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STEPHENS' KANGAROO RAT: NATURAL HISTORY, DISTRIBUTION, AND CURRENT STATUS

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ABSTRACT

The Stephens' kangaroo rat was federally listed as endangered in October 1988. Distribution of the species is limited to a portion of western Riverside County and two disjunct areas on either end of the San Luis Rey River drainage in northern San Diego County. The species selects habitat low or lacking in shrub cover, with ground cover dominated by herbaceous annual plants. Dispersion is patchy, and the colonies are recognized by concentrations of burrow entrances which are interconnected by both tunnels and surface runways. The species appears adapted for intermediate seral plant communities and demonstrates colonizing ability along dirt roads. Evidence of a prolonged breeding season suggests a relatively high reproductive potential. The County of Riverside has applied for a Section 10(a) permit to allow incidental take of the species. In accordance, a Habitat Conservation Plan (HCP) is being prepared, detailing critical aspects of the biology and identifying adequate preserve sites. A user fee for land development has been established to finance the HCP program.

INTRODUCTION

The Stephens' kangaroo rat (*Dipodomys stephensi*) is limited in distribution to a portion of western Riverside County, extreme southwestern San Bernardino County, and a portion of northern San Diego County (Bleich, 1977; O'Farrell et al., 1986). Optimal habitat is open grassland in flat or gently rolling terrain, also the ideal topography and soil for such agricultural crops as dryland grains and citrus fruits. Agriculture expanded in the low valley areas of western Riverside County late in the last century and continued unabated until recent decades. Urban expansion has steadily increased near, and more recently on, farm lands. The region is now one of the fastest growing in California.

Agriculture and early urban development accounted for significant loss of optimal habitat. Urban expansion and associated industrial development later encroached upon agricultural land, pushing cultivation to the base of steep hillsides and rock outcrops. Stephens' kangaroo rats have been pushed into marginal habitat by this activity, in many cases into virtually linear strips of such habitat. The demand for new residential and industrial land has reached the point that the marginal habitat, also marginal for building, is in imminent danger of exploitation.

In the past, spot examinations have documented the extirpation of known populations (Thomas, 1973). This trend continues at an alarming rate (O'Farrell and Uptain, 1989); 59% of previously known populations have been extirpated by development. A limited geographic distribution, declining numbers, habitat destruction, and the impending threat of further encroachment by urban and industrial expansion have resulted in state "threatened" and federal "endangered" listings.

Over the past six years, my colleagues and I have examined various aspects of the natural history and behavior of *D. stephensi*, including a detailed study of habitat selection (O'Farrell and Clark,

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1987). Recently, we conducted a range-wide survey to locate and map all existing major populations, assess relative abundance and habitat quality, and evaluate current land use and degree of endangerment (O'Farrell and Uptain, 1989). The purpose of the present paper is to summarize the current knowledge of this sensitive species.

DISTRIBUTION

The current boundaries of Stephens' kangaroo rat distribution are broader than previously thought (Figure 1). The northern border essentially follows Highways 91 and 10 and the western edge follows Highway 15. The southern and eastern limits of the range are not as clearly defined. The eastern border roughly follows a line from a point just west of Banning southward to Aguanga. This artificially delineated eastern border is amoeboid in shape, with finger-like projections of occupied habitat following natural drainages and other linear extensions of suitable habitat. The southern distribution is represented by two disjunct populations, one associated with the western San Luis Rey River drainage and the other adjacent to Lake Henshaw, on the eastern end of the San Luis Rey River.

Prior to the arrival of Europeans, the range of *D. stephensi* undoubtedly was somewhat larger than that just described. The westward extension would have been limited by the Santa Ana Mountains. The southern and eastern distributions

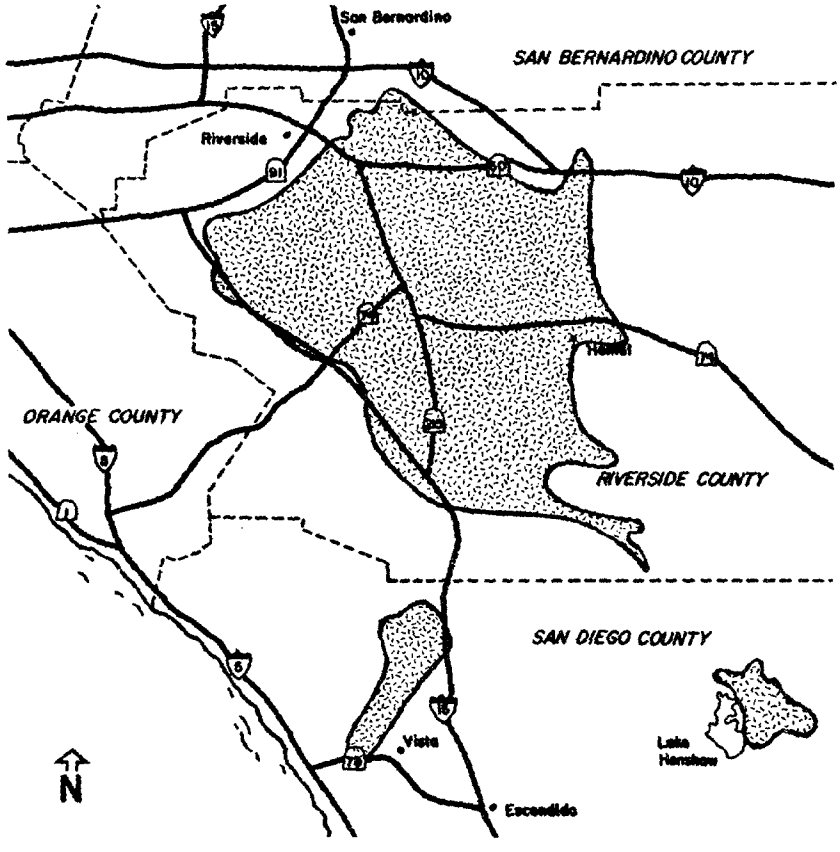

FIGURE 1. The current distribution of Stephens' kangaroo rat

would have been stopped by the change in topography and dominance of sage scrub and chaparral plant communities. The potential for a more expanded range to the north is greater, but the history of past development allows only conjecture as to actual limits of past occupation.

The two disjunct populations in the south are associated with several major drainages that presumably served as past movement corridors. Limited Stephens' kangaroo rat populations are known along Temecula and Wilson Creeks, but the expanse of rugged terrain and unsuitable vegetation from Aguanga to the Warner Ranch precludes this drainage as a viable movement corridor. The present and past known populations associated with the San Luis Rey River drainage appear to be the most likely source of colonization into the Lake Henshaw region. All but a few miles of terrain appears to have been suitable prior to human development. The most reasonable past corridor linking the main body of distribution with the Oceanside area may have been associated with the Santa Margarita River.

NATURAL HISTORY

No intensive, long-term studies have been performed that detail the major aspects of *D. stephensi* ecology. Consequently, much of the biology has been inferred from investigations of other species of kangaroo rats. This may have resulted in erroneous conclusions, because most species are adapted to shrubland habitats, whereas *D. stephensi* is a grassland specialist. Many misconceptions exist, which will be addressed below.

Habitat Selection

The Stephens' kangaroo rat is known as an inhabitant of open habitat (see Bleich, 1977 for a review), which was generally described by Lackey (1967a) and distinguished from that of the shrubland congener, the Pacific kangaroo rat (*D. agilis*). Lackey described a dispersion of the two species that was contiguous yet separate. Later, unpublished theses presented subsidiary information on habitat relationships using quantitative plant techniques suited for shrublands (Bleich, 1973; Bontrager, 1973). Hence, habitat affinity was described in terms of shrub species, with the grassland component completely ignored. Consequently, some biologists specifically, but incorrectly, look for certain shrub species common to the sage scrub plant community as indicators of possible *D. stephensi* presence.

A detailed study of habitat selection revealed that although the species may be found in habitats containing up to 30% aerial shrub cover, more than 75% of occurrences were in habitat patches totally devoid of shrubs (O'Farrell and Clark, 1987). Abundance was also positively related to a lack of shrub cover. However, it is misleading to designate preferred habitat simply as grassland. A strong positive correlation has been found between the proportion of annual forbs and grasses ($r = 0.76$; $0.10 > p < 0.05$; O'Farrell and Uptain, 1987).

In disturbed non-native grassland, two trends are apparent. Initial invasive weedy species are replaced by intermediate seral stages dominated by annual grasses or by annual forbs. Although both are annual, the grasses tend to persist for several years, resulting in the formation of dense mats of dried biomass. Annual herbaceous species disarticulate rapidly after they dry, resulting in substantial patches of bare ground. *D. stephensi* avoids dense grasses and thrives in areas dominated by herbaceous material. Presumably this is due to the presence of a more desirable food resource and the ability to use the specialized bipedal, hopping mode of locomotion in the open areas.

The diagnostic plant species in herbaceous grassland is red-stemmed filaree (*Erodium cicutarium*), which increases under grazing (Rice, 1987). It is not surprising that the most abundant populations occur in habitats receiving substantial grazing pressure. When grazing is reduced or eliminated, grasses increase proportionately. The

population described for the Warner Ranch in San Diego County (O'Farrell and Uptain, 1987) has decreased by approximately 90% over the past three years (O'Farrell and Uptain, unpublished data). Livestock has been changed from mixed Hereford stock to Holstein dairy cattle, grazing pressure has been reduced by half, and bunch grass (*Aristida* sp.) has become a dominant species.

Dispersion

Stephens' kangaroo rat is distributed in patches, even in large, seemingly homogeneous habitats and in the most densely populated areas (O'Farrell and Uptain, 1987). Generally, a patch consists of variously spaced burrow entrances connected by a network of surface runways. Although burrow entrances may be clustered, single entrances are most common (81% occurrence). Size of a patch and abundance of burrow entrances are affected by topography and soil, and vary through time as vegetation changes occur.

Characteristic cleared areas occur at most burrow entrances. These aprons show signs of various activities. Dust baths, small excavations (presumably for seed caches), and piles of plant duff may be found on or adjacent to aprons. Similar cleared areas at some trail intersections may function in social communication, through olfactory cues left from sand bathing. Much of the surface within an animal's home range is unexploited; less than 10% of all digging and foraging occurs more than 1 m from established trails and entrance aprons. This may reflect predator avoidance: the less time spent above ground, particularly when aerial cover is absent, the less the risk of encounter with potential predators.

A unique feature of the patchwork dispersion of burrow entrances connected by surface runways is a corresponding tunnel beneath each trail (O'Farrell and Uptain, 1987). Excavation revealed that entrances are connected by tunnels 21 to 23 cm deep, directly below surface runways and following precisely the twists and bends of these trails. Such an underground network allows safe travel from entrance to entrance without exposing an animal to aerial predators where vegetation provides no cover, or when moonlight heightens the risk of detection. Creation and use of this tunnel system appear specifically adapted to open grassland having limited aerial cover and containing surplus food resources that allow incomplete use of the occupied home range.

The concentration of burrows in discrete patches and the interconnection both above and below ground among burrow entrances suggests that multiple individuals probably use a specific patch. If a number of individuals do use the same burrow complex, then a degree of sociality not commonly attributed to kangaroo rats must exist. Eisenberg (1963) described agonistic behavior in kangaroo rats that suggested a primarily solitary existence. This information has been applied dogmatically over the years to all kangaroo rats, including *D. stephensi*. However, the assumption is not supported by observed dispersion patterns.

The distance between occupied patches varies with topography, vegetation, and soils. However, trace distribution is frequently found between patches, taking the form of one to several burrows not physically connected to the type of patches described above. Although this trace distribution may occur in open grassland, it is most commonly associated with dirt roads and other obvious movement corridors. Disturbed roadsides appear to be the major means of Stephens' kangaroo rat dispersal. All evidence (O'Farrell and Uptain, 1989) indicates that this species has extraordinary colonizing proficiency, due to its ability to exist in linear strips along disturbed roadways. In some cases, such occupied roadsides occur in habitat generally unsuitable for the species.

Stephens' kangaroo rat appears adapted for intermediate seral plant communities. Within the range of the species there is a dynamic habitat mosaic. Natural shrublands are disturbed by fire, grazing, or agriculture and proceed through a series of successional stages. After initial weedy growth, a variety of intermediate conditions develop. When vegetative conditions become ac-

ceptable, colonization by *D. stephensi* occurs as individuals disperse out from occupied patches. This situation is facilitated by trace distribution along roads through marginal or unsuitable habitat.

Reproduction

Like all kangaroo rats, *D. stephensi* has been presumed to have a conservative reproductive strategy, with a mean litter size of 2.5 (Lackey, 1967b) and a single litter per year expected. Reproductive data have been few, but early studies indicated a breeding season in late spring and early summer (Lackey, 1967b; Bleich, 1973; Bontrager, 1973); scrotal males and pregnant and lactating females were found in June and July, whereas juveniles occurred in July and August. However, Bontrager (1973) did note a juvenile as late as December.

More recent information from the technical literature indicates the potential for a prolonged breeding season and multiple litters per year. On 15 February, a pregnant individual was captured adjacent to the San Jacinto River northeast of Sun City; and on 1 March, six scrotal, two pregnant, and three estrous adults were collected with one estrous subadult and a single non-reproductively-active juvenile on Estelle Mountain (O'Farrell et al., 1985). One of the estrous adults contained a fresh copulatory plug.

Over a 3-year period on the Warner Ranch, reproductively active males and females were found in September, June, and February (O'Farrell and Uptain, 1985). Scrotal males were present during each of these months, but the greatest percentage (84%) occurred in February. Likewise, estrous and pregnant individuals were found in each of these months, with only 17% of the females reproductively active in June but 46% active in February.

Long-term, detailed reproductive studies are needed to clarify reproductive potential in *D. stephensi*. However, a generally milder climate than that encountered by most other kangaroo rats and a habitat with abundant food may account for prolonged breeding activity and a potentially higher reproductive rate than that expected for the genus. The non-native grassland in Southern California is generally at peak germination in mid-winter, in response to the onset of the fall rainy season. This fresh production of greens may account for the apparent strong, early reproductive activity.

CURRENT STATUS

Encroachment resulting in harm to *D. stephensi* or its habitat is expressly forbidden by law (USFWS, 1988). The pressures of expanding urban and industrial development in western Riverside County are at odds with the law protecting the species. Economic and political realities dictate that some areas occupied by the species will be lost. One way to accommodate development and still ensure the welfare of the species is to set aside adequate preserve sites.

After the formal federal listing became effective, the County of Riverside assumed the lead role in preparation of a Habitat Conservation Plan (HCP). The HCP is a necessary component of a Section 10(a) permit application to obtain the authorization for incidental take of an endangered species. The HCP will address the location, size, and quantity of preserve sites necessary to ensure the long-term survival of the species. The HCP also must address the means by which designated preserve lands may be obtained. A 3-year study is under way to determine preserve-site needs. Additionally, a county ordinance has been passed requiring all new development within the historic range of the species to be assessed user fees on an acreage basis. These fees are mandated in all unincorporated areas, and participating cities must assess similar fees for development within their boundaries. The fees will finance the HCP program.

In order to provide protection for the species during the preparation of the HCP, an Interim HCP has been prepared and an application for a

Section 10(a) permit submitted to the U.S. Fish and Wildlife Service. The Interim HCP has proposed a number of potential preserve sites throughout western Riverside County (Figure 2). An attempt has been made to include all areas with significant amounts of optimal habitat, so that (1) sufficient geographic variation will exist to maintain the maximum genetic variability possible, and (2) reasonable movement corridors are included to allow gene flow among populations. The Section 10(a) permit will allow limited take of Stephens' kangaroo rat outside the proposed preserve sites. No more than 20% of the total occupied habitat within the HCP area may be subjected to take during the interim period.

The establishment of a viable HCP and adequate preserve sites will aid the survival of Stephens' kangaroo rat. However, continued interest by the public in preserving native ecosystems is essential to ensure that such programs will be successful.

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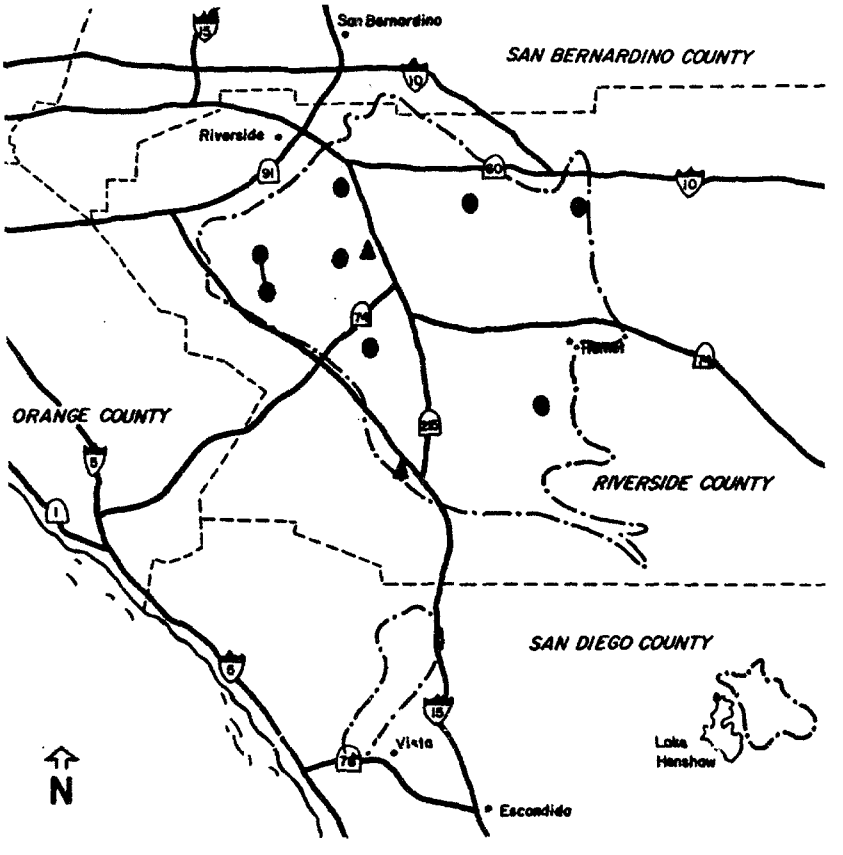

FIGURE 2. The location of proposed Stephens' kangaroo rat preserve sites in western Riverside County. Circles indicate sites encompassing significant acreage. Triangles are small sites containing current protected status (Mott Preserve and Santa Rosa Plateau Preserve).

concerning the biology of Stephens' kangaroo rat. T.M. O'Farrell prepared the maps. F.H. Emmerson, Peter Stine, and Art Davenport kindly provided critical reviews of the manuscript.

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