DISTRIBUTION OF THE HOUSEROCK VALLEY CHISEL-TOOTHED KANGAROO RAT
(*Dipodomys microps leucotis* Goldman)

By

Michael J. O'Farrell

1995

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DISTRIBUTION OF THE HOUSEROCK VALLEY CHISEL-TOOTHED KANGAROO RAT
(*Dipodomys microps leucotis* Goldman)

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EXECUTIVE SUMMARY

The Houserock Valley represents the easternmost edge of the distribution of the chisel-toothed kangaroo rat, *Dipodomys microps*. The subspecies occurring in the valley, *D. microps leucotis*, is effectively isolated from the nearest adjoining subspecies by the Kaibab Plateau, the Vermilion Cliffs, and the Paria Plateau. Past collection efforts have been limited to three locations within the valley and resulted in a total of 61 specimens, 45 of which were collected prior to 1947. The apparent rarity and isolation from the rest of the species prompted regulatory agencies to categorize the taxon as a federal Candidate Category 2 and state candidate for threatened or endangered status.

The present survey provided a valley-wide examination of occupation and subsequent mapping of the distribution of occupied habitat for *D. microps leucotis*. The entire valley was traversed by vehicle and walking transects in a focused search for kangaroo rat sign. All areas exhibiting such sign were sampled with Stoddard live traps to provide species identification. A total of 114 individuals were captured out of 368 localities sampled. Based on this survey methodology, occupied habitat was delineated on 7.5' USGS topographic maps. Habitat types were characterized and also delineated on maps.

Within the approximate 150,000-acre valley, an estimated total of 73,624 acres of occupied habitat was mapped. An additional estimated 4,194 acres of potentially suitable habitat was delineated. Two species of kangaroo rats made up most of the nocturnal small mammal community throughout the valley. *Dipodomys microps leucotis* was found in coarse loamy soils containing a gravelly component and in saltbush and blackbrush habitat types. *Dipodomys ordii*, although sometimes found sympatrically with *D. microps leucotis*, was more prevalent in sandy, mixed shrub and grassy habitats. The presence of sympatry coincided with increased levels of livestock disturbance in saltbush habitats. Overall abundance of *D. microps leucotis* was rated as low.

The geographically-restricted distribution, low general abundance, and evidence of intense past and present livestock use provides justification for considering the taxon sensitive. However, the species occurs over approximately half the valley and is relatively protected from future development due to federal ownership of most of the valley. The primary threat to continued existence of the taxon appears to be future levels of agricultural and livestock activities. Quantification of the relationship of livestock use to kangaroo rat success is key to assessing potential future threats. With that knowledge, formulation and implementation of a modest management plan is feasible and will provide sufficient protection of the species without the need for formal listing.

INTRODUCTION

The chisel-toothed kangaroo rat (*Dipodomys microps*) occupies primarily the Great Basin Desert of Nevada with more limited distribution in adjoining states (Hayssen, 1991). Of the 13 subspecies currently recognized, two occur in the extreme northwestern portion of Arizona designated as the Arizona Strip. This portion of Arizona lies north and west of the Colorado River and the Grand Canyon. The river and canyon serve as a barrier to more widespread southern distribution for many species of terrestrial small mammals in Arizona, including *D. microps*. Consequently, *D. m. celsus*, the adjacent subspecies, has an extended range in Arizona, Utah, and Nevada, whereas *D. m. leucotis*, the Houserock Valley chisel-toothed kangaroo rat, is confined to the Houserock Valley at the eastern end of the Arizona Strip.

Chisel-toothed kangaroo rats occur in a variety of habitats but tend to be most abundant in saltbush/shadscale associations or in higher elevation transitional communities dominated by blackbrush (see Hayssen, 1991 for a review). The Houserock Valley contains those habitat types but is surrounded by physical barriers (Grand Canyon, Vermillion Cliffs, Paria and Kaibab plateaus) with associated vegetation barriers that appear to have effectively isolated *D. m. leucotis*. Surveys to determine a connection with *D. m. celsus* or at least a more widespread distribution have proved negative (Spicer and Johnson, 1988). Although Hoffmeister (1986) expressed some reservation as to the subspecific status of the Houserock Valley population of kangaroo rats, it is currently recognized as a distinct taxonomic entity, *D. m. leucotis*.

As a taxon of limited distribution and known from few localities, *D. m. leucotis* is a candidate species in Arizona (AGFD, 1988) and a Category 2 federal candidate under the Endangered Species Act (USFWS, 1991). Virtually all of the Houserock Valley is within state (Arizona State Lands) or federal (National Park Service (NPS), U.S. Forest Service (USFS), Bureau of Land Management (BLM)) jurisdiction. The candidate status of *D. m. leucotis* mandates that the jurisdictional agencies address potential impacts to the species. However, the current status of the species is in question. Only eight localities had been found within the valley (Spicer and Johnson, 1988) prior to the present study. A total of 61 individuals were captured at those locations; 45 of the 61 came from a single location, 6 miles west of Navajo Bridge and all but 10 individuals were captured before 1949. Spicer and Johnson (1988) speculated that 45,000 acres within the 150,000-acre valley was suitable habitat. However, they cited a paucity of visual sign and great difficulty in trapping the species. Because of the lack of data on the species' status, it is not currently feasible to accurately evaluate impacts to the species of any action proposed within the Houserock Valley.

Detailed distributional and habitat preference data are lacking for the Houserock Valley chisel-toothed kangaroo rat. Standard distribution maps for mammals have consisted of placing discrete points on a map signifying points of capture or observation of the target species. With sufficient points, a rough polygon is circumscribed so as to define the entire area of occupation (for example see Hall, 1981; Hoffmeister, 1986). Those types of distribution maps provide an adequate overview of large-scale distribution but may bear little true relationship to the actual acreage occupied. Actual occupied acreage is particularly critical when management decisions must be made with respect to sensitive species. O'Farrell and Uptain (1989) provided the first range-wide mapping of occupied habitat for a federally-listed endangered small mammal species, delineating occupied habitat at a 7.5' scale. Those maps have provided the basis for identification of potential preserves and interconnecting corridors, as well as identifying significant threats and potential options for mitigating those threats. The purpose of the present study is to apply that technique and to provide a complete, valley-wide survey resulting in detailed maps delineating the acreage currently occupied by *D. m. leucotis*.

STUDY AREA

The Houserock Valley occupies the southeastern end of the Arizona Strip (Figure 1). The valley is roughly triangular in shape, bordered on the north by the Vermilion Cliffs and Paria Plateau, on the west and south by the Kaibab Plateau, and on the east and south by the Colorado River forming the upper portion of the Grand Canyon. Topography consists of undulating terrain cut by a series of major drainages tending roughly eastward from the Kaibab Plateau to the Colorado River. Elevations range from about 3100 ft (944 m) at Lee's Ferry in the northeastern corner to about 6000 ft (1829 m) along the western foothills of the Kaibab Plateau. Annual precipitation is generally below 11 inches (28 cm) with most falling within the late summer monsoon period (Sellers and Hill, 1974; USFS, personal communication). A precipitation gradient is apparent across the valley. Highest precipitation occurs near the base of the Kaibab Plateau and the Vermilion Cliffs, and decreases toward the central and lower elevation portions of the valley.

Private ownership within the valley is limited to approximately one section (640 acres) out of an estimated 150,000 acres total. BLM jurisdiction encompasses the majority of the valley with USFS management of the southern portion. Remaining jurisdiction represents relatively minor acreage. State lands are discrete patches of checkerboard through the BLM portion, Glen Canyon National Recreation Area comprises the northeasternmost extreme, and Grand Canyon National Park forms a narrow strip along the valley rim above the Colorado River.

Vegetation throughout the valley consists of a mosaic of plant communities best described as belonging to the Great Basin desertscrub biome (Turner, 1982). Individual plant communities contain elements of the Mohave Desert, at the lowest elevations, and Great Basin Desert over the middle and higher elevations (Phillips et al., 1987). The pattern of vegetation appears to be influenced by a combination of edaphic, topographic, and microclimatic features.

The soil mosaic within the Houserock Valley originated primarily from Kaibab limestone, sandstone and aeolian parent material. The western, central and southern portions are primarily of a limestone derivation. In the north, the Vermilion Cliffs provide the sandstone and aeolian material. Some areas associated with the cliffs contain soils of mixed origin with a high gypsum content and a mud shale component.

MATERIALS AND METHODS

Chisel-toothed Kangaroo Rat Distribution

Chisel-toothed kangaroo rat occurrence was determined by presence of sign diagnostic for kangaroo rats (e.g., burrow mounds, scat, tracks, tail drags; O'Farrell and Uptain, 1989) coupled with verification trapping. The entire valley was systematically searched for diagnostic sign on foot and by vehicle. Initially, representative areas were sampled with conventional trapping configurations. Parallel lines of 12 to 20 stations in length (ca. 15 m spacing between stations and ca. 45 m between parallel lines; 1 trap per station) were sampled 22-23 October 1993, 27-28 February 1994, and 27-29 June 1994 at various localities throughout the valley. Although trapping locations were selected because of the presence of kangaroo rat sign, trap success was poor, particularly for *D. m. leucotis*. Some negative results appeared to be due to reticence of kangaroo rats to enter traps. However, kangaroo rat burrow mounds were extremely sparse and the majority of traps were not in close proximity to occupied mounds. Individuals did not appear to be moving far from burrow mounds, further exacerbating meager trap success. Walking transects during the same time frame further revealed the sparse distribution of occupied kangaroo rat mounds. Because of the low frequency of occupied burrow mounds, a different trapping technique was needed.

The valley is intersected by a comprehensive network of dirt roads. Those roads provided the basis of establishing massive traplines, maximizing the coverage possible within the confines of time and personnel constraints. The modified trapping technique involved slowly traversing all dirt roads and examining all apparent burrow complex mounds up to 30 m on either side of the road. Each mound was examined for sign of kangaroo rat use, particularly the presence of fresh scat. If sign was present, a live trap was placed at every active burrow entrance. If multiple mounds were located within 100 m, it was counted as a single locality.

A GPS fix was taken at each locality with a Trimble Model "Scout". Offsets were calibrated by taking periodic fixes at known locations (e.g., road intersections, bench marks). Trapping locations were subsequently mapped onto USGS 7.5' topographic maps. The distribution of *D. m. leucotis* was delineated on the same maps using verification of presence by trap results. Secondarily, a combination of the presence of active diagnostic mounds, suitable soils, and adequate vegetation as revealed through positive trap results was used. The distribution as depicted on maps in Appendix 1 was transferred to full-scale mylar overlays for entry into the GIS data bases currently maintained by the BLM and USFS.

Live trapping was conducted using Stoddard live traps which have been proven to be statistically superior to standard Sherman live traps, particularly for heteromyid rodents (O'Farrell et al., 1994). Traps were opened and baited with a combination of crimped oats, mixed bird seed, and peanut butter in the late afternoon. Traps were checked at sunrise. Each animal captured was identified to species and gender, assessed for reproductive condition, relative age, weighed with a Pesola scale, and released at the point of capture. The hind foot of each kangaroo rat was measured to assist in species identification (*D. ordii* $\leq$ 41 mm; *D. m. leucotis* $\geq$ 42 mm; Hoffmeister, 1986).

The area of the valley to be covered was sufficiently large as to preclude regular use of multiple nights of trapping at a single location, due to time and monetary constraints. Each locality was trapped for only one night. However, when large areas yielded negative results due to inclement weather, those sites were sampled for an additional night. A summary of trapping results for all species captured is provided in Appendix 3.

Plant Communities

Habitat was characterized and mapped for all portions of the valley known or suspected to contain *D. m. leucotis*. Each major vegetation type was assigned a descriptive name based either on physiognomy or dominant species. Some of the vegetation types were sufficiently widespread within the valley to contain a number of sub-types. Sub-types were not mapped but were described. Identification and mapping of vegetation types was achieved by traversing the valley by vehicle and on foot, and recording the visual dominants observed. Interpretation of vegetation patterns was aided by use of soil maps (Brewer et al., 1991; Jorgensen, 1991), aerial photographs provided by the BLM and USFS, and the broad personal experience of the investigators with the plant communities of the region. Mapping was done on USGS 7.5' topographic maps. The distribution of vegetation types, as presented in Appendix 2, was transferred to full-scale mylar overlays for entry into the GIS data bases currently maintained by the BLM and USFS.

RESULTS

Plant Communities

Vegetation types were divided into seven categories (see Appendix 2 for the distribution of these vegetation types). The seven broad patterns of perennial plant distribution, herein designated as communities, were based on the presence of one or more dominant species. An eighth category was based on physiographic location (Wash/Canyon), that of the washes and canyons prevalent throughout the valley. Of the seven plant communities, two were homogenous (Shadscale, Blackbrush). The remaining five communities (Four-wing Saltbush, Ephedra-Yucca, Buckwheat-Wolfberry, Snakeweed, Big Sagebrush) exhibited wide variation in presence of dominant species. Big Sagebrush was characterized as a peripheral community delineating the southern extent of *D. m. leucotis* distribution. The most widely distributed community was Four-wing Saltbush. In descending order of estimated aerial extent, the remaining communities were Ephedra-Yucca, Shadscale, Snakeweed, Blackbrush, Buckwheat-Wolfberry, and Big Sagebrush. The distribution of plant communities was strongly influenced by edaphic conditions.

The following description of plant communities provides species composition of major perennials, soil types, and location within the valley.

Shadscale.—The shadscale (*Atriplex confertifolia*) dominated community occurred on low ridges and flats. That community was more common toward the northeast quadrant portion of the valley. Typical associated species were: shadscale, galleta (*Hilaria jamesii*), Indian ricegrass (*Achnatherum hymenoides*), prickleypear (*Opuntia* spp.), and fluffgrass (*Erioneuron pulchellum*).

Four-wing Saltbush.—The four-wing saltbush (*Atriplex canescens*) dominated community occurred on low ridges and flats. This community was more prevalent toward the northwest end of the valley on alluvial slopes descending from the toe of the Kaibab Plateau. Typical associated species were: blue grama (*Bouteloua gracilis*), green rabbitbrush (*Chrysothamnus viscidiflorus*), snakeweed (*Gutierrezia sarothrae*), sand dropseed (*Sporobolus cryptandrus*), ephedra (*Ephedra* spp.), winterfat (*Krascheninnikovia lanata*), prickleypear, and Indian ricegrass. The community varied from four-wing saltbush being the sole dominant with few scattered individuals of other species to a co-dominant four-wing saltbush-green rabbitbrush assemblage. In some areas, particularly at the toe of the Kaibab Plateau slope, blue grama formed a dense mat between widely scattered individuals of four-wing saltbush. Increased disturbance, primarily in the form of cattle grazing, resulted in a community composed of sparse four-wing saltbush with dense patches of stunted snakeweed.

Ephedra-Yucca.—The ephedra and narrow-leaved yucca (*Yucca angustissima*) community was composed of a mixture of shrubs and was the most variable community with respect to perennial species composition. Primarily confined to the sandy soils north and east (downwind) of Houserock Wash. Species commonly present within this community were: ephedra, narrow-leaved yucca, blackbrush (*Coleogyne ramosissima*), four-wing saltbush, Indian ricegrass, sand dropseed, snakeweed, and sand sagebrush (*Artemisia filifolia*). Extremely dense stands of this community type, with all the preceding species being co-dominant, occurred in very sandy soils at the confluence of Emmett and Houserock washes. In less sandy soils, farther from Houserock Wash at the west and east ends of the valley, four-wing saltbush dominated with a lesser yucca and ephedra component and increased Indian ricegrass and sand dropseed. Toward the middle of the valley, blackbrush became more important on less sandy soils between the Vermilion Cliffs and Houserock Wash. Other sandy sites, near gypsiferous soils in the same location, supported a shadscale-Indian ricegrass dominated assemblage.

Blackbrush.—The blackbrush dominated community occurred on broad ridges and aeolian deposits at the base of the Vermilion Cliffs. That community formed a series of scattered patches from Emmett Hill on the east to near the confluence of Soap Creek and the Grand Canyon. Blackbrush was consistently the dominant species, with scattered narrow-leaved yucca, ephedra, and Indian ricegrass.

Buckwheat-Wolfberry.—The buckwheat (*Eriogonum corymbosum*) and pale wolfberry (*Lycium pallidum*) dominated community was strongly associated with gypsiferous soils. Those soils supported a very sparse vegetation in the middle of the valley that was dominated by one or both species. Other associated species were very sparse, usually widely scattered individuals of prince's plume (*Stanleya pinnata*) and alkali saccaton (*Sporobolus airoides*)

Snakeweed.—The snakeweed dominated community occurred on gentle slopes in the middle and at the western end of the valley. The presence of that community was strongly correlated with ranching/agricultural practices. The degree and nature of disturbance determined species composition. Extreme disturbance resulted in bare soil around stock tanks and ranches with a surrounding perimeter of dense, stunted snakeweed. Decreased disturbance resulted in a reduction in snakeweed and a corresponding increase of various grasses. In some areas, grasses (e.g., galleta, sand dropseed, burro grass (*Scleropogon desvauxii*), and blue grama) predominated with very little snakeweed. It seemed likely, based on location and soils, that the majority of the snakeweed community type would support a form of four-wing saltbush community, in the absence of grazing.

Wash/Canyon.—The wash and canyon classification covered the gamut of vegetation occurring in those physiographic locations. Typical species occurring in the sandy/gravelly soils of the washes within Houserock Valley were: Apache plume (*Fallugia paradoxa*), sand sagebrush, salt cedar (*Tamarix* sp.), broom groundsel (*Senecio spartioides*), and rubber rabbitbrush (*Chrysothamnus nauseosus*). The deeper washes and canyons contain steep rocky walls effectively excluding kangaroo rats, thus these areas were beyond the limits of *D. m. leucotis* distribution and were not investigated.

Big Sagebrush.—The big sagebrush (*Artemisia tridentata*) dominated community occurred at the west edge of the valley and southern end of *D. m. leucotis* distribution. That community was treated as a border, thus the species composition reported here reflected a small part of the variation present within the larger community. Typical species present were: green rabbitbrush, four-wing saltbush, galleta, snakeweed, and scattered clumps of woodland comprised of pinyon (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*).

Rodent Populations

Richness of rodent species within the Houserock Valley was relatively high (10 species) reflecting the diversity of habitat types encountered. Five species of heteromyid rodents, three pocket mice and two kangaroo rats (Table 1) were captured. The kangaroo rats were by far the most abundant (see also Appendix 3). Four species of murid rodents and 1 sciurid species were also captured (Table 2). The diurnal antelope ground squirrel (*Ammospermophilus leucurus*) was the third most common species trapped. Although species richness was high, the numbers of individuals of most species supported by their respective habitat types was very low. Certain species, such as canyon mouse (*Peromyscus crinitus*) and desert woodrat (*Neotoma lepida*) occurred in habitat or used habitat features not shared by kangaroo rats, and thus were represented in the trapping results by few individuals. Other species of habitat generalists, such as little pocket mouse (*Perognathus longimembris*) and deer mouse (*Peromyscus maniculatus*) were surprisingly uncommon at all collection sites.

The presence of juvenile kangaroo rats of both species through the summer indicated a prolonged breeding season with the occurrence of secondary litters (Table 1). Estrus and pregnant females in August provided evidence of the production of at least a second litter. Reproduction appeared to be early for *A. leucurus*, with no juveniles captured later than June and less than 10% of all males showing any testicular activity through the summer (Table 2). All male ground squirrels captured in November had testicular swelling, indicative of the early stages of reproductive activity. Evidence of reproductive activity for the remaining species was limited, because of the small sample sizes involved.

Chisel-toothed Kangaroo Rat Distribution

Both species of kangaroo rats were found throughout most of the Houserock Valley, based on presence of visual surface sign and trapping results. Kangaroo rat tracks and scat provided a reliable identification and separation of burrow systems actively used by ground squirrels and woodrats of comparable size. Two general types of kangaroo rat burrow complexes were observed. One consisted of a discrete, raised mound with multiple burrow entrances scattered over and around the periphery. *D. microps leucotis* were always found to occupy that type of burrow complex, hereafter referred to as a mound. The second type was variable and

Table 1. Summary of sex ratio, age structure, and reproductive condition for heteromyid rodents captured in the House Rock Valley, Coconino Co., Arizona. M = Male; F = Female; SCR = Scrotal; EST = Estrus; PREG = Pregnant; LACT = Lactating.

		SEX RATIO/AGE STRUCTURE				REPRODUCTIVE CONDITION			
		ADULT		JUVENILE		MALE	FEMALE		
MONTH	TOTAL	M	F	M	F	SCR	EST	PREG	LACT
				Perognathus longimembris					
JUL 94	5	1	4	0	0	0	0	0	0
AUG 94	6	2	4	0	0	0	0	0	0
				Perognathus parvus					
AUG 94	1	0	1	0	0	0	0	0	0
				Chaetodipus formosus					
JUN 94	17	7	10	0	0	6	0	0	0
				Dipodomys microps leucotis					
JUN 94	7	3	3	1	0	2	0	0	2
JUL 94	25	4	16	1	4	3	0	0	7
AUG 94	81	38	42	0	1	27	3	3	14
NOV 94	1	0	1	0	0	0	0	0	0
				Dipodomys ordii					
OCT 93	8	5	3	0	0	0	0	0	0
FEB 94	10	5	5	0	0	4	2	0	0
JUN 94	2	1	1	0	0	1	0	0	1
JUL 94	34	17	15	1	1	9	0	1	3
AUG 94	146	72	72	1	1	49	4	1	5
NOV 94	12	9	3	0	0	1	0	0	0

Table 2. Summary of sex ratio, age structure, and reproductive condition for murid and sciurid rodents captured in the House Rock Valley, Coconino Co., Arizona. M = Male; F = Female; SCR = Scrotal; EST = Estrus; PREG = Pregnant; LACT = Lactating.

		SEX RATIO/AGE STRUCTURE				REPRODUCTIVE CONDITION			
		ADULT		JUVENILE		MALE	FEMALE		
MONTH	TOTAL	M	F	M	F	SCR	EST	PREG	LACT
				Peromyscus maniculatus					
OCT 93	4	2	2	0	0	0	0	0	0
FEB 94	1	1	0	0	0	0	0	0	0
JUN 94	2	0	2	0	0	0	0	0	0
JUL 94	1	0	0	0	1	0	0	0	0
AUG 94	1	0	0	0	1	0	0	0	0
				Peromyscus crinitus					
AUG 94	1	0	0	0	1	0	0	0	0
				Onychomys leucogaster					
OCT 93	3	1	2	0	0	0	0	0	0
FEB 94	2	2	0	0	0	1	0	0	0
JUL 94	2	1	1	0	0	1	0	0	0
AUG 94	17	11	6	0	0	2	0	0	0
NOV 94	6	3	3	0	0	0	0	0	0
				Neotoma lepida					
JUN 94	2	0	1	1	0	0	0	0	0
JUL 94	1	1	0	0	0	0	0	0	0
AUG 94	2	1	1	0	0	0	0	0	0
				Ammospermophilus leucurus					
JUN 94	12	5	6	1	0	0	0	0	0
JUL 94	22	11	11	0	0	2	0	0	1
AUG 94	17	3	14	0	0	0	0	0	1
NOV 94	5	3	2	0	0	3	0	0	0

dispersed in nature, ranging from a cluster of burrow entrances to widely scattered single entrances connected by well-used trails. When those burrow entrances were clustered, they never achieved a raised, mound configuration. The dispersed burrow complex type was used by *D. ordii*, which also was occasionally trapped at mounds with or without *D. microps leucotis*. Simply being captured at a mound did not necessarily imply active occupation of the mound. Many *D. ordii* released at a mound ran some distance away and entered a dispersed type of burrow system. With experience, it was possible to accurately predict the presence of *D. microps leucotis* simply by the presence of mounds.

The trap response for all rodents was poor, particularly with only a single night at most trapping locations (Appendices 1 and 3). There may be a seasonal change in trap response, with animals more likely to enter traps in the late summer. When selective trapping at blocks of mounds failed to yield any kangaroo rat captures due to inclement weather, an additional night of trapping was performed. A second night generally resulted in the capture of *D. microps leucotis*. With one exception, only a single adult *D. microps leucotis* was captured per mound; several locations in Appendix 3 indicate multiple individuals but those represented locations with separate burrows within 100 m or the presence of an adult and juvenile. It was relatively common to capture multiple *D. ordii* at a specific location which was consistent with the more dispersed nature of their burrow complexes.

The current study found the distribution of *D. microps leucotis* to extend from Badger Canyon in the northeastern portion of the valley to South Canyon Point near the southern extreme of the valley (Appendix 1). Except for the Emmett Hill area, the entire distribution was south of House Rock Wash and Highway 89A in the northern quadrant. North of those lines, *D. ordii* was the sole kangaroo rat occupant. Numerous walking transects were conducted through the area between Badger Canyon and Marble Canyon because of the report of *D. microps leucotis* being captured in this area (3 specimens 1 mile west of Navajo Bridge and 1 specimen one-half mile east of Navajo Bridge; Hardy, 1949). Only *D. ordii* were found north of Badger Canyon. We were unable to find any sign of kangaroo rat occupation at the locations given by Hardy (1949). Likewise, no sign was found north of Marble Canyon towards Lees Ferry.

The occurrence of *D. microps leucotis* was consistent with patterns of plant communities (Appendix 2) and associated soils (Jorgensen, 1991). The species was restricted to shadscale, four-wing saltbush, and blackbrush habitat types. Soils supporting those habitat types were Bison, Curob, Kinan, Monue-Seeg, Pagina, and Pennel series. All were moderate to very deep, average 10-20% gravel, with a moderate to rapid permeability. On U.S. Forest Service lands, the soil types were consistent but were named Lithic and Aridic Ustochrepts (Brewer, 1991). *D. ordii* was found coexistent with *D. microps leucotis* on those soil types although it was not found in shadscale and blackbrush habitats. Other areas occupied solely by *D. ordii* contained Aneth, Clayhole-Torriorthents complex, Monierco clay loam, Monue sandy loam, and Torriorthents-rock outcrop complex soils.

The area north of Highway 89A and the region around Marble Canyon extending to Lees Ferry was dominated by Torriorthents soils which tended to be shallow, have surface and subsurface shales, and contained gypsum. Neither kangaroo rat was found on this latter soil series.

Two areas judged as potentially suitable for *D. microps leucotis* were identified (Appendix 1). The one area north of Badger Canyon (Figure 1.04) represented an island of suitable soil and vegetation separated from the nearest occupied habitat by unsuitable soils and vegetation, and the steep-walled canyon. The other area was situated between House Rock Wash and North Canyon Wash (Figures 1.15 and 1.29). Soils were suitable for occupation but the extant snakeweed habitat appeared to be a result of past agricultural and grazing practices. Apparently, the lessee during the 1960's harrowed this entire area and seeded grasses for livestock grazing, contributing to the current snakeweed habitat type throughout this portion of the valley (D. Mackelprang, personal communication). Some of the soils in the northwest quadrant, particularly near the base of the Kaibab Plateau, appeared suitable although an apparent type conversion to snakeweed habitat has occurred (Figures 2.06, 2.08 and 2.09). No sign of *D. microps leucotis* was found and only *D. ordii* was captured in this region of the valley. Extreme agricultural and grazing activities have occurred in the past and the vegetation represented a type conversion to sparse snakeweed with dense surface covering of grasses, and woody native shrubs absent. That area was extensive and only contiguous to occupied habitat along the southern edge; therefore, that area was not mapped as potentially suitable.

An estimated 73,624 acres of habitat occupied by *D. microps leucotis* was determined from distribution maps (Table 3; see Appendix 1). An additional 4,194 acres were judged potentially suitable for future occupation, not counting the appropriate soils found in the northwestern quadrant of the valley subjected to major habitat type conversion. With respect to distribution by jurisdictional boundaries, the BLM lands contained the majority of occupied habitat. Within the valley proper, approximately half the acreage owned by each of the jurisdictional agencies was occupied by *D. microps leucotis*. Inasmuch as the boundary of the animal distribution and that of Grand Canyon National Park were not exact along the canyon rim above the Colorado River, the minimal acreage that occurs within the park was included in that given for the BLM.

Table 3. Summary of estimated acreages occupied by *Dipodomys microps leucotis* in the Houserock Valley, by jurisdictional ownership.

OWNERSHIP	OCCUPIED	POTENTIAL
Bureau of Land Management	57,073	3,734
U.S. Forest Service	12,301	-
Arizona State Lands	4,250	460
TOTAL	73,624	4,194

Relative abundance of *D. microps leucotis* throughout the occupied portion of the valley appeared to be generally low. Qualitative assessments throughout the valley, based on driving transects along established dirt roads and walking transects perpendicular to the roads, suggested a patchy dispersion of active mounds. Nowhere were mounds abundant. The greatest concentrations of burrows generally appeared in habitats relatively free of serious surface disturbance from agricultural and grazing activity, although well-developed blackbrush did not appear to support large numbers of the species. Areas subjected to increasing disturbance demonstrated a corresponding decrease in frequency of *D. microps leucotis* occurrence. That was particularly pronounced near livestock water sources. Heavily disturbed areas lacking shrubs seemed to account for species absence. As the presence and robustness of shrubs increased, so did the occurrence of active mounds.

DISCUSSION

The collection history for *D. microps leucotis* was summarized in detail by Spicer and Johnson (1988). Prior to initiation of the present survey, only 61 captures had occurred. All but two of those captures were confined to the blackbrush habitat at Emmett Hill, situated in the northcentral, and the shadscale habitat between Badger Canyon and Soap Creek, in the northeastern portion of the valley. The other two captures occurred in four-wing saltbush habitat where North Canyon Wash crosses Buffalo Ranch Road in the southwestern portion of the valley. That dispersion of captures indicated the potential for a broad distribution of the species throughout the valley. However, the paucity of individual captures suggested rarity and possibly patchy dispersion. The collection history and scarcity of known occupied locations have provided ample justification for considering this taxon as a candidate for threatened or endangered status (AGFD, 1988; USFWS, 1994).

The current study reinforced earlier observations that the species prefers saltbush (shadscale and four-wing saltbush) and blackbrush habitats (see Hayssen, 1991 for a review). However, sparse shadscale habitat in the extreme northeastern portion of the valley lacked sign of any kangaroo rat presence. Soils in that area were gypsiferous, shrubs were sparse and widely spaced, and vegetative ground cover was virtually non-existent. The sterile nature of the area appeared due to a combination of factors, primarily related to lenses of mudshales and leaching of toxic chemicals from adjacent cliff materials. The latter appeared to have a rather broad effect between the base of the Vermilion Cliffs and Highway 89A east of Emmett Hill, even when soils were superficially suitable based upon presence of *D. microps leucotis* on similar soils elsewhere in the valley.

The lack of rodent sign in general was striking in the gypsiferous soils between Sevenmile Draw and Navajo Bridge. However, Hardy (1949) reported collecting *D. microps leucotis* in those same soils 0.5 mi west of Navajo Bridge. Trapping effort conducted by Spicer and Johnson (1988) failed to produce the species. No trapping was done in the present survey because no sign of kangaroo rats was found. Coincident with the early trap report west of the bridge, Hardy (1949) also collected an animal identified as *D. microps leucotis* 1 mi east of the bridge. The apparent movement across the bridge has received subsequent attention but no further specimens were ever captured east of the bridge.

I find it extremely difficult to accept that the species formerly occurred in the gypsiferous soils north of Sevenmile Draw when it is conspicuously absent now. Pockets of this soil type elsewhere in the valley likewise are devoid of the species although adjacent soils are occupied, providing further evidence to support the current conclusion.

Earlier survey work in the Houserock Valley was concentrated in the northern and eastern end of the valley (Spicer and Johnson, 1988). Based upon habitat affinities apparent at their trapping locations yielding 10 individuals, they roughly estimated about 45,000 acres of habitat occupied by *D. microps leucotis*. The present study provided greater trapping coverage of the valley yielding 114 individuals. It appeared that approximately 72, 624 acres were occupied, with an additional 4194 acres potentially suitable for future occupation. It should be stressed that the presence within designated occupied acreage was patchy and general abundance appeared to be relatively low.

Trappability of *D. microps leucotis* has been historically low (see Spicer and Johnson, 1988) and low trappability was the rule throughout much of the present survey. The use of Stoddard live traps appeared to yield somewhat better trap results than previous studies (see O'Farrell et al., 1994 for an analytic comparison with Sherman traps). However, many locations trapped for a single night produced no kangaroo rats even when sign was present. Many trap locations demonstrated fresh kangaroo rat sign but neither species were captured (see Appendix 3). Such a situation indicated either trap avoidance or the possibility that a single animal uses multiple burrows and may not have been at that specific burrow on the night of trapping. Regardless, the number of mounds failing to yield a kangaroo rat decreased in late summer indicating a seasonal component in the willingness of kangaroo rats to readily enter a trap on the first night. *D. ordii* did not show the same reluctance to enter a trap. Locations that did not yield kangaroo rat captures the first night and that were trapped for an additional night, generally yielded a *D. microps leucotis*. Failure to trap a kangaroo rat at a mound generally was indicative of use by *D. microps leucotis*.

Burrows of *D. microps leucotis* have been characterized primarily as mounds (see Hayssen, 1991 for a review). Those mounds may range from 30 to over 67 cm high and may be 2 to 4 m in diameter. Mounds contained multiple openings. *D. ordii* burrows have been generally ignored (Garrison and Best, 1990). Hoffmeister (1986) noted that in the Houserock Valley, *D. microps leucotis* burrow entrances were larger than those of *D. ordii*. That would seem reasonable because *D. microps leucotis* is generally 15-30 g larger than *D. ordii*. Spicer and Johnson (1988) found no differences but suggested that insufficient sample size probably accounted for this lack. They also failed to note mounding and felt that location and appearance of burrows were similar for both species. The present study revealed that *D. microps leucotis* does produce mound structures and that these are readily attributable to the species with experience. It can be misleading when both species are captured at a single mound. However, most *D. ordii* captured at mounds did not enter the mound but rather moved some distance and entered single burrows generally at the base of a shrub. It is reasonable that *D. ordii* are simply attracted to the trap and/or bait at a mound but actually maintain their own burrow systems separate from *D. microps leucotis* mound complexes. A similar relationship has been noted betwee *D. spectabilis* and *D. ordii* in southern New Mexico (F.R. Kay, personal communication).

Range wide, both species exhibit differences in soil preferences (see Garrison and Best, 1990; Hayssen, 1991 for reviews). *D. microps leucotis* tends to select soils that have a rocky or gravelly component. *D. ordii*, on the other hand, prefers loose sandy soils. This was evident in the Houserock Valley. Aside from the presence of saltbush or blackbrush, *D. microps leucotis* usually occurred on soils with a surface gravel component. The notable exception was in the blackbrush habitat north of Emmett Hill and Highway 89A. The surface appeared to be a stabilized dune structure. The surface is undoubtedly of aeolian origin but the subsurface soils contain a gravelly structure (Jorgensen, 1991). The mixed shrub areas designated as Ephedra-Yucca habitat contained truly sandy soils, had abundant *D. ordii*, and a total absence of *D. microps leucotis*. In areas which yielded both species of kangaroo rats, fewer mounds were evident and the habitat appeared disturbed by concentrated livestock activity. A subjective trend was noted in saltbush habitats; the less disturbance, the greater the frequency of *D. microps leucotis* mounds, and the fewer *D. ordii* in trapping results.

Rodent species richness was consistent with the habitats sampled in the Houserock Valley (Hoffmeister, 1986). However, overall abundance was lower than expected. Normally, pocket mice (genus *Perognathus* and *Chaetodipus*) are seasonally more abundant than the larger kangaroo rats. Likewise, the ubiquitous *Peromyscus maniculatus* is the most common murid rodent in the same habitats. Although present in this study, these generalists were uncommon. Surprisingly, the generally uncommon *Onychomys leucogaster* was the most abundant murid species. The greater abundance of kangaroo rats may be due to sampling design since the majority of trapping was conducted only at occupied mounds. However, mice and ground squirrels frequently use kangaroo rat burrows elsewhere and would be expected to do the same in the Houserock Valley. Likewise, early trapping using conventional dispersion of traps failed to capture any more murids or pocket mice than mound trapping. Visually, very little small mammal sign was noticed over much of the valley.

The valley may not normally support large numbers of small mammals. However, the evident lack of reproductive activity and recruitment by most species may be indicative of past habitat disturbances or weather related effects. The ground squirrel population appeared to be robust, based on the frequency of sightings and captures. The two kangaroo rat species appeared to be reproductively active when expected. In fact, *D. microps leucotis* appeared to have a second reproductive effort during the present study, normally found only in above average years of vegetation productivity (Hayssen, 1991). It would appear that the kangaroo rats and ground squirrels are more tolerant to livestock disturbance than other small mammal species. At least one species of endangered kangaroo rat (*D. stephensi*) responds positively to certain types of livestock grazing (O'Farrell and Uptain, 1987; O'Farrell, 1990).

D. microps leucotis was accorded candidate status by state and federal agencies based on limited and isolated distribution, and the seeming rarity within the known distribution. The present study documents that the species occupies approximately half the valley (73,624 acres). Most of the unoccupied portions are edaphically and/or vegetationally unsuitable. Approximately 4,200 acres of additional habitat are potentially suitable for future occupation. There is further acreage in the northwestern corner that undoubtedly had past occupation and may have future potential. However, no attempt was made to quantify this acreage because of the extent of vegetative type conversion and intense livestock use. Spicer and Johnson (1988) pointed out that area as the only reasonable corridor connecting the Houserock Valley *D. microps* population with the nearest adjacent subspecies near Fredonia and Kanab. Connections were probably extant during hot, dry interglacial periods. At present, existing vegetation types (e.g., big sagebrush, pinyon-juniper) provided an effective barrier. Based on soil maps (Jorgensen, 1991) and results of the present study, it is possible that a portion of the northwest corner of the valley, along the base of the Kaibab Plateau extending northwards along House Rock Wash, might be suitable for *D. microps leucotis* occupation if a reversion of habitat is possible.

After a detailed analysis, Spicer and Johnson (1988) concluded that of the range of potential threats to *D. microps leucotis*, livestock activity presented the greatest threat to maintaining a viable habitat. They stated that grazing may actually have been more beneficial to *D. microps leucotis* than *D. ordii*, but the present study suggests that habitat degradation caused by past intense livestock use appears to favor *D. ordii*, at least in saltbush habitats. Large scale "habitat improvements" that apparently have occurred through the use of mechanical and habitat type conversion appear to have excluded *D. microps leucotis* from otherwise suitable areas in the snakeweed habitat type north of North Canyon Wash (Figures 1.15 and 1.29) and in the northwest quadrant of the valley (Figures 2.06, 2.08 and 2.09). Therefore, the question of threat and the need for listing this taxon should be addressed in light of results from the present survey.

The species is more widespread in the Houserock Valley than previously determined. Although abundance appears to be low over much of the occupied habitat, numbers do not appear to be as limited as earlier results indicated. Projected threats of development, associated roads, and introduction of house cats do not appear to be significant. The ownership by state and federal agencies provide sufficient protection from most of these possible threats and establishes the vehicle for adequate management efforts. The isolated, and relatively limited size of the taxon's range contributes a very real aspect of vulnerability. Unchecked livestock disturbance could be devastating for the long-term survival of the species. However, critical thresholds of use have not been established.

The present results suggest that *D. microps leucotis* is in a sensitive position but need not be listed by state and federal agencies if proper protection was implemented. Federal and state ownership of the majority of acreage promotes agency examination of any proposed activity that would impinge upon the species. Preparation and implementation of a modest management plan should provide sufficient protection to avoid the necessity for formally listing the taxon. In order to formulate the necessary management plan, certain information is needed. Site specific studies should be implemented to determine the dispersion of the species in different habitat types and establish the relationship between abundance and specific habitat features. By examining the range of currently occupied habitat, it should be possible to establish the relationship between habitat suitability and level of livestock pressure.

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Contact the Arizona Game and Fish Department, Heritage Data Management System (602-789-3618) regarding the appendices to this report.