# Stephens' Kangaroo Rat *Dipodomys stephensi*

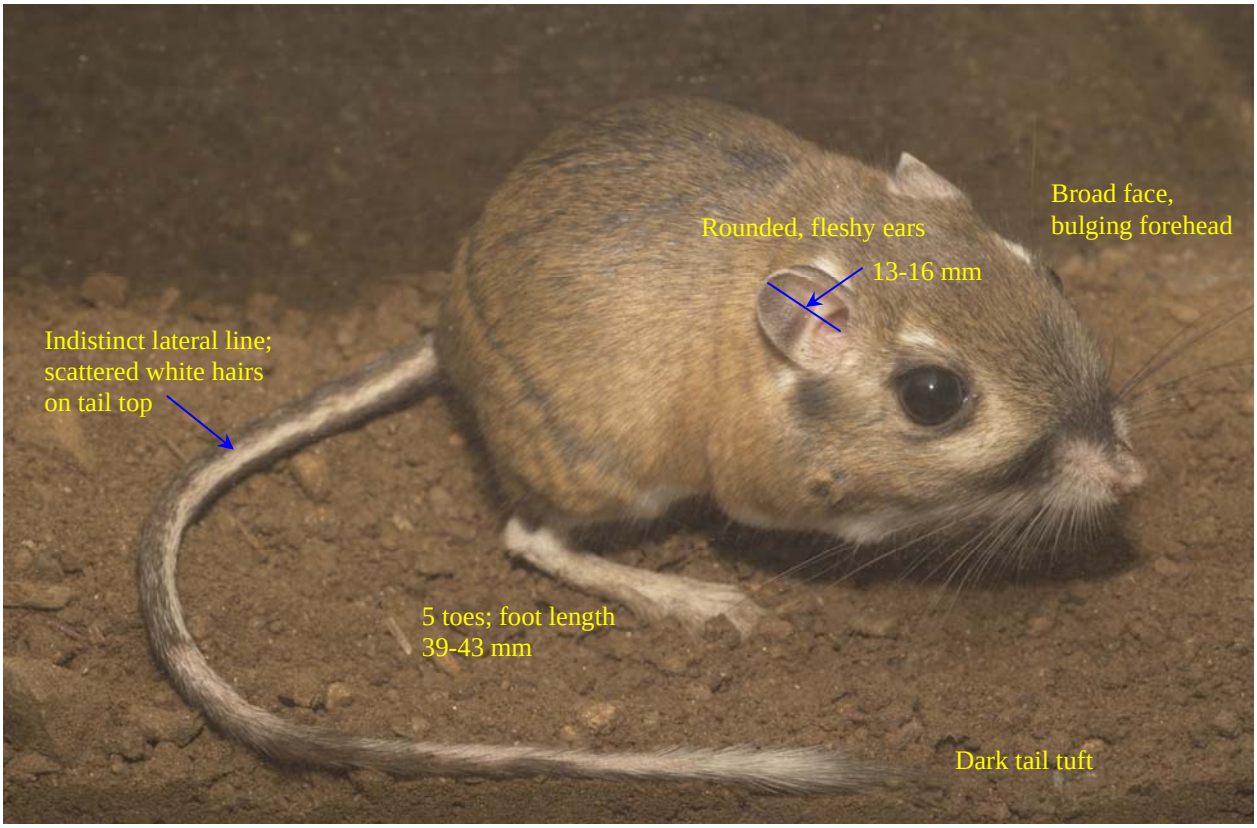


*Photo by Moose Peterson*.

**State of Knowledge**

Taxonomy

Distribution

Ecology

Stephens' kangaroo rat is a rare kangaroo rat of open grasslands or very sparse scrublands. Found primarily in the inland valleys of western Riverside County, Stephens' kangaroo rat is known to occupy a few scattered grasslands in northern San Diego County, particularly on and near Marine Corps Base Camp Pendleton, Fallbrook Naval Weapons Station, Lake Henshaw, Rancho Guejito, and Ramona. All kangaroo rats are **saltatorial** (jumping), nocturnal, burrow-dwelling rodents. True to their name, kangaroo rats have large hind limbs for jumping, small fore limbs, and long, tufted tails for balance. They are well adapted to arid conditions and can survive indefinitely without drinking free water. Their large eyes are adapted for night vision, and their greatly enlarged **tympanic bullae** (ear capsules) provide keen hearing (especially for low-frequency sounds) and may aid in balance when a kangaroo rat is rapidly zig-zag hopping to avoid predators. Like all **heteromyid** rodents, kangaroo rats also have external, fur-lined cheek pouches to transport food items to their burrows or **caches**. Although all kangaroo rat species look superficially similar, experts can distinguish the endangered Stephens' kangaroo rat from other local species by its generally larger size, broader face, less distinctly striped tail, and other subtle differences in coloration and the shape and size of ears, feet, and other features. Their habitat consists of sparse or disturbed grasslands with a high proportion of **forbs** (herbaceous

annual plants), and few if any shrubs, particularly on well-drained and **friable** (easy to dig) soils. They primarily eat seeds, along with some green vegetation and occasional insects.

**Conservation Status**

| Federal | State | County |
|---|---|---|
| Endangered | Threatened | Rare; populations stable or declining |

**Conservation —** California listed the Stephens' kangaroo rat as rare in 1971 and threatened in 1984. The U.S. Fish and Wildlife Service listed it as endangered in 1988 and prepared a draft recovery plan in 1997. As of 2005, a final recovery plan was being drafted based on comments received and new information on the species' distribution and genetics.

San Diego County supports several significant populations, some of which appear stable while others may be declining. Most San Diego populations live in areas not yet conserved or managed as biological reserves. Populations on Marine Corps Base Camp Pendleton and Fallbrook Naval Weapons Station are affected by military training, have no permanent protection, and appear to have declined since the 1990s. Camp Pendleton's integrated natural resources management plan establishes how the base will manage and monitor Stephens' kangaroo rat from 2002 through 2007. The Lake Henshaw population, the largest remaining in the species' geographic range, is primarily on land managed by the Vista Irrigation District and has no permanent protection. The Rancho Guejito population is on private ranch land and has no permanent protection. The Ramona population, discovered in October 1997, is partially protected at the Ramona Airport under an integrated habitat management plan and on some adjacent lands conserved in 2004-05 by the County of San Diego and The Nature Conservancy—but kangaroo rats on other private lands near Ramona are not yet conserved as of 2005. The County of San Diego has emphasized conservation of Stephens' kangaroo rat habitat as a priority of its north county Multiple Species Conservation Program.

**Threats —** The species is threatened by habitat removal and fragmentation throughout its range. In addition, many human actions kill kangaroo rats or destroy or degrade their habitat. These threats include discing for weed abatement, pasture improvement, or farming; irrigation or spraying of sewage effluent on pastures (which saturates soils and makes them unsuitable for burrowing); application of rodenticides and perhaps other poisons; predation by domestic pets, especially housecats; roadkill; and soil compaction by off-road vehicles, horses, and other livestock.

Human development and agricultural expansion have removed an estimated 85% of suitable habitat throughout the species' range. Many historical locations no longer support Stephens' kangaroo rats, and much of the remaining habitat consists of thin strips along roadways or field edges, at the bases of hills, or around rocky areas where discing and farming are difficult. Consequently, Stephens' kangaroo rat populations are scattered, with few large, **core** populations and many small, isolated populations. Isolation increases the risk of extirpation, especially in smaller populations. Fragmentation prevents movement between suitable habitat areas and threatens **genetic vigor** by promoting **inbreeding**. The Ramona population, which has probably been relatively small and isolated for thousands of years, appears to have very low genetic variability and some indications of adverse health effects (including brittle bones, hair loss, and liver abnormalities observed in captive animals).

Stephens' kangaroo rat populations undergo natural fluctuations in distribution and abundance under the influence of climate, fire, and other factors. These fluctuations may make isolated populations more susceptible to extirpation, as they may not have sufficient habitat to allow for natural population expansions and contractions in response to these cycles.

**Description —** The Stephens' kangaroo rat is a medium-sized (average adult weight about 67 g), broad-faced kangaroo rat, with large, 5-toed hind legs (including a small **dew claw**), small front legs, and external cheek pouches. The head appears large relative to the body due in part to the large auditory bullae. The pelage has a cinnamon buff overfur and pure white underfur, with a somewhat indistinct white lateral line on the flank. The tail is bicolored with a somewhat indistinct lateral white line, a long black tuft on the tip, and scattered white hairs on the nearly black dorsal and ventral surfaces (giving them a slightly grizzled appearance).

**Measurements**: Total length 277-300 mm., tail 164-180 mm., hind foot 39-43 mm., ear 13-16 mm.
**Diagnostic characters**: Broad, bulging forehead between the eyes. **Zygomatic arch** (cheek bone, beneath the eyes) as wide or wider than the **tympanic bullae** (the ear capsules below the ears). Indistinct white lateral line on tail and scattered white hairs on top of tail; black tail tuft. 5 toes, including dew claw. Relatively small, rounded, fleshy ears. **Baculum** (penis bone) of male bent at about 45-degree angle.
**Dental formula:** i 1/1, c 0/0, p 1/1, m 3/3, total 20.

**Comparisons —** Although superficially similar to other kangaroo rat species in San Diego County, the Stephens' kangaroo rat can be identified by experts familiar with subtle differences in size, coloration, and shape of various body parts. The Stephens' kangaroo rat is easily distinguished from the Merriam's kangaroo rat, which is much smaller (average 35 g) and has 4 toes on the hind foot (no dew claw).

One other species in the region, the Dulzura kangaroo rat, is closer in size to the Stephens' kangaroo rat, also has 5 toes, and is more difficult to differentiate from them. Compared with the Dulzura kangaroo rat, the Stephens' has a broader, rounder face, which gives it a bulging appearance between the eyes (Photo A). In the hand, a biologist can **palpate** (feel) with the fingers that the face is as wide or wider at the **zygomatic arch** (cheekbones) than at the **auditory bullae** (the large ear capsules at the rear of the skull, behind the eyes and beneath the ears). In the Dulzura (or other "narrow-faced" kangaroo rat species) the zygomatic arch is noticeably narrower than the auditory bullae and the face appears more triangular from the front (Photo B).

The white stripe on the sides of the tail is generally narrower and less sharply defined in Stephens' than in other local species, and the dark hairs on the **dorsal** aspect of the tail are often intermixed with white hairs that are generally lacking in other species. Some individuals captured at the Ramona Airport almost or completely lack the white lateral tail stripe, with nearly the entire tail being black with a salting of white hairs.


**Figure 1.** Face shape of Stephens' kangaroo rat (left) and Dulzura kangaroo rat (right). Note the broader, more bulging shape of the face between the eyes in Stephens' and the more sharply triangular face of the Dulzura. Note also the greater contrast in facial coloration and markings of the Dulzura. Both individuals were captured and photographed at the Ramona Airport. *Photos by Moose Peterson.*

The ears of Stephens' kangaroo rats tend to be rounder, fleshier, and lighter in color (dusky with a pinkish hue) than the ears of the Dulzura kangaroo rat (darker "elf ears"). In males, the **baculum** (penis bone) also varies between the two species when extruded by palpation. The baculum of Stephens' kangaroo rat tends to be thicker with a slight bend (average about 45 degrees and a maximum of about 60 degrees). In contrast, the Dulzura's baculum is thinner and bent at about 90 degrees.

As a final confirmation of species identification, a few guard hairs can be pulled or clipped from the back and examined under a microscope. The hairs of Stephens' kangaroo rats tend to be narrower (12.39$\pm$1.29 µm) than those of the Dulzura kangaroo rat (14.81$\pm$1.70 µm) and have fewer and smaller **medullary cells** across the width of the hair. In the Stephens' kangaroo rat, these cells tend to be oval or rounded and are arranged in regular rows only 1 or 2 cells wide across the shaft of the hair. In the Dulzura kangaroo rat, the medullary cells tend to be more flattened and arranged in irregular rows of 3 or 4 cells.

**Distribution** — The Stephens' kangaroo rat has a very restricted range for a mammal of its body size. Most populations are found in the San Jacinto Valley and adjacent areas of western Riverside County, including the Anza area. Species surveys in recent decades have extended the known range into scattered portions of San Diego County (Figure 2). The Lake Henshaw population was documented by Michael O'Farrell and Curtis Uptain in 1983, and is the largest contiguous population remaining in the species range. During the 1980s this population was estimated at about 14,000 individuals distributed over more than 11,000 acres. Its current size and distribution are not well documented, but it has probably declined since that time.

Stephen Montgomery discovered the Guejito population on private ranch land in 1991 and surveyed its distribution in 2004, finding the population to occupy about 1,219 ha (3,012 ac) and numbering in the thousands to perhaps tens of thousands of individuals. Montgomery also postulated the existence of the Ramona population, and Wayne Spencer confirmed its presence in October 1997. The Ramona population numbers up to perhaps a few thousand individuals on loamy soils centered in the grasslands west and north of the town of Ramona. Preliminary genetic analyses suggest that this and other San Diego populations were probably established by

range expansion from the San Jacinto Valley during a warmer, drier climatic period thousands of years ago, and that they may suffer from reduced genetic variability and vigor due to genetic isolation and perhaps inbreeding.

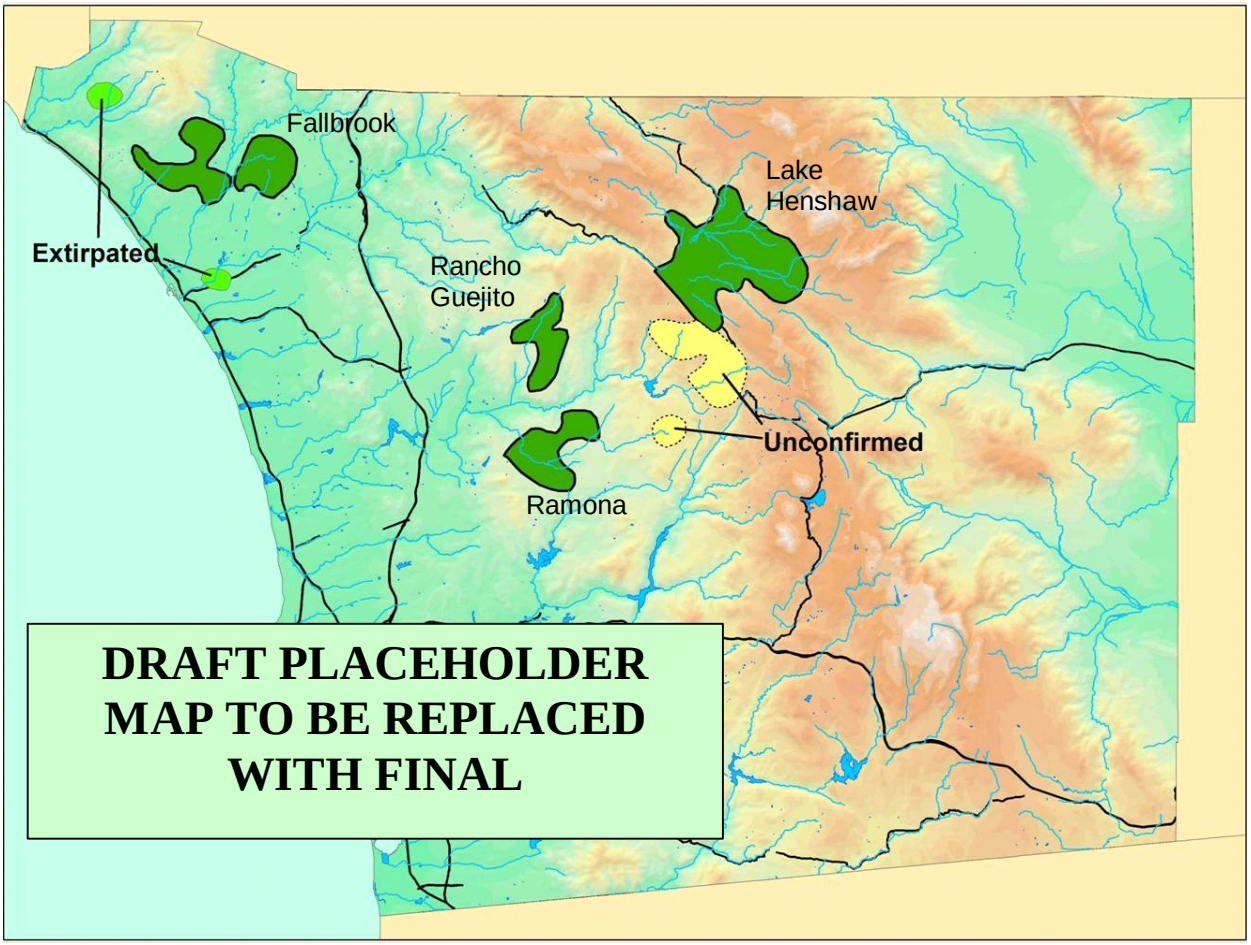


**Figure 2.** Current and historic range of Stephens' kangaroo rat in San Diego County.

The Camp Pendleton population is scattered across active military training areas, and is relatively small and vulnerable to extirpation. The total acreage occupied by Stephens' kangaroo rats there was estimated by Montgomery at about 800 acres in 1996, but may have dropped to less than half that amount by 2002. Adjacent Fallbrook Naval Weapons Station has somewhat larger and more contiguous habitat, but the area occupied there decreased from about 2,760 acres in 1992 to less than 400 acres in 2001.

Stephens' kangaroo rats have been found from near sea level to about 1,250 m elevation (Anza Valley, Riverside County). Moister conditions that favor denser perennial vegetation may limit the upper elevational distribution. Other limits to distribution probably include steep slopes (greater than about 40%) and extensive areas of unsuitable soils (clays, rocks) or dense vegetation (such as chaparral or woodlands).

**Habitat** — Stephens' kangaroo rats are habitat specialists that occupy open grassland or sparse coastal sage scrub with a preponderance of annual forbs, few if any shrubs (less than 30% shrub

cover), and abundant areas of bare ground. Typical habitat consists of both native and non-native forbs, such as filaree (*Erodium* sp.), dove weed (*Eremocarpus setigerus*), tar plant (*Hemizonia* sp.), and goldfields (*Lasthenia* sp.). Dense grass or shrub cover can exclude Stephens' kangaroo rats from otherwise suitable habitat, presumably by interfering with their natural bounding movements and ability to forage efficiently. They are primarily found on friable, loamy soils that facilitate burrowing, and are rarely found on soils high in clay or rock content, which make burrowing difficult, or on very sandy soils, in which burrows tend to collapse. They sometimes use clayey soils near more suitable habitat areas if other rodents (especially ground squirrels or pocket gophers) have created sufficient burrows for kangaroo rats to occupy; but these areas may only be occupied when populations are high and better habitat is fully occupied. Stephens' kangaroo rats tend to avoid steep slopes (greater than about 40%) and seem most abundant on gentle slopes (about 7 to 11%).

**Figure 3.** Stephens' kangaroo rat habitat in the Ramona Grasslands showing effects of grazing. Ungrazed grasslands left of the fence are too dense to support the species, which is abundant in the more open, grazed habitat to the right. *W. Spencer.*

Stephens' kangaroo rats are sometimes described as a **pioneer species**, because they often colonize areas following disturbances that open up the vegetation, such as fire or grazing. They will also readily colonize fallow agricultural fields. Such disturbances create the open conditions kangaroo rats need, and they encourage growth of forb species that serve as favored food sources. Moderate grazing, especially by cattle, can help maintain habitat value for Stephens' kangaroo rat by thinning vegetation, creating areas of bare ground, and promoting weedy forb growth. Overgrazing, especially by horses, can degrade habitat by reducing food sources, compacting soil, and crushing burrows.

Stephens' kangaroo rat habitat value can fluctuate from year to year in response to weather cycles, although patterns are not fully established. In general, population levels increase during summer in proportion to the previous winter's rainfall. Winter rains stimulate growth of food plants and increase reproductive output in Stephens' kangaroo rats. However, prolonged or very heavy rains (e.g., El Niño years) may make vegetation so dense that it interferes with the kangaroo rat's ability to move and forage, especially on finer soils that hold moisture well. Drier periods allow the habitat to open up, but do not produce as much food in the form of seeds and tender vegetation. Stephens' kangaroo rat populations probably respond in complex ways to this interplay between rains, soils, and vegetation.

**Diet —** Stephens' kangaroo rats are **granivores** (seed eaters) that feed mostly on the seeds and young shoots of filaree and other forbs, annual grasses, and some shrubs (including plants in the genera *Artemisia*, *Amsinckia*, *Avena*, *Brassica*, *Bromus*, *Eriogonum*, *Erodium*, *Salsola*, and *Schismus*). Stephens' kangaroo rats also ingest herbaceous forbs and occasional insects when available. They will forage for seeds that they smell on or below the soil surface, and will readily clip seed heads off of low-growing plants. When seeds are abundant, food caches are established within burrows or buried in shallow caches scattered around the home range (based on studies of other kangaroo rat species as well as direct behavioral observations of Stephens' kangaroo rats foraging at the Ramona Airport).

**Reproduction —** Although breeding behavior is not well studied in this species, Stephens' kangaroo rats are probably similar to most kangaroo rats in being generally **promiscuous** (both males and females mating with multiple partners, with no strong pair bonds). Like other kangaroo rats, Stephens' have relatively low reproductive output for a rodent of their size. However, Stephens' kangaroo rats may have somewhat higher reproductive output than most kangaroo rats, because moister conditions in their habitat can prolong the breeding season relative to that experienced in true deserts. Stephens' kangaroo rats typically produce two litters per year, with an average litter of 2-3 pups. The peak of the breeding season is in the late winter and spring, but males may be reproductive throughout the year. Reproduction is positively related to rainfall, but the pattern is not straightforward. Breeding is stimulated by young, green vegetation. In years with higher than average rainfall, Stephens' kangaroo rats may have a longer breeding season, more litters (up to 5 litters in a good year), and the possibility of females breeding in their birth year (as opposed to waiting until they are 1 year old).

Stephens' kangaroo rats are born **altricial** (naked and pink) but in captivity stop nursing by about day 18. Juveniles typically do not move far from their natal burrow, with home range centers about 30 m from their earliest record. However, they are capable of moving more than 400 m.

**Space-Use Patterns —** Even in suitable habitat, Stephens' kangaroo rats may be patchily distributed, with clusters of burrows often separated by unoccupied areas. Stephens' kangaroo rats are good dispersers and are probably capable of colonizing habitat patches hundreds of meters or more from other occupied habitats, so long as there is sufficiently open and gentle terrain to facilitate travel. They often disperse along dirt roads, trails, or the edges of agricultural fields, and readily take advantage of off-road vehicle tracks or large mammal trails through dense grasses that they otherwise tend to avoid. Typically, however, Stephens' kangaroo rats are sedentary (individuals remain in one general locale all their life) and maintain stable home ranges, averaging about 0.2 ha (0.5 ac) for males and 0.1 ha (0.25 ac) for females. Males' home ranges are irregular in shape and tend to overlap one another as well as those of females. In contrast, females' home ranges tend to be more circular in shape with less intra-sexual overlap. Population densities can range dramatically with habitat conditions, with less than 1 individual per ha to more than 8 individuals per ha. Typical densities in suitable habitat average about 2-4 individuals per ha (5-10 per ac) but can exceed 50 per ha (122 per ac) in summer in the best habitats and years.

**Activity patterns —** Stephens' kangaroo rats are primarily nocturnal. Individuals generally emerge shortly after dusk to forage, explore, dust bathe, socialize, and carry out other surface

activities. Most activity is concentrated in the early evening hours, but they may be active at any hour of the night. Stephens' kangaroo rats are active above ground all year round, but time spent outside the burrow may be reduced on cold or wet nights. Like other kangaroo rat species, they may also seem to limit aboveground movements on bright, moonlit nights, which make them more vulnerable to predators. Observations at the Ramona airport suggest that the animals are more active on cloudy nights than on clear nights around the full moon.

**Predators** — Common predators of kangaroo rats include snakes (e.g., gopher snakes, rattlesnakes, and whipsnakes), owls (e.g., barn and great horned owls), loggerhead shrikes, long-tailed weasels, and coyotes. House cats also may be serious predators where habitat areas are near residential development.

Little direct information has been collected on the anti-predatory behavior of the Stephens' kangaroo rat, but other kangaroo rats are known to reduce predation by limiting their activity in bright moonlight and switching activity from open areas to shrub habitat. W. Spencer has observed decreased activity by Stephens' kangaroo rats on moonlit nights at the Ramona airport, and after seeing a barn owl foraging over their habitat. Kangaroo rats escape predators by **richochetal** locomotion (explosive zig-zag hops) upon detecting low frequency sounds made by predators (such as air movement created by owl wings) or smelling snake odor. They may also confront snakes by **foot drumming** or kicking sand at the predator. They rapidly plug their burrows with dirt from the inside when they feel threatened.

**Behavior —** Stephens' kangaroo rats are generally solitary, although burrow-sharing is common. Adult males and females probably only come together for reproduction. Although not yet documented for the Stephens' kangaroo rat, some kangaroo rats communicate their individual identities to other by foot drumming "signatures" and scent deposition at sand-bathing sites. Sand bathing is an important behavior in many rodent species, especially those adapted to arid conditions. Rubbing the body through fine, powdery, sands, and then grooming, removes excess grease from the hair and may control **ectoparasites** (ticks and mites). Sand bathing also marks the location with the animal's scent, which is probably important to social communication and helps maintain social spacing systems.

Stephens' kangaroo rat is aggressively dominant over the slightly smaller Dulzura kangaroo rat where they occur in close association. This aggression presumably allows Stephens' kangaroo rats to occupy their favored open habitats, restricting the smaller Dulzura species to denser and less ideal shrub habitats.

**Sign —** Sign of Stephens' kangaroo rats is fairly obvious and diagnostic where populations are dense, but can be very difficult to discern when populations are sparse or ground cover is dense. Sign surveys (searching for burrows, trails, and scats) are best done in summer or early fall, when vegetation is most dry and open. To the trained eye, the burrow and trail systems have somewhat different characteristics from those of other local species of kangaroo rat, although sign alone cannot be used to confirm which species is present in an area. Each Stephens' kangaroo rat generally occupies a burrow system having on average 4 to 6 entrance holes connected by trails (Figure 4). These trails often mirror underground tunnels that connect the surface entrances. The entrance holes tend to be quite round, about 5 to 7 cm in diameter.

Entrances may be larger where the kangaroo rat took over an existing ground squirrel burrow, or where gradual erosion of the burrow enlarges it. The species often clears vegetation and other obstructions from around the entrance, out to about 15 to 30 cm radius. Aprons of soil may be pushed out from the mouth of the burrow. To deter predators or to maintain a suitable **microclimate** within their burrows, kangaroo rats will sometimes plug burrow entrances from the inside by pushing dirt up from below. The Stephens' kangaroo rat will occasionally clean old seed chaff, loose soil, and other debris from their burrows, pushing them into small piles outside the entrance hole. One may often find evidence of such "house cleaning" after rain. Other local species of kangaroo rats may conceal burrow entrances beneath shrubs, use trails less habitually, and may not groom the surrounding area as meticulously as Stephens' kangaroo rats.

Figure 4. *Top*: Typical Stephens' kangaroo rat burrow, showing round, clean entrance and a portion of the dirt apron. Note 8-cm-long pocketknife for scale.

*Bottom*: Two burrow entrances joined by a trail and probably connected underground. Both photos from Ramona Grasslands. *Wayne Spencer*.

**Research Needs**

- Basic natural history and behavior
- Genetics and effects of small, isolated populations
- Populations trends and cycles and relationships to management actions

*Authors: Wayne Spencer, Stephen J. Montgomery, Philip Behrends*

**Further Reading**

U.S. Fish and Wildlife Service. 1997. Draft recovery plan for the Stephens' kangaroo rat. Region 1, Portland, Oregon.

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