BLACK-TAILED PRAIRIE DOG: ASSESSMENT OF POTENTIAL HABITAT ON LANDS ADMINISTERED BY THE BUREAU OF LAND MANAGEMENT

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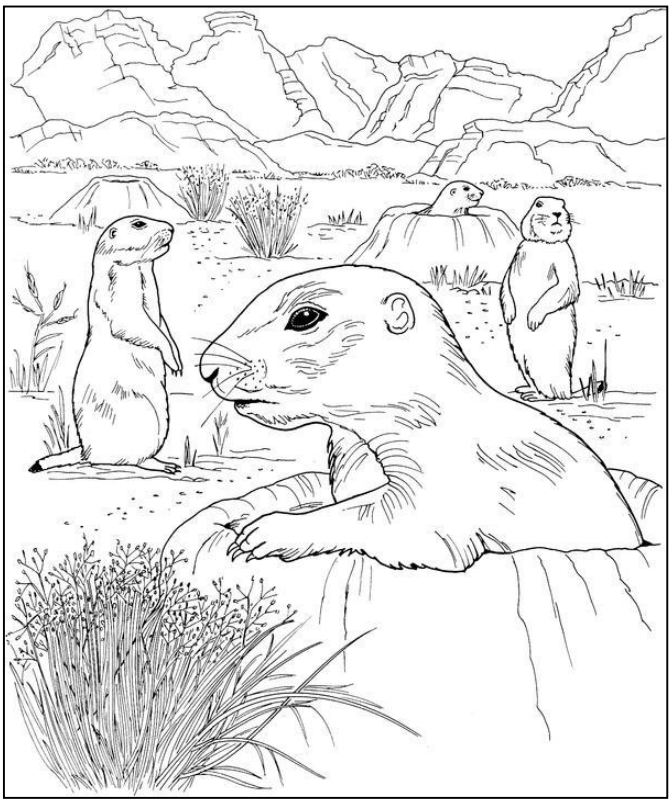

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EXECUTIVE SUMMARY

The black-tailed prairie dog previously inhabited southeastern Arizona, but has been extirpated since at least 1960 (Van Pelt 1999). Land use changes have significantly altered the landscape so that historic habitat had to be evaluated to determine if it would support the black-tailed prairie dog once again. The Arizona Game and Fish Department assessed habitat for the black-tailed prairie dog and identified possible re-establishment sites on lands in southeastern Arizona that are administered by the Safford Field Office, Bureau of Land Management.

In 2000, the Arizona Game and Fish Department identified 77,463 acres (31,362 ha) of potential black-tailed prairie dog habitat on lands administered by the Safford Field Office of the Bureau of Land Management. This potential habitat for the black-tailed prairie dog was identified at a course spatial scale and required further evaluation to determine if these lands would indeed serve as habitat for this species. To accomplish this, we analyzed environmental parameters of the initial model at a finer scale and used this information to identify and qualify potential areas for re-establishment. We reviewed current literature to ensure we had the best information available on habitat requirements for the black-tailed prairie dog and then refined specific components of the initial Arizona Game and Fish Department model using updated electronic information as well as data we collected on-the-ground. We applied a step-wise method and incorporated existing information whenever possible. Finally, we classified Bureau of Land Management lands into 1 of 4 categories of habitat suitability: excellent, fair, poor, or unsuitable.

None of the land identified in the initial model of potential habitat on Bureau of Land Management land, in its current state, met habitat requirements for the black-tailed prairie dog. Most of this potential habitat was dominated by creosote and had very little perennial grass or herbaceous cover. Many of these areas were highly volcanic with large rocks covering the ground and no evidence of any burrowing animals. However, 21,132 acres (8555 ha) of Bureau of Land Management lands could meet necessary site characteristics for black-tailed prairie dog habitat only with extensive vegetation manipulation.

The potential re-establishment areas for the black-tailed prairie dog identified in this report will be evaluated against other potential areas in southeastern Arizona. Areas with higher quality habitat requiring less vegetation modification should be pursued first if they exist.

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INTRODUCTION

In March 1999, the Arizona Game and Fish Department (Department) initiated a 12-step process to evaluate the feasibility of re-establishing the black-tailed prairie dog (BTPD; *Cynomys ludovicianus*) into its historical range in southeastern Arizona (Johnson and Glinski 1987). Part of this process includes determining if habitat currently exists that would sustain a BTPD population in southeastern Arizona. Soil, vegetation, slope, elevation, proximity of a site to private land, and natural dispersal barriers are important factors to consider when evaluating potential relocation areas for the BTPD.

In 2000, the Department identified potential BTPD habitat through a landscape-level modeling exercise (J. Hatten and B. Van Pelt, AGFD unpublished data, Figure 1). A bimodal habitat model was created using four environmental criteria and one socio-political criterion: slope <10%, elevation <8000 ft (2438 m), soils fine to medium in texture, vegetation composed primarily of grasses, and public or State Trust lands >2 miles (3.2 km) from private land. All 5 parameters were derived from existing electronic data layers using a geographic information system. Slope and elevation were generated from a digital elevation model (DEM) with 90-meter spacing. Classification of soil was based on the Natural Resource Conservation Service State Soil Geographic (STATSGO) database, a digital version of the 1975 General Soil Map for Arizona that presents major soil groups at a scale of 1:250,000 that were delineated with a minimum mapping unit of 1544 acres (625 ha; USDA 1994). Vegetation was modeled using Arizona GAP Analysis Program vegetation data as areas within 1 of 4 grassland biomes: Plains Grassland, Great Basin Shrub Grassland, Rocky Mountain Montane Grassland, or Scrub Grassland (Graham 1995). This dataset was created by digitally classifying Landsat Thematic Mapper imagery from 1991-1992 and has a minimum mapping unit of 247 acres (100 ha).

Over 202,000 acres (81,769 ha) met the 5 criteria, of which 77,463 acres (31,362 ha) were lands administered by the Bureau of Land Management, Safford Field Office (BLM). This potential habitat for the BTPD was identified at a course spatial scale and required further evaluation to determine if these lands would indeed serve as habitat for this species. To accomplish this, we analyzed environmental parameters of the initial model at a finer scale and used this information to identify and qualify potential areas for re-establishment. We applied a step-wise method and incorporated existing information whenever possible. This report addresses potential BTPD habitat solely on lands administered by the Safford Field Office.

STATUS AND DISTRIBUTION

The BTPD historically was the most widely distributed of the five prairie dog species, occurring in 11 states within the U.S. (Whicker and Detling 1988; Hoogland 1996). It ranged from southern Saskatchewan, Canada to northern Mexico throughout the Great Plains states and west to southeastern Arizona (Hall 1981; Foster and Hygnstrom 1990; Ceballos and others 1993).

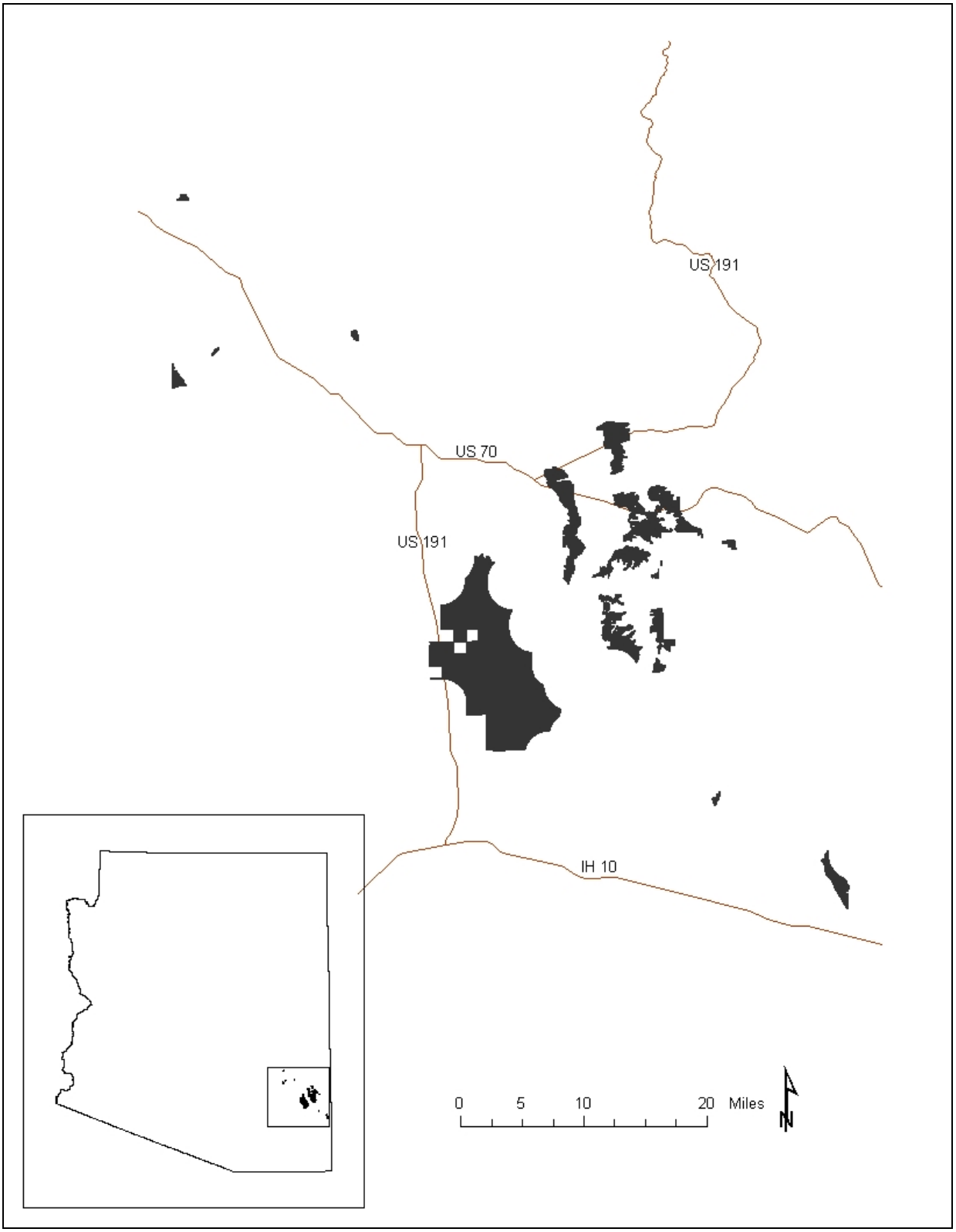

Figure 1. Potential black-tailed prairie dog habitat on lands administered by the Safford BLM Office as identified by 2000 habitat model (Hatten and Van Pelt, unpublished data).

The BTPD occurred in Cochise, Graham, Santa Cruz, and Greenlee counties in Arizona (Hall 1981; Hoffmeister 1986). There are anecdotal reports of large colonies of prairie dogs on ranches in the San Simon Valley, along the east base of Mount Graham, and west of Sonoita (Oakes 2000). During the past century the distribution and number of prairie dogs has been greatly reduced across its range due to intensive control programs, conversion of habitat to croplands, disease epizootic, and urbanization (Summers and Linder 1978; Miller and others 1994). The species now is considered uncommon in many areas of its former range and is extirpated from Arizona (Hoffmeister 1986; Hoogland 1996). The closest populations of BTPD to Arizona are in the upper San Rafael Valley in Sonora, Mexico.

TAXONOMY

Taxonomists recognize two subspecies of BTPDs: *Cynomys ludovicianus ludovicianus* (Plains subspecies) and *C. l. arizonensis* (Arizona subspecies; Hall 1981). The Arizona subspecies' range is northeastern Mexico, west Texas, and southern New Mexico. It was formerly found in southeastern Arizona. The Plains subspecies' range is New Mexico, north Texas, Oklahoma, Kansas, Nebraska, Colorado, Wyoming, Montana, North Dakota, South Dakota, and Canada. Although these two subspecies have been the subject of several taxonomic investigations, it generally is thought that *arizonensis* only is slightly differentiated from the dominant form *ludovicianus*. From a conservation and evolutionary standpoint, the uniqueness of these two subspecies may have significant management implications. For nomenclatural convenience in this document, we regard the species as monotypic.

BIOLOGY

The BTPD is a diurnal, burrowing rodent, almost 15 inches (38 cm) in length, including a 2.5 - inch (6.4 cm), black-tipped tail. Unlike some other species within the genus *Cynomys*, BTPDs do not hibernate, but may remain underground for several consecutive days during extremely cold weather (Hoogland 1996). BTPDs are highly social animals, living in family groups, or coteries, which typically consist of a breeding adult male, one to four breeding adult females and their offspring younger than 2 years of age.

A prairie dog town or colony typically is composed of different family groups, and in uncontrolled circumstances can cover thousands of acres of grassland (Dahlsted and others 1981; Knowles 1986). Females usually spend their entire lives in their natal coteries while males of breeding age disperse (Hoogland 1982; Hoogland 1995). Dispersal distance for the BTPD averages 2 miles (3.2 km; Biggins and others 1993).

HABITAT

In Arizona, BTPDs occurred in plains grasslands and at the upper limits of the desert grasslands, at elevations of 4136 to 5200 feet (1260 to 1584 m; Brown and others 1974). Dominant grasses in these biotic communities included blue grama (*Bouteloua gracilis*) mixed with threeawns (*Aristida* species). Habitat requirements specific to Arizona were never quantified, so the following information was summarized from studies conducted outside of Arizona. Because prairie dogs only occur in areas that have soil conducive to developing burrow systems, size of substrate and texture of soils influence the establishment and expansion of prairie dog colonies

(Roe and Roe 2003; Wagner and Drickamer 2004). BTPD burrows retain their shape and strength well in loamy soils with little to no gravel (Van Pelt and others 2001). Desired physical properties of these soil types are <30% clay, ~50% sand, >70% silt, at least 6.6 ft (2 m) deep, and have good drainage (Roe and Roe 2003, Trevino-Villarreal and others 1997). Level topography and low vegetation allow prairie dogs to detect predators at a distance (Hoogland 1995). Black-tailed prairie dogs avoid areas with tall vegetative cover and vegetation height within a colony is usually <1 ft (0.3 m; Krueger 1986; Clark and Stromberg 1987). They generally avoid slopes steeper than 10% but sometimes use areas with slopes up to 20% (Roe and Roe 2003). Black-tailed prairie dogs are selectively herbivorous, foraging on a variety of vegetation, including grasses, forbs, and cacti (Koford 1958) and to a lesser extent seeds and insects (Foster and Hygnstrom 1990).

STUDY AREA

The 77,463 acres (31,362 ha) of potential BTPD habitat on lands administered by the Safford Field Office of the BLM primarily are located within the San Simon and Whitlock Valleys of southeastern Arizona, south of Arizona State Highway 191 and north of Interstate Highway 10 (Figure 1). Topography varies from flat plains to rolling foothills of the Whitlock Mountains and Black Hills. Soils were derived from alluvium of mixed rock materials that make up the surrounding mountains. The dominant vegetation type is shrub-invaded desert grassland. The major land use is free-range cattle ranching. All potential BTPD habitat lies within one or more the following 8 BLM grazing allotments: Yuma Wash (#4032), Slick Rock (#5113), 111 Ranch (#5203), Creosote (#5701), Artesia (#5106), Tanque (#5108), Tollgate (#4033), and Hackberry (#5181).

METHODS

We reviewed current literature on habitat requirements for the BTPD (Table 1). We then refined each component of the initial Department model using updated electronic information as well as data we collected. Finally, we classified BLM lands into 1 of 5 categories of habitat suitability.

Elevation and slope

Re-evaluation of elevation and slope using a more precise DEM was not necessary. The original 90-m DEM used was derived from the more precise 30-m DEM. Reclassification with the 30-m DEM would increase the area classified as potential habitat based on the original model. We could only assess potential habitat identified in the original model. We considered slope in conjunction with soil and vegetation assessments described in subsequent sections.

Soil assessment

We used the Natural Resource Conservation Service's electronic Soil Survey Geographic (SSURGO) database to delineate soils by map unit on BLM lands at a scale of 1:24,000. A map unit depicts one or more soil series that have similar physical properties. The soil survey describes where each map unit is located on the landscape, composition of soils represented, Characteristics of each soil present, and other resource information. We determined soil map

Table 1. Biological criteria for black-tailed prairie dog habitat[1].

Elevation	<8000 ft
Slope	<20%; <10% preferred
Soil texture	Loamy
- gravel	Little or none
- clay	<30%
- sand	~50%
- silt	>70%
Ground cover	
- Bare soil	<40 %
- Total vegetative canopy	≥25%
- Productive suitable vegetative cover relative to total basal cover	≥25%
Vegetation height	<11.8 in
Colony area[2]	≥10 acres
Presence of plague	If BTPD population was extirpated by plague, relocation to area must be >1 year from date of outbreak

[1]Summarized by Roe and Roe, 2003
[2]Based on minimum colony areas reported in the literature, not on population viability assessment.

units that met BTPD habitat requirements based on gravel content, soil texture, depth, and drainage (Cathy McGuire, NRCS, personal communication; US Department of Agriculture 1993). We then re-classified BLM lands at this finer scale. Because soils in ephemeral drainages likely do not support burrow systems of the BTPD, we identified them on BLM lands through visual analysis of digital ortho quarter quads (DOQQ; 1:24,000 scale). We digitized all ephemeral drainages visible on the DOQQs. We then created a 10-m buffer around all drainages to quantify areas that would not serve as potential burrowing habitat for the BTPD. These areas were not excluded as general habitat for the BTPD, but were not identified as burrowing habitat. We did not collect soil samples during field surveys, but noted burrowing activity of rodents.

Vegetation assessment

We used existing data from The Nature Conservancy (TNC) and the BLM as well as on-the-ground vegetation assessment to determine if BLM lands met height, cover, and composition requirements for the BTPD. First we used TNC's 2004 broad-scale rapid assessment of Arizona's grasslands to classify BLM lands into 1 of 7 grassland categories based on amount of shrub cover and dominant perennial grass cover (Table 2). We used this information to identify areas that would not support the BTPD without extensive vegetation manipulation (that is historic or former grasslands requiring treatment to remove shrubs). We conducted a windshield survey of vegetation on BLM lands that were excluded from further analysis including lands with unsuitable soil or historic or former grassland based on TNC's assessment. We then completed a walking survey at a 0.6-mile (1-km) interval on all remaining BLM lands (that is lands with suitable soil types and/or lands not considered historic or former grassland based on TNC's assessment). During this survey, we visually assessed ground cover of unclassified areas, based on similarity

Table 2. Categories for The Nature Conservancy's 2004 broad-scale rapid assessment of Arizona grasslands[1].

Grassland description	Shrub canopy cover	Predominant herbaceous component
Native grassland with low shrub cover	<10%	Native perennial grasses and forbs
Shrub-invaded native grassland	10-35% with <15% mesquite	Native perennial grasses and forbs
Non-native grassland with low shrub cover	<10%	Non-native perennial grasses
Shrub-invaded non-native grassland	10-35% total, with <15% mesquite	Non-native perennial grasses
Historic or former grassland	>35% total and/or >15% mesquite	None[2]
Sacaton riparian grassland	Dominated by Big Sacaton; on floodplain terraces along drainages	
Transition grassland	<5% canopy cover of perennial grasses and/or severe soil erosion problems	

[1]Vector digital data completed on January 24, 2004 under direction of Heather Schussman, Fire Science Specialist for The Nature Conservancy in Tucson Arizona.
[2] Perennial grass canopy cover was usually <1% and always <3%.

to TNC classified areas, excluding areas with >35% shrub cover and little to no native perennial grass cover from further vegetation analysis. We also delineated open areas with <10% shrub cover. We qualitatively assessed SSURGO soil classifications for all areas covered by the walking survey based on soil surface and presence of small mammal burrows. During the walking survey we monitored green-up of perennial grasses to decide the optimal time to measure productive vegetation cover. We thoroughly reviewed DOQQs to check for consistency among all cover classifications identified by either TNC data or by visual assessment during the walking survey.

From August through October 2004 we conducted vegetation measurements to assess ground cover and composition of warm-season grasses and forbs. Due to lack of perennial grass cover throughout all BLM lands, we limited measurements to open areas with <10% shrub cover. We stratified these remaining areas based on range allotment boundaries, soil type, and vegetation type determined during walking surveys. We generated random points within each stratified polygon to estimate cover and species composition. We initially conducted both point and line transects to estimate cover, but found that 328 foot (100 m), 3.3 foot (1 m) interval point transects were adequate. All hits per plant species, litter, rock, or bare ground were recorded at each 3.3 foot (1 m) interval. Litter, rock, and bare ground were only scored if there was no aerial or basal hit of a plant species. We scored height and both basal and aerial canopy cover, with basal cover as the more stable indicator of presence. In conjunction with our assessment, we reviewed existing vegetation survey data for BLM lands. BLM range staff and cooperators collected cover data in August-October 2003 using a pace-transect method similar to the point-transect method that we used.

Sylvatic plague

We reviewed the history of sylvatic plague in southeastern Arizona in relation to areas identified as potential BTPD habitat. Because there are no written records of sylvatic plague in areas identified as potential BTPD habitat, our review of plague consisted of telephone interviews with personnel from the Arizona Department of Health Services.

CLASSIFICATION OF POTENTIAL AREAS FOR RE-ESTABLISHMENT

We developed a classification model to determine possible re-establishments sites on BLM lands (Appendix A). The Value Index system for evaluation and ranking actual or potential prairie dog complexes, as prepared by the BTPD Conservation Team, served as a basis for building this model (Van Pelt and others 2001). We considered all biological and land use parameters to classify BLM lands into 1 of 5 categories of habitat quality for the BTPD: excellent (model score 3.01 to 4), moderate (model score 2.01 to 3), fair (model score 1.01 to 2), poor (model score 0.01 to 1) and unsuitable (model score of 0; determined during preceding hierarchical analysis).

RESULTS

SITE CHARACTERISTICS

None of the land, in its current state, identified in the initial model of potential habitat on BLM land met habitat requirements for the BTPD. Most of this potential habitat was dominated by creosote and had very little perennial grass or herbaceous cover. Many of these areas were highly volcanic with large rocks covering the ground and had no evidence of burrowing animals. However, 21,132 acres (8555 ha) of BLM lands could meet necessary site characteristics for BTPD habitat with extensive vegetation manipulation.

Soil assessment

There were 17 soil map units identified on BLM lands, 10 of which might meet habitat requirements and 7 that likely would not meet habitat requirements for the BTPD (Table 3). Most of the unsuitable soil map units were located in the foothills of the Whitlock Mountains (Figure 2). Five of the 10 soil map units occurring on 3558 acres (1440 ha) or <5% of BLM lands had physical properties that likely would support burrow systems. These soil map units included Comoro soils, Bluepoint-Gothard complex, Gila Loam, Gila-Anthony-Bluepoint complex, and Guest & Hantz soils (Cathy McGuire, NRCS, personal communication). These soils are found on slopes ranging from 0-8% and are all classified as very deep, well-drained soils with gravel content <20% (Vogt 1980).

The other 5 soil map units located on 59,010 acres (23,891 ha) or 76% of BLM lands were questionable, but might support burrow systems. These included Continental-Tubac complex, Sonoita gravelly sandy loam, Tres Hermanos gravelly sand clay, Anthony-Gila complex, Glendale-Gila complex. Continental-Tubac complex, Sonoita gravelly sandy loam, and Tres Hermanos gravelly sandy clay soil map units had moderate gravel content (that is 10-40% in the

Table 3. Soil Map Units found on potential black-tailed prairie dog habitat on BLM lands

Soil Map Unit	Acres (Ha)	Description[1]
Arizo soils	1417 (574)	Very deep, excessively drained soils; 70-75% fine and medium gravel from 3 to 60 inch depth; on floodplains and recent alluvial fans
Anthony-Gila complex	334 (135)	Very deep, well drained soils; subject to frequent flooding and piping erosion; on recent alluvial fans
Artesia cobbly fine sandy loam	4890 (1980)	Moderately deep, well-drained soils; very gravelly sandy loam from surface to 25 inches; strongly cemented pan of silica-lime below 25 inches; on high alluvial fans and terraces
Atascosa-Graham-Rock outcrop	1448 (586)	Shallow, well-drained soils; bedrock begins 7 to 17 inches below surface
Bluepoint-Gothard complex	175 (71)	Very deep, moderately to excessively drained soils; loamy sand and sandy loam from surface to 60 inches; 50% barren because of exposed subsoil; on dunes and alluvial fans
Bonita cobbly silty clay	1307 (529)	Very deep, well-drained soils; cobbly silty to very gravelly clay with 75% fine and medium gravel from 38 to 55 inches; on high fans
Calciorthids and Torriothents	2339 (947)	Slope 2-58%; loamy, but cemented in places; on low hills
Cave-Duurorothids complex	2161 (875)	0-11 inches is gravelly loam, 11-14 inches is cemented pan, 14-48 inches is very gravelly sandy loam; on old high alluvial fans
Comoro soils	2165 (876)	Very deep, well-drained soils; fine sandy loam to sandy loam; on alluvial fans and terraces
Continetal-Tubac complex	20,497 (8298)	Slow permeability; 0-4 inches is gravelly sandy loam, 4-35 inches is red gravelly clay to clay; >35 inches is gravelly fine sandy loam to clay
Gila loam	703 (285)	Very deep, well-drained soils; no gravel content; subject to piping and gully erosion; on floodplains and alluvial fans
Gila-Anthony-Bluepoint complex	497 (201)	Very deep, well-drained soils; loam to gravelly sandy loam; on small drainage-ways, interfluves, and dunes
Glendale-Gila association	598 (242)	Very deep, well-drained soils; loam to silty loam; subject to piping erosion; on floodplains and alluvial fans
Graham-Rock outcrop	1331 (539)	Slope 15-30%; cobbly clay loam with hard basalt below 17 inches; 15% rock outcrop of exposed bedrock
Guest and Hantz soils	19 (8)	Very deep, well-drained soils; silty clay to gravelly silty loam; on floodplains and swales
Sonoita gravelly sandy loam	25,075 (10,152)	Very deep, well-drained soils; 10-20% fine gravel in all horizons; on alluvial fans and terraces
Tres Hermanos gravelly loam	12,507 (5063)	Very deep, well-drained soils; 20-40% fine and medium gravel in all horizons; on alluvial terraces

[1]Summarized from Vogt's 1980 Soil survey of San Simon area, Arizona, parts of Cochise, Graham, and Greenlee counties.

different soil horizons), but were included for further analysis based on similar gravel content found on existing BTPD colonies in Sonora, Mexico (Koprowski and Coates 2004). Anthony-Gila complex and Glendale-Gila complex had required physical properties for BTPD habitat, but were located in floodplains. These map units were included for further analysis because the soils are well-drained even though they are subject to frequent flooding.

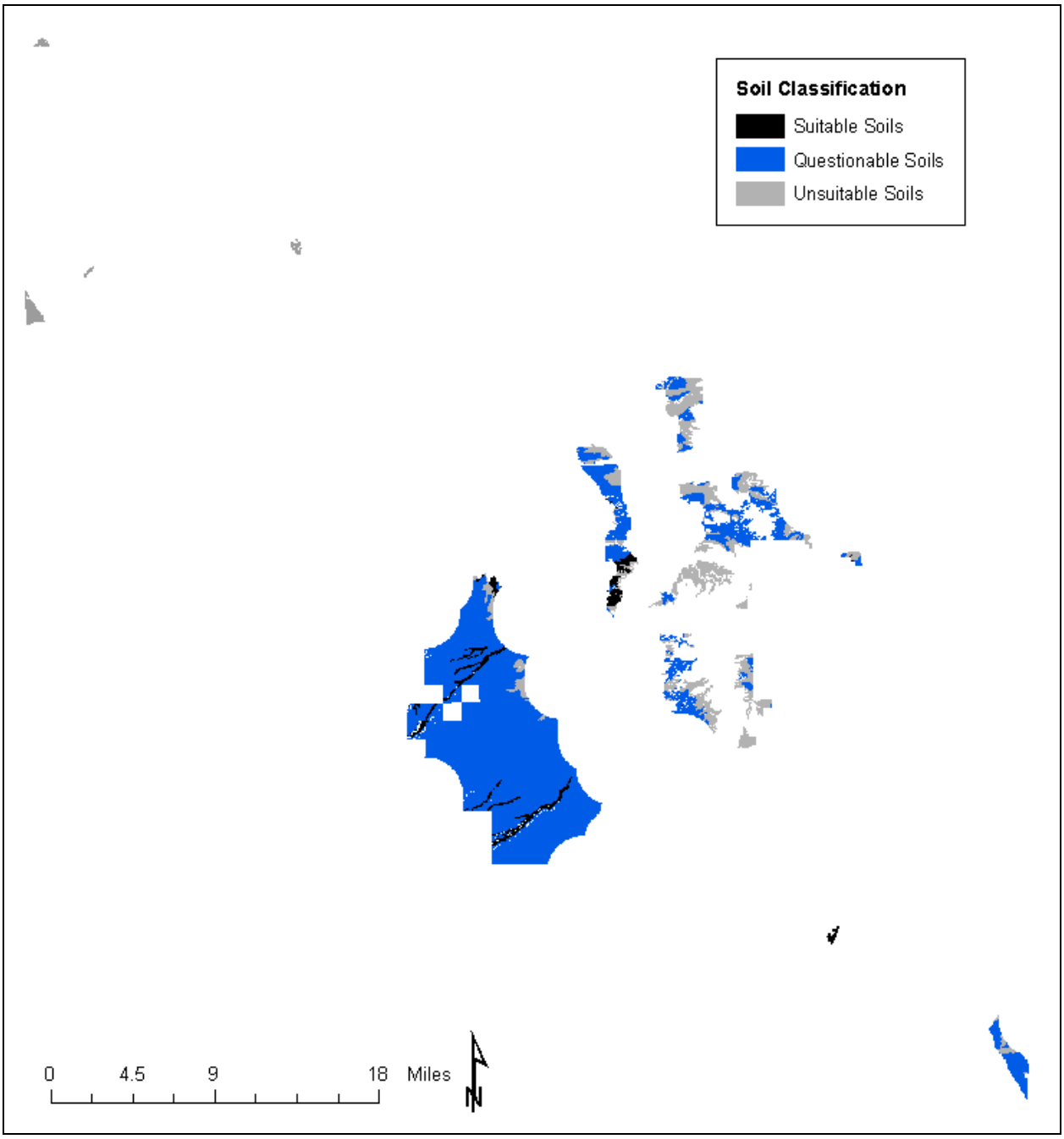

Figure 2. Revised soil classification for potential black-tailed prairie dog habitat on BLM lands based on Natural Resource Conservation Service's electronic Soil Survey Geographic database.

The remaining 7 soil map units on 14,895 acres (6030 ha) or >19% of BLM lands did not meet minimum BTPD habitat requirements for various reasons. Atascosa-Graham-Rock and Graham-Rock outcrop soil map units consisted of shallow soils found on slopes ranging from 15-70% and thus were excluded as potential habitat. Arizo soils and Bonita cobbly silty clay had gravelcontent >70% in ≥1 soil horizon. Artesia cobbly fine sandy loam and Cave-Durorthids complex were too shallow for BTPD burrow systems (that is 11-25 in or 28-64 cm with a

cemented pan below) and had very gravelly soils. Calciorthids and Torriothents were found on slopes up to 58% and did not support rangeland vegetation suitable for grazing. All lands identified by these 7 soil map units were classified unsuitable for BTPD habitat based on soil.

Vegetation assessment

The Nature Conservancy's 1996 broad-scale rapid assessment of Arizona's grasslands included classification of 58,923 acres (23,856 ha) or 75% of BLM lands identified as potential BTPD habitat (Figure 3). This assessment classified approximately 53,055 acres (21,480 ha) of BLM lands as historic grasslands, 3110 acres (1259 ha) as shrub-invaded non-native grasslands, and 2758 acres (1117 ha) as shrub-invaded native grasslands. There were no BLM lands identified by TNC as native grasslands with <10% shrub cover. During the windshield survey, ocular assessments of areas identified as historic grasslands confirmed that these areas had >35% shrub cover and <3% native grass cover. These areas were dominated by creosotebush (*Larrea tridentata*), mesquite species (*Prosopis* spp), and acacia species (*Acacia* spp) with most plants >11.8 inches (30 cm) tall. Lands identified as TNC historic grasslands and/or lands within the 7 unsuitable soil map units were excluded from additional vegetation analysis. Even though we excluded these areas from further analysis, we determined what, if any, modifications would be necessary to support the BTPD. This left 14,645 acres (5929 ha) of potential habitat that required further on-the-ground evaluation. The breakdown of these remaining lands by TNC's grassland assessment categories included 419 acres (170 ha) of shrub-invaded native grasslands, 3110 acres (1258 ha) of shrub-invaded non-native grassland, and 11,116 acres (4501 ha) with no TNC classification.

During the walking survey, we classified 2775 acres (1124 ha) of the BLM lands as unsuitable for BTPD habitat because they consisted of small narrow mesas atop undulating hills sloping down from nearby mountain ranges. This was not captured by the DEM used in the original habitat model. We classified another 6789 acres (2743 ha) as historic or former grasslands with >35% shrub cover and <3% native perennial grass cover. These areas had no TNC classification, but were adjacent to TNC historic or former grasslands and/or shared the same cover characteristics. We did not observe any native perennial grass within the area classified as shrub-invaded non-native grassland by TNC. Lehman lovegrass (*Eragrostis lehmannia*) dominated this area. Of the remaining 1971 acres (796 ha), we delineated 36 areas totaling 1174.4 acres (475.5 ha) with <10% shrub and tree cover ranging in size from 0.7 to 199.0 acres (0.3 to 80.6 ha). All classifications were verified and checked for consistency in the lab through cover analysis of corresponding DOQQs.

Due to lack of perennial grasses on all BLM lands, we made vegetation measurements to estimate forage cover and species composition only on the remaining 1971 acres of BLM lands with <10% shrub cover. This allowed us determine the most optimistic values for potential BTPD forage cover. Most areas measured had >40% bare ground and all areas had <5.9% perennial grass cover (Table 4). Annual grass cover and annual forb cover both varied widely from 0 to 49.1% and 0 to 59.3%, respectively. Perennial grasses included tobosa (*Hilaria mutica*), black grama (*Bouteloua eriopoda*), bush muhly (*Muhlenbergia porteri*), and threeawns (*Aristida* spp); annual grasses present included needle grama (*B. aristidoides*) and sixweeks grama (*B. barbinoides*); and dominant annual forbs included *Trianthema portulacastrum*,

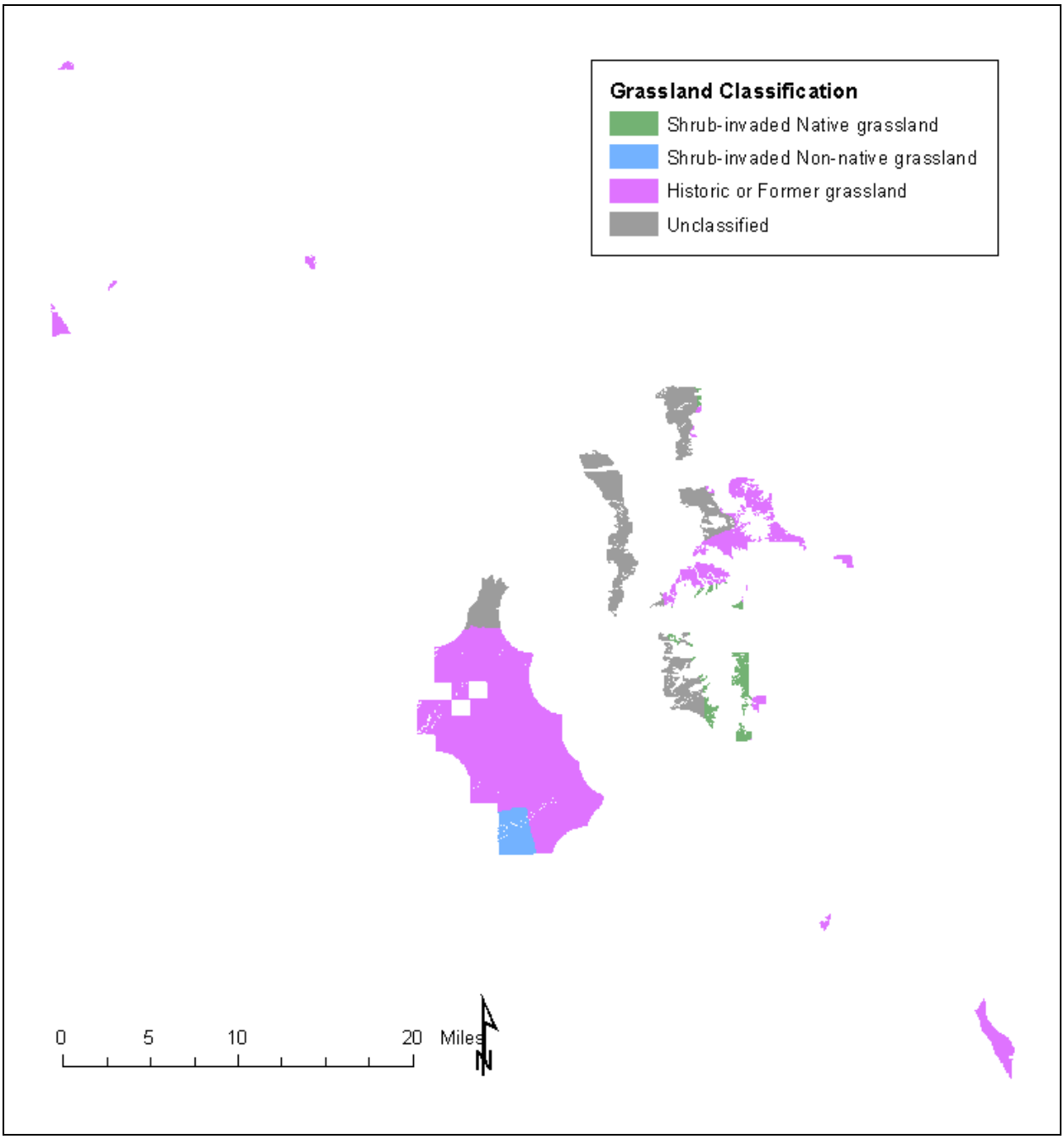

Figure 3. Classification of potential black-tailed prairie dog habitat on BLM lands based on The Nature Conservancy's broad-scale rapid assessment of Arizona's grasslands.

Tidestroma languinosa, *Pectis* sp. and *Boerhaavia* spp. (Appendix B). Dominant shrubs in these areas with <10% shrub cover included creosotebush, mesquite, and wolfberry (*Lycium* spp).

The BLM had recent cover data at 9 sites within potential BTPD habitat. Six of these sites fell within areas of unsuitable soil and were not used in our analysis. The remaining 3 sites were

within areas classified as historic grasslands by the TNC in area E. Shrub cover was estimated at 54.3+2.5%, perennial grass cover at 3.8+3.4%, and bare ground at 41.8+4.0%.

Table 4. Mean (+SD) estimate of ground cover in open areas of potential black-tailed prairie dog habitat on BLM lands [1]

	A North	A South	B	C Upper	C Middle	C Lower
Bare Ground	33.3±3.5	19.0±4.4	50.3±3.5	73.5±7.6	68±21.8	46.6±14.4
--Rock[2]	8.3±3.5	6.7±3.1	0.6±0.1	0.5±1.6	0	0
Litter	4.0±1.0	0	3.8±0.6	8.1±5.1	4.1±3.5	3.1±1.1
Total Vegetation	76.0±1.0	31.7±11.4	48.0±8.8	17.9±8.5	27.9±22.0	53.8±10.3
Perennial Grass	4.3±5.9	1.3±1.2	0.5±0.9	0.1±0.3	0	0
Annual Grass	37.0±12.1	12.7±4.0	25.7±10.7	6.4±4.7	2.3±0.9	0.5±0.5
Annual Forbs	16.0±10.8	7.0±8.0	13.3±11.0	8.3±4.3	22.9±13.9	49.1±10.2
Shrub/Tree/Cactus (>30 cm tall)	6.3±1.1	12.0±6.2	8.5±2.6	3.1±2.0	4.3±1.1	3.8±4.5

[1]See Appendix D for areas.
[2]Percent Rock cover included in bare ground cover.

Because there was virtually no perennial grass cover on BLM lands, we reviewed the 1980 soil survey to glean additional information on historic ground cover. In the 1980 soil survey, there were 24 perennial species included in the characteristic plant communities described for the 8 soil map units remaining in our analysis. These included 19 native perennial grasses and 5 shrubs or trees (Appendix C). Based on estimates of land area, normal production, and percent composition among soil map units, the most common grass species (in descending order) included bush muhly, black grama, sideoats grama (*B. curtipendula*), tobosa, and plains bristlegrass (*Setaria macrostachya*). Shrub and tree species were characteristic on 4 of the 8 soil map units. Based on land area, normal production, and percent composition among soil map units, creosotebush was the most dominant shrub or tree species followed by (in descending order) whitethorn acacia (*Acacia constricta*), desert zinnia (*Zinnia pulchellum*), crucifixion thorn (*Castela emoryi*), soaptree yucca (*Yucca elata*), and four-wing saltbush (*Atriplex canascens*). In addition to vegetation composition information, the soil survey rated soil series in each soil map unit as good, fair, poor, or very poor based on their potential to support different types of wildlife habitat. All soil series within the 10 soil map units on BLM lands had poor to fair potential for herbaceous plant production (that is native grasses and forbs) and hence, poor to fair potential as habitat for rangeland wildlife. A rating of fair meant that habitat could be created, improved, or maintained in most places with moderately intensive management. A rating of poor meant that limitations were severe for wildlife habitat, but habitat could be created, improved, or maintained with intensive management.

Sylvatic plague

In Arizona, plague only has been found at elevations >4500 feet (1372 m) above sea level; fleas taken from areas <4500 feet (1372 m) have never tested positive for plague (Craig Levy, Arizona Department of Health Services, personal communication). All BLM lands identified in the initial habitat model are <4500 feet (1372 m) above sea level. The closest evidence of plague was documented in the 1980s in the foothills of the Pinaleno Mountains near Fort Graham and the Chiricahua Mountains on Riggs Ranch. Serologies of coyotes (*Canis latrans*) in these areas revealed that they had eaten plague-infected rodents. Serological testing of carnivores in southeastern Arizona ceased by 1990 due to negative results for plague. However, plague outbreaks in rodent populations may have gone undetected in areas that were not sampled.

CLASSIFICATION OF POTENTIAL AREAS FOR RE-ESTABLISHMENT

Although none of the BLM lands met the minimum requirements for BTPD habitat, we determined that 36 discrete areas covering 21,132 acres (8555 ha) or <28% of BLM lands could support the BTPD with vegetation restoration (Figure 4). Discrete areas ranged in size from 9.5 to 9514 acres (3.8 to 3852 ha). There were >235 miles (385 km) of ephemeral drainages on these areas, ranging from 0 to 110.5 linear ft per acre (0 to 84.7 m per ha) of habitat. Ephemeral drainages buffered at an average width of 16.9 ft (5 m) covered 3.8±2.0% of a discrete area. Distance to nearest habitat was 0.6±1.4 miles (1.0±2.2 km). Proportion of habitat outside a discrete area within the average dispersal distance of a BTPD was 7.1±3.9%. Proportion of private land outside a discrete area within the maximum dispersal distance of a BTPD was 3.4±2.4%.

After applying the model equation presented in Appendix A, 9299 acres (3765 ha) were classified as fair areas for re-establishment and 11,833 acres (4791 ha) were classified as poor areas for re-establishment (Figure 5). Details of potential re-establishment sites are presented for each major area (Appendices D and E).

DISCUSSION

Soil structure is one of the most important habitat parameters to consider when choosing sites for re-establishing BTPDs (Roe and Roe 2003). Because BTPDs exclusively rely on burrows for protection from predators and extreme summer temperatures, soils must have the physical properties needed to maintain the integrity of deep, complex burrow systems. Researchers have found that BTPD will conduct exploratory burrowing behavior in rocky ground, gravelly soil or loose sand, but do not establish burrows in these areas (Roe and Roe 2003). Therefore, we removed land with unsuitable soils prior to assessing areas for re-establishment. In addition, 5 of the 11 sub-factors in the classification model were related to soil (that is MAPUNIT, SOILVEGP, VEGPROD, SLVEGP, and WASH). This more detailed assessment of soil quality revealed that soil types found on BLM lands were marginal as habitat for the BTPD.

Ephemeral drainages represented by the factor WASH were not excluded from habitat unless their density was >200 ft/acre. At this density, habitat is disrupted at an average 100-ft interval by ephemeral washes and the tall shrubby vegetation associated with them. Removal

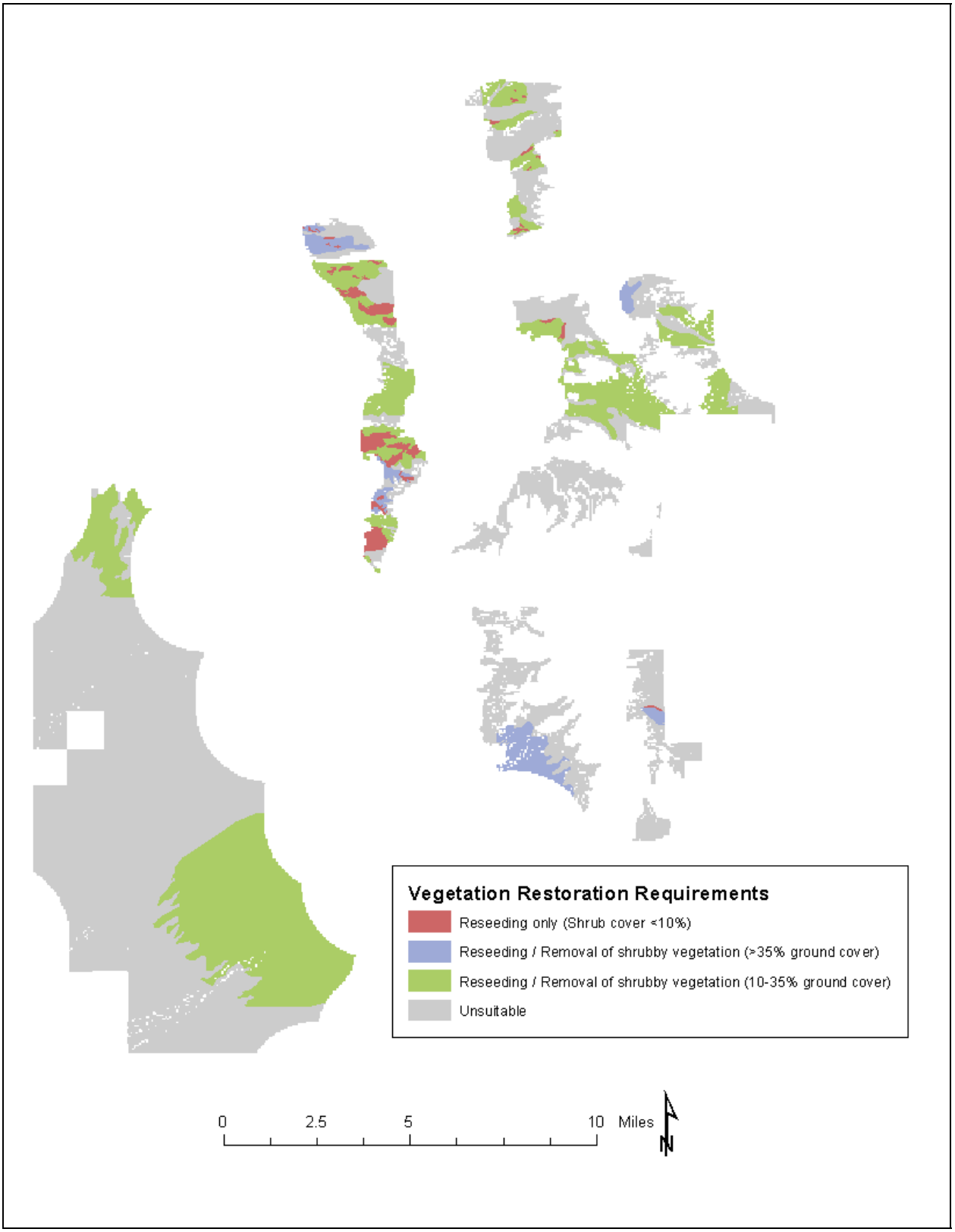

Figure 4. Classification of BLM lands based on vegetation manipulation required to support the black-tailed prairie dog.

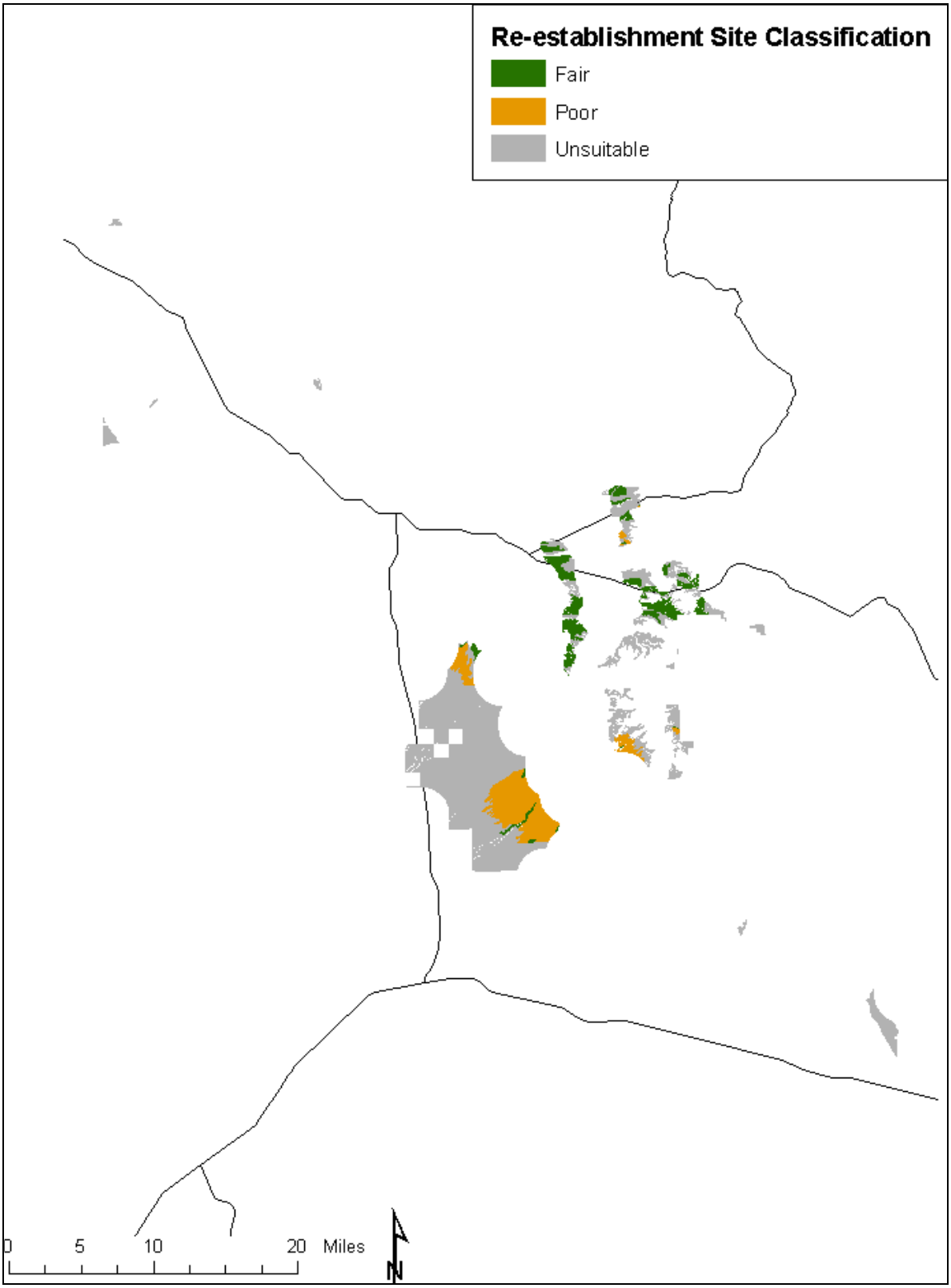

Figure 5. Categorical classification of potential black-tailed prairie dog re-establishment areas on BLM lands based on all 7 model factors.

of this shrubby vegetation would be extremely cost prohibitive. In addition, this density of ephemeral washes severely limits the amount of burrowing habitat available, so that the expense of vegetation removal would not be justified (that is, there are other areas where vegetation removal is more economical). Therefore, these areas were excluded from the model.

The paucity of perennial grass cover on BLM lands administered by Safford Field Office is not promising for re-establishment of the BTPD in southeastern Arizona. Many desert grasslands in the southwest, including those on BLM lands, have experienced shifts in plant dominance to the point that grasses have become scarce and the vegetation has been completely altered. What was once a native perennial grassland is now mesquite shrubland with a half shrub and/or nonnative grass understory. Restoration of desert grasslands is labor and time intensive. TNC considered the level of conversion on former or historic grasslands as permanent or requiring 40+ years of livestock exclusion for partial recovery of perennial grasses (Hennessey and others 1983; Valone and others 2002). Revegetation projects in the San Simon Valley from 1963 to 1973 revealed that native grasses successfully established when summer precipitation was well above average (Cox and Jordan 1983; Jordan 1970). However, density and yield of these grasses decreased throughout the study period and grasses virtually were absent 20 years after reseeding took place (Cox and Jordan 1983). Because most BLM land identified as potential re-establishment areas for the BTPD has >35% shrub cover and <1% native perennial grass cover, revegetation efforts needed for re-establishment of the BTPD on BLM lands could be costly.

Average colony size of the BTPD is typically 49.4 to 148.2 acres (20 to 60 ha), although colonies of <24.7 (10 ha) to complexes of several hundred hectares are not uncommon (Bishop and Culbertson 1976; Cheatheam 1977; Clark et al. 1982; Knowles 1986). The majority of potential BTPD re-establishment areas meet or exceed this average range, with three >1000 acres (405 ha) and one >9000 acres (3644 ha).

Potential re-establishment areas should be geographically situated to provide avenues for dispersal and population expansion. The physical and ecological variability in lands within and around identified potential re-establishment areas would likely influence dispersal among BTPD colonies (Koford 1948). Topographic variation, habitat isolation, and tall vegetation exacerbated by extensive ephemeral washes on BLM lands might be significant barriers to dispersal and expansion of colonies. BTPD dispersal usually is limited to approximately 3 miles (5 km) or less, although roads and livestock trails may facilitate movement (Garrett and Franklin 1988; Hoogland 1995). There is evidence of BTPD frequently using roads during dispersal for distances <6 miles (10 km; Knowles 1985). Although these discrete areas might not be good for dispersal and genetic interchange, there are some benefits to this disjunct habitat. Some prairie dog colonies should be geographically isolated to prevent loss in a catastrophic event (that is disease epidemic).

Habitat requirements for the black-tailed prairie dog were determined from studies of BTPDs in areas outside of Arizona. This raises some concern because available habitat in southeastern Arizona is similar to that in New Mexico and west Texas, but very different from that in states such as Colorado and North Dakota. Habitat requirements for BTPDs in Mexico and those of the Mexican prairie dog (*Cynomis mexicanus*) are worth noting because these animals are found in large arid grassland valleys associated with scrub vegetation, similar to that found in

southeastern Arizona. Studies of both of prairie dogs in Mexico are limited, but indicate that habitat requirements are similar and fall within the criteria set forth by Roe and Roe (2003) for re-establishment sites for the BTPD (Ceballos and others 1993, Koprowski and Coates 2004, Mellink and Madrigal 1993, Trevino-Villareal and others 1997). Soil samples taken from colonies of Mexican prairie dogs had silt loam soils low in clay, medium in sand, medium to high in silt, and gravel-free (Trevino-Villareal and others 1997). Soil samples taken from colonies of BTPD in Sonora, Mexico were ~50% sand, ~8% silt and clay, and ~40% gravel (Koprowski and Coates 2004). Trevino-Villareal and others (1997) also observed the Mexican prairie dog digging in rocky soils, but never establishing burrows in these soils (Trevino-Villareal and others 1997). Although Roe and Roe (2003) state that re-establishment sites should have soils with little to no gravel, we included soils with <40% gravel in our model for BLM lands because of Koprowski and Coates (2004) findings. Koprowski and Coates (2004) also measured ~20% grass cover, ~9% forb cover, and 70% bare ground cover on occupied BTPD habitat in Sonora, Mexico. Available grass cover on habitat of the Mexican prairie dog fell within the range of that on BTPD habitat, and relative percentage of grass consumed by the Mexican prairie dog was higher than relative available cover of grasses (Mellink and Madrigal 1993). The Mexican prairie dog has a diet similar to that of the BTPD, dominated by native perennial grasses and seasonal forbs, with seasonal variation resulting from the phenologic stage of different plants (Mellink and Madrigal 1993). This is similar to that of the BTPD. These studies emphasize the importance of soil type and availability of perennial grasses for habitat of all prairie dog species.

RECOMMENDATIONS

It is evident that tremendous vegetation modification, along with implementation of best management practices to maintain such modification, would be required to re-establish the BTPD on lands managed by the Safford BLM office. The potential re-establishment areas identified in this report will be evaluated against other potential areas in southeastern Arizona. Areas with quality habitat requiring less vegetation modification should be pursued first if they exist. Prior to any habitat improvement efforts, we recommend conducting site-specific soil analysis on potential re-establishment areas to determine if soils meet habitat requirements. This will prevent costly modification on areas that might not support BTPDs.

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APPENDIX A: Classification Model Factors

Potential for Re-establishment = Soil Quality + Perennial grass cover + Vegetation Restoration + Continuity + Connectivity + Proximity to Private Land

Soil quality = (MAPUNIT +SOILVEGP)/2

Physical characteristics (MAPUNIT)

(3) very deep, well-drained soil with <20% gravel content
(2) very deep, well-drained soil with 20-50% gravel content
(1) very deep, well-drained soil subject to frequent flooding
(0) shallow soil and/or >50% gravel content

Restoration Potential based on soil survey (SOILVEGP)

(4) habitat easily created, improved or maintained
(3) habitat could be created, improved, or maintained in most places with moderately intensive management
(2) limitations are severe for wildlife habitat, but habitat could be created, improved, or maintained with intensive management
(1) limitations are severe for wildlife habitat, and it is impractical or impossible to create, improve, or maintain habitat

Perennial Grass Cover = (VEGCOV + VEGPROD + SLVEGP)/3

Current perennial grass cover (VEGCOV)

(4) >40%
(3) 20-40%
(2) 10-20%
(1) 3-10%
(0) <3%

Historic perennial grass production (VEGPROD)

(4) >1000 pounds/acre
(3) 500-1000 pounds/acre
(2) 250-500 pounds/acre
(1) <250 pounds/acre

Historic native perennial grass composition (SLVEGSP)

(4) >15 species
(3) 10-15 species
(2) 5-10 species
(1) <5 species

Vegetation restoration (RESTORE)

(5) Area met all ground cover requirements for BTPD and required no habitat modification other than creating artificial burrows.
(4) Area that met ground cover requirements except forage cover (i.e., reseeding of native grasses needed).
(3) Area met forage cover requirements, but had 10-35% shrub cover (i.e., removal of shrubby vegetation needed).

(2) Area did not meet forage cover requirements and had 10-35% shrub cover (i.e., reseeding of native grasses and removal of shrubby vegetation needed).
(1) Area did not meet forage cover requirements and had >35% shrub cover (i.e., reseeding of native grasses and extensive removal of shrubby vegetation needed).

Continuity of habitat = (SIZE_F + WASH)/2

Size of contiguous habitat area (SIZE_F)
(4) >5000 acres
(3) 1000.01-5000 acres
(2) 100.01-1000 acres
(1) 10.01-100 acres
(0) <10 acres

Interruption by ephemeral drainages: defined as linear feet of washes per acre of habitat (WASH)
(4) <25 ft / acre
(3) 25.01 – 50 ft / acre
(2) 50.01 – 75 ft / acre
(1) 75.01 – 200 ft / acre
(0) > 200 ft / acre (i.e., areas of habitat <100 m wide between drainages)

Connectivity of habitat = (HAB_DIST + HAB_ISOL)/2

Shortest distance to nearest habitat: one discrete area to another (HAB_DIST)
(4) <200 m
(3) 200.01 – 1000 m
(2) 1000 – 3000 m
(1)3000 – 10, 000 m
(0) > 10,000 m

Isolation of habitat: 100 - % habitat within 2-mile buffer around contiguous habitat area (HAB_ISOL)
(4) 0-10%
(3) 10.01-25%
(2) 25.01-90%
(1) 90.01-100%

Proximity to private land (PRIV_ISOL)

Distance Factor: % private land within 10-km buffer around contiguous habitat area
(4) <5%
(3) 5.01-10%
(2) 10.01-30%
(1) 30.01-89%
(0) >89% (completely surrounded by private land at minimum 2-mile distance)

APPENDIX B: Percent cover of plant species on ground cover transects (Mean±SD)

Plant Species[1]	Area[2]					
	A North	A South	B	C Upper	C Middle	C Lower
Perennial Grasses						
Aristida sp. (aerial)	0.3±0.6	0	0	0	0	0
Aristida sp. (basal)	0.7±1.2	0	0	0	0	0
Bouteloua eriopoda (aerial)	1.3±2.3	0	0	0	0	0
Bouteloua eriopoda (basal)	0.7±1.2	0	0	0	0	0
Hilaria mutica (aerial)	0	0	0.2±0.3	0	0	0
Hilaria mutica (basal)	0	0	0.3±0.6	0	0	0
Muhlenbergia porteri (aerial)	1.3±1.5	0	0	0	0	0
Annual Grasses						
Bouteloua barbata	6.0±3.6	10.3±1.5	22.8±13.3	<0.01	0	4.5±4.4
Bouteloua aristidoides	31.0±13.5	0.7±1.2	2.8±3.0	0.4±0.6	0.9±2.3	0.6±1.3
Panicum arizonicum	0	0.3±0.6	0	0	0	0
Annual Forbs						
Amaranthus sp	0	0.3±0.6	0	0	0	0
Boerhaavia coccinea	3.0±2.6	1.0±1.7	0	0	0	2.0±3.7
Boerhaavia coulteri	0	0	0.3±0.6	10.1±10.0	0	0.1±0.3
Chenopodium sp.	0	0	0.2±0.3	0	0	0
Euphorbia florida	1.3±1.2	0	0	0	0	0.4±0.9
Euphorbia sp.	0.3±0.6	0	0.3±0.6	0.3±0.5	0	0
Hoffmanseggia densiflora	0	0	0.3±0.6	0	0.3±0.8	<0.01
Janusia gracilis	0.3±0.6	0	0	0	0	0
Pectis sp.	10.3±10.0	0	1.0±0.9	0.1±0.1	0	0.9±1.0
Proboscidea parviflora	0	0	0	<0.01	0	0
Stylocline micropoides	0.7±1.2	0	0	0	0	0
Tidestroma lanuginosa	0	2.3±3.2	0.8±0.3	2.7±1.2	0	0.2±0.4
Trianthema portulacastrum	0	3.3±4.9	10.3±9.8	38.0±22.5	26.3±22.9	3.0±4.4
Tribulus terrestris	0.3±0.6	0	0	0.7±1.2	0	0
Shrubs and Trees						
Acacia constricta	0	0	0	0	0.1±0.4	0.1±0.3

[1]Plant names follow Lehr, J.H. 1978. A catalogue of the Flora of Arizona. Northland Press, Flagstaff, Arizona. 203pp.
[2]See Appendix D for areas.

APPENDIX B (cont'd): Percent cover of plant species on ground cover transects (Mean±SD)

Plant Species	Area[1]					
	A North	A South	B	C Upper	C Middle	C Lower
Shrubs and Trees (cont'd)						
Acacia greggii	1.3±2.3	1.0±1.7	0	0	0	0
Artemesia filifolia	0	1.0±1.70	0.8±1.4	0.5±0.4	0.3±0.8	0.6±1.0
Atriplex elegans	0	0	0.5±0.9	0	0	0.4±0.7
Cercidium sp	1.0±1.7	0	0	0	0	0
Ephedra trifurca	0	0.3±0.8	0.5±0.9	0	0	0
Gutierrezia sarothrae	2.0±1.0	0	0.2±0.3	0	0	0
Larrea tridentada	0.3±0.6	4.7±4.5	2.3±4.0	0	0	0.7±1.1
Lycium sp	0	0	0	0	0	0.2±0.3
Prosopis sp	0.7±1.2	2.3±0.6	1.8±1.8	0.7±1.1	0	0.3±0.8
Zizyphus obtusifolia	0.7±1.2	0	0	0	0	0
Cacti						
Echinocereus sp	0	0	2.3±2.4	0	0	0.8±1.2
Opuntia sp (cholla)	0.8±1.3	1.7±1.5	0	0	0	0
Opuntia sp (prickly pear)	0.5±0.8	1.0±1.0	0	0	0	0

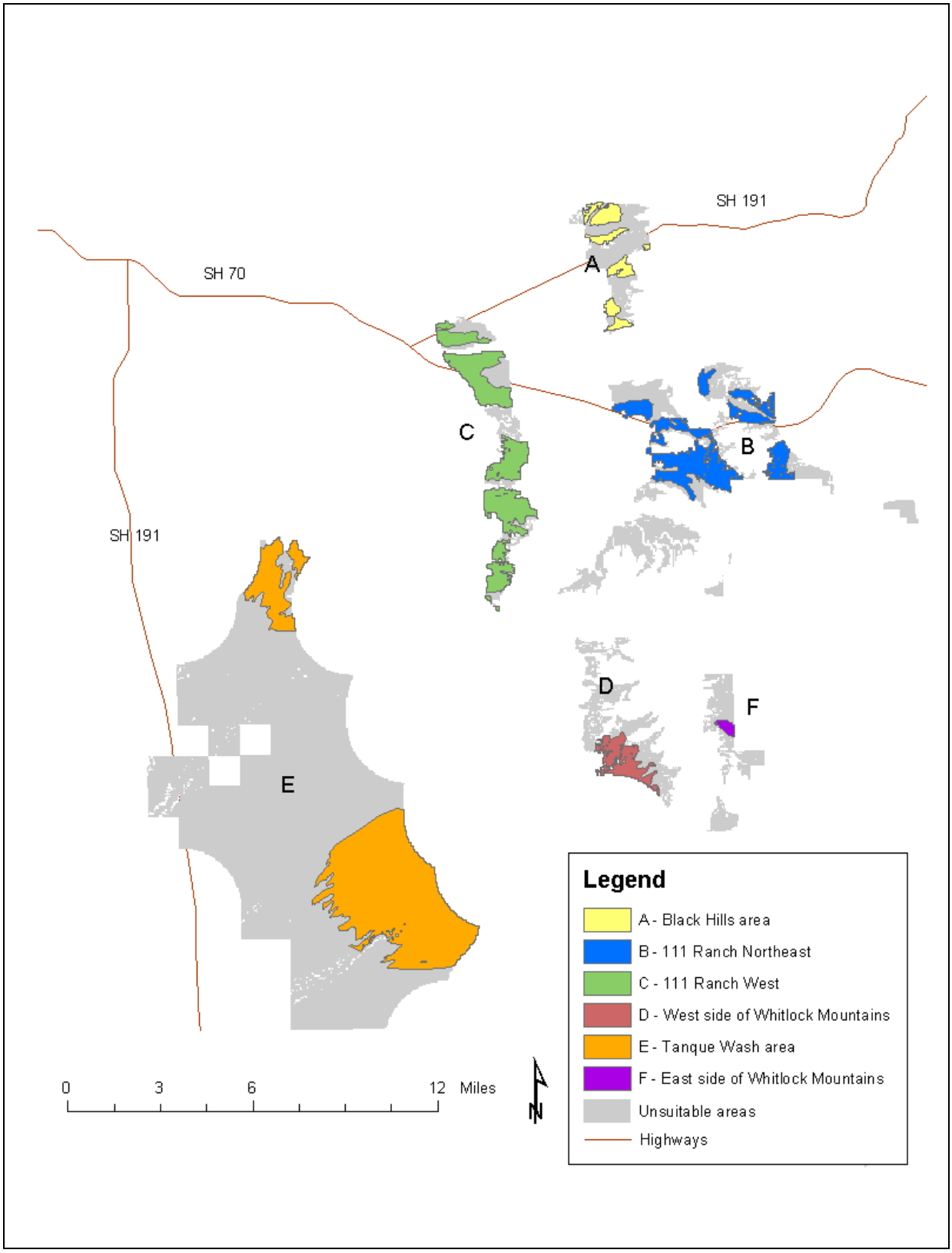
[1]Plant names follow Lehr, J.H. 1978. A catalogue of the Flora of Arizona. Northland Press, Flagstaff, Arizona. 203pp.
[2]See Appendix D for areas.

APPENDIX C: Major plant species historically found within soil map units on BLM lands identified as potential black-tailed prairie dog habitat[1]

	1[3]	12	13	20	21	24	38	40
Aristida sp.					X			
Bothriochloa barbinodes	X					X		
Bouteloua curtipendula	X	X	X		X	X	X	
Bouteloua eriopoda	X	X	X		X	X	X	X
Bouteloua gracilis			X					
Bouteloua hirsute		X			X		X	
Digitaria californica		X	X	X	X		X	
Eragrostis intermedia	X					X		
Hilaria mutica	X		X	X	X	X		
Leptochloa dubia	X					X		
Muhlenbergia porteria	X	X	X	X	X	X	X	X
Panicum obtusum	X					X		
Setaria macrostachya	X	X	X		X	X	X	
Sitanion Hystrix	X					X		
Sporobolis airoides	X			X	X	X		
Sporobolis contractus					X			
Sporobolis Wrightii	X			X	X	X		
Trichloriis crinata	X							
Tridens muticus								X
Castela emoryi				X				
Larrea tridentata				X				X
Zinnea pulchellum								X
Acacia constricta								X
Yucca elata				X				
Total number of species for soil map unit	13	6	7	8	11	12	6	6

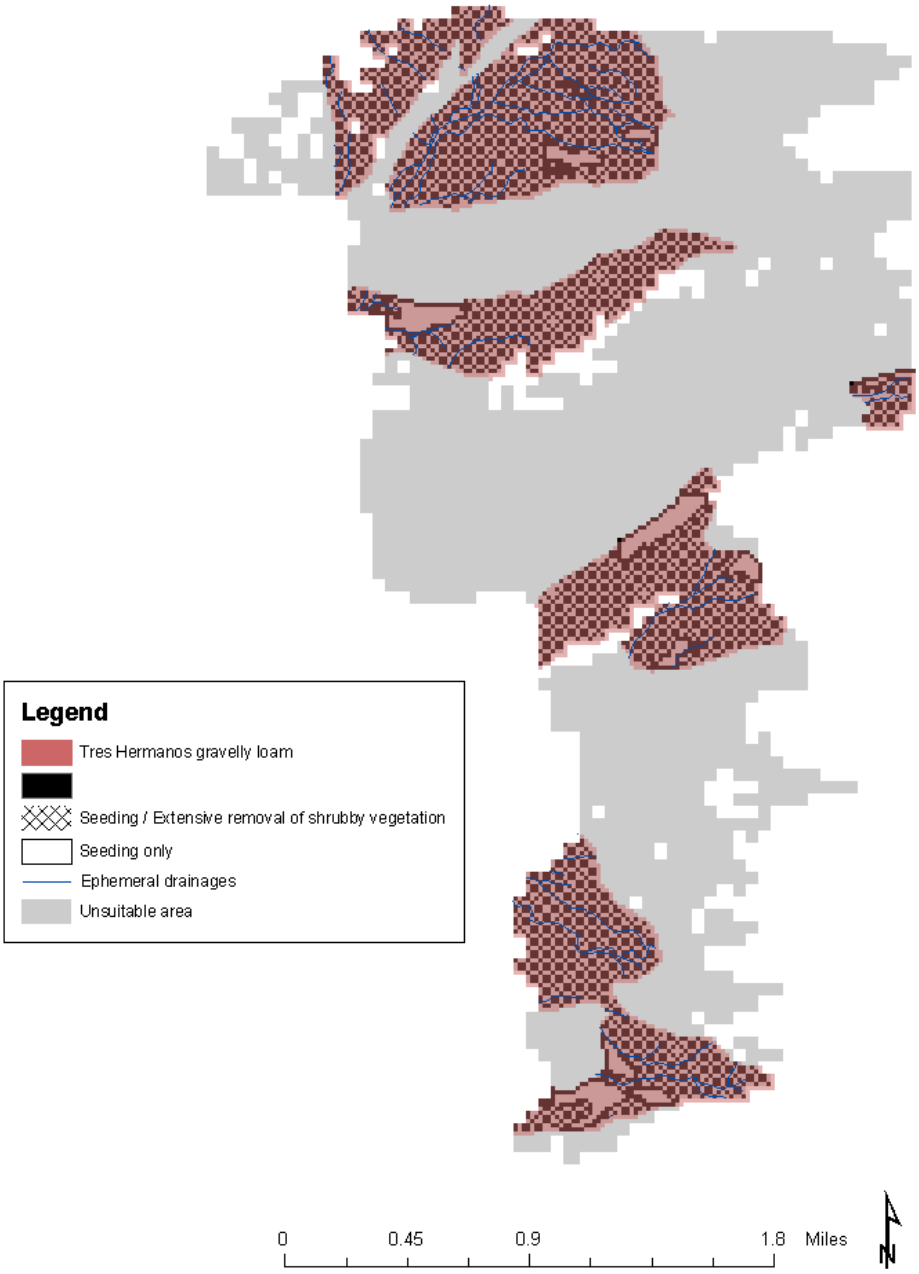
[1]Based on 1980 Soil Survey for the San Simon Valley
[2]Total area of BLM lands that will potentially support the plant species
[3]USDA Soil Map Unit: 1 = Anthony-Gila complex, 12 = Comoro soils, 13 = Continental-Tubac complex, 20 = Gila loam, 21 = Gila-Anthony-Bluepoint complex, 24 = Glendale-Gila complex, 38 =Sonoita gravelly sandy loam, 40 = Tres Hermanos gravelly sandy clay.

APPENDIX D: Area Reference



APPENDIX E: Summary and Photopoints

Polygon A- Black Hills area north and south of 191. Vegetation dominated by mature *Larrea tridentata*, *Prosopis* species, and *Opuntia* species. (>30 cm height) with senescent *Schismus barbatos*. *Acacia greggii* along numerous drainages. Small rodent burrows are present but few of larger animals such as *Dipodomys* species.



APPENDIX E (CONT'D): SUMMARY AND PHOTOPOINTS

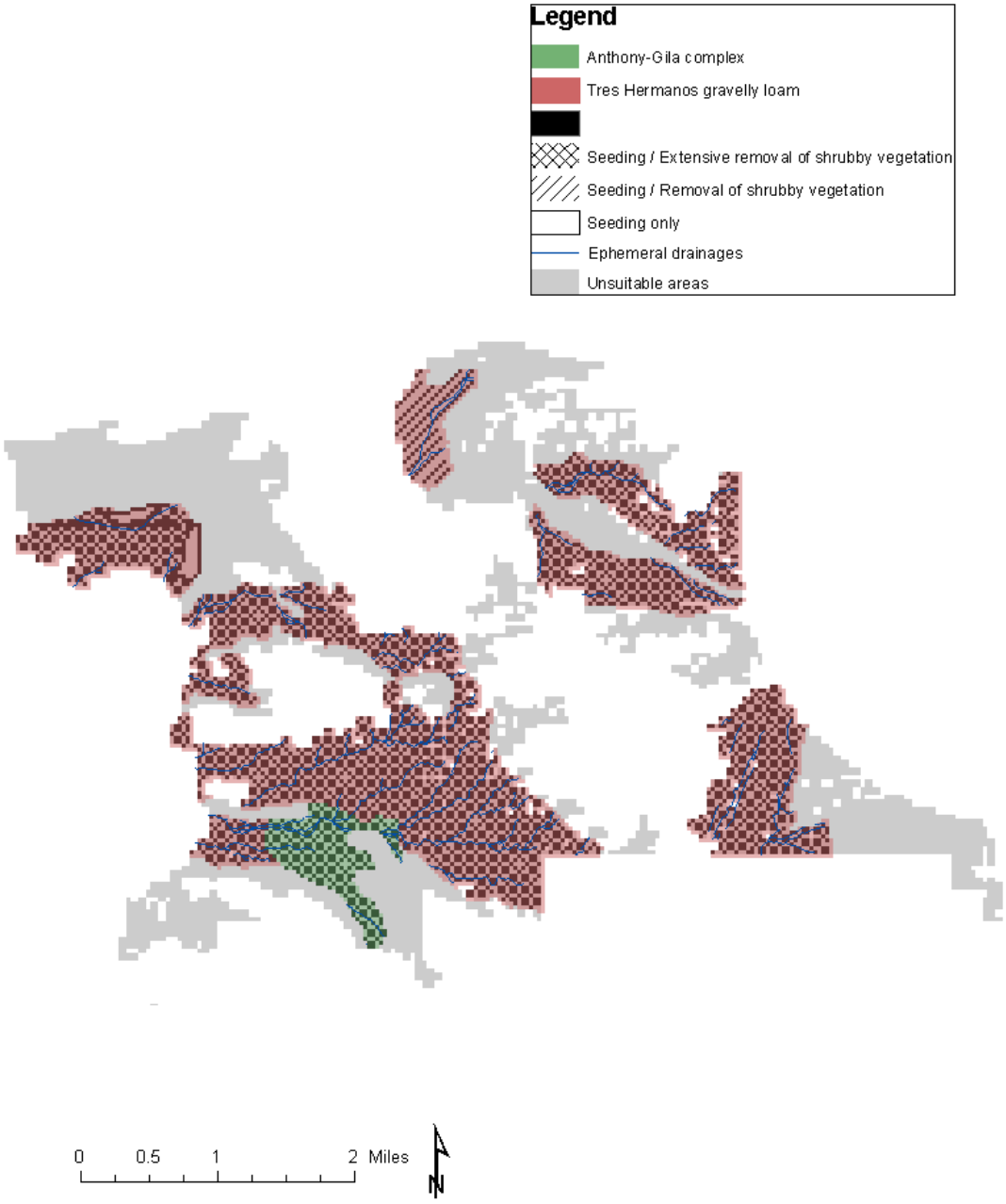
Polygon A

Photopoint A-1: type location.

Photopoint A-2: open area.

APPENDIX E (CONT'D): SUMMARY AND PHOTOPOINTS

Polygon B – 111 Ranch Northeast. Vegetation dominated by mature *Larrea tridentata* and *Prosopis* species (>30 cm height); a few areas have remnant *Hilaria mutica*. No small rodent burrows present. Soil surface very rocky (>10 cm diameter).



APPENDIX E (CONT'D): SUMMARY AND PHOTOPOINTS

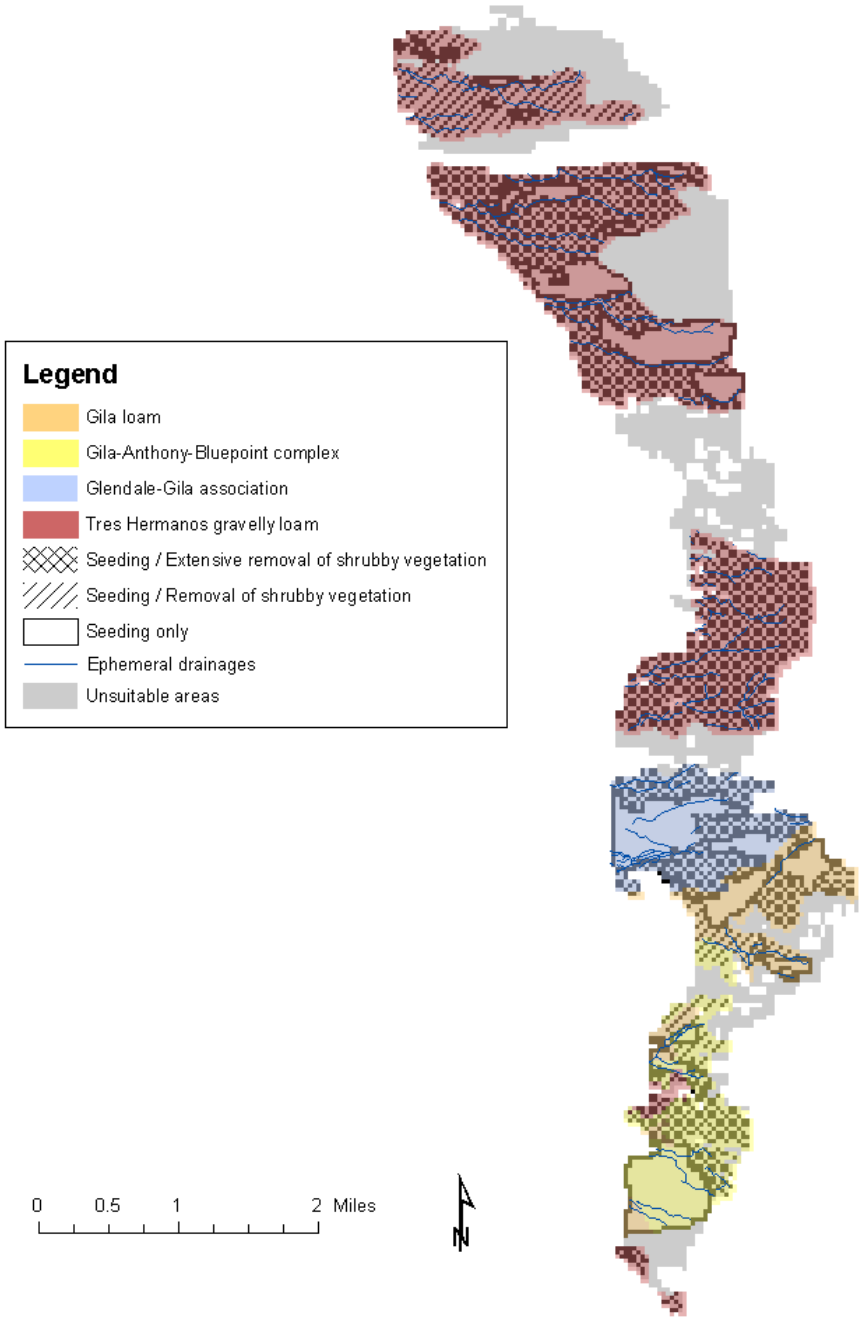
Polygon B

Photopoint B-1: type location.

Photopoint B-2: open area on Tres Hermanos gravelly sandy loam (soil map unit).

APPENDIX E (CONT'D): SUMMARY AND PHOTOPOINTS

Polygon C – 111 Ranch West. Most open of all areas. Vegetation dominated by *Artemesia* species and senescent *Schismus barbatos; m*ature *Larrea tridentata* and *Prosopis* species along numerous drainages. Erosion evident in many areas. Small rodent burrows are present, including those of *Dipodomys* species.



APPENDIX E (CONT'D): SUMMARY AND PHOTOPOINTS

Polygon C

Photopoint C-1: type location on Tres Hermanos gravelly sandy loam (soil map unit).

Photopoint C-2: type location on Gila-Anthony-Bluepoint complex (soil map unit). Senescent grass is *Schismus barbatus*.

APPENDIX E (CONT'D): SUMMARY AND PHOTOPOINTS

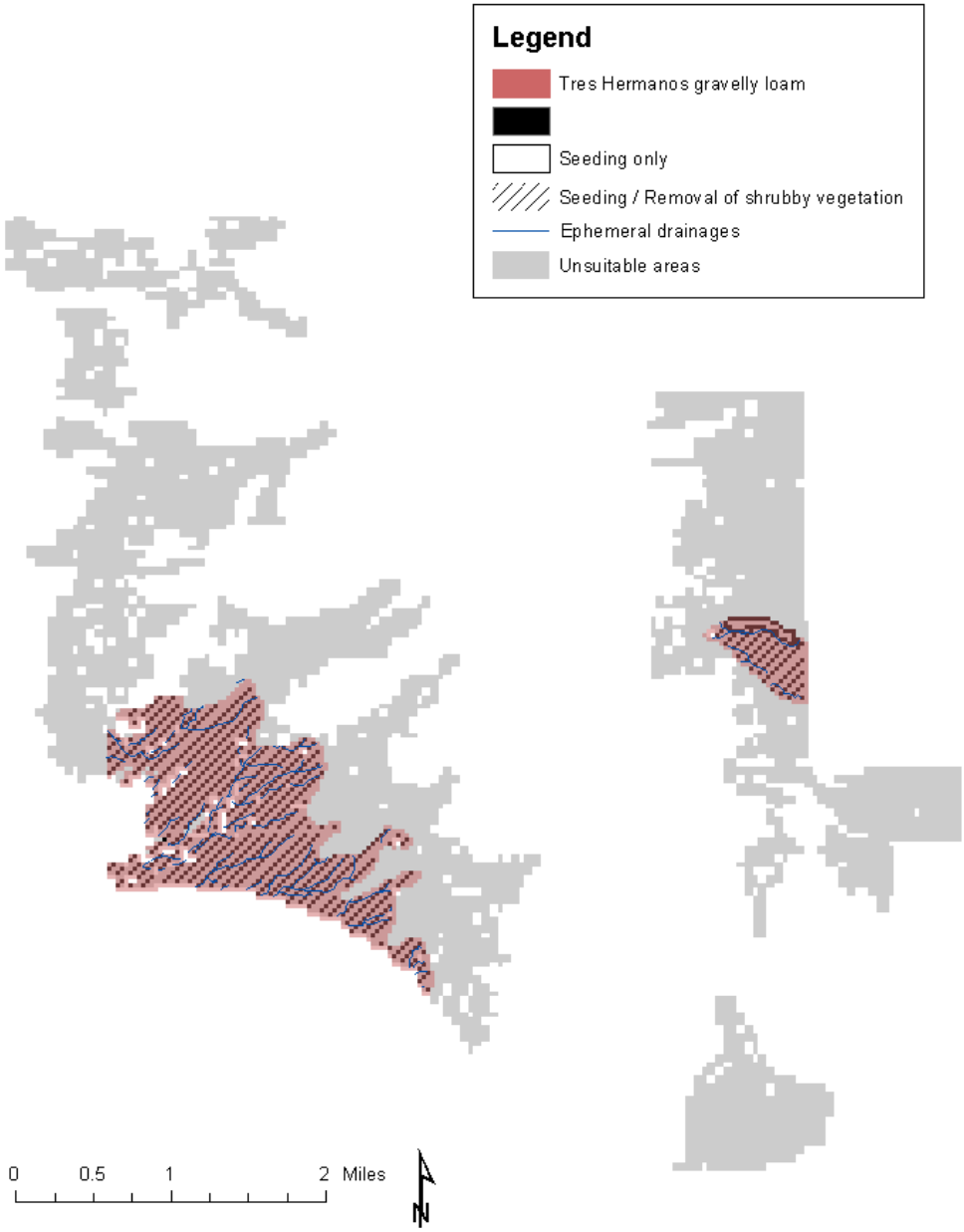
Polygon C

Photopoint C-3: type location on Gila loam (soil map unit).

Photopoint C-4: area with remnant *Hilaria mutica* area (approximately 100x200 meters) on Gila loam.

APPENDIX E (CONT'D): SUMMARY AND PHOTOPOINTS

Polygons D & F – East and West of the Whitlock Mountains. Areas characterized by rolling hills with deep cut drainages coming off of mountains. Vegetation dominated by mature *Larrea tridentata*, *Opuntia* species (>30 cm height) with some perennial native grasses in drainages. Small rodent burrows are present.

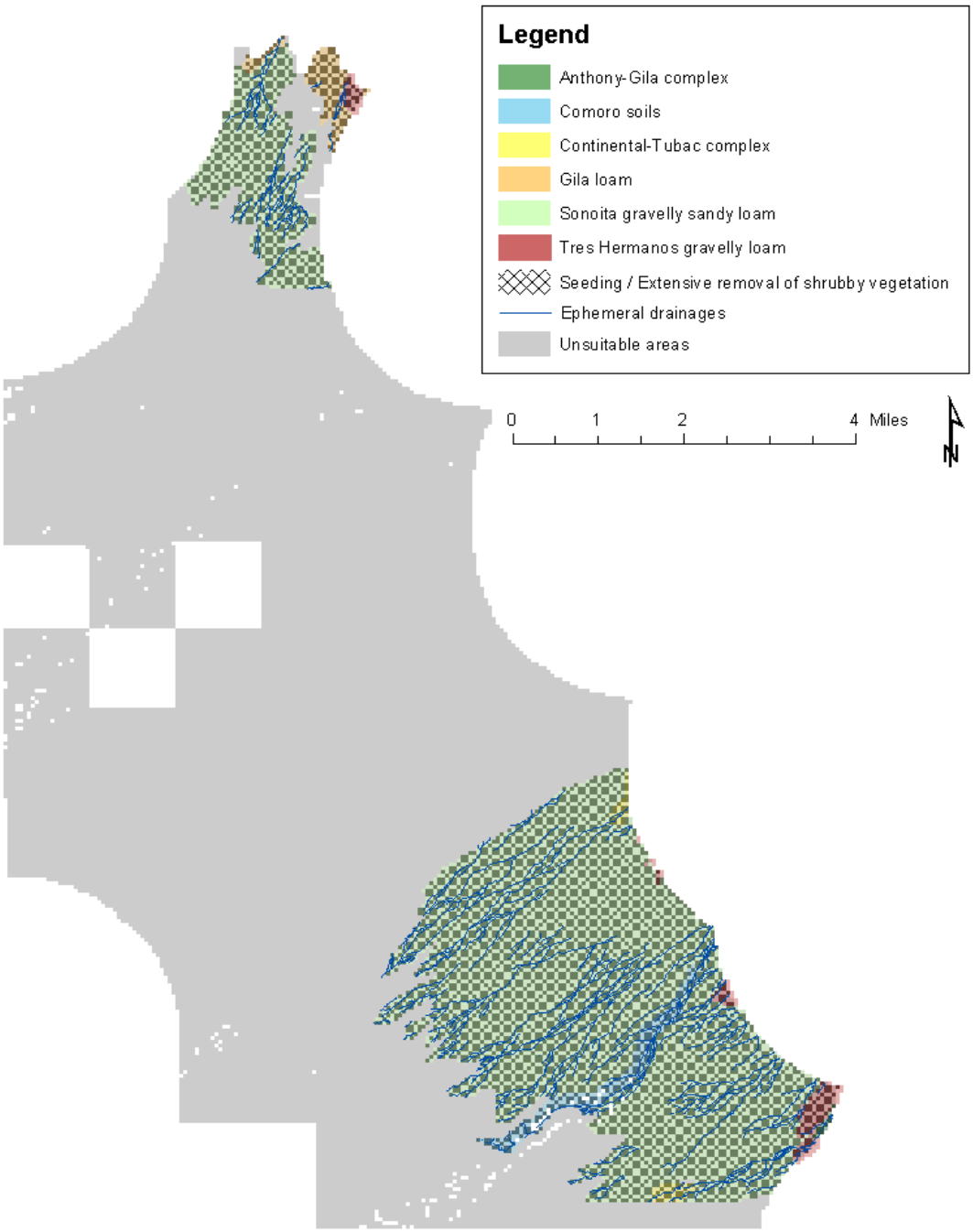


APPENDIX E (CONT'D): SUMMARY AND PHOTOPOINTS

Polygon D

Photopoint D-1: type location on Tres Hermanos gravelly loam (soil map unit).

Photopoint D-2: open area.

APPENDIX E (CONT'D): SUMMARY AND PHOTOPOINTS

Polygon E – Tanque Road Area. This area is characterized by rolling hills and has highest density of drainages of all areas. Vegetation dominated by mature *Larrea tridentata* and *Prosopis* species (>30 cm height). No native perennial grasses evident.