Stephens' Kangaroo Rat Survey

and

Management Recommendations

for the

Santa Ysabel Open Space Reserve
San Diego County, California

Prepared by

Wayne D. Spencer, Ph.D.

815 Madison Avenue

San Diego, California 92116

Prepared for

The Nature Conservancy

3033 Fifth Avenue, Suite 105

San Diego, California 92103

August 2002

Introduction

The endangered Stephens' kangaroo rat (SKR; *Dipodomys stephensi*) is restricted largely to the San Jacinto Valley and vicinity in western Riverside County, but San Diego County supports a few scattered populations. The sparse grasslands this species requires are already rare in San Diego County, and remaining grasslands are increasingly threatened by development. Most potential habitat on private lands in San Diego County has never been surveyed for SKR, so additional populations may exist. Even currently unoccupied habitat may be essential to maintaining and recovering populations of this rare species by providing dispersal corridors and areas for population expansion.

Grasslands in and near the Santa Ysabel Valley, in central San Diego County, appear to have strong potential to support SKR, and may play an important role in long-term species viability by maintaining habitat connectivity between known SKR populations. The Nature Conservancy (TNC) recently purchased for open space preservation two properties that include grassland habitat along the edges of the Santa Ysabel Valley. These properties, formerly comprising the Edwards Ranch, are to be managed by the County of San Diego as the Santa Ysabel Open Space Reserve (SYOSR). During October 2001, Wayne Spencer (CBI) and Stephen J. Montgomery (SJM Biological Consultants) performed a reconnaissance survey for the presence of kangaroo rats on the two SYOSR properties (East and West). Our intent was to record signs of kangaroo rats, which would then trigger a trapping survey to capture individuals and identify them to species—endangered SKR versus other kangaroo rat species (*D. simulans* or *D. agilis*). This report summarizes the biology of SKR, its known and potential distribution in San Diego County, and the results of the October 2001 reconnaissance survey. It also makes recommendations for future surveys and management actions on the SYOSR.

Stephens' Kangaroo Rat Biology

The Stephens' kangaroo rat is a rare heteromyid rodent of open grasslands or very sparse scrublands. Found primarily in the inland valleys of western Riverside County, SKR are known to occupy a few scattered grassland areas in northern San Diego County, particularly on and near Marine Corps Base Camp Pendleton, Fallbrook Naval Weapons Station, and near Lake Henshaw, Rancho Guejito, and Ramona. They may occupy other areas of the county that have not been sufficiently surveyed, such as the Santa Ysabel Valley. This section describes some pertinent aspects of the species' biology in San Diego County. Appendix A details additional information.

General Biology—Kangaroo rats are saltatorial (jumping), nocturnal, burrow-dwelling rodents. The SKR is generally larger than other kangaroo rat species it co-occurs with. Although all kangaroo rat species look superficially similar, the SKR can be distinguished from other local species by generally larger body size, broader face, less distinctly striped tail, and other subtle differences in coloration and the shape and size of ears, feet, bacula, and other features. SKR 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. They are highly evolved to survive arid conditions and can persist indefinitely without drinking free water. True to their name, kangaroo rats have large hind limbs for jumping, small fore limbs, and long, tufted tails for balance. 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 animals are rapidly zig-zag hopping to avoid predators. Kangaroo rats, like other heteromyid rodents, also have external fur-lined cheek pouches to transport seeds.

Conservation Status—California listed the SKR 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. A Final Recovery Plan is currently being drafted based on comments received and new information on species distribution and genetics. An SKR technical team is currently discussing the potential role that the recently discovered Ramona population, and other potentially occupied areas in the county, may play in species recovery. These areas were not considered in the Draft Recovery Plan, because they were outside the species' known range at the time.

The IUCN Red List classifies SKR as Lower Risk, Conservation Dependent (O'Farrell 1998). This assignment presumes that the species is at relatively low risk of extinction in the near future so long as the Riverside County SKR Habitat Conservation Plan provides sufficient preserve sites and will be fully implemented. However, adequate management and monitoring programs have not yet been systematically designed or implemented over the species' range, making attainment of these goals uncertain; and many remaining populations are outside of habitat reserves and subject to extirpation. The Draft Multiple Species Habitat Conservation Plan for Western Riverside County proposes additional conservation of the SKR in at least two areas that were not included in the SKR Habitat Conservation Plan (P. Behrends, personal communication). Whether these areas will actually be conserved and managed to benefit the species is uncertain.

No Habitat Conservation Plans yet cover the SKR in San Diego County. Populations on Marine Corps Base Camp Pendleton and Fallbrook Naval Weapons Station are affected by military training activities and receive little protection or active habitat management. The Lake Henshaw/Warner Springs population is primarily on land managed by the Vista Irrigation District, and although recent observations indicate the population is still large and well distributed, no detailed population studies have been performed since the 1980s. The Rancho Guejito population is on private ranch land, and its current population status is unknown. The Ramona population, discovered in October 1997, is partially protected at the

Ramona Airport under an Integrated Habitat Management Plan (Federal Aviation Administration, 2000), but largely unprotected on surrounding private lands.

Threats—The SKR is threatened by habitat removal and fragmentation throughout its range. In addition, many human land uses and actions kill individual kangaroo rats or destroy or degrade their habitat. These threats include discing for weed abatement, pasture improvement, or dry farming; irrigation or spraying of sewage effluent on pastures; application of rodenticides and perhaps other pesticides; predation by domestic pets; over-grazing by livestock; and soil compaction by off-road vehicles, horses, and other livestock.

Human development and agricultural expansion have removed an estimated 60% (based on 1984 data for Riverside County only; Price and Endo 1989) to 85% (2001 estimate by P. Behrends, personal communication) of suitable habitat in the species' range. Many historical locations no longer support the species, and much of the remaining habitat consists of thin strips along roadways, at the bases of hills, or around rocky areas where discing and farming are difficult. Consequently, SKR populations are very scattered, with few large core populations and many small, isolated populations. Isolation increases the risk of extirpation, especially in smaller populations. Habitat fragmentation prevents movement between patches and threatens genetic vigor by promoting inbreeding. It also prevents colonization or recolonization of unoccupied but suitable habitat areas.

A variety of evidence suggests that the Ramona population has extremely low genetic variability and that individuals may suffer adverse health effects from inbreeding. An analysis of mitochondrial DNA samples from about 12 SKR captured near Ramona found no genetic variation (A. Metcalf, personal communication). A population of 45 SKR was salvaged prior to construction at the Ramona Airport, held in captivity for 6 months, and then released into a fenced and improved habitat area. The captive population suffered a variety of unusual and unexplained health abnormalities before their release (e.g., spontaneous bone breakage, hair loss, and sudden death associated with liver abnormalities). Although the stress of captivity undoubtedly contributed to these conditions, the captive conditions were identical to those used for SKR and other kangaroo rat species in the past with no such problems (M. O'Farrell, P. Behrends, P. Kelly, S. Montgomery, M. Price, personal communications, and W. Spencer personal observations). Moreover, 2 Dulzura kangaroo rats held simultaneously with the 45 SKR showed no ill effects. The Ramona population also has some unusual color variations, including individuals with almost no white in the tail. Discussions are currently ongoing with the US Fish and Wildlife Service and other biologists concerning implications of this potential population genetic problem for species recovery and SKR conservation in San Diego County.

Distribution in San Diego County—The SKR has a very restricted range for a rodent 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.

The Lake Henshaw population was discovered by Michael O'Farrell and Curt Uptain in 1983, and is the largest in the county (estimated at about 14,000 individuals on 11,370 acres of occupied habitat by O'Farrell and Uptain 1989). The size and distribution of the population have not been systematically studied in recent years, and biologists suspect that the population has decreased since the 1980s (S. Montgomery, personal communication). However, recent observations by W. Spencer, S. Montgomery, and D. Grout suggest that the population is still large and well distributed in the Lake Henshaw/Warner Springs grasslands.

Stephen Montgomery discovered the Guejito population on private ranch land in 1991. It's size and current status are unknown, but available habitat is considerably smaller than the area at Lake Henshaw.

Stephen Montgomery and Wayne Spencer discovered the Ramona population in October 1997 (Ogden Environmental and Energy Services 1998). This population numbers in the hundreds to perhaps a few thousand individuals on loamy alluvial soils centered in the grasslands west of the town of Ramona. Preliminary genetic analyses indicate that this and other San Diego populations are derived from the larger populations to the north and contain only a fraction of their genetic variability (A. Metcalf, unpublished data). These small, derived populations were probably established by range expansion from the San Jacinto Valley during a warmer, drier climatic period thousands of years ago, and may currently suffer from reduced genetic variability and vigor due to genetic isolation and perhaps inbreeding.

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 Steve Montgomery at about 800 acres in 1996, but may have dropped to less than half that amount by 2002 (Montgomery et al. 1996, and S. Montgomery, personal communication). Adjacent Fallbrook Naval Weapons Station has somewhat larger and more contiguous habitat areas, but occupied acreage there decreased from about 2,760 acres in 1992 to less than 400 acres in 2001 (S. Montgomery, personal communication). However, D. Grout and S. Montgomery (personal communications) suspect that this apparent reduction may be due in part to different survey methods used between these two times.

Other grasslands in San Diego County have not been surveyed for SKR. The Santa Ysabel Valley represents one of the largest remaining grassland areas in the County. The Santa Ysabel grasslands lie only about 4 km from occupied habitat at Lake Henshaw. Moreover, based on topography, the Santa Ysabel Valley appears to be a potential "stepping stone" between the Lake Henshaw grasslands and the Ramona grasslands. Thus, evidence suggests that there is a likelihood of SKR living now, or at least in the past, within the Santa Ysabel Valley.

Population Genetics—Although the genetics results are preliminary, they are consistent with an hypothesis that SKR expanded south into San Diego County about 9 or 10 thousand years

ago via two broad avenues: a western expansion from the Temecula area of Riverside County into the Pendleton/Fallbrook/Guejito areas (north and west of the San Dieguito River Valley) and an eastern expansion into the Lake Henshaw and Ramona areas from the Anza area of Riverside County. The Ramona population has the lowest genetic variability of any population tested, and is most closely related to the Henshaw population (about 5 nucleotide step changes; A. Metcalf personal communications and Metcalf et al. 2001). Thus, evidence suggests that the Ramona population was derived from the Henshaw population thousands of years ago, independently of the Guejito population, which seems more closely related to the Pendleton/Fallbrook populations. This evidence also supports the hypothesis that grasslands lying between Henshaw and Ramona might currently, and probably formerly, supported SKR. The reduced genetic variability in all southern populations of SKR (as opposed to much higher variability in the central and northern portions of the species' range) are consistent with a "bottleneck dispersion" model of SKR population expansion towards the south during a drier interglacial period 9 or 10 thousand years ago.

Habitat Requirements—SKR 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 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 this species from otherwise suitable habitat, presumably by interfering with the species' natural bounding movements and its ability to forage efficiently. SKR are primarily found on friable, loamy soils that facilitate burrowing. They 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 there are sufficient burrows created by other rodents (especially ground squirrels or pocket gophers) that they can use.

SKR have been found from near sea level to about 1,250 m elevation in grassland and sparse scrublands. Moister conditions that favor denser perennial vegetation may limit the upper elevational distribution. Although occasionally found on slopes approaching 45% (A. Davenport, personal communication), SKR tend to avoid slopes greater than about 39%, and seem most abundant on slopes of 7 to 11% (Bleich 1973, Moore-Craig 1984, Price and Endo 1989).

Study Area and Methods

The two SYOSR properties (SYOSR East and West) lie on either side of State Route 79, generally north of State Route 78, near Santa Ysabel, San Diego County, California (Figures 1 and 2). The West property lies at about 2,700 to over 3,400 feet (823 to 1,036 m) elevation and supports a mosaic of oak woodland, chaparral, and native and nonnative grasslands. The southern-most portion of this property along State Route 78 appears to have some potential to support SKR (Area A on Figures 1 and 2). This area is mapped mostly as foothill/mountain perennial grassland, but has a high proportion of non-native annual forbs mixed in. Most of this area has stony, fine sandy loam soils, although lower-lying areas tend to have high clay content, and some portions have fairly deep, fine sands.

The SYOSR East property lies at about 1,900 to 4,200 feet (580 to 1,280 m) elevation and is covered with a mosaic of oak woodlands, native and nonnative grasslands, and riparian woodlands and scrubs. Two portions of the east property were considered to have some potential to support SKR: a lower area, at about 2,000 feet (610 m) elevation along State Route 79, that supports nonnative, annual grassland on fine sandy loam soils (Area B on Figures 1 and 2) and an upper area in the eastern half of the property, at approximately 4,000 feet (1,220 m) elevation, that supports foothill/mountain perennial grassland on coarse sandy loam soils (Area C on Figures 1 and 2). Cattle have grazed both areas under former ownership. Some cattle continue to sporadically graze the eastern area when they enter through deteriorated fencing from adjacent Native American property (S. Morrison, personal communication).

Field Reconnaissance—These three areas (two on SYOSR East and one on SYOSR West) were surveyed for diagnostic sign of kangaroo rats (burrows, scats, trails, etc.) on October 17, 2001. Wayne Spencer and Steve Montgomery walked essentially all habitat considered suitable for supporting SKR, with special attention to open areas dominated by annual forbs and grasses, on gentle slopes, and having deep sandy loam soils. Conditions were highly conducive to detecting kangaroo rat sign. Vegetation had sufficiently dried and thinned throughout the summer to where bare soils, rodent burrows, trails, scats, dust baths, and other signs of occupancy would be highly visible if present. Observations in occupied SKR habitat at the Ramona Airport during the same period (mid October 2001) confirmed that kangaroo rat sign was very obvious and easy to detect at this time, as it was throughout much of the summer and fall there. Kangaroo rats in Ramona (at about 1,400 feet elevation) were very active and abundant during October, due at least in part to a particularly good reproductive year following heavy, late, spring 2001 rains.

Habitat Evaluation Model—W. Spencer has prepared and refined a habitat evaluation model for SKR based on vegetation, soils, and slope. He first developed an early version of the model for the Santa Maria Valley (Ramona area) in 1998, shortly after he and Steve Montgomery first discovered the Ramona SKR population. He later expanded and refined this model as part of conservation planning efforts for the North San Diego County MSCP plan, which has targeted SKR as a priority species for reserve design. This version of the model was reviewed in 2001 by

an independent scientific advisory panel, which includes Dr. Patrick Kelly, a recognized authority on SKR and other kangaroo rat species. Most recently, this model was expanded to cover the entire county for purposes of depicting the known and likely distribution of SKR in the county. This was done as part of The Mammals of San Diego County project, a collaborative effort to update information on all San Diego mammal species. Expert opinion and limited field reconnaissance is currently being used to edit the resulting county-wide map to show all known SKR populations and other habitat areas likely to support SKR. The current draft of this SKR distribution map is included in Appendix A and was used in preparing this report.

The following factors were combined to create the SKR model:

1) **Soils.** Soils were ranked as having High, Medium and Low potential to support SKR based on physical soil characteristics as described in the San Diego Area Soil Survey (USDA 1973). SKR generally require well-drained soils that allow easy burrowing to at least about 24" or as deep as 46". The soil must also be able to support a burrow (e.g., pure sands collapse too easily). The soil rankings considered the full description of soil attributes, with a bias to potentially over-representing soil value to SKR for soil types having highly variable characteristics (i.e., leading to potential errors of commission rather than omission). The following general guidelines were used in assigning value to each soil type in the study area (a full listing of ranks is available upon request):

   High: Generally, any deep to very deep loamy soils (including sandy loams, loamy sands, loams, and silt loams that are generally deeper than about 32") with relatively low gravel, rock, or cobble content, and that are friable and not often saturated.

   Moderate: Generally, soils that don't quite qualify as high due to higher potential for saturation or impediments to burrowing, such as loamy soils that are moderately deep (about 16-32") or that have hard subsoils. Soil types in a soil series otherwise classified as High were decremented to Moderate if they have "very high" rock, cobble, or gravel content. Soil series otherwise ranked as Low, but having potential "inclusions" of deep, friable loams, were incremented to Moderate.

   Low: Non-loam soils (sands, clays, silts) or otherwise "very hard" soils (e.g., some clay loams or sandy clays that are classified as very hard or extremely hard); shallow or very shallow soils (less than 12" to a very hard subsoil or 16" to an impenetrable layer); soils in floodplains subject to periodic inundation; or predominantly unsuitable soils that may have smaller inclusions of suitable soils (e.g., clays with occasional sandy loam hillocks).

   None: All non-suitable soils or non-soil surfaces, including rock quarries, tidal flats, open water, gravel pits, etc.

2) **Vegetation.** SKR are strongly associated with open grasslands or very sparse coastal sage scrub. They are a pioneering species that may invade fallow agricultural fields

or the edges of active agricultural areas (such as cattle pasture or edges of row crops). Vegetation was therefore ranked for SKR as follows:

High: Grasslands (includes both native perennial and non-native annual grasslands, which are not differentiated in the vegetation database).

Moderate: Most Extensive Agriculture (includes row crops, pastures, fallow lands, etc.). Extensive agricultural areas on highly suitable soils may rank high.

Low: Coastal Sage Scrub (most coastal sage scrub in the study area is likely too dense to support the species, although SKR may occupy openings in coastal sage scrub or invade following disturbances, such as fire).

None: All other vegetation communities, developed lands, or intensive agriculture (greenhouses, orchards, etc.).

3) **Slope.** Gentler slopes (less than 30%) were ranked as high, and slopes over 30% as low. Although SKR may sometimes occupy steeper slopes, they are most abundant on gentler slopes and seem to prefer slopes less than about 11%.

All possible combinations of soils, vegetation, and slope rankings were assigned a value of Very High, High, Moderate, or Low in the following matrices. Grasslands on high quality (deep loam) soils and gentle slopes rank Very High. As with most burrowing rodents, habitat suitability falls off quickly with decreasing soil suitability; and quality falls off as vegetation becomes denser or slopes steeper. The intent of the model is to differentiate those areas most capable of supporting SKR populations over the long term, and thereby most important to species conservation. This model is therefore not overly conservative (as it should be if the intent were to predict possible occurrence of SKR for regulatory reasons). The model might predict low or no habitat value on some areas that actually support small numbers of SKR in some years. For example, although it is possible some SKR occur in the study area on steep coastal sage scrub slopes having clay loam soils (e.g., along road berms), these should not be considered priority conservation areas for SKR relative to more open, gentle grasslands on deep loams.

On the other hand, it should be noted that available soils and vegetation maps are fairly coarse relative to the scale at which SKR select habitats, and contain some inaccuracies. For example, there is a great deal of variation in the physical soil characteristics within a polygon mapped as a single soil series or type. Soil types that generally are not very good for SKR may have inclusions of high quality areas (e.g., pockets of deep sandy loams within otherwise heavier clay loams); and soil types that are generally good for SKR may contain large, unsuitable areas (e.g., where erosion has removed deeper loams). Thus, assignment of value to specific soil types was generally very conservative, tending to over-rate rather than under-rate some soils types. Field verification of on-the-ground soil and vegetation attributes is essential to determining actual SKR habitat potential. The model predictions were therefore investigated and field verified for the SYOSR properties. In addition we looked at

specific soil attributes on the properties to more specifically address their suitability for providing SKR habitat.

Table 1
SKR Habitat Suitability Rankings

<30% slope

	Soil Suitability			
Vegetation Type	**High**	**Moderate**	**Low**	**None**
Grassland	Very High	Moderate	Low	None
Extensive Agriculture	High	Moderate	Low	None
Coastal Sage Scrub	Low	Low	None	None
Other	None	None	None	None

>30% slope

	Soil Suitability			
Vegetation Type	**High**	**Moderate**	**Low**	**None**
Grassland	Moderate	Low	None	None
Extensive Agriculture	Low	Low	None	None
Coastal Sage Scrub	Low	Low	None	None
Other	None	None	None	None

Results and Discussion

Habitat Value—All three areas we surveyed in the field were predicted to be of high habitat value by the SKR habitat evaluation model (Figure 3). Field observations confirmed that the two areas that are within or adjacent to the Santa Ysabel Valley (Areas A and B on the Figures) both appear to have very high habitat value for SKR. In contrast, the higher elevation perennial grasslands on SYOSR East (Area C) do not appear suitable to support SKR. In general, soils in that area seemed too hard and compact to be ideal for SKR, with a relatively high stone and clay content. The elevation there (about 4,000 feet) is also at the upper limits at which SKR have been previously detected (about 3,600 to 4,100 feet at Anza Valley; Montgomery personal communication). We found little evidence of burrowing rodents in those upper elevation grasslands and no sign of kangaroo rats. Thus, although the habitat model predicted Area C to be of high SKR habitat value, field reconnaissance suggests this area has little potential to support SKR.

Soils—The soils in the Santa Ysabel Valley in general, and on Areas A and B of the SYOSR properties, are generally excellent in terms of their physical characteristics to support SKR. The predominant soils in the Valley (including Areas A and B) are from the Holland series, which seem ideal for SKR, and the Crouch series, which also seems highly suitable. Holland series soils are well-drained, moderately deep and fine sandy loams that formed from weathered micaceous schists. Holland types on gentler slopes, and in particular the deeper deposits that form in gentle valley bottoms, are physically ideal for providing SKR habitat. These fine sandy loams are very friable and hold burrow structures well, and they are well enough drained that they tend to support fairly open, forb-dominated vegetation that dries and disarticulates early in the summer. Holland series on steeper slopes seem less suitable, generally being shallower and rockier and supporting more oak woodland vegetation.

Crouch series soils have a coarser sand component than the Holland series, but are also well-drained, deep to moderately deep, and formed from weathered acid igneous rock and micaceous schists. The Crouch series seems slightly stonier and rockier than the Holland soils in the study area, and may contain more clay. For example, the Crouch coarse sandy loam soils mapped in survey area C seemed quite hard and compact, and not well suited to burrowing by SKR. Much of the area mapped as Crouch series soils are forested with oak or pine woodlands or chaparral.

Other soils in the study area that seem suitable for SKR (but occur less abundantly) include Reiff fine sandy loams, Calpine coarse sandy loams, Las Posas fine sandy loam, and loamy alluvial land. Sheephead rocky fine sandy loams are abundant on steeper, higher slopes that tend to be forested with oaks and pines, and seem generally unsuitable for SKR.

Sign Survey—Although both properties appear to have some areas of very high habitat value to support SKR, no kangaroo rat sign was detected during the 2001 field reconnaissance. In contrast, during March 2000, W. Spencer noted a potential burrow and one kangaroo rat scat in Area B

during a brief reconnaissance with TNC staff. Careful searching of this area during 2001 failed to reconfirm any sign there. This is in spite of the fact that the 2001 survey was done during a more favorable season for detecting kangaroo rat sign. Late summer-early fall surveys usually reveal more sign due to higher population densities in the post-reproductive season, more open vegetation, and a longer period for sign to build up after the rains end. In addition, SKR populations were significantly higher in 2001 than 2000 at the Ramona Airport, due to a prolonged reproductive season in 2001 that was triggered by late spring rains. All of this suggests that the chances of detecting kangaroo rats during the October 2001 survey should have been high, if any kangaroo rats were present. However, a general impression of our 2001 survey was that the sites had remarkably sparse sign of *any* rodents, including ground squirrels, deer mice, and pocket gophers. Although we have no data to support or refute any particular hypothesis explaining this observation, similar observations have been made in portions of the Ramona Grasslands on or near properties where rodenticide use was observed or suspected (M.O'Farrell and D. Bittner, personal communications).

Due to lack of any sign of kangaroo rat occupancy during 2001, Spencer and Montgomery advised The Nature Conservancy that trapping this year would not be fruitful, as it was highly unlikely to capture kangaroo rats. In our professional opinion, no SKR were present on the SYOSR properties during 2001, although it is highly likely they have occurred there in the past. SKR may still occur on other private properties in the Santa Ysabel Valley, and they could possibly colonize the SYOSR in the future.

During 2003 surveys by Hathaway et al. (2004), a USGS remote camera captured 8 photos of kangaroo rats at 2 camera locations (Cameras 3 and 4) on the west property. Six of the photos were taken at Camera 3 within a single 1-hour period (G. Turschak, personal communication), and were probably the same individual. Two photos were at Camera 4. Based on the best photograph at each camera location, W. Spencer identified these as Dulzura kangaroo rat (*Dipodomys simulans*) based on the broad, distinct lateral tail stripe, narrow face shape, and sharply contrasting markings. Habitat in the camera locations (as described by USGS and evident in the photos) appears generally suitable for Dulzura kangaroo rats, but not very suitable for SKR, due to presence of shrubs, bunch grasses, and oak leaves. Although Spencer and Montgomery did not survey this area in 2001, W. Spencer did visit this general location during the 2000 reconnaissance with TNC staff and did not consider it suitable for SKR.

Biogeographic Significance of Santa Ysabel Valley for SKR—Although SKR have not yet been confirmed within the Santa Ysabel Valley, they almost certainly have occurred there at least in the past, and they could still occur in some portions today or in the future. The present survey covered only a minor proportion of the total potential SKR habitat in the valley, and not necessarily the most highly suitable habitat (which would probably include the deeper, gentler soils of the valley bottom).

The Santa Ysabel Valley lies only 3 or 4 km southeast of the larger Lake Henshaw basin and its SKR population. These two grassland areas are connected by the rift valley followed by Highway

79 and Corrista Creek, which offers generally gentle terrain for dispersing SKR. Given that SKR currently are known to occur at Lake Henshaw and Ramona, the Santa Ysabel Valley is the most likely dispersal "stepping-stone" between these occupied habitat areas. It was almost certainly occupied in the past, at least when the more southerly populations (Ramona and Guejito) were first colonized (probably during a warmer, drier period thousands of years ago). Likewise, the smaller Ballena Valley (midway between Santa Ysabel and Ramona) was likely once occupied, as it appears to be another potential stepping stone of grasslands on suitable soils; but to my knowledge the Ballena Valley has never been surveyed for SKR.

In conclusion, SKR Populations near Lake Henshaw to the north and Ramona to the west may be genetically connected to one another via the Santa Ysabel Valley (and Ballena Valley). Habitat in the Santa Ysabel Valley appears highly suitable for SKR but has never previously been surveyed for the species. Even if the Santa Ysabel Valley does not currently support SKR populations, it probably supported SKR in the past and may again in the future if potential dispersal corridors are maintained between there and nearby occupied areas. SKR are relatively strong dispersers whose populations exhibit classic metapopulation behavior, in which populations may "wink" on and off in various locations over the landscape due to environmental variation and stochastic events. So long as suitable habitat areas are sufficiently connected, any given location may be unoccupied for a time, only to be recolonized from another, occupied site in the future. Maintaining this potential for natural metapopulation dynamics is probably essential to the long-term persistence of the species (Burke et al. 1991).

Future Survey and Management Recommendations

Although surveys failed to detect SKR on the subject properties during 2001, there is potential that they could be occupied in the future. Consequently, land management should be consistent with maintaining suitable habitat conditions and minimizing potential threats to SKR or other rodent species.

Surveys—I recommend periodic reconnaissance surveys for kangaroo rat sign in Areas A and B. Surveys could be repeated every 2-3 years, or only in years where expansion of SKR populations and dispersal into new areas is considered likely (for example, the second summer following an El Niño winter). Determination of when to survey could be triggered by observations at another known population, for example, based on results of yearly monitoring surveys at the Ramona Airport. If kangaroo rat sign is detected on the SYOSR, trapping surveys should be conducted to verify species and to collect genetics samples.

Land Management—Cattle grazing at moderate stocking densities could be used to continue providing potential habitat for SKR on Areas A and B. Horse grazing should be prohibited, because horses tend to compact soils and collapse burrows with their sharper hooves, and their grazing may reduce forb species favored as food sources by SKR. Riparian areas and oak woodlands should be fenced to keep cattle out, and grazing should be confined to open grasslands not supporting wetlands or sensitive plant species. Vegetation monitoring should ascertain the relative abundance of annual forbs versus grasses. Management for SKR habitat should strive to maintain sparse cover of annual forbs and grasses, and to prevent dense invasions by exotic grasses, such as *Bromus* and *Avena*, which can crowd out forbs and perpetuate an unnatural fire cycle that eliminates native plants.

If cattle are not retained on these areas, prescribed burns should be considered as a management tool, coupled with vegetation monitoring, to increase habitat value for SKR. Fall burns (just prior to winter rains) are thought to favor annual forbs over grasses, and hence may be best for maintaining SKR habitat value (M. O'Farrell, personal communications). However, some ecologists believe that spring burning, before seed set in annual grasses, may be preferable for restoring natural vegetation patterns in southern California. Experts in fire ecology should be consulted to determine optimal timing for vegetation management, considering both SKR habitat needs (e.g., favoring annual forb growth), and other vegetation management goals (e.g., promoting "natural" fire regimes). Results of ongoing monitoring at the Ramona Airport (which includes both grazing and fire as SKR habitat management tools) should also be consulted in prescribing management actions for the SYOSR (keeping in mind differences in elevation and climate).

Rodenticides, fertilizers, discing, planting, or irrigation should be prohibited from the SYOSR, particularly in or near Areas A and B.

Literature Cited

Bleich, V. C. 1973. Ecology of rodents at the United States Naval Weapons Station Seal Beach, Fallbrook Annex, San Diego County, California. M.A. thesis, California State University, Long Beach.

Burke, R. L., J. Tasse, C. Badgely, S. R. Jones, N. Fishbein, S. Phillips, and M. E. Soulé. 1991. Conservation of the Stephens' kangaroo rat (*Dipodomys stephensi*): Planning for persistence. Bull. Southern Calif. Acad. Sci. 90(1):10-40.

Federal Aviation Administration and County of San Diego Department of Public Works. 2000. Ramona Airport Integrated Habitat Management Plan. Prepared by KEA Environmental and Conservation Biology Institute. September 2000.

Hathaway, S., R. Fisher, C. Rochester, C. Haas, M. Mendelsohn, G. Turschak, D. Stokes, M. Madden-Smith, E. Ervin, K. Pease, and C. Brown. 2004. Baseline biodiversity survey for the Santa Ysabel Ranch Open Space Preserve. USGS Technical Report. Prepared for The Nature Conservancy and San Diego County Department of Parks and Recreation.

Metcalf, A. E., L. Nunney, and B.C. Hyman. 2001. Geographic patterns of genetic differentiation within the restricted range of Stephens' kangaroo rat, *Dipodomys stephensi*. Evolution, in press.

Montgomery, S. J., J. Sawasaki, and D. Mitchell. 1996. Survey report for Stephens' kangaroo rat on Marine Corps Base Camp Pendleton, California. Prepared for U.S. Marine Corps Base Camp Pendleton. August 1996.

Moore-Craig, N. A. 1984. Distribution and habitat preference of Stephens' angaroo rat on the San Jacinto Wildlife Area. Senior undergraduate thesis, University of California, Riverside.

O'Farrell, M. 1998. *Dipodomys stephensi* (Merriam 1907): Stephens' kangaroo rat. Pages 78-79 in Hafner, D. J., E. Yensen, and G. Kirkland, Jr. (compilers and editors). North American rodents: status survey and conservation action plan. IUCN/SSC Rodent Specialist Group. IUCN, Gland, Switzerland, and Cambridge, UK. *x* + 171 pp.

O'Farrell, M., and C. Uptain. 1989. Assessment of population and habitat status of the Stephens' kangaroo rat (*Dipodomys stephensi*). Report ot the State of California, The Resources Agency, Department of Fish and Game, Wildlife Management Division.

Ogden Environmental and Energy Services Co., Inc. 1998. Stephens' Kangaroo Rat Study for the Ramona airport Expansion Project, Ramona California. Prepared for KEA Environmental. January 1998.

Price, M.V. and P.R. Endo. 1989. Estimating the distribution and abundance of a cryptic species, *Dipodomys stephensi* (Rodentia: Heteromyidae), and implications for management. Conservation Biology 3:293-301.

U.S. Department of Agriculture (USDA). 1973. Soil survey, San Diego area, California. Soil Conservation Service, Washington, D.C. December.

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

Appendix A

Draft Species Account
Stephens' Kangaroo Rat
from
San Diego County Mammal Atlas Project