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UC-620

Pacific Northwest National Laboratory

Operated by Battelle for the
U.S. Department of Energy

National Training Center
Fort Irwin, California

Feral Burro Populations: Distribution and Damage Assessment

B. L. Tiller

December 1997

Prepared for the Department of Public Works,
U.S. Army, Fort Irwin, California
under a Related Services Agreement
with the U.S. Department of Energy
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Pacific Northwest National Laboratory
Richland, Washington 99352

Executive Summary

The following report was prepared by the U.S. Department of Energy's Pacific Northwest National Laboratory (PNNL) under MIPR#76DOEWA018 for use by the National Training Center, Fort Irwin, CA (NTC) to document 1) regional use of the NTC by burros, 2) influence of available water sources for burro use, 3) burro-related damage at several NTC sensitive habitat areas, and 4) management recommendations. All work described in this report was conducted in 1996 and 1997.

Roadside transects were conducted and mapped using Geographical Positioning Systems/ Geographical Information Systems (GPS/GIS) to indirectly measure relative abundance of feral burros (scat per mile) and to examine the spatial relationship of burro use to permanent or semi-permanent water sources that exist on the NTC. We also surveyed several permanent springs for burro-related damage and mapped the impact areas using GPS/GIS to quantify the extent of damage and to provide guidance on size and extent of burro exclosures in those areas. Photographs of the spring sites were also archived and permanent photo points were established for long-term monitoring of feral burro damage areas. In addition, aquatic invertebrate data collected during another spring site study were summarized and discussed in relation to burro-related impacts on the NTC's sensitive habitats. Several water-quality parameters were also obtained from each spring, including temperature, dissolved oxygen, pH, and total dissolved solids.

Roadside surveys demonstrated that spring sites profoundly influenced burro movements on the NTC, as over half of all burro signs observed during this study were found within 1 mile of known spring sites. Relative densities of burro signs on the NTC were low (less than 2 scat per mile) near Garlic Springs, Drinkwater Spring, and Bitter Springs; moderate (between 5 and 15 scat per mile) near McLean Lake, Cave Spring, and Desert King Spring; and high (greater than 15 scat per mile) at Two Springs and Leach Springs. We also observed four different herds of burros (totaling 21 individuals) near Leach Springs and one herd of 9 near McClean Lake.

Desert King Spring site assessment suggested low burro-related impacts there. The site had been used as a watering hole by burros; however, the spring consists of water trickling through an abandoned bath-tub, presumably put there from pre-military prospecting activities. Garlic Spring and Drinkwater Spring have barbed-wire fencing surrounding the spring, which effectively prevents extensive burro use there. Bitter Springs site had very little evidence of burro use, presumably due to the site's isolated location along the southern NTC border. Data collected during this study demonstrate significant impacts on xeric and/or riparian habitats at Cave Spring, Two Springs, and Leach Springs by feral burros. Cave Spring is a non-riparian rock quarry water pool; however, burro trails and loafing areas near the spring have damaged the surrounding xeric plant communities and the surface terrain at a significant cultural resource site. Leach Spring and Two Springs had extensive burro-related damage that has affected riparian habitat there. The results suggest that management measures be taken to better protect riparian-type sites from feral burro-related impacts.

Acknowledgments

We would like to thank the following individuals who were instrumental in providing technical guidance and recommendations for the work described here: Tom Campbell (China Lake Naval Air Weapons Facility); Dave Sjaastadd, Anthony Chavez, and Tom Eagan (Barstow, CA, Division of Bureau of Land Management); and Mike Stamm (Arizona Division of Bureau of Land Management). In addition, Dr. Charles L. Douglas (University of Nevada, Las Vagas) provided valuable data and insights previously gathered on feral burro populations in Death Valley National Park. Richard (Dick) Lewis provided computer access to RLA Communications base-station data for post-processing GPS data. Timothy Hanrahan, Pacific Northwest National Laboratory (PNNL) and Rhett Zufelt (Reach Consulting) provided computer graphics and GIS support. Michael Sackschewsky (PNNL) identified species and/or genera for all plant types collected for this study. Robert P. Mueller (PNNL) provided data on water quality parameters measured at these spring sites in 1996. Mickey Quillman and Carolyn Lackey (NTC Fort Irwin, Directorate of Public Works – Environmental Division) helped us gain access to the study sites and provided comments on an earlier version of this document.

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1.0 Objectives

The U.S. Army National Training Center (NTC), Fort Irwin, California, has a population of feral burros which resides both on the base and on portions of the NTC's proposed expansion area. Casual observations throughout the NTC, and particularly at several spring sites, suggest that burros may be having adverse impacts on native vegetation, water, soils, and cultural resources. If burro populations need to be controlled to preserve and maintain certain ecologically- or culturally-significant areas, the NTC must have sufficient data on the burro's demographic and regional-use characteristics to select among a variety of management options.

Prepared by the Pacific Northwest National Laboratory[a] (PNNL) for the NTC, this report assesses burro population distributions and analyzes environmental impacts caused by burros. The report also includes recommendations for management of burros to prevent further damage to some of the sensitive habitats and describes possible long-term monitoring activities for future burro management.

(a) Pacific Northwest National Laboratory is operated by Battelle for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.

2.0 Background

Domesticated Somalian and Nubian wild asses (*Equus asinus*), i.e., burros, were introduced into Mexico by Spaniards in the 1530s, and the animal populations spread northward into what is now the United States as a consequence of Spanish colonization. These hardy, desert-adapted animals provided transportation for people and equipment in this country for more than three centuries. Burros were introduced into areas that became National Parks more than 100 years ago by miners. Following the decline of mining activities, the advent of railroads, and the availability of motorized vehicles, burros were released to be become free-roaming (Woodward 1976; Clutton-Brock 1981). Since then, feral burros have maintained viable and/or increasing populations throughout much of the southwestern U.S., and in many cases, to the point at which population-control measure have been employed in an effort to conserve natural and cultural resources.

The control of feral burros was curtailed in California in 1953 when the state provided them with official protection. In 1959, Congress halted the pursuit of wild horses and burros from motorized vehicles by passing the "Wild Horses Annie Act," named after Mrs. Velma Johnston of Reno, NV, who intensively lobbied, almost single-handed, for its passage. Public Law 92-195, Wild and Free Roaming Horses and Burros, passed in 1971, provided protection for burros on federal lands administered by the Bureau of Land Management (BLM) and U.S. Forest Service.

Throughout the western United States, it became readily apparent that uncontrolled populations of wild horses and burros were detrimental to soils, native plant and animal communities, and cultural resources of the desert ecosystem. Recent literature demonstrates burros to be responsible for extensive habitat damage by overgrazing, selective species removal, trampling of plants, soil disturbance leading to erosion (Farrell 1973; Koehler 1974; Carothers et al. 1976; Fletcher and Wauer 1976; Woodward and Ohmart 1976; Norment and Douglas 1977), impact on small vertebrates (Carothers et al. 1976; Yancey and Douglas 1983; Yancey 1984), and competitive interactions with desert bighorn sheep (Seegmiller and Ohmart 1981; Dunn and Douglas 1982; Ginnett and Douglas 1982).

The need to manage these impacts and the mechanisms for doing so have been clearly established. Congress recognized the issues and established the wild horse and burro herd management areas and the parameters for management through the Wild Free Roaming Horses and Burro Act of 1971 (Public law 92-195) as amended, Section 3(b)(2). The Act requires that, if an overpopulation exists on a given area of public lands, appropriate action will be taken to remove excess animals from the range so as to achieve appropriate herd-management levels. The Public Range Improvement Act of 1976, Federal Land Policy and Management Act of 1976, and the California Desert Protection Act of 1994 (CDPA) include wild horse and burro population control measures. Also, the California Desert Conservation Area (CDCA) Resources Management Plan of 1980 identified herd-management areas (HMAs) and established appropriate management levels for wild horses and burros. In this plan, lands outside of the established HMAs are to be managed for other resources to the exclusion of horses and burros.

The Naval Weapons Center, China Lake, CA (NWC), is a military reservation encompassing 1,095,680 acres of southern California desert. The Mojave "B"/Randsburg Wash Test Range Complex lies within the Slate Mountain HMA and also lies immediately adjacent to the west border of Fort Irwin NTC. In 1980, NWC and BLM aerial count estimates of burros residing on the NWC were between 3,500 and 5,700 individuals and 700-800 feral horses. In an effort to coordinate with feral equine management efforts on federal lands administered by the BLM and National Park Service, the NWC has prepared a Final Environmental Impact Statement. The BLM and NWC have administratively managed for zero burros in the Slate Mountain HMA. Thus, burro round-ups and adoption programs have been conducted by the BLM and the NWC to continue management of a balanced ecosystem. In addition, the CDCA established the need for burro removals to occur on lands adjacent to the HMAs to control immigrating herds.

The NTC is located in the central Mojave Desert south of Death Valley and south-east of the NWC in San Bernardino County, CA. The NTC has been protected from public intrusion for over 50 years and is an important natural resource of the Mojave Desert ecosystem. The NTC lies immediately adjacent to the Slate Mountain Range's 156,000-acre HMA.

3.0 Methods

The NTC contains several water sources, some natural and others established during the pre-military mining activities (Figure 1). PNNL biologists conducted roadside surveys in the early summer of 1997 to illustrate regional use of the NTC by feral burros and documented the presence and quantity of burro-related damage at some of the springs. Water quality data and invertebrate communities were also summarized from Mueller and Blanton (1997) and related to the observed burro use at these areas.

We used scat-group density as an index for animal abundance (Neff 1968; Lancia et al. 1994) and recorded the number of burro scat-groups found along secondary roadways (Figure 2). We enumerated burro fecal piles (scat) along over 80 kilometers (km) (50 miles) of secondary roadways throughout the NTC in June 1997. Roadway surveys were mapped using GPS/GIS to indirectly measure the relative abundance of feral burros (scat per distance traveled) and examine the spatial distributions of burro use and proximity of significant water sources throughout the NTC. Secondary roads were classified as those that were not routinely bladed but were routinely used during training activities. This provided at least some consistency for visibility of burro scat along roadways where human activities may otherwise cause considerable changes in detection. One and sometimes two individuals surveyed the entire roadway for scat including the edges of roadways up to where vegetation did not look damaged by traffic. Vehicle speeds ranged between 5 and 10 miles per hour. We also set the truck trip meter to zero at the beginning and recorded number of sightings, mileage, activity types, and other special features of the area (e.g., shade tree or major burro trail crossing etc.). Scat was classified as either new (0 - 1 week), recent (1 week - 2 months), old (2 months - 1 year), or very old (greater than 1 year) for future examination of temporal changes in area-use patterns (see Appendix A).

At least 90 coordinate points were collected using the GPS at each scat observation and along all roadways, with dilution of precision no greater than 6%. All data were then post-processed (Geo-PC v. 2.2, Magellan Systems, Inc.) with base-station data from Los Angeles Communications, CA. In a few cases where scat densities were too great to be worth recording every observation, we recorded the number of scat observed per 0.4 km (0.25 mile)[a] section of road.

Since open water is scarce in the arid desert, this is often a limiting factor for ungulates. Previous studies have illustrated burros or burro groups in close proximity to significant water seeps or retention areas (Reddick 1981; Douglas and Hurst 1993). In addition, spring sites typically are rich in flora and fauna and are often near or within a culturally significant site. In this light, we focused damage assessment efforts in regions according to nearest permanent or semi-permanent spring site. One exception, however, was McLean Lake, where large missile craters near the south-central end of the otherwise dry lake-bed collected and retained

(a) All transect measurements include mile conversions for practical convenience when collecting additional data from vehicle trip meters.

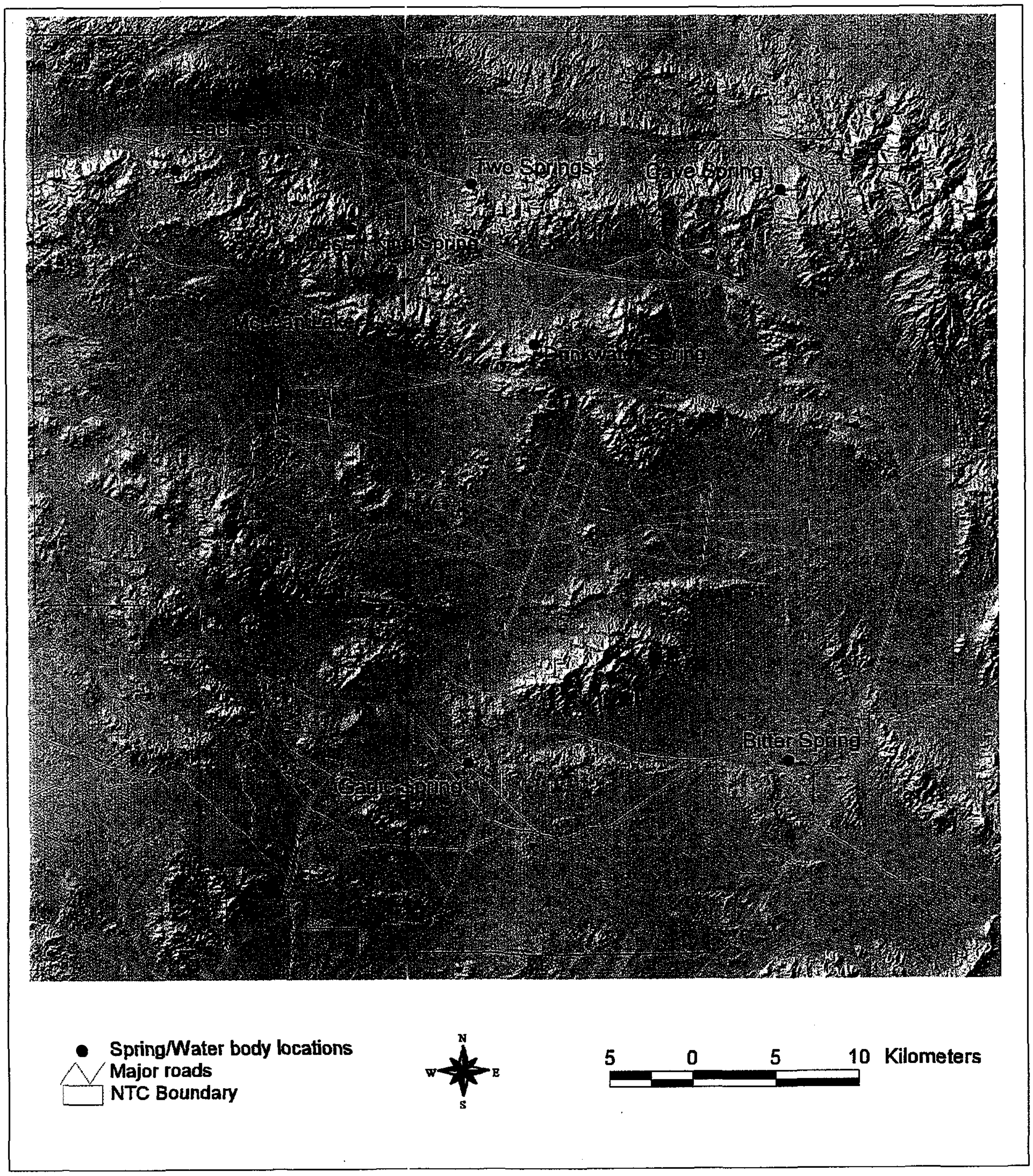

Figure 1. Fort Irwin National Training Center and Locations of Permanent or Semi-Permanent Spring Sites

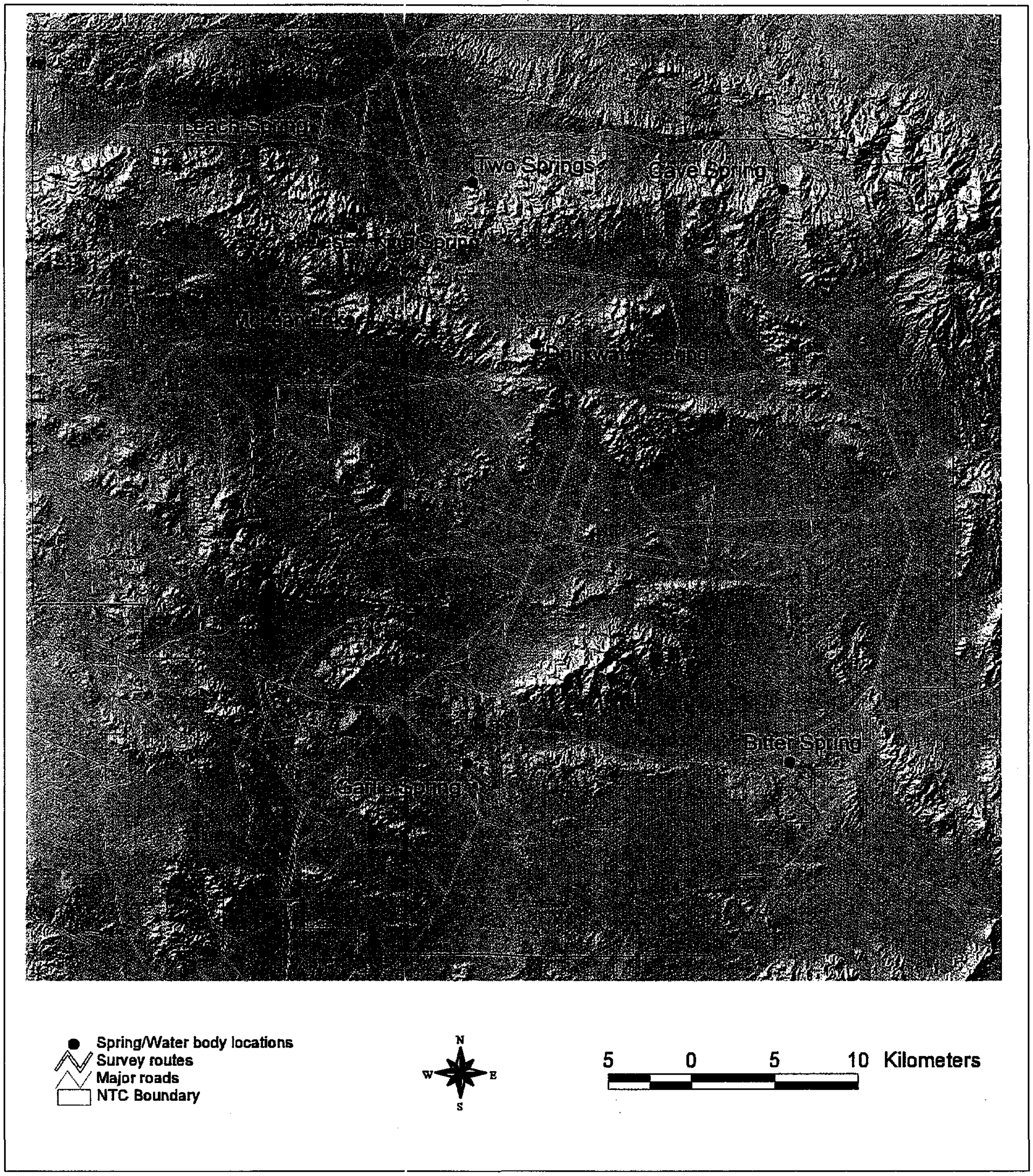

Figure 2. Fort Irwin National Training Center Burro Study Regions - Garlic Spring Road Survey Distance was 9.3 km (5.8 mi), Bitter Spring = 6.0 km (3.7 mi), Drinkwater Spring = 21.5 km (13.4 mi), McLean Lake = 15.8 km (9.8 mi), Cave Spring = 3.7 km (2.3 mi), Desert King Spring = 16.4 km (10.2 mi), Two Springs = 8.7 km (5.4 mi), and Leach Spring = 15.4 km (9.6 mi)

open water pools, sometimes for weeks after a rainfall. The sewage lagoons immediately adjacent to the Fort Irwin base proper (cantonment) were omitted from this study because burros have not been reported in or near the cantonment.

We also surveyed several permanent springs for burro-related damage and mapped the areas using GPS/GIS (as described above) to quantify the extent of damage and provide estimates of the size and extent of burro exclosures for those areas. The GIS data layers and spatial analyses were completed using ARC/INFO (ESRI, Redlands, CA). This software was used to illustrate area damage categories and to analyze road-side survey results.

Photographs of burro-related damage areas were digitized and archived, and permanent photo points were established at selected spring sites for long-term monitoring of the feral burro damage areas. In addition, aquatic invertebrate data collected during another spring site study (Mueller and Blanton 1997) was summarized according to intensity of burro-related impacts. Several water quality parameters were obtained from each spring.

Physical and chemical measurements were taken in the field at each sampling site to characterize the springs. Temperature and dissolved oxygen (DO) were measured with a Yellow Springs Model Y58 dissolved oxygen/temperature recorder, and pH and total dissolved solids (TDS) were measured with hand-held analytical probes. Measurements were taken in flowing sections exposed to sunlight.

Contacts were made with representatives of California Fish and Game Department (CF&G), the BLM, university ecologists, the National Park Service, and other military land managers to determine what is known regarding feral burro populations in areas surrounding the NTC.

4.0 Results

Results are drawn below for distributions of burros, based on scat counts, the impacts of burros on spring sites, and water quality at the springs.

4.1 Burro Distributions Relative to Water Sources

The February 1997 reconnaissance observations suggested that burros frequently used the secondary roadways during their night-time movements on the NTC. We used scat-group density as an index for animal abundance (Neff 1968; Lancia et al. 1994) and recorded the number of burro scat-groups found along secondary roadways in the survey regions (see Figure 2). Survey regions were identified according to the nearest water source. Over 80 km (50 miles) of secondary roadways were surveyed on the NTC and included over 550 burro scat observations (see Appendix A).

Figure 3 summarizes this data by region and reports the results as the number of burro scat-groups observed per unit distance (km). Leach Spring, Two Springs, and Desert King Spring regions all contained relatively high densities of burro scat (8 - 15 scat/km). Very little evidence of burro use was detected at Bitter Springs or Drinkwater Springs, and no evidence was found at Garlic Springs.

Over half of all scat recordings were within 1 kilometer (0.62 mile) from the water sources (see Figure 4). This illustrated the important role that spring sites play in the distribution of burros or burro groups on the NTC.

Sightings of scat more than 4 km from any spring site is in part explained by the presence of moderate burro activity found around McLean Lake (see Figure 3). No permanent or semi-permanent springs exist in this area. Therefore, the nearest distance calculations of scat from this area referred to either Desert King Spring or Leach Spring. McLean Lake does, however, contain large missile craters near the south-central end of the otherwise dry lake-bed. These craters collected and retained rainwater and run-off, sometimes for weeks after a rainfall. The presence of new, recent, old, and very old scat (Appendix A) suggested burros are year-round residents of the McLean Lake region.

Garlic Spring is located just east of the cantonment (Figure 2). We did not observe burro activity during reconnaissance or roadway surveys there. A perimeter fence with three lines of barbed wire had been placed around the spring site and surrounding area (approx. 50 m x 50 m).

Bitter Springs is also a relatively low burro-use area (see Figure 3). The spring is an isolated water source on the eastern boundary of the NTC. The spring site itself is a semi-permanent water source but almost 1 kilometer of the sandy soiled wash area is covered with mesquite (*Prosopis juliflora),* salt cedar (*Tamarix pentandra*) and other emergent vegetation. No evidence of riparian-type habitat damage was visible at this bitter springs, neither in the spring nor the fall of 1997. Mueller and Blanton (1997) reported that one small water pool there in 1996 had been dug out by burros.

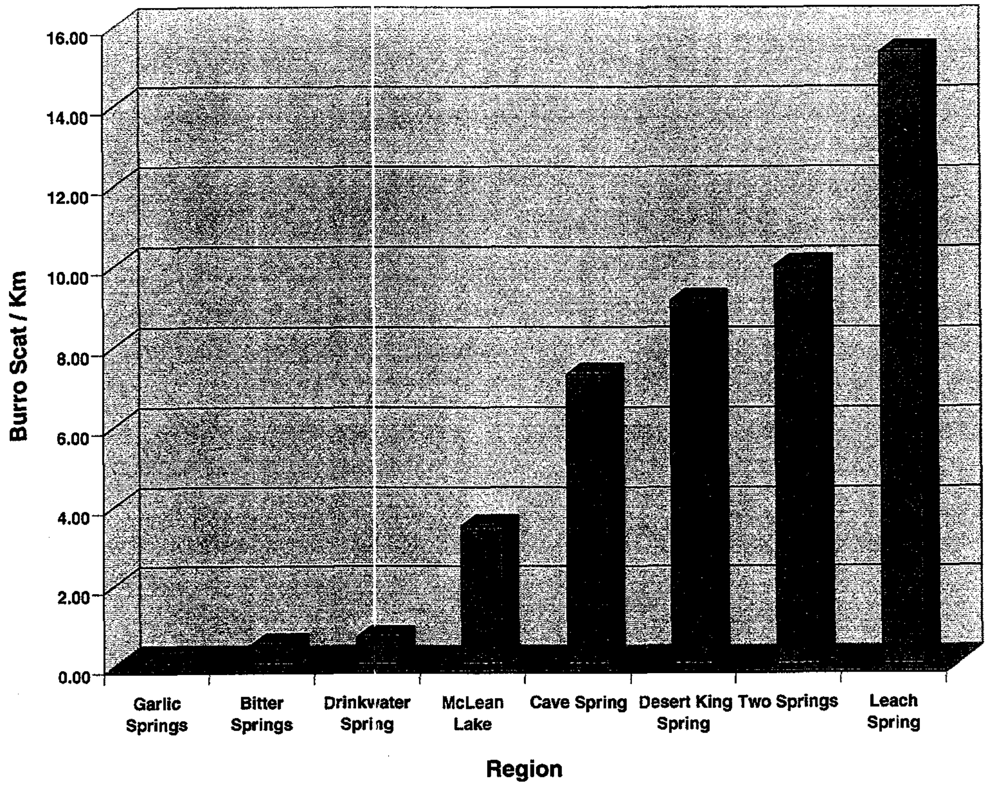

Figure 3. Relative Abundance Estimates of Burro Scat on the NTC

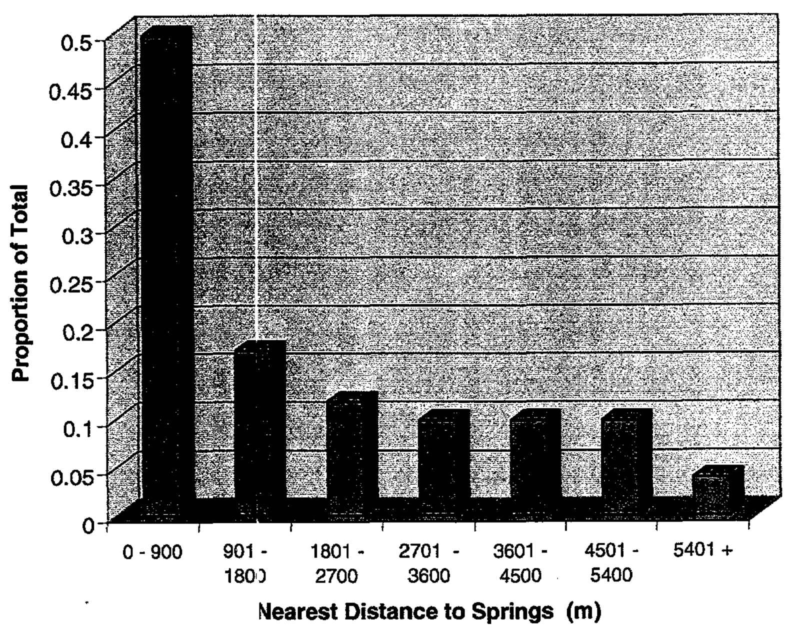

Figure 4. Location of Burro Scat Relative to Nearest Distance to Spring

Drinkwater Spring site is located in the north-central region of the NTC and is relatively close to much of the high-use burro areas (Figure 2). The semi-permanent spring site is within a xeric gully and consists of dense and vigorous stands of *Atriplex sp.* (the ocular estimate of average mean shrub height was 1 m). Two large creosote (*Larrea tridentata*) shrubs (approximately 2 m tall) and one large (1 m) bunch grass grow near the center of this area. The site has been fenced off with concertina wire (30 m x 30 m). Although one section of the wire allows foot traffic into the densely vegetated areas, the burros do not appear to be using the area at all. Some burro use was noticeable outside the fencing (Figure 3).

4.2 Site-Specific Impacts

This section documents site-specific damages caused by burros at the moderate and high-use spring sites. The McLean Lake region was not included as a damage-assessment site because it was not considered a sensitive habitat.

4.2.1 Cave Spring

Cave Spring (Figure 5) is a small pool which originates from a cavern at the base of a canyon near the northeastern portion of the NTC and is a remnant of mining activities prior to the 1930s. The wetted portion of the spring was 1.5 m wide and 8 m long with maximum water depth 1.3 m. The substratum consists of bedrock and gravel with organic matter. Water trickles from the cave into a grass/shrub vegetation area of about 3 m^2, then evaporates and/or disappears into the ground. The vegetation consists of vigorous *Atriplex sp.* shrubs with an understory of mixed annual grasses.

Burros frequently visit this spring site. The open water available to burros is a small (2 m x 1 m) pool, which extends into the granitic cavern. The size and configuration of the spring itself limits the available area for riparian plant and animal communities. Much of the surrounding area moistened by spring water was trampled down by burros.

Large stands of *Atriplex sp.* and desert Baccharis (*Baccharis sergiloides*) were present at the base of the spring seepage area. The burros did not appear to be browsing on these lower adjacent shrubs, but the burro trails leading into the water hole have left the ground devoid of plant life. Also, a 10 m x 10 m area immediately south of the spring has been used as a loafing area and is devoid of live vegetation (approximately 25% aerial ground cover of dead *Atriplex*) (Figure 6). It is likely the flora is dead here because one large live poplar tree (*Populus sp.*, approximately 4 m tall) provides shade next to the spring. Burros using this area have many other shade or loafing sites available because of the sheer cliffs and rocky bluffs in the canyon but seem to prefer the shade immediately adjacent to the spring source.

Cave Spring and the surrounding area is a culturally significant site (see Figure 7). Following mining abandonment by propectors, the area was used as a stop-over for travelers heading to or from Death Valley in the early 1900s. Disturbance of surface terrain on and around the cave entrances appears to have been caused primarily by burro loafing and bedding activities around the site.

Figure 5. Available Water at Cave Spring - Showing no emergent vegetation in burro trailways.

Figure 6. Cave Spring (left side) - Illustrating severe soil and vegetation damage from burro trampling and loafing. Photo also includes the shade tree (right side).

Figure 7. Cave Springs Cultural Site - Shade tree in Figure 6 is located at left edge of this photo. Shrubs (bottom of photo) were damaged by burro-related activities.

4.2.2 Leach Spring

Leach Spring originates from a man-made mine shaft near a rock outcrop formation in the northwest portion of the NTC (see Figure 2). The water pools were 15-25 cm in depth, and the water was clear but visibly turbid near the lower region watering hole, which is visited by burros. The substratum was mainly sand and cobble with mud in places. The stream bed width averaged about 60 cm.

This is also the closest water source to NWC. Burros have free access to the upper-most region of the Leach Spring. The spring travels from this upper region to several small pools within a rock-surrounded cavern along the mid-region of the spring. The mid-region of this spring acts as a natural exclosure to burro use and provides a reference riparian community in the absence of burro use (Figure 8). Vegetation within the undisturbed region was greater than 100% ground cover and was composed primarily of desert baccharis (75%), *Juncus sp.* (10%), mixed bunch-grasses (10%) and other species (5%) (see Appendix B). The lower regions of

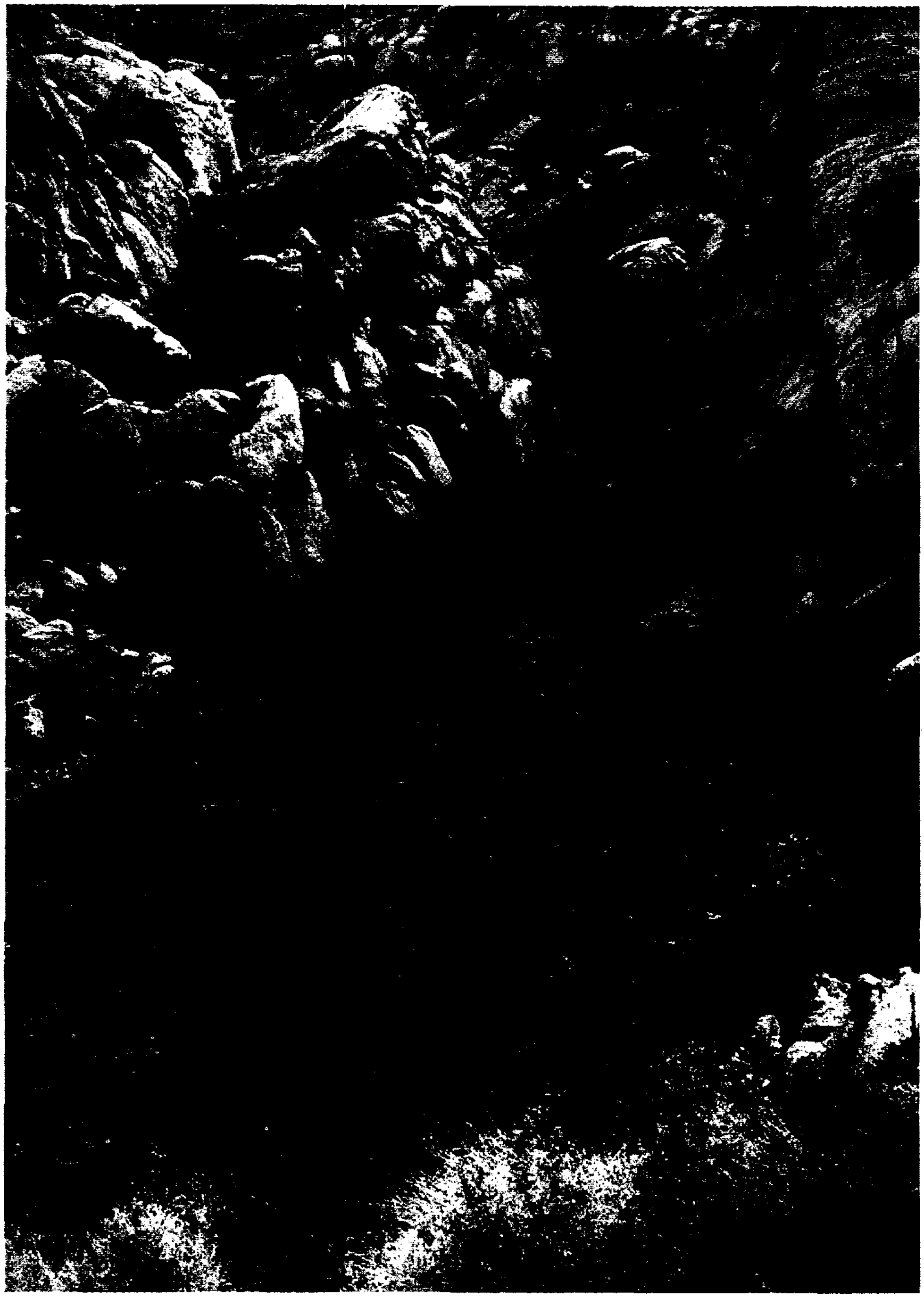

Figure 8. Leach Springs, Mid-Stream Region - Steep rocky terrain excludes burro use.

Leach Spring provided no natural protection from burro intrusion, evident from the numerous burro tracks, scat, and extensive loss of vegetation (see Figures 9 and 10). One colony of rushes *(Juncus spp.)* found in lower region had been recently browsed by burros and were all 10 cm or less in height, as compared to *Juncus* plant heights ranging from 30 to 100 cm in the undisturbed region of the spring.

We also found two large (greater than 5 meters tall) willow trees (*Salix sp*) in the lower impact region of Leach Springs. Both had been commonly used as shade trees by burros. The sheer trampling and bedding by burros at one tree has resulted in 100% bare ground there (see Figure 11). Bare ground cover under the second tree was 50% as some large fallen logs prevent burros from loafing there. We also estimated between 95% and 100% bare ground for the upper regions of Leach Spring, where burros use was high.

Leach Spring also had considerable impact by early prospecting activities. A pipe had been installed, beginning at the source of the spring and ending down near the willow trees. A large tub was also present near the *Juncus* patch, further reducing the available area with wetted soil for emergent vegetation. Water does not flow through the pipe.

We calculated aerial coverage of Leach Spring using GPS data (±1 m) and Arc/Info. All riparian vegetation was mapped according the intensity of burro use (Appendix C). The following table illustrates extent of aerial damage from burros at Leach Spring:

No Impact = Undisturbed, 0% bare ground	Moderate Impact = 50% - 90% bare ground	High Impact = 91% - 100% bare ground
272 m^2	566 m^2	236 m^2

Over 1,000 square meters of riparian vegetation was identified at Leach Springs. Undisturbed areas include only the mid-region of the spring site, where steep and rocky terrain essentially excluded burros from using that region. The second category refers to riparian regions where bare ground exposure was dominant (50% - 90%) but vegetation was present and vigorous there. High-impact areas were defined as those areas where bare ground was greater than 90% aerial cover and living vegetation was essentially absent.

4.2.3 Two Springs

Two Springs (Figure 12) is located near the north-central boundary of the NTC (see Figure 2) and consists of three small pools about 30 cm in depth, with riparian vegetation throughout the area. The immediate xeric plant community around Two Springs had also been used extensively by burros (see road transect data). GPS mapping of the water-influence area included over 670 m^2 of riparian vegetation primarily comprised of sedge (*Carex sp.*) and *Ranunculus sp.* Bunchgrasses (*Polypogon spp.)* and *Artemisia leudoviciana* were also sub-dominant in the riparian plant community. The soils were a mix of gravel/sand and sand/silt. Burros had recently been browsing and trampling near the center of the spring seep (*Carex sp.*, 10-cm height versus an unbrowsed height of 30 cm). Aerial extent of the intensively browsed section was 38 m^2 (Appendix C).

Figure 9. Leach Springs Lower Region - Extensive burro-related damage at the watering area.

The *Atriplex sp.* (saltbush) dominated community adjacent to the Two Springs has been influenced by shallow ground-water and impacted by burros (see Appendix C). We mapped over 8,900 m^2 dominated by saltbush and creosote shrubs that exhibited plant vigor resulting from the regional water source. Burro trails, loafing, and bedding activities in the nearby saltbush-dominated community were also very apparent.

This site also appeared to be within a burro pathway which ran north toward Death Valley or directly west toward China Lake NWC. It appeared that burros frequently travel between Two Springs and Leach Spring.

4.3 Water Quality

Table 1 presents the physical and chemical data for several springs identified in this study (data from Mueller and Blanton 1997). None of the water quality parameters indicated any relationship to burro use intensity. Water temperature varied and was related to the time of day samples were collected. Dissolved oxygen (DO) was quite variable and ranged from a low of

Figure 10. Leach Springs - Illustrates saltbush (*Atriplex sp.*) community adjacent to spring site, where burro trampling and loafing have caused extensive damage to the xeric plant communities.

Figure 11. Leach Springs Shade Areas Under Willow Trees Used by Feral Burros - Note extensive damage to vegetation and soil stability (*Juncus sp.* patch in background).

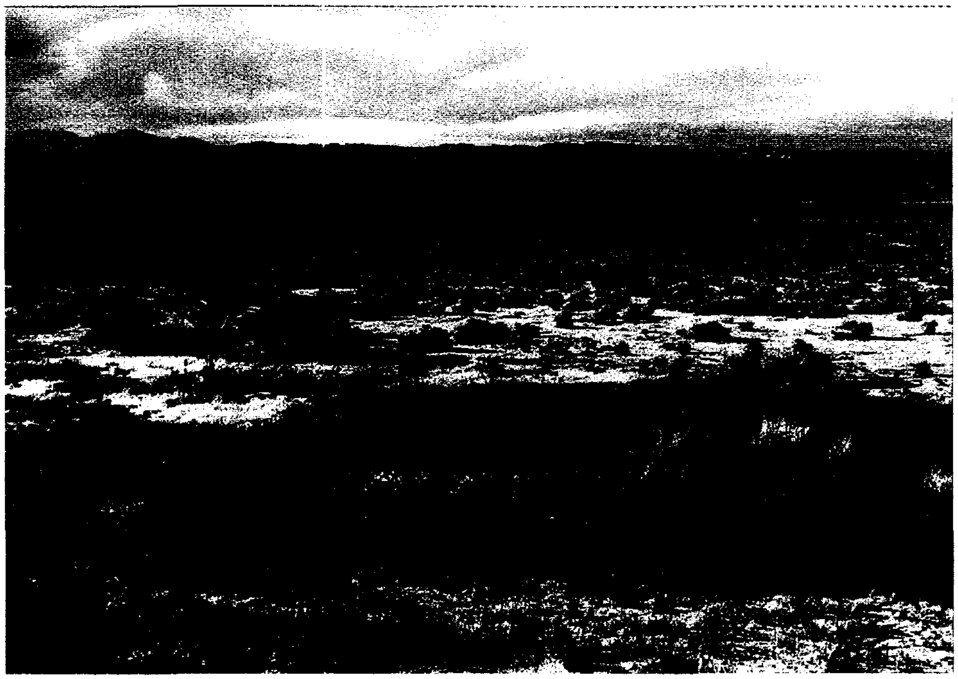

Figure 12. Two Springs

4 mg/l at Garlic Spring to a high of 15.2 at Cave Spring. Total dissolved solids (TDS) ranged from 171 mg/l at Leach Spring to 1280 mg/l at Bitter Spring during the spring of 1996. The high value at Bitter Spring was probably due to the sample being taken at a small isolated pool. Both TDS and pH were similar in range to water-quality parameters observed at springs sampled during 1995 in the Avawatz Mountain range just east of the NTC (Cushing and Mueller 1996).

Table 1. Physical and Chemical Measurements of Springs on the NTC, April 1996 (water data summarized from Mueller and Blanton 1997)

Water Source	Burro Use Index	Temp (ºC)	D.O. (mg/l)	TDS (mg/l)	pH	Number Invertebrate Families
Garlic Spr.	None	21.1	4	352	7.91	16
Bitter Spr.	Low	17.2	8.8	1280	8.33	10
Cave Spr.	Moderate	12	15.2	299	8.65	16
Two Spr.	High	16.2	4.5	399	7.7	6
Leach Spr.	High	10.6	11.4	171	7.32	17

This table also presents an index of relative richness of benthic invertebrates based on two comprehensive surveys at each spring during 1996 and a less comprehensive survey at Garlic and Bitter Springs in the spring of 1997. The diversity ranged from 6 to 17 families, with no apparent relationship to amount of burro use of the springs. Leach and Cave Springs had the most diversity of Coleoptera with six genera, followed by Two Springs with three genera. Mueller and Blanton (1997) also identified two new genera of Carabidae new to California, collected from Leach Spring during March 1996. Cave and Leach Springs were also the only locations where genera of Gerridae were found. Also, a single specimen of Salididae was collected from a light trap at Leach Spring.

Seed shrimps (Ostracods) were identified at Leach and Bitter Springs during 1996. Researchers found literally thousands occurring in the disturbed areas degraded by frequent burro activity at the lower region of Leach Spring and in small isolated pools at Bitter Spring.

No threatened, endangered, or state sensitive species listed by the California Fish and Game Department were identified at any of the sampling sites. Mueller and Blanton (1997) also compared the identified genera with the California Insect Survey listing of California's endangered insects and found at least two families proposed for listing, one Diptera (Ephydridae) and one Coleoptera (Curculionidae), which were not identified to species.

5.0 Discussion

Spring sites in the Mojave Desert ecosystem support more flora and fauna than any other community type known there (Krzysik 1984; Jakle 1985; Brandt et al. 1995). Roadside surveys demonstrated that spring sites profoundly influenced burro use of the NTC. Relative densities of burro sign on the NTC were low (less than 2 scat per mile) in the southern regions of the NTC near Garlic Spring, Bitter Spring and Drinkwater Spring; moderate (between 5 and 15 scat per mile) near McLean Lake, Cave Spring, Desert King Spring; and high (greater than 15 scat per mile) at Two Springs and Leach Spring.

Desert King Spring site assessment suggested low burro-related impacts there. The site had been used as a watering hole by burros; however, the spring existed as a water trickle that ran through an abandoned bath-tub, presumably put there from pre-military prospecting activities. Garlic Spring and Drinkwater Spring had barbed-wire fencing surrounding the spring that effectively prevented extensive burro use there. Garlic Spring lies within 3 km of the cantonment, which may partly explain the lack of burro use in the surrounding areas. The Bitter Springs site had very little evidence of burro use, presumably due to the site's isolated location along the southern NTC border. McLean Lake area has no spring site nor does it contain any relatively diverse and sensitive habitats (aside from the playa), but burros seem to use this valley on a regular basis. Large depressions created from military artillery have allowed water to collect there, providing temporary watering holes for burros. The McLean Lake region may also act as a corridor or stop-over for burros travelling between Leach Lake, Desert King Spring, and Two Springs.

Data collected during this study demonstrate significant impacts on xeric and/or riparian habitats at Cave Spring, Two Springs, and Leach Spring by feral burros. Cave spring is a non-riparian rock quarry water pool; however, burro trails and loafing areas near the spring site have caused moralities to the surrounding xeric plant communities and, as a result, have impacted surface terrain at a significant cultural resource site. Leach Spring and Two Springs had extensive burro-related damage that has affected riparian and adjacent xeric habitat there.

Aquatic resource surveys at water sources on the NTC in 1996 indicated that Cave Spring, Leach Spring, and Garlic Spring contained the most diverse macroinvertebrate communities throughout the NTC. Physical water measurements taken at selected spring sites did not depict any relationship to the frequency of burro use there. Mueller and Blanton (1997) found different macroinvertebrate compositions on the NTC when the water source was a pool versus faster-flowing reaches. Macroinvertebrate compositions could have been influenced by burro activities, causing change in the water flow patterns; however, no relationship to burro activity was observed.

Evidence (scat pellet-groups or tracks) of spring site usage by bighorn sheep (*Ovis canadensis*) was not observed at any spring site on the NTC. Brandt et al. (1995) found evidence of bighorn sheep at several springs in the Avawatz mountain range (proposed expansion area along eastern border).

6.0 Management Recommendations

The need to manage burro-related impacts to the environment and the mechanisms for doing so have been clearly established. Congress recognized the issues and established the wild horse and burro herd management areas and the parameters for management through the Wild Free Roaming Horses and Burro Act of 1971 (Public Law 92-195 as amended). Section 3(b)(2) requires that if an overpopulation exists on a given area of public lands, action is necessary to remove excess animals from the range so as to achieve appropriate herd management levels. The Public Range Improvement Act of 1976, the Federal Land Policy and Management Act of 1976, and the California Desert Protection Act of 1994 (CDPA) include wild horse and burro population control measures. Also, the California Desert Conservation Area (CDCA) Resources Management Plan of 1980 identified herd management areas (HMAs) and established appropriate management levels for wild horses and burros. In this plan, lands outside of the established HMAs are to be managed for other resources to the exclusion of horses and burros.

6.1 Phase I: Burro Removals, Spring Site Exclosures, and Alternate Waterholes

Direct reduction of burro numbers that reside near heavily impacted areas on the Fort Irwin NTC is needed to mitigate burro-related impacts at the spring sites studied in this report. Burro removal activities should focus on areas near Leach Spring, Two Spring, Cave Spring, and McLean Lake. These sites, which were heavily used by burros during this study, contain some of the most diverse aquatic macroinvertebrate communities found on the NTC and support the fact that they should be preserved as such. The relatively close proximity of Two Springs and Leach Spring to each other also substantiates the need to reduce burro access to both sites so as not to displace burro use from one spring to the other. Cave Spring also demonstrated high burro use there, but mitigation here is pivotal to the maintenance of a culturally significant site rather than to riparian habitat

The NWC's Final Environmental Impact Statement (FEIS) and Environmental Assessment for horse and burro population management on and adjacent to the base provides the framework for the determination of a Full-Force Effect and Finding of No Significant Impact by the BLM for removal of burros in the Slate Mountain HMA and adjacent areas in 1998. The NWC's FEIS identifies round-ups and water traps as routinely used techniques to effectively remove burros from these areas. Collaborative efforts with BLM and NWC are desired since the CDCA recommends lands outside the established HMAs also be managed for excessive burro populations (Slate Mountain HMA manages for zero burros).

Physical barriers should be placed around the aquatic resources that have been damaged by burros. These sites include Leach Spring, Two Springs, and Cave Spring. Desert King Spring exhibited moderate burro use of the area but the man-made disturbances at this small (1 m x 1 m) spring site have eliminated any significant natural features that may have existed there (except the presence of water). Spring site enhancement work at Desert King Spring should first be done to mitigate damage caused by human activities. Afterwards, a small-scale burro exclosure could be easily assembled there.

Spring site exclosures should coincide with burro-removal activities to prevent additional immigrating herds from establishing a regional use pattern (or water resource dependency) there. Exclosures should be of a design that prevents only burros from accessing the spring sites. It is possible that longer stretches of open water will develop by protecting the upper regions of the selected spring sites. In these cases, it may be possible to allow burros access to the lower regions without causing significant detrimental impacts to the spring site.

Alternate watering holes (passive water trough system) also need to provided to burros at three of these mitigation sites to ensure animals not captured during the direct removal efforts are not displaced to other spring sites currently not occupied by, or protected from, feral burros (a few sites on the NTC but primarily those in the Avawatz Mts.). Bighorn sheep are currently the only large herbivores utilizing spring sites in the Avawatz Mountains (Brandt et al. 1995). Watering troughs should be placed at Leach Spring, Two Spring, and possibly Cave Springs pending hydro-geological logistics there.

6.2 Phase II: Monitoring Burro Abundance, Distributions, and Spring Site Recoveries

The lack of intensive burro use at Garlic Spring, Drinkwater Spring, and Bitter Springs suggests little or no need for burro reduction/exclosure efforts there. However, annual or bi-annual road surveys should be conducted to continue monitoring regional use patterns by burros since population control measures will affect available water sources on the NTC. Burros not captured and removed directly during round-ups or trapping efforts may simply be displaced to other springs or water sources on the NTC.

Spring sites protected by burro exclosures in 1998 should be subsequently visited (monthly) to ensure continued integrity of the barriers. Plant composition, percent bare ground, and benthic invertebrates should be routinely (at least every other year) measured and site photographs taken and archived to document changes in the aquatic resources and riparian and/or adjacent xeric plant communities.

7.0 References

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Appendix A

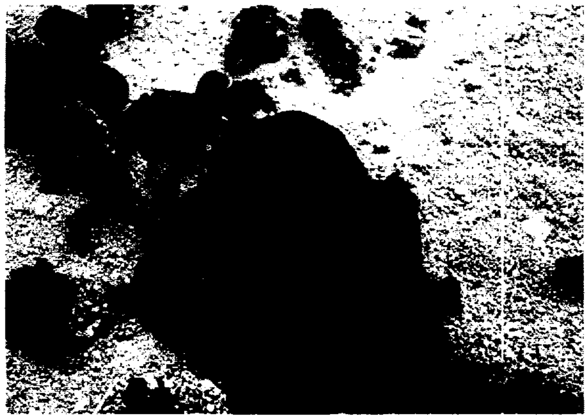
Burro Density Summary Data and Scat Classifications

Appendix A

Burro Density Summary Data and Scat Classifications

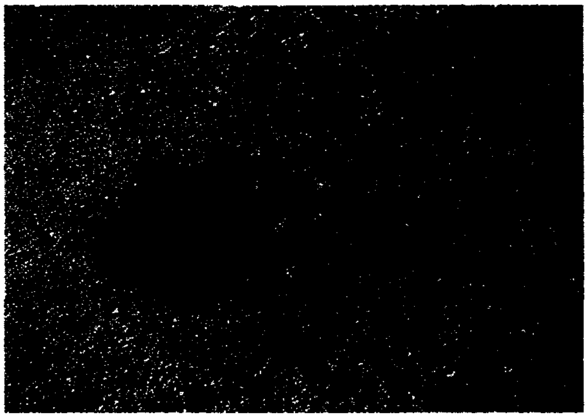
Nearest Spring	Scat Classifications: New	Recent	Old	Very Old	Scat total	Total miles	Total km	Scat/Km	Scat/Mile
Garlic Spring	0	0	0	0	0	5.8	9.3	0.00	0.00
Bitter Spring	0	1	2	0	3	3.7	6.0	0.50	0.81
Drinkwater Spring	0	3	1	11	15	13.4	21.6	0.70	1.12
McLean Lake	9	17	26	3	55	9.8	15.8	3.49	5.61
Cave Spring	5	8	11	3	27	2.3	3.7	7.29	11.74
Desert King Spring	19	48	58	25	150	10.2	16.4	9.13	14.71
Two Springs	2	42	38	5	87	5.4	8.7	10.01	16.11
Leach Spring	25	81	103	28	237	9.6	15.5	15.33	24.69
Totals	60	200	239	75	574	60.2	96.9		

Scat Classification "NEW":
Very dark, moisture still present.

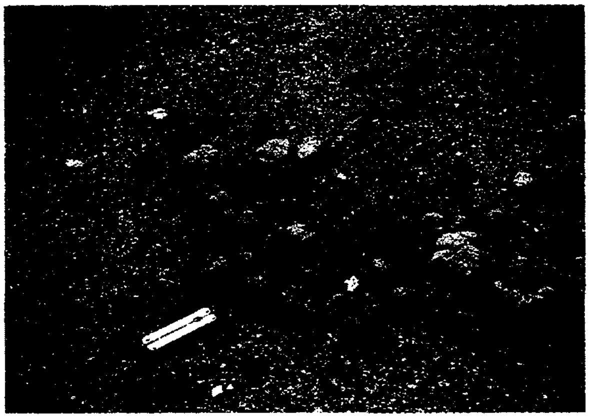


Scat Classification "RECENT":
Scat still dark in color but moisture is absent.

Scat Classification "OLD":
Scat is dry and slightly faded.



Scat Classification "VERY OLD":
Scat is very faded and not necessarily in-tact.



Appendix B

Plant Composition at Leach Spring and Two Springs

Appendix B

Plant Composition at Leach Spring and Two Springs

I) Plant Composition of Leach Springs Undisturbed Riparian Region (less than 5% bare ground)

75% *Baccharis sergiloides*
10% *Juncus sp.*
10% Rye Grass (*Elymus sp.)*
5% others:
Grasses - *Polypogon monspeliensis*

Forbs - *Brickellia sp.*
Datura sp.
Emmenanthe penduliflora
Solanum sp.
Shrubs - *Encelia farinosa*
Artemisia ludoviciana
Hymenoclea salsola

II) Plant Composition of Two Springs Riparian Region (less than 5% bare ground but heavily browsed)

80% *Carex sp.*
10% *Ranunculus sp.*
5% *Polypogon sp.*
5% *Artemisia ludoviciana*

Appendix C

GIS Figures for Leach Spring

Appendix C

GIS Figures for Leach Spring

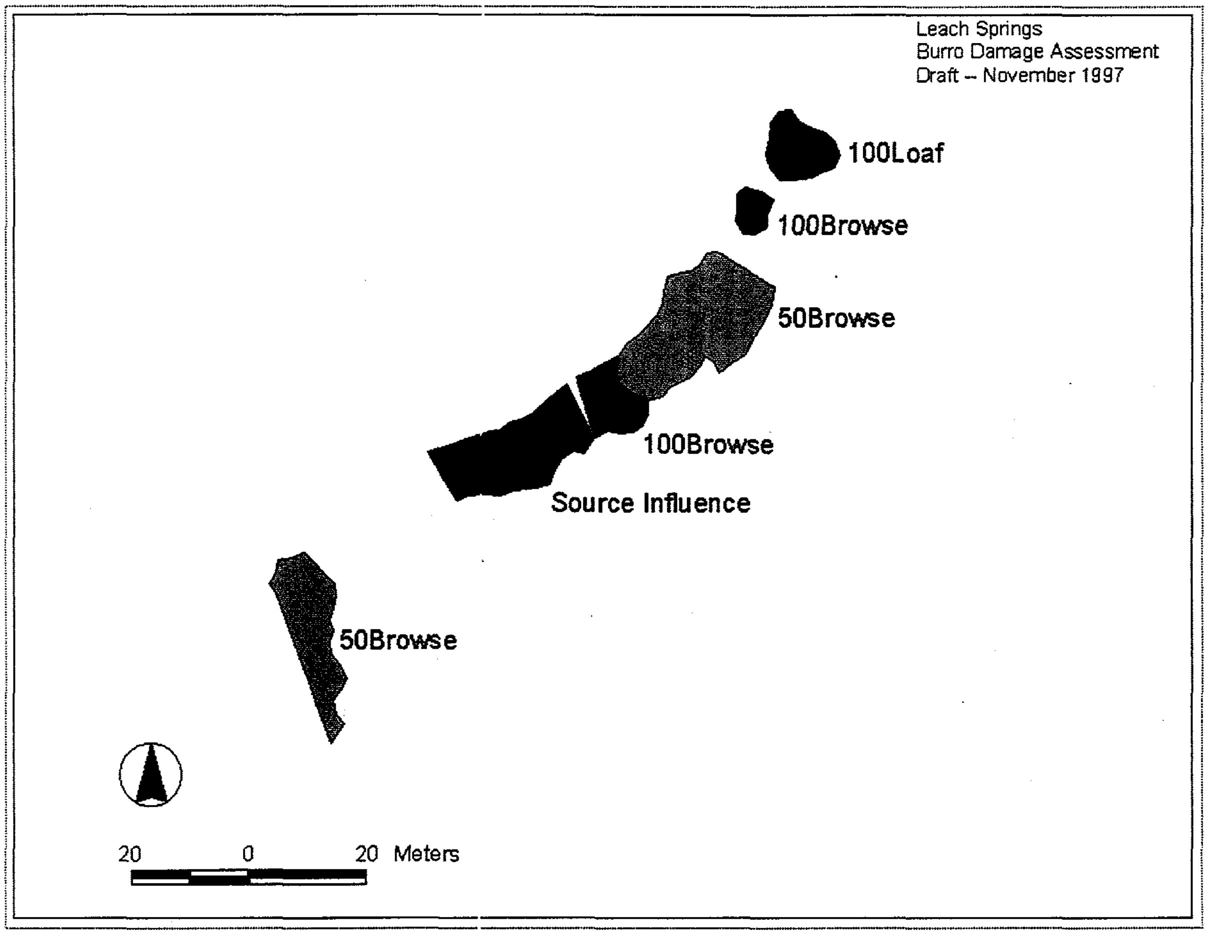


Figure C.1. GIS Map Layer of Leach Spring - Lower left, light red "50 Browse" is upper-region of spring site where burros have browsed on over 50% of all vegetation. Green-colored "Source Influence" section is area where steep rocky cliffs prevent burros from entering. "100 Browse" are areas where burro use has eliminated virtually all living vegetation. "100 Loaf" is the lower region of the spring site where willow trees provide shade for burros. Virtually all living vegetation in this area has eliminated. The map does not include damage to xeric community from trails, etc.

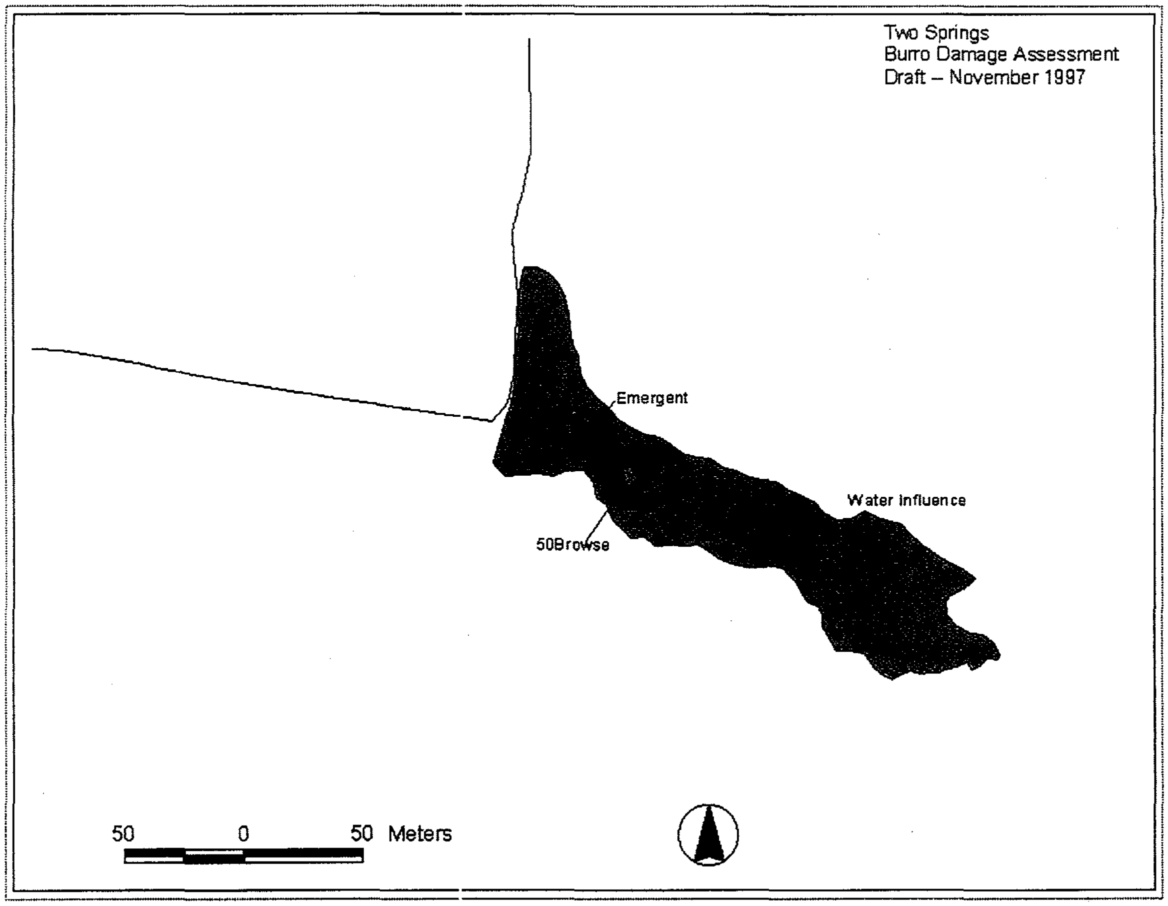


Figure C.2. GIS Map Layer for Two Springs in June 1997 - Light blue color "Emergent" comprised primarily of *Carex sp.* and *Ranunculus sp.* and illustrates aerial extent of riparian-type plants. "50 Browse" is area where burros have browsed upon over 50% of the plants there. *Carex sp.* was 10 cm tall as compared to 30 cm tall in remainder of "Emergent." "Water Influence" was all areas where the xeric community was more vigorous because of the water source.