THE HUALAPAI MEXICAN VOLE IN NORTHWESTERN ARIZONA: 1990-1995 FIELD INVESTIGATIONS

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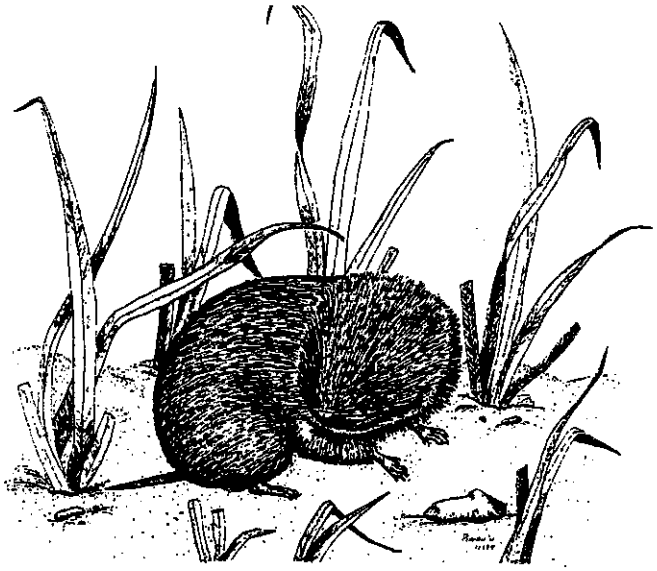

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INTRODUCTION

After an intensive field survey by Spicer et al. (1985), the Hualapai Mexican vole (*Microtus mexicanus hualpaiensis*) (HMV) was listed by the U.S. Fish and Wildlife Service (USFWS) as endangered in 1987 (USFWS 1987). The HMV is also included on the Arizona Game and Fish Department's (AGFD) list of *Threatened Native Wildlife in Arizona* (AGFD 1988), as endangered. A recovery plan (USFWS 1991) serves as a guideline for HMV management.

Monitoring efforts prior to this study failed to verify HMV activity in several historical locations (Mohave and Coconino counties, Arizona). As a result, since 1990 AGFD and USFWS have funded efforts to determine current HMV distribution and implement appropriate management activities. Cost-share funds and grants provided by the U.S. Forest Service (USFS) and Bureau of Land Management (BLM) have also helped support continuing genetic studies at the Museum of Southwestern Biology (MSB), University of New Mexico.

The Hualapai Mexican vole is one of three subspecies of *Microtus mexicanus* found in Arizona, and is primarily known from the Hualapai Mountains (Fig. 1). A second population discovered in 1913 in Prospect Valley was recently examined and tentatively reclassified as *M. m. hualpaiensis*, pending a larger sample size (Hoffmeister 1986). A third population of *M. mexicanus* was discovered in the Music Mountains in 1981 (Spicer et al. 1985). This population could be *M. m. hualpaiensis*, but specimens have not yet been assigned a subspecific classification. Due to the small sample size and the difficulty in classifying specimens from the Prospect Valley and Music Mountains, the status and range of the HMV have been in question since the last field evaluation by Spicer et al. (1985).

The status information herein reported is from an ongoing study that began in 1990. Field investigations focused on verifying the continued existence of the HMV in the Hualapai Mountains and other historical locations, and collecting specimens of *M. mexicanus* from various mountain ranges near the Hualapais for genetic analyses and comparative material.

METHODS

Surveys were conducted from December 1990 through June 1995. They originally concentrated in the Hualapai Mountains, Music Mountains, and on the Hualapai Indian Reservation. These areas include all historical HMV locations reported in Hoffmeister (1986) and Spicer et al. (1985) (Appendix 1). The search image used for identifying potential vole habitat was first

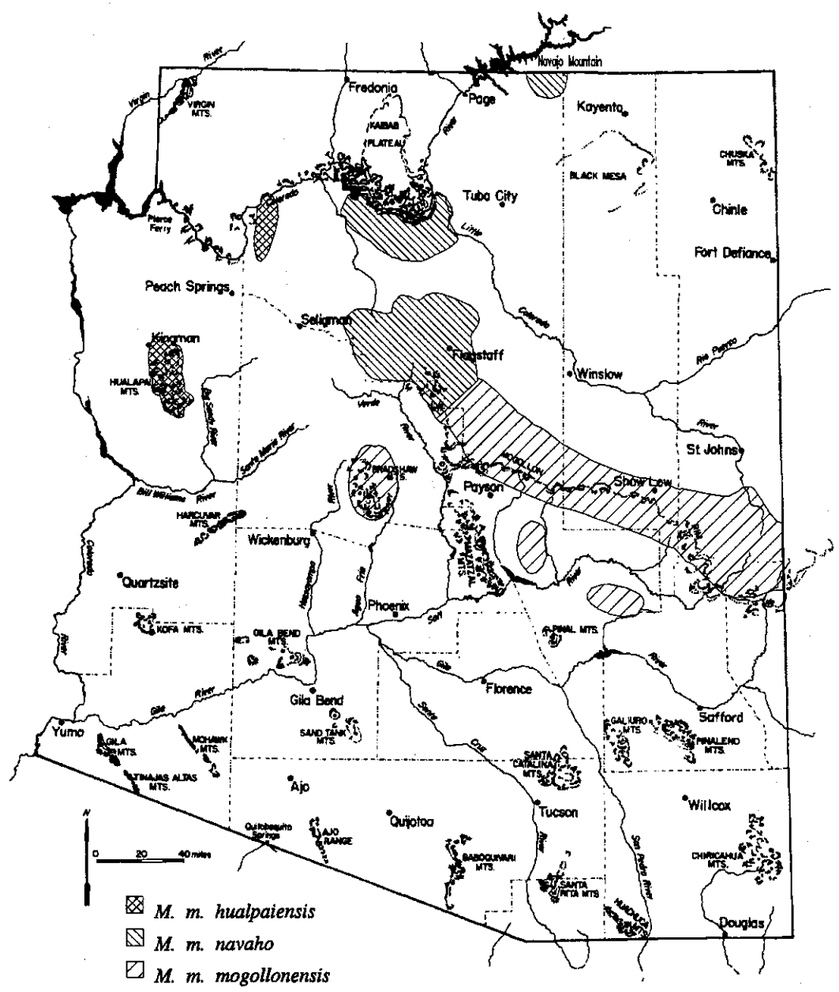

Figure 1. Range of *Microtus mexicanus* in Arizona (Adapted from Hoffmeister 1986).

recognized from a December 1990 aerial survey of the Hualapai Mountains (Belitsky 1991). Areas in which Gambel oak (*Quercus gambelii*) and ponderosa pine (*Pinus ponderosa*) were present, along with sufficient ground cover, became the focal point of our surveys.

After all known historically occupied areas had been surveyed, the same survey techniques were applied to other areas with potential vole habitat. These areas were chosen on the basis of location within the suspected range of HMVs and vegetation similar to historical sites. When new vole locations were discovered, specimens were collected for genetic analyses to help determine range boundaries outside the Hualapai Mountains. Ground searches were conducted on Navajo, Pine, Trinity, Round, and Mingus mountains. Big Chino Wash, Aubrey Cliffs, Black Hills, Big Black Mesa, and the Bradshaw, Sierra Prieta, Santa Maria, Juniper, Aquarius, Cottonwood, and Cerbat mountains were also surveyed. Helicopter flights of the Hualapai Indian Reservation, and Aquarius, Music, and Cerbat mountains were conducted to help identify potential vole habitat. As a follow up to aerial surveys, horse and mule pack trips were concentrated in remote locations of the Hualapai, Aquarius, and Cerbat mountains.

When potential habitat sites were found, they were examined for vole sign, which includes runways, scat, grass cuttings, and burrow entrances. Runways are tunnel-like paths that average 34.4 mm in width (Spicer et al. 1985) and are the most distinctive vole sign. If active sign was observed, Sherman live traps (7.6 x 8.9 x 22.9 cm) were placed in runways and checked every three to five hours. Traps were baited with rolled oats mixed with peanut butter. Polyester batting was added to prevent hypothermia of trapped animals. Information collected at each capture site included legal location, habitat description, species, sex, weight, and lengths of right hind foot, right ear, tail, and total body.

Interviews of knowledgeable people from BLM, Mohave County Parks Department, Prescott National Forest (PNF), Hualapai Tribe, Navajo Nation, and AGFD helped identify potential vole habitat and occupied areas, grazing activity, land ownership, human impacts, and other management history pertinent to this review.

Results

Trapping/Observations

During the 1991 field season, surveys were conducted in the Hualapai Mountains and adjacent mountain ranges from 13 May 1991 through 11 December 1991. Twenty-eight voles were identified in 577 trap nights. Five of the voles captured were submitted to MSB for genetic analyses. Twenty HMVs were captured and/or observed in 328 trap nights from three areas in the Hualapai Mountains (Appendix 2). Nine voles were found near Flag Mine, six in Wheeler Wash, and five at Camp Levi Levi. Eighteen were live-trapped and released unharmed at their capture sites, one was observed but not trapped, and one trap mortality occurred.

Three other areas in the Hualapais were surveyed, including Pine Peak Canyon where vole sign was observed among several inches of snow cover on 30 October 1991. Vole sign was also found on 13 November 1991 in Antelope Wash and Timber Wash. These locations were not trapped but evidence indicates that voles were active at these sites during 1991.

Eight *M. mexicanus* were identified in 249 trap nights from two areas outside the Hualapai Mountains (Appendix 3). In the Music Mountains, two voles were live-trapped and released unharmed and two were collected as voucher specimens. On the Hualapai Indian Reservation, two voles were live-trapped and released unharmed and two trap mortalities occurred.

During the 1992-1993 field season, surveys were conducted in the Hualapai Mountains and the surrounding mountain ranges. They were initiated on 14 April 1992 and concluded 30 June 1993. Ninty-nine voles were identified in 2473 trap nights. Forty of the total captured were submitted to MSB for genetic analyses. Thirty-four HMVs were captured and/or observed in 895 trap nights from 11 areas of the Hualapai Mountains (Appendix 2). Three of these areas are near known historical locations, including Timber Wash, Flag Mine, and Camp Levi Levi. Eight newly discovered locations where voles were verified are Antelope Wash, Cedar Wash, Frees Wash, Jeep Spring, Moss Wash, Pine Peak East, Wabayuma Peak, and South Hayden Trail. Twenty-five voles were live-trapped and released unharmed at their capture sites, three trap mortalities occurred, and six voles were observed in runways but not trapped.

Sixty-five *M. mexicanus* were identified in 1578 trap nights from five areas outside the Hualapai Mountains (Appendix 3). In the Bradshaw Mountains, 22 voles were identified. Nine were live-trapped and released unharmed at their capture sites, nine were collected as voucher specimens, and four trap mortalities occurred. In the Sierra Prieta Mountains, three voles were collected as voucher specimens. In the Santa Maria Mountains, 19 voles were identified. Five were live-trapped and released unharmed at their capture sites, 12 were collected as voucher specimens, and two were observed. On the Hualapai Indian Reservation, eight voles were identified. Seven were live-trapped and released unharmed at their capture sites, and one was observed. At the Aubrey Cliffs, 13 voles were identified. Four were live-trapped and released unharmed at their capture sites, four trap mortalities occurred, and five were collected as voucher specimens (only three were submitted for analyses; two were lost).

During the 1993-1994 field season, surveys were conducted in the Hualapai Mountains, as well as the surrounding mountains ranges. They were initiated on 6 July 1993 and concluded 30 June 1994. Thirty voles were identified in 2077 trap nights. Twelve of the total captured were submitted to the MSB for genetic analyses. Ten HMVs were captured and/or observed in 300 trap nights from two new locations of the Hualapai Mountains (Appendix 2). These locations include Ridge Road, an area along the road leading to Wild Cow Campground, and Jeep Spring. Three voles were live-trapped and released unharmed at their capture sites, and seven voles were observed in runways but not trapped.

Twenty *M. mexicanus* were identified in 1777 trap nights from four areas outside the Hualapai Mountains (Appendix 3). On the Hualapai Indian Reservation, two voles were live-trapped and released unharmed at their capture sites. On Mingus Mountain, ten voles were identified. Three were live-trapped and released unharmed at their capture sites, and seven were collected as voucher specimens. On Navajo Mountain, one vole was collected as a voucher specimen. In the Chino Valley area, which includes Round Mountain, Trinity Mountain, and Big Chino Wash, seven voles were identified. Four were collected as voucher specimens and three were observed.

During the 1994-1995 field season, surveys were conducted in the Hualapai Mountains, as well as the surrounding mountain ranges. They were initiated on 6 July 1994 and concluded 22 June 1995. Three voles were identified in 544 trap nights. Two voles were observed from the Hualapai Mountains but not trapped (Appendix 2). One vole was captured from the Music Mountains and submitted to the MSB for genetic analyses (Appendix 3).

Surveys in the Hualapai Mountains were conducted throughout the field season in previously occupied and new locations. In March and April 1995, 23 known vole locations were mapped using a Global Positioning System (GPS) unit. Both inactive and active sign were observed at various sites. These 1991-1995 vole locations will be referenced by Geographic Information Systems (GIS) which will help produce a more accurate map in the future.

In April 1995, a brief vole survey of the Pine Peak area was conducted in conjunction with the BLM La Cienega Allotment survey. Recent vole sign was observed in the drainage northeast of Pine Peak but the site was not trapped. A vole survey of the Boy Scout Camp at Camp Levi Levi was conducted for the Soil Conservation Service (SCS) in May 1995. No recent or old vole sign was observed, but the SCS is drafting a conservation plan for the Boy Scout Camp area.

Surveys outside the Hualapais were concentrated in mountain ranges on the Prescott National Forest, as part of a cost-share agreement with AGFD. In May 1995, surveys were conducted on Big Black Mesa, northern part of the Black Hills, and in the Perkinsville/Drake area. Potential habitat was found on Big Black Mesa and in the Black Hills but no vole sign was observed. In June 1995, additional surveys in the Juniper Mountains, Sierra Prieta Mountains, and on Mingus Mountain were completed. Potential habitat near Pine Springs in the Juniper Mountains was found but no vole sign was observed. Active vole sign was found in the Sierra Prieta Mountains and traps were set but no voles were captured. Active vole sign was also found on Mingus Mountain but no trapping efforts were initiated.

Total trapping efforts (1798 trap nights) from 13 May 1991 to 22 June 1995 identified 66 voles in the Hualapai Mountains (Appendix 2). These results prove that HMVs are extant and more widely distributed throughout the Hualapais than previously thought (Fig. 2). Individuals of several age classes were captured, suggesting a reproducing population persists in several

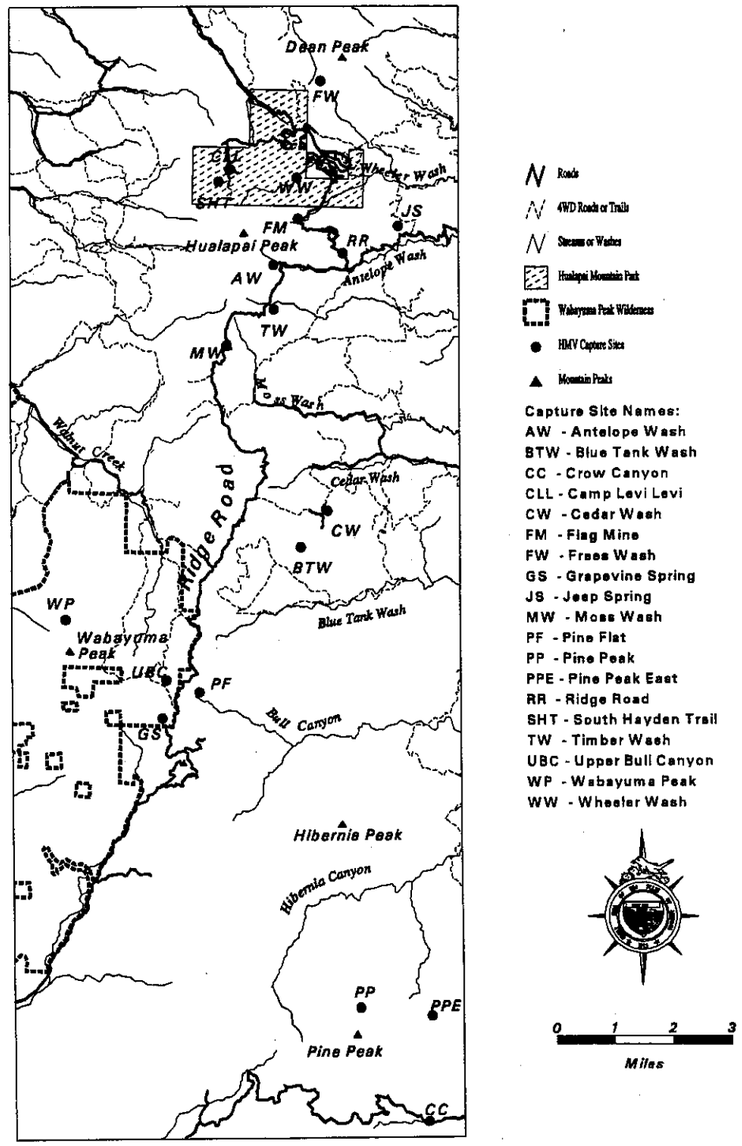

Figure 2. Locations where *Microtus mexicanus hualpaiensis* were captured or observed in the Hualapai Mountains, Arizona from 1923 to 1995.

locations within this mountain range. Figure 3 shows the trapping effort outside the Hualapais which identified 94 voles in 3873 trap nights (Appendix 3). A total of 56 *M. mexicanus* have been submitted to the MSB for genetic analyses and comparative material.

Other mammals captured in *M. mexicanus* runways include brush mice (*Peromyscus boylii*), deer mice (*Peromyscus maniculatus*), Western harvest mice (*Reithrodontomys megalotis*), cliff chipmunks (*Eutamias dorsalis*), and white-throated wood rats (*Neotoma albigula*).

Aerial Surveys

In December 1990, a survey involving 3.0 hours of helicopter charter over the Hualapai Mountains identified potential vole habitat in six remote locations (Belitsky 1991). Only three locations were ground searched and successful in occupying voles. In May 1992, a survey involving 4.8 hours of helicopter charter over the Music Mountains and the Hualapai Indian Reservation identified ten potential habitat areas. In August 1992, ground searches of sites in the southern part of the Music Mountains near Laughing Jack Butte, T25N R13W Sec 22, 27, 28, 29, were conducted but no vole sign was found. In November 1992, a survey involving 3.2 hours of helicopter charter over the Aquarius Mountains identified four potential habitat areas. Ground searches near Sam Spring, T17N R11W Sec 27 SW¼, were conducted but no vole sign was found. Three other areas were located on the north facing slopes of Bonner Peak and two unnamed peaks in Sections 28 and 33, however, because the area is remote and has limited access, surveys were concluded. A follow up survey on horseback was completed in October 1993 but no vole sign was observed. In March 1993, a survey involving 2.2 hours of helicopter charter over the Cerbat Mountains identified seven potential habitat areas. Ground searches of six sites were conducted but no vole sign was found.

Mule Pack Trips and Horseback Surveys

After aerial surveys were completed, the BLM Kingman Resource Area provided assistance during follow up surveys where potential vole habitat was found in remote locations. As a result of the December 1990 aerial survey, mule pack trips were conducted in October 1992 near Pine Peak and in April 1993 near Wabayuma Peak of the Hualapai Mountains. Both surveys proved successful as voles were identified in these two new locations. In April 1993, another pack trip was conducted in the Cerbat Mountains, however, no vole sign was observed. A horseback survey of potential sites in the Aquarius Mountains was completed in October 1993, but no evidence of vole activity was observed.

Unsuccessful Surveys

In May and September 1993, brief surveys were conducted for potential vole habitat and sign in the Juniper Mountains and Pine Mountain Wilderness Area of the Prescott National Forest.

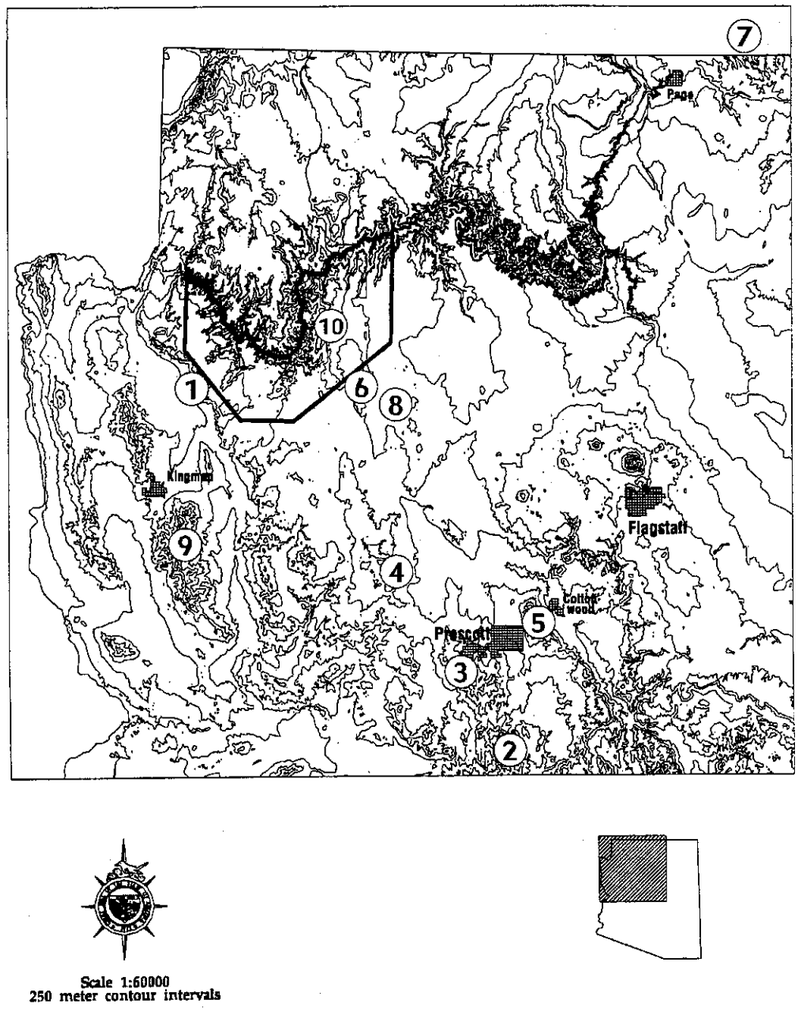

Figure 3. Locations where *Microtus mexicanus* were captured or observed in Arizona from 1991 to 1995. 1) Music Mountains, 2) Bradshaw Mountains, 3) Sierra Prieta Mountains, 4) Santa Maria Mountains, 5) Mingus Mountain, 6) Aubrey Cliffs, 7) Navajo Mountain, 8) Chino Valley, 9) Hualapai Mountains, 10) Hualapai Indian Reservation.

Habitat similar to known vole locations in the Hualapais was found near Pine Springs in the Juniper Mountains, however, no vole sign was observed. No potential vole habitat was found near Pine Mountain as sufficient ground cover was lacking. The Cottonwood Mountains were briefly surveyed in September 1993 but no habitat or sign was found. In April 1994 and May 1995, surveys were conducted on Big Black Mesa, northern part of the Black Hills, and in the Perkinsville/Drake area of the Prescott National Forest. Potential habitat was found on Big Black Mesa and in the Black Hills but no vole sign was observed.

Habitat Evaluation

M. mexicanus trapped during 1991-1995 were associated with pinyon-juniper or pine-oak vegetation belts. The pinyon-juniper belt, in the Upper Sonoran Life Zone (Lowe 1964), is characterized by Elmore and Janish (1976) as dry and rocky or gravelly with limited rainfall. Average annual precipitation is between 25 and 51 cm. Elevation ranged from 1372 to 1981 m. The dominant plants are usually drought resistant. The pine-oak belt, also in the Upper Sonoran Life Zone, is characterized by Elmore and Janish (1976) as intermediate in moisture supply, temperature, and soil conditions. Average annual precipitation is between 51 and 64 cm. Elevation ranged from 1981 to 2438 m. Various species of shrubs and grasses are common in both the upper pinyon-juniper belt and lower pine-oak belt.

In the Hualapai Mountains, all vole habitat sites occurred to some degree within the pine-oak vegetation belt. The dominant plants found at most sites include ponderosa pine, Gambel oak, common hoptree (*Ptelea angustifolia*), New Mexican locust (*Robinea neomexicana*), Quaking aspen (*Populus tremuloides*), mountain snowberry (*Symphoricarpos oreophilus*), columbine (*Aquilegia chrysantha*), Arizona black walnut (*Juglans major*), canyon grape (*Vitus arizonica*), fendlerbush (*Fendlera rupicola*), goldenrod (*Solidago* spp.), *Baccharis* spp., and a perennial mutton grass (*Poa* spp.). Aspect of all vole areas ranged from 290 to 114°. Slope varied from 0 (Ridge Road) to 41 percent (Flag Mine). Elevation ranged from 1536 to 2392 m.

The Mingus Mountain and Navajo Mountain vole locations both are in the upper pine-oak vegetation belt. Voles trapped on Mingus Mountain were in a grassy meadow with adjacent ponderosa pine overstory. Quaking aspen, ponderosa pine, Fendler rose (*Rosa fendleri*), and snowberry were the most common plants found at the Navajo Mountain vole location. The elevation on Mingus Mountain was 2310 m, aspect 320°, and slope 0 percent. On Navajo Mountain the elevation was 2707 m, aspect 154°, and slope 20 percent.

Vole habitat in the Bradshaw Mountains, Sierra Prieta Mountains, and Santa Maria Mountains is similar, occurring within the upper pinyon-juniper and lower pine-oak vegetation belts. The dominant plants at most sites include ponderosa pine, Arizona black walnut, Fremont cottonwood (*Populus fremontii*), alligator juniper (*Juniperus depeanna*), New Mexican locust, Gambel oak, thinleaf alder (*Alnus tenuifolia*), alfalfa (*Medicago sativa*), sweet clover (*Melilotus alba*), lupine (*Lupinus sp.*) and a perennial mutton grass. The aspect of all vole areas was 226° in the

Bradshaws, 46° in the Sierra Prietas, and 298 to 123° in the Santa Marias. Slope varied from 3 to 18 percent. Elevation ranged from 1584 to 2072 m.

Habitat in the Music Mountains, Hualapai Indian Reservation, Aubrey Cliffs, and Chino Valley area also is within the upper pinyon-juniper and lower pine-oak vegetation belts. The dominant plants found at some or all of these sites include pinyon pine (*Pinus edulis*), ponderosa pine, one-seed juniper (*Juniperus monosperma*), mountain mahogany (*Cercocarpus sp.*), manzanita (*Arctostaphylos pringlei*), cliffrose (*Cowania mexicana*), silktassel bush (*Garrya flavescens*), shrub live oak (*Quercus turbinella*), big sagebrush (*Artemisia tridentata*), New Mexican locust, Gambel oak, snowberry, and a perennial mutton grass. The aspect of all vole areas ranged from 17 to 67° in the Musics, 163 to 315° on the Reservation, and from 272 to 13° at Chino Valley and Aubrey Cliffs. Slope varied from 0 to 40 percent. Elevation ranged from 1676 to 2133 m.

Discussion

The Hualapai Mexican vole is a poorly defined subspecies, mainly because the specimen sample size is limited. Hoffmeister (1986) examined seven specimens and commented, "Our attempts to get specimens from the Hualapais were unsuccessful, and we suspect that the populations of *Microtus mexicanus* in these mountains are exceedingly small or perhaps no longer extant." The lack of specimens collected over the years may support speculation that this subspecies has never been very abundant. However, it could also reflect the extent of trapping effort in suitable habitat. The first four specimens were collected in 1923, but the subspecies was not described for another 15 years (Goldman 1938). Until the mid-1980s, there had been only six other specimens collected from the Hualapai Mountains. In 1984, Spicer et al.(1985) conducted the first thorough field evaluation of the species' status and five more specimens were collected. This study, which began in 1990, has identified 66 voles, increasing the total number of *M. m. hualpaiensis* captured or observed in the Hualapais to 81.

Because monitoring efforts during and after the Spicer et al. (1985) study failed to verify activity in new and historical locations, the HMV was considered rare and thought only to occupy small patches of suitable habitat that had been threatened by drought, grazing by livestock and elk, human recreation, and other activities. As a result, the HMV was listed by the USFWS as endangered on 1 October 1987 (USFWS 1987). This action raised the level of interest and concern for the subspecies substantially and consequently, funding was allocated for this study.

Over the years, subspecific classification of *M. mexicanus* in Arizona has been debated. The 1913 Prospect Valley specimens, originally classified as *M. m. mogollonensis* (Cockrum 1960), were reclassified to *M. m. hualpaiensis* by Hoffmeister (1986) based on body and skull measurements that seemed more comparable to that subspecies (Spicer et al. 1985). However, a larger sample size may indicate that they belong to *M. m. navaho*, to which they would seem more referable on a geographic basis (Hoffmeister 1986). Voles collected from the Music

Mountains in 1981 are of unknown subspecific classification but may also be referable to *M. m. hualpaiensis* based on geographic proximity (Spicer et al. 1985). The purpose of recent genetic studies by MSB is to better define the taxonomic status and geographic distribution of Mexican voles in their entire range, including *M. m. hualpaiensis* from northwestern Arizona.

Genetic studies included two methods of analyses. Protein electrophoresis measured the genetic variability within each population, genetic similarity among populations, and the evolutionary relationships between populations. Mitochondrial DNA was also used to analyze restriction site variation within populations.

Before genetic studies were performed, morphologic characteristics were analyzed and are summarized in Frey (1989) using 1775 specimens from the entire range of *M. mexicanus*. To assess subspecies boundaries, 42 populations, 16 in Arizona, were analyzed using 23 different characters. According to multivariate analyses, definite morphological differences occur between voles in the U.S. and Mexico. Frey and Yates (1995) report on genetic data that also support this conclusion. Variation observed at 11 genetic loci suggests that voles from Arizona, including *M. m. hualpaiensis*, belong to the northern *mogollonensis* group. This includes populations from New Mexico and Texas, rather than the southern *mexicanus* group from Mexico (Figure 4). If her analyses are accepted, voles from the Hualapai Mountains will be regarded as *Microtus mogollonensis hualpaiensis*.

In Arizona, it appears that voles from the Hualapai Mountains, Music Mountains, and Prospect Valley area of the Hualapai Indian Reservation, make up a group that is genetically distinct from voles found on the south rim of the Grand Canyon (*M. m. navaho*) and from the Mogollon Plateau (*M. m. mogollonensis*). This conclusion is based on genetic results that indicate unique alleles are shared at the IDH-1 and GDH loci (Frey and Yates 1995). The level of genetic differentiation found so far is typical of differences between other subspecies of mammals, therefore, these populations **may** all be referable to *M. m. hualpaiensis*. However, the presence of unique characters suggests that independent evolution has occurred within each population.

Inclusion of the Music Mountain specimens in this group is in contrast to Frey (1989), who found them to be distinct in morphology from specimens known from the Hualapai Mountains (Frey and Yates 1993). Furthermore, Frey and Yates (1995) report on the presence of a unique allele at the IDH-2 locus and high frequencies of IDH-1(A) and GDH(C) in populations from the Music Mountains. This supports morphologic data which suggests a high level of divergence has occurred in this population relative to other populations in northwestern Arizona. Based on these results, this population may ultimately warrant subspecific status.

According to Frey and Yates (1995), populations from the Aubrey Cliffs, Chino Wash, Santa Maria Mountains and the Bradshaw Mountains are genetically closely related and also **tentatively** regarded as *M. m. hualpaiensis*. Populations from Round Mountain and the Sierra

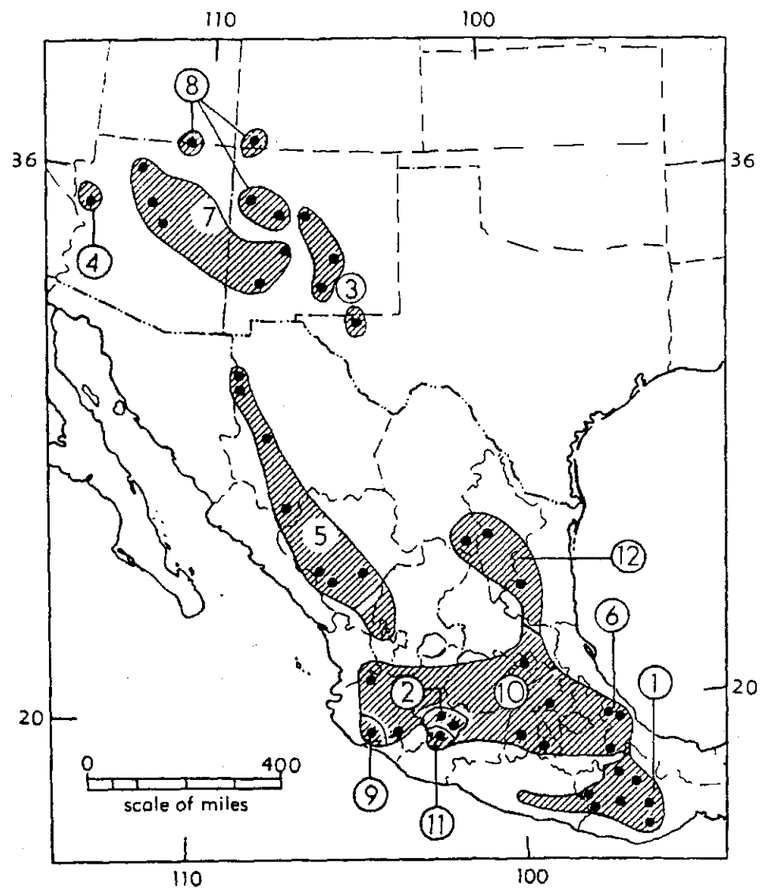

Figure 4. Distribution of *Microtus mexicanus* (modified from Hall 1981). Subspecies are: 1 *M. m. fulviventer*, 2 *M. m. fundatus*, 3 *M. m. guadalupensis*, 4 *M. m. hualpaiensis*, 5 *M. m. madrensis*, 6 *M. m. mexicanus*, 7 *M. m. mogollonensis*, 8 *M. m. navaho*, 9 *M. m. neveriae*, 10 *M. m. phaeus*, 11 *M. m. salvus*, 12 *M. m. subsimus*.

Prieta Mountains had different genetic characteristics but may be grouped with this subspecies based on geographic proximity. Voles from the Grand Canyon, San Francisco Mountains, and Mormon Lake area (all *M. m. navaho*) were genetically similar to voles on the Mogollon Rim (*M. m. mogollonensis*). Although no clear genetic separation was found between these two subspecies, morphologic data supports retention of both taxa as described in Hoffmeister (1986).

Results from these analyses expand the possible distribution of *M. m. hualpaiensis* in Arizona tremendously. However, these taxonomic conclusions should be considered tentative as they are based on small samples. Increased sample sizes are needed to better assess allozyme variation among populations of *M. mexicanus* from northwestern Arizona. In addition to the genetic uncertainties, various habitat requirements are not yet fully understood. Unlike most species of *Microtus*, which are associated with mesic or wet habitats dominated by graminoid vegetation, *M. mexicanus* is routinely found in xeric habitats (Tamarin 1985). However, field surveys from Spicer et al. (1985) were concentrated near permanent or intermittent water sources, and found voles in moist grass-sedge areas. Due to ongoing drought conditions in the Hualapais, no water was present in these historical vole locations in 1990. As a result, most of the habitat sites that were evaluated during this study included more mesic areas away from drainages.

According to Tamarin (1985), habitat factors that appear most important in influencing local distribution of *Microtus* are: vegetation type, moisture conditions, and amount of cover. Our observations of HMVs in 1991 through 1994 correspond well with his conclusions. However, at times it is difficult, if not impossible, to find evidence of HMV occupation in historical locations. Even though rainfall recharged some water sources in 1991, we did not find vole activity in several historical locations associated with permanent or intermittent water. In July 1993, active sign was observed at the 1984 Pine Flat and Grapevine Spring locations but no voles were trapped. Perhaps, reoccupation of these sites will require several years of average or better rainfall.

Our surveys have found that HMVs in the Hualapai Mountains use dry, grassy areas on moderate to steep slopes with mainly north facing aspects. Gambel oak was present at most capture sites and in areas adjacent to ponderosa pine. We suggest that permanent or intermittent water may not be critical for this subspecies. However, availability of grass probably is critical and grass is dependent on adequate water. We are hopeful that continued monitoring of HMV sites over the next few years will help clarify this.

Our studies also indicate that site occupancy for HMVs may be seasonal due to fluctuation of the habitat factors mentioned above. For example, in 1991, ten sites were monitored in the Hualapais from May through August. Vole sign was readily visible, and at most sites, voles were captured. However, in late August, sign of recent activity was not apparent in nine of the ten sites. Runways were inconspicuous and burrow entrances were entombed with spider webs, resulting in unsuccessful trapping efforts. The same observations were made for most of the

1992 trap locations. This demonstrates the importance of surveying potential and historical HMV sites early in the growing season if they are to be used for population monitoring.

High numbers of *Microtus* are often associated with herbaceous vegetation of early secondary succession because graminoid vegetation serves both as the primary cover and the major food source (Tamarin 1985). Voles that were captured in the Music Mountains, on the Hualapai Indian Reservation, and near Pine Peak Canyon in the Hualapai Mountains were all associated with pinyon-juniper habitat that burned 20 to 40 years ago. This association suggests that fire, which promotes secondary succession, may play an important role in creating and maintaining vole habitat.

CONCLUSIONS

During the past five years, information has been collected on the HMV that was previously lacking. The HMV was once thought to be restricted to the Hualapai Mountains. Recent genetic studies by MSB were conducted to better define the taxonomic status and geographic distribution of Mexican voles in their entire range, including *M. m. hualpaiensis* from northwestern Arizona. Preliminary results suggest the HMV may exist outside the Hualapais, which would expand its distribution tremendously. However, these taxonomic conclusions should be considered tentative as they are based on small sample sizes. Additional specimens are needed to better assess allozyme variation among populations.

The HMV was also previously thought to occupy among the most restricted habitats of any North American mammal. Historically, voles were only found in moist grass-sedge areas along permanent or semi-permanent waters fed by springs or seeps in either open forest or chaparral habitat. We did not find voles in this habitat type. Instead, voles were found in dry, grassy areas on moderate to steep slopes with ponderosa pine and Gambel oak overstory. This expands known vole habitat in the Hualapai Mountains.

Field investigations indicate the HMV is not as rare as it once was thought to be. When listing occurred, only 15 specimens from seven locations were known from the Hualapai Mountains. This study found 66 voles from 14 locations, which increases the total number known from the Hualapais to 81 voles from 21 locations.

HMV studies need to be continued, to supplement the information already known, or tentatively known. Implementation of the recovery plan requires that additional data be collected so that meaningful downlisting criteria can be developed (USFWS 1991). Until this information is known, recovery objectives for the HMV can not be met.

RECOMMENDATIONS

1) Determine taxonomy and geographic distribution of the HMV. Continue collecting specimens of all *M. mexicanus* populations in Arizona for genetic analyses to substantiate subspecific classifications and range boundaries within the state. Until these questions are answered, the range of *M. m. hualpaiensis* is uncertain.

2) Protect existing HMV populations and their habitat. Specific habitat requirements for HMVs need to be determined. Include measurement of soil moisture and temperature, sampling of vegetation, determination of fire history, and long-term monitoring of known HMV sites to clarify the role of succession in habitat suitability.

3) Monitor HMV populations in the Hualapai Mountains. Implement a monitoring effort using passive integrated transponder (PIT) tags on voles from selected habitat sites to determine population densities and dispersal patterns. If genetic analyses prove that HMVs are geographically isolated from any other subspecies, baseline population estimates will be needed to evaluate the viability of these populations.

LITERATURE CITED

Arizona Game and Fish Department. 1988. Threatened native wildlife in Arizona. Arizona Game and Fish Department Publication, Phoenix, Arizona.

Belitsky, D.W. 1991. Hualapai Mexican vole survey. Unpublished Arizona Game and Fish Department report to U.S. Fish and Wildlife Service. Phoenix, Arizona.

Buus, T.C. 1985. Wildlife Biologist. Personal communication.

Cockrum, E.L. 1960. The recent mammals of Arizona: their taxonomy and distribution. University of Arizona Press, Tucson.

Elmore, F.H. and J.R. Janish. 1976. Shrubs and trees of the southwest uplands. Southwest Parks and Monuments Association, Tucson, Arizona.

Frey, J.K. 1989. Morphologic variation in the Mexican vole (*Microtus mexicanus*). M. S. Thesis, Emporia State University, Emporia, Kansas.

Frey, J.K. and T.L. Yates. 1993. Hualapai Mexican vole (*Microtus mexicanus hualpaiensis*) genetic analysis. Unpublished Museum of Southwestern Biology final report to Arizona Game and Fish Department, Phoenix, Arizona.

Frey, J.K. and T.L. Yates. 1995. Hualapai vole (*Microtus mogollonensis hualpaiensis*) genetic analysis. Unpublished Museum of Southwestern Biology final report to Arizona Game and Fish Department, Phoenix, Arizona.

Goldman, E.A. 1938. Three new races of *Microtus mexicanus*. J. of Mammalogy. 19:493-495.

Hall, R.S. 1984. U.S. Bureau of Land Management. Wildlife Biologist. Personal communication.

Hoffmeister, D.F. 1986. Mammals of Arizona. Arizona Game and Fish Department and University of Arizona Press, Tucson.

Jones, B.K. 1984. U.S. Bureau of Land Management. Wildlife Biologist. Personal communication.

Lowe, C.H. (ed.) 1964. The vertebrates of Arizona. The University of Arizona Press, Tucson.

Peck, R.L. 1984. U.S. Bureau of Land Management. Wildlife Biologist. Personal communication.

Spicer, R.B., R.L. Glinski, and J.C. deVos, Jr. 1985. Status of the Hualapai vole (*Microtus mexicanus hualpaiensis* Goldman). Unpublished report to U.S. Fish and Wildlife Service. Arizona Game and Fish Department, Phoenix, Arizona.

Tamarin, R.H. (ed.). 1985. Biology of new world *Microtus*. Special Publication No. 8 of The American Society of Mammalogists.

U.S. Fish and Wildlife Service. 1987. Endangered and threatened wildlife and plants: Hualapai vole. Federal Register. Vol. 52, No. 190:36776-36779.

U.S. Fish and Wildlife Service. 1991. Recovery plan for the Hualapai Mexican vole (*Microtus mexicanus hualpaiensis*). U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

Wright, J.W. 1984. Los Angeles County Museum of Natural History. Personal communication.

Appendix 1. Localities and dates for specimens and observations of *Microtus mexicanus* in three areas of northwestern Arizona, 1913 through 1985. NM=National Museum of Natural History, UI=University of Illinois Natural History Museum, UA=University of Arizona Mammal Collection.

LOCATION	ELEVATION (m)	DATE	EVIDENCE OF OCCURRENCE	NUMBER OF SPECIMENS	PLACE OF DEPOSITION	REFERENCES
Hualapai Mountains						
Hualapai Peak (HP)	2560	10/01/23	Skin and skull	4 (1 lost)	NM	Goldman (1938)
Flag Mine (FM)	2048	11/14/62	Skin and skull	1	UI	Hoffmeister (1986)
Hualapai Peak	2377	04/15/68	Skin and skull	1	UI	Hoffmeister (1986)
Upper Blue Tank Wash (BTW)	1643	10/23/78	Skin only	1	UA	Peck (pers. comm.)
Timber Wash (TW)	2109	05/22/79	Pit-trapped/released	1	-	Peck (pers. comm.)
Timber Wash	2121	05/29/79	Skin and skull	1	UA	Peck (pers. comm.)
Timber Wash	2109	06/08/79	Pit-trapped/escaped	1	-	Peck (pers. comm.)
Camp Levi Levi (CLL)	2034 2194-2255	09/83	Observed sign	0	-	Wright, Jones, Hall (pers. comm.)
Pine Flat (PF)	1780	06/01/84	Skin and skull	2	UI & UA	Spicer et al. (1985)
Pine Flat	1780	06/01/84	Live-trapped/released	2	-	Spicer et al. (1985)
Upper Bull Canyon (UBC)	1841	07/18/84	Observed sign	0	-	Spicer et al. (1985)

Appendix 1 (continued). Localities and dates for specimens and observations of *Microtus mexicanus* in three areas of northwestern Arizona, 1913 through 1985. NM=National Museum of Natural History, UI=University of Illinois Natural History Museum, UA=University of Arizona Mammal Collection.

LOCATION	ELEVATION (m)	DATE	EVIDENCE OF OCCURRENCE	NUMBER OF SPECIMENS	PLACE OF DEPOSITION	REFERENCES
Hualapai Mountains						
Grapevine Spring (GS) [redacted]	1695	07/20/84	Live-trapped/released	1	-	Spicer et al. (1985)
Pine Peak (PP) [redacted]	Unknown	06/07/85	Observed sign	0	-	Hall and Peck (pers. comm.)
Music Mountains						
Upper Lost Creek (LC) [redacted]	1707	05/06/81	Skeleton only	1	UA	Buus (pers. comm.)
Lost Creek [redacted]	1670	05/06/81 06/02/81	Skin and skull	3	UA	Buus (pers. comm.)
Hualapai Indian Reservation						
Prospect Valley (PV) [redacted]	1372	09/26/13	Skin and skull	2	NM	Cockrum (1960)

Appendix 2. Localities and dates for evidence of *Microtus mexicanus hualpaiensis* in the Hualapai Mountains, Arizona, 1990 to 1995.

LOCATION	ELEVATION (m)	DATE	TRAP NIGHTS	EVIDENCE (captures/ observations)	AGE/SEX (A=adult, S=subadult, J=juvenile, U=unknown)
Pine Peak (PP)					
[redacted]	1829	11/07/90	0	sign only	-
	2012	10/30/91	0	sign only	-
Flag Mine (FM)					
[redacted]	2088	05/13/91	26	3/0	U/2♂[1], U/♀[1]
	2088	11/14/91	20	2/0	A/♂, A/♀
	2100	06/24/92	0	0/1	U
	2100	04/14/93	40	0/0	-
	1996	05/15-16/91	40	3/0	U/2♂[1], U/♀[1]
	2073	05/24/91	41	1/0	A/♀
Wheeler Wash (WW)					
[redacted]	2042	05/30/91	26	sign only	-
	2042	06/11-12/91	100	4/0	A/2♂, A/♀, J/♂
	2085	06/13/91	23	1/0	A/♀
	2073	06/13/91	17	1/0	A/♀[2]
Camp Levi Levi (CLL)					
[redacted]	2307	07/11-12/91	10	3/1	J/3♂, U
	2301	07/12/91	10	1/0	A/♂
	2301	06/24-26/92	65	3/0	A/2♀, S/♀[3]
	2316	06/23-26/92	65	9/0	A/♀[3], A/3♀, A/5♂
South Hayden Trail (SHT)					
[redacted]	2392	09/27/91	15	sign only	-
	2392	06/25-26/92	24	2/2	S/2♂, 2U

[1]Not weighed; age unknown
[2]Trap mortality; skin and skull deposited at Arizona Game and Fish Department, carcass deposited at Museum of Southwestern Biology
[3]Trap mortality; skin, skull and carcass deposited at Museum of Southwestern Biology

Appendix 2 (continued). Localities and dates for evidence of *Microtus mexicanus hualpaiensis* in the Hualapai Mountains, Arizona, 1990 to 1995.

LOCATION	ELEVATION (m)	DATE	TRAP NIGHTS	EVIDENCE (captures/ observations)	AGE/SEX (A=adult, S=subadult, J=juvenile, U=unknown)
Antelope Wash (AW)					
[redacted]	2054	11/13/91	0	sign only	-
	2054	07/29/92	15	0/1	U
	2078	04/15-16/92	60	2/0	S/♂, J/♂
	2078	04/15/93	30	0/0	-
Timber Wash (TW)					
[redacted]	2072	11/13/91	0	sign only	-
	2073	07/28/92	28	0/0	-
	2073	07/29/92	7	0/0	-
	2073	08/26/92	100	1/0	A/♂
	2073	07/07-09/93	100	sign only	-
Cedar Wash (CW)					
[redacted]	1908	05/20/92	47	1/0	S/♂
	1901	05/20/92	47	2/0	A/♂, A/♀
Frees Wash (FW)					
[redacted]	2255	09/30/92	20	1/0	J/♂[3]
	2255	07/06-08/94	125	sign only	-
Pine Peak East (PPE)					
[redacted]	1950	10/07-08/92	110	3/0	A/3♂
Jeep Spring (JS)					
[redacted]	1743	10/08/92	39	1/0	A/♀
	1804	04/27-29/94	30	0/6	6U
	1804	03/22/95	0	0/1	U
	1804	07/06-08/94	100	sign only	-

[3]Trap mortality; skin, skull and carcass deposited at Museum of Southwestern Biology

Appendix 2 (continued). Localities and dates for evidence of *Microtus mexicanus hualpaiensis* in the Hualapai Mountains, Arizona, 1990 to 1995.

LOCATION	ELEVATION (m)	DATE	TRAP NIGHTS	EVIDENCE (captures/ observations)	AGE/SEX (A=adult, S=subadult, J=juvenile, U=unknown)
Blue Tank Wash (BTW)					
[redacted]	1829	08/18/92	29	0/0	-
Democrat Mine (DM)					
[redacted]	1950	10/08/92	19	0/0	-
	1987	10/08/92	20	0/0	-
Wabayuma Peak (WP)					
[redacted]	1969	04/08/93	80	1/1	A/♂, U
Moss Wash (MW)					
[redacted]	2011	05/20/93	50	2/1	S/♀, J♀, U
	2011	11/09/93	0	0/1	U
Pine Flat (PF)					
[redacted]	1798	07/08-09/93	10	sign only	-
	1798	10/13-15/93	60	sign only	-
Ridge Road (RR)					
[redacted]	1920	02/23-24/94	100	3/0	A/3♀
	1920	07/06-08/94	20	0/0	-
	1920	09/01-02/94	30	sign only	-
Crow Canyon (CC)					
[redacted]	1536	02/09/95	0	0/1	U

Appendix 3. Localities and dates for *Microtus mexicanus* identified from areas outside the Hualapai Mountains, Arizona and collected for the Museum of Southwestern Biology genetic study, 1991 to 1995.

LOCATION	ELEVATION (m)	DATE	TRAP NIGHTS	EVIDENCE (captures/ observations)	AGE/SEX (A=adult, S=subadult, J=juvenile, U=unknown)
Music Mountains					
East Tank (ET) [redacted]	1646	07/16/91	35	0/0	-
Grand Wash Cliff (GWC) [redacted]	2012 2012 1987 1987	07/17/91 10/02-03/91 07/13/94 08/15-18/94	40 70 80 170	sign only 4/0 1/0 0/0	- A/♂[2], A/2♀[1], J/♂[2] J/♂[3] -
Bradshaw Mountains					
Goodwin Wash (GWN) [redacted]	1706 1706	07/13-16/92 03/16-18/93	261 180	5/0 17/0	A/2♂[3], A/♂[2], A/♀[3], S/♂[2] A/♂[2], A/2♂[3], A/4♀[2], A/5♀[3], S/♂[2], S/♂[3], S/♀[2], S/♀[3], J/♂[3]
Sierra Prieta Mountains					
Mt. Francis (MF) [redacted]	2072 2072	09/24/92 06/20-21/95	70 19	3/0 sign only	A/2♂[3], S/♂[3] -
Santa Maria Mountains					
Camp Wood (CPW) [redacted]	1725 1725	07/28-31/92 08/04-07/92	137 369	0/0 8/0	- A/♂[2], A/2♂[3], A/♀[2], A/2♀[3], 2U
Stringtown Wash (SW) [redacted]	1670 1670	05/18/93 05/27-28/93	0 40	0/1 4/1	U A/2♂[3], A/♀[2], A/♀[3], U

[1]Skin and skull deposited at Arizona Game and Fish Department, carcass deposited at Museum of Southwestern Biology
[2]Released unharmed
[3]Skin, skull and carcass deposited at Museum of Southwestern Biology

Appendix 3 (continued). Localities and dates for *Microtus mexicanus* identified from areas outside the Hualapai Mountains, Arizona and collected for the Museum of Southwestern Biology genetic study, 1991 to 1995.

LOCATION	ELEVATION (m)	DATE	TRAP NIGHTS	EVIDENCE (captures/ observations)	AGE/SEX (A=adult, S=subadult, J=juvenile, U=unknown)
Santa Maria Mountains					
Tadpole Wash (TPW) [redacted]	1658	05/28/93	30.	1/0	S/♀[3]
Pine Creek (PC) [redacted]	1633 1633	05/18/93 05/27-28/93	0 20	sign only 2/0	- A/♂[3], A/♀[3]
Apache Creek (AC) [redacted]	1584 1584	05/18/93 05/27/93	0 80	sign only 2/0	- A/♂[3], A/♀[3]
Mingus Mountain					
Mingus Mountain (MM) [redacted]	2310	08/03-06/93	240	10/0	A/♂[3], A/♂[2], A/♀[2], A/3♀[3], S/2♂[3], S/♀[2], J/♂[3]
Hualapai Indian Reservation					
Park Tank (PT) [redacted]	2054 2054	06/08-10/0/93 07/15/93	100 188	4/1 1/0	A/♀[2], S/2♂[2], S/♀[2], U A/♀[2]
Sage Tank (ST) [redacted]	1981 1981	06/08-10/93 07/12-16/93	50 120	3/0 sign only	A/♀[2], J/2♂[2] -
Timber Sale (TS) [redacted]	2133 2133	06/08-09/93 07/12-16/93	27 120	sign only 1/0	- S/♀[2]

[2]Released unharmed
[3]Skin, skull and carcass deposited at Museum of Southwestern Biology

Appendix 3 (continued). Localities and dates for *Microtus mexicanus* identified from areas outside the Hualapai Mountains, Arizona and collected for the Museum of Southwestern Biology genetic study, 1991 to 1995.

LOCATION	ELEVATION (m)	DATE	TRAP NIGHTS	EVIDENCE (captures/ observations)	AGE/SEX (A=adult, S=subadult, J=juvenile, U=unknown)
Hualapai Indian Reservation					
Oak Tank (OT)					
[redacted]	1975	12/10-11/91	90	4/0	A/♂[2], A/♀[4], S/♂[4], S/♀[2]
	1975	07/13-16/93	54	sign only	-
Juniper Tank (JT)					
[redacted]	2012	11/19/91	14	sign only	-
Aubrey Cliffs					
Pine Canyon Dam (PCD)					
[redacted]	1926	06/16-18/93	160	12/0	A/♂[2], A/2♂[3], A/3♀[2], A/♀[3], S/♀[3], J/2♂[3], J/2♀[3]
Pine Canyon Tank (PCT)					
[redacted]	1993	06/17/93	54	1/0	J/♂[3]
Navajo Mountain					
Navajo Mountain (NM)					
[redacted]	2707	09/01/93	156	1/0	A/♀[3]
	2707	10/26-27/93	30	0/0	-
Chino Valley					
Round Mountain (RM)					
[redacted]	2115	09/15/93	100	1/0	S/♂[3]
Trinity Mountain (TM)					
[redacted]	1853	05/04/94	162	0/2	2U
	1920	05/11-13/94	100	sign only	-
Big Chino Wash (BCW)					
[redacted]	1676	05/24-25/94	80	1/0	A/♂[3]
	1676	05/25/94	70	1/0	S/♀[3]
	1676	06/07-10/94	357	1/1	A/♂[3], U

[2]Released unharmed
[3]Skin, skull and carcass deposited at Museum of Southwestern Biology
[4]Skin and skull deposited to Hualapai Tribe, carcass deposited at Museum of Southwestern Biology