2_27_96	807.0	41	12.97	0.00535575	53.56	21.68
2_27_97	804.6	45	14.23	0.005896016	58.96	23.87
2_27_98	805.6	38	12.02	0.004972739	49.73	20.13
2_27_99	806.4	57	18.03	0.007451893	74.52	30.17
2_27_100	806.5	41	12.97	0.005359203	53.59	21.70
2_27_101	802.5	51	16.13	0.006699888	67.00	27.13
Total	10543.66	553.00	174.89	0.005529032	55.29	22.38

Section 22 (100.1 ha)

Name	Shape_Length (m)	Number_Active	PD Count	PD / transect	PD / ha	PD / acre
2_22_74	1363.4	103	32.57	0.007964256	79.64	32.24
2_22_75	1242.0	63	19.92	0.005347297	53.47	21.65
2_22_76	1115.2	52	16.45	0.00491548	49.15	19.90
2_22_77	898.7	39	12.33	0.004574524	45.75	18.52
2_22_78	845.6	49	15.50	0.006108523	61.09	24.73
2_22_79	652.0	39	12.33	0.006306073	63.06	25.53
2_22_80	620.1	40	12.65	0.006800512	68.01	27.53
2_22_81	471.6	28	8.86	0.006259453	62.59	25.34
2_22_82	337.4	22	6.96	0.006873534	68.74	27.83
2_22_83	209.9	15	4.74	0.007534172	75.34	30.50
2_22_84	81.7	1	0.32	0.001289992	12.90	5.22
Total	7837.50	451.00	142.63	0.006066167	60.66	24.56



MXD: S:\TASK1\COM_Wildlife\Prairie Dog Data\Annual Surveys\2017\MXDs\Eastern_Zone_PD_Survey_2017.mxd

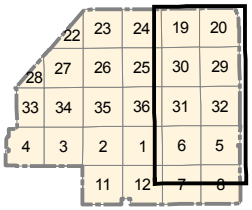
Aerial photography taken August 6, 2013

U.S. Fish & Wildlife Service

Rocky Mountain Arsenal

National Wildlife Refuge

Black-Tailed Prairie Dog Management Program Eastern Zone



Wildlife Fence

Prairie Dog Mgmt Zones (2,995 Acres)

Refuge Boundary

Section Line

Prairie Dogs per Acre

- 0 to 6
- > 6 to 10
- > 10 to 14
- > 14 to 20
- > 20 to 83 (Maximum)

N

0 0.2 0.4 0.6

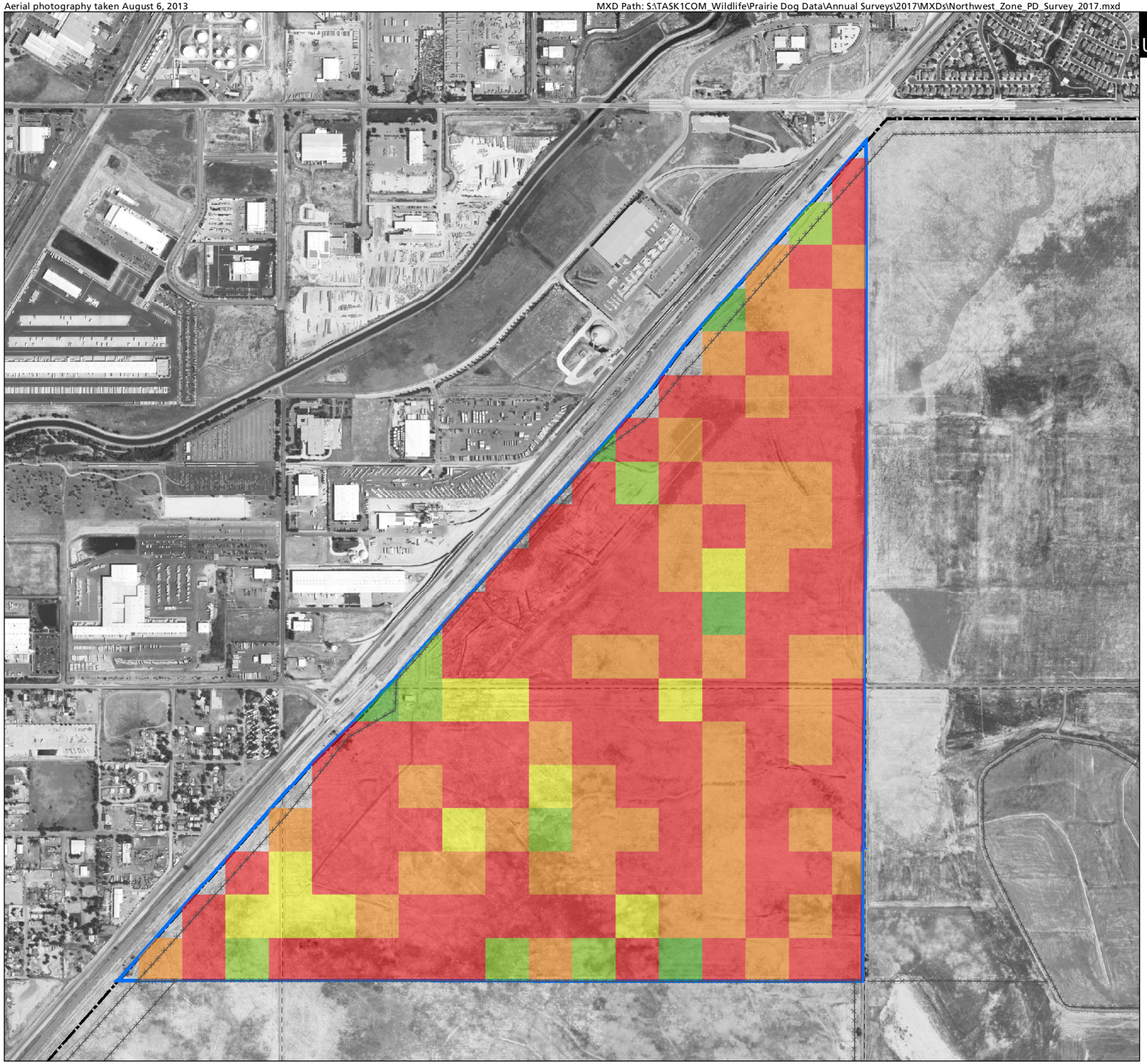
Miles

Transverse Mercator Projection
UTM Zone 13 North, Units Meters
North American Datum 1983
Data Sources: USFWS, USDA

2017
Black-Tailed Prairie Dog
Density and Activity Survey

Aerial photography taken August 6, 2013

MXD Path: S:\TASK1COM_Wildlife\Prairie Dog Data\Annual Surveys\2017\MXDs\Northwest_Zone_PD_Survey_2017.mxd



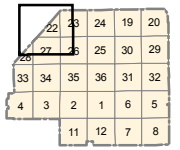
U.S. Fish & Wildlife Service

Rocky Mountain Arsenal

National Wildlife Refuge

Black-Tailed Prairie Dog Management Program

Northwest Zone



Wildlife Fence

Section Lines

Refuge Boundary

Prairie Dog Mgmt Zones (2,995 Acres)

Prairie Dogs per Acre

- 0 to 6
- > 6 to 10
- > 10 to 14
- > 14 to 20
- > 20 to 83 (Maximum)

N

0 0.1 0.2 0.3

Miles

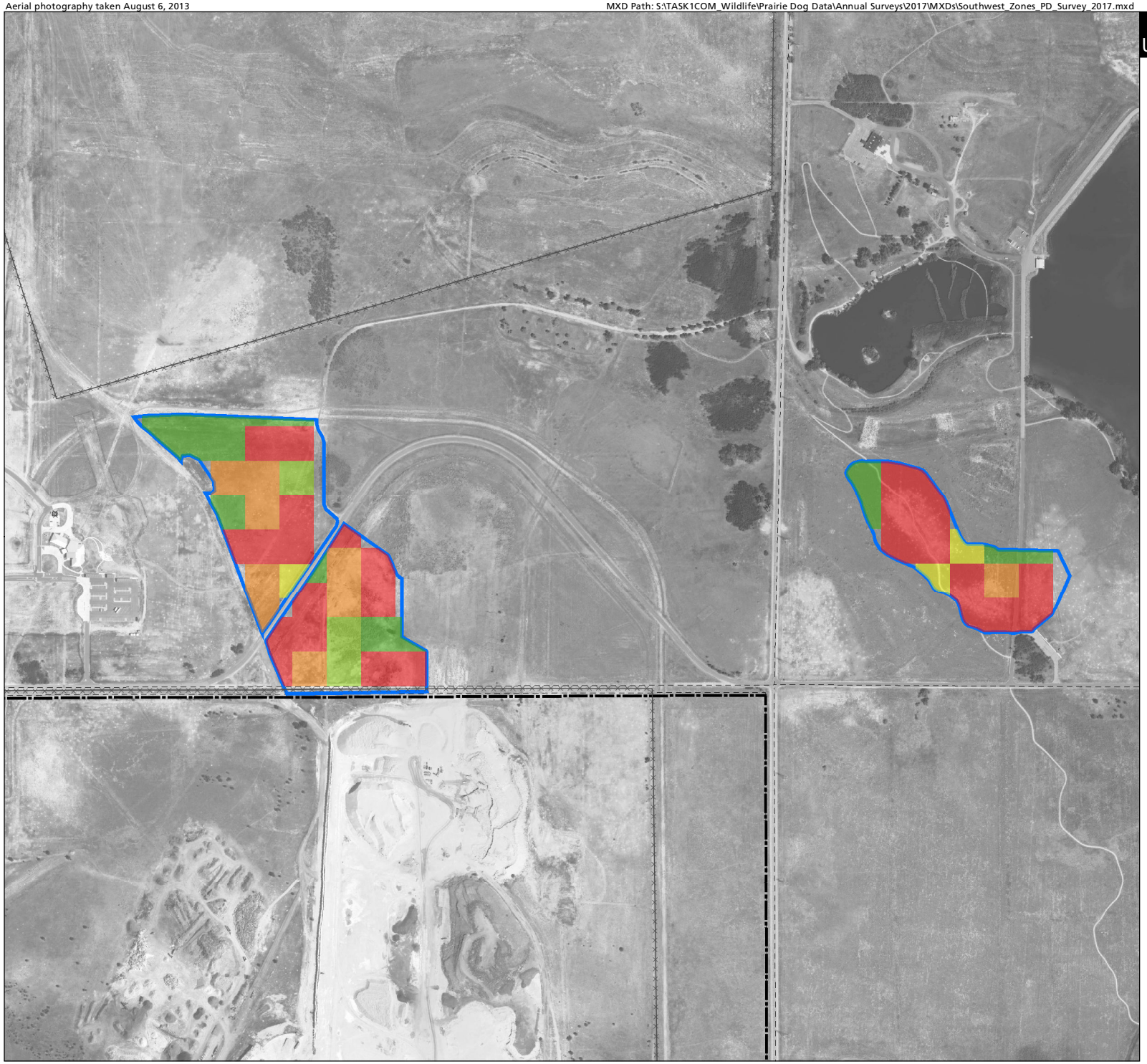
Transverse Mercator Projection
UTM Zone 13 North, Units Meters
North American Datum 1983
Data Sources: USFWS, USDA

2017

Black-Tailed Prairie Dog Density and Activity Survey

Aerial photography taken August 6, 2013

MXD Path: S:\TASK1COM_Wildlife\Prairie Dog Data\Annual Surveys\2017\MXDs\Southwest_Zones_PD_Survey_2017.mxd



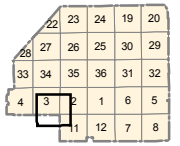
U.S. Fish & Wildlife Service

Rocky Mountain Arsenal

National Wildlife Refuge

Black-Tailed Prairie Dog Management Program

Southwest Zones



- Wildlife Fence
- Section Lines
- Refuge Boundary
- Prairie Dog Mgmt Zones (2,995 Acres)

Prairie Dogs per Acre

- 0 to 6
- > 6 to 10
- > 10 to 14
- > 14 to 20
- > 20 to 83 (Maximum

N

0 0.06 0.12 0.18

Miles

Transverse Mercator Projection
UTM Zone 13 North, Units Meters
North American Datum 1983
Data Sources: USFWS, USDA

2017

Black-Tailed Prairie Dog Density and Activity Survey