Remote Sensing Survey of Black-tailed Prairie Dog Towns in the Historical New Mexico Range

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Table of Contents

Tables

Figures

Introduction

Background

On 2 February 2000, the US Fish and Wildlife Service (USFWS) released the 12-month finding on a petition to list the black-tailed prairie dog (*Cynomys ludovicianus*) as threatened under the Endangered Species Act (USFWS 2000). The USFWS found that listing was warranted but precluded by other higher priority actions, and the black-tailed prairie dog was added to the Candidate List. (USFWS 2000). The most recent candidate review found no substantial change in the species' status since the 12-month finding (USFWS 2002).

Historically, the black-tailed prairie dog occupied eleven midwestern and western states, including New Mexico (Van Pelt 1999). Towns could cover hundreds of thousands of acres and contain thousands of individuals (Bailey 1905). The species occurred in approximately the southeastern half of New Mexico (Schmitt and Sawyer 2001, Figure 1). Determination of the status and distribution of the black-tailed prairie dog is a primary goal of the Conservation and Management Strategic Plan for Black-tailed Prairie Dogs in New Mexico (New Mexico Black-tailed Prairie Dog Working Group 2001). The historical range has not previously been surveyed, and, because the area is extremely large (44 million acres) and primarily privately owned, ground-based surveys would be prohibitively expensive and difficult if not impossible to accomplish. Therefore, the New Mexico Black-tailed Prairie Dog Working Group (working group) chose to use remote sensing techniques to survey the historical range of the black-tailed prairie dog in New Mexico.

Several remote sensing techniques have been used to survey and study prairie dog disturbance. Johnson et al. (2000) used Landsat ETM+ satellite imagery to survey for prairie dog towns on national grasslands in New Mexico. Sidle et al. (2001) used an aerial line-intercept technique to estimate the number and size of towns for a large region in the northern Great Plains. Aerial photographs can provide information about the location, number, and size of black-tailed prairie dog towns (Dalsted et al. 1981, Schenbeck and Myhre 1986, Uresk and Schenbeck 1987). Aerial photography has been used to study re-vegetation of extirpated towns (Schenbeck and Myhre 1986), town expansion (Uresk and Schenbeck 1987), size and location of towns (Tietjen et al. 1978), and the dynamics of growth of towns (Dalsted et al. 1981). All of these methods have drawbacks. For example, resolution of Landsat imagery does not allow detection of most prairie dog disturbance. Standard aerial photography is not geo-referenced and thus is not useful for spatial analysis. Aerial line-intercept surveys do not provide town boundaries or allow for spatial analysis, and it can be more expensive than other methods. We chose to survey for black-tailed prairie dog disturbance in New Mexico using digital orthophoto quadrangles (DOQs), which avoid most of these problems.

DOQs are useful for identifying prairie dog disturbance because they have very high resolution (1 m), and they reveal prairie dog disturbance such as mounds and vegetation removal. DOQs combine the image characteristics of an aerial photograph with the geometric qualities of a map. 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). DOQs are developed by the United States Geological Survey (USGS) National Mapping Division.

The geographic extent of the DOQ is equivalent to a quarter-quad plus a range of 50 m to 300 m beyond the extremes of the corner points.

The goals of this project were to:

1. survey the historical range of the black-tailed prairie dog in New Mexico, using photo interpretation of DOQs, to determine the distribution of towns in New Mexico.
2. create a baseline GIS database of black-tailed prairie dog town locations in New Mexico,
3. create a GIS database of previously-documented prairie dog towns,
4. attribute the GIS database with additional information, including county, land ownership, and town acreage,
5. evaluate accuracy of the method by comparing data from field checks with photo interpretation data, and
6. create maps of detected prairie dog towns.

Methods

We delineated the area to be surveyed based on the GIS layer of the historical range of the black-tailed prairie dog in New Mexico (Schmitt and Sawyer 2001, Figure 1). We employed traditional aerial photo interpretive techniques (Lillesand & Kiefer 1987) to search for black-tailed prairie dog disturbance. Images were either offered free of charge on the Resource Geographic Information System (RGIS) website or purchased from the USGS through the RGIS program. We searched each individual DOQ using ERDAS Imagine software. The geo-referenced DOQ images were in either LizardTech's MrSID or Tagged Image File (TIF) format. We used both black and white (76.5%) and color (23.5%) images. We applied a standard deviation stretch to each DOQ to provide even contrast across the image and make searching easier. Most of the imagery we used (93%) was acquired from 1996-1997.

Black-tailed Prairie Dog Town Identification

The mounds created by prairie dogs at burrow entrances show up as bright, roughly circular spots on DOQs. They are typically clumped spatially and are often surrounded by a lighter halo on the image, indicative of vegetation cropped by the prairie dogs.

Each image was brought into ERDAS Imagine and kept at the default image scale setting, approximately 900 m by 1300 m. After stretching out the contrast with the standard deviation setting, we examined the screen left to right, down, right to left, and so on, until the whole screen had been reviewed. We then moved one screen to the right and repeated the process. When the entire image had been scanned, we zoomed out two steps, such that the screen now covered approximately 1800 by 2600 m, and repeated the scanning process, this time looking for any indications of the halo/clipped vegetation effect.

When we identified a potential town, we extracted that portion of the DOQ to a new image and made a polygon shapefile of the town boundary using ERDAS Imagine software (Figure 2). Whenever possible, the town polygon was generated by tracing the clipped-vegetation halo surrounding the mounds. If no clip line was evident, the polygon connected the outermost mounds.

We assigned the same unique site identification number, beginning with the interpreter's initial, to the extracted image and the site polygon. We used the ArcView extension XTools (DeLaune 2001) to generate the area (acres and hectares) for each polygon. We employed an ESRI ArcView script to generate the geographic coordinates for the center of each site. After the first interpreter identified a site, a second person reviewed the image and designated the site as either a town or a questionable town. If questionable, the reason was recorded, and the code was added to the shapefile attribute table (Table 1). For this report, we refer to potential towns (including questionable towns) and their associated acreages as sites, total towns, or total acreages, and we refer to probable towns/acreages that we do not consider questionable as simply towns or town acreages.

DOQs were not available for all lands within the historic range of the black-tailed prairie dog. Ninety-nine DOQs were unavailable from RGIS. We filled gaps in Colfax and Union Counties by creating DOQs from National Aerial Photography Program (NAPP) photographs, the same photography used by the USGS to produce DOQs. We ordered a total of 56 quads, all acquired in 1997. The quads were scanned at 800 dots per inch (dpi) and viewed in ERDAS Imagine to search for evidence of prairie dog towns. Once evidence of a town was found, Earth Data Analysis Center (EDAC) orthorectified only the images containing sites, using ERDAS Imagine Orthobase.

Assembling Additional Datasets

In addition to the data generated by aerial photo interpretation, we gathered reports and GIS data from individuals and agencies that had completed field surveys for the black-tailed prairie dog in New Mexico. Data from Roswell and Las Cruces BLM Field Offices were acquired as GIS layers. Other data were compiled from reports and entered into a GIS (Paternoster 1997, Sager 1996, Sager 2000). We used these datasets to check sites encountered during the photo interpretive process. Finally, the GIS data derived from the above sources were used to recheck the aerial photography to see if any sites had been missed.

Spatial Analysis

Using the Identity function of the ArcView extension XTools, we assigned county and ownership type to each polygon with apparent prairie dog disturbance. Where the polygon covered more than one county or ownership type, the polygon was split into separate records. We then assigned the date the DOQ was acquired to each record. We determined the mean site size and total area of sites for each county and ownership category.

Using the ESRI ArcView Spatial Analyst, we ran the calculate density function to determine the distribution density of towns within the historic range (ignoring questionable sites). We used a cell size small enough that adjacent towns would be analyzed separately and large enough that the process would not take too long to complete. For each cell within the historic range, we summed the number of towns in the 1 km search radius and divided by the area of the circle. For example, if two towns were found within the 1 km search radius, the number 2 would be divided by the number of km^2 in the circle (approximately 3.142 km^2), giving a result of 0.64 prairie dog towns per km^2 for that cell.

We conducted a cluster analysis to identify complexes of towns. Using the measuring tool in ArcView, we identified all towns within 7 km of another town. A cluster was composed of three or more towns, each with at least one other town within 7 km. Polygons were drawn over all of the towns in a cluster, following the connections between closest towns where possible. Subsequently the extension Nearest Features 3.6d was used to confirm that all towns within each cluster were in fact within 7 km of at least one other town, and that any other towns were more than 7 km away from any cluster. The complex acreage is the sum of town acreage within a cluster, not the total acreage within the cluster polygon.

Ground-truthing

Members of the working group are cooperating in an effort to field check a subset of the sites we found on the imagery. However, final results of these surveys are not yet available. We therefore report results of only two field checking efforts performed by our office. First, a summer student on loan to us from USDA Wildlife Services, accompanied by a USDA field representative, field checked 89 towns in Quay, Roosevelt, Curry, and DeBaca Counties during July 2001. The student estimated size of active towns by logging mileage on the vehicle odometer. During September and October 2001, NMNHP personnel conducted separate checks of several questionable towns in Lincoln and Chaves Counties. In both cases, the researcher found the location of the suspected town using maps and a GPS unit and noted whether an active prairie dog town was present. On these visits, no attempt was made to delineate the town boundary or perform an accurate assessment of town area.

For deliverables we provide this report and a GIS ArcView 3.3 project file that includes GIS layers and DOQ imagery.

Results

The estimated historical range of the black-tailed prairie dog in New Mexico covers 44,366,642 ac. (Schmitt and Sawyer 2000). We scanned 1220 out of a total of 1263 potential DOQs (96.6%), which covered 44,325,794 acres (99.9%). The remaining 43 quadrangles were either partially or entirely unavailable or of poor image quality (Figure 3). Of the 43 remaining quadrangles, 24 were partially scanned for evidence of probable towns. Of the 24 partially-scanned quads, we scanned one quarter of four quads, 2 quarters of 17 quads, and 3 quarters of 3 quads.

Out of the 1,220 quads scanned, 297 were color images (24%). Of the 297, 273 were in the southwest part of the state (Hidalgo, Luna, Grant Counties), or on the southern border with Texas (Eddy and Otero Counties). None of these had any sites we designated as towns. Of the remaining 24, only 8 had towns, on the Texas border of Roosevelt and Lea Counties.

The historical range of the black-tailed prairie dog in New Mexico covers 23 counties. Of these, only Sierra County did not have at least one potential black-tailed prairie dog town site. Of the 22 counties where we found possible prairie dog disturbance, 16 had probable towns (Table 2). We found 867 potential sites, covering 77,906 acres. Of these, we identified 60,294 acres as probable towns. We considered the remaining 17,612 acres to be questionable.

During this study we found towns that ranged in size from less than one acre to 2,360 acres. We found three towns over 1,000 ac in area, one town larger than 2,000 ac, and no towns larger than 5,000 ac. The mean site size was 72.18 ac and the mean town size was 96.13 ac. The largest numbers of towns, the largest single towns, and the largest total acreages in towns occurred in Lea and Roosevelt Counties (Table 3, Figure 4). These two counties accounted for 42% of all potential sites and 49%, nearly half, of all acreage identified as having potential prairie dog disturbance.

We performed a GIS analysis to create a continuous surface depicting the density of prairie dog towns in the study area (Figure 5). The greatest concentrations occurred within Lea County, northeast of Lovington, probably continuing into Texas (0.048 to 0.06 towns per km^2). The Quay-Curry County line shows a smaller "hotspot" of similar density (0.048 to 0.06 towns per km^2). A "warm" spot (0.036 to 0.048 towns per km^2) occurred in eastern Roosevelt County. Portions of Colfax and Union Counties also had concentrations, but they were less dense (0.012 to 0.024/square kilometer).

The GIS analysis showed that 84.1% of the towns acreage was located on private land, while only 52.7% of the historic range is on private land. State land had the second-largest area of prairie dog disturbance, with 12.9% of the towns acreage (Table 4), approximately in proportion to the 12.68% of the historic range on state land. BLM contained less than 1% of the towns acreage, compared to 17.4% of the historic range. Department of Defense and US Fish and Wildlife Service also had proportionally fewer acres in towns (1.5% and 0.8% respectively) than they owned in the historic range (4.3% and 9.4%, respectively). Note that the percentages of the historic range owned are approximate, because when ArcView computes ownership in an area, it includes the entire area of parcels only partially included in the range. Thus, land ownership along the historic range boundary is likely to be slightly over-estimated, meaning that the percent of the historic range in prairie dog towns would be under-estimated. Along the eastern edge of the historic range, private land appears slightly under-represented and US Forest Service somewhat over-represented, compared to the rest of the range. However, we do not believe that these small discrepancies could greatly alter the general trends described above and evident in Table 4.

Field Checks

We field checked 89 (10%) of 867 sites, representing 7% of the total sites acreage (Table 5). On the imagery, we had identified 73 of the 89 as towns and the remaining 16 as questionable. Of the 73 identified as towns, 38 towns (52%) still had prairie dog activity, 27 (37%) were no longer active, and 8 (11%) showed no signs of current or previous prairie dog activity. Therefore, we accurately identified 89% of actual prairie dog towns on the aerial photography. The percent of false positives, those sites that we identified as towns which turned out not to be towns, was 11%. However, this figure does not distinguish error from towns lost between the time of the imagery and the time of the field check, about five years.

Of the 16 sites we identified as questionable, 13 (81%) were found not be towns, 2 (12%) were actually towns, and 1 (6%) was found to be an extirpated town. Therefore, we missed positively identifying one extirpated and two active towns, a maximum false negative rate of 3%. Note that the two active towns could have originated after the imagery was taken. Because we have no way of knowing when these towns arose, the false negative rate may be lower than 3%. However, we only field checked towns or possible towns found on the imagery; thus, there may have been other false negatives that went undetected. The only way to find all false negatives is to conduct a 100%, on-the-ground survey at the time the imagery is made. This was impossible for this study, leaving us with the (possibly high and probably low) false negative rate of 3%.

Examples of errors are shown in Figures 6 through 13. We believe our accuracy has improved with experience. More field data would be necessary to verify this. We now know that some questionable sites were created by activity of harvester ants, Gunnison's prairie dogs (*Cynomys gunnisoni*) or bannertail kangaroo rats (*Dipodomys spectabilis*). This study has provided useful locational data on these species.

We used GIS data developed from previous field work (Bureau of Land Management, Las Cruces and Roswell Field Offices; Paternoster 1997; Sager 1996, 2000) to re-check sites we might have missed. Of the 15 towns Sager (2000) found, we found 8 on the photos. We found 30 of the 60 Sager (1996) sites. We found only 28 sites out of 84 found by Paternoster (1997). We found four of nine towns from BLM Roswell Field Office data. Finally, we found 3 out of 20 BLM Las Cruces towns. (See Discussion for possible explanations for these discrepancies.).

Complexes

The analysis of complexes (minimum three towns each) revealed two complexes over 5,000 ac in area, for a total of 43,875 ac, or 72.6% of the total state towns acreage. Five complexes were between 1,000 and 5,000 ac and totaled 8,087 ac or 13.4% of the state towns acreage. The remaining 20 complexes were less than 1,000 ac in area (Figure 14).

Landscape Features

We investigated the feasibility of performing a GIS analysis of the general vegetation type around towns, using the GAP map to define habitat type. The preliminary analysis showed that most towns were in agricultural habitat, which is not consistent with our impressions from scanning the DOQs or from the field checks we have performed. It appears that the resolution and accuracy of the GAP map are inadequate for analysis at the spatial scale of the prairie dog towns.

An in-depth GIS analysis is beyond the scope of this project. However, the analysis should be repeated using a reliable vegetation map for the core prairie dog areas, should one become available, or when the revised GAP map is complete. Analysis of other landscape features, for example, topography or soils, could provide a basis for a habitat model.

Discussion

The Survey Method

There are several big advantages to surveying for prairie dog disturbance using digital aerial photography. The first and possibly most important is access. With 85% of town acreage on private land, access could be a formidable obstacle. Even assuming full cooperation of all landowners (probably an unrealistic assumption), acquiring permission and working out the logistics of entry could take longer than our entire DOQ survey. The cost of travel to roadless areas would make a ground survey prohibitively expensive.

Other remote sensing methods avoid the access problem, but each poses its own difficulties. Johnson et al. (2000) demonstrated that Landsat imagery lacks the resolution offered by DOQs. The aerial line-intercept technique is expensive and of questionable accuracy. IKONOS satellite imagery, which has high resolution, is very expensive for use over a wide area, and its availability can be unpredictable.

The second advantage of a DOQ survey is cost. We completed a 100% survey of 99.9% of the historic range of the black-tailed prairie dog in New Mexico, 44,325,794 acres, for only $68,085. Third, the entire survey took about 15 months, even with substantial delays in funding and image availability. Finally, the data are importable into a GIS, which allows analyses that would be impossible with data from ground surveys or aerial transects. The archived aerial photography and GIS layers provide a permanent baseline record of prairie dog towns that will be useful for monitoring.

However, the method is not perfect. The primary drawback is availability of the aerial photography. Although we were able to survey 99.9% of the historic range, we had to create our own DOQs from the NAP photography for 4 % of the range. The imagery we used was almost entirely five to six years old. Thus, we can only estimate the present-day area of occupation. When more ground-truthing data become available, we will be able to construct a model that incorporates losses into an estimate of current acreage. Ideally, a factor to incorporate new towns should also be included in this model. To create such a “gain” factor, 100% coverage of several areas would be necessary, to detect towns created since the imagery was made. There are currently no plans for this type of field survey.

A second difficulty is that the photographic quality of the DOQ can affect ability to distinguish prairie dog disturbance from other types of disturbance; e.g., ant mounds or cattle activity. We concluded that black and white (1-band) DOQs were easier to interpret than natural color (3-band) images. Others have found color infra-red superior to black and white images for locating prairie dog towns (Pucherelli et al. 1999). Images subjected to MrSID compression (4x) were difficult to interpret. There also may be limits to the ability of the interpreter to resolve small town sites. Cheatheam (1973) found it difficult to identify towns less than 10 ac in size on black and white aerial photographs at 1:20,000. The DOQs used in this project were roughly at the 1:12,000 scale. We were able to identify sites less than one acre, as were Pucherelli et al. (1999). Topography might also affect image clarity. Towns in flat, open country such as in Lea County are more easily identified than ones in more topographically complex regions such as those in Lincoln, Union, and Colfax Counties. Because of this difference, ground-truthing efforts should include field checks in various habitats.

We failed to detect significant numbers of towns identified by previous researchers (Sager 1996, 2000; Paternoster 1997). We found only 28 of 84 towns identified by Paternoster (1997). Because the Paternoster study was conducted at about the same time that the majority of the aerial photos were taken, we expected a much higher correlation between the two datasets. A possible explanation for the discrepancies is that the locality information in the Paternoster report was not precise. His data were provided in township, range, and quarter section. We declared a fit when we found a town within the quarter section designated by Paternoster, but towns found outside the quarter section were not defined as matches. It appeared that in some cases we found the same towns, but his locations were a quarter section off from ours. It is possible that it was difficult to determine quarter section locations from maps in the field, due to the rather flat landscape, and this caused errors in Paternoster's location data. The Paternoster town sites occur in the highest town density areas in the state (Figure 5).

We found eight of 15 Sager (2000) towns. For two of the 15 sites, we did not have DOQ coverage. The imagery was made several years before the Sager study, leaving open the possibility that some towns were new in 2000. We found 30 of 60 Sager (1996) towns. Five of the Sager (1996) towns are located on quads that were unavailable for this study. We had to make the DOQs for much of this area, and it is possible that we scanned at a resolution that was too high. We used the higher resolution because it allowed us to differentiate disturbance types in a landscape where other kinds of disturbance occur. Also, each image requires a different stretch, and the resulting contrast may have been too high or too low. As in the Paternoster (1997) study, the area surveyed by Sager (1996) is a high-density area.

From this study we conclude that the survey method we used, based on digital aerial photography, is the best method currently available for statewide survey of black-tailed prairie dog disturbance, taking accuracy, speed, and cost into consideration. If complete coverages of the imagery were made available more frequently, the problems with this method would be minimal.

Status of the Black-tailed Prairie Dog in New Mexico

For reasons detailed above, the current number of occupied towns is not known. Based on the few sites that were field checked (about 7% of the sample), it appears that at least 30% of the towns became unoccupied sometime between the acquisition of the photos (typically 1996-1997) and the 2001 field checks. However, the actual rate of town loss could be lower if the expansion of existing towns or the establishment of new towns were taken into account. Likewise, the effect of distorted images due to undulating topography in such areas as Lincoln, Union and Colfax Counties might have caused us to miss some of the small towns found in previous field studies. One other study suggests that losses on the order of 30% are not unexpectedly high. In a field checking effort of previously-known towns in eastern Colorado, EDAW (2000) found a 58% reduction in acreage. The time elapsed between the EDAW field checks and previous surveys varied from two to five years, and some data were apparently over ten years old (although the exact time elapsed between surveys was not entirely clear from the report).

The New Mexico Black-tailed Prairie Dog Working Group (2001) set a target goal of 97,000 acres occupied by black-tailed prairie dogs by the year 2011. This target is based on an assumed starting acreage of 50,000 and a 6.5% increase per year. What is the status of black-tailed prairie dogs in New Mexico today? We conclude that: 1. black-tailed prairie dogs occupied approximately 60,000 acres of New Mexico in 1996-1997. 2. at the time of the survey, prairie dogs were concentrated in a small part of their former range. Only six counties (or seven if Chaves County is included) had appreciable numbers of prairie dog towns, but prairie dog disturbance was distributed at a much lower density throughout much of the historic range. Preliminary field checking data suggest the possibility that acreages have declined as much as 30% in the last six years, but we have no data on the number of new towns that appeared during that time. More field data are badly needed to allow a more accurate estimate of the current acreage occupied by the black-tailed prairie dog in New Mexico.

Management and Research Recommendations

1. Because 85.5% of the town acreage was on private land, concerted management efforts in cooperation with private landowners are necessary.
2. Currently, black-tailed prairie dogs are concentrated in only seven New Mexico counties. Research, monitoring, and management efforts should occur in these areas, with the goal of conserving existing prairie dogs.
3. Efforts should also be made to increase numbers in areas where prairie dogs are sparsely distributed, to prevent further losses and extirpation in those areas.
4. For the remote sensing data to be most useful, it is necessary to better understand rates of gain and loss over time. More field data are necessary to allow construction of a reasonably accurate model to estimate current status based on five-year-old imagery.
5. A GIS analysis of landscape and vegetation data could provide a habitat model that would be useful in determining sites for landowner incentives, prairie dog introductions, or other conservation and management actions.
6. An ongoing monitoring program should be established to follow selected sites on the ground and selected sites using DOQs or other imagery (such as IKONOS if it becomes available and affordable).
7. Research is needed on the causes of black-tailed prairie dog decline in New Mexico. Of particular importance are current rates of town growth, establishment, and decline, and the effects of plague and control efforts on prairie dog populations.

Table 1. Reasons for designating towns as questionable.

Code (GIS)	**Reason for designation as questionable**
1	Questionable due to presence of agricultural activity. If the agricultural field is used again for agriculture, the prairie dog town will be lost.
2	Site likely to be Gunnison's prairie dog (*Cynomys gunnisoni*) town.
3	Questionable due to grazing activity. It was unclear whether the disturbance was due to prairie dogs or cattle.
4	Questionable due to vegetation cover. Black-tailed prairie dog towns are typically found in grasslands where there is evidence of clipped vegetation. These questionable sites may have a higher density of shrubs and an unclipped appearance.
5	Questionable due to the appearance of the surrounding landscape. The disturbance was typically found within open forests or in landscapes very different from the grasslands where prairie dogs are typically found.
6	Questionable due to the appearance of the dots (mounds) or lack of haloing (unclipped areas). Sometimes the mounds were too large or had irregular or poorly-defined borders.
7	Likely to be harvester ant (*Pogonomyrmex* sp.) mounds. Often found within grasslands at the edge of woodlands.

Table 2. Acreages of sites by county, showing towns and questionable towns.

County		Acres	Mean Acres	S.D Acres	Min Acres	Max Acres
Chaves	Towns	1309.232	62.344	56.001	8.116	201.579
	Questionable	1092.198	91.017	75.203	9.299	289.874
Colfax	Towns	3618.327	129.226	148.019	3.122	518.770
	Questionable	93.329	23.332	19.136	4.429	44.235
Curry	Towns	6223.933	64.164	67.810	1.237	375.041
	Questionable	1110.315	79.308	52.865	16.904	171.449
De Baca	Towns	466.864	51.874	54.393	10.640	185.214
	Questionable	493.647	70.521	86.490	10.031	248.624
Dona Ana	Towns	3.042	NA	NA	NA	NA
	Questionable					
Eddy	Towns	51.495	NA	NA	NA	NA
	Questionable					
Grant	Towns					
	Questionable	567.347	94.558	160.558	1.404	417.734
Guadalupe	Towns	40.610	NA	NA	NA	NA
	Questionable	147.582	49.194	48.465	1.099	98.021
Harding	Towns	2507.870	131.993	116.012	23.834	436.354
	Questionable	485.918	97.184	77.255	13.352	186.736
Hidalgo	Towns					
	Questionable	880.065	51.769	75.955	5.943	233.047

County		Acres	Mean Acres	S.D Acres	Min Acres	Max Acres
Lea	Towns	21799.318	148.295	250.603	2.706	2359.562
	Questionable	1904.198	45.338	44.576	2.466	196.948
Lincoln	Towns	251.398	NA	NA	NA	NA
	Questionable	1296.679	51.86716	63.46525	2.034	287.008
Luna	Towns	95.445	NA	NA	NA	NA
	Questionable	209.491	52.373	23.995	20.716	74.915
Mora	Towns	122.475	24.495	40.364	2.171	96.422
	Questionable	114.374	28.594	30.634	10.203	74.400
Otero	Towns					
	Questionable	277.987	69.497	16.568	50.557	84.171
Quay	Towns	3554.474	46.769	44.757	4.046	204.149
	Questionable	191.333	63.778	56.233	0.419	107.763
Roosevelt	Towns	13417.084	86.007	122.908	1.490	837.893
	Questionable	1048.080	55.162	65.122	2.967	255.933
San Miguel	Towns					
	Questionable	263.352	65.838	60.135	9.195	138.072
Santa Fe	Towns					
	Questionable	163.675	32.735	28.958	6.124	80.078
Socorro	Towns					
	Questionable	94.019	NA	NA	NA	NA
Torrance	Towns	48.761	16.254	19.274	<0.01	37.547
	Questionable	5641.480	141.037	286.562	<0.01	1612.945
Union	Towns	7717.886	100.232	108.674	4.917	719.651
	Questionable	602.577	54.780	87.512	3.034	293.147
Total						

Table 3. Relative acreage of sites by county (including questionable towns).

Counties	Acres	% of County Acreage	% of Total Acreage	% Acreage on Private Land
Chaves	2401.430	0.062%	3.08%	61.56%
Colfax	3711.656	0.154%	4.76%	81.72%
Curry	7334.248	0.814%	9.41%	86.98%
De Baca	960.511	0.064%	1.23%	98.64%
Dona Ana	3.042	0.000%	<0.01%	0.00%
Eddy	51.495	0.002%	0.07%	100.00%
Grant	567.347	0.022%	0.73%	12.81%
Guadalupe	188.192	0.010%	0.24%	100.00%
Harding	2993.788	0.220%	3.84%	92.28%
Hidalgo	880.065	0.040%	1.13%	58.11%
Lea	23703.516	0.843%	30.43%	83.98%
Lincoln	1548.077	0.050%	1.99%	70.22%
Luna	304.936	0.016%	0.39%	13.46%
Mora	236.849	0.019%	0.30%	100.00%
Otero	277.987	0.007%	0.36%	18.19%

Counties	Acres	% of County Acreage	% of Total Acreage	% Acreage on Private Land
Quay	3745.807	0.203%	4.81%	99.82%
Roosevelt	14465.164	0.921%	18.57%	88.05%
San Miguel	263.352	0.009%	0.34%	12.65%
Santa Fe	163.675	0.013%	0.21%	100.00%
Socorro	94.019	0.002%	0.12%	100.00%
Torrance	5690.241	0.266%	7.30%	95.32%
Union	8320.463	0.339%	10.68%	73.32%
Total	77905.860			83.28%

Table 4. Ownership of sites.

Ownership	Questionable Acres	Town Acres	% of all Town Acres by Ownership	% of Historic Range	Total Acres
BLM	763.05	332.27	0.54	17.38	1095.32
BOR	13.71	1.16	0.00	0.07	14.87
DoD	127.07	903.64	1.47	4.25	1030.71
FS	129.11	487.91	0.79	9.35	617.02
FWS	230.03	152.12	0.25	0.27	382.15
Private	13368.78	51869.14	84.10	52.66	65237.92
State	2304.87	7926.21	12.85	12.68	10231.08
Total	16936.62	61672.44	100.00	96.66	78609.06

Table 5. Results of groundtruthing.

Author's Determination	Groundtruth Results	N	%	Acres	Mean Acres	S.D. Acres	Min Acres	Max Acres
Town	Town	38	42.7	1969.5	51.8	54.1	2.2	204.1
Town	Extirpated	27	30.3	1805.1	66.8	76.4	4.1	375.0
Town	No Town	8	9.0	267.3	33.4	22.9	7.7	74.5
Questionable	No Town	13	14.6	1103.6	84.84	77.1	0.4	287.0
Questionable	Town	2	2.2	268.8	134.4	37.6	107.7	161.0
Questionable	Extirpated	1	1.1	38.0	-	-	-	-
Total		89	99.9	5452.3				

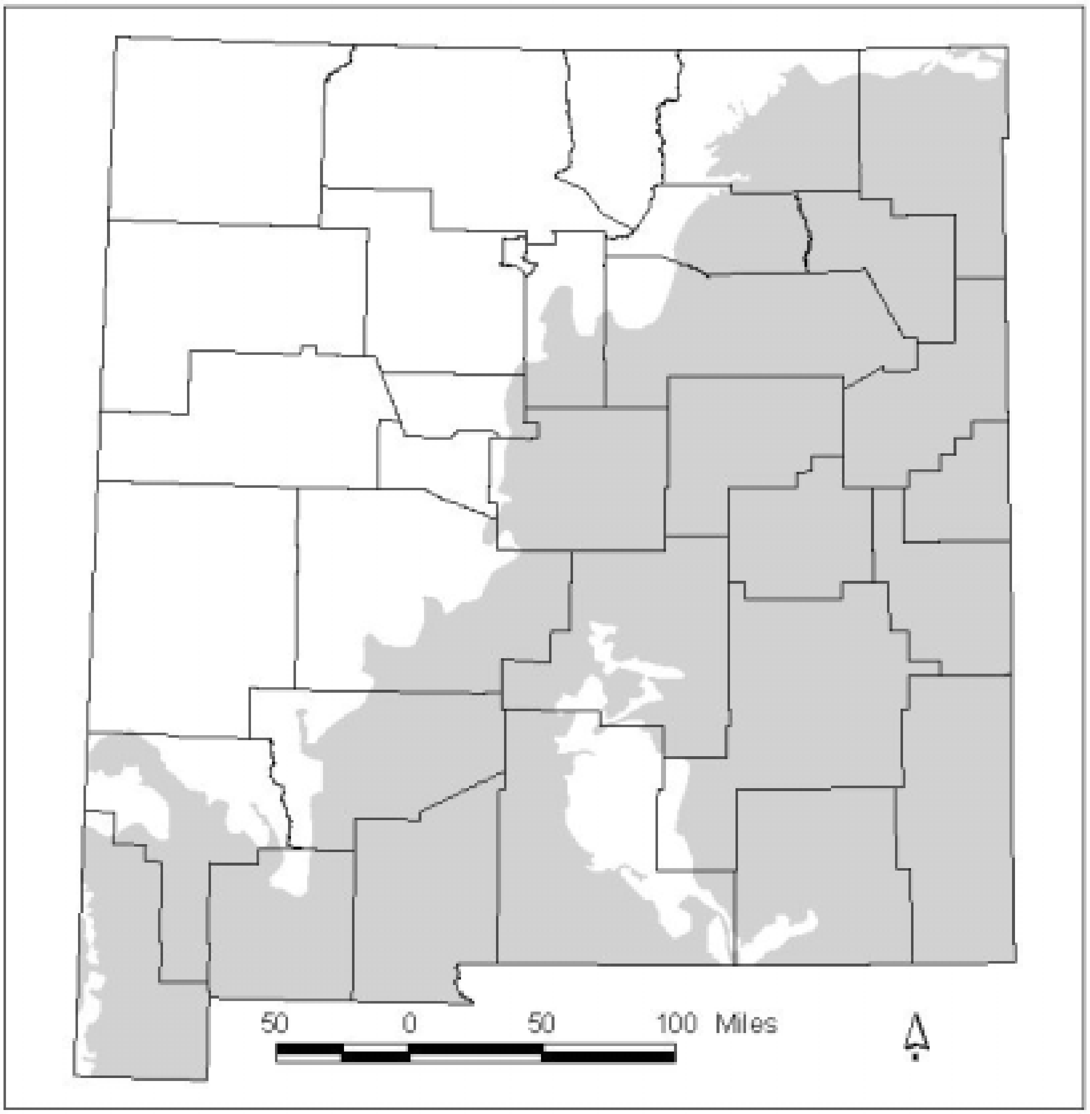

Figure 1. Historic range of the black-tailed prairie dog in New Mexico.

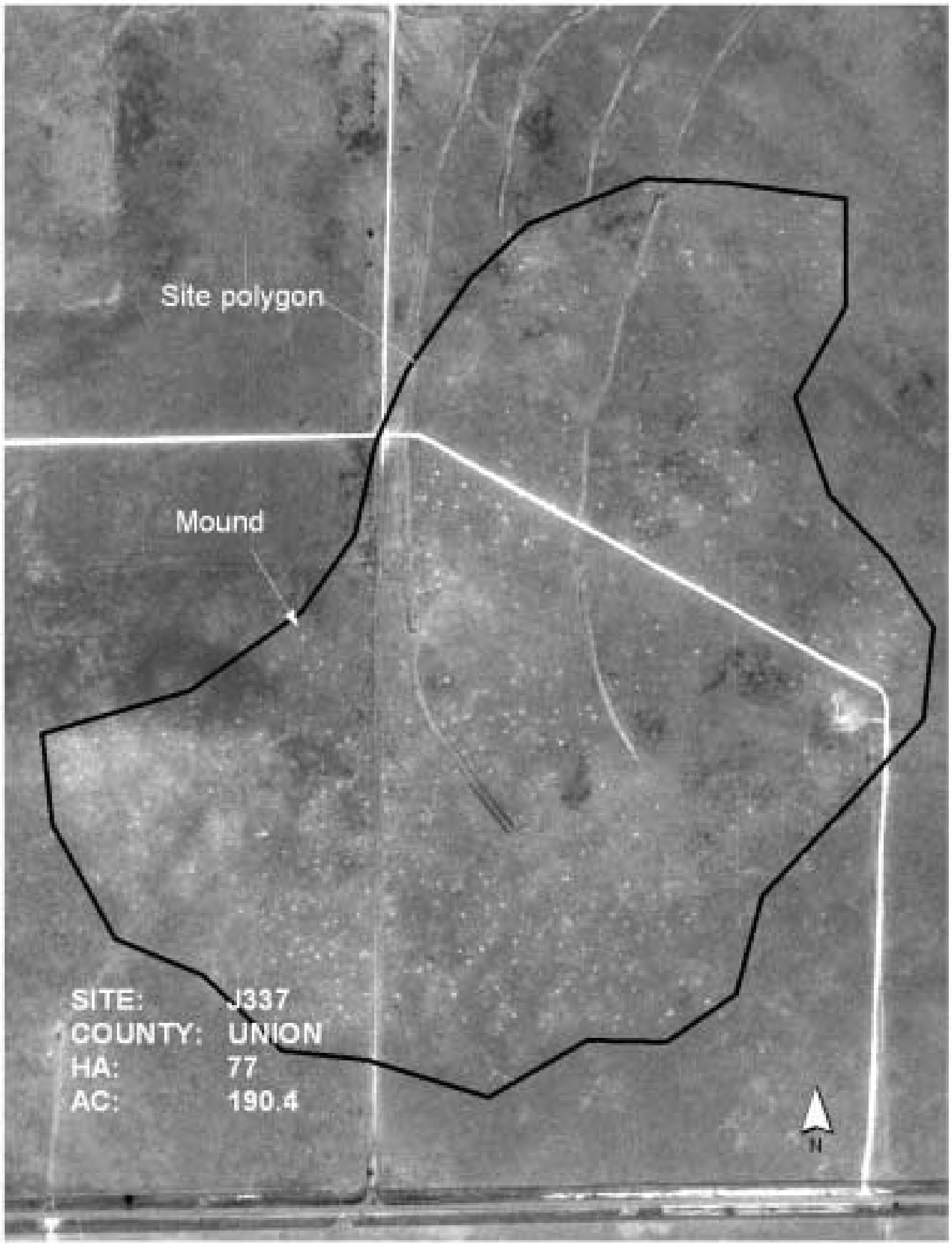

Figure 2. DOQ with polygon designating a black-tailed prairie dog town.

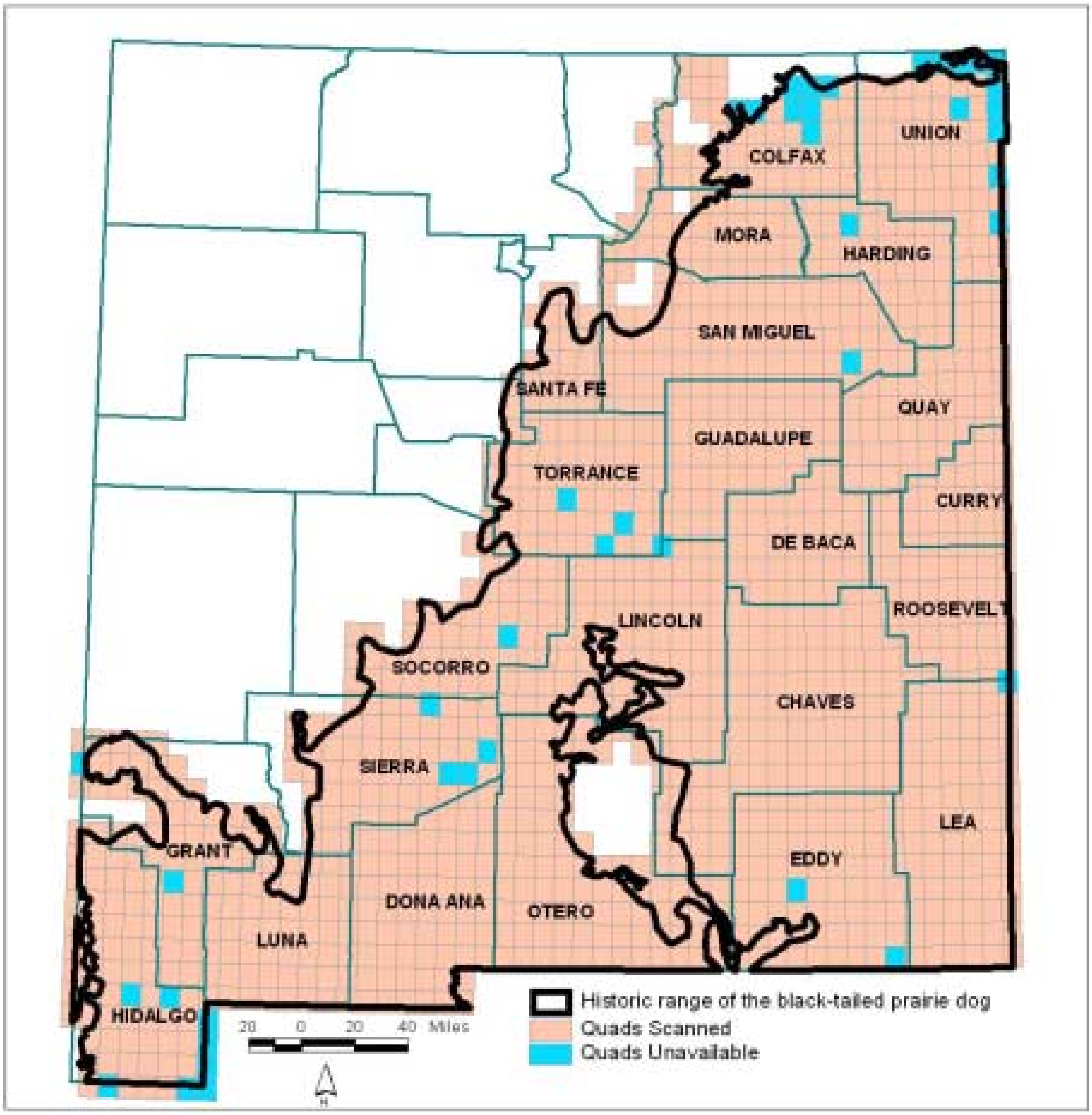

Figure 3. Status of quads scanned within the historic range of the black-tailed prairie dog.

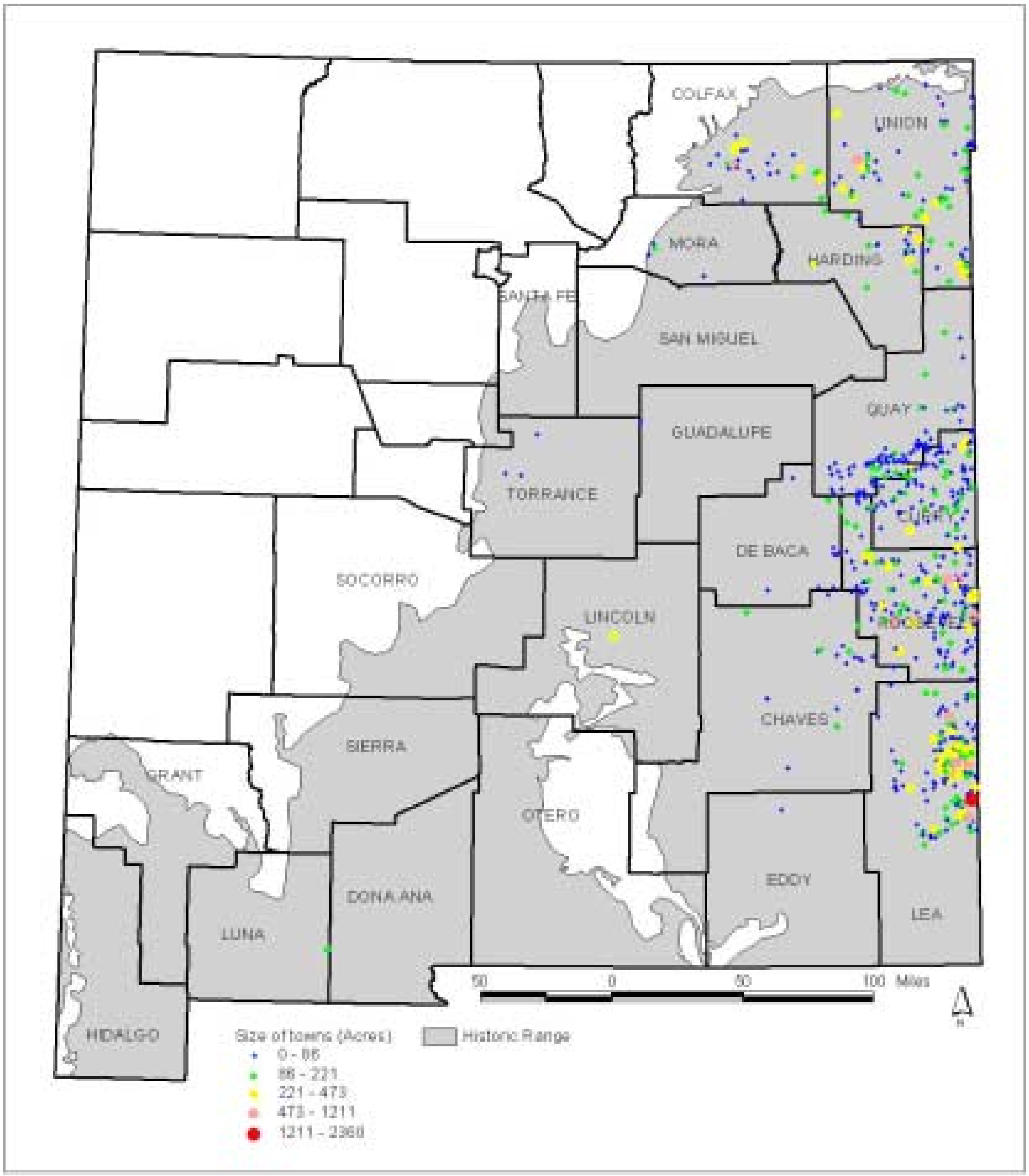

Figure 4. Sites designated as towns (questionables not included), ranked by acreage.

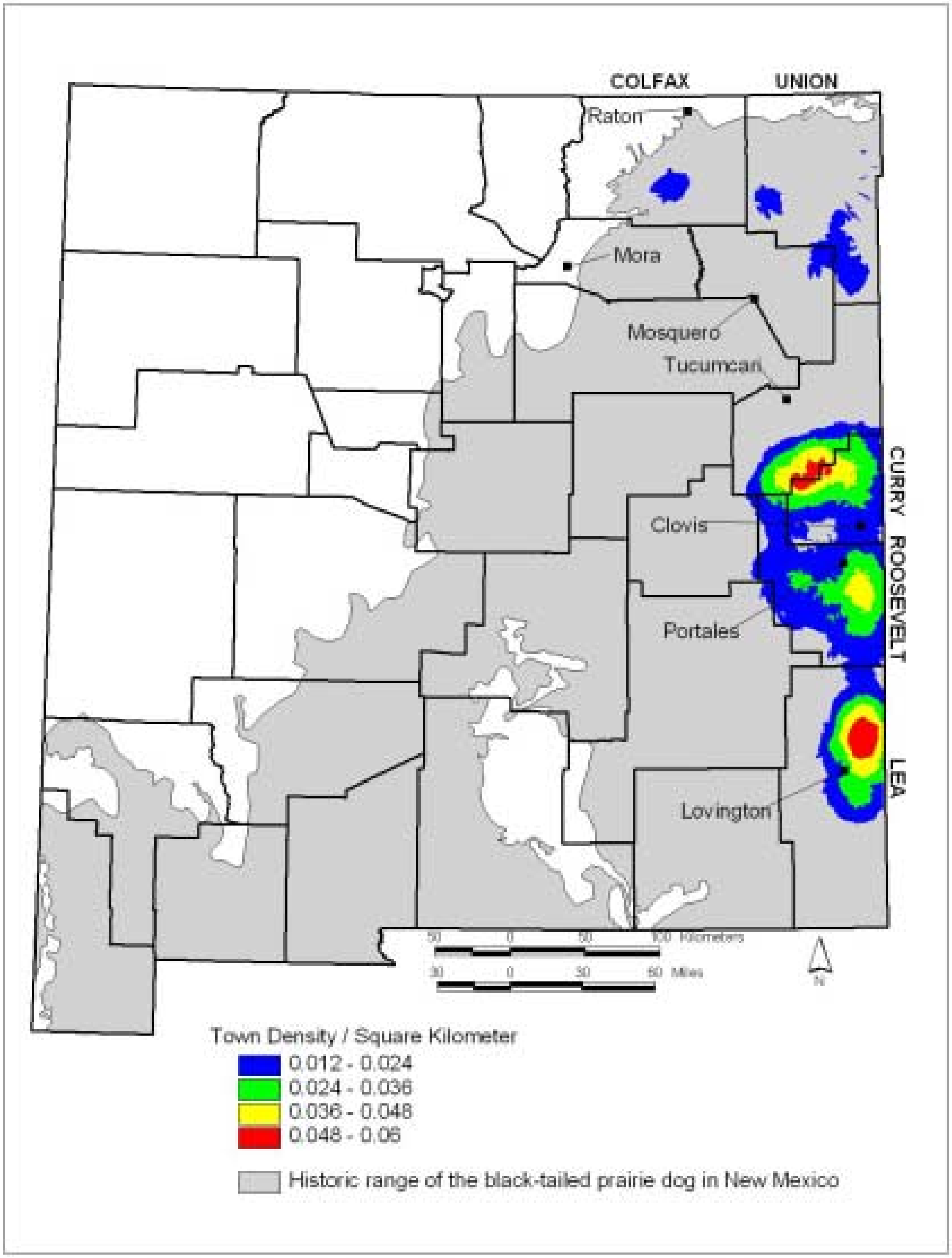

Figure 5. Black-tailed prairie dog town density/square kilometer.

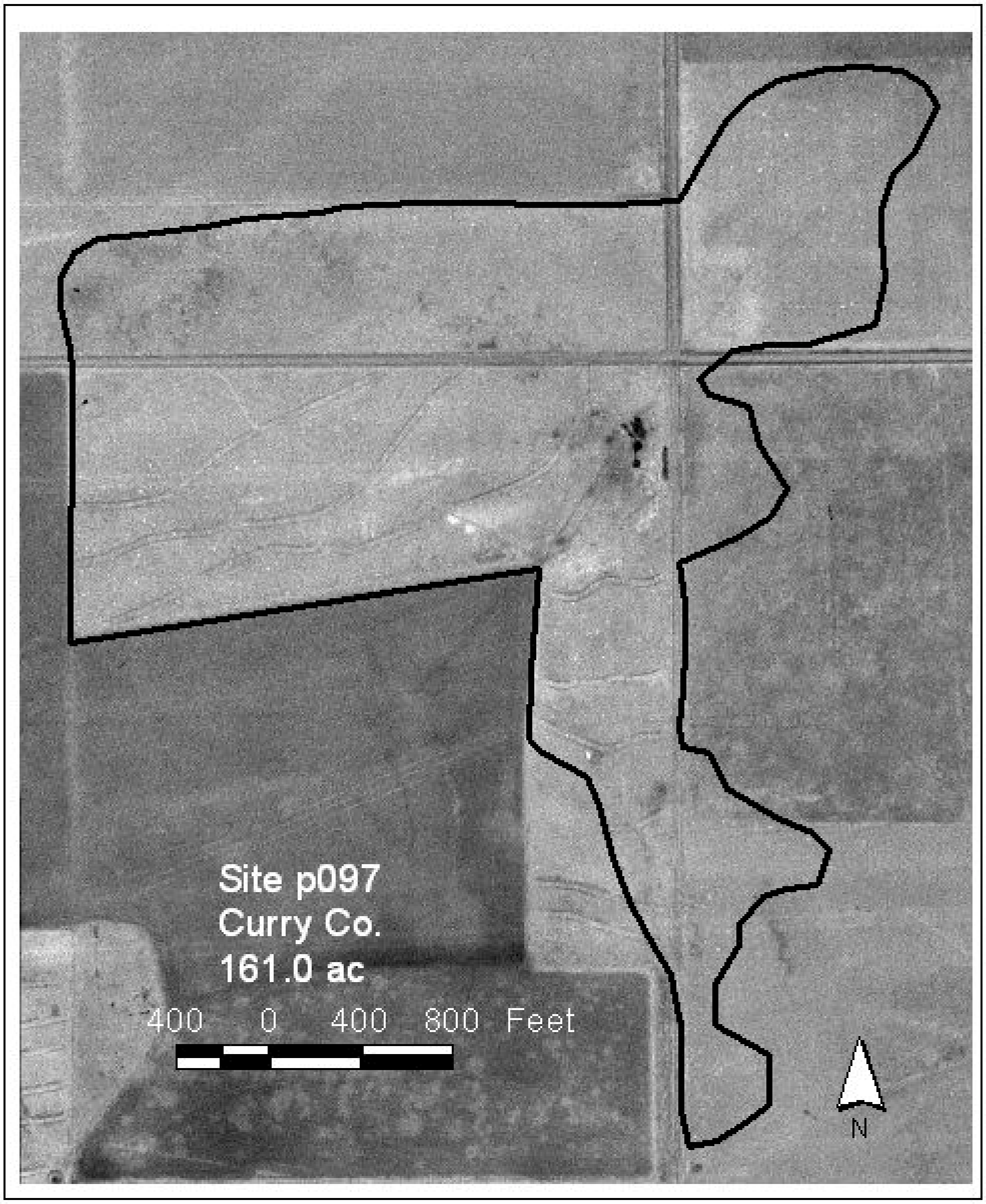

Figure 6. Questionable site proved to be a prairie dog town within an agricultural area. Questionable due to agricultural activity and lack of clear mound/halo features.

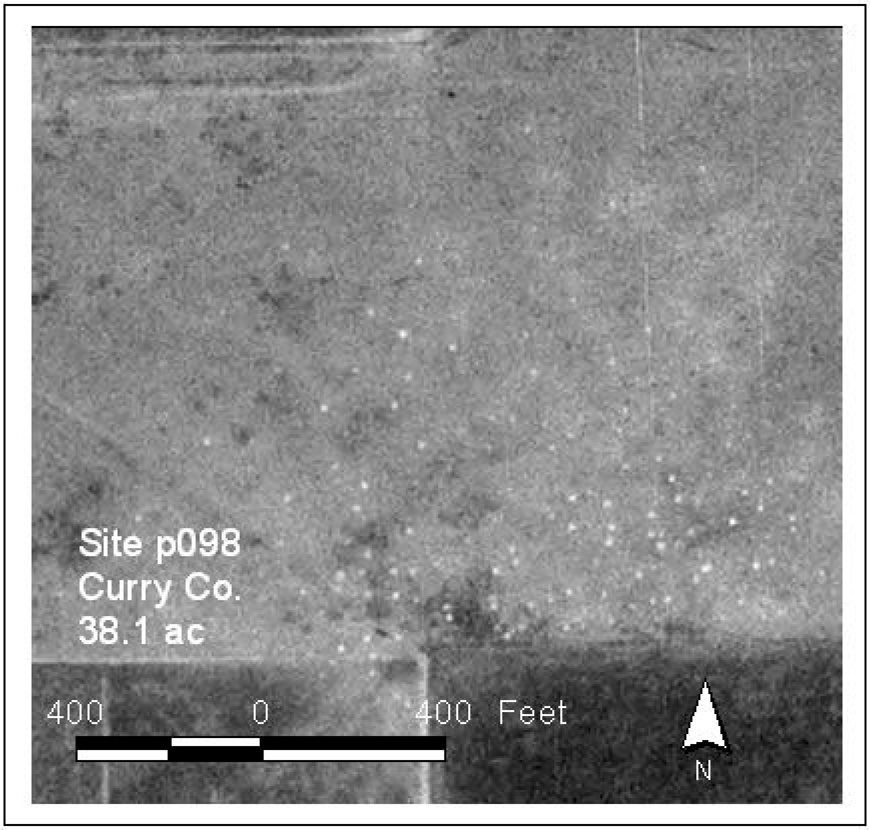

Figure 7. Questionable site proved to be an extirpated prairie dog town.

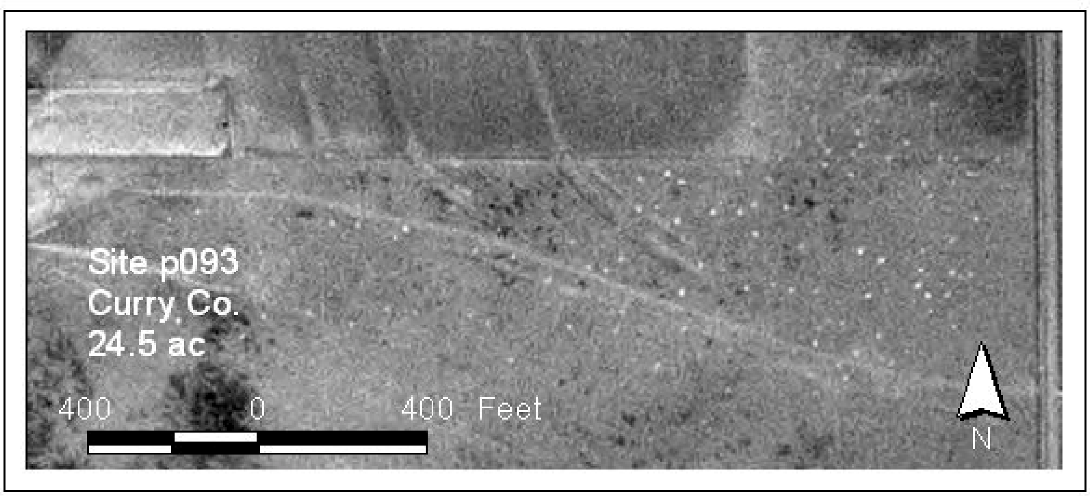

Figure 8. Designated as a town site but field checking found no evidence of a town. The lack of clipped vegetation (halo) for this site should have been diagnostic.

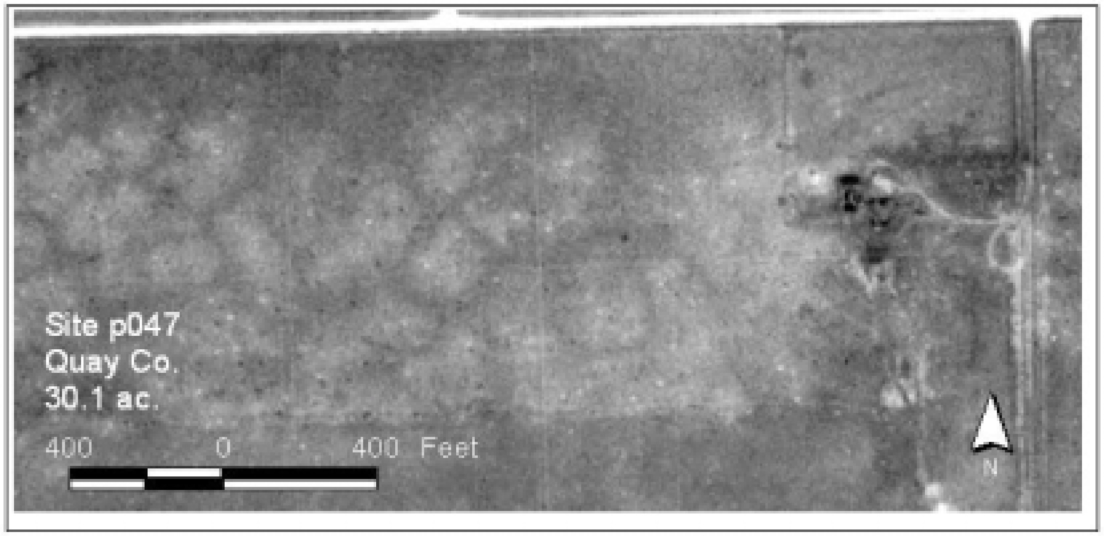

Figure 9. Site designated as a town but field checking found no evidence of a town. The image lacks the bright circles indicative of black-tailed prairie dog mounds.

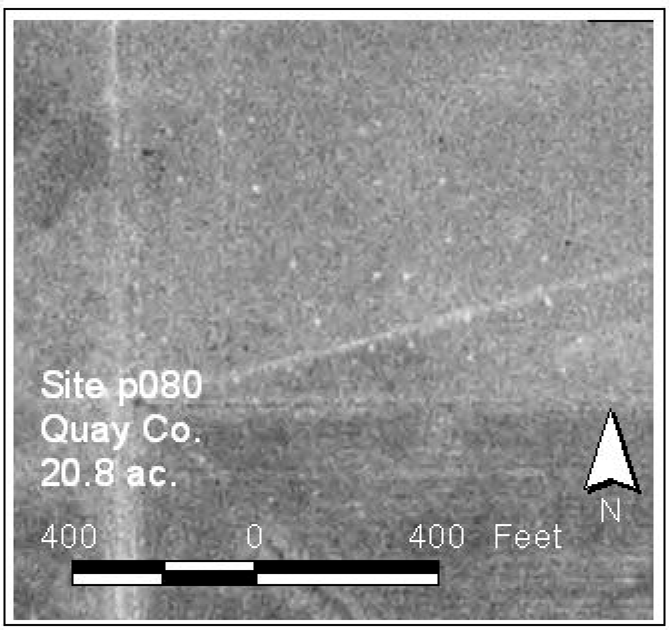

Figure 10. Site designated as a town but field checking found no evidence of a town. The image lacks the halo indicative of a black-tailed prairie dog town.

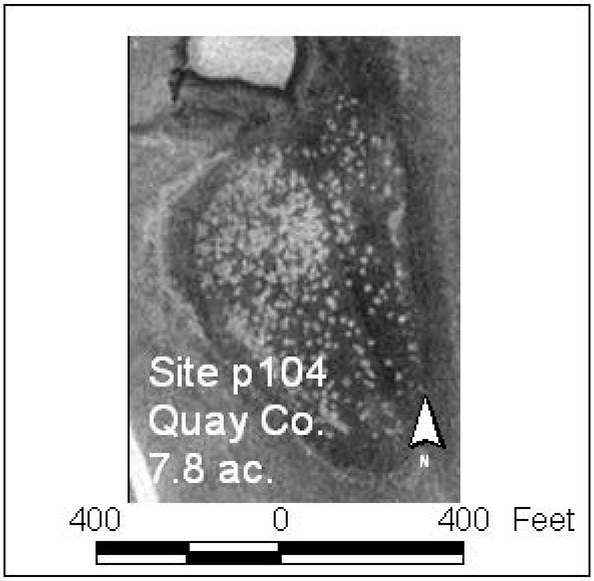

Figure 11. Site designated as a town but field checking found no evidence of a town. Site was found to be a playa with high levels of vegetation, with several dry spots creating the impression of a black-tailed prairie dog town. Image lacks the halo indicative of a black-tailed prairie dog town.

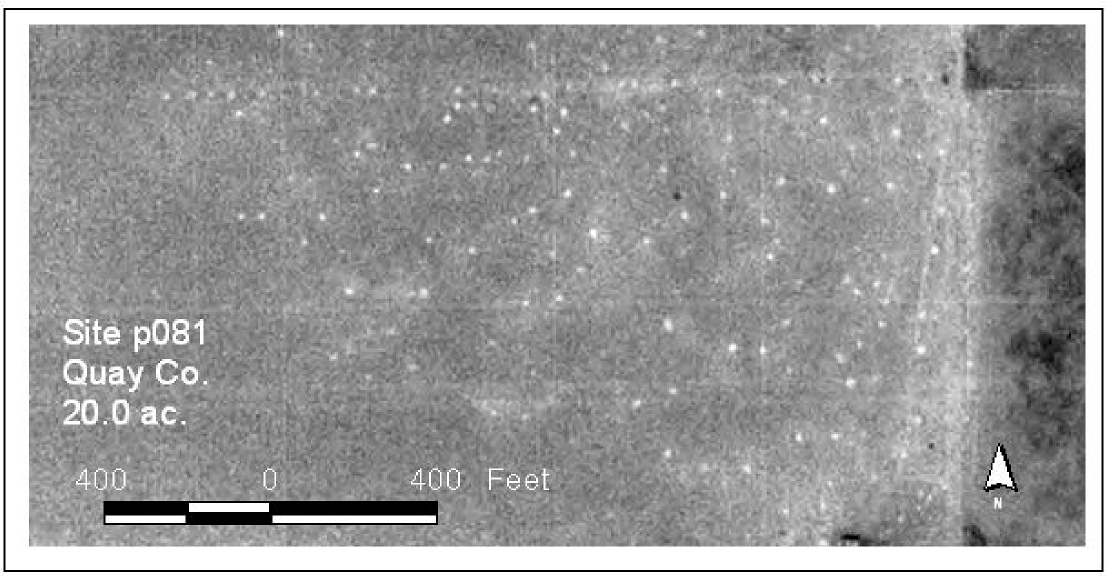

Figure 12. Designated as a town site but field checking found no evidence of a town. Site is sufficiently similar to an actual black-tailed prairie dog town image that it warrants further investigation.

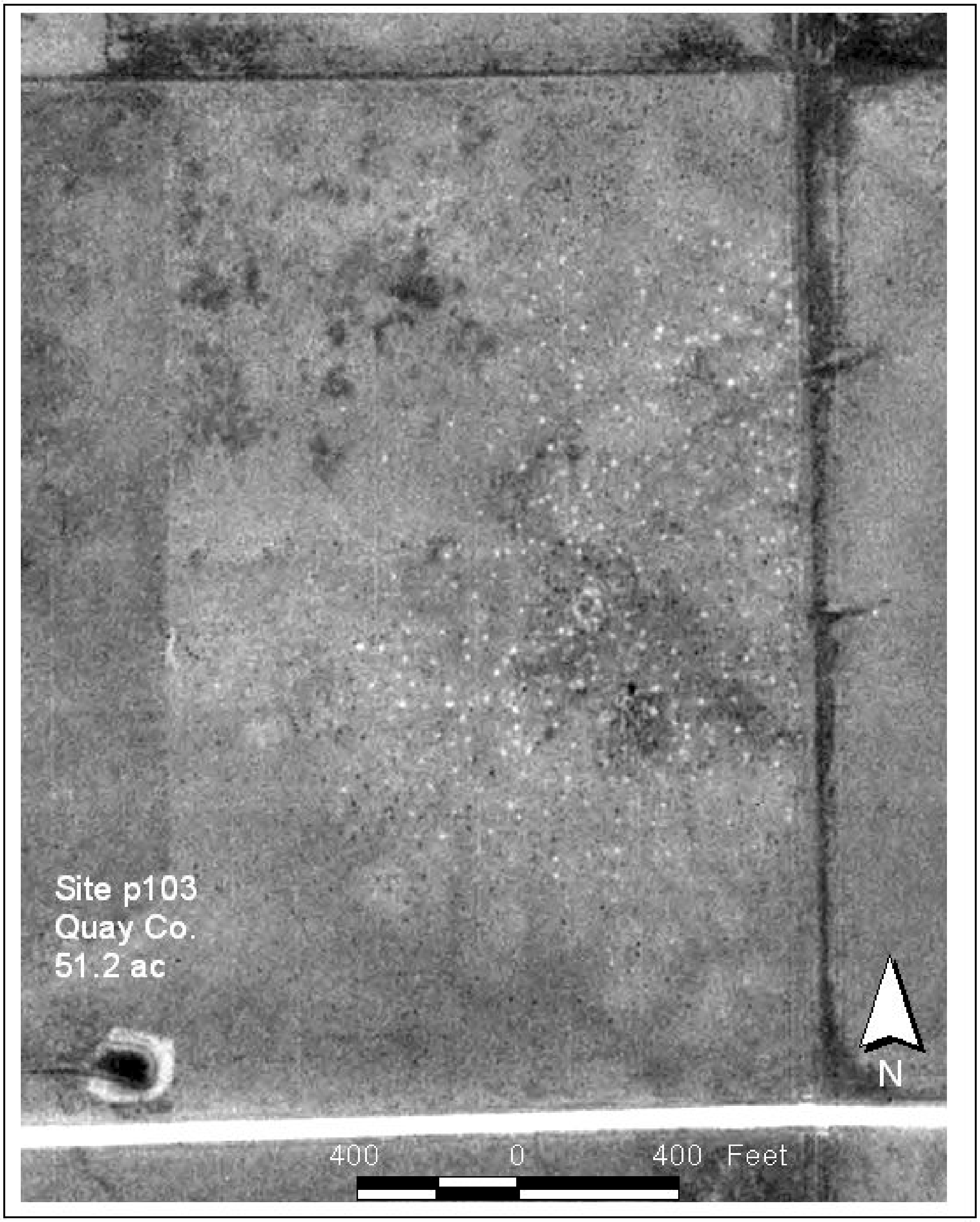

Figure 13. Designated as a town site but field checking found no evidence of a town. Site is sufficiently similar to an actual black-tailed prairie dog town image that it warrants further investigation.

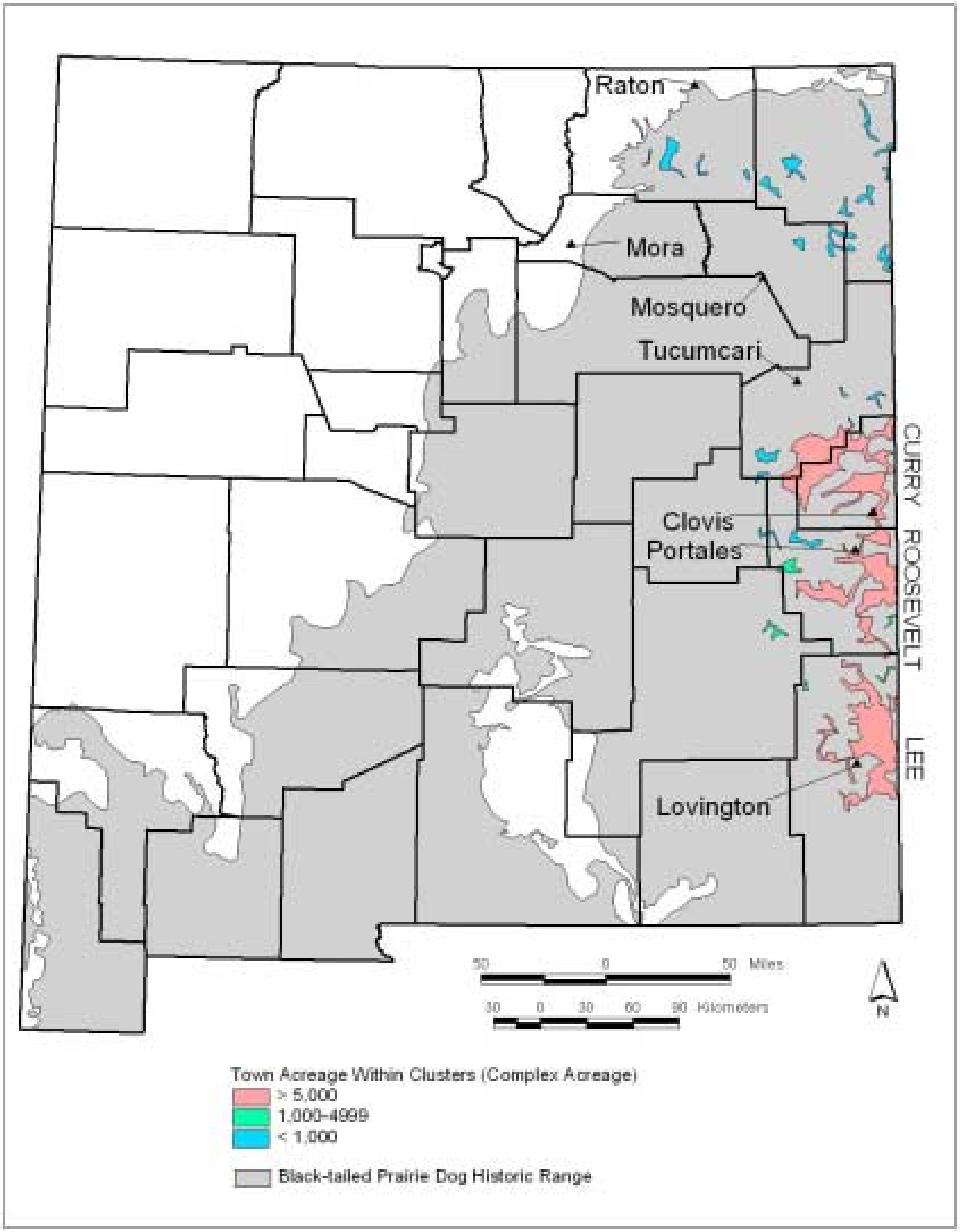

Figure 14. Black-tailed prairie dog town complexes.

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