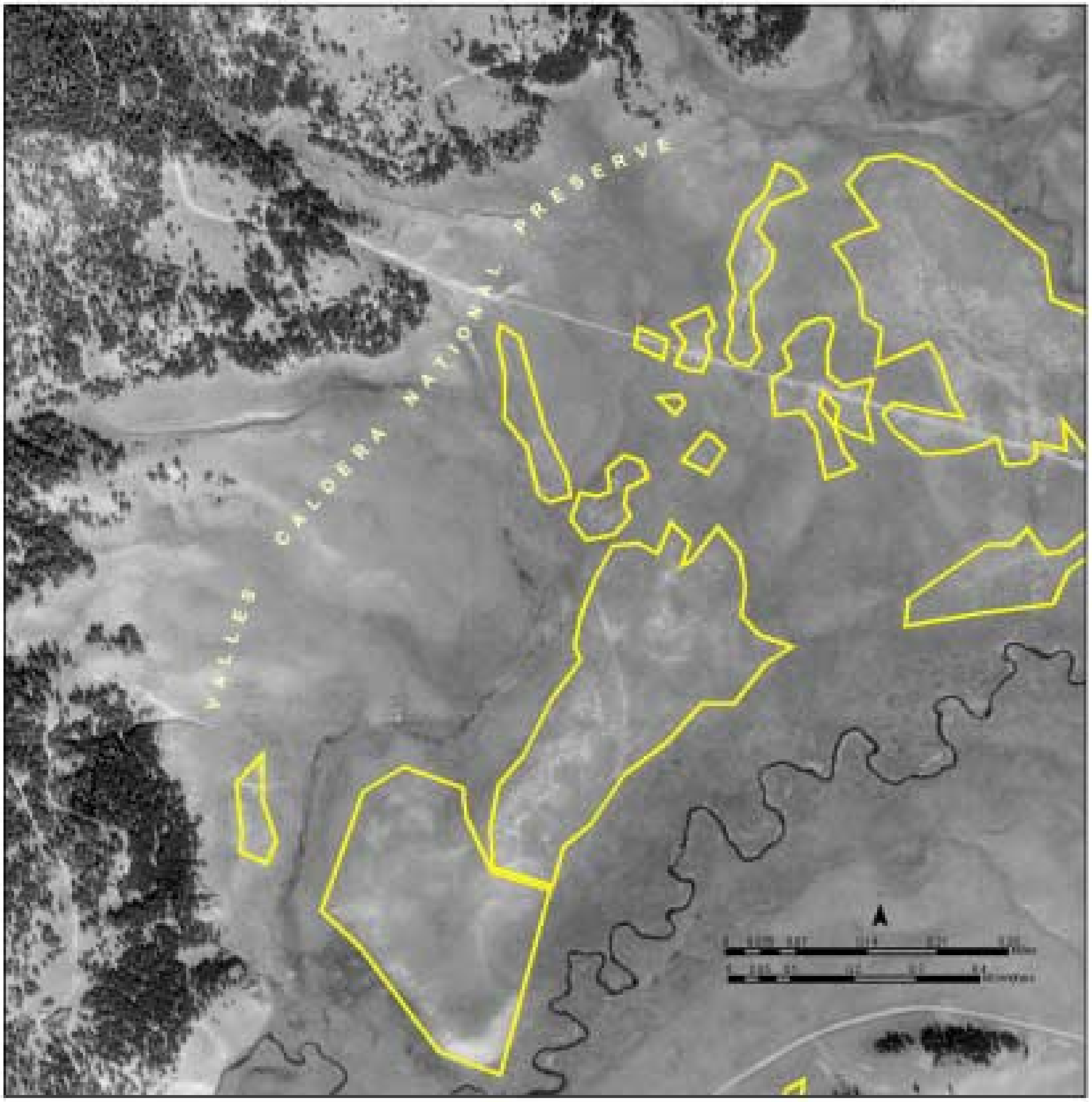
Evaluation of Remote Sensing Methods to Survey for Gunnison's Prairie Dogs

Final Report



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Introduction

Status

The Gunnison's prairie dog (*Cynomys gunnisoni*) occurs in northern Arizona, southwestern Colorado, northwestern New Mexico, and extreme southeastern Utah. The current range of the Gunnison's prairie dog is approximately 27,163,497 ha (67,121,000 ac), 45% (approximately 12,223,573 ha; 30,204,450 ac) of which occur in New Mexico (Knowles 2002). Although there is no information on current population status or trend of the Gunnison's prairie dog in New Mexico, a substantial decline has been documented (Hubbard and Schmitt 1984). Probable causes of decline include poisoning, sylvatic plague, and habitat loss. Estimates of the former abundance of Gunnison's prairie dogs in New Mexico are based on historical records of acreage poisoned during prairie dog control efforts. Knowles (2002) estimated that, in the early 1900s, more than 1,821,125 ha (4,500,000 ac) were occupied by Gunnison's prairie dogs in New Mexico. By 1982, prairie dog-occupied area in New Mexico was estimated at approximately 30,352 ha (75,000 ac, Knowles 2002). In the absence of a rangewide survey, it is unclear how the occupied range has changed since the 1982 estimate.

The Gunnison's prairie dog is not regulated by the New Mexico Department of Game and Fish (NMDGF) and currently has no special conservation status in New Mexico. A petition has been filed with the US Fish and Wildlife Service to list the Gunnison's prairie dog as threatened under the Endangered Species Act (Forest Guardians 2004). The current range occurs largely on private and tribal lands. Due to the size of the current range and access issues, the New Mexico Department of Game and Fish and Bureau of Land Management requested that we study the feasibility of using Digital Orthophoto Quadrangles (DOQs) to survey for Gunnison's prairie dogs in New Mexico.

Survey Method Considerations for Black-tailed vs. Gunnison's Prairie Dogs

In our previous study of black-tailed prairie dogs in New Mexico (Johnson et al. 2003, 2004), we found that the mounds created at burrow entrances showed up on DOQs as bright, roughly circular spots. Given the differences in range, behavior, and ecology of black-tailed and Gunnison's prairie dogs, it was unclear whether Gunnison's prairie dog colonies could be readily identified using photo interpretation of DOQs. Gunnison's prairie dogs are found in the northwestern part of New Mexico (16 counties; Figure 1) between 1524-3658 m elevation (Burt and Grossenheider 1976). In contrast, the black-tailed prairie dog occupies the eastern plains and southwestern grasslands of NM up to 1818 m (Hubbard and Schmitt 1984). The New Mexico ranges of the two species overlap little (Findley 1975). Natural history differences between Gunnison's and black-tailed prairie dogs could potentially affect the feasibility of remote sensing surveys for Gunnison's.

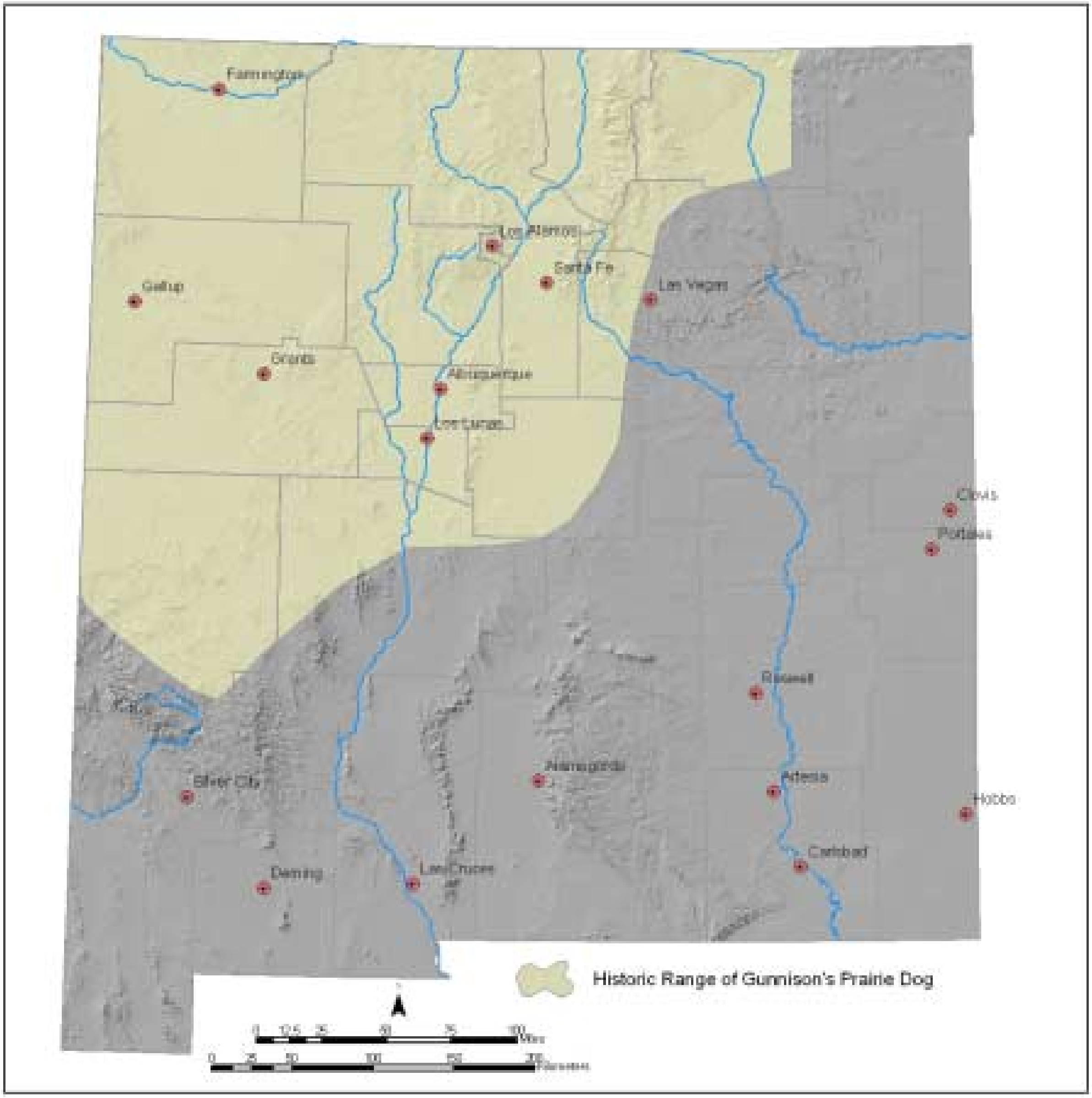

Figure 1. Historic range of Gunnison's prairie dog in New Mexico

Habitat

The black-tailed prairie dog is "truly a prairie species" (Hubbard and Schmitt 1984). In New Mexico, black-tailed prairie dogs are found primarily in flat, open, shortgrass habitats (BISON-M 2000, Johnson et al. 2003). In contrast, Gunnison's prairie dogs are more often found where grassland intrudes into woodland or forest vegetation (Hubbard and Schmitt 1984). They can be found in brush, juniper, pine, and aspen habitats (Longhurst 1944, Findley 1975). Topography and vegetation vary from arid lowlands to mesic intermountain valleys, benches, plateaus (Pizzimenti and Hoffmann

1973; Knowles 2002), playas, floodplains, croplands, and urban areas (Hubbard and Schmitt 1984). The Gunnison's prairie dog is known to tolerate shrubs, including sagebrush (*Artemisia* spp.), rabbitbrush (*Chrysothamnus* spp.) and saltbush (*Atriplex* spp.) (Fitzgerald and Lechleitner 1973, Hubbard and Schmitt 1984). Hubbard and Schmitt (1984) noted that the often inconspicuous burrows of Gunnison's prairie dogs made colonies difficult to find in shrubby sites.

Colony Size and Burrow Structure

Black-tailed prairie dogs are highly colonial and have well-developed mounds at their burrows. Density estimates range from 1.6-68.5 per ac (Knowles 1982, O'Meilia 1980). They can occur in extremely large colonies, up to thousands of individuals, covering hundreds of hectares (eNature.com 2003). Colony size in New Mexico averages around 39 ha (96 ac, Johnson et al. 2003). In contrast, density estimates for Gunnison's prairie dogs range from 1.6 to 23.1 per ac (Fitzgerald and Lechleitner 1973, Van Pelt 1995). Gunnison's prairie dogs often do little to shape their mounds, and their activity may have little visible impact on their environment (Longhurst 1944; Fitzgerald and Lechleitner 1973).

Gunnison's prairie dogs are reported to occur in extensive towns with densely aggregated burrows, as well as in "towns" described as isolated burrows, but they typically occur in small aggregations, generally fewer than 50 to 100 individuals (Pizzimenti and Hoffmann 1973). Longhurst (1944) reported that NM Gunnison's prairie dog burrows were as likely to be isolated as aggregated. Gunnison's modify burrow entrances less than black-taileds do. Fitzgerald and Lechleitner (1973) reported that, "Only 13% of burrow entrances had well-developed mounds …while 77% of the burrow entrances had little excavated soil associated with them." Longhurst (1944) noted a correlation between the size of the mounds and the steepness of the slope on which they were located. Gunnison's prairie dogs living on the valley floor built larger mounds than those in the mountains, and those burrows were enlarged over the course of several seasons.

Behavioral Ecology

Gunnison's prairie dogs are less gregarious than black-tailed prairie dogs and tend to modify the vegetation less. They do not usually clear all vegetation from burrow entrances to obtain an unobstructed view (Merriam, 1901). Adult Gunnison's prairie dogs may aestivate in July and hibernate from Oct or Nov. to March (Burt and Grossenheider 1976). Longhurst (1944) reported that "on stormy days there was little or no activity and few dogs ventured from their burrows."

DOQ Surveys

Considering accuracy, speed, and cost, we concluded that digital aerial photography was the best method currently available for a rangewide survey of black-tailed prairie dog towns, which we completed in 2003 (Johnson et al. 2003). A DOQ is a quarter-quadrangle image (3.75' of latitude by 3.75' of longitude) of 1 m ground resolution, cast on the Universal Transverse Mercator Projection (UTM) in the North American Datum of 1983 (NAD83). The geographic extent of a DOQ is equivalent to a quarter-quad plus a range of 50-300 m beyond the extremes of the corner points. DOQs are developed by the United States Geological Survey (USGS) National Mapping Division. They combine the image characteristics of an aerial photograph with the geometric qualities of a map. Most importantly, the high resolution (1 m) of DOQs allows visualization of prairie dog disturbance such as mounds and vegetation impacts.

The NM Black-tailed Prairie Dog Working Group recognized the need to evaluate the potential of a DOQ survey for Gunnison's prairie dogs. The following reasons were identified (C. Hayes pers. comm.):

1. Information from Knowles' (2002) status report needs updating.
2. The Prairie Dog Interstate Conservation Team is developing a Conservation Assessment for Gunnison's prairie dogs. New Mexico trails the other states (especially AZ and CO) in data acquisition and conservation planning.
3. In July 2001, the Western Association of Fish and Wildlife Agencies directed development of a Gunnison's and white-tailed prairie dog conservation plan, to be coordinated by the Utah Division of Wildlife.

The purpose of this study was to evaluate the potential of the remote sensing method for surveying the historical range of Gunnison's prairie dogs in New Mexico. Specific goals were to:

1. gather information on known Gunnison's prairie dog towns in New Mexico and create a GIS of these sites,
2. delineate prairie dog disturbance on DOQs of areas known to contain Gunnison's prairie dogs,
3. evaluate the accuracy of the photo-interpretation method by using GIS to compare previously-documented towns to towns identified on DOQs, and
4. create maps of previously-known and DOQ-detected prairie dog towns.

Methods

Assembling Datasets

During 2004 we gathered reports and spatial data from individuals and federal, state, and tribal agencies that had completed field surveys for Gunnison's prairie dogs in New Mexico (Appendix A). The field data were collected from 1973-2004, but the majority of data used for this report were from 2003 (Appendix A). Data were available either as points or polygons. Point data were in the form of either Global Positioning System (GPS) data or Township, Range, Section (TRS) data. GPS points usually represented a prairie dog burrow or burrows within a town and were accurate to ±10 m. TRS points were Section locations with accuracy of 1 mi^2. In the GIS, we converted TRS points to centroid points within the given section. We acquired 153 points: 107 TRS, 33 GPS, and 13 from other sources such as topographic maps (Figure 2).

All polygon data were acquired as GPS data representing the outline of a town. In some cases we received point data that clearly represented the outline of a town. We developed these into polygons. We compiled 380 polygons (4693.6 ha, Figure 2), of

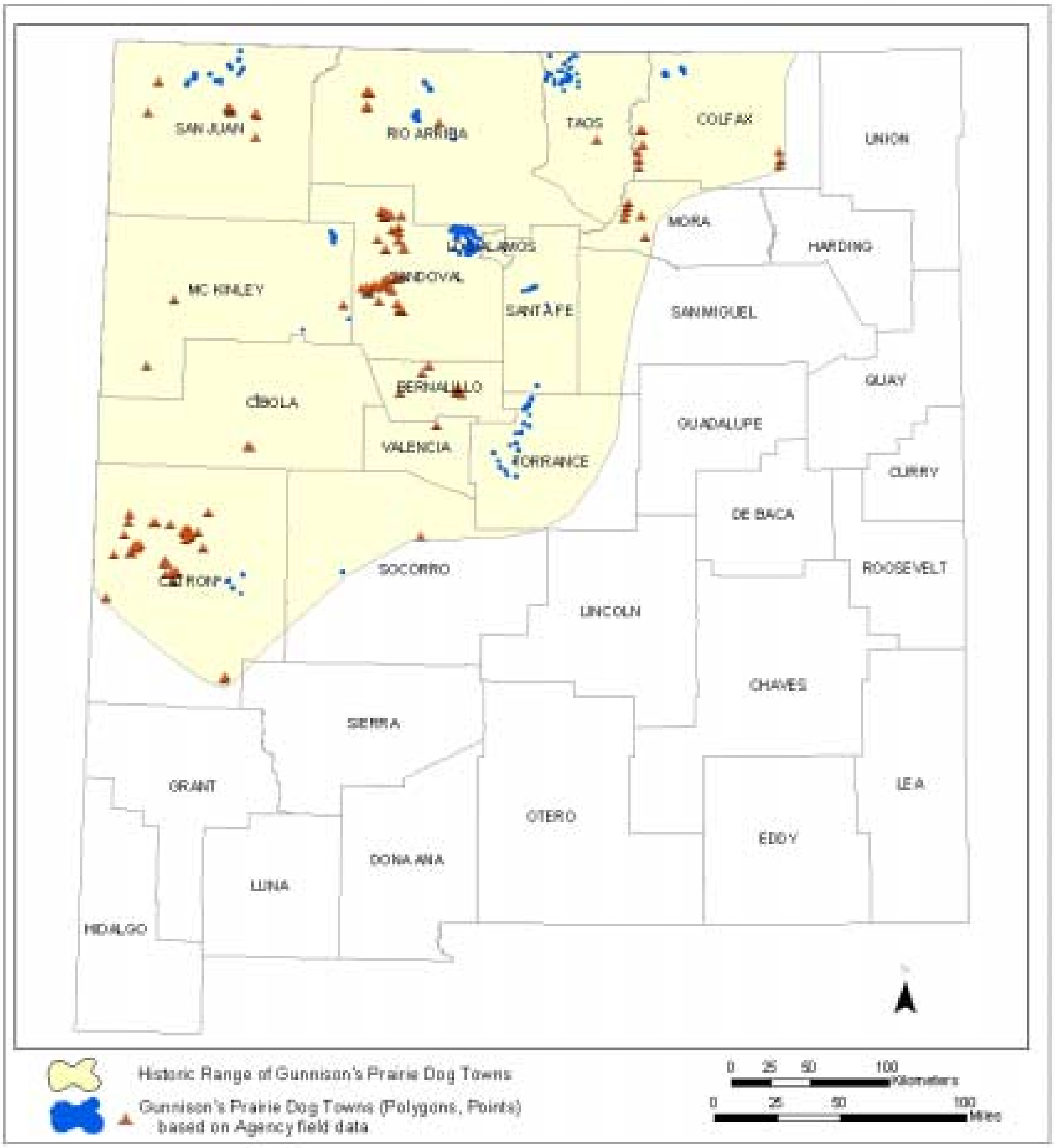

Figure 2. Known Gunnison's prairie dog towns (points and polygons), based on agency field data.

which 264 were active (3685.6 ha), 107 inactive (989.9 ha), and 9 of unknown status (18.1). We compiled the data into a GIS and used the polygon and point data to determine which DOQs to search during the photo interpretive process. These known locations were distributed over 131 DOQs. Without viewing the GIS layer showing the known towns, we searched specific DOQs using our photo interpretive process. The goal was not to survey the entire historical range, rather to evaluate the method by surveying only those quads known to have prairie dogs.

Survey

We employed traditional aerial photo interpretive techniques (Lillesand & Kiefer 1987) to survey a subset of DOQs in the historical New Mexico range of Gunnison's prairie dogs (Figure 1), delineated by Hubbard and Schmitt (1984). We purchased geo-referenced DOQ images in Tagged Image File (TIF) format from the USGS through the New Mexico Resource Geographic Information System (RGIS) program. We used black and white images from 1991-2001, the majority (65%) from 1997. Each DOQ image was brought into ESRI ArcMap and kept at the raster resolution, approximately 900 m by 1300 m (*see* Appendix C for a list of DOQs scanned). We examined the screen left to right, down, right to left, and so on, until the entire screen had been reviewed. We then moved one screen to the right (or down) and repeated the process until the entire image had been viewed. When we identified a potential town, we drew a polygon connecting the outermost mounds of the town boundary using ArcMap software (Figure 3). Each polygon was assigned a unique site identification number. We used the XTools extension (Popov and Chikinev 2003) to generate the area (ac, ha) for each polygon. For this report, we consider all polygons created in this manner to be potential towns, because we performed no ground-truthing on the towns delineated on DOQs. Finally, the original GIS data on known Gunnison's prairie dog towns were compared with the DOQ interpretation to determine the efficiency of the method (Figure 4).

Spatial Analysis

Using the Select by Location tool in ArcMap, we determined the percentage of the original GIS data that overlapped with the photo interpreted polygons. In addition, we repeated the analysis using a buffer of 250 m and 500 m around each GPS point and GPS polygon, to account for town movement that may have occurred between the time of the photo (e.g., 1996-97) and the time of the field mapping (e.g., 2003). Original TRS points were placed in the center of a section (1 mi^2). We added a buffer of 0.6 mi to each TRS point to include the entire section.

Ground-truthing

There was no ground-truthing of DOQ-identified towns. Instead, we spent considerable time contacting land managers and processing recent data they provided on known towns (Appendix A). We also compiled an additional list of potential sources (Appendix B). The GIS data representing known points and towns were used as a "field check" for the photo interpretation methods.

Inter-observer Comparison

To investigate consistency between observers, a second observer (Jackie Smith, JS) scanned a subset of DOQs previously scanned by the primary observer (Tracey Ostheimer, TO). JS scanned about 13% of the 195 DOQs surveyed for the project (25 DOQs). The 25 DOQs were chosen to represent a variety of habitat types and to include DOQs with and without prairie dog disturbance.

Results

Area Scanned

The estimated historical range (including unoccupied habitat) of the Gunnison's prairie dog in New Mexico is 12,246,934 ha (30, 262,173 ac) in area (derived from range map of Gunnison's prairie dogs in NM, Hubbard and Schmitt 1984). Approximately 3,064 DOQs (quarter quadrangles) cover this historical New Mexico range. We scanned 6.4% of the range, approximately 782,269 ha (1,932,987 ac), covered by 195 DOQs. The 195 DOQs occurred in 14 of 16 counties in Hubbard and Schmitt's (1984) "present distribution" (Table 1).

Table 1. Summary of data on known Gunnison's prairie dog towns acquired from land managers, by county.

County (Hubbard & Schmitt 1984)	Number DOQs scanned	% of Total DOQs scanned	DOQ Dates	Dates of Acquired Point Data	Dates of Acquired Polygon Data
Bernalillo	5	2.56	1996	2000, 2002, 2003	--
Catron	29	14.87	1996, 1997	2000, 2003	--
Cibola	2	1.03	1997	2003	2003
Colfax	13	6.67	1997	1985, 1986, 1996	1996, 2003
McKinley	4	2.05	1997	1987, 1998	2002, 2003
Mora	6	3.08	1997, 2001	1996, 2003	--
Rio Arriba	13	6.67	1997	2003, 2004	2003
San Juan	32	16.41	1991, 1997, 1998	1998, 2002	2002, 2003
San Miguel	1	0.51	1997	--	1996
Sandoval	26	13.33	1996, 1997	1973, 1978, 1981,1991, 1997, 1998, 1999, 2001, 2002, 2003	2003
Santa Fe	7	3.59	1996, 1997	2003, 2004	1996, 2003
Socorro	13	6.67	1996, 1997	1997, 2000	--
Taos	14	7.18	1997	2003	2003
Torrance	41	21.03	1996, 1997, 1998	2003	1996
Los Alamos	0	0.00	--	--	--
Valencia	0	0.00	--	--	--

Data on Known Gunnison's Prairie Dog Towns

Some data from contributors came from outside the contributing agency's property boundaries. Thus, " contributor" and "owner" are not necessarily the same entity. Although there is no way to determine acreage from the point data, from the polygon data we know that there are at least 380 Gunnison's prairie dog towns (including active, inactive, and unknown status towns) covering at least 4,694 ha (11,599 ac) in New Mexico. Over half of the field data were collected in 2000 or after, but we do not know whether these towns were active in 2004. Towns ranged in area from less than 0.01 ha (0.024 ac) to 397.6 ha (982 ac). The mean town size was 12.3 ha (30.4 ac). The majority of the town data acquired were from Sandoval County, (59.9%) and Rio Arriba County (11.3%, Table 2). The major contributor was Bandelier National Monument (Table 3). The majority of point data also came from Sandoval County (38.6%, Table 4). Of all towns, 71.3% were reported to be active, 20.1% inactive, and 8.6% of undetermined status (Table 5).

We received 153 point locations, of which 107 were derived from TRS data, 33 from GPS data, and 13 from other sources such as topographic maps. Accurate acreages cannot be computed for these data, because point data have no area and TRS data provide only the section a town occurred in, but not the area of the town.

Accuracy Results

Using photo interpretation, we identified 29,210 ha of potential Gunnison's prairie dog disturbance in 14 counties (Figure 5). Potential towns were found in various grassland habitats, including grasslands that intrude into or are surrounded by woodland (pinyon, juniper, ponderosa pine) or scrubland (sage) habitat.

Using DOQs, we detected 50% (191) of the original known Gunnison's prairie dog towns provided as polygons. To account for changes in town size and location between the time the photos were taken and the year the field data were collected, we added 250 m and 500 m buffers around each of the original polygons and re-calculated accuracy. The DOQ polygons intersected 76% (288) of the original towns with 250 m buffers and 84% (321) with 500 m buffers (Table 6).

Of the 153 points representing known Gunnison's prairie dog towns, 46 were GPS points or from topographic maps. Of these, 5 (11%) fell within polygons of prairie dog disturbance found on DOQs. When a 250 m buffer was added to each of the original points, 14 (30%) of the buffer points intersected DOQ-identified disturbance. When a 500 m buffer was added to each of the original points, 22 (48%) of the buffer points intersected DOQ polygons (Table 6).

Our TRS points were section coordinates (accurate to within 1 mi^2) converted to section centroids in our GIS database. Each centroid point was given a 0.6 mile buffer, to include the entire section. Of the 107 original TRS points, we identified 67% (72) of buffered TRS sections on the DOQs as having prairie dog disturbance.

Table 2. Area (ha) of known Gunnison's prairie dog towns by county and land ownership.

	Ownership							
County	Bureau of Land Management	Private	State of New Mexico	Tribal Lands	U.S. Forest Service	Valles Caldera National Preserve	Grand Total	% Total Area by County
Catron		34.3	85.2		13.6		133.1	2.8
Cibola					1.0		1.0	0.0
Colfax		345.4					345.4	7.4
McKinley		0.1	194.4	14.4	0.7		209.7	4.5
Rio Arriba	0.1		0.0	532.6			532.7	11.3
San Juan	311.4	8.1					319.5	6.8
Sandoval						2813.1	2813.1	59.9
Santa Fe		32.2					32.2	0.7
Socorro		3.0					3.0	0.1
Taos	36.4	2.0	4.6				43.0	0.9
Torrance		261.1					261.1	5.6
Total	*347.9*	*686.0*	*284.2*	*547.1*	*15.3*	*2813.1*	*4693.6*	

Table 3. Area (ha) of known Gunnison's towns by data contributor (as distinct from owner).

	Status (ha)				
Citation	Active	Inactive	Unknown	Grand Total	% Total
Bandelier National Monument	1793.3	989.9	16.3	2799.5	59.6
BLM Farmington Field Office	528.4			528.4	11.3
BLM Socorro Field Office (Hawks Aloft)	392.8			392.8	8.4
BLM Taos Field Office (Hawks Aloft)	43.1			43.1	0.9
Eagle Environmental	3.7			3.7	0.1
Earth Data Analysis Center	13.6			13.6	0.3
Jicarilla Reservation	532.6			532.6	11.3
Public Service Company of New Mexico	19.2			19.2	0.4
Tuner Endangered Species Fund	345.4			345.4	7.4
USFS Mount Taylor Ranger District			1.8	1.8	0.0
USFS Quemado Ranger District	13.6			13.6	0.3
Grand Total	*3685.6*	*989.9*	*18.1*	*4693.6*	

Table 4. Data contributor and county of towns represented by point data.

Source	County													
	Bernalillo	Catron	Cibola	Colfax	McKinley	Mora	Rio Arriba	San Juan	Sandoval	Socorro	Taos	Valencia	Grand Total	% of Total
BLM Albuquerque Field Office					1				58				59	38.6
Kirtland Air Force Base	5												5	3.3
Eagle Environmental					1		1	1					3	2.0
Marron & Associates					1			13	1			1	16	10.5
Natural Heritage New Mexico				6		3				1			10	6.5
L. Sager				3		3							6	3.9
Taschek Environmental	3										1		4	2.6
USFS Gila Ranger District		2											2	1.3
USFS Jicarilla Ranger District							6						6	3.9
USFS Quemado Ranger District		40	2										42	27.5
Grand Total	8	42	2	9	3	6	7	14	59	1	1	1	153	

Table 5. Status of towns represented by point or polygon data.

Status	Polygon	Point	Total	% Status
Active	264	116	380	71.29
Inactive	107		107	20.08
Unknown	9	37	46	8.63
Total	380	153	533	

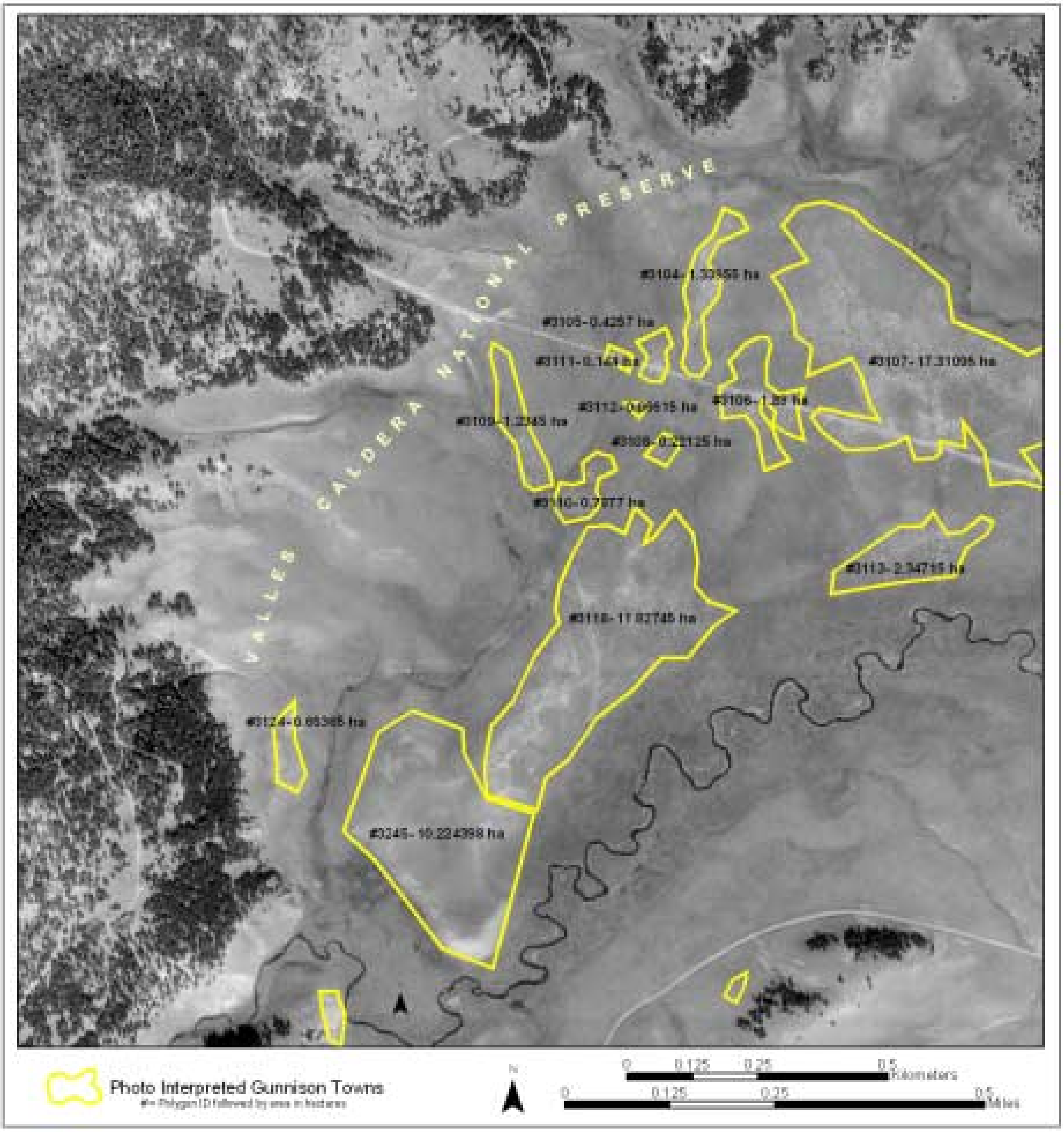

Figure 3. DOQ with photo interpreted towns delineated.

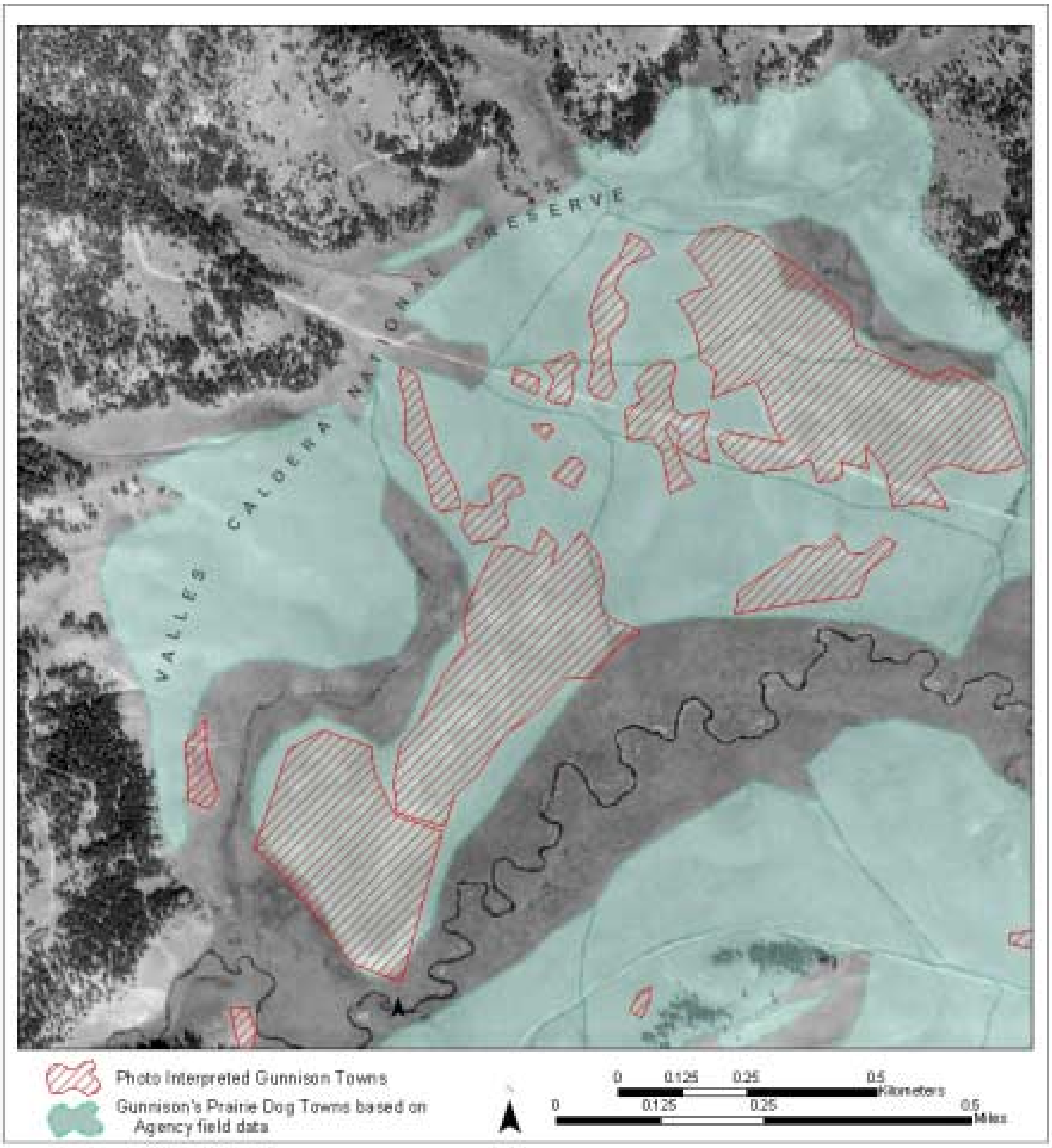

Figure 4. Photo interpreted towns overlaid on towns from agency field data within the Valles Caldera National Preserve.

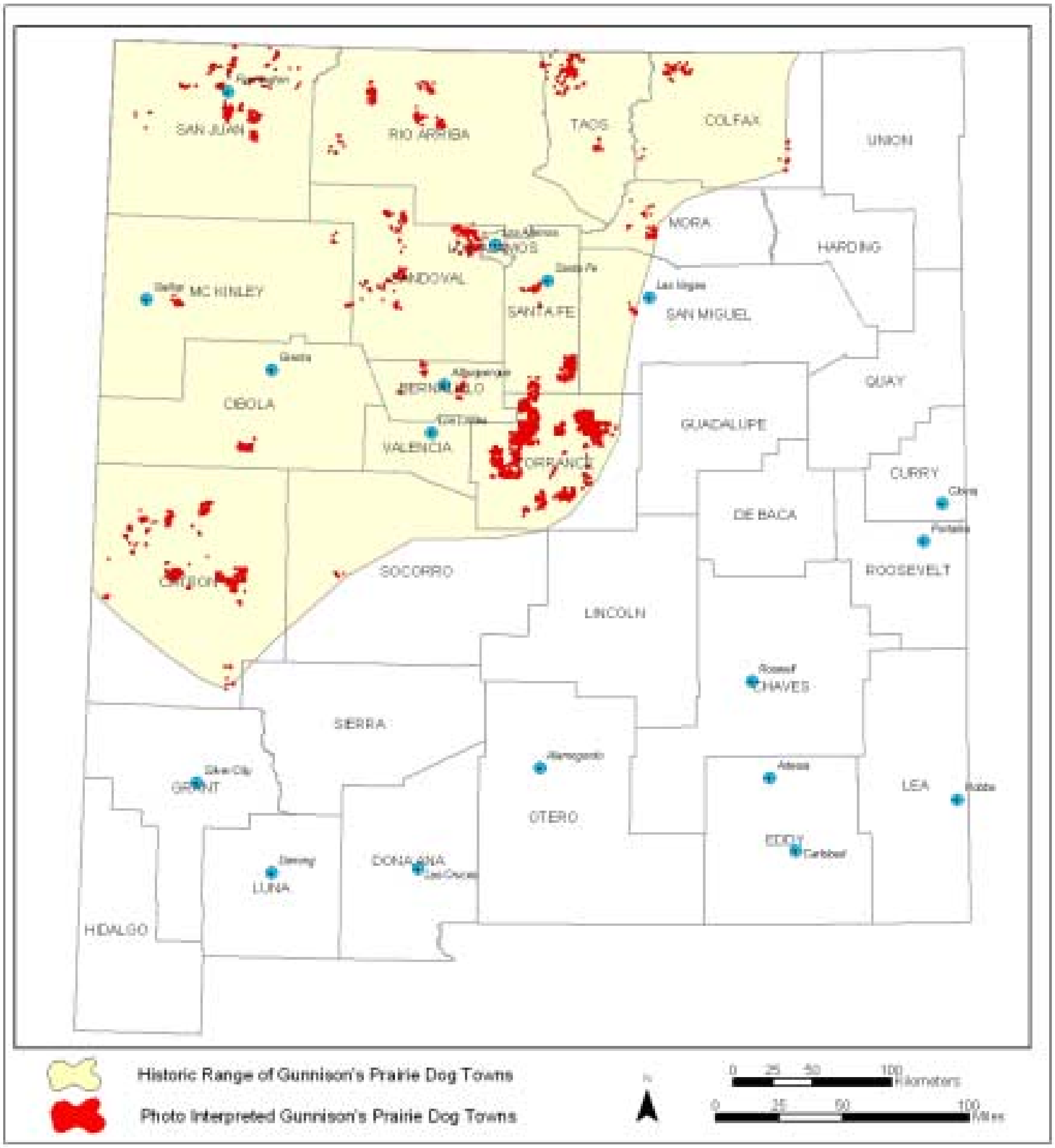

Figure 5. Photo-interpreted Gunnison's prairie dog towns delineated from DOQs.

Table 6. Accuracy of Gunnison's prairie dog photo interpretation for point and polygon data.

Source Data	Number Detected on DOQs	% Accuracy
Polygon		
Originals	380	
Intersect	191	50
250 m buffer	288	76
500 m buffer	321	84
Point GPS		
Originals	46	
Intersect	5	11
250 m buffer	14	30
500 m buffer	22	48
Point TRS		
Original	107	
Section	72	67

Inter-observer Comparison

There were notable discrepancies between the results for the two observers. The primary observer (TO), who scanned all 195 DOQs for this report, found 5617.4 ha (13,880.6 ac) of apparent prairie dog disturbance on the subset of 22 DOQs chosen for inter-observer comparison. The second observer (JS) found 8037 ha (19,859.4 ac) of apparent prairie dog disturbance on the same 22 DOQs. The overlap between the two observers was 4121.5 ha (10,184.2 ac), or 73% of TO's total and 51% of JS's total. This limited comparison suggests that the DOQ survey method for Gunnison's prairie dogs has potential for significant inter-observer discrepancies.

Discussion

The Survey Method

Johnson et al. (2003) demonstrated that DOQ imagery provides an efficient means of surveying for black-tailed prairie dogs in New Mexico. Black-tailed prairie dog burrow entrances were typically surrounded by a lighter halo on the DOQs (indicative of cropped vegetation), and burrow entrances showed up on the DOQ as white dots. Gunnison's prairie dog burrows are less clumped and towns are smaller on average than those of black-tailed prairie dogs. Gunnison's prairie dog habitat is much more varied than that of black-tailed prairie dogs. Known and potential towns occurred in various grassland habitats, including grasslands interspersed with woodland (pinyon, juniper, ponderosa pine) or scrubland (sage) habitat. Topography where Gunnison's prairie dogs occur is much more varied. Thus, in addition to the obstacles encountered with the black-tailed prairie dog DOQ survey (Johnson et al. 2003, 2004), DOQ surveys for Gunnison's present several unique challenges.

Pros:

The DOQ survey method has several advantages over other survey methods. It is cost-effective for large landscape areas, provides complete coverage, produces geo-referenced data useful for GIS, and avoids access difficulties related to land ownership. The archived aerial photography and GIS layers provide a permanent baseline record of prairie dog towns that is useful for monitoring (Johnson et al. 2003, 2004).

We found that Gunnison's disturbance does show up on DOQs, although it is less obvious than that of black-taileds. DOQs were available for all areas of interest for this project, as were recent field data to provide checks of our surveys.

Cons:

The majority of DOQs we used were about seven years old. This method cannot account for changes between the time of the imagery and the time of the field survey. Thus, we can only estimate the current area of occupation. The photographic quality of the DOQ can affect ability to distinguish prairie dog disturbance from other types of disturbance; e.g., ant mounds, bannertail kangaroo rat (*Dipodomys spectabilis*), disturbance, or cattle activity.

There also may be limits to the ability of the interpreter to resolve small towns. In another study in the southwest, average Gunnison's prairie dog colony size was 46 ha, while in northeastern New Mexico, Gunnison's prairie dog colony size was reported at 33 ha (81.5 ac, Clark et al. 1982). The average size of the known towns compiled during this project was 12.3 ha. Varied topography might also affect image clarity. Habitat is also important. Gunnison's towns in agricultural habitat were by far the easiest to identify. Because of this differential detectability by habitat, ground-truthing efforts must include field checks in various habitats.

In this study, Gunnison's towns did not exhibit obvious haloing as was evident in black-tailed prairie dog colonies. Without halos it is difficult to differentiate between prairie dog and other causes of disturbance such as harvester ants, kangaroo rats, or ground squirrels (Johnson et al. 2003). In addition, Gunnison's burrow entrances are frequently not built into mounds and do not show up clearly on the DOQs.

Accuracy and Consistency

The buffers added to account for changes in town size and location were quite large. Although buffering apparently improved our accuracy, 500 m buffers were so large that they could have intersected towns other than known, target towns. The most parsimonious way to evaluate accuracy would be to look at the un-buffered data, which suggest an accuracy of only 50% (polygon data), 11% (point data), and 67% (TRS data, but these were section data buffered at 0.6 mi.). These numbers must be considered in light of the potential changes that could have occurred in the six years intervening between the imagery and the field surveys. However, similar comparisons for black-taileds suggest a more acceptable 82% accuracy rate (Johnson et al. 2004).

Our comparison of results from two different observers suggests that the DOQ survey method for Gunnison's prairie dogs has potential for significant inter-observer discrepancies. Gunnison's prairie dog disturbance is difficult to discern, and naïve observers are likely to interpret the same imagery differently. The second observer delineated the majority of the disturbance found by the first observer but also included additional areas. This result could occur if the second observer connected small adjacent polygons into one, including small areas without burrows, while the first observer drew separate polygons around each small area with burrows. Thus, it is possible that with more training, observer interpretations would become more consistent. Nevertheless, it is clear that Gunnison's prairie dog disturbance is less evident than that of black-taileds, and errors of interpretation are much more likely.

Field Checks

Extensive field checking was beyond the scope of this project. Known Gunnison's prairie dog towns allowed us to check the accuracy of the photo interpretation but did not give us information on the percent of false positives, those sites we identified on DOQs as towns that were not actually towns. A field check of new sites found in the imagery would not provide an accurate indication of the rate of false positives, because towns present on the DOQs could have disappeared in the intervening years. The only way to find all false negatives is to conduct a 100%, on-the-ground survey at the time the imagery is made.

Ground Surveys

Even ground surveys cannot always reveal the status of a Gunnison's prairie dog colony. Hawks Aloft (2003) surveys in the Taos area found 37 colonies, of which 43% were considered active, 35% inactive, and 22% unknown. Likewise, during Gunnison's surveys at the Valles Caldera National Preserve, 248 colonies were mapped, of which 64% were active, 35.5% inactive, and 0.5% unknown (K. Beeley pers. comm. 2003). As demonstrated in these two examples, it can be difficult to see prairie dogs, even in an active colony. Unlike black-tailed prairie dogs, Gunnison's prairie dogs may hibernate from Oct or Nov. to March or April (Burt and Grossenheider 1976). The Hawks Aloft surveys were completed April-June (Hawks Aloft 2003) and therefore could have missed hibernating animals. In addition, weather and time of day may influence detection probabilities (Powell et al. 1994).

Aerial Line-intercept

The aerial line-intercept technique is expensive and of questionable accuracy. W. Andelt (2003, pers. comm.) reported that aerial survey crews from Colorado and Utah, using line intercept methodology, significantly overestimated the lengths of white-tailed and Gunnison's's prairie dog colonies compared to lengths measured on the ground. Proportions of transects with prairie dog colonies detected by the two aerial crews were only weakly correlated. Further, the two crews did not consistently report finding prairie dogs in the same areas along the same transects. Lengths of transects with prairie dog colonies observed from the air compared to the lengths ascertained from the ground were not related to the aerial crews' ratings of how visible colonies were on transects nor to ratings of habitat types observed from the air. Thus, differences in acreage reported in consecutive surveys may be related to variation among crews rather than visibility of prairie dog disturbance.

Miller (2004) reported on a field review of aerial line-intercept transect surveys performed for the Colorado Division of Wildlife. On the Comanche National Grasslands, field surveyors found that only 58% of the area estimated to be occupied was actually occupied by prairie dogs. On the Pawnee National Grasslalnds, 48% of the estimated occupied area was actually occupied. Discrepancies were attributed to flaws in the protocol.

Conclusions

As expected, the accuracy of DOQ photo interpretation as a survey method for Gunnison's prairie dogs was lower than for black-tailed prairie dogs. Prior to recent studies evaluating the line-intercept method (W. Andelt pers. comm., Miller 2004), it might have seemed most prudent to abandon the DOQ method for Gunnison's surveys, in favor of the aerial line-intercept technique. However, it is now apparent that the line-intercept method, in addition to being costly and lacking important spatial attributes, may be quite inaccurate and have low repeatability.

At this time, there appears to be no excellent method for range-wide survey of Gunnison's prairie dogs. Of the methods available, ground access to a large proportion of the species' range would be impossible, and ground surveys would be cost prohibitive. Line-intercept transects are costly, lack spatial information, produce inconsistent results, and may greatly over-estimate the area of active towns. Available DOQs for most of the state are six to seven years old, and Gunnison's prairie dog disturbance is difficult to discern on DOQs. A limited ground-truth study of the new sites detected in this study would provide more information on the false positive rate with the DOQ method. In addition, a new round of digital orthophotos is in the planning stages. New DOQ surveys and field checking without a long time lag could greatly improve the utility of the DOQ method for both prairie dog species. The best solution would be to use imagery with higher resolution than DOQs that was available for the same times as field data. NM BLM is investigating the availability of such imagery (P. Sawyer pers. comm.).

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Appendix A. Data Sources

CONTRIBUTOR	CONTACT PERSON	PHONE	DATE	TYPE OF DATA
BLM, Albuquerque Field Office	Randall Legler	(505) 761-8791	1973-2003	Township, Range, Section (TRS) data
BLM, Taos Field Office	ValerieWilliams	(505) 751-4716	2003	Global Positioning System (GPS) point data
Eagle Environmental, Inc.	Dale Stahlecker	(505) 466-3453	2003	GPS point data
Lawry Sager, Environmental Consultant	Lawry Sager	(505) 474-6282	1996	GPS point data from 1996 report of Survey of Black-tailed prairie dogs
Hawks Aloft, Inc.	Gail Garber	(505) 828-9455	2000	GPS points from Torrance County, and Plains of San Agustin (Socorro and Farmington BLM)
Jicarilla Apache Reservation, Jicarilla Game & Fish Department	Tom Watts	(505) 759-3255	2003	GPS point data
Kirtland Air Force Base, Natural Resource Manager	Carol Finley	(505) 846-0053	2003	GPS point data
Marron & Associates	Paul Knight	(505) 898-8848	2002, 2003	GPS point data
Navajo Nation, Navajo Fish & Wildlife Department, Navajo Natural Heritage Program	David Mikesic	(928) 871-7070	2000	GPS polygon data
NPS, Bandelier National Monument	Kay Beeley	(505) 672-3861x542	2002	GPS polygon data (Valles Caldera National Preserve)
Public Service Company of New Mexico	Doug Campbell	(505) 241-2025	2003	GPS point data
San Juan College, Farmington Branch	Don Hider	(505) 566-3772	2002, 2003	GPS polygon data
Taschek Environmental Consulting	Jim Nelleson	(505) 821-4700	2000	GPS point data
Turner Endangered Species Fund, Vermejo Park Ranch	Dustin Long	(505) 375-2488	2003	GPS polygon data
UNM, Department of Biology	Ana Davidson	(505) 277-9165	2003	GPS point data
UNM, Earth Data Analysis Center	Paul Neville	(505) 277-3622 x244	2003	GPS polygon data
UNM, Museum of Southwestern Biology, Division of Mammals	Mike Bogan	(505) 346-2870	2002	GPS point data

CONTRIBUTOR	CONTACT PERSON	PHONE	DATE	TYPE OF DATA
UNM, Museum of Southwestern Biology, Natural Heritage New Mexico	Kris Johnson	(505) 277-3822 x 223	1985-1997	GPS data points obtained from NHNM spatial database.
USFS, Jemez Ranger District	Jo Wargo	(505) 829-3535	2003	TRS point data
USFS, Jicarilla Ranger District	Dave Seery	(505) 632-2956	2003	TRS point data
USFS, Mt.Taylor Ranger District	Bob Woyewodzic	(505) 287-8833	2003	Estimated polygons
USFS, Quemado Ranger District, Gila National Forest	Pat Morrison	(505) 773-4678	2003	TRS point and GPS polygon data
USFS, Quemado Ranger District, Gila National Forest	Art Telles	(505) 773-4678	2003	TRS point data

Appendix B. Potential Future Sources of Data

CONTACT OFFICE	CONTACT	PHONE	TYPE OF DATA
Blue Earth Ecological Consultants	John Pittenger	(505) 983-2687	
Ecosphere Consulting	Erin Powell	(505) 327-3088	
Forest Guardians	Nicole Rosmarino	(719) 523-4123	
NM Transportation Department	Steve Reid	(505) 827-5254	
Playa Lakes Joint Venture	Christopher Rustay	(505) 266-6968	Santa Fe and Taos
Prairie Ecosystems, Santa Fe Office	Paula Martin	(505) 758-7008	Mapping prairie dog colonies in 2004
Pueblo of Zuni	Raymond Smith	(505) 325-1864	
Pueblo of Zuni, Fish & Wildlife Department, Department of Natural Resources	Tim Trimble	(505) 783-4731	Mapping prairie dog colonies in 2004
Pueblo of Zuni, Fish & Wildlife Department, Department of Natural Resources	Tony Povilitis, Director	(505) 782-5851	
Rocky Mtn. Bird Observatory	David Hanni	(970) 482-1707	Farmington area data in various reports
SWCA Environmental Consultants, Inc.	Claudia Oaks	(800) 828-8499	
Turner Endangered Species Fund	Joe Truett	(505) 539-2188	
University of New Mexico	Jean-Luc Cartron	jlec@unm.edu	Plains of San Agustin
USFS, Black Range Ranger District	Jeff Rivera	(505) 894-6677	
USFS, Cuba Ranger District	Ramon	(505) 289-3264	
USFS, Las Vegas Ranger District	Mike Lujan	(505) 425-3534	Potentially Obaro Mtn. and North Wahoo within Black Range

Appendix C. Digital Ortho Quadrangles Scanned

DOQ Name	DOQ	Acquisition Date	County	Code1	Code2
Albuquerque East	NE	10/6/1996	Bernalillo	3510615	35106a5
Albuquerque East	SE	10/6/1996	Bernalillo	3510615	35106a5
La Mesita Negra	SW	10/6/1996	Bernalillo	3510618	35106a8
Volcano Ranch	NE	10/6/1996	Bernalillo	3510627	35106b7
Volcano Ranch	SE	10/6/1996	Bernalillo	3510627	35106b7
Wall Lake	NW	10/9/1996	Catron	3310831	33108c1
Spring Canyon	SW	10/9/1996	Catron	3310841	33108d1
Shaw Mtn	NE	10/9/1996	Catron	3310871	33108g1
Luna	NW	10/10/1996	Catron	3310878	33108g8
Horse Mtn East	SW	10/9/1996	Catron	3310881	33108h8
Horse Mtn East	NE	10/9/1996	Catron	3310881	33108h8
Horse Mtn West	NE	7/2/1997	Catron	3310882	33108h2
Tularosa Canyon	NW	10/18/1997	Catron	3310884	33108h4
Tularosa Canyon	NE	10/18/1997	Catron	3310884	33108h4
Tularosa Canyon	SE	10/18/1997	Catron	3310884	33108h4
Tularosa Canyon	SW	10/18/1997	Catron	3310884	33108h4
Aragon	NE	10/18/1997	Catron	3310885	33108h5
Mangas Mtn	NE	7/2/1997	Catron	3410813	34108a3
Mangas Mtn	SW	7/2/1997	Catron	3410813	34108a3
Gallo Mtns East	SE	10/18/1997	Catron	3410815	34108a5
Gallo Mtns West	NW	10/18/1997	Catron	3410816	34108a6
Black Peak	NE	10/18/1997	Catron	3410817	34108a7
Jones Canyon	SE	10/10/1996	Catron	3410818	34108a8
Mangas	NW	7/2/1997	Catron	3410823	34108b3
Escondido Mtn	NE	10/18/1997	Catron	3410824	34108b4
Escondido Mtn	SE	10/18/1997	Catron	3410824	34108b4
Largo Mesa	NE	10/18/1997	Catron	3410825	34108b5
Ponderosa Tank	NE	10/18/1997	Catron	3410826	34108b6
Red Hill	SW	10/18/1997	Catron	3410827	34108b7
Red Hill	NE	10/18/1997	Catron	3410827	34108b7
Omega	NE	10/6/1997	Catron	3410833	34108c3
Armstrong Canyon	SE	10/18/1997	Catron	3410835	34108c5
Tejana Mesa SW	SW	10/18/1997	Catron	3410836	34108c6
Blaines Lake	SE	5/31/1996	Catron	3410837	34108c7
Sand Canyon	NW	10/9/1997	Cibola	3410768	34107f8
York Ranch	NE	10/9/1997	Cibola	3410861	34108f1
Abbott	NE	10/9/1997	Colfax	3610433	36104c3
Sauble Circle Dot Ranch	NE	10/9/1997	Colfax	3610443	36104d3
Sauble Circle Dot Ranch	SE	10/9/1997	Colfax	3610443	36104d3
Casa Grande	SW	10/9/1997	Colfax	3610488	36104h8
Osha Mountain	NE	10/4/1997	Colfax	3610533	36105c3
Osha Mountain	SE	10/4/1997	Colfax	3610533	36105c3

DOQ Name	DOQ	Acquisition Date	County	Code1	Code2
Palo Flechado Pass	NE	10/4/1997	Colfax	3610543	36105d3
Palo Flechado Pass	SE	10/4/1997	Colfax	3610543	36105d3
Eagle Nest	SE	10/4/1997	Colfax	3610553	36105e3
Van Bremmer Park	NW	10/5/1997	Colfax	3610571	36105g1
Van Bremmer Park	SW	10/5/1997	Colfax	3610571	36105g1
Vermejo Park	SW	10/5/1997	Colfax	3610581	36105h1
Vermejo Park	SE	10/5/1997	Colfax	3610581	36105h1
Star Lake	SW	10/9/1997	McKinley	3510784	35107h4
Star Lake	NW	10/9/1997	McKinley	3510784	35107h4
Church Rock	SE	10/6/1997	McKinley	3510855	35108e5
Cerro Parido	SW	10/5/1997	McKinley & Sandoval	3510753	35107e3
Rainsville	NW	3/16/2001	Mora	3510582	35105h2
Lucero	NE	3/19/2001	Mora	3610512	36105a2
Comanche Peak	NE	3/16/2001	Mora	3610513	36105a3
Comanche Peak	NW	3/16/2001	Mora	3610513	36105a3
Holman	NE	10/4/1997	Mora	3610514	36105a4
Holman	SE	10/4/1997	Mora	3610514	36105a4
Chacon	SW	10/4/1997	Mora	3610523	36105b3
El Vado	NW	10/4/1997	Rio Arriba	3610656	36106e6
Pounds Mesa	NW	10/4/1997	Rio Arriba	3610657	36106e7
Los Indios Canyon	NE	10/4/1997	Rio Arriba	3610658	36106e8
Cedar Canyon	SE	10/4/1997	Rio Arriba	3610668	36106f8
Cedar Canyon	NE	10/4/1997	Rio Arriba	3610668	36106f8
Horse Lake	SE	10/4/1997	Rio Arriba	3610677	36106g7
Horse Lake	SW	10/4/1997	Rio Arriba	3610677	36106g7
Gonzales Mesa	NE	10/9/1997	Rio Arriba	3610744	36107d4
Gonzales Mesa	SW	10/9/1997	Rio Arriba	3610744	36107d4
Leandro Canyon	NW	10/4/1997	Rio Arriba	3610762	36107f2
Bixler Ranch	SW	10/4/1997	Rio Arriba	3610772	36107g2
Archuleta	NW	10/13/1997	San Juan	3610776	36107g6
Archuleta	SW	10/13/1997	San Juan	3610776	36107g6
Turley	NE	10/13/1997	San Juan	3610777	36107g7
Aztec	SW	10/9/1997	San Juan	3610778	36107g8
Aztec	NE	10/9/1997	San Juan	3610778	36107g8
Aztec	SE	10/9/1997	San Juan	3610778	36107g8
Anastacio Spring	SE	10/13/1997	San Juan	3610786	36107h6
Cedar Hill	NE	10/9/1997	San Juan	3610788	36107h8
Cedar Hill	SW	10/9/1997	San Juan	3610788	36107h8
Cedar Hill	SE	10/9/1997	San Juan	3610788	36107h8
Carson Trading Post	NE	10/9/1997	San Juan	3610841	36108d1
Gallegos Trading Post	NE	10/9/1997	San Juan	3610851	36108e1
Hugh Lake	NW	10/13/1997	San Juan	3610852	36108e2
Yellow Hill	SE	5/11/1998	San Juan	3610857	36108e7
Yellow Hill	NE	5/11/1998	San Juan	3610857	36108e7
Yellow Hill	SW	5/11/1998	San Juan	3610857	36108e7
Yellow Hill	NW	5/11/1998	San Juan	3610857	36108e7

DOQ Name	DOQ	Acquisition Date	County	Code1	Code2
Farmington South	SW	10/13/1997	San Juan	3610862	36108f2
Farmington South	SE	10/13/1997	San Juan	3610862	36108f2
Flora Vista	SE	10/15/1997	San Juan	3610871	36108g1
Flora Vista	SW	10/15/1997	San Juan	3610871	36108g1
Farmington North	NW	10/13/1997	San Juan	3610872	36108g2
Farmington North	NE	10/13/1997	San Juan	3610872	36108g2
Youngs Lake	SE	6/8/1991	San Juan	3610873	36108g3
Youngs Lake	NW	6/8/1991	San Juan	3610873	36108g3
Youngs Lake	NE	6/8/1991	San Juan	3610873	36108g3
Waterflow	SW	6/23/1991	San Juan	3610874	36108g4
Waterflow	NW	6/23/1991	San Juan	3610874	36108g4
Chimney Rock	SE	9/24/1991	San Juan	3610875	36108g5
La Plata	NE	10/13/1997	San Juan	3610882	36108h2
La Plata	SE	10/13/1997	San Juan	3610882	36108h2
La Plata	SW	10/13/1997	San Juan	3610882	36108h2
Ojitos Frios	SW	9/29/1997	San Miguel	3510553	35105e3
Ojito Spring	SW	10/6/1996	Sandoval	3510658	35106e8
Holy Ghost Spring	NW	10/6/1996	Sandoval	3510668	35106f8
Bland	NW	10/11/1996	Sandoval	3510674	35106G4
Redondo Peak	NW	10/11/1996	Sandoval	3510675	35106g5
Redondo Peak	NE	10/11/1996	Sandoval	3510675	35106g5
La Ventana	NW	10/6/1996	Sandoval	3510678	35106g8
Valle Toledo	NW	10/11/1996	Sandoval	3510684	35106h4
Valle Toledo	SW	10/11/1996	Sandoval	3510684	35106h4
Valle Toledo	SE	10/11/1996	Sandoval	3510684	35106h4
Valle San Antonio	NW	10/11/1996	Sandoval	3510685	35106h5
Valle San Antonio	NE	10/11/1996	Sandoval	3510685	35106h5
Valle San Antonio	SW	10/11/1996	Sandoval	3510685	35106h5
San Pablo	NW	10/6/1996	Sandoval	3510688	35106h8
Cabezon Peak	NE	10/4/1997	Sandoval	3510751	35107e1
Cabezon Peak	NW	10/4/1997	Sandoval	3510751	35107e1
Guadalupe	NE	10/2/1997	Sandoval	3510752	35107e2
Guadalupe	NW	10/2/1997	Sandoval	3510752	35107e2
San Luis	SW	10/4/1997	Sandoval	3510761	35107f1
San Luis	SE	10/4/1997	Sandoval	3510761	35107f1
Arroyo Empedrado	SW	10/13/1997	Sandoval	3510762	35107f2
Arroyo Empedrado	SE	10/13/1997	Sandoval	3510762	35107f2
Headcut Reservoir	NW	10/4/1997	Sandoval	3510771	35107g1
Mesa Portales	NE	10/4/1997	Sandoval	3510781	35107h1
Cuba	SW	10/5/1997	Sandoval	3610618	36106a8
Arroyo Chijuillita	SE	10/4/1997	Sandoval	3610711	36107a1
Arroyo Chijuillita	SW	10/4/1997	Sandoval	3610711	36107a1
White Lakes	SE	11/2/1997	Santa Fe	3510527	35105b7
White Lakes	NE	11/2/1997	Santa Fe	3510527	35105b7
White Lakes	NW	11/2/1997	Santa Fe	3510527	35105b7
Seton Village	SW	10/9/1996	Santa Fe	3510558	35105e8

DOQ Name	DOQ	Acquisition Date	County	Code1	Code2
Agua Fria	SE	10/6/1996	Santa Fe	3510661	35106f1
Agua Fria	SW	10/6/1996	Santa Fe	3510661	35106f1
Squaw Peak	NW	10/18/1997	Socorro	3310783	33107h3
Mesa Del Yeso	NE	10/6/1996	Socorro	3410627	34106b7
Arroyo Landavaso	SW	10/7/1996	Socorro	3410713	34107a3
Taos	NW	10/4/1997	Taos	3610545	36105d5
Sunshine	NW	10/5/1997	Taos	3610576	36105g6
Cerro De La Olla	SW	10/4/1997	Taos	3610577	36105g7
Cerro De La Olla	NE	10/4/1997	Taos	3610577	36105g7
Cerro De La Olla	NW	10/4/1997	Taos	3610577	36105g7
La Segita Peaks	NE	10/4/1997	Taos	3610578	36105g8
La Segita Peaks	SE	10/4/1997	Taos	3610578	36105g8
La Segita Peaks	SW	10/4/1997	Taos	3610578	36105g8
Ute Mtn	NW	10/5/1997	Taos	3610586	36105h6
La Segita Peaks NE	SW	10/4/1997	Taos	3610587	36105h7
La Segita Peaks NE	NE	10/4/1997	Taos	3610587	36105h7
La Segita Peaks NE	SE	10/4/1997	Taos	3610587	36105h7
Pinabetoso Peaks	SW	10/4/1997	Taos	3610588	36105h8
Pinabetoso Peaks	NE	10/4/1997	Taos	3610588	36105h8
Progresso NE	NW	10/5/1997	Torrance	3410547	34105d7
Progresso NE	NE	10/5/1997	Torrance	3410547	34105d7
Progresso	NW	10/5/1997	Torrance	3410548	34105d8
Progresso	SW	10/5/1997	Torrance	3410548	34105d8
Negra SW	SE	10/6/1997	Torrance	3410556	34105e6
Negra SW	NE	10/6/1997	Torrance	3410556	34105e6
Laguna Del Pero South	NE	10/5/1997	Torrance	3410558	34105e8
Pedernal	NE	10/5/1997	Torrance	3410566	34105f6
Lucy	NW	10/5/1997	Torrance	3410567	34105f7
Lucy	NE	10/5/1997	Torrance	3410567	34105f7
Santo Nino Canyon	NW	10/1/1997	Torrance	3410574	34105g4
Santo Nino Canyon	SW	10/1/1997	Torrance	3410574	34105g4
North Lucy	NW	10/5/1997	Torrance	3410575	34105g5
North Lucy	NE	10/5/1997	Torrance	3410575	34105g5
North Lucy	SW	10/5/1997	Torrance	3410575	34105g5
Pedernal Mtn.	NW	10/5/1997	Torrance	3410576	34105g6
Pedernal Mtn.	NE	10/5/1997	Torrance	3410576	34105g6
Lobo Hill SE	NW	9/10/1998	Torrance	3410577	34105g7
Rock Lake	SE	5/23/1998	Torrance	3410586	34105h6
Rock Lake	SW	5/23/1998	Torrance	3410586	34105h6
Gran Quivera	NW	10/5/1997	Torrance	3410631	34106c1
Mountainair	NW	10/8/1996	Torrance	3410652	34106e2
Mountainair	NE	10/8/1996	Torrance	3410652	34106e2
Mountainair	SW	10/8/1996	Torrance	3410652	34106e2
Mountainair	SE	10/8/1996	Torrance	3410652	34106e2
Punta De Agua	NE	10/8/1996	Torrance	3410653	34106e3
Ewing	NE	10/9/1996	Torrance	3410662	34106f2

DOQ Name	DOQ	Acquisition Date	County	Code1	Code2
Ewing	SW	10/9/1996	Torrance	3410662	34106f2
Ewing	SE	10/9/1996	Torrance	3410662	34106f2
Torreon	NE	10/8/1996	Torrance	3410663	34106f3
Torreon	SE	10/8/1996	Torrance	3410663	34106f3
Estancia	NW	10/7/1996	Torrance	3410671	34106g1
Estancia	NE	10/7/1996	Torrance	3410671	34106g1
Estancia	SE	10/7/1996	Torrance	3410671	34106g1
Estancia	SW	10/7/1996	Torrance	3410671	34106g1
Milbourn Ranch	SE	10/9/1996	Torrance	3410672	34106g2
Moriarty South	NW	10/7/1996	Torrance	3410681	34106h1
Moriarty South	NE	10/7/1996	Torrance	3410681	34106h1
Moriarty South	SW	10/7/1996	Torrance	3410681	34106h1
Moriarty South	SE	10/7/1996	Torrance	3410681	34106h1
Moriarty North	NE	10/7/1996	Torrance &Santa Fe	3510611	35106a1
Moriarty North	SE	10/7/1996	Torrance &Santa Fe	3510611	35106a1